ONONDAGA COUNTY NONPOINT ENVIRONMENTAL BENEFITS PROJECT

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Introduction

Nonpoint source (NPS) pollution is unlike industrial and municipal pollution; it comes from diffuse sources and is the result of rainfall or snowmelt moving over and through the ground. As the water travels it carries human-source and animal-source pollutants. NPS pollution occurs over a wide area and is usually associated with land use activities such as agricultural cultivation, grazing, construction, urbanization and forest management. These pollutants may include fertilizers, herbicides, pesticides, insecticides, sediment, bacteria, nutrients, oils and grease, and toxic chemicals.

The objective of the Onondaga Lake Agreement, Nonpoint Source Environmental Benefit Project (EBP) was to implement nonpoint source reduction projects and management strategies to reduce nutrient inflow to Onondaga Lake from agricultural and urban practices and to evaluate the effectiveness of these projects.

Amended Consent Agreement

In January 1997, Onondaga County executed an Amended Consent Judgment (ACJ) in settlement of litigation initiated in connection with alleged violations of state and federal water pollution control requirements. The ACJ obligated Onondaga County to perform NPS environmental-benefit projects (EPB) in the Onondaga Lake watershed. This obligation was partly based on the results of a framework watershed model that was developed in 1994. The model identified nutrient loadings throughout the Onondaga Lake watershed on the basis of loading provided by Agway, Inc. and land use provided by the USDA, Natural Resources Conservation Service (Moffa and Associates, 1995). As depicted in Figure 1, it was projected that NPS phosphorous contributed the greatest annual loads to Onondaga Lake.

The EBP obligations are being met through this demonstration project involving best management practices (BMPs) implementation on three farms and two urban sites in the Onondaga Lake watershed. The major objective of the demonstration project is to implement BMPs to reduce nutrient inflow to Onondaga Lake and to document water quality before and after BMP implementation.

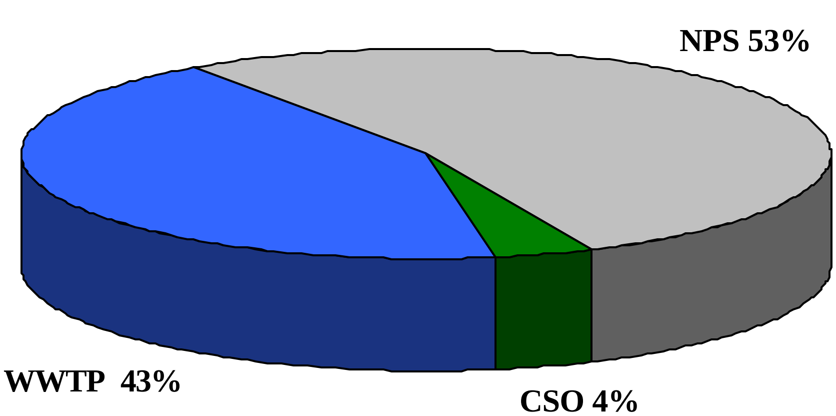

Figure 1. Onondaga Lake Phosphorous Sources

Scope of Work

The three agricultural sites were chosen to represent the prominent agricultural trends in New York State. Specifically, the Rohe Farm represents a typical family-owned, 100-head dairy farm that plans to continue operations as usual. The Guptill Farm is a family-owned farm that recently made the transition from dairy farming to beef cattle and heifer-livestock handling and is currently in the process of organic certification. The Leubner Farm is also a family-owned dairy farm but has expanded from a 150-head operation to a more than 400-head operation.

The two urban sites were chosen to represent typical municipal urban runoff. The stormwater vegetative filter strip at the Burnet Park Zoo treats and controls runoff from a typical urban parking lot. The stormwater vortex (Downstream Defender™, Hydro International) unit on East Seneca Turnpike treats runoff from a major city street. The catchment area on East Seneca Turnpike is very steep and is treated with heavy applications of salt and sand during winter months. The urban BMPs are not discussed in this paper.

There were three major elements of work for the EBP: BMP design and implementation, water quality monitoring and effectiveness evaluation.

BMP design and implementation spanned much of the project time period from March 1999 to November 2001. This work element can be further broken into potential BMP identification, selection, planning, design, farmer review, bid and contract, construction, implementation and modifications. BMP identification, selection, farmer review, bid and contract proceeded from March 1999 to October 2000. BMP construction, implementation and modifications began in June 2000 and continued until November 2001. The time frames for activities varied for each farm with work proceeding most rapidly at the Rohe Farm, then Guptill Farm, with the later dates involving work at the Leubner Farm.

