APPENDIX 1

City of Princeton Point-Nonpoint Source Trading Summary

Finalized For the Princeton NPDES Permit MN0024538
April 2015

Executive Summary

With the 2015 reissuance of the Princeton Wastewater Treatment Facility National Pollutant Discharge Elimination System (NPDES) permit, the Minnesota Pollution Control Agency (MPCA) authorizes the City of Princeton's (Permittee) proposal to offset the total phosphorus (TP) pollutant loading from its wastewater treatment facility (WWTF) to the Rum River in an innovative manner that provides flexibility to the Permittee while ensuring a degree of water quality protection that is superior to that which would have resulted from a traditional wastewater treatment approach.

The combination of upstream nonpoint source pollutant loading reductions and advanced TP removal at the WWTF ensure a net TP loading reduction to the Rum River and Lake Pepin while providing additional water quality benefits such as stream bank stabilization and sediment reduction. This permit meets the guidelines for pollutant reduction trading developed by the MPCA as well as the U.S. Environmental Protection Agency's (EPA) Water Quality Trading Policy.

This Point-Nonpoint Source Trading Summary document outlines the criteria that restoration projects must meet to be approved by the MPCA. The NPDES Permit for the Princeton WWTF includes more specific information regarding the approved trades, the resulting discharge limits resulting from the approved trades, the long-term monitoring and maintenance of the sites and the criteria for requesting additional restoration projects in the future.

Introduction

In October 2012, the Permittee initiated operations of a new continuously discharging wastewater treatment facility built to replace its existing non-discharging stabilization pond system. The new facility's discharge to the Rum River was considered a new discharge to an Outstanding Resource Value Water which required the preparation of a nondegradation analysis as specified in Minn. R. 7050.0180 and resulted in the inclusion of advanced treatment requirements in Princeton's NPDES permit. State policy and federal regulations prohibit the issuance of a National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) permit for a new source of a pollutant upstream of impaired waters prior to the completion of a Total Maximum Daily Load (TMDL) for the impairment. Lake Pepin, a riverine lake approximately 175 river miles downstream of the Princeton WWTF, is impaired due to excess phosphorus and chlorophyll-a. Since a TMDL has not yet been completed for the Lake Pepin excess nutrient impairment, the Princeton WWTF NPDES permit requires the offset of the facility's effluent phosphorus load through reductions of other sources of phosphorus in the Lake Pepin watershed. Pollutant load reduction offsets are also referred to as Water Quality Trading.

In order to account for the phosphorus load from the new discharge, the Permittee entered into an agreement with Metropolitan Council Environmental Services (MCES) to conduct point-point pollutant trading. MCES agreed to remove TP at its Metro WWTF to a level lower than required in its NPDES permit so that the TP load could be transferred to the Princeton WWTF's NPDES permit. The Permittee would provide some type of "payment" to MCES for the additional treatment. The "payment" was in the form of nonpoint source pollutant reduction projects within the Rum River watershed. The agreement between the Permittee and MCES expires upon reissuance of the Metro WWTF NPDES permit. The Permittee has requested to utilize the restoration projects that have been completed within the Rum River watershed as a point-nonpoint pollutant trade to account for the Princeton WWTF's discharged phosphorus load. The best management practices (BMPs) that they constructed have been reviewed and have been determined to provide adequate phosphorus control until the Lake Pepin TMDL has been completed and a Waste Load Allocation (WLA) has been assigned to the Princeton WWTF. The Permittee will no longer be required to maintain the nonpoint source restoration projects after a water quality based effluent limit consistent with assumptions and requirements of an EPA approved Lake Pepin TMDL has been incorporated into its NPDES permit.

The original point-point trade with MCES involved a 1.2:1 trade ratio and resulted in a reduction of 2,721 kilograms (6,000 pounds) per year (kg/yr) from the Metro WWTF and an increase of 2,267 kilograms (5,000 pounds) at the Princeton WWTF of TP. In consideration of MCES's transfer of TP, the Permittee completed nonpoint source restoration projects within the Rum River watershed which resulted in a total phosphorus load reduction of 4,568 kilograms (10,071 pounds) per year.

The MPCA has worked with the Permittee to analyze their reductions to insure that they meet MPCA point-nonpoint (P-NP) trading requirements similar to previous P-NP trades completed in Minnesota. This includes a trade ratio of 2.6:1 and additional requirements as outlined in this document.

Trade crediting calculations are based on conservative professional estimates. The Permittee is required to achieve and maintain MPCA-approved credits according to the NPDES permit. These requirements are based upon a trading ratio of 2.6:1 which is determined as follows:

- 1.0 (Basic 1:1 Trading Ratio Requirements)
- + 0.6 (Engineering safety factor reflecting potential site-to-site variations)
- + 1.0 (Net reduction factor to achieve load reductions that improve water quality.)
- = 2.6 (Overall Trading Ratio)

Utilizing a trade ratio of 2.6:1 requires a nonpoint reduction of 4,841 kg/yr (10,673 pounds per year (lbs/yr)), based on P effluent limits of 1.0 milligrams per Liter (mg/L) from October through April and 0.3 mg/L May through September. To date, the Permittee has achieved 4,568 kg/yr (10,071 lbs/yr) in nonpoint reductions based on MPCA calculations. The value of the trades leaves the Permittee 273 kg/year (602 lbs/year) short of the total needed. The actual discharge from this facility was 151 kg/year (333 lbs/year) based on actual Discharge Monitoring Report (DMR) data from October 2012 through November 2014. At this time, further nonpoint reductions are not necessary. However, additional trades will be necessary as discharge flow values and mass values increase towards the permitted amounts. See the NPDES permit for additional requirements.

All future trades are required to be done according to this document.

