Appendix A:

USDA, NRCS, OR. Conservation Practice Standard 590. Nutrient Management. 2020. Portland, OR.

United States Department of Agriculture

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 for nitrogen (N), phosphorus (P), and potassium (K), which accounts for all known measurable sources and removal of these nutrients for the crop rotation.

Sources of nutrients include, but are not limited to, commercial fertilizers (including starter and in-furrow starter/pop-up fertilizer), animal manures, legume N 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.

Follow all applicable State requirements and regulations when applying nutrients near areas prone to contamination, such as designated water quality sensitive areas, (e.g., lakes, ponds, rivers and streams, sinkholes, wellheads, classic gullies, ditches, or surface inlets) that run unmitigated to surface or groundwater.

Soil and tissue testing and analysis
Base the nutrient management plan on current soil test results in accordance with land grant university (LGU) guidance from Oregon (Oregon State University), Washington (Washington State University), and/or Idaho (University of Idaho), or industry practice when recognized by the LGU. Use soil tests no older than 2 years when developing new nutrient management plans. Use tissue testing, when applicable, for monitoring or adjusting the nutrient management plan in accordance with LGU guidance, or industry practice when recognized by the LGU.

For nutrient management plan revisions and maintenance, take soil tests on an interval recommended by the LGU or as required by local rules and regulations.

Collect, prepare, store, and ship all soil and tissue samples following LGU guidance or industry practice. The test analyses must include pertinent information for monitoring or amending the annual nutrient management plan. Follow LGU guidelines regarding required analyses, sampling methods, and test interpretations. Appropriate references include: PNW 570-E "Monitoring Soil Nutrients Using a Management Unit Approach" and EC 628 "A Guide to Collecting Soil Samples for Farms and Gardens."

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 or use an alternative NRCS- or State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternative certification programs must have solid stakeholder support (e.g., State department of agriculture, LGU, water quality control entity, NRCS State staff, growers, and others) and be State or regional in scope.

Maintain soil pH within ranges which enhance the adequate level for plant or crop nutrient availability and utilization as recommended by LGU. For liming guidance, refer to EM 9057 "Applying Lime to Raise Soil pH for Crop Production (Western Oregon)" or EM 9060 "Eastern Oregon Liming Guide."

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. In the absence of such guidance, test at least annually, or more frequently if needed to account for operational changes (e.g., feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. If no operational changes occur and operations can document a stable level of nutrient concentrations for the preceding 3 consecutive years, manure may be tested less frequently, unless Federal, State, or local regulations require more frequent testing. Follow LGU guidelines regarding required analyses and test interpretations. Refer to PNW 533 "Fertilizing with Manure and Other Organic Amendments" and PNW 673 "Sampling Dairy Manure and Compost for Nutrient Analysis." Analyze, as a minimum, total 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.

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 all nutrient imports, exports, and on-farm transfers.

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.

Complete an NRCS-approved nutrient risk assessment for N on all fields where nutrient management is planned unless the State NRCS, in cooperation with State water quality control authorities, has determined specific conditions where N leaching is not a risk to water quality, including drinking water. Where N leaching is a risk, use the NRCS Nitrate Leaching Potential tool found on Web Soil Survey: Start WSS > Soil Data Explorer > Suitabilities and Limitations for Use > Land Management > Nitrate Leaching Potential.

Where the predominance of Nitrate Leaching Potential is high, use Technology and/or Application Considerations in this standard to reduce the risk of nutritent leaching.

Complete an NRCS-approved nutrient risk assessment for P when any of the following conditions are met—

- P application rate exceeds LGU fertility rate guidelines for the planned crop(s).
- The planned area is within a P-impaired watershed.
- The site-specific conditions equating to low risk of P loss have not been determined by the NRCS in cooperation with the State water quality control authority.

In Oregon, use Agronomy Technical Note (TN) #26 “The Phosphorus Index.”

Any fields excluded from a P risk assessment must have a documented agronomic need for P, based on soil test P and LGU nutrient recommendations.

For fields receiving manure, where P risk assessment results equate to—

- LOW risk.—Manure can be applied at rates to supply P at greater than crop requirement not to exceed the N requirement for the succeeding crop.
- MODERATE risk.—Manure can be applied at rates not to exceed crop P removal rate or the soil test P recommended rate for the planned crops in rotation.
- HIGH risk.—Manure can be applied at rates not to exceed crop P removal rate if the following requirements are met:
    - A soil P drawdown strategy has been developed, documented, and implemented for the crop rotation.
    - Implementation of all mitigation practices determined to be needed by site-specific assessments for nutrients and soil loss to protect water quality.
    - Any deviation from these high-risk requirements that would increase the risk of P runoff requires the approval of the Chief of the NRCS.
- ZERO OUT.—-No P should be applied.

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 matter content, and local climate to minimize risk to the environment.

Determine nutrient concentrations of all nutrient sources (e.g. commercial fertilizers, manure, organic by-products, biosolids) prior to land application.

Determine nutrient contribution of cover crops, previous crop residues, animal manures, and soil organic matter.

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

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.

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. Refer to PNW 601-E "Managing Salt-Affected Soils for Crop Production."

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.

Nutrient rate

Plan nutrient application rates for N, P, and K using LGU recommendations or industry practices when recognized by the LGU. Lower-than-recommended nutrient application rates are permissible if the client's objectives are met. A comprehensive online library of Oregon State University fertilizer application guides for both organic and inorganic nutrient sources is available:
https://catalog.extension.oregonstate.edu/topic/agriculture/fertilizer-guides

At a minimum, determine the rate based on crop/cropping sequence, current soil test results, and NRCS-approved nutrient risk assessments. Where applicable, use realistic yield goals.

For new crops or varieties where LGU guidance is unavailable, industry-demonstrated yield and nutrient uptake information may be used.

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.

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.

Exceptions for the above criteria related to surface-applied nutrients when there is a risk of runoff can be made when specified conditions are met and adequate conservation measures are installed to prevent the offsite delivery of nutrients. NRCS, in cooperation with the State water quality control authority, will define adequate treatment levels and specified conditions for applications of manure if soils are frozen and/or snow covered or the top 2 inches of soil are saturated. At a minimum, must consider the following site and management factors:

- Climate (long-term)
- Weather (short-term)
- Soil characteristics
- Slope
- Areas of concentrated flow
- Organic residue and living covers
- Amount and source of nutrients to be applied
- Setback distances to protect local water quality

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.