BMP design and implementation focused on typical agricultural pollution sources. Each agricultural site included a series of related BMPs to reduce nutrient runoff from the farming operations. An operation and maintenance (O&M) plan for each farm was developed with the farmer. The O&M plan identified water quality risks and corrective BMPs to reduce the risk. It was essential to have the farmer co-develop the O&M plan to ensure that the BMPs complemented the farmer's existing farming operations and were economically viable for operation and maintenance by the farmer.

Water quality monitoring work began with the installation of rain gauges in May 1999. Water quality samples were collected from May 1999 to May 2000 for pre-BMP conditions. Water quality samples were collected from November 2000 to November 2001 for post-BMP conditions.

Water quality monitoring was conducted on a monthly basis during wet weather/higher flow events in order to determine the effectiveness of the agricultural BMPs. Additional sampling occurred during the snowmelt season since as much as 90% of the yearly annual load can occur during the spring runoff period (WERF, 1999). Approximately one year of water quality data prior to and after BMP implementation was collected. Samples were analyzed for total suspended solids, total Kjeldahl nitrogen, total phosphorous and ortho-phosphorous.

The effectiveness evaluation served to demonstrate the measurable water quality benefits of the BMPs. The effectiveness of the BMPs at each agricultural site was assessed through the comparison of water quality data from the pre- and post-BMP periods, which included estimates of loads using calibrated hydrographs. Additionally, hydrographs for the typical water year were developed for each agricultural site. These hydrographs together with the water quality data were used to estimate a first-order approximation of pollutant loads.

Agricultural BMP Implementation

BMP design and implementation focused on typical agricultural pollution sources, such as poor manure and milk waste handling, animals herding in streams, drain tiles discharging directly into streams and poor roof water management. Table 1 identifies the water quality risks initially found at the Rohe farm and the implemented BMP solution. These water quality risks and BMP solutions were typical of those found and implemented on the Guptill farm and Leubner farm.

Table 1. Rohe Farm Water Quality Risks and Implemented BMPs

Water Quality Risk	BMP Solution
Accumulated manure solids in stream Milk house wash water discharged to stream through a pipe	• Excavated manure solids from stream and applied to fields • Intercepted wash water and applied to vegetative strip using a level lip spreader
Manure handling station runoff discharged to stream through a pipe	• Prevented run-on to station by intercepting clean roof water and polluted surface water • Conveyed clean roof water directly to stream • Intercepted polluted surface water and applied to vegetative strip using a level-lip spreader
Manure liquids (urine) and solids from manure handling discharged to stream through a pipe	• Intercepted manure liquids (urine) and solids using a sump pit and pump in the manure handling station • Liquids and solids pumped into spreader and applied to fields
Unstablized barnyard area with drain tile to stream	• Stablized barnyard with a concrete pad with bump walls for cleaning • Contained animals in barnyard with fencing, which separated the animals from the stream edge • Intercepted barnyard runoff with barkfilter • Disconnect drain tile
Clean roof water falling on barnyard area Animal pasture/loafing area near stream	• Intercepted clean roof water with eve troughs and conveyed water directly to stream • Created a buffer zone with fencing and stablized walkways to pastures further from the stream • Stablized walkways with geotextile and compacted stone dust

Photos were taken during the pre- and post-BMP periods. The photos presented below represent only a few of the pre-BMP conditions and BMP solutions.

Figures 2 and 3 depict the original condition of the barnyard at the Rohe farm, which was difficult to clean. When it was cleaned, manure solids were scraped off the edge of the concrete pad onto the ground where a tile drainpipe was buried that discharged directly into the stream. The improvements to the barnyard included surface stabilization and curbing so that the area could be periodically scraped and cleaned to reduce the amount of manure runoff and sedimentation. A barkfilter was installed for solids retention and fencing was installed to exclude the animals from the stream thus providing a buffer between the concentrated animal area and the stream. Figures 4 and 5 illustrate the implemented BMPs.


Figures 2 and 3. Rohe Farm Pre-BMP Barnyard


Figures 4 and 5. Rohe Farm Post-BMP Barnyard

Figure 6 depicts the pre-BMP conditions at the Guptill farm where the actual streambed and surrounding riparian areas were used for cattle pasturing and feeding. The farmer chose this area because of its water supply and shade qualities. Improvements included removing the animals from the streambed and riparian areas and developing an alternative area for pasturing and feeding. Once the animals were removed from the streambed area, the area was revegetated with tall fescue and reed canary grasses. Figures 7 and 8 illustrate the revegetated streambed area and a portion of the fencing installed for the rotational grazing pastures.

