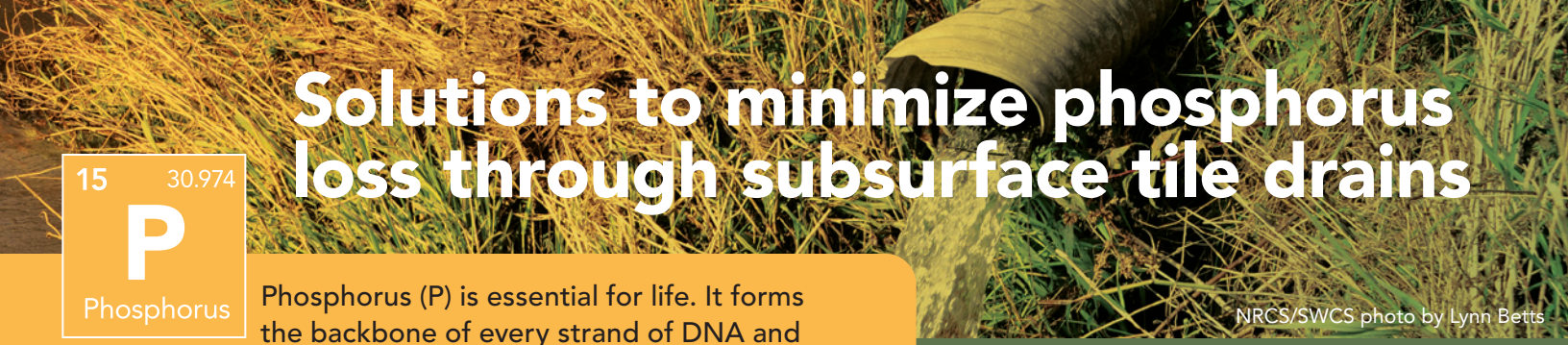
Solutions to minimize phosphorus loss through subsurface tile drains



NRCS/SWCS photo by Lynn Betts

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P
Phosphorus

Phosphorus (P) is essential for life. It forms the backbone of every strand of DNA and helps build strong bones and teeth in our bodies. However, phosphorus that is lost under typical agricultural management practices can lead to negative consequences in our natural environment, like toxic algal blooms in local waters. Subsurface tile drains are one way phosphorus can move from agricultural fields to downstream waters, like lakes and rivers. Historically, phosphorus losses via subsurface drainage were not considered significant, but further research has shown this conduit of phosphorus loss from fields should not be ignored, especially considering the very small amounts of phosphorus that can cause algal growth in ponds, lakes, and reservoirs.

The goals of this factsheet are to: Explain how and why phosphorus can move with tile drainage, and present practical options to reduce this movement of phosphorus from fields.

Movement of Phosphorus to Tile Drains

Phosphorus that moves with water is typically transported in one of two forms.

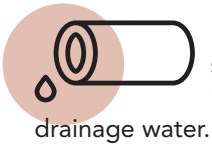
1. 'Particulate P', also known as sediment-bound P, is often associated with soil erosion and runoff of water over the surface of fields. However, this form of phosphorus can also enter drain pipes through surface inlets or risers, or through cracks and root holes that allow preferential flow to the tile.
2. 'Dissolved P' is essentially floating invisibly in water similar to salt that is dissolved in water.

Subsurface drainage water can contain both particulate and dissolved phosphorus.

Factors Influencing Phosphorus Transport to Tile Drains

Soil Characteristics | **Preferential flow** in soils can move phosphorus more quickly to the tile line. Because of preferential flow, phosphorus that is broadcast on the soil can move directly to the tile line without being filtered by soil. Preferential flow is most common in fine-textured soils when there are cracks and other small conduits that are direct channels to the tile. Fine-textured soils tend to have greater **phosphorus sorption capacity** compared to coarse-textured soils, which can reduce the movement of P to drains, unless the soil becomes saturated with phosphorus or preferential flow bypasses the soil. Phosphorus solubility increases under conditions such as high water tables or saturated soils (that is, **reduced conditions**), but this is less likely to occur where a tile drainage system is properly functioning.

Climate | Greater losses of phosphorus are often associated with **precipitation events** that increase water flow through drains, as well as **cooler, wetter months** during the non-growing season.



Drainage Design | **Tile drain spacing** generally does not affect phosphorus concentrations in drainage water. **Placing tile drains deeper** can reduce the concentration of phosphorus in water, but it can also increase the phosphorus load lost due to increased water discharge compared to shallow placement.

Tillage | **Conservation tillage** reduces erosion and sediment-bound particulate phosphorus losses, but it can increase the number of preferential flow paths and dissolved phosphorus loss to drains.

Soil Test Phosphorus (STP) | **Greater STP values** are generally associated with greater phosphorus losses through drains.

Phosphorus Source, Rate, Placement, and Timing | Regardless of the **source**, greater **rates** of phosphorus application increase the potential of phosphorus loss. **Placing** and leaving phosphorus fertilizer on the soil surface can lead to greater phosphorus losses than incorporating it in the soil. Phosphorus belongs IN the soil, not ON the soil. **Timing** phosphorus applications in the fall and winter can increase losses compared to spring and summer.

