# DRAFT

# NMP Lessons Learned

# Erosion Control

The U.S. Environmental Protection Agency (USEPA) established the National Monitoring Program (NMP) in 1991 under Section 319 of the Clean Water Act (CWA) to achieve the following two objectives:

1. To scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution, and
2. To improve our understanding of nonpoint source pollution.

State and local watershed projects included in the NMP conduct six to ten years of intensive water quality and land treatment monitoring in accordance with a nationally consistent set of guidelines to accomplish these objectives. Implementation of pollution control technologies is expected to occur in a controlled manner supportive of the experimental designs (e.g., paired watersheds, upstream-downstream) used by the projects. USEPA funding is directed primarily to monitoring and evaluation, while other sources are typically tapped to fund the implementation of pollution control measures.

As of September 2005, USEPA had approved 25 projects in the lower 48 States. These projects addressed a range of water quality problems caused by such sources as cropland, livestock operations, grazing land, stream modification, urban runoff, septic systems, recreation, and coal mining. Pollution control measures implemented include stream restoration, erosion and sediment control, urban runoff control, nutrient management, riparian protection, acid neutralization, septic system repairs, and a host of others.

While the NMP is ongoing, many of the NMP projects have reported final results, and several others have reported early findings. It is against this backdrop that lessons learned by NMP projects have been gathered and summarized in a series of evaluations including this one focused on erosion control. The findings in this document are based on analysis and reporting by Don Meals and Steve Dressing (Tetra Tech, Inc.) of project reports, annual project summaries (Szpir et al. 2005), and direct communication with project personnel.

The primary emphasis of this evaluation relates to the two NMP objectives, but the success of watershed projects is dependent upon a foundation of design, process, cooperation, and resources. For this reason, lessons learned address a range of factors known to play significant roles in determining the outcome of watershed projects.

**The Projects**

Five of the NMP projects addressed erosion and sedimentation problems in agricultural watersheds primarily through erosion control measures for both cropland and streambank erosion:

- Lake Pittsfield, Illinois
- Sycamore Creek, Michigan
- Whitewater Creek, Minnesota
- Elm Creek Watershed, Nebraska
- Bad River, South Dakota

Sedimentation was the major water quality problem in Lake Pittsfield, IL; sediment from farm operations, gullies, and shoreline erosion has decreased the surface area and storage capacity of Lake Pittsfield. The **Lake Pittsfield, IL** project reduced sediment transport and delivery to the lake by constructing several settling basins and pool/riffle structures in the watershed. U.S. Department of Agriculture (USDA) cost-share programs are also funding implementation of agricultural best management practices (BMPs) in the watershed. Monitoring was completed in 2004; a final report is being finalized (due December 2005).

The **Sycamore Creek, MI** project focused on sediments and nutrients from cropland. Sediment deposits in Sycamore Creek adversely affected fish and macroinvertebrate habitat and depleted oxygen from the water column. Land treatment consisted primarily of streambank stabilization techniques funded under Section 319 and sediment and nutrient reducing BMPs on cropland funded through the USDA Sycamore Creek Hydrologic Unit Area (HUA) project. The Sycamore Creek project was completed in 1997 and a final report was provided in 1999.

The **Whitewater Creek, MN** project is addressing impairments associated with turbidity and bacteria, sediment, elevated water temperature, low dissolved oxygen, and habitat issues in a dairy and beef agricultural watershed in southeastern Minnesota. Major nonpoint sources include streambank erosion, degraded riparian areas, runoff and erosion from cropland, feedlot runoff, and animal waste on cropland and pasture land. The Whitewater Creek Project is designed to evaluate BMP effectiveness in two settings: (1) paired-watershed evaluation of CRP enrollment, changes in tillage and crop rotations, and grass buffers; and (2) biological monitoring of multiple sites targeting practices such as cropland erosion control, nutrient and pesticide management plans, and managed grazing. Land treatment in the project area has not yet been completed.

Loss of riparian vegetation and streambank erosion contributed to impairment of a coldwater trout stream by sedimentation, increased temperatures, and high peak flows in the **Elm Creek Watershed, NE** NMP project. Land treatment for creek remediation included streambank stabilization, livestock exclusion, conservation tillage, and erosion and sediment control practices, many of which were installed through a HUA program. Post-treatment monitoring concluded in 1999 and a final report was completed in 2005.

Soil erosion, primarily from poor grazing management and poorly maintained riparian areas is causing excessive sedimentation to the main channel of the Missouri River. The **Bad River, SD** NMP Project is determining the effectiveness of rangeland, cropland, and riparian BMPs such as rotational grazing, vegetation planting, and fencing on these problems. Post-BMP monitoring will continue through 2006.