Concept of Point - Nonpoint Source Trading

Point-nonpoint source (P-NPS) pollutant trading refers to the substitution of nonpoint source pollutant load reductions for point source pollutant load discharge requirements by a discharger permitted under the NPDES permit. To meet the TMDL goals, the Permittee will treat its effluent discharge according to the requirements of its NPDES permit and participate in P-NPS trading. MPCA requires that such trades result in pollutant reductions that are:

- Equivalent to the point source discharge in their water quality impact. Equivalence refers to the physical substitution of nonpoint reductions traded for point source loads, taking into account all relevant factors, for example, differences in time, place and chemical form of point and nonpoint source loadings and the sensitivity of the receiving water. In this trade, it has been determined that sufficient safety factors for nonpoint BMPs are in place to meet this definition.

- Additional to NPS reductions that would be likely to occur in the absence of a trade. Additionality requires that nonpoint source load reductions that are credited to a point source in a P-NPS trade would not have occurred otherwise, in the absence of P-NPS trading. For example, in this trade, feedlot corrections or conservation tillage are not allowable trade credits because there is a regulatory program for feedlots and a cultural trend of adoption of conservation tillage already existing.

- Accountable so that the NPS measures proposed in the trade will be implemented and maintained to achieve their intended result on water quality. Accountability refers to the need to ensure that a P-NPS trade satisfies the above criteria of equivalence and additionality, and that terms of the trade agreement are being lived up to. Only the nonpoint source BMPs verifiable by field inspections or other physical measures have been selected.

A framework for P-NPS trading has been developed. In order to implement P-NPS trades, the following definition of what constitutes a trade has been developed.

Trade: A trade is a direct reduction in NPS load which is applied against the point source load.

The Permittee will achieve phosphorus nonpoint source load reductions by completing projects that include nonpoint source reduction practices. The Permittee will work with the MPCA, its consultant and local land owners and oversee the selection of restoration project sites for trading. MPCA approval is required for all selected sites and the use of the pollutant reduction estimates. All pollutant reduction estimations calculated for the 2015 NPDES permit followed the formulas submitted by the Permittee or its consultant in late 2014 and early 2015. All pollutant reduction estimations calculated in the future will follow the requirements of this document unless approved in advance by the MPCA.

Assumptions of Point-Nonpoint Source Trading

The P-NPS trade proposal assumes many physical process restraints. The following is a list of conditions which selection of BMPs are based on:

1. In order to maintain the exceptional quality of the Rum River, BMP’s must occur upstream of the discharge point in the Rum River basin.

2. Phosphorus will be treated as a conservative and persistent compound. The phosphorus entering the watershed at any location will be assumed to cycle downstream and exert a load on the lower reach of the Rum River at some future date.

3. The Midwest Plan Service publication, which provides the manure estimates, reflects the current professional estimates of manure content for the parameters of phosphorus.

4. The Universal Soil Loss Equation (USLE) and the Revised Soil Loss Equation (RSLE) reflect the current professional expertise for projecting soil erosion rates from sheet, rill and ephemeral gullies. Local Natural Resource Conservation Service (NRCS) and Soil and Water Conservation Service Districts (SWCD) can determine the equation coefficients for sites in their respective areas.

5. Delivery ratios of sediment and phosphorus contents of soils are based on conservative professional estimates unless justification of higher rates can be provided.

6. As with any estimation process using average or conservative numbers, the use of several sites increases the probability that the averages or conservative estimates are reflective of the sites in the whole basin. When using several sites, the variance of a specific site below the estimated average value is accounted for by the excess of a different site in the population. The system developed has an overall safety factor of approximately two worked in to the conservative estimating process.

7. The choices of average or conservative values is constantly improving as the knowledge base on the nonpoint sciences improves and the number of research sites increases. As documentation increases and modifications to the following calculations are justified, this document may be updated to remain current. Previously approved trades will remain credited at the values previously agreed to; modifications will only apply to trade sites yet to be approved by the MPCA. Any modifications to this document will be completed through a permit modification.

8. The term “surface water entry points” will be defined as streams, rivers, wetlands, ditches, and surface tile intakes which are connected to the main stem of the Rum River. Watersheds entering lakes have a greater assimilative capacity and therefore must be justified prior to use in this agreement.

9. Land locked areas, and watershed divides within a larger BMP implementation site will be factored out of all pollutant reduction calculations by estimating only contributing acres associated with the Rum River.

10. The trading credits for BMPs will be divided among those providing funding. Costs for BMP installation will be totaled. All parties (i.e., Local Governmental Units (LGUs), state and federal offices, private organizations, etc.) contributing to the installation costs and estimation of maintenance costs will determine the percent credits. Operation and research costs provided by third parties will not be calculated in the crediting process. In cases where the Permittee is using loan funding to pay for the BMP, and they intend to repay the loan, the credits associated with that amount will be granted to the Permittee.

Minimization of Associated Risks

The use of nonpoint source BMPs to trade for a point source discharge does pose some risk. The effectiveness of BMPs in reducing NPS loading depends on the type of BMP selected, its location on the landscape, and the quality of its design and maintenance. It also depends on weather. Most NPS BMPs are effective during normal storm events and may not operate during drought or extreme storms. Risks associated with BMP implementation will be reduced by conservative estimates of pollutant credit units. Specific examples include:

- In calculating phosphorus loading from soil erosion, conservative estimates of the soil phosphorus content are used. In the event that site-specific soil sampling justifies a higher phosphorus content, a safety factor of 0.75 may be used in the crediting calculations.

- A delivery ratio (DR) of 100 percent for NPS in the riparian zone will be used. However, a DR of 20 percent will be used for lands within a one-quarter mile of the stream and a DR of 10 percent will be used for areas further away. These DRs are highly conservative on sites being targeted in this process.

- Land locked areas and watershed divides within larger restoration project sites will be factored out of the pollutant credit calculations.

