Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

CODE 590

(ac)

DEFINITION

Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve plant health and productivity
- Reduce excess nutrients in surface and ground water
- Reduce emissions of objectionable odors
- Reduce emissions of particulate matter (PM) and PM precursors
- Reduce emissions of greenhouse gases (GHG)
- Reduce emissions of ozone precursors
- Reduce the risk of potential pathogens from manure, biosolids, or compost application from reaching surface and ground water
- Improve or maintain soil organic matter

CONDITIONS WHERE PRACTICE APPLIES

All fields where plant nutrients and soil amendments are applied. Does not apply to one-time nutrient applications at establishment of permanent vegetation.

CRITERIA

General Criteria Applicable to All Purposes

Develop a Nutrient Management Plan (NMP) for nitrogen (N), phosphorus (P), and potassium (K), which accounts for all known measurable sources and removal of these nutrients.

Sources of nutrients include, but are not limited to, commercial fertilizers (including starter and in-furrow starter/pop-up fertilizer), animal manures, legume fixation credits, green manures, plant or crop residues, compost, organic by-products, municipal and industrial biosolids, wastewater, organic materials, estimated plant available soil nutrients, and irrigation water.

When irrigating, apply irrigation water in a manner that reduces the risk of nutrient loss to surface and ground water.

Minimum application setbacks are to be used around all sensitive areas (e.g., sinkholes, wellheads, gullies, ditches, or surface inlets) where manure nutrients are applied consistent with the setback restrictions (Table 1). Table 1 distances may need to be increased where a pond or lake is used for a

potable water supply or recreation area, or a stream impaired by excess nutrients, etc. Setback distances from water and drainageways etc. is measured from the top of the edge of the bank at field level.

Prior to the application of any fertilizer and/or manure, repair all broken Subsurface (tile) Drains (606) that are resulting in blow holes.

Soil and tissue testing and analysis
NMP should be based on the most recent current soil test results in accordance with the Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa (Bulletin 974). Current soil tests are those that are no older than 3-4 years depending on the crop rotation and or intensity of the sampling. Shorter intervals may be appropriate if nutrient applications and crop yields are sufficiently variable to make nutrient status levels difficult to predict. When developing a new NMP use soil tests no older than 2 years. For crops not included in the Tri-State Fertilizer Recommendations, use sampling procedures recognized by the land grant university (LGU) for that crop. Use tissue testing, when applicable, for monitoring or adjusting the NMP in accordance with the Tri-State Fertilizer Recommendations, or industry practice when recognized by the LGU.

Collect, prepare, store, and ship all soil and tissue samples following the Tri-State Fertilizer Recommendations guidance or industry practice. The test analyses must include pertinent information for monitoring or amending the annual nutrient plan. Follow the Tri-State Fertilizer Recommendations guidelines regarding required analyses and test interpretations.

Soil samples for soil tests should represent 25 acres or less. For precision nutrient management plans, one soil sample should represent no more than 6 acres for grid sampling and no more than 12 acres for a zone management system. When a zone precision NMP is being developed, soil fertility, soil types, cropping history, and crop management practices should be taken into consideration when delineating the zones.

Tri-State Fertilizer Recommendations are calibrated to an 8-inch sample collection depth. If a different sample depth is used it should be noted in the plan and recommendations adjusted based on sample depth. Consistency in sample depth is essential to compare test results over time. A separate 4-inch-deep soil sample should be collected in continuous no-till or permanent pastures situations to determine lime need for pH management.

Maintain soil pH within ranges which enhance the adequate level for plant or crop nutrient availability and utilization. Refer to the Ohio Agronomy Guide and/or the Tri-State Fertilizer Recommendations for crop/soil specific details on soil pH and lime recommendations.

For soil test analyses, use laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program under the auspices of the Soil Science Society of America and NRCS.

Manure, organic by-product, and biosolids testing and analysis
Collect, prepare, store, and ship all manure, organic by-products, and biosolids following LGU guidance or industry practice when recognized by the LGU. Planned applications should be based on a 3- or 4-year rolling average discarding any outliers. In the absence of such guidance, test at least annually, or more frequently if operational changes occur impacting manure nutrient concentrations (e.g., feed management, animal type, manure handling strategy, storm water diversion etc.).Manure may be tested less frequently if no operational changes occur and operations can document a stable level of nutrient concentrations for the preceding 3 consecutive years unless Federal, State, or local regulations require more frequent testing. Follow LGU guidelines regarding required analyses and test interpretations. Analyze, as a minimum, total N, ammonium N, total P or P_2O_5, total K or K_2O, and percent solids.

When planning for new or modified livestock operations, and manure tests are not available yet, use the output and analyses from similar operations in the geographical area if they accurately estimate nutrient

output from the proposed operation or use “book values” recognized by the NRCS (e.g., NRCS Agricultural Waste Management Field Handbook) and the LGU until actual test can be taken.

