INDIANA NUTRIENT AND SEDIMENT TRANSPORT RISK ASSESSMENT TOOL (NASTRAT)

Background

The USDA – Natural Resources Conservation Service (NRCS) released their National Nutrient Management Policy in 1999 and again in 2012. Among many things, the policies required each state NRCS office to address the potential water quality concerns associated with nutrient applications and offsite losses of nutrients, with an increased emphasis on phosphorus. It also required states to address manure applications based on P. The Policy provides states with three options for addressing P including agronomic soil test P, soil P threshold values, and the P Index (PI) (NRCS, 1999). The scientific community generally regards the PI as the best of the three risk assessment tool concepts.

Lemunyon and Gilbert (1993) developed the PI concept to evaluate the impacts of both landforms and management practices on phosphorus runoff potential. A ranking for the assessed sites comparatively identifies the greatest or lowest risk sites for P movement. The ranking is accomplished through a weighting procedure for each of the contributing site characteristics (i.e. soil erosion potential, runoff potential, soil test P, and fertilizer and organic P application rate, time, and method). Theoretically, the resulting comparative ranking helps producers, technical service providers (TSPs) and agency personnel identify sensitive areas and recommend management alternatives to reduce the risk of P loss.

The original PI coupled landform properties with management and conservation practices. As a result, PI rankings were dependent upon manure or other nutrient application rate, timing, and method. While this PI ranking concept is useful for assessing the P loss potential of a site with planned manure/nutrient applications, it is not particularly useful for identifying inherent site limitations that may be addressed to increase the suitability for planned manure/nutrient applications. Therefore, most current PIs are not easily implemented to determine optimum manure/nutrient allocation strategies for an operation, as the PI result is not calculated until after the planned application has been made. In addition, most PIs do not consider nitrogen (N) loss potentials, nor do they address soil erosion concerns directly, but rather through the impact of soil erosion on P loss potential.

Ideally, an assessment tool should identify inherent site N, P and sediment transport potentials and provide management strategy options to reduce the risk of N, P, and sediment transport. From this information the assessment tool could then generate a risk-based manure application priority scheme, and assesses N, P, and sediment transport potentials after making planned manure applications. Based on the assessment tool evaluation the producer or TSP could then modify manure/nutrient application rates, methods, or timing to minimize the potential negative impact resulting from their planned application strategy. This was the operational model used to develop the Indiana Nutrient and Sediment Transport Risk Assessment Tool (NASTRAT).

Overview of Indiana Nutrient and Sediment Transport Risk Assessment Tool

The Indiana NASTRAT is initially used to evaluate inherent site and soil characteristics for potential N, P and sediment loss based on initial planned crop rotations and associated tillage practices. Identified inherent concerns may then be reduced by utilizing appropriate agronomic management activities (AMAs) and conservation practices (CPs) to address specific N, P and sediment transport mechanisms. Following the initial assessment, planned nutrient applications (i.e. manures, biosolids, and commercial fertilizers) are made and the NASTRAT is rerun to identify additional concerns resulting from planned nutrient applications. Identified concerns are addressed by altering nutrient application rate, timing or method, or by using other AMAs or CPs to reduce N, P or sediment transport potential. Resource professionals can discuss all available AMAs and CPs that may be used to address concerns identified by the NASTRAT and choose those options that best match producer goals and capabilities. The following site and soil characteristics are used in the NASTRAT to assess N, P and sediment transport potential:

Soil Erosion – Water
Soil Erosion – Wind
Surface Runoff Class
Nitrate Leach Index
Subsurface Drainage Potential
Flooding Potential
Soil P Test
Distance to Waterbody

Additional information on these site and soil characteristics can be found in the next section titled “Indiana Nutrient and Sediment Transport Risk Assessment Tool Components”.

Any individual site or soil characteristic identified as high or very high before or after planned nutrient applications have been made will be addressed to a medium and/or lower ranking by altering nutrient application rate, method or timing or by using other appropriate AMAs and/or CPs alone or in combination to reduce N, P and sediment loss risk to an acceptable level. Refer to the section titled “Conservation Practices (CP) and Agronomic Management Activities (AMA)” for methods to lower risks to acceptable levels. All nutrient application rates are based on the NRCS Field Office Technical Guide (FOTG) Nutrient Management (590) standard.

