



**Natural Resources Conservation Service**  
**CONSERVATION PRACTICE STANDARD**  
**PHOSPHORUS REMOVAL SYSTEM**

**CODE 782**

**(no)**

**DEFINITION**

A system designed to remove dissolved phosphorus (P) from surface runoff, subsurface flow, or groundwater usually consisting of a sorption media with a high affinity for dissolved P, a containment structure that allows flow through the media and retains the media so that it does not move downstream, and a means to remove and replace the media.

**PURPOSE**

This practice is used to accomplish the following purpose:

- To improve water quality by reducing dissolved phosphorus loading to surface water through the sorption of phosphate (dissolved) P from drainage and runoff water.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where phosphorus (P) presents a resource concern to surface water bodies and is mobilized and transported as a dissolved constituent with a dissolved P concentration of 0.5 mg/l or greater. Sources of dissolved P in agricultural areas include ditches, tile drains, livestock heavy use areas, manure storage and handling areas, fields saturated with P relative to the soil sorption capacity, and other areas with high impervious surface area and converging flow.

This practice does not apply to the treatment of particulate phosphorus which is typically bound to soil particles. If adsorbed P is a concern, use other practices such as NRCS Conservation Practice Standard (CPS) 350, Sediment Basin or CPS 638, Water and Sediment Control Basin.

**CRITERIA**

**General Criteria Applicable to All Purposes**

The water to be treated must have a dissolved phosphorus concentration of 0.5 mg/l or greater (Stoner, et al., 2012). Document dissolved P levels by testing a minimum of two (2) water samples from the site obtained separately in the Winter (January-March) and Spring (April-June) using an EPA approved collection and testing protocol.

Divert phosphorus-rich flow into a bed of phosphorus sorption material (PSM) where the water is in contact with the media for a specified amount of time (retention time, RT) before being able to freely flow out of the material by gravity.

Select a PSM based on availability, performance, and water chemistry at the site. Sources of PSM include steel slag, drinking water residuals, acid mine drainage residuals, bauxite mining waste, paper mill waste, fly ash, and gypsum waste. Characteristics of the PSM must be known prior to design. Characterize the PSM by pH and the amount of Ca, Mg, Fe and Al. As appropriate, characterize the density and proposed gradation of the material.

Design the phosphorus removal system to achieve a minimum average annual reduction of 50% of the total dissolved P load present in the drainage system. The fraction removed will be a function of the portion of the flow diverted through the PSM and the efficiency of P removal.

Design the phosphorus removal system for a minimum 10-year design life with replacement or renewal of the PSM and other components as needed.

Provide a hydraulic retention time (RT) through the phosphorus removal system sufficient to achieve the target load reduction in dissolved phosphorus at the design flow rate.

Determine the phosphorous removal system size and configuration based on:

- average annual flow volume
- maximum runoff flow rates for various size storms
- typical dissolved phosphorus concentrations to be treated
- hydraulic head
- area constraints
- maximum flow rate at design retention time
- desired load reduction (%)
- desired life span of media
- physical properties of media
  - hydraulic conductivity
  - bulk density
  - porosity
- chemical properties of media
  - phosphorus sorption characteristics
  - toxicity analysis of proposed media considering both safety (metals and sodium) and method of disposal

If the peak flow rates and annual flow volume are not known, base the surface flow peak discharge and annual flow volume calculations on an appropriate hydrology model.

Design the system as a gravity flow system. Design the structure inlet and outlet such that water flows evenly through the media to minimize preferential flow.

Design water control structures as needed to maintain the water level in the system at desired elevations with appropriate freeboard. Use criteria from NRCS CPS 587, Structure for Water Control.

Use material that is recyclable and/or disposable when it has used up its phosphorus removal capacity. Ensure all used media is disposed of in a proper manner following applicable permits, which may include disposal in a landfill.

Design the containment structure to ensure that the PSM is retained during high flow events and protected from erosion/washout. Media can be retained in a drainage ditch using a dam with appropriate subsurface drainage, held in boxes, tanks, or units made of metal, wood, plastic, etc., or media can be housed within earthen berms. Use geotextile lining, where needed, to prevent the migration of soil particles into the phosphorous removal system based on the soils and geology of the site.