These factors are multiplicative in the equations used. The conservative nature of the numbers for phosphorus per ton and delivery ratios will result in underestimating the phosphorus reduced by at least a factor of two on "typical" sites ensuring that phosphorus reduction goals will be achieved.

To ensure the appropriate use of these ranges, site visits by MPCA staff may be coupled with communications with other organizations such as the Soil and Water Conservation District during the selection process. To make a final selection of BMPs, it is necessary to go beyond the question of equivalence to address the criteria of additionality and accountability. Which combination of BMPs would result in pollutant reductions that probably would not have occurred in the absence of trading? Which BMPs most lend themselves to accountability? That is, for which ones would installation, effectiveness and maintenance be easiest to confirm? What type of BMP could be implemented through the fewest possible number of enforceable contracts with landowners?

Any currently regulated practice cannot be used in the trade as the permitting program would require the change anyway. Some BMPs, such as reduced tillage, are being widely adopted because they make economic sense, and further adoption is likely with or without payments from a trade. Trading eligible BMPs that have been identified to date include:

1. **Soil Erosion BMPs,** including sheet, rill and ephemeral gully erosion, gully erosion, stream, river, and ditch bank erosion.
2. **Cattle Exclusion,** separating cattle from waterways for protection against bank erosion and direct manure impacts.
3. **Rotational Grazing With Cattle Exclusion,** to enhance forages for pollutant reductions from filtering processes and plant nutrient uptake.
4. **Critical Area Set Aside,** of highly erodible land.
5. **Wetland Treatment Systems,** for phosphorus removal from tile outlets or other agricultural related runoff.

6. **Alternative Surface Tile Inlets,** which connect surface water ponding to subsurface tile.
7. **Cover Cropping,** to increase the residue cover for soil protection against erosion.
8. **Storm Sewer System Retrofitting,** to add BMPs to existing systems. BMPs cannot be tied to new development or re-development and cannot be in area which is subject to NPDES/SDS stormwater permitting requirements (MS4, Industrial or Construction).

As trading practices become adopted on a more widespread basis, it is likely that additional BMP categories will be identified. These additional BMP categories can be added to this list during permit reissuance or a permit modification.

The variety of BMPs which can be implemented all contain aspects of their establishment or performance which require special considerations by the operator. Some of the changes will be new to the operator and technical assistance will be required as part of the BMP set up (i.e., rotational grazing of cattle may bring forage questions to bear and technical assistance through the establishment period will be provided). All BMPs with vegetative components will require an establishment criteria to ensure a dense stand. In addition, some BMPs which treat sediment by filtering or settling require on-going maintenance:

- To ensure sheet flow conditions are maintained in upland flow areas.
- To remove sediment build ups which obstruct the operation of the BMP.
- To re-establish a structure or plant life after major storm events or fire.
- To remove harmful infestations (such as, carp from treatment wetlands, destructive insects in vegetation and beavers from bioengineering sites).

At the time of the site crediting and approval, the responsibilities and technical assistance proposed to address the above issues for the site will be considered.

There are many alternative ways of achieving the required NPS load reduction. To evaluate the effectiveness and cost of some of the most promising BMPs, the MPCA has used a system of BMP crediting that estimates the reductions in NPS loading that can be expected to result from the implementation of BMPs.

1. Soil Erosion BMPs

Sources of sediment, nitrogen, phosphorus and biochemical oxygen demand (BOD) occur naturally throughout the basin. The transport of these pollutants to the river is accelerated by intensive land use management such as roads, drainage, construction activities and agricultural practices. In addition, some land use activities provide increased sources of nutrients for vegetative needs such as cropping or lawns. The BMP Soil Erosion crediting system is based on established programs. The first is soil erosion protection. The U.S. Department of Agriculture NRCS has been successful in defining soil movement from sheet and rill formations with the use of an equation which is based on soil type, field slope, length of slope, vegetation, and management practices. The Universal Soil Loss Equation, as it is called, is used to predict the erosion tons generated at the field in tons per acre per year. For large gullies or bank erosion, soil loss is estimated by calculating the area which has been eroded divided by the number of years during which the process took place. Once the volume has been established by either of these methods, a conservative value of nutrient content of the soil is calculated. Then a coefficient is used to conservatively estimate how much of the field or bank erosion is transported to the nearest surface water.

2. Cattle Exclusion

The increased density of animals for agricultural production can also increase the NPS loading associated with storm runoff. The elimination of direct deposits of manure in the riparian zone and bank erosion from animal traffic can be credited. The riparian zone typically has higher delivery ratios associated with it due to its proximity to the water body. The estimated time, number of animals and manure produced is necessary to credit the existing scenario changes in delivery when the animals are no longer allowed access. Likewise, the current bank erosion recession rates are used to estimate future protection provided by stabilizing the current bank and preventing future access.

3. Rotational Grazing With Cattle Exclusion

Pastured areas not currently classified as feedlots may still contribute significant loads of phosphorus. The MPCA has a feedlot permitting process for sites where animals are concentrated to such an extent that natural vegetation is destroyed. However, most existing animal grazing systems which maintain vegetation can greatly reduce the delivery of manure to the water. Cattle exclusion when combined with rotational grazing and the use of buffers or easements can be practiced to lower the amount of phosphorus impacts on the water body. To estimate this process, the number of animals, the manure content and the time spent in relation to the water is all estimated for the before conditions. This is then compared with the post conditions where the time spent in close relation to the water is eliminated. Delivery of manure volumes from each "paddock" can then be compared with each scenario to predict whole farm reductions of manure delivered to the water. In addition, the management scenarios need to estimate the time the animals occupy each paddock or area of the pasture to rotate the animals sufficiently to prevent a "feedlot" situation and improve the quality of the vegetative stand. The water quality benefit comes from combinations of: (a) improved rotation management providing a better forage, improved nutrient uptake as the plant is in a growth phase and added soil cover; (b) the use of vegetative filter strips which separate cattle from the water and filter sediment and associated phosphorus in runoff; and (c) the dispersion of manure throughout the pasture providing more opportunities for phosphorus uptake due to proximity of the upper end of the pasture and the water body.