Indiana Nutrient and Sediment Transport Risk Assessment Tool Components

Most data to analyze the NASTRAT tool are available in the Web Soil Survey **http://websoilsurvey.nrcs.usda.gov/** and/or Purdue's Manure Management Planner (MMP) software **http://www.purdue.edu/agsoftware/mmp/**

Nutrient and Sediment Transport Risk Assessment Tool Component Table*

<table>
<tr><td>Transport and Loss Potential Components</td><td colspan="6">Transport and Loss Potential (Value)</td></tr>
<tr><td>Soil Erosion Water (RKLS)</td><td colspan="2">Low
<20</td><td colspan="2">Medium
20 – 37</td><td colspan="2">High
>37</td></tr>
<tr><td>Soil Erosion Wind (CI)</td><td colspan="2">Low
<250</td><td colspan="2">Medium
250 - 500</td><td colspan="2">High
>500</td></tr>
<tr><td>Surface Runoff Class</td><td>Negligible</td><td>Very Low</td><td>Low</td><td>Medium</td><td>High</td><td>Very High</td></tr>
<tr><td>Leach Index (LI)</td><td colspan="2">0 – 2
Low</td><td colspan="2">3 – 9
Medium</td><td colspan="2">10 +
High</td></tr>
<tr><td>Subsurface Drainage Potential</td><td>Very Low</td><td>Low</td><td colspan="2">Medium</td><td>High</td><td>Very High</td></tr>
<tr><td>Flooding Frequency (F)</td><td colspan="2">None/Rare</td><td colspan="2">Occasional</td><td colspan="2">Frequent</td></tr>
<tr><td>Soil P Test Bray P₁/M3</td><td>Low
≤ 25 ppm</td><td>Medium
26 – 50 ppm</td><td colspan="2">High
51 – 100 ppm</td><td>Very High
101 – 200 ppm</td><td>Excessive
>200 ppm</td></tr>
<tr><td>Distance to Waterbody</td><td colspan="2">Low
100 ft +</td><td colspan="2">Medium
31 – 99 ft</td><td colspan="2">High
≤ 30 ft</td></tr>
</table>

*Using the information in the section titled "Indiana Nutrient and Sediment Transport Risk Assessment Tool Components" will determine the values used in this table. All Transport and Loss Potential Components with a value to the right of the bold tri-bar are considered high or very high and must be addressed. This includes the values for "Flooding Frequency – Frequent" and "Soil P Test Bray P1/M3 – Excessive". Methods to address these components are found in the section titled "Conservation Practices (CP) and Agronomic Management Activities (AMA)".

Soil Erosion – Water

"Soil Erosion – Water" is determined by the Revised Universal Soil Loss Equation (RUSLE2) and erosion estimates from gullies present in a field or management unit.

The RUSLE2 is a tool to predict the *long-term average annual soil loss from water erosion* in ton/acre/year from specific field conditions using specific management systems. RUSLE2 does not estimate or predict soil loss for individual events or soil loss from an individual year's specific weather and related factors. The formula for predicting long-term average annual soil loss from water erosion for the predominant soil in the field or management unit with RUSLE2 is:

A = R * K * LS * C * P, where

A = Predicted Average Annual Soil Loss (Tons/Acre/Year)
R = Rainfall-Runoff Erosivity Factor
K = Soil Erodibility Factor
LS = Length-Slope Factor
C = Cover-Management Factor
P = Support Practice Factor

Gully erosion is determined on fields where gullies are present. The formula for predicting long-term average annual soil loss for the predominant soil in the field or management unit from gully erosion is:

GE = TW + BW/2 x GD x GL x BD/2000 x YP, where

GE = Gully erosion in tons/acre/year
TW = Average width of the top of the gully channel in feet
BW = Average width of the bottom of the gully channel in feet
GD = Average depth of the gully channel in feet
GL = Length of the gully channel in feet
BD = Soil bulk density in lbs./ft^3 of dry soil
YP = Number of years gully has been present

The following table provides a guide for approximate unit weight of various soils for soil bulk density (BD).

Approximate Unit Weight [1]

Texture	Dry Density Lb/$ft.^3$	Texture	Dry Density Lb/$ft.^3$
Sand	110	Sandy Clay Loam	95
Loamy Sand	100	Clay Loam	95
Sandy Loam	95	Silty Clay Loam	95
Loam	85	Sandy Clay	95
Silt Loam	85	Silty Clay	90
Silt	90	Clay	85

[1]Data and estimates from published soil survey, laboratory data, and soil interpretation records are to be used where available. Parent materials, soil consistency, soil structure, pore space, soil texture, and content of coarse fragments all have influence on unit weight.

