Appendix G

Sediment and Nutrient Trades with Forestry and Drinking Water Treatment Facility

(Added May 2009)

Contents

Note to Readers: Prior to reading this appendix, please review the Point Source – Nonpoint Source Trading Scenario (referred to as the Scenario). This appendix provides a variation on the type of nonpoint source trading partners that a point source buyer might want to consider. The information provided in the Scenario will be the same for this type of trade except where noted below. Keep in mind that there are a range of options for how water quality trading can occur that will vary according to the needs at the local level. The hypothetical example discussed throughout this appendix illustrates just one of the many options an NPDES permit writer and stakeholders might use to develop a trading program.

Introduction

The trading example described in Appendix G follows the Scenario and focuses on three areas that the Toolkit does not cover elsewhere: (1) trading by drinking water treatment facilities, (2) trading of sediment loading and (3) trades involving vegetative plantings with an emphasis on forestry.

As described in 40 CFR 122.45(d) and 40 CFR122.45(e), effluent limitations for all NPDES permit holders that discharge continuously must be stated as maximum daily and average monthly discharge limitations, unless impracticable. However, for noncontinuous dischargers (as some water treatment facilities are), the permit writer must ensure only that effluent limitations are stated to meet the requirements of section 122.45(e)1-4.

There are no national effluent limitation guidelines for drinking water treatment facilities. The permitting authority and permit writer must use best professional judgment (BPJ) to establish technology-based NPDES permit limits that are based on the existing source performance standards described in the CWA and NPDES regulations (i.e., BPT, BCT, and BAT). Water quality-based effluent limits are developed to meet state water quality standards. The final limitations included in NPDES permits must satisfy both the technology requirements and water quality standards.

Large drinking water treatment facilities often rely on surface water as their water source and use flocculation, sedimentation, filtration, and disinfection as treatment processes. Suspended solids from source water are often settled in a sedimentation basin. In some situations, the quality of the influent water can be very poor because of high turbidity and high sediment loads. The sediment removed through the treatment process must be disposed of. The treatment facility might find that it is more cost effective to return some or all the sediment to the river and create offsets that will reduce sediment loading upstream (e.g., control land erosion). However, to do this, the treatment facility must demonstrate to the permitting authority/permit writer that its discharge of sediment will not adversely affect the waterbody at the point of discharge.

Sediment is fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits and is transported by, suspended in, or deposited by water. Eroding soil particles largely contribute to the sedimentation of waterbodies. Sediment particles range in size that directly affects the settling velocity and how the particles will affect a waterbody. Soil erosion can produce gravel and coarse sand sediments (> 0.85 mm diameter) as well as fine sediments made up of sand (0.05–2 mm), silt (0.002 to 0.05 mm), and clay (< 0.002 mm). Larger sized particles (gravel and coarse sands) quickly settle out, filling interstitial rock spaces. This can clog drainage ways, increase potential for flooding, decrease reservoir capacity, and negatively affect benthic organism communities. Finer sands can remain suspended for a period of time before settling out downstream. Fine particles such as clay and silt generally remain suspended in a flowing water column. This causes turbidity, which decreases sunlight penetration, disrupting photosynthetic processes.

There are a number of factors to consider when deciding whether allowing sediment discharges at a certain location as allowed by trading is appropriate. For example, given the adverse effects that can result from sediment settling, sediment discharges should occur in large, fast-flowing, high-volume rivers so that the minimum flow velocity will not result in settling sediment particles. In addition, the treatment facility's discharge should be shown to have minimal impact on the overall loadings to the waterbody. Background amounts of suspended and embedded sediment are essential to the ecological function of a waterbody. Sediment discharged to a waterbody should maintain natural or background levels without adversely affecting the waterbody. **Therefore, sediment trading on other than a fast-flowing, high-volume river might not be feasible under most conditions.** The permit writer and the entities involved must clearly define both baseline pollutant loads and the load to be traded in the credit buyer's permit so as not to discharge in quantities that would adversely affect the receiving waterbody.

Vegetation can stabilize stream banks from erosion and filter sediments and nutrients from runoff flow to waterways. Runoff carries sediment, sediment-bound pollutants, and dissolved contaminants. Fast-flowing runoff can easily transport sediment to surface waters because of an insufficient amount of time for particles to settle out and infiltrate the ground. Leaves and branches intercept rainfall and runoff, slowing its movement, and reducing its erosive power. Vegetative roots and surface litter improve soil structure, which increases infiltration. Once in the soil, contaminants can become immobilized, transformed by microbes, or taken up by vegetation. Surface litter also acts as a covering that protects exposed soils and stabilizes slopes from erosion. An additional water quality benefit that trees can provide is that they are capable of intercepting and trapping airborne particulate matter, preventing deposition to surface waters (USDA National Agroforestry Center, 2004).

