Developing a Watershed Restoration Plan for the Neshanic River Watershed

Task 6: Evaluate Agricultural Best Management Practices Report

September 13, 2006 – March 31, 2011

Submitted to: New Jersey Institute of Technology
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Newark, New Jersey 07102-1982
NJIT suffix: 993449

Project Funding: New Jersey Department of Environmental Protection
319(H) Grant
Prime Contract number RP06-068

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Background

The Neshanic Watershed is 31 square miles located in Hunterdon County with parts of Raritan Township, East Amwell Township, Flemington Borough, and Delaware Township within its boundaries. The Neshanic River and its branches have been determined to be impaired for aquatic life, phosphorus, total suspended solids, and copper (NJDEP, 2004). In addition the Total Maximum Daily Load for fecal coliform has been adopted for the Neshanic River. The Total Maximum Daily Load requires that the fecal coliforms be reduced by 87% (NJDEP, 2003).

In 2005 the North Jersey Resource Conservation and Development Council (NJRC&D) joined the Neshanic River Watershed Restoration Plan project team led by the New Jersey Institute of Technology (NJIT). The project was developed to create a detailed plan that presents management options, which if implemented, would improve water quality in the watershed with particular emphasis on bacteria, phosphorus and sediment. The Neshanic River Watershed Restoration Plan was funded in 2006 by the New Jersey Department of Environmental Protection (NJDEP) through the Clean Water Act Section 319(h) program. Having worked with the agricultural community in Hunterdon County for over two decades NJRC&D focused its efforts on Task 6 of the project work plan: Evaluate Agricultural Best Management Practices.

Task 6: Evaluate Agricultural Best Management Practices

Since 1999 NJRC&D has been working with a group of proactive citizens who farm land in the Raritan River Basin to address issues arising from potential water quality impacts from agriculture. The group, the Raritan Watershed Agricultural Committee (RWAC), has developed position papers on several issues including: riparian areas, phosphorus management, and land management to control invasive species. For Task 6 of the Neshanic River Watershed Restoration Plan Project a *Neshanic Farmers Group* was created from RWAC members. NJRC&D and NJIT worked with this group to create an understanding of farming practice typical for the Neshanic River watershed. This was to include crop types, crop rotation, tillage, fertilizer and pesticide usage. This information was used to build input files for biophysical modeling using the Soil and Water Assessment Tool (SWAT) and evaluate the potential of achieving pollutant load reductions from agricultural sources.

Originally it seemed the Neshanic Farmers Group would provide the required data for the SWAT model to assess agricultural practices within the Neshanic River watershed. However, there were obstacles that were encountered which made the meeting with the group less robust than anticipated.

From 1999 to 2004, the RWAC met regularly, however in recent years the committee has not been as active as the watershed management funding has shifted from large watershed projects to smaller sub watershed efforts. Many of the farmers from the Neshanic project area have had not participated in the RWAC and/or did not recall the benefits of this committee to their local Board of Agriculture and Agriculture Development Board. This compounded with the passing of the New Jersey Highlands Act, which affected land development rights of farmers in the region, created a hesitation to share information that would potentially fuel future regulation. It was decided by North Jersey RC&D and NJIT to use additional methods to gather information about the agricultural practices in the Neshanic Watershed.

Agency staff familiar with the area provided some generalities in regards to tillage practices and implementation of some NRCS facilitated conservation practices. In addition, one-on-one conversations took place with area farmers willing to share information about their operation.

An agricultural land use inventory was used to gather information about the spatial distribution of agricultural activities. These inventories involved staff and trained volunteers driving around in the watershed and gathering what information they could from the roadside. This data was later entered into geographic information system (GIS) to create a GIS layer on distribution of agricultural activities.

The agricultural Best Management Practices were selected from the Natural Resource Conservation Service's Field Office Technical Guide (USDA NRCS, 2010). The select practices were chosen using additional NRCS reporting that showed the practices were both effective for the impairments in the Neshanic River watershed and more readily adopted in the Hunterdon County area.

Meetings with the Neshanic Farmers Group

Methodology

The first Neshanic Farmer Group meeting was held on September 27, 2007. The meeting had four farmers present. They were given background information about the project and showed the water sampling data. Information shared about cropping systems, fertilizers, and pesticides use was sparse. Since the RWAC had not met regularly for some time there was uncertainty about the project and how the information would be used. Farmers were not willing to share detailed information about their farming practices in the group meeting.

A second Neshanic Farmer Group meeting took place on February 25, 2008. Seven farmers from the Neshanic were present. At that meeting, Rutgers presented the water quality data from 2007. The attendees offered many thoughts about farming practices and other matters as they relate to water quality. The point was made that there will not be a single solution, and that there will have to be a variety of changes in order to realize non-impaired waters. The following are some other comments made by farmers:

- Restart aerial application of cover crops, which enlists the use of an airplane to spread seeds allowing for pre-harvest planting.
- Water does not have a chance to infiltrate; it gets piped right out into the stream.
- Small horse operations are often mismanaged and should be investigated as a source of phosphorus and bacteria.
- Someone needs to haul away manure from horse farms. Most of them don't have enough land to safely spread it on-site.
- Septic systems may be leaching into old tile drainage systems in developments that are built on old farm fields.
- If homeowners are fertilizing their lawns, maybe they should have nutrient management plans.

No additional meetings were held with the Neshanic Farmer Group. North Jersey RC&D staff envisioned convening the group to meet once the SWAT model results were available. It was decided that until the time when clearer model results and sampling data were available it was not necessary to call another meeting of this group. At this meeting we anticipated providing specific examples where we have applied the model and shown cost-benefit relationships.

Interviews with agency representative and individual farmers were conducted when the Neshanic Farmer Group was not forthcoming about their operations. These smaller interviews helped fill in the gaps to gain a generalized view of farming in the Neshanic watershed.

Results

The results of the meeting and interviews helped to provide a baseline for agricultural operations in the Neshanic. Several scenarios were developed with the information provided by the Neshanic Farmer Group and one on one interviews to help calibrate the SWAT model.

Agricultural Land-Use Inventory

Methodology

The Neshanic watershed was surveyed three times in order to develop an agricultural land use inventory. This inventory was completed to help spatially define the watershed to calibrate the SWAT model. This was accomplished by driving all public roads within the Neshanic watershed and observing how the land was used.

The first inventory was conducted by Dana Ronyack, the project coordinator, with three Natural Resources Conservation Service Earth Team volunteers and a NJDEP AmeriCorps Watershed Ambassador in October 2006 and April 2007. The team drove all public roads within the Neshanic watershed and annotated an aerial map for all agricultural land uses visible from the road.

Two subsequent inventories were conducted by project coordinator Abigail Jones with the help five volunteers from the South Branch Watershed Association. The volunteers were trained in crop identification and each given a crop photo ID sheet to help identify crops at different stages of growth and/or post-harvest. They were also instructed to note lawn health in residential areas. Using a simple code they noted land use in parcels indicated on grid system maps designed by NJIT for the Neshanic River watershed. The sample grid map is shown in Figure 1 and the code used in the inventory in Table 1.