4. Critical Area Set Aside

Critical area set aside refers to the conversion of land use practices in areas which are excessively vulnerable to soil erosion. Traditional soil conservation sites have been steep sloped bluffs or hills, where removal of vegetation or plowing of soil had greatly accelerated the erosion rate. Combining this concept with criteria that are concerned with the proximity to a hydraulic system that delivers the eroded soil to the river, will allow small changes in vegetative management or bio-engineering to provide large protective savings in river load. The targeting of riparian corridors, steep slopes directly connected to the river, and restoring previously drained isolated wetlands, all fit into this category.

5. Wetland Treatment Systems

The construction of wetland treatment systems specifically for water quality enhancement defines the wetland treatment system nonpoint source trading BMPs. Wetlands are a valuable watershed management tool in any basin. Wetlands help stabilize hydraulic peaks, provide necessary habitat for the many species critical to the food chain and settle sediments out of the runoff. However, not all wetlands remove nutrient loading from the watershed. Some wetlands act as sinks for phosphorus much of the year only to pulse the mass of stored nutrients out during stressful times such as after drought periods or snow melt. The constructed wetland treatment system is designed to control the way the nutrients are captured and stored or converted so that the mass of nutrients are not available to be released downstream. By maximizing optimum depths, surface area and detention time, phosphorus is captured and buried. This type of wetland may limit some types of habitat use, but is targeted specifically for chemical (nutrient removal) and sediment treatment.

The science of nutrient treatment by wetlands is relatively new to the design processes in colder climates. Mixed results have often been obtained. Excellent results have been obtained by a system on the Des Plaines River near Chicago, Illinois. The basic concepts designed for with this constructed wetland provide controlled depths ranges to prevent re-suspension of sediments, prevention of short circuiting of flows and adequate detention times which all provide for the loading rates for settling characteristics.

- Wetland Research will be targeted at assessing the performance of wetland treatment sites in Minnesota. The research can be provided by another partner or non-trade participant.

6. Alternative Surface Tile Inlets

Surface tile inlets are a length of pipe, slotted or not, which connects the surface water ponding in depressions directly to the subsurface tile. Alternative surface tile inlets means changing past, traditional surface tile inlets by using rock filters and/or buffered areas.

7. Cover Cropping

Cover cropping means using small grain crops planted in the spacing between row crops, or using small grain crops planted after the harvest of the cash crop such as peas, to increase the residue cover for soil protection against erosion. The establishment criteria for the cover crop for each cash crop shall be provided according to the permit.

8. Storm Sewer System Retrofitting

Storm sewer system retrofitting means working with the city storm sewer system and the addition of catch basin sumps, mechanical grit separation chambers and detention BMPs (e.g. stormwater ponds, infiltration trenches or rain gardens) to remove TP from the stormwater runoff. The Permittee is not an MS4 permit holder and any stormwater TP loading reductions it makes are voluntary. BMPs cannot be tied to new development or re-development. If the Permittee becomes an MS4 permit holder, this portion will have to be re-evaluated.

Other Trade Values Exist

A trade of nonpoint controls to mitigate for point source TP discharges has several other valuable contributions to the environment. This trade was set up considering primarily the NPS contribution to the reduction goals of phosphorus in the Rum River watershed and Lake Pepin. Many NPS pollutant reduction practices have the potential to generate various benefits in addition to the TP reductions that are generating credits for this permit. For example, the Permittee’s stream bank restoration projects help reduce sediment loading to the Rum River. Other types of restoration projects may also sequester significant quantities of carbon from the atmosphere or provide valuable wildlife habitat. These additional benefits help contribute to water quality goals or other environmental goals and potentially be economically beneficial to the Permittee.

In addition, the Princeton trade is a pioneering agreement in municipal wastewater treatment which could help Minnesota break new ground in environmental protection. It provides a flexible means of compliance for the Permittee, and allows municipal expansion to proceed while ensuring a degree of water quality protection that is superior to that which could have resulted from a more traditional approach. Lessons learned from this experience could lead to significant improvements in water quality protection programs.

Water Quality Trade Crediting Calculations

Point Nonpoint Trades will be facilitated as follows.

"High Delivery Zone" means the corridor of land along a stream, river or other watercourse that demonstrates high interaction of the soils with the watercourse. High Delivery Zones may include floodplains with a high flood return frequency, or land with convex slopes toward the watercourse that does not allow eroded materials to redeposit before overland flow enters the watercourse. The MPCA shall determine whether a proposed site is a High Delivery Zone or not.

The Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) shall be used to project the soil erosion rates from sheet, rill, and ephemeral gullies. The local NRCS and SWCD staff shall determine the USLE and RUSLE coefficients for proposed trade sites in their respective local areas.

Credits under more than one BMP for the same site shall not be allowed unless adequate justification is provided demonstrating that the accumulative credits are additive.

Trade crediting calculations are based on conservative professional estimates. The Permittee is required to achieve and maintain MPCA-approved credits according to the permit. These requirements are based upon a trading ratio of 2.6 which is determined as follows:

- 1.0 (Basic 1:1 Trading Ratio Requirements)
- \+ 0.6 (Engineering safety factor reflecting potential site-to-site variations)
- \+ 1.0 (Net reduction factor to achieve load reductions that improve water quality.)
- = 2.6 (Overall Trading Ratio)

1. Soil Erosion BMPs

Soil erosion BMPs are intended to reduce the impacts of sheet, rill, and ephemeral gully erosion; gully erosion; stream, river, and ditch bank erosion; and erosion at surface tile inlets. The following process shall be used to calculate the phosphorus credits from soil erosion BMPs.