For manure analyses, use laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program under the auspices of the Minnesota Department of Agriculture or other NRCS-approved program that considers laboratory performance and proficiency to assure accurate manure test results.

For nutrient management plans developed as a component of a comprehensive nutrient management plan for an animal feeding operation (AFO) follow policy in NRCS directive General Manual (GM) 190, Part 405, “Comprehensive Nutrient Management Plans.” These plans must include documentation of the volumes and nutrient content of all nutrient imports, exports, and on-farm transfers. Nutrient application beyond agronomic need for P should be viewed as a short-term solution and other alternatives such as reducing nutrients in the manure and/or developing manure marketing strategies should be strongly considered.

Nutrient loss risk assessments
Use current NRCS-approved nitrogen, phosphorus, and soil erosion risk assessment tools to assess the site-specific risk of nutrient and soil loss. See “Assessing Nutrient Loss Risk in Ohio” (Nutrient Management Technical Note, Assessing Nutrient Loss Risk in Ohio) for the detailed procedure of the approved nitrogen and phosphorus risk assessment.

Complete an NRCS-approved nutrient risk assessment for N and P on all fields where nutrient management is planned.

For fields receiving commercial fertilizer and/or manure, where P risk assessment results equate to—

- LOW risk.—Commercial fertilizer and/or manure can be applied at rates to supply P at the P recommendation rate. Applications can account for multiple years in the crop rotation in one application. When such applications are made no additional P may be applied until the crops in rotation have utilized the applied P and the application cannot be greater than crop requirement for N for the succeeding crop. In addition to the rate criteria above, the placement, timing and erosion control criteria documented in Ohio Nutrient Management Tech Note (“Assessing Nutrient Loss Risk in Ohio”) must be met.
- MODERATE risk.—Commercial P fertilizer cannot be applied. Manure can be applied at rates not to exceed crop P removal for the planned crops in rotation. Applications can account for multiple years in the crop rotation in one application. When such applications are made no additional P may be applied until the crops in rotation have utilized the applied P and the application cannot be greater than crop requirement for N for the succeeding crop. When applications of manure are made at the moderate risk an adapted P management system that draws down STP over time is required. In addition to the rate criteria above, the placement, timing and erosion control criteria documented in Ohio Nutrient Management Tech Note (“Assessing Nutrient Loss Risk in Ohio”) must be met.
- HIGH risk.—Commercial P fertilizer and/or manure cannot be applied except for applications of manure at rates less than or equal to 50% crop removal. These manure applications are to facilitate change within the manure collection, storage, handling and land application systems and are documented in the current conservation plan. Additional small applications of dilute wastewater or other liquid manure effluent with low P may be applied through irrigation at low annual rates; no greater than the lesser of 50% crop removal or 35 lb/ac P_2O_5. When applications of dilute wastewater or other liquid manure are made at the high risk an adapted P management system that draws down STP over time is required. In addition to the rate criteria above, the placement, timing and erosion control criteria documented in Ohio Nutrient Management Tech Note (“Assessing Nutrient Loss Risk in Ohio”) must be met.

- VERY HIGH risk.— Commercial fertilizer and/or manure cannot be applied. Small applications of dilute wastewater or other liquid manure effluent with low P may be applied through irrigation at low annual rates; no greater than the lesser of 50% crop removal or 35 lb/ac P_2O_5. When applications of dilute wastewater or other liquid manure are made at the very high risk an adapted P management system that draws down STP over time is required. In addition to the rate criteria above, the placement, timing and erosion control criteria documented in Ohio Nutrient Management Tech Note ("Assessing Nutrient Loss Risk in Ohio") must be met.

The 4Rs of nutrient stewardship
Manage nutrients based on the 4Rs of nutrient stewardship—apply the right nutrient source at the right rate at the right time in the right place—to improve nutrient use efficiency by the crop and to reduce nutrient losses to surface and groundwater and to the atmosphere.

Nutrient source
Choose nutrient sources compatible with application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

Determine nutrient values of all nutrient sources (e.g. commercial fertilizers, manure, organic by-products, biosolids) prior to land application. Recognize that the solubility of nutrients can differ significantly depending on source. Generally commercial fertilizers are manufactured to be soluble and available for plant uptake. Manures are a mix of inorganic P that is readily available and organic P that is slower to release. The concentration and solubility of P in manures vary by species, manure storage and treatment. Planned applications of different sources should reflect an understanding of the different properties of the planned nutrient source.

Apply manure or organic by-products on legumes at rates no greater than the LGU estimated N removal rates in harvested plant biomass, not to exceed P risk assessment limitations.

For any single application of nutrients applied as liquid (e.g., liquid manure, nutrients in irrigation water, fertigation)—

- Do not exceed the soil's infiltration rate or water holding capacity.
- Apply so that nutrients move no deeper than the current crop rooting depth.
- Avoid runoff or loss to subsurface tile drains.