There is an advantage to trades involving trees: (1) trees are uniquely suited to controlling some processes of erosion on stream banks and shorelines, and (2) trees are likely to remain established for a longer period than herbaceous plantings, thus providing more certainty to the credit buyer of long-term nutrient or sediment control.

Many trading programs could be designed that involve growing trees that would be similar to the Scenario outlined in the Toolkit related to herbaceous BMPs; however, there are a few differences. This appendix outlines circumstances when establishing trees along waterways to manage nutrient and sediment loadings would be most effective. It also includes a hypothetical example of a sediment trading program with forestry.

Generating Credits

The following questions discuss circumstances in which it might be appropriate to engage in trading with forestry entities. While this appendix focuses solely on the ability to generate credits for sediment trades, planting vegetation as buffers to waterways can also lead to nitrogen and phosphorus reductions. The discussion below can apply to trading sediment, nitrogen, and phosphorus.

1. Under what conditions would it be feasible to use vegetative planting as an offset for a point source sediment or nutrient limit?

To control pollutants in runoff (vegetative filters and riparian buffers as best management practice (BMP) options)

- Conditions include areas in and downslope of diffuse agricultural or urban nonpoint source areas (e.g., cropland, livestock grazing and enclosure areas, disturbed land, parking lots, malls and other urban nonpoint source areas) where sediment and nutrients can leave these areas and enter open waterways in surface runoff or in shallow groundwater flow. These areas could be adjacent to permanent or intermittent streams, lakes, ponds, and wetlands (i.e., riparian zones) or in upland zones.

To control eroding sediments from stream banks and shorelines (stream bank stabilization as BMP options)

- Conditions include stream banks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries that are susceptible to erosion and where this erosion process can be mitigated by establishing vegetation.

2. How should vegetated areas be designed to function properly as nonpoint source sediment and/or nutrient offsets?

To control pollutants in runoff

- Removal of contaminants from surface runoff requires that runoff water be sufficiently slowed to allow sediment and sediment associated pollutants to settle out. Plant root systems that are established through herbaceous and woody groundcovers hold soil in place, allow greater infiltration of water, and trap incoming sediment, nutrients, and chemicals. Areas should be positioned appropriately and designed to have sufficient width, length, density, and groundcover structure to intercept and effectively trap pollutants in surface runoff or shallow subsurface flow. Guidance on specific practices IS in USDA-NRCS Field Office Technical Guides (FOTG).
- Existing drainage ditches and underground pipes that would transport pollutants directly from source areas into the waterbody should be closed or plugged to allow passage and filtration of drain water through the planting zone.
- Surface runoff flow through the planting area should be managed to maintain sheet flow, thereby promoting even interception and infiltration. Concentrated flows should be controlled both in the planting area and in areas immediately adjacent and up gradient of the planting area.

- **An example—Riparian Buffers**: mainly woody vegetation (trees or shrubs) sediment, organic material, nutrients, pesticides, and other chemicals found in surface runoff. Design criteria and considerations should follow the USDA-NRCS FOTG for Riparian Forest Buffer (Conservation Practice Standard, Code 391) pertaining to the purpose of reducing pollutants in runoff. In situations where surface runoff volume or pollutant load is relatively high, typically when slopes are greater than 10 percent or when erosion flow into the proposed buffer site is greater than 10 tons/acre/year, other conservation practices should be used in combination with tree plantings. Filter strips, field borders, critical area plantings, or grassed waterways are recommended. These additional practices will slow and disperse the excess runoff before it enters the tree planting area. Design criteria and considerations for these conservation practices should follow the FOTG for Filter Strips, Field Borders, Critical Area Plantings and/or Grassed Waterways (Conservation Practice Standard, Code 393, 386, 342 and/or 412) with specific regard to their use in conjunction with a Riparian Forest Buffer (Code 391).
- **An example—Vegetated Filter Strips**: Contrary to riparian forested buffers, filter strips use mainly herbaceous vegetation for contaminants in surface runoff. Design criteria and considerations should follow the USDA-NRCS FOTG for Filter Strips (Conservation Practice Standard, Code 393). Trees can also be planted and grown in the filter strip as long as adequate structure and density of herbaceous groundcover is maintained. Weed control is permitted around individual trees during the initial growing seasons to promote survival and establishment but only to the extent that the continuity of herbaceous ground cover between individual trees is not compromised along the length and width of the tree planting area. As the trees grow larger, the canopy should be managed to maintain adequate herbaceous ground cover for functioning effectively for slowing and dispersing surface runoff flow.