Step 1: Calculate the reduction in soil erosion. The following methods of estimating the erosion rate apply, based on the erosion mechanism:

A. Sheet, Rill, and Ephemeral Gully Erosion: Calculate the site erosion rate before and after installing the BMP using the USLE or RUSLE. (The equation used shall be that currently used by the local NRCS and SWCD). Express the results in tons/acre/year (SED_b and SED_a).

B. Streambank and Gully Erosion:

   1. Using the existing contours, determine the volume of soil removed by gully erosion and/or streambank erosion (VOL).

2. Using the land operator as a reference, determine the amount of time in years it has taken to produce the gully and/or streambank erosion (VOL/YRs).

3. Using the Soil Density Values below, convert the volume per year determination to tons/year (SED_b). SED_a shall be equal to zero.

Soil Density Values

Soil Textural Class	Dry Density (tons/ft^3)
Sands, loamy sands	0.055
Sandy loam	0.0525
Fine sandy loam	0.05
Loams, sandy clay loams, sandy clay	0.045
Silt loam	0.0425
Silty clay loam, silty clay	0.04
Clay loam	0.0375
Clay	0.035
Organic	0.011

Step 2: Calculate the reduction in sediment delivered to the watercourse.

A. Sheet, Rill, and Ephemeral Gully Erosion: Using the Delivery Ratio (DR) Table below, enter the sheet and rill erosion category to calculate the delivery ratio for the site before and after implementation of BMP(s). Sediment reduction in tons (SEDRT) equals the difference between these values times the acres that the practice is applied over. $SEDRT_b$ = Area * (SED_b*DR_b) and $SEDRT_a$ = Area * (SED_a*DR_a).

Delivery Ratio Table

Area	Surface Tile Inlets Absent			Surface Tile Inlets	
	High Delivery Zone	Non-High Delivery Zone less than ¼ mile from watercourse	Non-High Delivery Zone greater than ¼ mile from watercourse	Without a Standpipe	With a Standpipe
Gully Erosion Channelized to Watercourse	95%	95%	50%	NA	NA
Gully Erosion Non-Channelized to Watercourse	NA	15%	5%	20%	10%
Sheet, Rill Erosion	95% maximum	15%	5%	20%	10%
Streambank Erosion	95%	NA	NA	NA	NA

B. Streambank and Gully Erosion: Using the Delivery Ratio Table above, select the appropriate delivery ratio (DR_b). Multiply the soil erosion rate (SED_b in tons/year) by the delivery ratio to determine the amount of soil reaching the river (Sediment Reduction Delivery Calculation - SEDRDC), excluding landlocked areas or watershed divides within the site. The results shall be in tons/year delivered. $SEDRDC = SED_b * DR_{b.}$

Step 3: Determine the phosphorus values associated with the sediment runoff.

A. Sheet, Rill, and Ephemeral Gully Erosion: To determine the annual phosphorus mass reduced (SEDRTP), take the sediment tons per acre before and after (similar to step 2, without the area; $SEDRTP_b = SED_b * DR_b$ and $SEDRTP_a = SED_a * DR_a$) and enter the Phosphorus Enrichment Table. Phosphorus enrichment values represent the phosphorus attachment potential of different soil types combined with the settling characteristics of the different particles. The phosphorus attachment in the parent material is as presented in the table below for each soil type (e.g., 1.00 pound/ton for silt), however, as sands deposit out and clays continue on the move and the soil that remains on the move contains more P per ton of soil. This table is from the CREAMS model algorithm for sediment-attached phosphorus and adjusts for phosphorus content of the parent material type. To determine the enrichment, take the phosphorus content results (phosphorus) for the "before value" and subtract the "after value" from the table. (P_b and P_a), Phosphorus Reduction Delivery Calculation: $PRDC = P_b * Area- P_a * Area$.

B. Streambank and Gully Erosion: Determine the phosphorus values associated with the sediment. Using the default values in the table below, calculate the amount of phosphorus delivered (PDEL) to the river, excluding landlocked areas or watershed divides within the site (PDEL). PDEL = SEDRDC * PhosContent.

Soil Type	Sand	Silt	Clay	Peat
Phosphorus Content Factor	0.85 lb/ton	1.00 lb/ton	1.15 lb/ton	1.50 lb/ton

NOTE: The values used in Step 3 are conservative. At certain trade sites, soils may have enriched phosphorus content due to past application of fertilizers. Higher phosphorus levels may be justified through site-specific soil sampling. However, to account for uncertainties associated with the sample process, site-specific values shall be multiplied by a safety factor of .75 to calculate the amount of phosphorus delivered, unless a site-specific soil sampling plan is approved in advance.