Figure 1. Sample Grid Map Used in Land Use Inventory

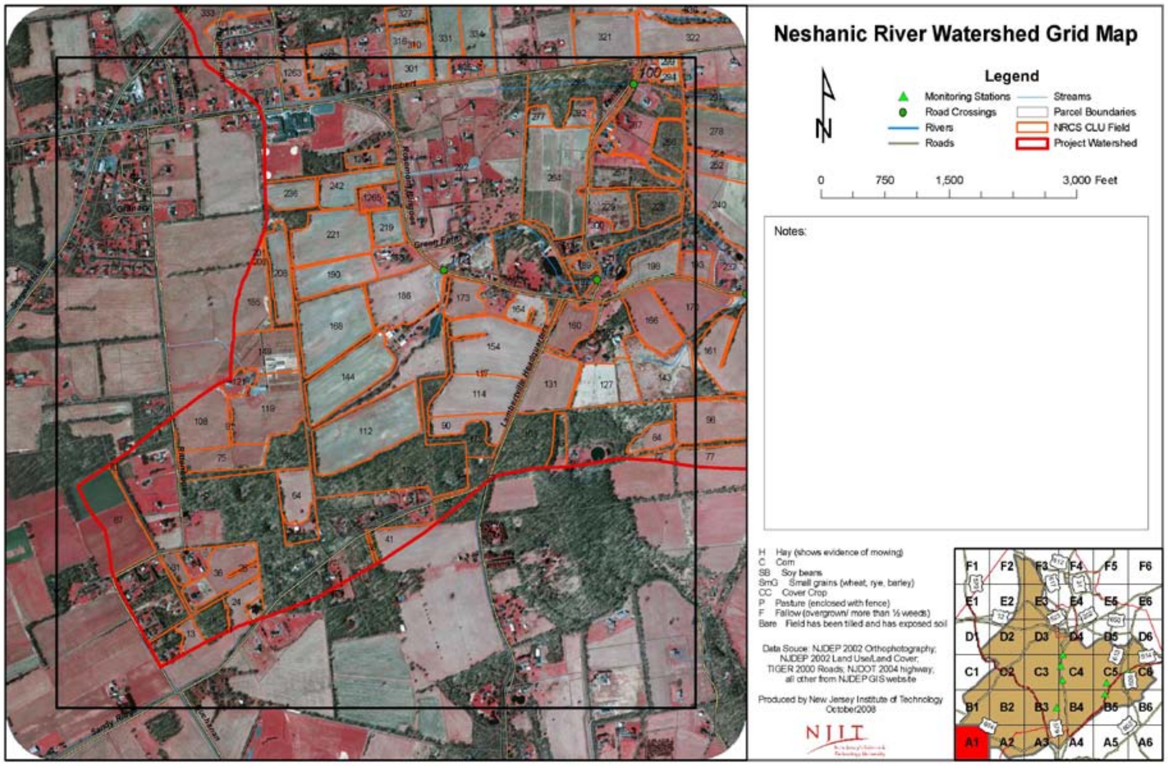

Table 1. The Map Codes Used in Land Use Inventory

H	Hay (shows evidence of mowing)
C	Corn
SB	Soy beans
SmG	Small grains (wheat, rye, barley)
CC	Cover Crop
P	Pasture (enclosed with fence)
F	Fallow (overgrown/ mixed weeds)
Bare	Field has been tilled and has exposed soil *Try to determine the previous crop.*
	Others: write the crop or land use (e.g. Christmas trees, houses, nursery, etc.)

Results

The results of the inventories were applied to publicly available geographic information system layer provided through New Jersey Department of Environmental Protection, such as 2002 Land Use/Land Cover, air photos from 2002 and 2007 as well as web providers of aerial imagery such as Google Maps and Microsoft Live Maps. Data from the maps was transferred into a spatial format using Geographic Information System (GIS) mapping software. A copy of the Farm Service Agency Common Land Unit (CLU) GIS layer was obtained. Using 2002 air photos, tracts were deleted that had been developed and were no longer in agricultural production. The CLU layer only shows fields that have participated in federal programs (Farm Bill programs, subsidies, base acres, etc.) Some areas designated agricultural in the 2002 DEP LU/LC layer were not shown on the CLU layer; those polygons were added to the modified CLU layer. New attributes were added to the modified CLU layers to accept the crop and animal information gathered from surveys. Since the watershed was assessed on several occasions, there were new attributes for each time period to track the crop rotations. Animal numbers were noted although animal numbers on a farm are very fluid. Additionally there was the problem of simply not being able to see from public roads the animals in the barn, just over the hill out of sight or simply sold off.