Application rates applied as liquid (e.g., liquid manure, nutrients in irrigation water, fertigation) of a single application are to be adjusted not to exceed the field capacity of the soil to avoid nitrogen and/or phosphorus loss. At the time of liquid manure application, use the Practical Soil Moisture Interpretations procedure (Table 2) to determine if the planned application rate is in excess of the Available Water Capacity (AWC), if so, reduce application rate to the AWC limitation.

Determine nutrient contribution of cover crops, previous crop residues, and soil organic matter and adjust application rates based on regional best practices recognized by LGU's.

For enhanced efficiency fertilizer (EEF) products, use products defined by the Association of American Plant Food Control Officials as EEF and recommended for use by the State LGU.

For operations following USDA's National Organic Program, apply and manage nutrient sources according to program regulations.

In areas where salinity is a concern, select nutrient sources that limit the buildup of soil salts. When manures are applied, and soil salinity is a concern, monitor salt concentrations to prevent potential plant or crop damage and reduced soil quality.

Nutrient rate

Plan nutrient application rates for N, P, and K using LGU recommendations or industry practices when recognized by the LGU. The current Tri-State Fertility Recommendations is to be used for corn, soybean, wheat and alfalfa; other LGU publications are to be used for crops not included in the Tri-State Fertility Recommendations publication. For new crops or varieties where LGU guidance is unavailable, industry-demonstrated yield and nutrient uptake information may be used. Lower-than-recommended nutrient application rates are permissible if the client's objectives are met.

Estimate realistic yield potentials or realistic yield goals using LGU procedures or based on historical yield or growth data, soil productivity information, climatic conditions, nutrient test results, level of management, and/or local research results considering comparable management and production conditions.

At a minimum, determine the rate based on crop/cropping sequence, current soil test results, realistic yield goals and NRCS- approved nutrient risk assessments. Where applicable, use realistic yield goals. When applying nutrients, the phosphorus and/or potassium application rate can account for multiple years in the crop rotation in one application. When such applications are made, the rate must not exceed:

- The acceptable phosphorus risk assessment criteria.
- The single application limitation for the planned time of year as listed in the "Determining the most Limiting Manure Application Rate" (Table 3).
- And no additional phosphorus and/or potassium may be applied until the crops in rotation have utilized the applied nutrients. The exception is if the soil test values falls within the buildup range of the Tri-State Fertilizer Recommendations.
- Applications of phosphate (P_2O_5), and potash (K_2O) via fertilizer, manure, or other organic by-products can be made for multiple years of the rotation as long as:
  - no more than 500 Lbs/ac of potash (K_2O) are applied in any one year
  - no more than 250 Lbs/ac of (P_2O_5) are applied in any one year
  - NOTE: In cases where liquid manure exceeds 75 Lbs P_2O_5 per 1000 gallons or solid manure exceeds 100 Lbs P_2O_5 per ton the P_2O_5 rates can be increased up to a maximum of 500 Lbs P_2O_5 /acre as long as nitrogen rates for the next crop are not exceeded nor the annual limit for K_2O of 500 Lbs/acre. This increase in the application rate restrictions should only be used when application equipment can not apply at lower rates and the application field has a low or moderate P loss potential.

Nutrient application timing and placement

Consider the nutrient source, management and production system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment to develop optimal timing of nutrients. For N, time the application as closely as practical with plant and crop uptake. For P, time planned surface application when runoff potential is low. Time the application of all nutrients to minimize potential for soil compaction.

For crop rotations or multiple crops grown in one year, do not apply additional P if it was already added in an amount sufficient to supply all crop nutrient needs.

To avoid salt damage, follow LGU recommendations for the timing, placement, and rate of applied N and K in starter fertilizer or follow industry practice recognized by the LGU.

Do not surface apply nutrients when there is a risk of runoff, including when—

- Soils are frozen.
- Soils are snow-covered.
- The top 2 inches of soil are saturated.
- When there is a greater than 50% chance of rainfall of more than 0.5" within 24 hours of the application of manure.

- When there is a greater than 50% chance of rainfall of more than 1” within 12 hours of the application of commercial fertilizer

Emergency liquid manure surface applications can be applied to frozen and/or snow covered. Soil is considered frozen, for criteria above, if manure cannot be injected or immediately incorporated. Surface application on frozen and snow-covered soil is not acceptable. Solid manure can be stockpiled using the Ohio NRCS Short Term Storage of Animal Waste (Code 318). An emergency exists as a temporary situation due to unforeseen causes and after all other options have been exhausted. In this situation only limited quantities of liquid manure shall be applied to address manure storage limitations until non frozen soils are available for manure application. All applications of liquid manure to frozen and snow-covered soils must be documented in the producers records and must be applied in accordance to ALL the following criteria:

- The rate of application shall not exceed the lesser of 5,000 gallons/acre or P removal for the next crop.
- Applications are to be made on land with at least 90% surface residue cover (cover crop, good quality hay or pasture field, all corn grain residue remaining after harvest, all wheat residue cover remaining after harvest).
- Manure shall not be applied on more than 20 contiguous acres. Contiguous areas for application are to be separated by a break of at least 200 feet.
- Apply manure to areas of the field with the lowest risk of nutrient transport such as areas furthest from streams, ditches, waterways, with the least amount of slope.
- Application setback distance must be a minimum of 200 feet from grassed waterways, surface drainage ditches, streams, surface inlets, water bodies and 300 feet minimum from all wells springs and public surface drinking water intakes. This distance may need to be further increased due to local conditions.
- For fields exceeding 6% slope manure shall be applied in alternating strips 60 to 200 feet wide generally on the contour, or in the case of contour strips on the alternating strips.

Fertilizers and/or manures that are applied to soils that are listed as frequently flooded must be incorporated or applied with subsurface placement if the applications are made during the listed periods. Frequently flooded soils are defined by the National Cooperative Soil Survey (or in the Flooding Frequency Soil List posted in Section II FOTG).

Liquid manure applications on fields that are subsurface (tile) drained require additional precautions. When applied to fields with subsurface drains, the liquid can follow soil macropores directly to the tile drains creating a surface water pollution hazard from direct tile discharge. A field is considered subsurface drained if 1/3 or more of the field is subsurface drained; however, even a field with one subsurface drainage line may present a risk of manure/wastewater movement to subsurface drains and cause a direct discharge. Research has shown that the higher the solids content of liquid manures, the less likely it is to move to subsurface drainage systems. An inspection of all tile outlets shall be made before, during and after all liquid manure applications. If manure is detected in any outlet, the outlet shall be plugged, and the application must be stopped.

The precautions listed below must be taken for all liquid manure applications made to subsurface (tile) drained fields to reduce the risk of nutrient loss. These criteria listed below may be waived if the producer can verify there is no prior history of manure discharge via subsurface drains. However, if there is a discharge the producer is liable for damages.

- Do not apply application rates (volume) that would exceed the lesser of the AWC (Table 2) in the upper 8 inches or ½ in per acre (13,500 gallons/acre) per application.
- Surface apply the liquid manure uniformly onto a growing crop or cover crop. If the field is not established in a growing crop or cover crop implement the following:

- Use a full width tillage tool prior to manure application that can disrupt/close (using horizontal fracturing) the preferential flow paths (worm holes, cracks, root channels) in the soil, or till the surface of the soil 3-5 inches deep to a condition that will absorb the liquid manure. This is especially important if shallow tile are present (< 2 feet deep). Any pre-application tillage should leave as much residue as possible on the soil surface. The adsorption of liquid manure by the soil in the root zone will minimize nitrogen loss and the manure/nutrient runoff potential.
- For perennial crops (hay or pasture), or continuous no till fields where tillage is not an option, all tile outlets from the application area are to be plugged prior to the application.
- If injection is used, inject only deep enough to cover the manure with soil. Till the soil at least 3 inches below the depth of injection prior to application, or all tile outlets from the application area are to be plugged prior to application.
- Apply at very low rates 0.2 or less inches per acre (5,500 gallons/acre) to reduce liquid manure movement to tiles.

Fields or areas of fields that have systematic “surface drainage” systems (e.g. shallow surface drains spaced 100 – 200 feet apart – NRCS Practice Code 607) require additional precautions. Manure can only be applied in these surface drains with minimal risk of surface runoff if special precautions listed below are taken. THIS DOES NOT APPLY TO THE COLLECTOR SURFACE DRAINS (mains) OR DRAINS BORDERING THE FIELDS.

- Limit LIQUID manure application rates to ½ in per acre (13,500 gallons/acre) or less per application.
- Surface apply the liquid manure uniformly onto a growing crop or cover crop.
  - If the field is not established in a growing crop or cover crop, till the surface at least 3 to 5 inches deep prior to liquid manure surface application. For SOLID manure incorporate within 24 hours. This can be done with full-width tillage implements with soil disturbance to a depth of 3-5 inches.
  - For fields that have no subsurface (tile) drainage, the liquid manure can be injected directly with no prior tillage.

Organic nutrients should not be applied to cropland over 15% slope or to pastures/hayland over 20% slope unless one of the following precautions is taken:

- Surface apply the liquid manure uniformly onto a growing crop or cover crop.
- If there is not a growing crop or cover crop, immediate incorporate, band, or inject the manure on the contour, UNLESS the field has 80% ground cover (residue and/or canopy).
- Applications are timed during periods of lower runoff and/or rainfall (Late May to Mid- October).
- Apply low rates through split applications (separated by rainfall events). Apply no more than 10 wet tons/acre for solid manure/wastes; or 5000 gallons/acre for liquid manure/wastes.
- The field is established in contour strips and utilizing a no-till cropping system.