To prevent sediments from eroding stream banks and shorelines

- An assessment should be conducted in sufficient detail to identify the causes contributing to instability and erosion and to ensure with reasonable confidence that establishing trees or shrubs on the bank or shoreline will contribute significantly to long-term control of the erosion. The assessment should provide estimates of the time it will take for erosion controls to become fully functional, sediment load reductions obtained at the site, and any sediment load increases that the site installation might cause elsewhere along the banks and channel. The time it will take for controls to become fully functional depends on the BMPs installed.
- Design criteria and considerations should follow the FOTG for Streambank and Shoreline Protection (Conservation Practice Standard, Code 580) pertaining

to vegetative techniques that include woody plant materials for controlling erosion.

3. What kind of vegetation should be planted?

- Favor trees, shrubs, or other herbaceous vegetation adapted to the locality and site conditions. Ultimately, the required technical specification of the BMP being installed should be followed.
- Favor native, noninvasive species. Substitution with improved and locally accepted cultivars is allowed.
- For nitrogen control, avoid nitrogen-fixing species (e.g., alder, locust).
- Favor species that have multiple values such as those additionally suited for various products (e.g., timber, biomass, nuts, fruit), wildlife habitat, aesthetics, and for riparian plantings, those that promote healthy aquatic ecosystems.

4. Are there additional management considerations to be made when considering vegetation planting for sediment and nutrient reductions?

- Fertilizers or other nutrient- or sediment-containing amendments should not be applied in the planting area.
- Livestock should be controlled or excluded as necessary to achieve and maintain appropriate vegetative cover and health for proper functioning. Trees and vegetation should also be protected from other wildlife in nonagricultural areas that could threaten the health and proper function of the plantings.
- Any manipulation of species composition, structure, and stocking of overstory, understory, or groundcover vegetation should maintain the pollutant reduction functions of the area.
- Periodic removal of some plant products (trees, herbs, nuts, forages) can occur, if the pollutant-reduction function is not compromised by the loss of vegetation or harvesting disturbance.
- Any other activities that create soil and vegetation disturbance, such as cultivation activities and traffic, should be minimized so as not to compromise the pollutant reduction function of the area.
- For installing BMPs that require vegetative maintenance, the landscaping practices should aim to reduce fertilizer and pesticide use whenever possible through practices such as the following:
  - Using compost as a soil amendment
  - Implementing an Integrated Pest Management program
  - Spot treating whenever possible
  - Setting mower blades higher to fight weeds and diseases without pesticides

- Leaving deciduous tree leaves on the ground so the can contribute to building soil organic matter levels
- Leaving grass clippings in place (instead of bagging) when mowing
- Using mulch around trees and in flowering beds as weed prevention

5. How to calculate sediment and nutrient reductions for credits?

Before calculating water quality credits, all credit sellers and buyers must determine what their baseline, minimum control levels and trading limits are. Baselines apply to the buyer and seller. Minimum control levels apply only to the buyer and trading limits apply only to the seller.

Baselines—This is the level of control which would apply in the absence of trading.

Nonpoint Source Credit Sellers—If a TMDL is established for the watershed, this is the baseline. If there is no TMDL, the state and local requirements or existing practices or both should determine the baseline. At no point should the baseline be less than existing practices.

Point Source Credit Buyers—For point sources, the baseline would be the water quality-based effluent limitation (WQBEL). Facilities are not allowed to trade to meet a technology-based effluent limitation (TBEL), therefore, trading would only be done to meet a more stringent WQBEL.

Minimum Control Levels—Even when trading, a point source discharger is expected to treat the effluent to a certain minimum level. When a TBEL is applicable to a facility, the TBEL would be the minimum control level. As previously stated, facilities are not allowed to trade to meet a TMDL. In other words, the facility must treat the effluent to that level rather than trade. When a TBEL does not exist, then the existing level of discharge would be the minimum control level unless the permitting authority decided to impose a more stringent level to prevent localized impacts.

Trading Limits—The level of control that a pollutant is controlled beyond the baseline becomes the trading limit. For nonpoint source sellers, this is dependent on the type of BMP installed and what type of pollutant reduction it achieves.