Figure 2. Summary of Land Use Inventory

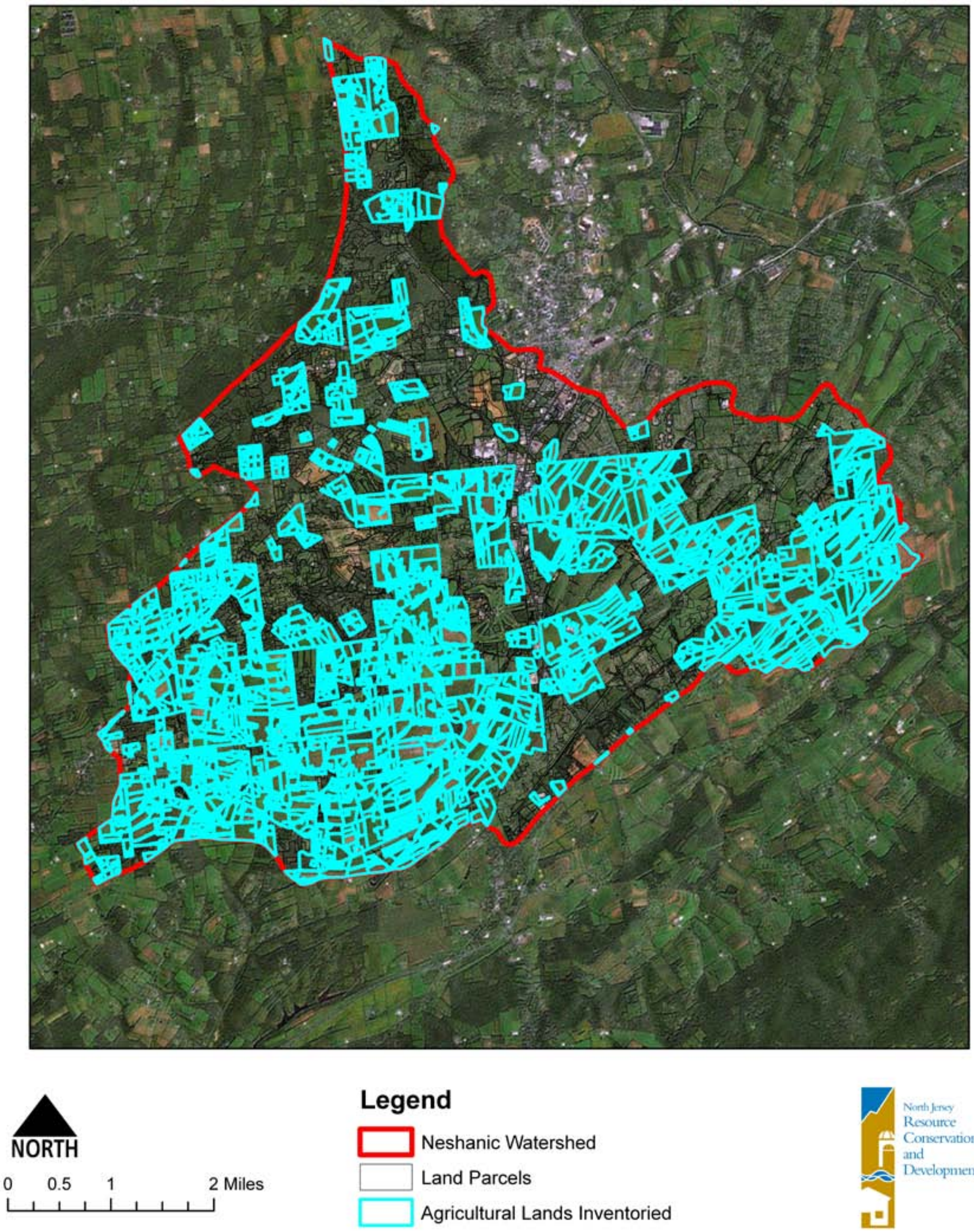

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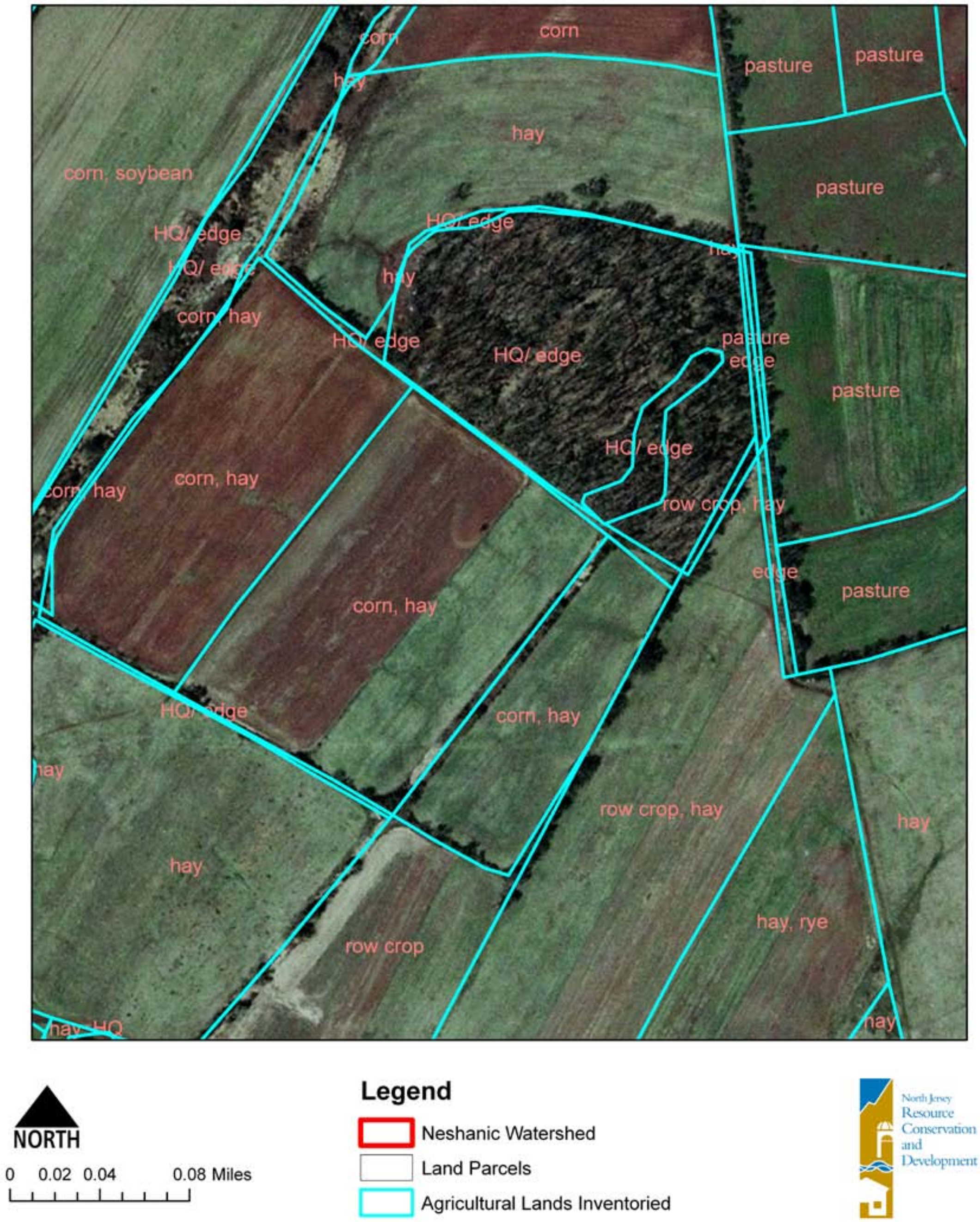
Figure 3. Example of Agricultural Lands Inventoried



Combined Results: Typical Agriculture and Operation Schedules

The information collected through the Neshanic Farmer Group, one-on-one interviews with farmers and agency interviews compiled with the agricultural land-use inventory was used to create a general overview of agriculture types indicative of the Neshanic watershed with some corresponding operation schedules. The operation schedules would eventually be used to build input files for comparisons in the SWAT.

According to the land use inventory discussed above, the agricultural lands are used in several ways. First, the majority of agricultural lands are used for traditional row-crop production to produce corn, soybean, wheat and rye. Second, the agricultural lands in the watershed also consist of significant amount of hay and pasture to support the beef and dairy farms as well as the growing equine industry in the watershed. Although there are small scale niche farms that produce high value crops such as nursery stock, orchard fruit, alpacas, and heirloom animals, they do not occupy significant amount of lands and therefore are not subject to detailed investigation on their operation.

Grain Farms – Traditional grain farms in the Neshanic watershed generally grow corn, soybean, and occasionally winter wheat and rye. The typical crop rotations include continuous corn, continuous soybean and corn-soybean rotation. Many of these grain farms are operated by full-time farmers who also commonly rent acreage to augment their land base, since commodity crops, with their slim profit margins, provide a better economic return when grown at a larger scale.

Beef and Dairy – There are a just handful of commercial beef and dairy operations in the project area. The operations are relatively small on a national scale, but are large farms for the northern New Jersey region. These farms are characterized by some grazing lands, but are dominated by the barn and barnyard area that is heavily used and often minimally protected making it prone to runoff, erosion, and loss of manure directly to ditches and streams. Manure from the barns is utilized on adjacent crop fields.

Niche Farms – These are relatively small farms (5-20 acres) that produce high value crops such as nursery stock, orchard fruit, alpacas, heirloom animals, etc. To be profitable on small acreage, the operation is intensive. Even so, the farm is often not a full-time endeavor for the operator, so the operators generally receive a majority of their income from off-farm sources. These small farms have not typically utilized NRCS technical assistance and conservation planning assistance.

Equine – The Equine industry is robust in the Neshanic as well as elsewhere in New Jersey. Some may argue to what extent equine operations should be considered “Agricultural” as a vast majority of horses are kept for pleasure, not to pull the plow. However issues of hay production, pasture management, and manure management are all closely tied with equine operations and are handled by agricultural professionals. Horses produce a large volume of manure which is often not handled properly in order to prevent water pollution. Small paddocks and grazing areas are commonly stocked too heavily to maintain vegetation. Overgrazed pastures are prone to erosion, compaction under weight of hoofs, and susceptible to runoff which carries fecal bacteria and nutrients to waterways. The majority of equine operations have not typically utilized NRCS technical assistance and conservation planning.

Tables 2-16 below summarize the general operational schedules of typical crops, pasture and hay production in the watershed based on interviews with farmers, and agricultural specialists, and conservationists from federal, state and county agencies under three different scenarios: baseline, best case and worst case. The baseline scenario represents the typical farm operation under the existing condition. The best case scenario represents the achievable operations with good nutrient management practices. The worst case scenario represents the possible situations without consideration of any water quality impacts.