Additional gully erosion information can be found in the eFOTG, Section I, Erosion Prediction, Gully Erosion.

Fields or management units with irrigation induced erosion will be addressed accordingly (i.e. irrigation water management, nutrient rate reduction, conservation tillage, etc…).

Soil Erosion – Wind

"Soil Erosion – Wind" is determined by the Wind Erosion Equation (WEQ). The WEQ is a tool to predict the *long-term average annual soil loss from wind erosion* in ton/acre/year from specific field conditions using specific management systems. Like RUSLE2, WEQ does not estimate or predict soil loss from individual events or soil loss from an individual year's specific weather and related factors. The formula for predicting long-term average annual soil loss from wind erosion for the predominant soil in the field or management unit with WEQ is:

$E = f\,(IKCLV)$ where:

E = estimated average annual soil loss in tons/acre/year
f = indicates relationships that are no straight-line mathematical calculations
I = Soil erodibility index (12, 21, 38, 48, 56, 86, 134, 160, 180, 220, 250, 310)
K = soil surface roughness factor
C = Climatic factor (3, 4, 5, 6)
L = the unsheltered distance
V = the vegetative cover factor

Together, the RUSLE2, gully and WEQ prediction equations used in the NASTRAT indicate the potential gross movement of soil within a field or management unit. Best professional judgment is used to determine the percent of gross soil erosion, or net soil erosion that may move offsite and enter ditches, streams, or other waters of the state. It is the net soil erosion value that is used to determine the long-term average annual amount of soil that may leave the crop production area of the field or management unit.

Surface Runoff Class

"Surface Runoff Class" is determined from a table that uses soil permeability and percent slope of the predominant soil in the field or management unit. Surface runoff class provides a relative risk of soil solution movement from the surface of a field or management unit.

Table 1. The **Surface runoff class** site characteristics determined from the relationship of the soil permeability class and field slope. Adapted from the soil survey manual (1993) Table 3-10.

Soil Permeability Class*					
Slope (%)	Very Slow	Slow	Moderately Slow and Moderate	Moderately Rapid and Rapid	Very Rapid
Concave**	N	N	N	N	N
<1	M	L	N	N	N
1 –5	H	M	L	VL	N
5 – 10	VH	H	M	L	VL
10 – 20	VH	H	M	L	VL
>20	VH	VH	H	M	L

N = Negligible, VL = Very Low, L = Low, M = Medium, H = High, VH = Very High

*Permeability class of the least permeable layer within the upper 39 inches of the soil profile. Permeability classes for specific soils can be obtained from the published soil survey or from the local USDA – NRCS field offices.

Soil Permeability Classes in inches per hour (in/hr): Very Slow (<0.06 in/hr) Slow (0.06 – 0.20 in/hr) Moderately Slow (0.20 – 0.60 in/hr) Moderate (0.60 – 2.00 in/hr) Moderately Rapid (2.00 – 6.00 in/hr) Rapid (6.00 – 20.00 in/hr) Very Rapid (>20.00 in/hr)

**Area from which no or very little water escapes by overland flow.

Nitrate Leaching Index

"Nitrate leach index" (LI) was developed using annual precipitation, rainfall distribution data and hydrologic soil groups. The LI is used to determine the degree to which water percolates below the crop root zone in certain soils.

Subsurface Drainage Potential

"Subsurface drainage potential" is determined from a simple matrix table that uses soil drainage class and depth to seasonal high water from the predominant soil in the field or management unit, and the presence of artificial subsurface drainage and surface tile inlets.

Artificial subsurface drainage can increase the risk of N, P and sediment losses and tile inlets and tile outlets can serve as direct hydrologic connections to surface waters.

Table 2. Subsurface drainage class matrix table for use in the Indiana nutrient and sediment transport risk assessment tool.

Depth to Seasonal High Water Table	Soil Drainage Class: Very Poorly Drained	Poorly Drained	Somewhat Poorly Drained	Moderately Well Drained	Well Drained	Somewhat Excessively Drained	Excessively Drained
- - feet - -	Subsurface Drainage Potential*						
0 – 1	H	VH	VH	VH	VH	VH	
1 –3	M	M	M	M	H	H	H
3 –6	L	L	L	L	M	M	M
>6		VL	VL	L	L	L	L

* VL = Very Low, L = Low, M = Medium, H = High, VH = Very High.