Additional Criteria to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater

Apply conservation practices to avoid nutrient loss and control and trap nutrients before they can leave the field(s) by surface, leaching, or subsurface drainage (e.g., tile, karst) when there is a significant risk of transport of nutrients.

Conservation practices must be coordinated to avoid, control, and/or trap manure and nutrients from leaving the field by surface or subsurface drainage (e.g., tile). The number of applications and the application rates must also be considered to limit the transport of nutrients to tile. Erosion, runoff, and water management controls are to be installed, as needed, on fields where nutrients are applied. Sheet and rill erosion shall be managed within the tolerable soil loss for the field (using current NRCS Sheet and

Rill Erosion Prediction Technology found in Section I, FOTG, Ohio NRCS) and ephemeral and gully erosion shall meet minimum quality criteria stated in Section III, FOTG, Ohio – NRCS.

Additional Criteria to Reduce the Risk of Potential Pathogens From Manure, Biosolids, or Compost Application From Reaching Surface and Groundwater

When applicable, follow proper biosecurity measures as provided in NRCS directives GM-130, Part 403, Subpart H, "Biosecurity Preparedness and Response."

Follow all applicable Federal, Tribal, State, and local laws and policies concerning the application of manure, biosolids, or compost in the production of fresh, edible crops.

Apply manure, biosolids, or compost with minimal soil disturbance or by injection into the soil unless it is being applied to an actively growing crop, a minimum of 30 percent residue exists, or there is a living cover that has a fibrous root system with 75 percent or more cover. Do not surface apply manure, biosolids and or compost if a storm event is forecasted with a greater than 50% chance of rainfall of more than 0.5" within 24 hours of application.

Additional Criteria to Reduce Emissions of Objectionable Odors, PM and PM Precursors, and GHG and Ozone Precursors

To address air quality concerns caused by odor, N, sulfur, and particulate emissions; adjust the source, timing, amount, and placement of nutrients to reduce the negative impact of these emissions on the environment and human health. One or more of the following may be used:

- Slow or controlled release fertilizers.
- Nitrification/urease inhibitors.
- Incorporation or injection.
- Residue and tillage management.
- Other technologies that minimize the impact of these emissions.

Do not surface apply solid nutrient sources, including commercial fertilizers, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material and emissions offsite. Do not surface apply liquid nutrient sources when there is a high probability that wind will blow the liquid droplets applied from sprinklers or other applicable methods offsite.

Reduce the potential for volatilization by applying sources subject to volatilization during cooler, higher humidity conditions or by placement that minimizes vulnerability to volatilization.

Additional Criteria to Improve or Maintain Organic Matter

Design the plant or crop management systems so the soil conditioning index (SCI) organic matter subfactor is positive. Plan additional conservation practices such as Residue and Tillage Management No-Till and/or Reduced Tillage (329 and/or 345), Conservation Crop Rotation (328) and Cover Crops (340) as needed to meet this soil conditioning index (SCI) requirement.

Apply manure, compost, or other organic nutrient sources at a rate and with minimal disturbance that will improve soil organic matter without exceeding acceptable risk of N or P loss.

For low residue plant or cropping systems, apply adequate nutrients to optimize plant or crop residue production to maintain or increase soil organic matter.

CONSIDERATIONS

General Considerations

Development of nutrient management plans by conservation management unit (CMU). A CMU is a field, group of fields, or other land units with similar treatment needs and planned management to simplify planning activities and facilitate development of conservation management systems.

Develop site-specific yield maps using a yield monitoring system, multispectral imagery or other methodsto delineate low- and high-yield areas, or zones, and make the necessary management changes. Use variable rate nutrient application based on site-specific factor variability. See NRCS directive Agronomy Technical Note (TN) 190, AGR.3, “Precision Nutrient Management Planning.”

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in NRCS’ national nutrient policy in GM-190, Part 402, “Nutrient Management.” Consider using an adaptive approach to adjust nutrient rate, timing, form, and placement as soil biologic functions and soil organic matter changes over time. See NRCS directive Agronomy Technical Note (TN) 190, AGR.7, “Adaptive Nutrient Management Process.”

When developing new nutrient management plans, consider using soil test information no older than 1 year rather than 2 years.

Develop a whole farm nutrient budget (nutrient mass balance), including all imported and exported nutrients. Imports may include feed, fertilizer, animals and bedding, while exports may include crop removal, animal products, animal sales, manure, and compost.

Provide a nutrient analysis of all nutrient sources exported (manure or other materials).

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standard (CPS) Feed Management (Code 592).

Use Prescribed Grazing (Code 528) to enhance nutrient cycling and improve soil nutrient cycling functions.

Do not apply manure in situations where an excess (greater than soil test K recommendation) causes nutrient imbalances in crops or forages.