It should be noted that there are significant pesticide applications in agricultural operations as shown in those tables. Since the water quality impacts of pesticides are not a focus of the project, there is no detailed investigation on their application rates and impacts.

Table 2: Schedule of management operations for corn under the Baseline scenario

Date	Operation	Type	Rate
4/10	Tillage	Chisel plow	
4/15	Fertilizer	Anhydrous ammonia	130 lbs/ac N
4/15	Pesticide	Atrazine	
4/15	Pesticide	Prowl	
4/17	Tillage	Disk	
5/10	Planting	Regular Corn	
5/10	Fertilizer	N granule	10.5 lbs/ac N
5/10	Fertilizer	P2O5	31.5 lbs/ac P
5/10	Fertilizer	K2O	9 lbs/ac K
6/1	Pesticide	Bicep or lumax	
6/15	Pesticide	Distinct or Banvel or Clarity or Celebrity Plus	
7/15	Pesticide	Headline or Warrior fungicide	
10/15	Harvest and kill		

* Applied SWAT tillage codes: 16- Hallow 10 Bar Tine 36 ft, 58-Chisel plow Gt 15 ft, 66-Moldboard plow-2-Way-4-6b, 104-Disk plow Gt 23 ft. Fertilizer codes: 1- N granule, 2-P2O5 granule, 3-Anhydrous ammonia.

Table 3: Schedule of management operations for corn under the Best Case scenario

Date	Operation	Type	Rate
4/15	Fertilizer	Anhydrous ammonia	130 lbs/ac N
4/15	Pesticide	Atrazine	
4/15	Pesticide	Prowl	
5/10	Planting	Regular Corn	
5/10	Fertilizer	N granule	10.5 lbs/ac N
5/10	Fertilizer	P2O5	31.5 lbs/ac P
5/10	Fertilizer	K2O	9 lbs/ac K
6/1	Pesticide	Bicep or lumax	
6/15	Pesticide	Distinct or Banvel or Clarity or Celebrity Plus	
7/15	Pesticide	Headline or Warrior fungicide	
10/15	Harvest and kill		

Table 4: Schedule of management operations for corn under the Worst Case scenario

Date	Operation	Type	Rate
4/1	Tillage	Moldboard	
4/10	Tillage	Chisel plow	
4/15	Tillage	Disk	
4/15	Fertilizer	Anhydrous ammonia	130 lbs/ac N
4/15	Fertilizer	P2O5	100 lbs/ac P
4/15	Fertilizer	K2O	80 lbs/ac K
4/15	Pesticide	Atrazine	
4/15	Pesticide	Prowl	
4/17	Tillage	Disk	
5/10	Planting	Regular Corn	
5/10	Fungicide	Carboxin, diazinon and …	
5/10	Fertilizer	N granule	20 lbs/ac
5/10	Fertilizer	P2O5	40 lbs/ac
5/10	Fertilizer	K2O	20 lbs/ac
6/1	Pesticide	Bicep or lumax	
6/15	Pesticide	Distinct or Banvel or Clarity or Celebrity Plus	
7/15	Pesticide	Headline or Warrior fungicide	
10/15	Harvest and kill		
10/20	Tillage	Moldboard	

Table 5: Schedule of management operations for soybean under the Baseline scenario

Date	Operation	Type	Rate
5/1	Tillage	Chisel	
5/20	Tillage	Disk	
5/27	Planting	Regular Soybean	
5/27	Fertilizer	P2O5	25 lbs/ac P
5/27	Fertilizer	K2O	70 lbs/ac K
6/15	Pesticide	Classic or First rate	
10/15	Harvest and kill		

Table 6: Schedule of management operations for soybean under the Best Case scenario

Date	Operation	Type	Rate
5/27	Planting	Regular Soybean	
5/27	Fertilizer	P2O5	25 lbs/ac P
5/27	Fertilizer	K2O	70 lbs/ac K
6/15	Pesticide	Classic or First rate	
11/1	Harvest and kill		

Table 7: Schedule of management operations for soybean under the Worst Case scenario

Date	Operation	Type	Rate
4/25	Tillage	Moldboard	
5/1	Tillage	Chisel	
5/15	Tillage	Disk	
5/20	Tillage	Disk	
5/27	Planting	Regular Soybean	
5/27	Fertilizer	P2O5	40 lbs/ac P
5/27	Fertilizer	K2O	60 lbs/ac K
6/15	Pesticide	Classic or First rate	
11/1	Harvest and kill		
11/5	Tillage	Moldboard	

Table 8: Schedule of management operations for rye/winter wheat under the Baseline scenario

Date	Operation	Type	Rate
3/15	Fertilizer	N granule	40 lbs/ac N
4/20	Pesticide	harmony	0.5 oz/ac
7/1	Harvest and kill		
10/8	Tillage	Chisel	
10/8	Tillage	Disk	
10/10	Planting	Rye/wheat	
10/15	Fertilizer	N granule	20 lbs/ac N
10/15	Fertilizer	P2O5	50 lbs/ac P

Table 9: Schedule of management operations for rye/winter wheat under the Best Case scenario

Date	Operation	Type	Rate
3/15	Fertilizer	N granule	40 lbs/ac N
4/20	Pesticide	harmony	0.5 oz/ac
7/1	Harvest and kill		
10/10	Planting	Rye/wheat	
10/15	Fertilizer	N granule	20 lbs/ac N
10/15	Fertilizer	P2O5	50 lbs/ac P

Table10: Schedule of management operations for rye/winter wheat under the Worst Case scenario

Date	Operation	Type	Rate
3/15	Fertilizer	N granule	40 lbs/ac N
4/20	Pesticide	harmony	0.5 oz/ac
5/15	Pesticide	Warrior	3.84 oz/ac
7/1	Harvest and kill		
7/5	Tillage	Moldboard	
10/1	Tillage	Moldboard	
10/5	Tillage	Chisel	
10/10	Tillage	Disk	
10/12	Planting	Rye/wheat	
10/15	Fertilizer	N granule	20 lbs/ac N
10/15	Fertilizer	P2O5	50 lbs/ac P

Table 11: Schedule of management operations for timothy under the Baseline/Best Case scenarios

Date	Operation	Type	Rate
4/15	Fertilizer	N granule	60 lbs/ac N
4/15	Fertilizer	P2O5	13 lbs/ac P
6/15	Harvest		
6/20	Fertilizer	N granule	50 lbs/ac N
8/15 (1st-5th years)	Harvest		
Renew stand in 6th year			
8/15	Harvest and kill		
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/1	Tillage	Hallow	
10/10	Fertilizer	N granule	60 lbs/ac N
10/10	Fertilizer	P2O5	45 lbs/ac P
10/10	Planting	Timothy	

Table 12: Schedule of management operations for timothy under the Worst Case scenario

Date	Operation	Type	Rate
4/15	Fertilizer	N granule	60 lbs/ac N
4/15	Fertilizer	P2O5	40 lbs/ac P
6/15	Harvest		
6/20	Fertilizer	N granule	50 lbs/ac N
8/15 (1st-5th years)	Harvest		
Renew stand in 6th year			
8/15	Harvest and kill		
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/1	Tillage	Hallow	
10/10	Fertilizer	N granule	60 lbs/ac N
10/10	Fertilizer	P2O5	45 lbs/ac P
10/10	Planting	Timothy	

Table 13: Schedule of management operations for hay under the Baseline/ Best Case scenarios