Fields with artificial subsurface drainage (at any depth) automatically receive a minimum ranking of medium (M) and fields with surface tile inlets automatically receive a minimum ranking of high (H).

Flooding Potential

Flooding is the temporary covering of soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Shallow water standing or flowing during or shortly after rain or snowmelt is excluded from the definition of flooding. Standing water (ponding) or water that forms a permanent covering is excluded from the definition. The flooding frequency and duration classes are determined for the predominant soil in a field or management unit on a monthly basis using data from the NRCS soil survey.

Particulate and soluble N and P, and soil loss from fields during flooding events can contribute significantly to nutrient and sediment to P loading of surface waters.

Soil Test Phosphorus

"Soil test phosphorus" is based on the Bray P_1 or Mehlich 3 soil test method. Samples are collected from the surface 8 inches of the soil.

Soil test P ranking categories for the Indiana NASTRAT are *not* the same rankings used to determine fertilizer P rates for agronomic purposes.

The soil test P ranking system is provided in the NASTRAT summary table.

Distance to Waterbody

"Distance to waterbody" is defined as the nearest field distance to a perennial ditch, stream, creek, river, pond and/or lake as defined by the USGS Quad map.

The distance to waterbody ranking system is provided in the NASTRAT summary table.

Conservation Practices (CP)
&
Agronomic Management Activities (AMA)

The key to the Nutrient and Sediment Transport Risk Assessment Tool (NASTRAT) is the development of a conservation plan to address the resource concern(s) identified by the NASTRAT. With the implementation of an appropriate conservation plan that includes Conservation Practices (CP) and Agronomic Management Activities (AMA) to address the identified risks, nutrients can be applied according to the guidance in IN FOTG Standard (590) Nutrient Management. CPs are conservation practices from the NRCS FOTG Section IV. AMAs are management activities not defined by the NRCS FOTG, but when implemented can have a mitigating effect on the identified risk.

The NASTRAT will be conducted to assess the potential for nutrient movement from a field under any of the following conditions:

- The Bray P1/Mehlich 3 soil test is > 200 ppm, or
- The field has an identified or designated nutrient related water quality impairment, or
- The producer deems the nutrient application rate from IN FOTG Standard (590) Nutrient Management "Table 2" as too restrictive.

Fields with any NASTRAT component identified as high or very high (columns right side of solid line on NASTRAT Component Table) must choose appropriate mitigation techniques such as CPs and AMAs to address the identified resource concern to a medium and/or lower ranking. The goal is to address resource concerns with a conservation management system through the conservation planning process to the quality criteria level. It may be possible, that any one CP or AMA may address a high percentage of the offsite nutrient loss potential alone. However, many cases will require combinations of CPs and AMAs to address the identified nutrient and sediment loss potential.

It is critical to evaluate that the CPs and AMAs chosen to address one loss mechanism do not increase another loss mechanism. The amount, source, placement, form and timing of nutrient applications also have to be considered. These will need to be combined with the CPs and AMAs chosen to ensure compatibility with the various loss mechanisms.

Base nitrogen (N) application rates on realistic yield goals and legume/organic credits according to the most-current Purdue University (Purdue) fertilizer recommendations. Organic nutrient application rates can not exceed the nitrogen needs of the planned crop as explained in the IN FOTG Standard (590) Nutrient Management. Organic nitrogen application(s) are based on the potentially available nitrogen (PAN) as the material leaves the waste storage. Excess organic nitrogen applications are not allowed based on estimated losses due to timing or method of application. The Pre-Sidedress Soil Nitrate Test (PSNT) may be used to justify and determine additional nitrogen applications. Nitrogen application rates at the planned crop N needs will often meet 3-4 years of crop phosphorus needs. The amount, source, placement and timing of nitrogen applications will address most nitrogen loss pathways, although CPs may also be needed.

Phosphorus application rates for commercial fertilizer are based on the most-current Purdue fertilizer recommendations. Organic nutrient application rates of phosphorus must follow Indiana (IN) Field Office Technical Guide (FOTG) Standard (590) Nutrient Management Table 2. NASTRAT components with a high or very high concern must be addressed with CPs and AMAs and/or required rate reductions until the resource concern is addressed to medium and/or lower ranking.