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 if a storm event is forecast within 24 hours.

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.

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.

Apply manure, compost, mulch, 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 (Planning and Cropping Systems)

Consider development of nutrient management plans by conservation management unit (CMU). A CMU is a field, group of fields, or other land units of the same land use and having similar treatment needs and planned management. A CMU is a grouping by the planner to simplify planning activities and facilitate development of conservation management systems. A CMU has definitive boundaries such as fencing, drainage, vegetation, topography, or soil lines.

Develop site-specific yield maps using a yield monitoring system, multispectral imagery or other methods. Use the data to further 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.”

Use legume crops and cover crops to provide N through biological fixation. Cover crops with a carbon to nitrogen ratio (C/N) 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, which usually produce residues with higher overall C/N than legume monocultures, resulting in lower rates of N release from residues of mixtures compared to only legume residues. Residues left on the soil surface also release N more slowly than residues incorporated into soil.

Use winter hardy grass cover crops to take up excess N after the cash crop growing season and promote contribution of the nitrogen to the next plant or crop.

Refer to PNW 636 “Estimating Plant-Available Nitrogen Release from Cover Crops” for additional methods of cover crop crediting.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration (e.g., reduced or no tillage. filter strip, contour farming, or contour buffer strips).

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. If using biosolids as a nutrient source for crops, review PNW 508 "Fertilizing with Biosolids."

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.

Soil, Tissue, and Manure Testing Considerations

Use soil tests no older than one year in systems where N loss is a concern.

Provide a nutrient analysis of all nutrient source exports (manure or other materials).

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.

For winter wheat, sweet corn, and silage corn, use the pre-sidedress soil nitrate test and post-harvest soil nitrate testing to guide N applications:

- EM 8978 "Silage Corn (Western Oregon) Nutrient Management Guide"
- EM 9272 "Nutrient and Soil Health Management for Sweet Corn (Western Oregon)"
- PNW 615 "Nutrient Management for Field Corn Silage and Grain in the Inland Pacific Northwest"
- EM 9020 "Using the Nitrogen Mineralization Soil Test to predict spring fertilizer N rate for Soft White Winter Wheat grown in Western Oregon"
- EM 8832-E "Post-Harvest Soil Nitrate Testing for Manured Cropping Systems West of the Cascades"

Maximize N efficiency in irrigated cropping systems by Fertigation or side-dressing of N fertilizer based on soil nitrate or plant tissue testing during the growing season.

Conduct additional analyses where specific site conditions warrant (ex: Alkali flats)

Technology Considerations

Use bioreactors and multistage drainage strategies to mitigate nutrient loss pathways, as applicable.

Use manure treatment systems that reduce pathogen content from manure.

Use strategies to reduce the risk of nutrient movement or loss, such as

- High-efficiency irrigation systems and technology
- Enhanced efficiency fertilizers
    - Slow or controlled release fertilizers

    - Nitrification inhibitors
    - Urease inhibitors
        - EB 0208 “Factors Affecting Nitrogen Fertilizer Volatilization”
        - EB 0209 “Management to Minimize Nitrogen Fertilizer Volatilization”
        - BUL 927 “Best Management Practices for Minimizing Ammonia Volatilization from Fertilizer Nitrogen Applications in Idaho Crops”
- Tissue testing, chlorophyll meters, or real-time sensors

Livestock Considerations

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. To develop P budgets, refer to “Phosphorus on the farm from feed grains and by-products.”

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

Use targeted or prescribed livestock grazing to enhance nutrient cycling and improve soil nutrient cycling functions.

Application Considerations

Use application methods, timing, technologies or strategies to reduce the risk of nutrient movement or loss, such as—

- Split nutrient applications
- Banded applications
- Injection of nutrients below the soil surface
- Incorporate surface-applied nutrient sources when precipitation capable of producing runoff or erosion is forecast within the time of a planned application.
- Restrict surface applications when “temperature inversions” will be present.
- Apply manure, compost, or other nutrient sources with minimal soil disturbance and at a rate that will improve soil organic matter without exceeding acceptable risk of N or P loss.
- Oregon Department of Agriculture (ODA) Manure Spreading Advisory Tool located at https://www.oregon.gov/ODA/programs/NaturalResources/Pages/MSA.aspx

Excessive Nutrient Considerations

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).

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

Elevated soil test P levels may lead to reduced mycorrhizal fungal associations.

PLANS AND SPECIFICATIONS

In the nutrient management plan, document—

- Conservation plan map (or equivalent) and topographic map.
- 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 (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc) as prescribed by the Oregon Department of Environmental Quality (DEQ):
https://www.oregon.gov/deq/wq/programs/Pages/Biosolids.aspx. Responsibility for soil heavy metal monitoring (when required by a DEQ permit) is typically borne by the biosolids generator (e.g. city wastewater treatment plant representative), not the landowner or producer.

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. 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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Appendix B:

USDA, NRCS. Agronomy Technical Note 26. The Phosphorus Index. 2013. Portland, OR.

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
PORTLAND, OREGON June 2013

AGRONOMY TECHNICAL NOTE NO. 26

THE PHOSPHORUS INDEX-INTERIM

Soils Contract: Ron Raney
Agronomy Contact: Denise Troxell

The Phosphorus Index for Oregon was developed by a nutrient management advisory group comprised of members from the Natural Resources Conservation Service in Oregon and Washington, Oregon State University, Washington State University, and the agricultural industry.

The Phosphorus Index is a field-level assessment tool designed to evaluate the relative potential for off-site movement of phosphorus from the landscape. The purpose of the Phosphorus Index is to provide field personnel, watershed planners, and land managers with a tool to assess various soils, landforms, and management practices for potential risk of phosphorus movement into surface waters. Conservation planners can use the Phosphorus Index to develop alternatives that include management and conservation practices that will reduce the potential for phosphorus transport to surface waters.