Implementing a soil health management system that reduces tillage or other soil disturbance, includes a diverse rotation of crops and cover crops, keeps roots growing throughout the year, and keeps the soils covered to reduce nutrient losses, and improves—

- Nutrient use efficiency, rooting depth, and availability of nutrients.
- Soil organic matter levels.
- Availability of nutrients from organic sources.
- Aggregate stability and soil structure.
- Infiltration, drainage, and aeration of the soil profile.
- Soil biological activity.
- Water use efficiency and available moisture.

Use legume crops and cover crops to provide N through biological fixation. Cover crops with a carbon to nitrogen ratio below 20:1 can release a large amount of soluble N after being plowed or tilled into the soil when an actively growing crop is not present to take up nutrients, leading to increased risks of nitrate movement and nitrous oxide emissions. The nitrous oxide emissions often occur in high soil moisture conditions, such as when a legume cover crop is plowed down in fall or early spring. To avoid these losses, use grass-legume or grass-legume-forbs mixtures with a more balanced carbon to nitrogen ratio.

Use winter hardy grass cover crops to take up excess N after warm season cash crop to recycle nutrients, improve soil health and reduce soil erosion.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration (e.g., filter strip, contour farming, or contour buffer strips).

Use Denitrifying Bioreactor (code 605) and Drainage Water Management (code 554) to mitigate nutrient loss pathways, as applicable.

The use of nutrient loss risk tools based on The Ohio State University On-Field Ohio or Nutrient Tracking Tool (NTT) can be used to refine nutrient management alternatives for the application methods, timing, transport, and other conservation treatment to reduce loss risk.

Nutrients must be applied with the right placement, in the right amount, at the right time, and from the right source to minimize nutrient losses to surface and groundwater. The following nutrient use efficiency strategies or technologies must be considered:

- Slow and controlled release fertilizers.
- Nitrification and urease inhibitors.
- Incorporation or injection.
- Timing and number of applications.
- Coordinate nutrient applications with optimum crop nutrient uptake.
- Pre-Sidedress Nitrate Test (PSNT), and Pre-Plant Soil Nitrate Test (PPSN)) and other residual N testing that can be used to predict nitrogen availability in the soil (if applicable).
- Tissue testing, chlorophyll meters, and spectral analysis technologies that measure crop uptake.
- Other Ohio State University recommended technologies that improve nutrient use efficiency and minimize.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, (e.g., high soil test P levels can result in zinc deficiency in corn). Elevated soil test P levels may lead to reduced mycorrhizal fungal associations and immobilize some micronutrients, such as iron, zinc, and copper.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

When a recycled product (e.g., compost) is to be used as a nutrient source on food crops or as food for humans or animals, make sure that pathogen levels have been reduced to acceptable levels (reference the Food and Drug Administration's Food Safety Modernization Act). www.fda.gov/FSMA When the recycled product has come from another farming operation, implement biosecurity measures and evaluate the risk of pathogen transfer that could cause plant or animal diseases.

Pathogens and other pathogenic organisms may be contained in manure and should be utilized in a manner that minimizes their exposure to animals and humans. Use manure treatment systems that reduce pathogen content from manure. It is preferable to apply manure on pastures and hayland soon after cutting or grazing before re- growth has occurred.

PLANS AND SPECIFICATIONS

In the nutrient management plan, document—

- Aerial site photograph(s), imagery, topography, or site map(s).
- Soil survey map of the site.
- Soil information including: soil type, surface texture, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and ponding frequency.
- Location of designated sensitive areas and the associated nutrient application restrictions and setbacks.

- Location of nearby residences, or other locations where humans may be present on a regular basis, that may be impacted if odors or PM are transported to those locations.
- Results of approved risk assessment tools for N, P, and erosion losses.
- Documentation establishing the application site presents a low risk for P transport to local water if P is applied in excess of crop requirement.
- Current and planned plant production sequence or crop rotation.
- All available test results (e.g. soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient budget and management plan are based.
- When soil P levels are increasing above an agronomic level, include a discussion of the risk associated with P accumulation and a proposed P draw-down strategy.
- Realistic yield goals for the crops (where applicable for developing the nutrient management plan).
- Nutrient recommendations for N, P, and K for the entire plant production sequence or crop rotation.
- Listing, quantification, application method and timing for all nutrient sources (including all enhanced efficiency fertilizer products) that are planned for use and documentation of all nutrient imports, exports, and onsite transfers.
- Guidance for implementation, operation and maintenance, and recordkeeping.

For variable rate nutrient management plans, also include—

- Geo-referenced field boundary and data collected that was processed and analyzed as a GIS layer or layers to generate nutrient or soil amendment recommendations per management zone. Must include site-specific yield maps using soils data, current soil test results, and a yield monitoring system with GPS receiver to correlate field location with yield.
- Nutrient recommendation guidance and recommendation equations used to convert the GIS base data layer or layers to a nutrient source material recommendation GIS layer or layers.
- After implementation, provide application records per management zone or as applied map within individual field boundaries (or electronic records) documenting source, timing, method, and rate of all nutrient or soil amendment applications.