The following are resource concerns identified by the NASTRAT and the CPs and AMAs that address the resource concerns. There may be other CPs and AMAs not listed that could also be used to address the identified loss mechanisms. The CPs and the numbers that follow are from the NRCS FOTG Section IV. While these CPs and AMAs are listed by resource concern it is generally most appropriate to treat resource concerns with conservation systems or groups of practices that work together to solve a problem.

Soil Erosion (Water)
CP – The goal is to avoid detachment and transport of sediment offsite through sheet and rill erosion and includes but is not limited to one or more of the following practices:

- Residue and Tillage Management - Mulch Till (345);
- Residue and Tillage Management - No Till / Strip Till (329);
- Residue and Tillage Management - Ridge Till (346);
- Cover Crop (340);
- Conservation Crop Rotation (328);
- Critical Area Planting (342);
- Forage and Biomass Planting (512);
- Conservation Cover (327);
- Terrace (600);
- Contour Buffer Strips (332)
- Field Border (386)
- Tree and Shrub Establishment (612).

Erosion from concentrated water flow is included in the NASTRAT Soil Erosion component. It is important in offsite sediment delivery and must be addressed. Additional CPs that address soil erosion from concentrated flow includes:

- Grassed Waterway (412);
- Water and Sediment Control Basin (638);
- Diversion (362);
- Terrace (600);
- Critical Area Planting (342);
- Grade Stabilization Structure (410).

CP – Buffers designed to the criteria to address water quality may reduce offsite sediment loss from a “high” risk to a “medium” risk. Refer to IN FOTG Standards (393) Filter Strip, (390) Riparian Herbaceous Cover, (391) Riparian Forest Buffer, or (327) Conservation Cover. Consider wider filter strips as slope and slope length increase.

AMA – Restrict nutrient applications until erosion has been addressed to “T”. Soil loss greatly increases N and P losses. Avoid applications at times of high loss potential (i.e. prior to forecasted precipitation events, saturated soils, etc…). Use application equipment that preserves residue when making manure applications. Irrigate onto a growing crop.

Planning Criteria to meet when addressing this resource concern may include, but not limited to:

- Soil Erosion – Sheet, Rill, and Wind Erosion;
- Soil Erosion – Concentrated Flow;
- Water Quality Degradation – Excessive Sediment in Surface Waters.

Soil Erosion (Wind)
CP – The goal is to avoid detachment and movement of the soil through the wind erosion process and would include many of the same practices as water erosion. Additional CPs include:

- Cross Wind Trap Strips (589C);
- Hedgerow Planting (422),
- Stripcropping (585);
- Windbreak - Shelterbelt Establishment (380);
- Irrigation Water Management (449).

Areas of high wind erosion potential with few windbreaks and fencerows need to consider offsite losses to drainage ditches and other waterbodies. Filter strips and other conservation buffers can decrease the potential of soil particles being deposited offsite in drainage ditches, streams, creeks, rivers and other perennial waterbodies.

AMA – Avoid additional applications of nutrients until wind erosion has been addressed to “T”.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Soil Erosion – Sheet, Rill, and Wind Erosion;
- Water Quality Degradation – Excessive Sediment in Surface Waters.

Surface Runoff Class
CP – The goal is to decrease offsite runoff by increasing infiltration (soil quality and nightcrawlers) and diverting offsite water flow and reducing slope length. This is accomplished with many of the same CPs for soil erosion, including but not limited to:

- Residue and Tillage Management - Mulch Till (345);
- Residue and Tillage Management - No Till / Strip Till (329);
- Residue and Tillage Management - Ridge Till (346);
- Cover Crop (340);
- Conservation Crop Rotation (328);
- Critical Area Planting (342);
- Forage and Biomass Planting (512);

- Conservation Cover (327);
- Field Border (386);
- Diversion (362);
- Contour Buffer Strip (332);
- Terrace (600);
- Grassed Waterway (412);
- Water and Sediment Control Basin (638);
- Grade Stabilization Structure (410).

The minimum filter strip width to reduce a "high" to a "medium" risk is 50'.