Date	Operation	Type	Rate
4/10	Fertilizer	N granule	40 lbs/ac N
4/10	Fertilizer	P2O5	13 lbs/ac P
4/10	Fertilizer	K2O	25 lbs/ac K
4/20	Pesticide	2,4-D	1 qt/ac
4/20	Pesticide	Banvel	1pt/ac
4/20	Pesticide	Sevin	
5/15	Harvest		
5/20	Fertilizer	N granule	50 lbs/ac N
7/15	Harvest		
7/20	Fertilizer	N granule	50 lbs/ac N
9/15 (1st-5th years)	Harvest		
Renew stand in 6th year			
9/15 (6th year)	Harvest and kill		
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/1	Tillage	Hallow	
10/1	Fertilizer	N granule	50 lbs/ac N
10/1	Fertilizer	P2O5	45 lbs/ac P
10/10	Planting	Orchard grass mix with wheat or rye nurse crop	

Table 14: Schedule of management operations for hay under the Worst Case scenario

Date	Operation	Type	Rate
4/15	Fertilizer	N granule	40 lbs/ac N
4/15	Fertilizer	P2O5	40 lbs/ac P
4/15	Fertilizer	K2O	40 lbs/ac K
4/20	Pesticide	2,4-D	1 qt/ac
4/20	Pesticide	Banvel	1pt/ac
4/20	Pesticide	Sevin	
5/15	Harvest		
5/20	Fertilizer	N granule	50 lbs/ac N
7/15	Harvest		
7/20	Fertilizer	N granule	50 lbs/ac N
9/15 (1st-5th years)	Harvest		
Renew stand in 6th year			
8/14, 6th year	Harvest and kill		
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/5	Tillage	Harrow	
10/5	Fertilizer	N granule	50 lbs/ac N
10/5	Fertilizer	P2O5	45 lbs/ac P
10/5	Fertilizer	K2O	135 lbs/ac K
10/10	Planting	Orchard grass mix with wheat or rye nurse crop	

Table 15: Schedule of management operations for pasture under the Baseline/Best Case scenarios

Date	Operation	Type	Rate
4/15	Fertilizer	N granule	25 lbs/ac N
4/15	Fertilizer	P2O5	20 lbs/ac P
4/15	Fertilizer	K2O	25 lbs/ac K
4/20	Pesticide	2,4-D	1 qt/ac
4/20	Pesticide	Banvel	1pt/ac
4/20	Pesticide	Sevin	
7/1	Harvest		
7/10	Fertilizer	N granule	25 lbs/ac N
9/15	Harvest		
Renew stand in 6th year			
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/1	Tillage	Harrow	
10/10	Planting	Orchard grass mix with wheat or rye nurse crop	

Table 16: Schedule of management operations for pasture under the Worst Case scenario

Date	Operation	Type	Rate
4/15	Fertilizer	N granule	40 lbs/ac N
4/15	Fertilizer	P2O5	40 lbs/ac P
4/15	Fertilizer	K2O	40 lbs/ac K
4/20	Pesticide	2,4-D	1 qt/ac
4/20	Pesticide	Banvel	1pt/ac
4/20	Pesticide	Sevin	
5/15	Harvest		
5/20	Fertilizer	N granule	50 lbs/ac N
7/15	Harvest		
7/20	Fertilizer	N granule	50 lbs/ac N
9/15 (1st-5th years)	Harvest		
Renew stand in 6th year			
9/15 (6th year)	Harvest and kill		
10/1	Tillage	Moldboard	
10/1	Tillage	Disk	
10/5	Tillage	Harrow	
10/5	Fertilizer	N granule	50 lbs/ac N
10/5	Fertilizer	P2O5	45 lbs/ac P
10/5	Fertilizer	K2O	135 lbs/ac K
10/10	Planting	Orchard grass mix with wheat or rye nurse crop	

Agricultural Best Management Practices Evaluation and Summary

An Agricultural Best Management Practice (BMP) is a structural, non-structural or management style that has been determined to be a means to reduce non-point source pollution and protect natural resources while still allowing for the profitable use of the resources. There is a wide variety of BMPs for use in a farming operation designed to address areas or functions of an operation that are potentially lending to the leaching and run-off of pesticides, fertilizers and manure. Many of these BMPs are supported and promoted through government agencies on all levels along with non-profit agencies. Realizing that there is a cost associated with the implementation of these BMPs with results that benefit the good of everyone there is often government cost-share available. The cost share is provided to offset the financial burden of a farm owner. The BMPs not only have a positive impact on water quality, but they often help an operation in both short and long term profitability and sustainability.

Methodology

There are many factors that go into deciding which agricultural BMPs are to be put in place on any given farm. These factors are not only guided by what is the most effective for the given situation but also by financial constraints and a farmer's willingness to adopt. It is also important to use BMPs that work well together by addressing the different points in the non-point source pollution cycle.

Using available resources the following charts show several BMP options for livestock and cropping systems. As suggested by New Jersey Department of Agriculture's *On-Farm Strategies to Protect Water Quality,* the chosen BMPs address the pollution at four different points in the pollution transport cycle to aid in choosing the appropriate action. Addressing non-point source pollution at the correct juncture in the pollution transport cycle will yield the greater result. Furthermore, addressing non-point source pollution at multiple junctures may yield synergistic results.

The process used to determine which BMPs were the most applicable for the Neshanic were as follows:

1. Using the Natural Resources Conservation Service (NRCS) Conservation Practice Physical Effects (CPPE) report BMPs were evaluated in the following water quality categories: Excessive Nutrients and Organics in Surface water, Excessive Suspended Sediment and Turbidity in Surface Water, and Harmful Levels of Pathogens in Surface Water. CPPE reports scores practices in a range between -5 to 5 showing negative or positive environmental impact. Practices which summed 4 or higher in the three categories were chosen. BMPs in this report are included in section four of NRCS Electronic Field Office Technical Guide. As such each BMP has standards defining the practice, where it applies and detailed requirements for installing the practice.

2. Using NRCS Performance Result System (PRS) we were able to cross reference the practices selected from the CPPE report with practices that were already in place in Hunterdon and ones that were planned but never applied in Hunterdon. This helped to show farmers willingness and indicated the need for the practice in the target area. Limiting factors with the PRS data include the fact that not all practices implemented in the field are reported in PRS. Practices implemented on farm with cost share assistance from USDA are recorded in PRS as implemented, however many completed practices not associated with USDA funding are not reported in the PRS database. Additionally, PRS only captures planned and completed practices implemented by farmers who are working with NRCS and have their farm practices documented in a farm conservation plan.

3. Through cross referencing effective BMPs from the CPPE report with practical BMPs for Hunterdon from PRS we derived a list of target BMPs. This list was further refined by selecting BMPs that are generally cost-shared through Farm Bill programs. The financial assistance to farmers will provide a much needed incentive to help in the implementation of these practices. From the Agricultural Water Enhancement Program cost-share list approximate cost is also listed if available.

4. From choice practices the most applicable were selected and categorized into either livestock or cropping systems.

5. They were then divided into the different points in the pollution cycle: Availability, Detachment, Transport and Deposition.

After the BMPs were selected the NRCS cost-share tables for the Agricultural Water Enhancement Program for 2010 was used to estimate costs for implementation. To help future assessment, any available Total Phosphorus reduction estimates available from the NRCS Conservation Effects Assessment Project Report, The University of Maryland Chesapeake Bay Program, and the Journal of Soil and Conservation were noted for each practice.

Results

The resultant list of Agricultural Best Management Practices could be used to further enhance the data collected for the watershed by providing remedies for any externalities created during agricultural production. The information gathered through farmer interviews and field surveys coupled with this collection of BMPs was used by NJIT to build input files for the biophysical modeling using SWAT in Task 7 in order to evaluate the potential to achieve pollutant load reduction from agricultural sources in the watershed restoration plan.