Effective Management Strategies

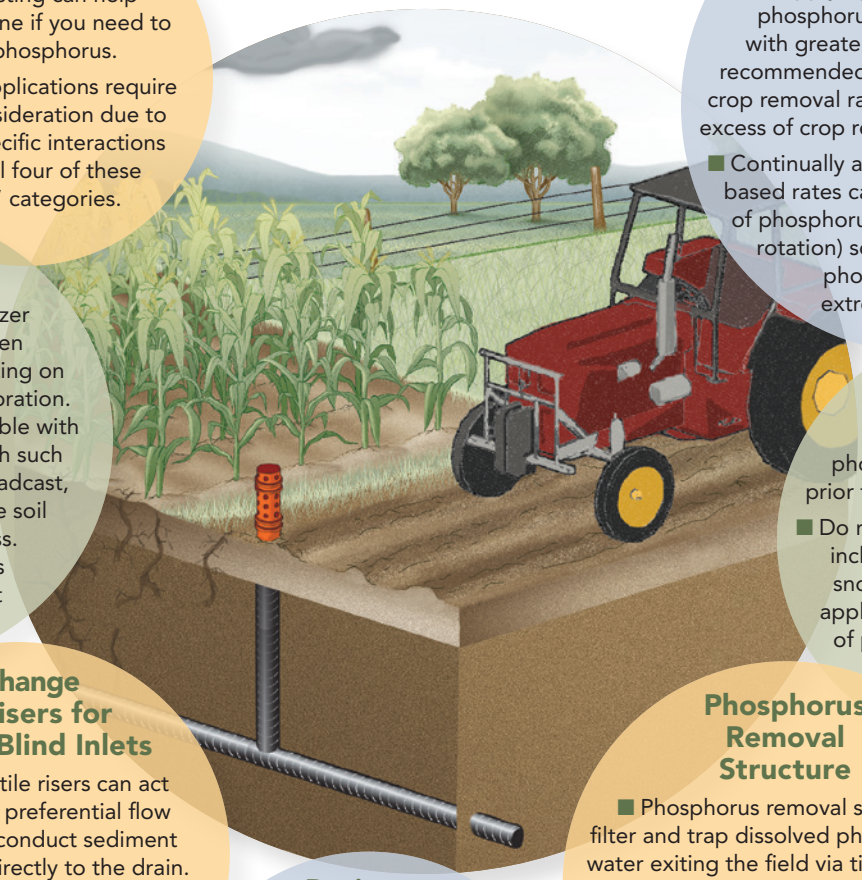
How can we manage our fields to reduce phosphorus loss in tile drains?

Right Source

- Soil testing can help you determine if you need to apply phosphorus.
- Manure applications require special consideration due to manure-specific interactions among all four of these "Right" categories.

Right Rate

- Regardless of source, applying greater amounts of phosphorus typically is correlated with greater phosphorus losses. It is recommended phosphorus be applied at crop removal rates; applying phosphorus in excess of crop removal is not recommended.
- Continually applying manure at nitrogen-based rates can lead to over application of phosphorus. Regular (once per crop rotation) soil testing to determine phosphorus needs is extremely important.



Right Placement

- Place phosphorus fertilizer under the soil surface when possible instead of broadcasting on top of the soil without incorporation. Subsurface application is possible with new equipment, and although such application is slower than broadcast, moving phosphorus into the soil is critical for reducing loss. Remember, phosphorus belongs IN the soil, not ON the soil.

Right Timing

- Avoid applying phosphorus fertilizer 1–2 days prior to a large precipitation event.
- Do not apply phosphorus fertilizer, including manure, to frozen or snow-covered ground. Spring applications could lower the risk of phosphorus loss compared to fall or winter.

Exchange Tile Risers for Rock or Blind Inlets

- Traditional tile risers can act as man-made preferential flow conduits that conduct sediment and nutrients directly to the drain. Alternatively, consider implementing rock inlets or blind inlets to help reduce sediment and particulate phosphorus loads into the drainage system.

Phosphorus Removal Structure

- Phosphorus removal structures filter and trap dissolved phosphorus in water exiting the field via tile drainage. This type of conservation practice is most cost effective on soils that have greater soil test phosphorus levels (>100 ppm of Mehlich-3 or Bray-1 phosphorus tests, or approximately 200 lb/acre of phosphorus).

Drainage Design

- Use the Golden Rule of Drainage: drain only what is necessary for good crop growth and trafficability, and not a drop more. Use outlet controls to minimize non-growing season drainage. Shallower depth of tile placement is recommended to reduce P loss.

Learn More

This factsheet is based on a recent review of the science for tile drainage and is not intended to address every possible mechanism of phosphorus loss or solution to reduce phosphorus loss. **For more information, see the original publication: King, K.W., M.R. Williams, M.L. Macrae, N.R. Fausey, J. Frankenberger, D.R. Smith, P.J.A. Kleinman, and L.C. Brown. 2015. Phosphorus transport in agricultural subsurface drainage: A review. J. Environ. Qual. doi:10.2134. jeq2014.04.0163**

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Illinois Extension publication number CSWQ-0120