If increases in soil P levels are expected above an agronomic level (i.e., when N-based rates are used), document—

- Soil P levels at which it is desirable to convert to P-based planning.
- A long-term strategy and proposed implementation timeline for soil test P drawdown from the production and harvesting of crops.
- Management activities or techniques used to reduce the potential for P transport and loss.
- For AFOs, a quantification of manure produced in excess of crop nutrient requirements.

OPERATION AND MAINTENANCE

Review or revise plans periodically to determine if adjustments or modifications are needed. At a minimum, review and revise plans as needed with each soil test cycle, changes in manure management, volume or analysis, plants and crops, or plant and crop management.

Monitor fields receiving animal manures and biosolids for the accumulation of heavy metals and P in accordance with LGU guidance and State law.

For animal feeding operation, significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content.

Calibrate application equipment to ensure accurate distribution of material at planned rates. Under field operating conditions the acceptable error rate for accurate calibration is within +/- 10%. For products too

dangerous to calibrate, follow LGU or equipment manufacturer guidance on proper equipment design, plumbing, and maintenance.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation to explain the difference.

Protect workers from and avoid unnecessary contact with nutrient sources. Take extra caution when handling anhydrous ammonia or when managing organic wastes stored in unventilated tanks, impoundments, or other enclosures.

Use material generated from cleaning nutrient application equipment in an environmentally safe manner. Collect, store, or field apply excess material in an appropriate manner.

Recycle or dispose of nutrient containers in compliance with State and local guidelines or regulations.

Maintain records for at least 5 years to document plan implementation and maintenance. Records must include—

- All test results (soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient management plan is based.
- Listing and quantification of all nutrient sources (including all enhanced efficiency fertilizer products) that are planned for use and documentation of all nutrient imports, exports and onsite transfers.
- Date(s), method(s), and location(s) of all nutrient applications.
- Weather conditions and soil moisture at the time of application, elapsed time from manure application to rainfall or irrigation event(s).
- Plants and crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and plant or crop residues removed.
- Dates of plan review, name of reviewer, and recommended adjustments resulting from the review.

For variable rate nutrient management plans, also include—

- Maps identifying the variable application location, source, timing, amount, and placement of all plant and crop nutrients applied.
- GPS-based yield maps for crops where yields can be digitally collected.

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Table 1:

Minimum Setback Distances and Vegetative Treatment Requirements for the Application of Manure and other Organic By-Products.

These setbacks and vegetative treatment requirements were primarily established to reduce loss risk associated with pathogens. CAFO's must additionally follow the setbacks defined in the Ohio Department of Agriculture (ODA) rules regarding manure application (Ohio Administrative Code 901:10-2-14). Additional setbacks may apply to sludge that is regulated by the Ohio Environmental Protection Agency (OEPA) and septage regulated by the Ohio Department of Health.

Type of Sensitive - Setback Area	Manure Surface Application	Manure Incorporation or Direct Injection
Residences / Private Wells down slope from the application area	100 ft	100 ft
Sinkholes	300 ft	100 ft
Pond or Lake	100 ft. at a minimum 35 ft of the 100 must be Vegetative Barrier[2] Or 300 ft	35ft. Vegetative Barrier
• Streams[1] • Ditches[1] • Surface Inlets	35 ft Vegetative Barrier Or 35 ft with 50% residue cover at time of application Or 100 ft	None
Grassed Waterway	35 ft	None
Field Surface Drains	35 ft	None
Public Wells	300 ft	100 ft
Developed Springs down slope from the application area.	300 ft	300 ft
Public Surface Drinking Water Intake	300 ft	300 ft

1. All listed measurements are from top of bank.
2. Vegetative Barriers are permanent vegetation consisting of grass, grass/legume mix, trees/shrubs, or trees/shrubs and grass/legumes.
3. Setback requirement for field surface drains are only required if the criteria listed Nutrient application Timing and Placement section are not met. When this criterion is not met the applications of manure must abide by this 35 ft setback distance.

Table 2.

Available Water Capacity (AWC): Practical Soil Moisture Interpretations for Various Soil Textures and Conditions to Determine Liquid Manure Volume Applications not to exceed 100% AWC (Field Capacity).