The difference between trading limit and the baseline (assuming applicable trade ratios are also applied) determines the number of credits generated.

To control pollutants in runoff

- Credit is obtained for reducing pollutant load generated from the area on which the plantings have been established and for reducing the load of sediment and nutrients in runoff from a source area that passes through the planting area to a waterway. As previously mentioned, the time it takes for controls to become established and fully functional depends on the type of BMP installed and vegetation used.

  – **An example—Riparian Buffers**: Tree plantings in riparian zones, apply the same effectiveness and trading ratio levels as would be appropriate for Riparian Forest Buffer (Code 391), Filter Strip (Code 393) in a riparian zone, or Riparian Herbaceous Cover (Code 390) of similar dimension and circumstance (Dosskey, 2007). Upland planting areas can be expected to function less efficiently for nitrogen reduction (smaller percent reduction of nitrogen load in runoff) than riparian planting areas of similar size and conditions. Enhanced infiltration in upland planting areas diverts more nitrogen to subsurface flow, and shallow subsurface filtration typically is significant in only riparian zones.

To control eroding sediments from stream banks and shorelines

- Credit is obtained for reducing pollutant loads generated from the area on which the plantings have been established. Because some bank erosion is natural over the long term, complete elimination of sediments from bank erosion sources should not be expected. Furthermore, installing offsets at one location can increase erosion rates at another. As the hypothetical example at the end of this appendix will illustrate, when calculating reduction credits, the most conservative control obtained should be assumed. Additionally, the calculation must take into consideration any increases in erosion that the stream bank could experience that should be determined in the stream bank assessment.

6. How long will it take to get adequate sediment and nutrient reduction coverage?

To control pollutants in runoff

- The generation of nutrient and sediment loads is reduced, and filtration is increased as soon as tillage, fertilization, grazing, and other disturbance are halted. For surface runoff filtering, the herbaceous groundcover vegetation becomes established. Removal of loading can be accomplished within one growing season after planting, but ultimately it depends on the type of vegetation planted.

To control eroding sediments from stream banks and shorelines

- Specialized bioengineered practices that include trees and shrubs for stabilizing toe slopes and anchoring steep banks provide immediate protection. Bioengineering creates a system of living plant materials used as structural components. Woody vegetation (shrubs and trees) is installed in specified configurations that offer immediate soil protection and reinforcement. With time as roots develop, the system creates resistance to sliding or shear displacement in the stream bank (USDA-NRCS, 1996).

- Vegetative plantings alone can provide stream bank protection on small streams or areas subject to minimal erosive forces. For protecting banks from greater erosive energy of flood flows, wave action, and ice action, establishing mature trees and shrubs could be required or using vegetative plantings in combination with bioengineered practices. The lag time for adequate growth and development of protective trees and shrubs can vary from one growing season to many years depending on site needs, growth rates of the selected species, and the site conditions.

7. How long will sediment and nutrient reduction coverage last?

To control of sediments in runoff

- Full coverage lasts as long as sheet flow is maintained and herbaceous vegetation is not buried by sediment buildup. Where sediment load is very high, coverage may last for as short as one growing season. Longer coverage can be expected where sediment loads and associated deposition rates are lower. Effectiveness may be restored or maintained by periodic sediment removal, re-grading, and re-establishment of herbaceous cover.

To control phosphorus in runoff

- For total phosphorus, coverage will be similar to sediment where most runoff phosphorus is sediment-bound, such as in runoff from cultivated agricultural fields. For dissolved phosphorus, coverage depends upon how quickly the phosphorus immobilization capacity of the soil and vegetation in the planting area becomes saturated. Where dissolved phosphorus loads are high, such as in runoff from confined livestock areas, and the soil capacity is low, phosphorus saturation could occur within a few years. Soil testing might be needed to monitor the immobilization capacity for dissolved phosphorus.

To control nitrogen in runoff

- Nutrient reduction coverage will last as long as the planting areas are maintained as designed for proper functioning.

To control sediments from eroding stream banks and shorelines

- Sediment reduction coverage will last as long as there are no other instabilities existing or created elsewhere in the watershed that would propagate through the channel network to the site.

Background Information

Riparian forest buffer and filter strip-type practices have been approved for nonpoint source water quality trades by environmental protection agencies in several states (e.g., Idaho[1], Michigan[2], Oregon[3], Colorado[4], Pennsylvania[5], Virginia[6], and Vermont[7]). The approved application and design specifications could differ somewhat from the NRCS FOTG for those practices.