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Figure 6. Guptill Farm Pre-BMP Streambed Area Used for Grazing and Feeding

Figures 7 and 8. Guptill Farm Post-BMP Streambed Area and Rotational Grazing Fencing

Figure 9 depicts the original manure handling station at the Leubner farm, which was poorly drained and therefore difficult to use and clean. Manure solids and associated nutrients accumulated around the manure handing station and eventually reached the stream through drainage pipes and overland flow. Improvements included installing new concrete walls around the existing manure handling pad to facilitate manure clean up. A concrete chute was constructed to convey drainage from the manure ramp to the bark filter. These improvements are illustrated in Figures 10 and 11.

Figure 9. Leubner Farm Pre-BMP Manure Handling Station

Figures 10 and 11. Leubner Farm Post-BMP Manure Handling Station

Data Analysis

Water quality samples were taken downstream from the farmsteads once per month for one year before and after BMP implementation. Instantaneous flow measurements were taken at the same time as the water quality data. Occasionally, water quality samples and instantaneous flow measurements were taken upstream of the farmsteads.

Estimation of Annual Runoff Hydrographs

In the effort to calculate pollutant loads, annual runoff hydrographs from each farm were developed using USGS flow data and the instantaneous flow measurements taken in the field during water quality sampling.

Average daily flow data obtained from the nearest downstream USGS gauging station were used to estimate flows for each of the three farmsteads. The USGS flow data were proportioned to represent the watershed area contributing to the sampling location on each farm in comparison to the watershed area contributing to the gauging station. The instantaneous flow measurements collected in the field were then used to calibrate the proportioned USGS data to account for site-specific trends and characteristics. Figure 12 shows the proportioned USGS data hydrograph, the calibrated hydrograph and the instantaneous flow measurements collected in the field for the Rohe farm.