This version of the Phosphorus Index, dated June 2013, is in place until superseded by a the updated Washington/Oregon component-based phosphorus index anticipated within one year. This interim Phosphorus Index satisfies the requirements of Title 190, National Instruction, Part 302, *Nutrient Management Policy Implementation* and the updated policy for providing nutrient management-related technical assistance found in Title 190, GM, Part 402, Nutrient Management.

Phosphorus Concerns in the Environment

Eutrophication is the process of enrichment of water with nutrients, mainly phosphorus and nitrogen, which results in excessive growth of algae and nuisance aquatic plants. The movement of phosphorus in runoff and eroded sediment from agricultural land to surface water can accelerate eutrophication. Phosphorus is the limiting nutrient in most fresh water systems. The eutrophic condition and excessive aquatic plant growth cause depletion of oxygen in water due to heavy oxygen demand by microorganisms as they decompose organic material. The pH of water also increases as algae and other aquatic plants consume carbon dioxide.

Eutrophication impairs water use for fisheries, wildlife, recreation, agriculture, industry, and drinking due to excessive growth of algae and other aquatic plants. Some blue-green algae can form compounds that are toxic to livestock, humans, and other animals. Accelerated eutrophication is often associated with increases in water pH, causing an increase in ammonia concentrations, which can be harmful to fish and other aquatic animals.

Phosphorus Movement in the Landscape

Phosphorus movement in runoff occurs in sediment-bound and dissolved forms. Sediment P is attached to mineral and organic particles and is transported during erosion events. In general, sediment P contributes about 60 to 90 percent of the P transported in runoff from most cultivated land. Dissolved P makes up the largest portion of the total P in runoff from non-cultivated lands such as pastures, hayland, forests, and cropland using no-till practices. Most sediment P is not readily available for algae and plant uptake because it is chemically bound with mineral (particularly iron, aluminum, and calcium) and organic compounds. Sediment P can however represent a long-term source of P for algae and aquatic plant uptake from the water body. Most dissolved P is immediately available for aquatic plant uptake.

Phosphorus Movement Factors

The main factors influencing P movement can be separated into two main categories: **transport and source factors.** The following factors are considered in the Phosphorus Index for Oregon.

Transport factors:
- Yearly erosion rate by crop(sheet and rill, wind)
- Irrigation-induced erosion
- Runoff class
- Flooding frequency
- Distance to surface waters / buffer width
- Subsurface drainage

Source Factors:
- Soil test P concentration
- Commercial P fertilizer application rate
- Commercial P fertilizer application method
- Organic P source application rate
- Organic P source application method

Each factor is assigned a ***Phosphorus Loss Rating*** of ***None, Low, Medium, High, or Very High*** based on the relative risk of phosphorus transport to surface waters. In addition, each factor is assigned a ***Factor Weight*** ranging from 0.25 to 1.50, based on the relative contribution of that factor to P transport.

Separate Phosphorus Indices were developed for Western and Eastern Oregon. Differences in cropping systems, tillage practices, irrigation systems, climatic factors, and soil phosphorus testing methods across the state made it necessary to have separate indices.

Descriptions of Phosphorus Index Factors

Yearly Soil Erosion

This factor includes both sheet and rill and wind erosion. Irrigation-induced erosion is addressed in other factors. Sheet and rill erosion is the detachment of soil particles by raindrop impact, surface runoff from rainfall, and snowmelt runoff on frozen or thawing soil. Wind erosion is the detachment and transport of soil particles by wind forces. Sheet and rill erosion rates are

estimated with the Revised Universal Soil Loss Equation (RUSLE2). Wind erosion rates are estimated using the Wind Erosion Prediction System (WEPS). These soil loss models predict long-term average erosion rates, over the entire crop rotation, in tons of soil loss per acre per year.
The Phosphorus Index requires an entry of the annual erosion rate by crop for the year(s) of the nutrient application. This provides a more accurate way to assess the risk nutrient runoff. Instructions for pulling annual soil loss values from RUSLE2 and WEPS are outlined in "**Procedures for Making a Phosphorus Index Assessment"** beginning on Page 6.

RUSLE2 and WEPS do not predict sediment transport and delivery to a water body. The prediction models are used here in the Phosphorus Index to quantify the movement of soil, thus potential for sediment and attached phosphorus transport on a slope or unsheltered distance toward a water body.

Soil Erosion from Sprinkler Irrigation

This factor is evaluated by comparing the application rate of the sprinkler irrigation system (inches of water per hour) with the infiltration rate of the soil. A visual assessment of runoff and soil erosion caused by irrigation water is also conducted to assign a *Phosphorus Loss Rating* to this factor.

Soil Erosion from Surface Irrigation

This factor is used on fields that are surface irrigated through furrows or corrugations with devices such as siphon tubes or gated pipe. Erosion rates are evaluated using the Surface Irrigation Soil Loss (SISL) model described in Agronomy Technical Note 35. SISL predicts average sediment delivery to the bottom of irrigated fields, in tons per acre per year. SISL does not predict sediment transport and delivery to a water body. Erosion prediction models are used in the Phosphorus Index to quantify the movement of soil, thus potential for sediment and attached phosphorus transport toward a water body. This factor is used only in the Eastern Oregon Phosphorus Index.

Runoff Class

The *runoff class* is determined from the *hydrologic group* assigned to the soil map units in a field, and the average slope gradient. *Hydrologic groups* are groups of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. (National Soil Survey Handbook, Part 618.35). Criteria for runoff classes are given under ***Procedures for Making a Phosphorus Index Assessment*** in this document.

Flooding Frequency Class

Flooding is the temporary covering of the 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. Floodwaters can carry both sediment-bound and dissolved P into surface waters. Estimates of flooding frequency are based on the interpretation of soil properties and other evidence gathered during soil survey fieldwork. Flooding frequency is defined as the number of times flooding occurs over a period of time and is expressed as a class. Definitions of flooding frequency classes are given under ***Procedures for Making a Phosphorus Index Assessment*** in this document.

Distance to Perennial Surface Waters / Buffer Widths

This factor considers the flow distance from the edge of the field to the closest perennial surface water, which may include streams, lakes, and those irrigation and drainage ditches that contain water year around. It also considers the presence and width of a vegetated buffer adjacent to that surface water. The closer the edge of the field is to surface water, the higher the potential risk of P transport to that water.