Each state determines effectiveness levels and trading ratios for nonpoint source BMPs and by determination processes of its own choosing. Consequently, effectiveness levels and trading ratios can differ from state to state for essentially the same nonpoint source control practice.

Research indicates that forested filter strips are equally effective as herbaceous filter strips for surface runoff control as long as substantial herbaceous groundcover is established and maintained in the forested strips (Dosskey et al. 2007).

The hypothetical example below is used to illustrate a trade agreement that offsets sediment loads with forestry BMPs.

[1] Idaho Department of Environmental Quality. Idaho's Agricultural Pollution Abatement Plan (2003).

[2] Michigan Department of Environmental Quality, Surface Water Quality Division, Water Resource Protection, Part 30 Water Quality Trading, Rule 323.3006.

[3] Oregon Department of Environmental Quality's Permit 101141 section 9(c)(1)(d).

[4] Colorado Department of Public Health and the Environment. Non-point Source Management Program (2000 and 2005 Supplement).

[5] Pennsylvania Department of Environmental Protection. Trading Nutrients and Sediment Reduction Credits Policy: Guidelines, Appendix A and Attachments (December 30, 2006).

[6] Virginia Department of Environmental Quality. Trading Nutrient Reductions from Non-Point Source BMPs in the Chesapeake Bay Watershed: Guidance for Agriculture Landowners and Your Potential Trading Partners (February 5, 2008).

[7] Vermont Statues Title 10 Conservation and Development, Chapter 47 Water Pollution Control § 1264a. Interim stormwater permitting authority.

Centerville Water Treatment Plant

Waterbody

The Great North South River (GNSR)—a highly turbid river that is impaired for sediment but has no established total maximum daily load (TMDL). The impairment is the result of both man-made activities, such as nonpoint source runoff and point source discharges, and natural stream bank erosion from the mainstem and its tributaries.

Buyer

The Centerville Water Treatment Plant (WTP)—a large conventional drinking WTP that discharges its waste stream on a noncontinuous basis.

Seller

Pine Hill Land Developer (Pine Hill) —the Little Muddy Creek is a tributary of the GNSR. It enters the river 5 miles upstream of the Centerville WTP. Pine Hill owns land adjacent to 25 miles of Little Muddy Creek. This land was historically in agriculture production but has been fallow for the past 15 years. Pine Hill purchased the land 2 years ago and anticipates developing a subdivision in the next 20 years. This creek is subject to stretches of moderate and severe stream bank erosion, contributing in the range of 150–300 and 600–700 tons of sediment per stream mile per year into Little Muddy Creek (The Federal Interagency Stream Restoration Working Group, 1998).

Scenario

The Centerville WTP discharges its waste stream directly to the GNSR. Actual flow discharge data indicates that an average of 10 million gallons/day (mgd) is discharged when discharges occur. The City of Centerville is projecting an increase in population growth over the next 10 years. In response, the Centerville WTP is expanding its facility to serve the community, including areas upstream of Little Muddy Creek. This expansion will increase the discharge flow to 15 mgd. The discharge includes total suspended solids (TSS) along with other pollutants typically associated with conventional water treatment.

The Centerville WTP has a water quality-based effluent limitation (WQBEL) derived from a narrative water quality criterion in the state water quality standards that requires, in part, that receiving waters be "free from suspended solids or other substances attributable to human activity that form objectionable deposits or adversely affect aquatic life." The permitting authority has implemented this narrative criterion through a combination of a mass loading TSS limitation and a concentration-based TSS limitation for the Centerville WTP.

The permitting authority is allowing the plant to meet its mass loading limitation on a seasonal basis. The discharge from the Centerville WTP must achieve a mass loading of less than 225 tons/season which must be met for the spring (March–May) and fall seasons (September–November) and a concentration-based maximum daily TSS limitation of 60 mg/L TSS during discharge events. The permitting authority has determined that, together, the concentration and mass loading limitations would be protective of water quality standards in the receiving water and would exceed technology-based requirements developed using BPJ for water treatment plants similar to the Centerville plant.

The permitting authority has authorized the expansion of the plant but maintains that the facility must not increase its total discharge beyond the current tons/season requirement or the concentration-based limitation of 60 mg/L due to the existing sediment impairment of the GNSR

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

and the need to continue meeting a technology-based requirement. The expansion will not affect the WTP's ability to meet the 60 mg/L concentration-based limitation, but to in order to allow the WTP to expand and still meet the mass loading WQBEL, the permitting authority is allowing a trade agreement to be incorporated into the Centerville's WTP NPDES permit.