AMA – Soluble phosphorus loss levels begin to increase when soil test phosphorus is greater than 50 ppm. Reduce application rates. Avoid applications at times of high loss potential (i.e. prior to forecasted precipitation events, saturated soils, etc…). Use application equipment that preserves residue when making manure applications. Consider light incorporation of manure on soils with low erosion potential. Avoid applications during times of high runoff potential (frozen, snow covered or saturated ground). Avoid applications to areas of concentrated flow. Address current and avoid additional compaction. Avoid tillage and nutrient applications when field conditions are conducive to compaction. Reduce the weight of application equipment. Control equipment traffic. Irrigate on growing crops.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Soil Quality Degradation – Organic Matter Depletion;
- Soil Quality Degradation – Compaction;
- Excess Water – Ponding, flooding, seasonal high water table, seeps, and drifted snow;

Nitrate Leaching Index

CP – The goal is to tie up nitrogen and decrease the nitrogen leach potential. This is accomplished by, but not limited to:

- Residue and Tillage Management - Mulch Till (345);
- Residue and Tillage Management - No Till / Strip Till (329);
- Residue and Tillage Management - Ridge Till (346);
- Cover Crop (340);
- Conservation Crop Rotation (328);
- Critical Area Planting (342);
- Irrigation Water Management (449);
- Forage and Biomass Planting (512);
- Conservation Cover (327).

AMA – On areas with a high leach potential, use a combination of the following;

- Establish realistic field-by-field yield goals.
- Take legume/organic credits.
- Apply nitrogen as close to crop utilization as possible.
- Consider split applications.
- Reduce application rates.

- Use nitrification inhibitors when appropriate.
- Organic nutrient application rates will not exceed the N needs of the planned crop.
- Use PSNT to determine additional nitrogen needs after manure applications.
- Use crops and crop rotations that utilize N.
- Utilize seasonal control of tile outlets.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Water Quality Degradation – Excess Nutrients in Surface and Ground waters.

<u>Subsurface Drainage Potential</u>
Fields with artificial subsurface drainage (at any depth) automatically receive a minimum ranking of medium (M) and fields with surface tile inlets automatically receive a minimum ranking of high (H).

CP – The goal is to decrease nutrient losses via field tile. This is accomplished by, but is not limited to:

- Constructed Wetland (656);
- Cover Crop (340);
- Forage and Biomass Planting (512);
- Filter Strip (393);
- Drainage Water Management (554).

AMA – Reduce application rates of liquid materials near and over tile lines when possible. Match application to infiltration rates and adjust to avoid ponding and runoff. Monitor tile line outlets after application of liquid materials for movement of material and be prepared to plug tile line. Follow all and consider additional setback distance requirements from tile inlets/risers. Use filter strips around tile inlets/risers. Reduce/avoid applications of liquid materials when soils are dry and cracked. Utilize seasonal control of tile outlets. Avoid excessive build up of soil test P in areas with tile. Consider not using liquid manure application method. If irrigating, make applications to a growing crop. If soil test phosphorus is > 200 ppm consider taking deep profile soil samples to a depth of 24 inches in 8 inch increments to check for downward movement of phosphorus.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Excess Water – Ponding, flooding, seasonal high water table, seeps, and drifted snow;
- Water Quality Degradation – Excess Nutrients in Surface and Ground waters.

Flooding Potential

CP – Areas with a high flooding potential are at high risk for nutrient applications. Consider land use change from annual crop production to:

- Riparian Forest Buffer (391);
- Conservation Cover (327);
- Filter Strip (393)
- Tree and Shrub Establishment (612).

Consider land use change from annual crop production with Programs such as the Wetland Reserve Program (WRP), Conservation Reserve Program (CRP), Floodplain Easement (FPE) and Bottomland Hardwood Forest Restoration. If nutrient applications are needed, CPs that decrease erosion and runoff will decrease soil loss potential from out of bank flow. Scour areas should be vegetated.

AMA – Apply nutrients as close to crop utilization as possible. Don't apply nutrients prior to or during the month when flooding is predicted. Inject nutrients. Make side-dress application of NH3. Make no surface nutrient applications. Avoid building up soil tests to decrease chances of loss in absorption, through runoff and below ground loss mechanisms.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Soil Erosion – Excessive Bank Erosion from Streams, Shorelines, or Water Conveyance Channels
- Excess Water – Ponding, flooding, seasonal high water table, seeps, and drifted snow;

Soil Test Phosphorus

CP – Preventing erosion and runoff decreases P losses. This is accomplished with, but not limited to:

- Residue and Tillage Management - Mulch Till (345);
- Residue and Tillage Management - No Till / Strip Till (329);
- Residue and Tillage Management - Ridge Till (346);
- Cover Crop (340);
- Conservation Crop Rotation (328);
- Critical Area Planting (342);
- Forage and Biomass Planting (512);
- Conservation Cover (327);
- Diversion (362);
- Terrace (600);
- Grassed Waterway (412);
- Water and Sediment Control Basin (638).