Vegetated buffers are effective in trapping sediment-bound P in runoff water. They are less effective in reducing dissolved P transport. Dissolved P can flow through a buffer and enter surface water. The wider the vegetated buffer, the more effective it will be in reducing total P transport to surface water. Vegetated buffers that are commonly used adjacent to perennial water include filter strips (NRCS Standard 393) and riparian forest buffers (NRCS Standard 391).

Subsurface Drainage

Recent research has shown that P can leach through the soil profile, and the risk of leaching is directly related to the soil test P concentration in the soil. The higher the P concentration, the greater the potential for leaching. When subsurface drainage is present, such as perforated pipe tile drains, dissolved and sediment-bound P can enter the drains and be directly transported to surface water at the drain outlet. This factor therefore considers whether tile drains are present in the field, and the soil test P concentration.

Soil Test P

A soil sample from the site is necessary to assess the level of "available P" in the surface layer of the soil. Available P is the level customarily reported in a soil test analysis by commercial soil test laboratories. The soil test level for "available P" does not ascertain the total P in the soil. It does however, give an indication of the amount of total P that may be present because of the general relationship between the forms of P (organic, adsorbed, and labile) and the dissolved P available for crop uptake. The higher the soil test P level, the greater the risk of P transport to surface waters.

The depth at which soil samples are collected for available P analysis should be determined from the fertilizer or nutrient management guides for the crops being grown on the site. These guides are available from Oregon State University or Washington State University Cooperative Extension Services. Sampling depth is normally 0 to 6 inches or 0 to 12 inches for cultivated crops, and generally corresponds to typical depth of primary tillage. For established pastures that have not been cultivated for many years, a sample depth of 0 to 3 inches may be appropriate because P tends to be concentrated near the surface when the soil is not cultivated.

In eastern Oregon, soil test P levels should be determined using the Olsen (sodium bicarbonate) extraction method. In western Oregon, the Bray P1 extraction method should be used.

P Fertilizer Application Rate

The P fertilizer application rate is the amount of commercial phosphate fertilizer (P_20_5), in pounds per acre per year, which is applied to the soil. This factor does not include phosphorus from organic sources. The higher the application rate, the greater the risk of P transport to surface waters.

Commercial P Fertilizer Application Method

The manner in which P fertilizer is applied to the soil and the length of time that fertilizer remains on the soil surface will affect potential P movement. Banding or incorporating P fertilizer into the soil reduces the risk of P transport. P fertilizer that is surface applied, and not incorporated into the soil, has a higher risk of transport to surface water.

The time of year that P fertilizer is applied also affects the risk of P movement. P fertilizer that is applied during the winter and early spring in Western Oregon, when heavy or prolonged precipitation events are likely to occur, creates a higher risk of P transport than applications made from mid-spring to early fall. In Eastern Oregon, there is a greater risk of P transport when fertilizer is surface applied and not incorporated prior to irrigation or winter precipitation.

Organic P Source Application Rate

The organic P source application rate is the amount of phosphate (P_2O_5) contained in organic material that is applied to the soil, in pounds per acre per year. An analysis of the organic material is desirable to determine the phosphorus content. When an analysis of the organic material is not available, values from the Animal Waste Management Field Handbook can be used. The higher the application rate, the greater the risk of P transport to surface waters.

Organic P Source Application Method

The manner in which organic P material is applied to the soil, and the length of time it remains on the soil surface will affect potential P movement. Injecting or incorporating organic P sources into the soil reduces the risk of P transport. Organic P material that is surface applied, and not incorporated into the soil, has a higher risk of transport to surface water.

The time of year that organic P is applied also affects the risk of P movement. Organic P that is applied during the winter and early spring in western Oregon, when heavy or prolonged precipitation events are likely to occur, creates a higher risk of P transport than applications made from mid-spring to early fall. In Eastern Oregon, there is a greater risk of P transport when organic material is surface applied and not incorporated prior to irrigation or winter precipitation.

Procedures for Making a Phosphorus Index Assessment

Use the Phosphorus Index Worksheets in Appendix 1 for Western Oregon, Appendix 2 for Eastern Oregon, to make a field assessment of P transport potential. The worksheets are designed to be used on individual fields. Normally a worksheet is completed for each field. A single assessment can be made for a group of fields if the user is certain that all the source and transport factors are the same for each field.

For each transport and source factor, except those determined by formulas, the *Weighted Rating Value* has been calculated on the worksheets by multiplying the *Factor Weight* by the

Phosphorus Loss Rating. For example, a site with a Soil Erosion rate (RUSLE) of 5 tons per acre per year receives a *Phosphorus Loss Rating* of *Medium* or 2 points. The *Factor Weight* of 1.5 multiplied by 2 points results in 3 points for the *Weighted Rating Value*. This value is given in parentheses at the bottom of the cell that contain the 4-6 tons per acre per year soil erosion rate.

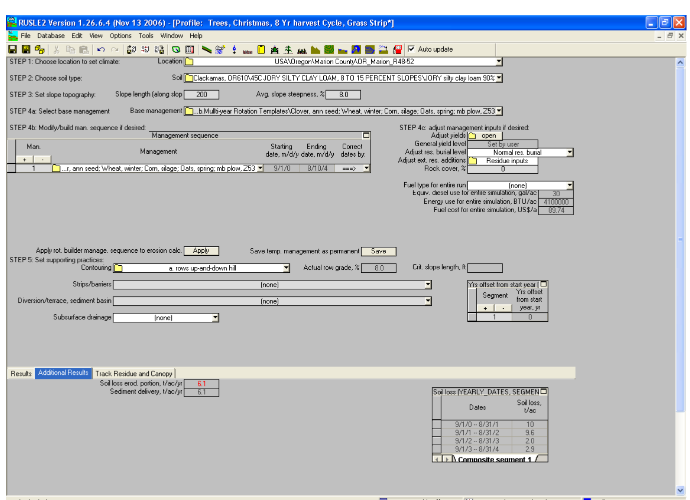
The worksheets are designed so that an assessment can be made for both the *current* and *planned* conditions. For example, during the planning process a producer may select a conservation system alternative that would reduce soil erosion rates, and also install a vegetated buffer next to a perennial stream. This system would reduce the risk of P transport and would result in a lower *Phosphorus Index Total Rating Value*. See Appendix 3 for an example of a completed Phosphorus Index Worksheet. Electronic copies of the Phosphorus Index worksheets are available on the NRCS Oregon home page under Technology/Oregon Ecological Sciences/Agronomy/Oregon Agronomy Technical Notes/The Phosphorus Index, Agronomy Technical Note #26.