It should be noted that several other NMP projects addressed erosion control as part of a broad set of water quality problems and land treatment approaches. The water quality results and lessons learned from these projects are reported in detail in other publications.

**The Bottom Line: Water Quality Results**

Two of three completed projects (Lake Pittsfield, IL and Sycamore Creek, MI) have documented significant water quality improvements following land treatment. Two projects are still in progress (MN, SD) and do not yet have definitive results to report. Implementing numerous water and sediment control structures (WASCOBs) and sediment retention basins, the Lake Pittsfield project reduced sediment delivery to the lake by 25 to 40%; sediment yields from the watershed have dropped significantly and have stabilized at lower levels since implementation was completed with the addition of in-stream stone weirs. Average sediment concentrations also have decreased as a result of land treatment, despite elevated stream discharge in the post-treatment period. In Michigan, monitoring results suggest that no-till farming practices plus streambank stabilization have caused a 60% reduction in suspended solids load and a 57% reduction in total P in Willow Creek. Sediment and P reductions were highly correlated with the percentage of watershed land under no-till. A 40% reduction in sediment delivery to Lake Sharpe from the Bad River watershed has been documented in the South Dakota project based on data from other sources; post-treatment NMP monitoring is not yet complete. The Bad River project has also observed an increase in riparian vegetation following improved riparian management. The Nebraska NMP project did not document any significant changes in water quality in Elm Creek, which continues to be degraded under runoff conditions. The project also reported that fish and invertebrate communities in Elm Creek continue to fluctuate in response to degradation by runoff events

Several other NMP projects reported significant improvements in erosion and sediment related water quality, even though their primary land treatment addressed other water quality problems. Among the projects focusing on grazing and riparian issues, the **Morro Bay, CA** (rangeland livestock exclusion), **Long Creek, NC** (livestock exclusion/riparian buffers), **Pequea/Mill Creek, PA** (livestock exclusion), **Stroud Preserve, PA** (riparian forest buffer), **Lake Champlain Basin Watersheds, VT** (livestock exclusion, riparian restoration), and **Otter Creek, WI** (Livestock exclusion/barnyard management) all reported significant reductions in turbidity, TSS concentration and load, or in-stream sedimentation. This pattern tends to confirm the importance of managing grazing land and riparian zones as an approach to controlling sediment levels in aquatic systems. In the comprehensive nutrient management/animal waste/erosion control group, the **Lightwood Knot Creek, AL** project reported a significant reduction in stream bedload and the **Sny-Magill, IA** project reported a decline in stream turbidity. Finally, the **Walnut Creek, IA** project, focusing on prairie restoration, also documented significant decreases in stream turbidity.

**Conclusions:**

- Implementation of erosion control measures can yield significant water quality improvements in several different ecoregions of the U.S.

- Improvements in water quality following erosion control treatment were demonstrated by measurements of TSS and turbidity, and in one case P loads.
- Water quality improvements in the Michigan NMP project were statistically linked to the percentage of land in no-till.
- Because of the dynamics of sediment delivery to water bodies, there may be considerable lag time between erosion control at the source and improved water quality.

**Table 1. Erosion Control**

| State | Treatment | Physical/Chemical | | | | Biological | | | | Temperature | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Turbidity/ TSS | P | N | Other | Bacteria | Invertebrates | Fish | Habitat | | |
| IL | WASCOBs, sediment retention basins | ↓ | | | | | | | | | |
| MI | No-till, streambank stabilization | ↓ | ↓ | ↓ | | | | | | | |
| MN | Cons. tillage, crop rotations, cropland erosion control, grazing mgt., buffers | | | | | | | | | | 1 |
| NE | Cropland erosion control, cons. tillage, filter strips, streambank stabilization | ⇔ | | | | | ⇔ | ⇔ | | ⇔ | |
| SD | Rangeland, grazing, and riparian management | ↓ | | | ↑ Riparian Vegetation | | | | | | 2 |
| | Range of % change | 25 – 60 % | 57% | | | | | | | | 3 |

**Notes:** ↓ ↑ ⇔

1 No results available as full land treatment implementation has not yet occurred.
2 TSS reductions documented by other monitoring (TMDL, USGS); NMP data not yet conclusive
3 Percent change values are for very general examples only; percent reductions are only valid in the proper context