BMPs for Livestock

Table 17: AVAILABILITY

Best Management Practice	# planned last five years	# applied last five years	Average cost	Cost share available	% Reduction in TP Univ. of MD/CBP	% Reduction in TP NRCS CEAP	% Reduction in TP JSWC
Access Control/Livestock exclusion fencing	45 ac	9 ac	$4.78 per foot	YES	60%		

*Practice included even though not represented on PRS because of growing support in region.

Table 18: DETACHMENT

Best Management Practice	# planned last five years	# applied last five years	Average cost	Cost share available	% Reduction in TP Univ. of MD/CBP	% Reduction in TP NRCS CEAP	% Reduction in TP JSWC
Prescribed Grazing	965 ac	746 ac	$241-$324 per acre	YES	25%*		

*Needs peer-review

Table 20: DEPOSITION							
Best Management Practice	**# planned last five years**	**# applied last five years**	**Average cost**	**Cost share available**	**% Reduction in TP Univ. of MD/CBP**	**% Reduction in TP NRCS CEAP**	**% Reduction in TP JSWC**
Riparian Forest Buffer	107 ac	31 ac	$1081-$2596 per acre	YES	50%-75% depending on land-type		43%
Riparian Herbaceous Cover	164 ac	3 ac	$292-$303 per acre	YES	50%-75% depending on land-type		43%

BMPs for Cropland

Table 21: AVAILABILITY							
Best Management Practice	**# planned last five years**	**# applied last five years**	**Average cost**	**Cost share available**	**% Reduction in TP Univ. of MD/CBP**	**% Reduction in TP NRCS CEAP**	**% Reduction in TP JSWC**
Nutrient Mgt.	16435 ac	5297 ac	$25-$77 per acre	YES	135% of modeled crop intake		47%

Table 22: DETACHMENT							
Best Management Practice	**# planned last five years**	**# applied last five years**	**Average cost**	**Cost share available**	**% Reduction in TP Univ. of MD/CBP**	**% Reduction in TP NRCS CEAP**	**% Reduction in TP JSWC**
Cover Crop	4980 ac	1428 ac	$71-$142 acre	YES	On Conv. Till Early-15% Stand10% Late- 0%		

Table 23: TRANSPORT							
Best Management Practice	**# planned last five years**	**# applied last five years**	**Average cost**	**Cost share available**	**% Reduction in TP Univ. of MD**	**% Reduction in TP NRCS CEAP**	**% Reduction in TP JSWC**
Contour Farming	541 ac	147 ac	Unavailable	YES		20 % lb/ac/yr	
Strip Cropping	300 ac	73 ac	Unavailable	YES		23 % lb/ac/yr	

*When strip cropping and contour farming are used together NRCS show a 37 % lb/ac/yr TP reduction and JSWC shows 44%

Table 24: DEPOSITION							
Best Management Practice	**# planned last five years**	**# applied last five years**	**Average cost**	**Cost share available**	**% Reduction in TP Univ. of MD**	**% Reduction in TP NRCS CEAP**	**% Reduction in TP JSWC**
Riparian Forest Buffer	107 ac	31 ac	$1081-$2596 per acre	YES	50%-75% depending on land-type		43%
Riparian Herbaceous Cover	164 ac	3 ac	$292-$303 per acre	YES	50%-75% depending on land-type		43%

Nutrient Management

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). In addition the Total Maximum Daily Load for fecal coliform has been adopted for the Neshanic River. The Total Maximum Daily Load requires that the fecal coliforms be reduced by 87% (NJDEP, 2003).

Currently in the Neshanic watershed there are agricultural properties which apply fertilizers based solely on crop needs or a time schedule without current soil tests. This condition can lead to over application resulting in run off of excess nutrients into surface water.

General Description

Nutrient management is managing the amount, source, form, and timing of the application of nutrients and soil amendments. It includes having current soil test to understand what is already in the soil for the plants use so it can be taken into account when applying fertilizer. This avoids applying more than the crop needs. Nutrient management plans are often developed by a person certified in nutrient planning.

Proposed Locations

Any and all agricultural land that receive fertilizers amendments of any kind are excellent candidate for a nutrient management plan. The use of a plan is the only assurance that fertilizers are being applied in the proper amounts determined by the data available. The locations can be prioritized by the subwatershed ranked according to the total phosphorus loading.

Implementation

Any farmer can have a nutrient management plan written for him through several government agencies, including NRCS. There are often local agencies and non-profit offering this service for little or no cost. The use of a nutrient management plan can often lead to reduced input cost to farmer. Plans can also discover nutrient deficiency and PH imbalances. Addressing these imbalances can increase yields and avoid potential pest issues. Soil fertility is link to many agricultural issues. If proper promotion is conducted it should be one of the easier practices to implement in the watershed

Cost

The cost of implementing a nutrient management plan is estimated in NRCS AWEP 2010 practice catalog to be $25.36 per acre in a grain crop and $52.56 an acre in specialty crops. This cost is almost always cost shared and often funded 100%. This practice is supported by agricultural professional, agencies, and farmers.

Expected Results

An implementation of nutrient management plans watershed wide would reduce the nutrients available for run off. If they are not applied to begin with they will not be there. There is the added benefit of understanding how timing of these applications not only affects availability to the crops but there potential for run off. Since manure is a nutrient that can be applied a nutrient management plan inherently addresses the issues of manure storage and application, creating a dialog with the producers to solve these issues.

Livestock Access Control Exclusion Fencing

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). In addition the Total Maximum Daily Load for fecal coliform has been adopted for the Neshanic River. The Total Maximum Daily Load requires that the fecal coliforms be reduced by 87% (NJDEP, 2003).

Phosphorus and fecal coliforms can be transmitted to surface water from livestock manure via direct deposit and runoff. One of the current livestock management practices used in the Neshanic Watershed is to allow animals to have access to public surface water. This condition is conducive to manure runoff and direct deposit. Installation of fences along a watercourse protects against these forms of contamination. Fencing also allows for the healing of the riparian area which filters run-off from pastures. There are some management hurdles to the farmer and installation costs. Currently there is funding from multiple sources to help offset the cost not only for the installation of the fencing but for alternate water sources for the livestock and other operational challenges.

General Description

Livestock access control fencing is installed generally at least 35 feet from the bank of the watercourse depending on the stream width and other site specific conditions. The 35 foot corridor allows for the establishment of a riparian zone for increased protection from manure runoff. The type of fencing utilized depends on livestock type and site conditions. Once installed livestock is no longer able to direct deposit manure while watering or crossing. Additional damage that may have occurred on stream banks can be repaired and the stream will heal to a more natural state, reducing bank erosion.

Proposed Locations

Access control fencing should be installed along all waterways which run through property with livestock that have access to the waterway. The locations can be prioritized by the subwatershed and ranked according to the combined fecal coliform and total phosphorus loading. The total linear feet of watercourse flowing through pasture in the Neshanic watershed is approximately 24663 linear feet. Any of this watercourse that allows livestock access is an excellent location for the installation of livestock access control fencing.

Implementation

While fencing may be installed by any contractor or landowner, technical assistance should be obtained from the Natural Resource Conservation Service (NRCS) or other support agency to ensure the effectiveness and longevity of the fencing. There is also the potential for cost share to help offset any expenses accrued by the landowner. Cost share will very often help fund associated practices like the installation of an alternate water source for livestock. There are currently many sources of cost share from both state and federal government including the NRCS Agricultural Water Enhancement Program (AWEP) that targets the Neshanic as one of the priority watersheds.