Instructions for the Phosphorus Index Worksheets

1. **Site information** – Enter information about the fields included in the assessment. Include information on soil map units, soil test P level and lab method, soil sample depth, crop rotation, and the person(s) making the assessment

2. **Yearly Soil Erosion** – Use the Revised Universal Soil Loss Equation (RUSLE2) and/or Wind Erosion Equation (WEQ) to determine average annual erosion rates over the crop rotation. See Section 1 of the Field Office Technical Guide for RUSLE and WEQ instructions.

   As described previously, the Phosphorus Index requires an entry of the <u>yearly</u> erosion rate by crop for the year(s) of the nutrient application. To find this yearly value in RUSLE2, run a Profile to determine average annual erosion over the rotation as usual. Then, view yearly erosion rates by navigating to the bottom of the Profile screen and selecting the "Additional Results" tab. On the right hand side of the screen is a table titled "Soil Loss, YEARLY DATES, SEGMENT." To determine the yearly erosion rate by crop for the crop year(s) of the nutrient application, pull the soil loss values from the appropriate period(s), and add together if needed.



RUSLE2 Profile Screen: Note Additional Results tab highlighted in blue at the bottom.

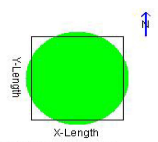
To determine the yearly erosion rate by crop for the year of the nutrient application in WEPS (or crop interval erosion in the case of wheat-fallow rotations that take longer than one year to complete), follow established instructions to complete the WEPS run for the rotation. Annual erosion (or crop interval erosion in the cast of wheat-fallow rotations) in WEPS is listed in the Run Summary Report. It can also be found in the Detailed Report for every year on 12/31 of each crop year.

Run Summary NRCS Natural Resources Conservation Service

Example

Run Date:	Wednesday, May 29, 2013, 02:32 PM
Client Name:	Ima Farmer
Farm No:	--- **Tract No:** 9999 **Field No:**1
Run Location:	Runs
Management:	Denise_Marybeth_Mint_Wheat_Hay.man
Soil:	Ochoco_123_45_ASHY_SL.ifc

Simulation & Site Information



Field shape approximate

X-Length:	2384.2 ft
Y-Length:	2384.2 ft
Radius:	1345.1 ft
Area:	130.5 ac
Elevation:	2500.0 ft
Orientation:	0.0 °

Mode:	NRCS
Soil Loss	2.0 t/ac/yr
Site:	UNITED STATES OREGON CROOK
Location:	44.37° N, 120.94° W
Cligen:	METOLIUS 1 W
Windgen:	REDMOND (AWOS)

Erosion

Period	Crop/Residue	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt	Suspen	PM10
Rot. year: 1	Mint	0.0	0.0	0.0	0.0	0.00
Rot. year: 2	Mint	0.1	0.1	Trace	0.1	Trace
Rot. year: 3	Mint	0.1	0.1	Trace	0.1	Trace
Rot. year: 4	Mint	11.5	11.5	4.0	7.5	0.30
Rot. year: 5	Wheat, winter, CMZ 50 hi ppt 14-16in spac	13.7	13.7	4.5	9.2	0.36
Rot. year: 6	Timothy Timothy	8.7	8.7	2.7	6.0	0.23
Rot. year: 7	Timothy Timothy	0.0	0.0	0.0	0.0	0.00
Rot. year: 8	Timothy	0.2	0.2	0.1	0.2	Trace
Ave. Annual		4.3	4.3	1.4	2.9	0.11

Crop Interval Erosion

Date Range	Crop	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt	Suspen.	PM10
Jun 16, 08 - Jun 15, 04	Mint	0.5	0.5	0.2	0.4	0.01
Jun 16, 04 - Aug 01, 05	Wheat, winter, CMZ 50 hi ppt 14-16in spac	20.6	20.6	6.7	14.0	0.55
Aug 02, 05 - Jun 15, 08	Timothy	13.2	13.2	4.5	8.7	0.34

Harvests

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For fields where both sheet and rill and wind erosion occur, the yearly erosion rates should be combined.

3. **Soil Erosion from Sprinkler Irrigation** – Evaluate the application rate of the existing and/or planned irrigation system. Compare the application rate to the infiltration rate of the soil map units. Oregon Engineering Handbook Irrigation Guide, Part OR681, and Irrigation Water Management (Version 2.0) software have information on sprinkler infiltration rates for most irrigated soils. Make a field visit to visually assess the erosion and runoff that occurs as a result of irrigation water applications.

4. **Soil Erosion from Surface Irrigation** (Eastern Oregon only) – Use the Surface Irrigation Soil Loss (SISL) average erosion rate estimate for the entire crop rotation. See Agronomy Technical Note 35 for SISL instructions. Assign a *Low* Phosphorus Loss Rating for this factor if a well functioning tail water return flow/reuse (pump back) system is in place.

5. **Runoff Class –** Use the following table to select the *Runoff Class* when field slope measurements are available. Hydrologic Group can be found via the Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/. Field slope measurements are preferable for determining the *Runoff Class*, especially for soil map units with broad slope classes. There are separate Factor Weights for nonirrigated and irrigated conditions in the Eastern Oregon worksheet.

Slope (%)	Hydrologic Group			
	A	B	C	D
	Runoff Classes			
< 1	Negligible	Negligible	Low	Low
1 – 5	Negligible	Low	Medium	Medium
6 – 10	Very Low	Medium	High	High
11 – 20	Low	Medium	High	Very High
> 20	Medium	High	Very High	Very High

6. **Flooding Frequency Class** (Western Oregon only) – Use the class assigned in Appendix 4 – Soils Data for the Phosphorus Index unless more accurate local information on flooding frequency is available. *Flooding Frequency Classes* are defined as follows (National Soil Survey Handbook, Part 618.26):

   None – No reasonable possibility of flooding; near zero percent chance of flooding in any year or less than 1 time in 500 years.