**Table explanation and caveats:**

- Shaded rows represent projects providing most definitive evaluation of livestock exclusion/riparian practices; other projects included some livestock and/or riparian practices, but were less tightly focused.
- Downward arrows (↓) represent significant decrease in concentration or load. Upward arrows (↑) represent significant increase in concentration or load or significant improvement (e.g., in invertebrates). Sideways arrows (⇔) indicate no significant change. Empty cells indicate that project did not measure that variable or has not reported results.
- Percent reductions should be interpreted only as very general examples. Their utility is limited by the facts that:
  a) Some important variables like habitat cannot be expressed as a percent;
  b) For simplicity, the matrix does not distinguish between concentration and load; concentration and load may change in opposite directions if, for example, a BMP greatly reduces flow while slightly increasing concentration;
  c) Percent reduction depends largely on the starting point – the same BMP may give a much larger percent reduction in a situation of extreme impairment compared to a lesser initial problem; and
  d) In most cases, the range of percent reductions is so wide that choosing a specific value becomes an arbitrary exercise.

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**Impacts on State Nonpoint Source programs: Applicability of results to state policies and programs**

Experiences and results of NMP projects in this group have direct applicability to state nonpoint source policies and programs. These applications occurred in several categories:

- **Understanding of nonpoint source pollution**:
  - The Lake Pittsfield, IL project demonstrated the need to consider stream channel stabilization and how it is affected by both upstream and downstream control measures.
  - The Sycamore Creek, MI project found that because measured average annual sediment loading at the outlet of Sycamore Creek (MI) was only 6-12% of planning estimates based on erosion and sediment delivery, caution must be applied when using such planning estimates to target resources.

- **Design of treatments for nonpoint sources**:
  - Information gained from monitoring in the Lake Pittsfield, IL project at various stages of implementation (conservation practices, WASCOBs and SRB, stone weirs) was used to assess the success of implementation and the need for additional control measures.
  - The Sycamore Creek, MI project showed that conservation tillage alone will not solve sediment-related water quality problems; streambank stabilization must be done in conjunction with land-based erosion control to solve sediment problems

- **Significant water quality response to land treatment**:
  - Both the Lake Pittsfield, IL and the Sycamore Creek, MI NMP projects demonstrated that erosion control measures can reduce sediment loads at the watershed outlet.

**Impacts on State Nonpoint Source programs: Communications by projects to disseminate results**

Few projects reported making a special effort to communicate their results to state or regional agencies beyond routine reports, posting information on web sites, and other project information and education (I&E). Experience in the Michigan and Minnesota projects showed that, in general, projects run out of or in close cooperation with state agencies had better opportunities to communicate their results and lessons learned than did projects operated mainly outside of state government.

**Impacts on State Nonpoint Source programs: Documented impacts on state programs**

No significant impacts on state nonpoint source programs have been documented for projects in this group.

**Project Design and Execution: Observations and Lessons**

Measured water quality improvements are the end product of a series of choices and actions that begin with project selection. USEPA selected NMP projects using criteria that addressed problem identification, nonpoint source control objectives, size of the project area, institutional roles and responsibilities, critical areas, the watershed treatment plan, monitoring, and evaluation (USEPA, 1991). Observations and lessons learned by the five erosion control projects in these and related areas are discussed below to aid future projects.

**Project Design: Water quality problem characterization**

> *Accurate identification of nonpoint source pollutants and sources is critical to design a watershed land treatment program to resolve the water quality impairment:*
>
> **Treat the right problem with the right solution**

Some projects had specific, on-site data to document water quality impairments, including identification of the pollutants causing the impairments and the sources of those pollutants. Projects can successfully use regional or generic information to establish water quality impairments, pollutants, and sources, but this is risky if it turns out that there is no real water quality problem in the study watershed. The Sycamore Creek, MI project in particular noted that accurate identification of nonpoint source pollutants and sources is critical to design a watershed land treatment program to resolve the water quality impairment, i.e., treat the right problem with the right solution. Experience in the Lake Pittsfield, IL project demonstrated that processes associated with the water quality problem can change over time as monitoring revealed that implemented practices weren't solving the sediment problem. Consequently, in this project, land treatment practices also evolved over time as major sources of the sediment load shifted and additional practices became necessary. Sometimes, even extensive background data are not enough. In the Whitewater Creek, MN watershed, water quality impairments, pollutants, and sources identified through a number of sources, including the state 303d list, a state watershed diagnostic project (Minnesota Clean Water Partnership program) and a USDA P.L. 566 project, project staff reported that more background water quality data would have improved study site selection.