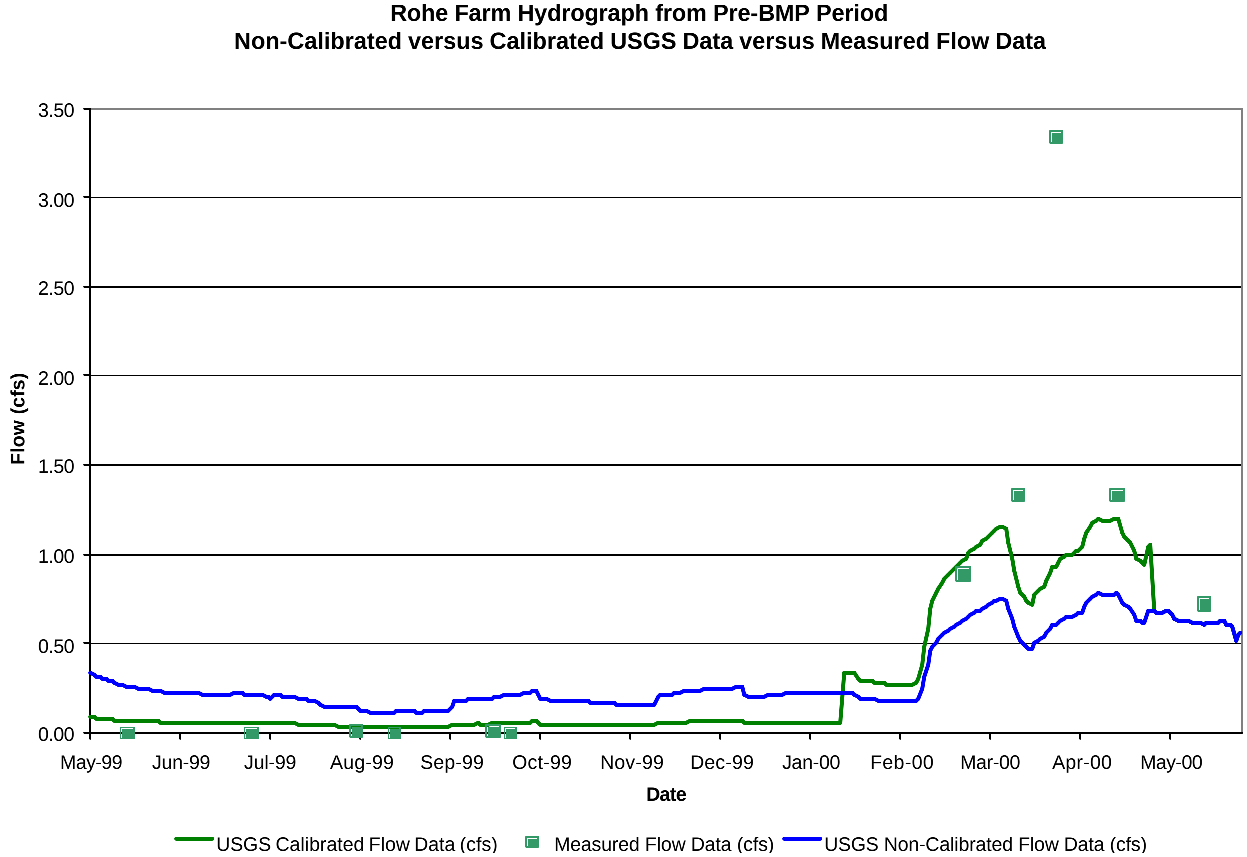

Figure 12. Rohe Farm Hydrograph from Pre-BMP Period Non-Calibrated versus Calibrated USGS Data versus Measured Flow Data

Estimation of Average Nutrient Concentrations and Nutrients Loads

Based on the pre-BMP and post-BMP raw data it is apparent that there are two distinct flow scenarios that occur during the year, namely, the spring runoff period and the summer and fall runoff period. In general the spring runoff period is characterized by higher sustained flows and lower nutrient concentrations, whereas the summer and fall runoff period is characterized by predominately lower flows with some short periods of high flows and higher nutrient concentrations.

Hydrologic responses are a function of physical watershed characteristics, precipitation characteristics and weather conditions. As a result each hydrologic year is unique. Based on this understanding it was not appropriate to simply compare the month of May in the pre-BMP period to the month of May in the post-BMP period. Therefore, average seasonal nutrient concentrations were developed.

The timing and duration of the seasonal nutrient concentrations were not based on calendar days but rather on hydrologic data. For example, May of 1999 during the pre-BMP period was considered part of the summer and fall runoff period because the majority of the snowmelt had occurred in the preceding two months. Conversely, May of 2001 during the post-BMP period was considered part of the spring runoff period because the snow pack runoff was still apparent.

Nutrient loads for the pre- and post-BMP periods were calculated by using the average seasonal nutrient concentrations and the calibrated hydrographs. A total phosphorous load chart comparing the pre- and post-BMP periods at the Rohe farm is presented in Figure 13. In general, lower concentrations of nutrients were measured during the post-BMP summer/fall season and therefore there was a significant reduction in pollutant loads.