Phosphorus Enrichment Table

Sediment Delivery Rate (tons/ac/year)	Phosphorus Enrichment Value (lbs/acre)			
	Clay	**Silt**	**Sand**	**Peat**
0.01	0.05	0.04	0.03	0.06
0.02	0.08	0.07	0.06	0.10
0.03	0.11	0.10	0.08	0.15
0.04	0.14	0.12	0.10	0.18
0.05	0.17	0.15	0.12	0.22
0.06	0.19	0.17	0.14	0.25
0.07	0.22	0.19	0.16	0.29
0.08	0.24	0.21	0.18	0.32
0.09	0.27	0.23	0.20	0.35
0.1	0.29	0.25	0.22	0.38
0.2	0.51	0.44	0.38	0.66
0.3	0.70	0.61	0.52	0.92
0.4	0.88	0.77	0.65	1.15
0.5	1.1	0.9	0.8	1.4
0.6	1.2	1.1	0.9	1.6
0.7	1.4	1.2	1.0	1.8
0.8	1.5	1.3	1.1	2.0
0.9	1.7	1.5	1.2	2.2
1	1.8	1.6	1.4	2.4
2	3.2	2.8	2.4	4.2
3	4.4	3.9	3.3	5.8
4	5.6	4.8	4.1	7.3
5	6.7	5.8	4.9	8.7
6	7.7	6.7	5.7	10.1
7	8.7	7.6	6.4	11.4
8	9.7	8.4	7.2	12.7
9	10.7	9.3	7.9	13.9
10	11.6	10.1	8.6	15.1
11	12.5	10.9	9.3	16.3
12	13.4	11.7	9.9	17.5
13	14.3	12.4	10.6	18.7
14	15.2	13.2	11.2	19.8
15	16.0	14.0	11.9	20.9
16	16.9	14.7	12.5	22.0
17	17.7	15.4	13.1	23.1
18	18.6	16.1	13.7	24.2
19	19.4	16.9	14.3	25.3
20	20.2	17.6	14.9	26.3
21	21	18.3	15.5	27.4
22	21.8	19.0	16.1	28.4
23	22.6	19.6	16.7	29.5
24	23.4	20.3	17.3	30.5
25	24.1	21.0	17.8	31.5
26	24.9	21.7	18.4	32.5
27	25.7	22.3	19.0	33.5
28	26.4	23.0	19.5	34.5
29	27.2	23.6	20.1	35.5
30	27.9	24.3	20.7	36.4

2. Cattle Exclusion

Cattle exclusion means fencing and an alternative water supply that provides a separation distance protecting the waters of the state and their shorelands.

The following process shall be used to calculate the phosphorus credits from cattle exclusion.

Step 1: Determine the number of head and size of animals. The maximum grazing density for cattle that can be supported without supplemental feeding is one animal per acre (head/ac) over a 5-month grazing season for steers. Other cattle pasture operations shall determine the land's capacity and document the assumptions. The animal count shall be determined by the typical weight categories given in the Midwest Plan Service's Cattle Waste Facilities Handbook (MWPS-18). Keep separate counts for each animal category presented (HEAD).

Step 2: Determine the manure load generated by the herd. The MWPS-18 lists standard production rates for phosphorus (MP):

MP = HEAD * MWPS-18 P
MTP = Phosphorus from all the animal categories presented

Step 3: Determine the field layout before and after cattle exclusion has been implemented. The pasture area shall be divided into a High Delivery Zone and a non-High Delivery Zone. For large pastures, the non-High Delivery Zone shall be divided based on the delivery ratio as shown below:

Area	High Delivery Zone	Non-High Delivery Zone less than ¼ mile from watercourse	Non-High Delivery Zone greater than ¼ mile from watercourse
Delivery Ratio	100%	40%	20%

Step 4: Determine the amount of phosphorus delivered in each portion of the pasture before and after implementation of the BMP. Deposition of manure in pasture areas shall be directly proportional to the amount of time spent by the animals in each area. The following time distribution shall be used for cattle having unrestricted access in the riparian zone:

Month	**Time in High Delivery Zone**
May	25%
June	25%
July 0–15	25%
July 15–30	36%
August	36%
September	25%
Average	**28%**

The alternative water supply shall be located in the pasture, as specified in the operation and maintenance plans, to minimize the time the cattle are next to the exclusion fencing.

Time not spent in the High Delivery Zone shall be spread equally throughout the upland pasture area in the following distribution: the ratio of the total field size to the portion less than ¼ mile or greater than a ¼ mile from the watercourse. The amount of phosphorus deposited in each portion of the pasture shall be calculated based on the ratio of the field size to the portion of land less than or equal to ¼ mile and greater than or equal to ¼ mile. For example, if 20 percent of the field exceeds ¼ mile, then 20 percent of the manure shall be allocated the 20 percent delivery ratio after the cattle exclusion is implemented. Example time distributions (TD) are shown below (in this example, zero percent of the field is located more than ¼ mile from the watercourse):

<u>Example Time Distributions</u>

Pasture Area Cattle Management	**Before Cattle Exclusion**	**After Cattle Exclusion**
High Delivery Zone	28%	0%
Non-High Delivery Zone less than ¼ mile from watercourse	72%	100%

Step 5: Determine amount of phosphorus delivered.

The amount of phosphorus delivered shall be calculated from the amount deposited in each pasture area multiplied by that area's delivery ratio, and shall be adjusted according to:

- Herd Size: If a substantial portion of the pasture would fall under a conservation easement, the herd size shall be reduced in the calculations to reflect the decreased carrying capacity after the implementation of cattle exclusion.

- Filter Strips: Filter strip credit may be allowed for management areas where flow characteristics and vegetation are such that filtering out of solids is enhanced. The minimum width of the easement for application of a filter strip function is 25 feet for stem grass vegetation and 50 feet for woody vegetation. Filter strips are assumed to remove 30 percent of particulate pollutants and 0 percent of soluble pollutants. The relative distribution of soluble/particulate fractions shall be 50 percent/50 percent for manure-based phosphorus.

$LPDR_B$ = MTP * THZ * DR + MTP * TG1/4 * DR + MTP * TL1/4 * DR
$LPDR_A$ = MTP * TG1/4 * DR + MTP *TL1/4 * DR

DR = Delivery Ratios as determined by table on Delivery ratios
THZ = time assumed to be in High Delivery Zone (28% of the time)
TG1/4 = time determined to be spent in pasture more distant than a ¼ mile
TL1/4 = time determined to be spent in pasture closer than a ¼ mile
MTP = Phosphorus from all the animal categories presented

Filter Strip Crediting

FilterLE = $LPDR_B$ - $LPDR_A$ – ($LPDR_A$ * TE* Solidf)

TE = equals a treatment efficiency of 30% removed of particulate matter.
Solidf = equals the assumption of 50% of manure being in solid versus soluble.