   Very Rare – Flooding is very unlikely but possible under extremely unusual weather conditions; less than 1 percent chance of flooding in any year or less than 1 time in 100 years but at least 1 time in 500 years.

   Rare – Flooding unlikely but possible under unusual weather conditions; 1 to 5 percent chance of flooding in any year or 1 to 5 times in 100 years.

   Occasional – Flooding is expected infrequently under usual weather conditions; 5 to 50 percent chance of flooding in any year or 5 to 50 times in 100 years.

   Frequent – Flooding is likely to occur often under usual weather conditions; more than a 50 percent chance of flooding in any year or more than 50 times in 100 years, but less than a 50 percent chance of flooding in all months in any year.

   Very Frequent – Flooding is likely to occur very often under usual weather conditions; more than a 50 percent chance of flooding in all months of any year.

   Flooding frequency classes assigned to soil map units can also be found in the FOCS soil database *Water Features* table.

7. **Distance to Perennial Surface Waters / Buffer Widths** – Determine the shortest distance from the edge of the field **down slope** to a perennial surface water body, which may include streams, lakes, and those irrigation and drainage ditches that contain water year around. Topographic maps, soil survey maps, local information, and field observations can be used to identify perennial surface waters. Determine the average width of existing and planned vegetated buffers adjacent to the perennial surface water. The buffer should meet NRCS technical standards in order to be considered in the rating.

8. **Subsurface Drainage –** Determine whether subsurface drainage, such as perforated tile drains, are present in the field. If drains are present, use the soil test P level to determine the *Phosphorus Loss Rating*.

9. **Soil Test P** – Enter the soil test P level (ppm) for the field into the formula to calculate the *Phosphorus Loss Rating*. The Olsen (sodium bicarbonate) extraction method should be used in Eastern Oregon. The Bray P1 method should be used in Western Oregon.

10. **Commercial P Fertilizer Application Rate –** Enter the phosphate (P_2O_5) fertilizer application rate for the field into the formula to calculate the *Phosphorus Loss Rating*. Average annual application rates over the entire crop rotation should be used for this factor. Elemental P can be converted to P_2O_5 according to the following formula: P x 2.29 = P_2O_5

11. **Commercial P Fertilizer Application Method –** Select the predominant method used to apply commercial P fertilizer and the timing of applications

12. **Organic P Source Application Rate –** Enter the organic source P_2O_5 application rate for the field into the formula to calculate the Phosphorus Loss Rating. Average annual application rates over the entire crop rotation should be used for this factor. Elemental P can be converted to P_2O_5 according to the following formula: P x 2.29 = P_2O_5

13. **Organic P Source Application Method –** Determine the predominant method used to apply organic sources of P and the timing of applications.

14. Sum the Transport and Source Factor *Weighted Rating Values* and use the formulas on the worksheets to determine the *Total Rating Value* and *Site Vulnerability Class*.

Interpretations of the Phosphorus Index Site Vulnerability Class

LOW – The site has a LOW potential for P movement from the site. If farming practices are maintained at current levels, the probability of an adverse impact to surface water resources from P losses from this site are low. Phosphorus can be applied at rates greater than crop requirement

MEDIUM – The site has a MEDIUM potential for P movement from the site. The probability for an adverse impact to surface water resources is greater than that from a LOW vulnerability rated site. Some remedial action should be taken to lessen the probability of P movement. Phosphorus can be applied not to exceed the crop requirement rate.

HIGH – The site has a HIGH potential for P movement from the site. There is a high probability for an adverse impact to surface water resources unless action is taken to reduce the risk of P movement and probable water quality degradation. Phosphorus can be applied not to exceed the crop removal rate if the following requirements are met:

- A soil phosphorus drawdown strategy has been implemented, and
- A site assessment for nutrients and soil loss has been conducted to determine if mitigation practices are required to protect water quality.

ZERO OUT – Environmental threshold above which the risk of P loss from a field is too great to warrant the application of P for plant production.

Precautions in the Use of the Phosphorus Index

The Phosphorus Index is an assessment tool to be used by planners and land managers to assess the risk of phosphorus transport toward a water body. It also can be used to identify the critical factors of soil, topography, and management that most influence the movement. Using these factors, the index can help in the selection of management alternatives that would significantly address the potential impact to surface water quality and reduce the risk. The index is intended to be part of the planning process that takes place between the land manager and resource planner.

The Phosphorus Index is not designed to be used to determine whether land managers are in compliance with water quality regulations or standards that have been established by local, state, or federal agencies. Any attempt to use this index for regulatory purposes would be beyond the intent of the assessment tool and the concept and philosophy of the group that developed it.

Attachments to this Technical Notes include:

- **An Eastern Oregon Example P Index**
- **A Western Oregon Example P Index**
- **East side worksheet**
- **West side worksheet**

And may be found in Section IV of the Oregon FOTG under CPS 590 Nutrient Management.

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Producer: ______________ County: ________ Tract No. _____ Field No(s). ______ Date: ________

Soil Map Unit(s): ____________ Soil Test P: _____ ppm Lab. Method: ________ Sample Depth: _______

Crop Rotation: ______________________ Nutrient Application Method(s) ______________________

Planner: ______________ Notes: ____

		PHOSPHORUS LOSS RATING					**Weighted Rating Value**	
TRANSPORT FACTORS	Factor Weight						**Current**	**Planned**
Annual Soil Erosion – (T/ac/yr) for the year(s) of the nutrient application.	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	______	______
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)	______	______
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)	______	______
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)	______	______
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)	______	______
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)	______	______
						Transport Factors Subtotal (TFS)		