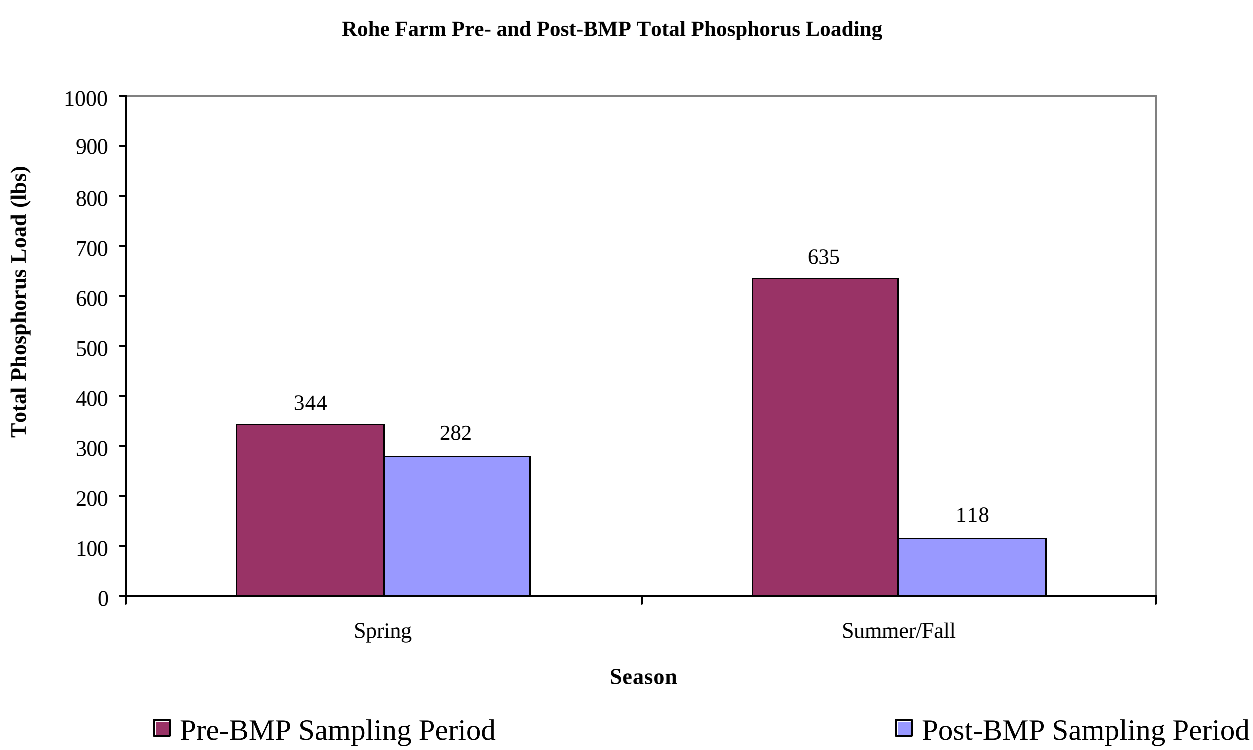

Figure 13. Rohe Farm Pre- and Post-BMP Total Phosphorous Loads

Conclusions and Recommendations

Onondaga Lake Nonpoint Source Environmental Benefit Project began in mid-1999 with pre-BMP implementation water quality monitoring. During the period from mid-1999 to the summer of 2000, agricultural and urban BMPs were developed and designed in cooperation with the farm owner and municipal representatives. Working with the farm owner during this development and design stage was especially important in that it was essential that the BMPs complemented the farmer's existing farming operations and were economically viable in terms of operating and maintenance by the farmer. Post-BMP water quality monitoring occurred from the fall of 2000 to the fall of 2001.

The cost of BMP construction and implementation on each farm was approximately $45,000. In the cases of the Rohe and Guptill farms, this expenditure was enough to address the majority of water quality risks on each of the farms. On the other hand, in the case of the Leubner Farm, which is approximately four times as large as the other farms, this expenditure was only enough to address major water quality risks; other water quality risks have been identified but remain to be addressed. As a frame of reference, there were many direct discharges and diffuse sources of pollution on each of the farms. At the Rohe and Guptill farms, the direct discharges were generally addressed through source control and treatment; the diffuse sources were addressed through source control. At the Leubner farm many of the direct discharges were addressed through treatment, but additional work is required for source controls to enhance the treatment and address the diffuse sources of pollution. In general, the investment made on each farm was appropriate for dealing with the major point sources, however diffuse sources still exist.

Water quality data suggests that significant water quality improvements can be achieved by implementing agricultural BMPs. The most significant reduction in pollutant load occurred during the summer and fall seasons, where during the post-BMP period few "concentration spikes" occurred as compared to the pre-BMP period. This suggests that the implemented BMPs reduced pollutant loads from the point sources. However very little difference was seen in the spring runoff period suggesting that the diffuse sources still exist.

The agricultural EBP sampling approach yielded data that provided only a first-order approximation of farmstead runoff before and after BMP implementation; prior to this sampling program there were no such site-specific data available for farmstead runoff available in Onondaga County. The sampling approach was consistent with budgetary constraints, which allotted 85% of the budget to BMP implementation and the remaining 15% to sampling and monitoring, laboratory analyses, data analyses, meetings and reporting. To improve upon this sampling approach, a multiyear program could be implemented to increase the probability of comparative pre- and post-sampling years. For the current project the pre-sampling year was very dry and the post-sampling year was moderately wet. Additionally, farm setting is very important. For the current project farms were chosen to represent a cross section of agricultural business trends, not for water quality monitoring purposes. For an improved water quality monitoring program, farm setting and hydrologic relief should be set as a priority.

The commitment of the farmer was critical to the long-term success of the project, as the farm staff will continue to maintain these improvements in the years to come. Each farm, to varying degrees, achieved adoption of the stewardship concept. The farms that adopted this principle earlier were able to be more active partners in developing structures and strategies that would protect water quality and enhance the efficiency of their operation. A continued relationship between the farmers and the local Soil and Water Conservation District is also important in maintaining these improvements in the years to come.