Cost

While fencing prices can vary according to livestock type and landowners preferences, the NRCS AWEP 2010 practice catalog approximates the unit cost of fencing to be $4.78 a foot for use as a livestock barrier. This cost will be greatly offset if the landowner applies and qualifies for cost share. Currently funding can be up to 100% of cost.

Expected Results

Livestock access control fencing will completely eliminate the direct deposit of livestock manure directly into our streams. Any damage being done to stream beds due to livestock access will be stopped. If an appropriate riparian buffer is coupled with this practice, the added filtration would result in an additional potential reduction of 75% of total phosphorus.

Riparian Buffer

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). Phosphorus can be transmitted to surface water from chemical fertilizer and manure runoff from agricultural operations. Currently in the Neshanic watershed field crops are often planted near the edge of watercourses and many watercourses have insufficient riparian buffers if any. This condition is conducive to fertilizer runoff. Establishment of riparian buffers along fields with agricultural activities will effectively help to filter out phosphorus resultant of agricultural activities.

General Description

A riparian buffer is a vegetated area of at least 35 feet along the bank of the watercourse depending on the stream width and other site specific conditions. The vegetated corridor can contain both herbaceous plants and trees. Benefits for water quality tend to increase with a wider buffer containing a forested area, although herbaceous cover alone has been shown to reduce total phosphorus runoff up to 75%.

Proposed Locations

Riparian buffers should be planted along all waterways which run through agricultural land. The locations can be prioritized by the subwatershed ranked according to the total phosphorus loading.

Implementation

While a riparian buffer may be installed by any contractor or landowner, technical assistance should be obtained from the Natural Resource Conservation Service (NRCS) or other support agency to ensure proper plant selection and buffer width. If livestock are present, fencing will have to be installed to prevent damage to the buffer. There is a cost in implementation for materials and labor, maintenance, and for land taken out of production. The land in the buffer will still be considered for farmland assessment. There is cost share to help offset any expenses accrued by the landowner. In addition there are annual payments offered by the Farm Service Agency through the Conservation Reserve Enhancement Program to compensate for land taken out of production. Non-profit conservation groups are often interested in buffers and can also become involved in assisting in the implementation and maintenance of buffer strips.

Cost

Riparian buffer planting costs vary due to site specific conditions and landowner decisions. According to the NRCS AWEP 2010 practice catalog, Riparian Herbaceous buffers range from $292.25 to $303.35 per acre. Riparian forest buffers range from $1,081.56 to $2,596.56 per acre. This cost will be offset if the landowner applies and qualifies for cost share. Currently funding can be up to 100% of cost.

Expected Results

A reduction of total phosphorus from agricultural runoff filtering through a riparian buffer area can be up to 75%. In addition riparian buffers help to stabilize stream banks and beds, filter sediment, reduce runoff velocity, and benefit wildlife.

Prescribed Grazing

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). In addition the Total Maximum Daily Load for fecal coliform has been adopted for the Neshanic River. The Total Maximum Daily Load requires that the fecal coliforms be reduced by 87% (NJDEP, 2003).

Currently in the Neshanic watershed there are agricultural properties which have overstocked or poorly managed pastures. This conditions lead to pastures which have less than sufficient vegetated cover required to prevent erosion and manure run-off.

General Description

Prescribed grazing is having a plan in place that manages grazing and browsing of animals to ensure there is always adequate ground cover while ensure proper nutrition for the livestock. Generally a prescribed grazing plan will be written by a pasture professional. At times it requires temporary fencing for rotational grazing activity, pasture reseeding and a reduction in animal units.

Proposed Locations

A prescribed grazing plan should be considered as a possible solution for any livestock operation that has poor pasture conditions. This would include land that is overstock. The locations can be prioritized by the subwatershed ranked according to the combined fecal coliform and total phosphorus loading.

Implementation

A farmer can have a prescribed grazing plan written for him through several government agencies, including NRCS. This plan may require a farm to install fencing or provide alternate watering. In addition a pasture might have to be reseeded, fertilized, limed or enhanced. All of these practices might not be cost shared, but there can be economic benefits to healthy pastures that can further offset cost.

Cost

The cost of implementing a prescribed grazing plan varies according to the pasture needs and existing conditions. There is also a cost in a learning curve to the operator. The end result is often healthier pasture which can in return make the plan worth any cost to the landowner. Estimated cost to initiate a prescribed grazing plan in the NRCS AWEP 2010 practice catalog is between $241.97 and $321.30 per acre, not including fencing, watering or seeding.

Expected Results

An implemented prescribed grazing plan will allow for pasture to regain healthy vegetation. The vegetation will aid in filtering manure and nutrient run-off before entering public water. Healthy pastures will reduce phosphorus loading and manure run-off.

Cover Crop

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). Phosphorus is often carried into surface water attached to soil particles during erosive events. Exposed soil is vulnerable to erosion by getting dislodged by rainfall and swept away. There are fields in the Neshanic that remain more or less exposed soil in between cropping cycles, lending to the overall erosive potential of the area. In addition these fields may have an excess of phosphorus left from over application of manure to meet plants nitrogen requirements.

General Description

Cover crops are described in the NRCS New Jersey Field Operation Technical Guide as being grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and other conservation purposes.

Proposed Locations

There are 4,333 acres of cropland in the Neshanic watershed. Any of these acres that are left barren can be potential cover crop locations. The locations can be prioritized by the subwatershed ranked according to the total phosphorus loading.

Implementation

Cover crops are widely accepted by agricultural professional and farmers to have many benefits, water quality being just one of them. Proper cover crop selection has led to operators reducing cost, reducing tillage, reducing herbicide uses and increasing soil health. Cover crops can easily be worked into any cropping system that has fields not in use for all or part of the year. With proper promotion, education and assistance cover crops can be implement watershed wide with excellent benefits.

Cost

Cover crops vary in cost depending on the cover crop selection. According to NRCS AWEP 2010 practice catalog the least costly is winter cover crop cost $71.50 per acre while a legume in the summer is estimated at $443.40 per acre. There is cost share available for these practices. There is often a return to the operation with reduced fertilizer needs and increased soil health.

Expected Results

An implementation of cover crops to barren crop fields will help to reduce run off. Cover crops reduce both wind and water erosion. Nutrients left over from previous fertilizer and manure applications in the soil profile will be captured and recycled making them unavailable for run off.

Contour Farming

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). Phosphorus can be transmitted to surface water from chemical fertilizer and manure runoff from agricultural operations. Currently in the Neshanic watershed some row crops are planted in straight rows without regards to the contours in the land or slope direction. This condition is conducive to increased erosion and fertilizer runoff.

General Description

Contour farming is described in the NRCS Field Operations Technical Guide as using ridges and furrows formed by tillage, planting and other farming operations to change direction of run off from directly downslope to around the hill slope. In essence this means farming with the natural shape of the land instead of against it. In addition the crop itself is used to slow water velocities with the ridges and furrows formed in row crops. The overall result is the reduction of the erosive capacity of the field which in turn reduces the potential for run off. This practice has limits as it is most effective on slopes between 2 and 10 percent without excessive rolling topography.

Proposed Locations

Contour farming should be used on all appropriately sloped agricultural land with row crops not in a no-till system. The locations can be prioritized by the subwatershed ranked according to the total phosphorus loading.