AMA – Fields, subfields and grids with soil test P in excess of 50 ppm show no agronomic need for additional phosphorus. Based on IN 590 Table 2, organic nutrient applications for soil test P of 51-100 ppm are not to exceed 1.5 x Crop P_2O_5 removal, soil test P of 101-200 ppm not to exceed crop P_2O_5 removal and no additional applications of phosphorus if the soil test phosphorus is > 200 ppm.

If NASTRAT components of high or very high concern are adequately addressed, phosphorus applications to meet multiple year phosphorus needs of the crop and that do not exceed the nitrogen needs of the planned crop, are allowed as long as the soil test phosphorus is ≤ 200 ppm, or 590 Table 2 can be used.

Soil test phosphorus (STP) greater than 50 ppm increases loss potential of soluble phosphorus from runoff and STP > 200 ppm increases loss potential of soluble phosphorus via tile.

Application rates should be decreased, and manure with a lower analysis can be used to decrease hauling distances. Rotate manure applications on fields with soil test P > 50 ppm.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Water Quality Degradation – Excess Nutrients in Surface and Ground waters.

Distance to Waterbody

CP – The goal is to establish setbacks and/or develop buffers for nutrient applications between edge of field and waterbody with the use of:

- Filter Strip (393);
- Riparian Forest Buffer (391);
- Access Control (472);
- Fence (382).

Following all required applicable setback distances for manure applications reduces a "high" to a "medium" risk. Increase setback distances for manure applications under special circumstances. Consider setbacks for commercial fertilizer applications. Filter strips and other buffers can filter water flow and assist in maintaining setback distances. Buffers designed to the criteria to address water quality may reduce offsite sediment loss from a "high" risk to a "medium" risk. Refer to IN FOTG Standards (393) Filter Strip, (390) Riparian Herbaceous Cover, (391) Riparian Forest Buffer, or (327) Conservation Cover. Consider wider filter strips as slope and slope length increase.

AMA – Avoid applications close to waterbodies, inject and/or incorporate nutrients and decrease the amount to be applied.

Quality Criteria to meet when addressing this resource concern may include, but not limited to:

- Water Quality Degradation – Excess Nutrients in Surface and Ground waters.
- Water Quality Degradation – Excessive Sediment in Surface Waters.

Agronomic Management Activities

A variety of agronomic management activities such as amount, source, placement, form and timing can greatly impact loss mechanisms of nutrients (N&P).

The placement and timing of phosphorus applications are important factors in determining and reducing the loss potential. A "Very Low" or "Low" P source application method can reduce a "High" or "Very High" Surface Runoff Class and a "High" Distance to Waterbody to medium or lower. If the P source application method is "High" or "Very High", increase the Surface Runoff Class and Distance to Waterbody loss component higher one factor. If the component can't be addressed with method/timing or other CPs and AMAs then the application rate is reduced back to the 590 Table 2. Use the following table to determine the P source application method rating.

P Source Application Method				
Placed or injected 2" or more deep (Very Low)	Incorporated < 1 week (Low)	Incorporated > 1 week or not incorporated April – October (Medium)	Incorporated > 1 week or not incorporated Nov – March (High)	Surface applied to frozen or snow covered soil (Very High)

References

Lemunyon, J.L., and R.G. Gilbert. 1993. The concept and need for a phosphorus assessment tool. Journal of Production Agriculture. 6:483-486.

NRCS. 1999. Nutrient Management. 190-GM, Part 402, Issue 9, 3/99. Web: http://www.nhq.nrcs.usda.gov/BCS/nutri/gm-190.html

Pionke, H.B., W.J. Gburek, A.N. Sharpley, and J.A. Zollweg. 1997. Hydrologic and chemical controls on phosphorus loss from catchments. *In* H. Tunney, ed., Phosphorus Loss to Water from Agriculture, pp. 225-242. CAB International Press, Cambridge, England.

Sims, J.T., R.R. Simard, and B.C. Joern. 1998. Phosphorus loss in agricultural drainage: historical perspective and current research. Journal of Environ. Qual. 27:277-293.

Williams, J.R., and D.E. Kissel. 1991. Water Percolation: An indicator of nitrate nitrogen leaching potential. In Follett, Keeny and Cruse (eds.), Managing Nitrogen for Groundwater Quality and Farm Profitability. Soil Science Society of America, Madison, WI.