3. Rotational Grazing with Cattle Exclusion

The operation and maintenance plans for rotational grazing shall include a description of the enhanced forage species for the pastures, including the vegetation criteria to determine over-grazed pastures from properly rotated pastures.

Rotational grazing with cattle exclusion shall be credited similar to Cattle Exclusion except for the time spent in distant pastures and reductions in the delivery ratio attributed to manure rates being closer to agronomic rates. More credit may be obtained if rotational grazing documents more time spent in the pastures farther than ¼ mile from the watercourse. Acceptable documentation includes establishing a rotational grazing plan and recording the rotational movement in that operation, and an annual “T” transect of the forage grasses present. The “T” transect shall consist of determining the vegetation species found every foot along two 100-foot lines perpendicular to each other in each field paddock. If the paddock shaping has dimension(s) of less than 100 feet, then the count may be reduced to every six inches along a 50-foot length. The vegetation ratios shall meet the enhanced forage vegetation criteria included in the project operation and maintenance plan. Over-intensive grazing shall identify which grass species dominate the “T” transect, for example, a pasture that is dominated by Kentucky bluegrass or bare soils.

Steps 1-2. Follow Cattle Exclusion Steps 1-2.

Step 3: Determine the field layout before and after cattle exclusion with rotational grazing has been implemented. The pasture area shall be divided into a High Delivery Zone and a non-High Delivery Zone. For large pastures, the non-High Delivery Zone shall be divided based on the delivery ratio as shown below:

Area	High Delivery Zone	Non-High Delivery Zone less than a ¼ mile from watercourse	Non-High Delivery Zone greater than a ¼ mile from watercourse
Delivery Ratio	100%	20%	10%

Step 4. Follow Cattle Exclusion Step 4. Example time distributions (TD) are shown below:

<u>Example Time Distributions</u>

Pasture Area Cattle Management	**Before Cattle Exclusion**	**After Cattle Exclusion**
High Delivery Zone	28%	0%
Non-High Delivery Zone less than ¼ mile from watercourse	36%	50%
Non-High Delivery Zone greater than ¼ mile from watercourse	36%	50%

Step 5. Follow Cattle Exclusion Step 5.

4. Critical Area Set Aside

Critical area set aside means changing the principal land use to reduce high erosion levels.

The following process shall be used to calculate the phosphorus credits from critical area set aside.

Set asides may be credited for this permit only if it is verified that the land being credited is not eligible for the Conservation Reserve Enhancement Program (CREP). The permit credit may be used to extend the CREP corridor on land adjacent to the watercourse. If the CREP program sets aside a site stream corridor but does not set aside the whole site, critical area set aside phosphorus credits under this permit may be available for the non-corridor portion of that site.

River Flood-Scoured Areas

Step 1: Determine portion of field subject to scour excavation. This information may be obtained by direct observation of field conditions, or through physical records including maps and photographs. The erosion volumes shall be calculated by averaging the previous events in a documented manner. (AREA, VOL). The volume of the soil is determined by multiplying the area by the depth of scour over that area if evenly eroded or, if irregular in shape, determining that volume voided as described in Soil Erosion BMPs.

Step 2: Determine the period of time the scouring occurred. This may be determined from topographic map records, or as determined and justified by a professional engineer (TIME).

Step 3: Using the soil density values under Soil Erosion BMPs, calculate the weight of the soil eroded (SED) by multiplying the dry density and the volume (tons/acre). SED = VOL * Density.

Step 4: Determine the erosion rate (VER). VER = SED/TIME (tons/acre/yr).

Step 5: Follow Soil Erosion BMPs Step 3B, assuming a 95 percent delivery ratio. SEDP = VER * DR * PhosContent (lbs of P/yr).

Bluffs

The calculations for bluff critical area set asides shall follow the soil erosion calculations under the Soil Erosion BMPs that most closely apply to the type of erosion at the site. In addition, the special practices needed to maintain soil stability during set aside installation and throughout the project trade duration shall be detailed. The design shall consider protecting the site against upland contributing flows from surface and groundwater sources, and providing stability at the toe of the bluff.

Restored Wetlands

The calculations for restored wetlands critical area set-asides shall follow the sheet, rill, and ephemeral gully erosion calculations under the Soil Erosion BMPs. In addition, it shall be demonstrated that restored wetland-contributing areas shall remain hydraulically unconnected with the watershed to which it previously drained. If a restored wetland contributing area remains hydraulically connected with the watershed to which it previously drained, it is not eligible for Critical Area Set Aside credits, but may be eligible for Constructed Wetlands Treatment Systems credits.

5. Constructed Wetland Treatment Systems

Constructed wetland treatment systems shall be designed, constructed, operated and maintained as adapted from Robert Pitt, November 2, 1993, as follows:

1. Treatment systems can have poor water quality and water-contact recreation and consumptive fishing should be discouraged.

2. The wetland shape shall be simple to encourage good water circulation. The length shall be about three to five times the width for maximum detention efficiency and the inlets and outlets shall be widely spaced to minimize short-circuiting. Lower length to width ratios may be allowed if justification can be provided based on the design flows, vegetation establishment and/or energy of the unchannelized water in the wetland.

3. The inlet and outlet areas shall be protected from scour erosion.

4. Minimum and maximum depths of the wetland shall be considered. The depth shall not be such that anoxic layers readily develop. The bounce of the wetland water depth shall not vary sufficiently to impair aquatic emergent vegetation in the wetland.

5. Maximum flows to be treated shall be designed for by providing adequate detention times and emergency spillway or flow bypasses. These design aspects can be met in many varying alternatives. However, the main planning consideration driving a wetland treatment is the capture and long term storage of the sediment and nutrients. The approved system will strongly address these issues in the site design.

6. The water level bounce and vegetation shall be controlled such that at least 70 percent of the permanent pool remains vegetated with emergent varieties.