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Tract _______________

Fields _______________

SOURCE FACTORS	Factor Weight	PHOSPHORUS LOSS RATING					Weighted Rating Value: Current	Weighted Rating Value: Planned
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10	(_________ - 40) x 0.10 = _______ (Soil Test P)		Assign 0 points if Soil Test P < 40 ppm		_____	_____
Commercial P Fertilizer Application Rate	1.00			__________ x 0.02 = ________ (lbs/ac P_2O_5)			_____	_____
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	_____	_____
Organic P Source Application Rate	1.00			__________ x 0.02 = ________ (lbs/ac P_2O_5)			_____	_____
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	_____	_____

Total Rating Value TFS + SFS	**Site Vulnerability Class**
<= 25.0	**Low**
25.1 – 50.0	**Medium**
50.1 - 75.0	**High**

	Current	**Planned**
Transport Factors Subtotal (TFS)		
Source Factors Subtotal (SFS)		
Total Rating Value (TFS **+** SFS)		
Site Vulnerability Class		

EXAMPLE – PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

> 75.0	**Zero Out**

Producer: Willamette Valley Dairy	County: Polk	Tract: 1045	Field(s): 1	Date: May 29, 2013
Soil Map Unit(s): 73 - Wapato sicl	Soil Test P: 129 ppm	Lab. Method: Bray P1	Sample Depth: 0 – 12 inches	
Crop Rotation: corn silage with ryegrass cover crop	Nutrient Application Method(s): big gun for manure liquids, spreader for solids			
Planner: Resource Conservationist	Notes: Field edge is 250 feet from a perennial stream and there is a buffer about 15 feet wide. Producer plans to increase buffer width to 40 feet and reduce annual P_2O_5 applications to 250 lb/ac.			

TRANSPORT FACTORS	Factor Weight	**PHOSPHORUS LOSS RATING**					**Weighted Rating Value** Current	Planned
Annual Soil Erosion – (T/ac/yr) for the year(s) of the nutrient application.	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	2.25	2.25
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)	0.56	0.56
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)	2.0	2.0
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)	2.25	2.25
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)	1.12	0
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)	0	0

Transport Factors Subtotal (TFS)	8.18	7.06

EXAMPLE – PHOSPHORUS INDEX WORKSHEET – WESTERN OREGON

Tract ****** Field(s): 1

SOURCE FACTORS	Factor Weight	PHOSPHORUS LOSS RATING					Weighted Rating Value: Current	Weighted Rating Value: Planned
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10	(129 - 40) x 0.10 = 8.9 (Soil Test P)		Assign 0 points if Soil Test P < 40 ppm		8.9	8.9
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02	0 x 0.02 = 0 (lbs/ac P_2O_5)				0	0
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	0	0
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02	Current: 700 x 0.02 = 14.0 (lbs/ac P_2O_5)		Planned: 250 x 0.02 = 5.0 (lbs/ac P_2O_5)		14.0	5.0
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	4.0	2.0

Total Rating Value TFS + SFS	Site Vulnerability Class
<= 25.0	Low
25.1 – 50.0	Medium
50.1-75.0	High
> 75.0	Zero Out

	Current	Planned
Transport Factors Subtotal (TFS)	8.18	7.06
Source Factors Subtotal (SFS)	26.90	15.90
Total Rating Value (TFS + SFS)	35.08	22.96
Site Vulnerability Class	Medium	Low

PHOSPHORUS INDEX WORKSHEET – **EASTERN** OREGON

Producer: ____________________ County: __________ Tract _______ Field(s) ________ Date: __________

Soil Map Unit(s): ________________ Soil Test P: ________ ppm Lab. Method: __________ Sample Depth: __________

Crop Rotation: ______________________________ Nutrient Application Method(s) ______________________________

Planner: ____________________ Notes: ____

		PHOSPHORUS LOSS RATING					Weighted Rating Value	
TRANSPORT FACTORS	Factor Weight						**Current**	**Planned**
Annual Soil Erosion – (T/ac/yr) for the year(s) of the nutrient application.	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	______	______
Soil Erosion from Sprinkler Irrigation	0.25	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.25)	Application rate = infiltration rate OR Little to no visible runoff at field borders (0.5)	Application rate > infiltration rate OR Visible runoff at field borders (2.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (4.0)	______	______
Soil Erosion from Surface Irrigation – tons/ac/yr (SISL)	1.00	< 1 (0)	1 – 3 OR tail water return flow in place (1.0)	4 – 6 (2.0)	7 – 15 (4.0)	> 15 (8.0)	______	______
Runoff Class	1.00 – nonirri-gated 0.50 - irrigated	Negligible (0)	Very low or low (0.5 IRR, 1.0 NIRR)	Medium (1.0 IRR, 2.0 NIRR)	High (2.0 IRR, 4.0 NIRR)	Very High (4.0 IRR, 8.0 NIRR)	______	______
Distance to Perennial Surface Waters / Buffer Widths	0.50	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.5)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.0)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (2.0)	< 100 feet AND No buffer next to surface waters OR Return flow from surface irrigation occurs with no buffer (4.0)	______	______
Subsurface Drainage	0.50	No tile drains (0)	Tile drains present Soil Test P (Olsen) < 40 ppm (0.5)	Tile drains present Soil Test P (Olsen) 40 - 120 ppm (1.0)	Tile drains present Soil Test P (Olsen) 121 - 170 ppm (2.0)	Tile drains present Soil Test P (Olsen) > 170 ppm (4.0)	______	______
						Transport Factors Subtotal (TFS)		

Tract ______ Fields ________

SOURCE FACTORS	Factor Weight	**PHOSPHORUS LOSS RATING**					**Weighted Rating Value** Current	**Weighted Rating Value** Planned
Soil Test P – 0-12" ppm (Olsen $NaHCO_3$)	1.00	(Soil Test P – 20) x 0.10 (_________ - 20) x 0.10 = _______ (Soil Test P) Assign 0 points if Soil Test P < 20 ppm					______	______
Commercial P Fertilizer Application Rate	1.00	__________ x 0.02 = ________ (lbs/ac P_2O_5)					______	______
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Placed with planter OR Injected deeper than 2 inches OR Incorporated by plowing (1.0)	Incorporated deeper than 3 inches by disking, chiseling, etc. (2.0)	Incorporated less than 3 inches deep by harrowing, etc. (4.0)	Surface applied – not incorporated prior to irrigation or winter precipitation (8.0)	______	______
Organic P Source Application Rate	1.00	__________ x 0.02 = ________ (lbs/ac P_2O_5)					______	______
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated immediately (1.0)	Incorporated deeper than 3 inches by disking, chiseling, etc. within 5 days of application (2.0)	Incorporated less than 3 inches deep by harrowing, etc. within 21 days of application (4.0)	Surface applied – not incorporated prior to irrigation or winter precipitation (8.0)	______	______