The Centerville WTP will enter into a trade agreement with Pine Hill and Takon Land Conservancy that will generate the credits Centerville WTP needs to meet its WQBEL. Takon Land Conservancy is a nonprofit environmental organization that has agreed to work with Pine Hill to implement and install stream bank stabilization BMPs along the Little Muddy Creek before the expansion of the WTP. These stabilization mechanisms will be used to offset the additional sediment load that will result from the expansion of the WTP. Takon will take on the responsibility of conducting a land and channel stability assessment to determine the best locations along the eroding stream bank to achieve sediment reduction as well as determining the value of net sediment credits that can be generated. Erosion rates will be measured before installing the stream bank stabilization mechanisms as well as throughout the duration of the permit to ensure that the sediment reductions are achieved and maintained.

Through studies, modeling, and field evaluations, the buyer has provided documented evidence that the increased discharge (even under critical, low-flow conditions) of other pollutants from the plant, which are commonly used in the coagulation and filter backwash processes, will not cause an exceedence of water quality standards beyond the facility's established mixing zone. The increased sediment load to the GNSR will also not have a localized impact beyond the allowable mixing zone because the offsets upstream will have reduced the turbidity of the downstream water to which the WTP discharges and the quantity of sediments discharged is negligible compared to the sediment already present in the GNSR.

Example: Trade Agreements

What You Need to Know…

Pollutant: Total Suspended Solids (TSS) (milligrams per liter [mg/L])

Driver: A WQBEL for TSS of 450,000 lbs/season = 225 tons/season

Season: Given the seasonal volatility of sediment loading into the GNSR, only during certain points of the year (spring and fall) is the GNSR impaired for TSS. During the spring and fall seasons, the Centerville WTP is subject to meeting the WQBEL of 225 tons/season. Spring is defined as the 90-day period from March 1 through May 29. Fall is defined as the 90-day period from September 1 through November 29.

Credit Buyer: *Expanding Centerville WTP*

- **Baseline Discharge Concentration**
  Discharge from Filter Backwash, Sedimentation Basin Washdown: 60 (mg/L)

- **Baseline Flow**
  Discharge from Filter Backwash, Sedimentation Basin Washdown: 10 mgd

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

- **Maximum Permitted Sediment Load**
  225 tons/season
- **Total Sediment Load Currently Discharged from WTP**
  175 tons/season

Proposed Change in Discharge:

- **Proposed Flow Increase**
  + 5 mgd
- **Proposed Increase in Potential Total Sediment Load**
  5 mgd * 60 mg/L * 8.34 * 90 days/season = 225180 lbs/season = 113 tons/season
- **Total Sediment Load after Expansion**
  175 + 113 = 288 tons/season
- **Load Reduction necessary to remain in compliance with the WQBEL**
  288 – 225 = 63 tons/season

Credit Seller: *Pine Hill land developer*

Step 1: Estimate Sediment Load from Land with no BMPs

In a multiyear study conducted by a technical stream analyst from Takon Land Conservancy before the permit effectiveness, stream bank erosion calculations were used to measure and determine average annual erosion rates:

- **Stream bank erosion calculations**—The rate of erosion is determined by placing measuring stakes along the stream bank and observing the drop in soil level over time. From this study the following range in annual erosion rates were determined:
- **Moderate stream bank erosion**—150 to 300 tons of sediment/stream mile/year
- **Severe stream bank erosion**—600 to 700 tons of sediment/stream mile/year

Step 2: Planning and Installing BMPs along 5 Miles of the Little Muddy Creak Stream Bank

Takon Land Conservancy will install combinations of the following bioengineered stream bank stabilization mechanisms as determined suitable for each segment of the eroding stream bank. The stream technical analyst chose these types of practices because of their ability to become effective within one growing season. They also provide the same amount of protection year round because they do not depend on leaves to function properly. The roots, and to some extent the stems, of the plants provide the stabilization (Dosskey, 2008).

Structural Measures

Tree Revetment. Uprooted, live, whole trees that have a diameter of at least 12 inches are cabled together and anchored by earth anchors and buried in the bank. Easter red cedar (*Juniperus virginiana*) are common to use in the Midwest because of its abundance and rot resistance. Trees are laid on their sides and secured to the bases of eroded stream banks. Tree tops are pointed downstream

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

and overlapped about 30 percent. The abundant and dense branching slows the water flow while promoting sediment and nutrient trapping. Revetment ends are anchored at stable points along the bank. The diameter of the tree's crown is two-thirds the height of the eroding bank, and trees are at least 20 feet tall.