7. A routine maintenance schedule will be developed, which will address:
    a. The sediment accumulation.
    b. Provisions for unforeseen circumstances (such as carp re-suspending the sediments).
    c. The inspection and replacement of structures.
    d. Establishment and maintenance of the vegetation.

The following equation shall be used to calculate the phosphorus credits from constructed wetland treatment systems:

$$\ln[C_0/C_i] = -k/q$$

where:

C_0 = outlet mean annual phosphorus concentration in mg/L

C_i = inlet mean annual phosphorus concentration in mg/L

k = first order rate constant set at 12.1 meters depth per year (23.7 meters depth per year may be used instead when intensive and continuing monitoring and assessment is provided for a site-specific treatment efficiency; a monitoring and assessment project shall be a minimum of three years long but no longer than six years; upon completion of the assessment at the site the long term average treatment efficiency shall be used)

q = loading rate in meters of depth per year

Sediment trapping phosphorus reduction credits shall be based on the difference in flow-weighted mean annual water concentration of TP of the inlet and the outlet. Other forms of estimating the inlet concentrations other than monitoring will be reviewed upon submittal to the MPCA. The volume treated shall be determined by the design flows based on the average year's cycle as determined by flow data (if available) at the location. Wetland intensive and continuing monitoring and assessment shall be targeted at assessing the performance of wetland treatment sites in Minnesota. This monitoring and assessment may be provided by another partner or non-trade participant.

For wetland treatment sites using the 23.7-meter depth rate constant, a multiplier of 1.3 times the credit shall be applied to remove site-variability safety factor. (This multiplier reflects the use of known data instead of estimates.) $(C_0 - C_i)$*(volume in million gallons/year)*8.34=pounds reduced.

6. Alternative Surface Tile Inlets

Surface tile inlets are a length of pipe, slotted or not, which connects the surface water ponding in depressions directly to the subsurface tile. Alternative surface tile inlets means changing past, traditional surface tile inlets by using rock filters and/or buffered areas.

The following process shall be used to calculate the phosphorus credits from alternative surface tile inlets.

Step 1. Determine the area in the subwatershed feeding the surface tile inlet. (A=AREA).

Step 2. Determine the RUSLE/USLE erosion rate for that portion of the site in this subwatershed. (ER=Erosion Rate).

Step 3. Determine the sediment treatment efficiency of the pre-existing surface tile inlet. The tile inlet shall have been installed at least one year prior to issuance of the initial P-NPS trading NPDES permit. The following factors shall be considered in determining the treatment efficiency:

- Slope of field at inlet
- Type of inlet at site

Surface Inlet Delivery Ratio = SIDR

Tile Inlet Method of Delivery	No Standpipe	With A Standpipe
Delivery Ratio	20%	10%

Step 4. Determine the prior sediment delivery mass. $SedDR_b$ = ER * A * SIDR.

Step 5. Determine the after sediment delivery mass. $SedDR_a$ = ER * A * SIDR *TE.

TE = Surface Tile Inlet Alternative Treatment Efficiencies

Method	Treatment Efficiency
Buffered	35%
Rock Filter	50%

Step 6. Determine the phosphorus content of the soil by using the $SedDR_b$ and $SedDR_a$ values to enter the Phosphorus Enrichment Table under the Soil Erosion BMPs. $PSIDR_b$, $PSIDR_a$.

Step 7. Determine the phosphorus reduction by subtracting $PSIDR_a$ from $PSIDR_b$.

Step 8. Determine the phosphorus credit estimate for the site: PCREST = $PSIDR_b - PSIDR_a$.

7. Cover Cropping

Cover cropping means using small grain crops planted in the spacing between row crops, or using small grain crops planted after the harvest of the cash crop such as peas, to increase the residue cover for soil protection against erosion. The establishment criteria for the cover crop for each cash crop shall be provided according to the permit.

The following process shall be used to calculate the phosphorus credits from cover cropping.

Step 1: Calculate the site erosion rate before and after installing the BMP using the USLE or RUSLE. (The equation used shall be that currently used by the local NRCS and SWCD.) Express the results in tons/acre/year (SED_b and SED_a). The cropping management factor "C" will be the only change in the calculation for before and after BMP calculations.

Step 2: Using the Delivery Ratio Table below, enter the sheet and rill erosion category to calculate the delivery ratio for the site before and after implementation of BMP(s). Sediment reduction in tons equals the difference between these values times the acres that the practice is applied over.
$SEDR_b = SED_b * DR$. $SEDR_a = SEDa * DR$.

Delivery Ratio Table

Area	Less than a ¼ mile from watercourse	Greater than a ¼ mile from watercourse	Surface Tile Inlets Without a Standpipe	Surface Tile Inlets With a Standpipe
Sheet, Rill Erosion	15%	5%	20%	10%

Step 3: To determine the annual phosphorus mass reduced, take the sediment tons per acre before, $SEDR_b$, and after, $SEDR_a$, and enter the Phosphorus Enrichment Table under Soil Erosion BMPs (P_b, and P_a). Phosphorus enrichment values represent the phosphorus attachment potential of different soil types combined with the settling characteristics of the different particles. To determine the enrichment, take the phosphorus content results (phosphorus) for the "before value" and subtract the "after value" from the table. (P_b and P_a), PRDC = P_b * Area - P_a. * Area.

8. Storm Sewer System Retrofitting

Storm sewer system retrofitting means working with the city storm sewer system and the addition of catch basin sumps, mechanical grit separation chambers and detention BMPs (e.g. stormwater ponds, infiltration trenches or rain gardens) to remove TP from the stormwater runoff. The city is not an MS4 permit holder and any stormwater TP loading reductions it makes are voluntary. BMPs cannot be tied to new development or re-development.

Phosphorus reductions will have to be calculated based on the type of technology used, flow rates, phosphorus levels in the stormwater, phosphorus reduction rates, etc.