The table below shall be used to determine the percent AWC at the time of application and the liquid volume in gallons that can be applied not to exceed the 100% AWC (field capacity). To determine the percent AWC in the upper 8 inches use a soil probe or similar device to evaluate the soil to a depth of 8 inches. Use the descriptions below to determent the percent AWC for the soil texture being evaluated. The planned application rate of liquid manure must not exceed the listed amount to reach 100% AWC. This is a general assessment procedure to determine an application rate that will not exceed the water holing capacity at the time of application. Field conditions may vary greatly. Producers should monitor tile and watch for excessive surface ponding and reduce application rate as needed to prevent discharge. **For liquid manure applications on subsurface (tile) drained fields maximum application rate is the lesser of 13,500 gallons/acre or the listed rate in the table below.**

Currently available soil moisture as a percent Field Capacity	Sands Loamy Sands	Sandy Loam Fine Sandy Loam	Very Fine Sandy Loam, Loam, Silt Loam, Silty Clay Loam, Clay Loam Sandy Clay Loam	Sandy Clay Silty Clay Clay
<25% AWC	Dry, loose and single-grained; flows through fingers	Dry and loose; flows through fingers.	Powdery dry; in some places slightly crusted but breaks down easily into powder.	Hard, baked and cracked; has loose crumbs on surface in some places.
Amount to reach 100% AWC	**20,000 gallons/ac**	**27,000 gallons/ac**	**40,000 gallons/ac**	**27,000 gallons/ac**
25-50% AWC	Appears to be dry; does not form a ball under pressure.	Appears to be dry; does not form a ball under pressure.	Somewhat crumbly but holds together under pressure.	Somewhat pliable; balls under pressure.
Amount to reach 100% AWC	**15,000 gallons/ac**	**20,000 gallons/ac**	**30,000 gallons/ac**	**20,000 gallons/ac**
50-75% AWC	Appears to be dry; does not form a ball under pressure.	Balls under pressure but seldom holds together.	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure.	Forms a ball; ribbons out between thumb and forefinger.
Amount to reach 100% AWC	**10,000 gallons/ac**	**13,500 gallons/ac**	**20,000 gallons/ac**	**13,500 gallons/ac**
>75% AWC	Sticks together slightly; may form a weak ball under pressure.	Forms a weak ball that breaks easily, does not stick.	Forms ball; very pliable; slicks readily if relatively high in clay.	Ribbons out between fingers easily; has a slick feeling.
Amount to reach 100% AWC	**5,000 gallons/ac**	**7,000 gallons/ac**	**11,000 gallons/ac**	**7,000 gallons/ac**
100% AWC or Field Capacity	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.
Above Field Capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles: free water forms on surface

Table 3.

Determining the Most Limiting Planned Manure Application Rates. Additional limitations may be required for liquid manure applications based on the soil moisture at the time of application; see Table 1 (Available Water Capacity).

Time of Year	Drainage	Field Situation	Limiting Application Rate Criteria[1] Tons/Ac Gallons/Ac	Nitrogen[2]	P_2O_5	K_2O
April - June	Subsurface Drained or High N Leaching Potential		13,500 gal/ac	Next Crop Needs[4] factoring N Losses	Recommendation or Crop Removal < 250 Lbs/ac[5]	500 Lbs/ac
		Steep fields[3]	10 tons, 5,000 gal. or contoured strips or incorporated immediately			
	Not Subsurface Drained					
July - Sept	Subsurface Drained or High N Leaching Potential	No Growing Crop	13,500 gal/ac	50 lbs/ac[6]	Recommendation or Crop Removal < 250 Lbs/ac[5]	500 Lbs/ac
		Growing Crop or Cover Crop		Next Crop Needs[4] factoring N Losses		
		Steep fields[3]	10 tons, 5,000 gal. or contoured strips or incorporated immediately	50 lbs/ac[5]		
	Not Subsurface Drained			Next Crop Needs[4] factoring N Losses		
Oct - March	Subsurface Drained or High N Leaching Potential		13,500 gal/ac	Next Crop Needs[4] factoring N Losses	Recommendation or Crop Removal < 250 Lbs/ac[5]	500 Lbs/ac
		Steep fields[3]	10 tons, 5,000 gal. or contoured strips or incorporated immediately			
	Not Subsurface Drained					

1. Planned manure application rates cannot exceed any of the listed rate criteria for the planned month, field drainage status and field situation. Additional limitations may be required for liquid manure applications based on the soil moisture at the time of application; see Table 2 (Available Water Capacity).
2. Nitrogen limitation should be based on the likely nitrogen available to the next crop. Typically, 1/3 of the organic N will be available the first year after application and consideration should be given to volatilization losses.
3. Steep fields are defined as Pasture > 20% slope or Cropland > 15% slope. If parts of the field are steep implement the additional criteria to the extent needed to minimize in field movement of manure.
4. Next crop needs should be the N recommendation for non-legume crops and no more than 150 lbs/ac for legume crops.
5. In cases where liquid manure exceeds 75 Lbs P_2O_5 per 1000 gallons or solid manure exceeds 100 Lbs P_2O_5 per ton the P_2O_5 rates can be increased up to a maximum of 500 Lbs P_2O_5 /acre.
6. The 50 lbs/ac as applied N limitation for summer applied manure should be based on the NH4 or NH3 content + 1/3 of the organic N.