Dormant Post Plantings. The post plantings serve as a permeable revetment of rootable vegetative material that is placed along the stream bank to reduce the stream velocity allowing for sediment to be deposited within the treated area. Live posts of locally native willows in combination with locally native cottonwoods and dogwoods are cut approximately 9 feet long and 5 inches in diameter. The basal ends of the post are tapered for easier insertion into the ground. Approximately half of the post length is installed into the saturated soil, pointing upwards, along the eroding stream bank. Two rows are posts are inserted along the bank in a triangular formation. All posts are 3 feet apart.

Soil Bioengineering

Live Stakes. A system of live stakes is used to create a living root mat to stabilize the soil. Erosion control fabric is placed on the slopes subject to erosive degradation. Side branches on the live stakes are cleanly removed keeping the bark intact. The basal ends are cut at an angle, and the top is cut square. The stakes are roughly 1-inch diameter and 3 feet long. Four-fifths of the length of the live stake is inserted into the ground, and soil is firmly packed around it. They are packed into the ground at right angles to the slope. The live stakes are installed 2 to 3 feet apart using triangular spacing with a density of two to four stakes per square yard. Lives stakes are installed the same day that they are prepared. Locally native willows intermixed with cottonwood and dogwoods are also suitable for live stakes.

Live Fascines. Branch cuttings (approximately 10 feet long) from locally native young willows and shrub dogwoods are bound together with untreated twine to form 6- to 8-inch diameter cylinders. The bundles are placed at an angle on the erosive slope to reduce erosion and shallow sliding. Starting at the base of the slope, trenches are dug, 10 inches wide and deep. Trenches are excavated on the contour of the slope every 3 feet. Long straw and annual grasses are placed between each trench. Dead stout stakes that are 2.5 feet long are driven directly through the live fascine. The top of the dead stout stake is flush with the installed bundle. The live stakes (from above) are installed on the down slope of the side bundle with 3 inches still protruding from the ground. Most soil is used to fill in along the sides of the bundles.

Step 3: Estimate Sediment Load Reductions from BMPs

Once installed and if maintained appropriately throughout the lifetime of the trade, the stabilization mechanisms are assumed to reduce erosion rates of 150 tons sediment/stream mile/year and 600 tons sediment/stream mile/year to near zero for the segments of stream on which they are established. However, because channel energy and sediment loads tend to maintain equilibrium, treatment that reduces sediment inputs at one location can often increase erosion rates at other locations nearby, yielding less of an overall stream load reduction than anticipated from reductions at only the treated site (Dosskey, 2008). Therefore, this load increase must be accounted for when estimating total sediment load reductions.

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

Step 3a: Estimate Sediment Load Reductions at Treated Sites

A range in erosion rates is determined for over the course of a year. While the stabilization mechanisms will reduce erosion to near zero year round, for calculating the amount of sediment credit for terms of the permit, the most conservative control (150 tons and 600 tons) should be assumed for the wettest seasons of the year (spring and fall). These BMP installments should provide equal sediment reduction year round because they are not dependent on leaves for proper function. The roots and, to some extent, the stems of the plants provide the stabilization function. Three (3) miles of stream bank experiencing moderate erosion and two (2) miles of stream bank experiencing severe erosion as determined by Takon Land Conservancy

- **Moderate Stream bank erosion** = 150 tons sediment/mile/year
  (150 tons/mile/year) × (3 miles) × (year/365 days) × (90 days/season) = 111 tons/season
- **Severe Stream bank erosion** = 600 tons sediment/stream mile/year
  (600 tons/mile/year) × (2 miles) × (year/365 days) × (90 days/season) = 296 tons/season

Step 3b: Estimate Sediment Load Increases along Other Segments of the Stream

Conservative estimates from the land and stream channel stability assessment conducted by Takon Land Conservancy:

0.5 miles of stream bank experience erosion rates of 5 tons/stream mile/year

2.5 miles of stream bank experiencing erosion rates of 15 tons/stream mile/year

1.5 mile of stream bank experiencing erosion rates of 30 tons/stream mile/year

Sediment load increase = (0.5 × 5) + (2.5 × 15) + (1 × 20) = 60 tons/year = 15 tons/season

Step 3c: Estimate Total Sediment Savings

111 tons/season + 296 tons/season = 407 tons of sediment saved/season on treated sections

407 tons of sediment saved/season – 15 tons sediment released/season = 392 tons of TSS saved and available for credit during the 90-day spring season and the 90-day fall season.