Ensure that the quality of discharge water from treatment structures is not detrimental to downstream waters.

Grade the structure site to minimize overland runoff into the containment structure. Allow for settlement as appropriate. Dispose of excess soil removed during the installation of the system in a sound manner such as blending with the adjacent landscape or hauling away.

Where needed for safety or to prevent compaction of the media, identify the structure location with appropriate signage or fence the site to avoid equipment travel over the system.

Protect all disturbed areas from erosion within 14 days of construction completion by seeding and mulching. Refer to CPS Critical Area Planting (Code 342) and Mulching (Code 484) for seeding and mulching criteria.

### **Additional Criteria for Treating Surface Runoff Flow**

Design the structure to drain completely during periods of low or no flow to prevent the potential for anoxic conditions that would promote the dissolution of iron-rich minerals. If an iron-rich phosphorus sorption media is utilized, design the phosphorus removal structure to flow from the top-downward through the sorption media.

### **CONSIDERATIONS**

Other conservation practices and management systems may be used to achieve a reduction of phosphorous levels separately or in conjunction with this practice. Examples include Nutrient Management (590), Cover Crop (340), Drainage Water Management (554) and Waste Treatment (629).

Flow control structures can be used in drainage ditches in areas of low relief in order to achieve sufficient hydraulic head to reach the desired flow velocity and residence time.

Consider impacts of phosphorus removal systems installation and flow control structures on the proper flow and function of drainage systems such as tile systems and surface ditches.

If the treatment structure is part of an inlet into a pipe system that drains terraces or basins, provide measures so the structure does not plug from sedimentation in the basin.

Consider the effects on downstream water bodies or groundwater that may affect other water uses or users. For example, the initial flow from the system at start up may contain undesired contaminants.

### **PLANS AND SPECIFICATIONS**

Prepare plans and specifications that describe the requirements for applying the practice according to this standard.

As a minimum, include the following items:

- A plan view of the layout of the phosphorus removal system and associated components
- Topographic map of area contributing phosphorus
- Typical cross sections of the phosphorus removal system showing elevations
- Profiles of the phosphorus removal system including critical inlet and outlet elevations
- Details of required structures for water level control
- Site characteristics, including maximum flow rates for various sized storms, typical dissolved P concentrations, average annual flow volume
- Seeding requirements, if needed
- The type of PSM to be used, including all chemical and physical characteristics required for proper design
- Desired % load reduction and life expectancy
- Design peak flow rate
- Planned method of recycling or disposal
- Construction specifications that describe in writing site specific installation requirements of the Phosphorus Removal System and associated components.

## OPERATION AND MAINTENANCE

Prepare an operation and maintenance (O&M) plan and review it with the land manager and maintenance technician. Include normal repetitive activities in the application, use, and repair and upkeep of the practice. Keep the plan site specific and include a description of the following as appropriate:

- All required inputs necessary to operate the system
- Planned water level management and timing
- Inspection and maintenance requirements of the Phosphorus Removal System and contributing drainage system, especially upstream surface inlets
- Weekly inspection of monitoring apparatus
- PSM replacement schedule and PSM disposal method.

Because this is an interim standard and annual reporting of the system's performance is required by the State Conservationist, operation of the system must include monitoring and reporting to confirm system performance and provide information to improve the design and management of this practice. Monitoring must be conducted for the first three full years of operation and be reported annually to the NRCS State Conservationist no later than April 30. The annual report must include:

- Daily and monthly precipitation amounts
- Continuous flow volumes
- Sampling and water testing for phosphorus (both dissolved and total P) in milligrams per liter, at the phosphorus removal system inlet and outlet, at specified frequencies or dates, with a corresponding record of water level elevations, flow rates, temperatures and other data important to the design and performance of the system. Water testing must conform to an approved EPA protocol for the constituents being tested
- Results of weekly maintenance visits
- A summary of system performance, problems, etc.

As of April 2019, Edge-of-field Water Quality Monitoring – Data Collection and Evaluation, Conservation Activity Code 201, and Edge-of-field Water Quality Monitoring – System Installation, Conservation Activity Code 202, may be available to support the monitoring requirements of this practice.

## REFERENCES

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UNDER EVALUATION