Total Rating Value TFS x **SFS**	**Site Vulnerability Class**
< = 100	**Low**
100.1 - 400	**Medium**
400.1 - 600	**High**
> 600	**Zero Out**

	Current	**Planned**
Transport Factors Subtotal (TFS)		
Source Factors Subtotal (SFS)		
Total Rating Value (TFS **x** SFS)		
Site Vulnerability Class		

Producer: Irrigated Cropland Farm	County: Malheur	Tract: 1045	Field(s): 3	Date: May 29, 2013
Soil Map Unit(s): 11B - Frohman sil, 2-5%	Soil Test P: 43 ppm	Lab. Method: Olsen ($NaHCO_3$)	Sample Depth: 0-12 inches	
Crop Rotation: 7 yr alfalfa - 2 yr corn silage - 1 yr winter wheat	Nutrient Application Method(s): See Cropland Inventory Worksheet #3			
Planner:	Notes: Manure application: 20 tons/ac solids = 200 lb/ac P_2O_5 during the first year of corn silage			

		PHOSPHORUS LOSS RATING					Weighted Rating Value	
TRANSPORT FACTORS	Factor Weight						Current	Planned
Annual Soil Erosion – (T/ac/yr) for the year(s) of the nutrient application.	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	2.25	
Soil Erosion from Sprinkler Irrigation	0.25	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.25)	Application rate = infiltration rate OR Little to no visible runoff at field borders (0.5)	Application rate > infiltration rate OR Visible runoff at field borders (2.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (4.0)	0	
Soil Erosion from Surface Irrigation – tons/ac/yr (SISL)	1.00	< 1 (0)	1 – 3 OR tail water return flow in place (1.0)	4 – 6 (2.0)	7 – 15 (4.0)	> 15 (8.0)	2.0	
Runoff Class	1.00 – nonirrigated 0.50 - irrigated	Negligible (0)	Very low or low (0.5 IRR, 1.0 NIRR)	Medium (1.0 IRR, 2.0 NIRR)	High (2.0 IRR, 4.0 NIRR)	Very High (4.0 IRR, 8.0 NIRR)	0.5	
Distance to Perennial Surface Waters / Buffer Widths	0.50	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.5)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.0)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (2.0)	< 100 feet AND No buffer next to surface waters OR Return flow from surface irrigation occurs with no buffer (4.0)	0	
Subsurface Drainage	0.50	No tile drains (0)	Tile drains present Soil Test P (Olsen) < 40 ppm (0.5)	Tile drains present Soil Test P (Olsen) 40 - 120 ppm (1.0)	Tile drains present Soil Test P (Olsen) 121 - 170 ppm (2.0)	Tile drains present Soil Test P (Olsen) > 170 ppm (4.0)	0	
						Transport Factors Subtotal (TFS)	4.75	

EXAMPLE – PHOSPHORUS INDEX WORKSHEET – **EASTERN** OREGON

Tract **88,888** Field: 3

SOURCE FACTORS	Factor Weight	PHOSPHORUS LOSS RATING					Weighted Rating Value Current	Weighted Rating Value Planned
Soil Test P – 0-12" ppm (Olsen $NaHCO_3$)	1.00	(Soil Test P – 20) x 0.10	(43 – 20) x 0.10 = 2.3 Soil Test P	Assign 0 points if Soil Test P < 20 ppm			2.3	
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02	28 lbs/ac P_2O_5 x 0.02 = 0.6				0.6	
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Placed with planter OR Injected deeper than 2 inches OR Incorporated by plowing (1.0)	Incorporated deeper than 3 inches by disking, chiseling, etc. (2.0)	Incorporated less than 3 inches deep by harrowing, etc. (4.0)	Surface applied – not incorporated prior to irrigation or winter precipitation (8.0)	2.0	
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02	(200 lbs/ac P_2O_5 / 10 years) x 0.02 = 0.4				0.4	
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated immediately (1.0)	Incorporated deeper than 3 inches by disking, chiseling, etc. within 5 days of application (2.0)	Incorporated less than 3 inches deep by harrowing, etc. within 21 days of application (4.0)	Surface applied – not incorporated prior to irrigation or winter precipitation (8.0)	2.0	

Total Rating Value TFS x SFS	Site Vulnerability Class
<= 100	**Low**
100.1 - 400	**Medium**
400.1 - 600	**High**
> 600	**Zero Out**

	Current	Planned
Transport Factors Subtotal (TFS)	4.75	
Source Factors Subtotal (SFS)	7.3	
Total Rating Value (TFS **x** SFS)	12.05	
Site Vulnerability Class	Low	

Appendix C:

Additional references:

1. Manure sampling
    - Bary, A., C. Cogger, Dan Sullivan. 2016. Fertilizing with Manure and Other Organic Amendments. A Pacific Northwest Extension Publication. PNW 533.
    - Moore, A., M. Haro-Marti, and L. Chen. 2015. Sampling Dairy Manure and Compost for Nutrient Analysis. A Pacific Northwest Extension Publication. PNW 673. (Reviewed 2023).
2. Soil sampling
    - Fery, M., J. Choate, and E. Murphy. 2018. A Guide to Collecting Soil Samples for Farms and Gardens. Oregon State University Extension Service. EC 628. (Revised November, 2022).
    - Staben, M.L., J.W. Ellsworth, D.M. Sullivan, D. Horneck, B.D. Brown, and R.G Stevens. 2003. Monitoring Soil Nutrients Using a Management Unit Approach. A Pacific Northwest Extension Publication. PNW 570-E. (Reviewed 2024).
    - Sullivan, D.M., and C.G. Cogger. 2003. Post-harvest Soil Nitrate Testing for Manured Cropping Systems West of the Cascades. Oregon State University Extension Service. EM 8832-E. (Revised March, 2023).