Step 4: Apply an Applicable and Scientifically Based Trade Ratios

Uncertainty Ratio: 2:1 due to the uncertainty of accurately measuring nonpoint source BMP performance as well as accounting for its design, installation, maintenance, and operation over the duration of the permit. Because some bank erosion is natural over the long term, complete elimination of sediments from bank erosion sources should not be expected. Installing the above-mentioned BMPs will result in sediment reductions to near zero in only treated sections of Little Muddy Creek. While it is possible for erosion to be reduced to near zero, there are many factors such as poor design, large storms, and channel incision that can reduce the expected sediment reductions to values much greater than zero. The 2:1 uncertainty ratio accounts for this inefficiency and uncertainty.

Delivery Ratio: 1.1:1 based on fate and transport modeling to account for the difference in transport and settling velocity of various sized sediment particles.

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

Equivalency Ratio: 2:1 to account for the variation in particle size being discharged and variation in particle size being protected from stream bank stabilization installments.

Trade Ratio to be applied: $2 \times 1.1 \times 2 = 4.4$

Step 5: Determine Net Reduction Credits and Value Available for Sale

Total sediment savings = 392 tons/season

Apply trade ratio: 392 tons saved by seller ÷ 4.4 = 89 tons available for purchase by buyer

Each ton available for purchase is equal to one credit.

392 tons of sediment saved/season that are worth 89 credits available for sale

The Trade Agreement

The scheduled expansion of the Centerville WTP is scheduled to take 1 year. At the end of the expansion, the permit will be renewed, and it will contain the provisions for trading.

Centerville WTP must purchase credits to account for a reduction of 63 tons/season. This requirement must be met during both the spring and fall seasons to meet its WQBEL. For every ton of sediment the WTP needs, it must purchase one credit. The WTP needs 63 credits, and there are 89 available for purchase. Centerville WTP was given a 1-year compliance schedule, which allows time for the BMPs to be installed and become fully operational in that time frame. At the time of completion of the WTP expansion, the BMPs should be in place and fully functional. Until then, the facility will operate under the current permit conditions. The permit writer will include both limitations that apply if trading occurs and the limitations that apply if no trading occurs.

The basic terms of the trade agreement are as follows:

- Pine Hill will implement BMPs along at least the 5 miles of eroding stream bank that will result in an estimated TSS load reduction of 392 tons/season. Pine Hill guarantees this TSS load reduction for as long as the BMPs are in place and functioning properly.
- Centerville WTP will require a 63 tons/season of TSS reduction to meet its WQBEL.
- Centerville WTP will purchase at least 63 credits from Pine Hill's load reduction. On the basis of the 2:1 uncertainty ratio that is applied to all nonpoint source credits, the 1.1:1 delivery ratio based on fate and transport modeling, and the 2:1 equivalency ratio based on the various particle sizes of sediment that are discharged and protected, Pine Hill will need to implement BMPs to reduce 277 tons of sediment both in the spring and fall season to generate the 63 credits. (63 tons/season × 4.4 = 277 tons/season)
- Pine Hill will install BMPs one year before the effective date of Centerville's renewed NPDES permit to ensure that BMPs are achieving estimated pollutant load reductions and are generating full credits.
- Centerville WTP will enter into a memorandum of understanding with the Takon Land Conservancy to perform monthly monitoring and inspection at Pine Hill properties to ensure that the

Centerville Water Treatment Plant Example: Trade Agreements *(continued)*

estimated TSS load reductions are achieved through BMP implementation. If the Takon Land Conservancy fails to perform this function, Centerville WTP will conduct the monthly monitoring and inspections and submit the necessary monitoring and inspection reports.

As the permittee, Centerville WTP is required to notify the permitting authority in writing within 7 days of becoming aware that credits used or intended for use to comply with the terms of this permit are unavailable or determined to be invalid. This notification must include an explanation of how the permittee will ensure compliance with the WQBELs established in this permit, either by implementing on-site controls or by conducting approved emergency sediment offset project approved by the NPDES permit writer.

Failure to fulfill the terms of this trade agreement will result in Pine Hill's ineligibility to participate in future trading activities with any permitted point source in the state for a period of 5 years from the time of the breach of the trade agreement terms.

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