The total potential crop land that can benefit from contour farming in the Neshanic watershed is approximately 4,333 acres. Any of these parcels with the appropriate slope in row crops not in a no-till system will benefit from a reduced erosive capacity when farming on the contour.

Implementation

This practice in its simplest form is just changing the direction in which an operation plants it rows from “up and down” the slope to across the slope. Field condition do vary and for this system of planting to work at its highest potential it will often require detailed planning from an agricultural professional. Contour farming might also need to be used in conjunction with other practice, such as terraces or filter strips, to realize its full potential. While there is not always cost share available for the practice of contour farming itself being that it is just a change in field orientation, there is often cost share for practices that need to be installed to help the system function properly. Consideration will have to be taken into account for operator learning curve.

Cost

The actual cost of contour farming does not have a figure attached because it is not a physical implementation but rather a change in how a farmer plants. Cost for support practices are on a field to field basis but are often cost shared. A conservation planner from NRCS can provide free technical assistance in making decisions about what supportive practice will be necessary and guide landowners to appropriate cost share programs.

Expected Results

Contouring farming can reduce erosion, reduce the transport of phosphorus to surface water and increase water infiltration. The effectiveness of contour farming is amplified when incorporated with a strip cropping system. Strip Cropping is the growing in systematic arrangement of row crops, small grains and forages of equal strips.

Animal Waste Management Rules and Regional Manure Composting

The following does not describe a specific Best Management Practices as above but discusses a manure management strategy for the watershed. This strategy includes following the current guidelines set forth from NJDA regarding farm waste management and establishing regional manure composting options for agricultural waste.

Current Conditions

The Neshanic Watershed has been determined to be impaired for phosphorus (NJDEP, 2004). In addition the Total Maximum Daily Load for fecal coliform has been adopted for the Neshanic River. The Total Maximum Daily Load requires that the fecal coliforms be reduced by 87% (NJDEP, 2003).

Currently in the Neshanic watershed there are many agricultural properties which have livestock that produce more manure than can be safely spread on the land due to overstocking or limited onsite use. In some cases this manure is being handled in a fashion which can potentially pose an environmental threat. Manure piled in hydrologically sensitive areas or without proper distance from streams can leak phosphorus and fecal contaminants into public surface water. The issue of manure generation and use needs to be addressed using an animal waste management plans and regional manure composting.

NJDA Animal Waste Management Rules

General Description

Every farm has different requirements to address the issue of animal waste. Animal waste management planning is not one specific best management practice, but it is a holistic approach to appropriately address animal waste and the inherent externalities within the Neshanic watershed.

The New Jersey Department of Agriculture (NJDA) has identified the need to proactively address non-point source pollution from agricultural animal waste. In response to that need the Animal Waste Management Rules were created to require certain levels of livestock operations or operations receiving manure to develop Animal Waste Management Plans. These plans contain best management practices allowing the farm to operate without creating non-point pollution from manure. Ensuring all appropriate agricultural operation had one of these plans in action is an excellent first step in resolving this manure generated pollution.

Proposed Locations

All farms covered under the Animal Waste Management Rules should develop and implement a plan as required by the law. The guidance to develop the plans is provided by NJDA publications and further help from Rutgers Cooperative Extension is available. Other farms not covered by these rules ideally should voluntarily develop and implement these plans, but this step might not be taken.

Implementation

The Animal Waste Management Rules are already in place and active. By design these rules will protect water quality if they are followed. County and municipality involvement in promoting and ensuring that landowners understand and are meeting the requirements of these rules would enhance the rules effectiveness in protecting water quality. This involvement could come from local agricultural and environmental boards working in concert to help landowners with compliance. The rules state that all best management practices are installed by March 2012. County and local government could help NJDA with seeing those landowners are able to meet these goals.

Cost

The cost associated with promoting the New Jersey Animal Waste Management Rules would be the staff time and outreach mechanisms used in establishing a system to promote the rule. County and local government could potentially work with the NJDA in creating this system. Currently there are free training and assistance to develop Animal Waste Management Plans available to landowners and operators.

Expected Results

The promotion and support of NJDA Animal Waste Management Rules in municipalities within the Neshanic Watershed as a means to safely manage livestock manure generated in the region will help to mitigate any potential phosphorus and fecal contamination generated through manure use, storage, and disposal in the watershed.

<u>Regional Manure Composting</u>

General Description

Composting is an established technology that is currently being used throughout New Jersey by private and public entities. Livestock properties with enough area can draw upon public knowledge and government cost share to set up small on-site composting facilities. Rutgers Cooperative Extension holds classes to teach landowners how to compost and NRCS provides cost share for composting projects through various USDA programs.

In addition to the traditional agricultural operation we have many smaller farms or properties with livestock not covered by the Animal Waste Management Rules. These properties still have the potential to create non-point source pollution. A sound and affordable solution needs to be created to address the manure generated in these special, but frequent circumstances. Onsite and regional composting is potentially solutions to address this aspect of managing manure within a community. Composting turns raw manure to a safe and biologically stable organic material.

The option of a regional composting should be explored. Animal waste could be hauled or dropped off to a facility and turned into compost to be sold publicly or used by the community. Varying scales of such facilities exist within New Jersey. Hamilton Township in Mercer County has a large facility where a contractor turns the yard waste of the residences into compost which is sold publically and provided free to residents. There is also a successful horse stall waste composter, AgChoice, operating in Sussex County. In addition there are smaller on farm facilities able to take more manure than they produce onsite. These successful models could be used as guidance in setting up a regional manure composting options to serve Hunterdon County residences, helping to protect and restore the Neshanic Watershed

Proposed Locations

The Neshanic Watershed is not large enough to pose a real restriction on facility sites. If there are several smaller on farm composting sites they could be placed in strategic locations to reduce cost and time in hauling. A larger facility would ideally be centralized to serve multiple municipalities.

Implementation

Smaller onsite composting can be set up within the watershed, in accordance to the regulatory standards set by the New Jersey Department of Environmental Protection. Farms with the space and means could compost animal waste for themselves and with appropriate exemption from NJDEP take in waste from other properties. Once composted, manure no longer contains pathogens and is a valuable soil amendment, although it should still be used with a nutrient management plan to avoid over application. If enough of these on farm facilities were strategically placed with coordinated efforts they could potentially help serve the community need for manure management.

Establishing a larger regional composting facility will require cooperation between state, county, municipalities, and individuals. This cooperative effort holds the possibility to turn a regional problem into a regional asset. A regional composting facility will turn a potential pollutant into a usable and marketable product while protecting water resources. This project can be worked into the national and state green initiative helping to create jobs, local business and a cleaner Neshanic.

Cost

There is a range of prices for on-site farm composting facilities based on the needs and preference of a land owner. The price range listed in the NRCS AWEP 2010 practice catalog ranges from $.10 to $16.73 per square foot. There is cost share available for the construction of the facility. There is not cost share available for some of the equipment which is required to run the facility, such as a tractor or a windrow turner. If an operator does not own this equipment it will be an out of pocket expense.

The initial set up cost of a large regional composting facility can be quite high. New Jersey Department of Environmental Protection requires permit for such a facility can range over $30,000. The space and equipment are another cost consideration. While there is a high cost involved, large regional composting facilities have proved to provide both profit and community service.

Expected Results

The use of composting facilities as a means to safely manage manure generated from livestock will help to mitigate any potential phosphorus and fecal contamination generated through manure storage and disposal in the watershed. Secondary benefits are from turning manure into a safer alternative fertilizer than the raw spreading of manure. There is also potential for local economy to benefit through employment and business opportunities present in regional composting.

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