**Project Design: Nonpoint source control objectives**

Most of the projects expressed their nonpoint source control objectives very generally, e.g., "determine how well erosion control practices have reduced the amounts of sediment entering [the lake]" or "document water quality improvements in the watershed due to the implementation of BMPs." The Elm Creek, NE project expressed somewhat more specific goals, including reduction of sediment load by 50% and reduction of maximum summer water temperature, stream sedimentation, and peak flows.

As a general rule:

- If stated, quantitative goals should be tied to success in restoring beneficial uses or to hypothesized treatment effectiveness. For example, if a 50% reduction in bacteria levels is stated as a goal, that goal should be related to a water quality standard or other indicator that shows whether achieving that goal will solve the impairment, or to an hypothesis that treatments to be implemented can achieve that reduction.

- If only qualitative goals are stated (e.g., document effectiveness), the variables by which effectiveness is to be documented should be stated, e.g., document effectiveness on sediment load or mean P concentration.

- Statement of objectives for treatment design/installation/extent is not equivalent to statement of objectives for resulting water quality.

- Projects need to be flexible in setting objectives; ability to redirect effort to new objective(s) revealed by monitoring can give important results.

**Project Design: Identification of critical areas**

The NMP included both projects designed to solve watershed-scale problems and projects designed to assess the effectiveness of practices at the subwatershed or field scale. Some projects encompassed both scales. The importance of traditional critical area delineation varies with project objectives, ranging from crucial for the cost-effective solution of watershed-scale problems to unimportant for some demonstrations of specific practices at individual sites.

*Visual observation alone may be insufficient to identify critical areas when pollutant delivery pathways are not fully understood.*

Critical area delineation at the watershed scale was performed using a range of approaches even within the same project, including stream proximity and direct observation of visible sediment-contributing areas (MI), sediment yield estimates (MI and MN) and watershed models (MN). For larger watersheds with agricultural lands, critical areas were typically identified by agriculture and conservation agencies (IL, MI, MN, NE), according to their own priorities. The Lake Pittsfield project reported that visual observation alone is not always adequate to identify critical areas. The relationships among in-stream sediment loads, upland sediment delivery, and stream bank erosion are often not fully understood when projects develop their implementation plans.

**Project Design: Land treatment plan**

For the most part, NMP projects ultimately relied on voluntary implementation of control measures by landowners. However, achievement of NMP objectives was more likely when the NMP project had full control over the targeting and scheduling of practice implementation, rather than relying on another agency or program to implement land treatments. Control of implementation is key to the success of evaluation monitoring efforts at any scale; control was more easily obtained in smaller scale studies and studies within areas owned or controlled by those groups or agencies conducting the studies.

*Control of practice selection and implementation scheduling is key to the success of all projects.*

Flexibility and continuous interpretation of monitoring data are key to an effective land treatment plan because BMPs may need to be adjusted, changed, or added based upon progress made over time. It may be appropriate to factor monitoring into the BMP selection process, particularly for watersheds in which sediment sources may change as practices are implemented (Lake Pittsfield) or understanding of source behavior changes (Sycamore Creek). In either case, if monitoring data show that initial BMPs lack a key component for nonpoint source control, the ability to adjust the land treatment plan will contribute to project success.

Some specific lessons learned with respect to development of a land treatment plan include:

- Where cooperation by landowners was necessary, BMP selection was based on acceptability to the landowner, as well as water quality effectiveness, and cost (MI).
- Well-documented cost, applicability, and performance data are essential to the selection and site-specific implementation of appropriate practices (IL).
- Written agreements with landowners are strongly encouraged, and contract terms should include scheduling requirements that fit the monitoring and evaluation plan (MN).
- In most cases, better coordination between monitoring and land treatment agencies is needed to guide implementation within the constraints of a monitoring design (MI).

**Project Design: Water quality monitoring**

*It is difficult to measure and attribute changes in water quality to land treatment without a specific, well-funded monitoring design and plan. General sampling after BMP installation is not effectiveness monitoring.*

It is evident from the experiences of a few of the NMP projects that all key personnel should be trained before monitoring programs are designed. Those conducting monitoring must be knowledgeable of the water quality problems, the BMP implementation plan, and the monitoring design options prior to planning the monitoring program. It is also clear that adequate funding to achieve monitoring objectives must be secured before any monitoring occurs to ensure that suitable data are collected without interruption. In turn, those who conduct the monitoring should be held accountable for at least the following:

- Detailed monitoring budgets with a justification for each monitoring site, parameter, and collection frequency, including funding for some degree of "over sampling," particularly in the early years as those conducting the monitoring learn more about the system and problems through the collection and analysis of data.
- Clear statistical analysis plans before monitoring begins, with annual reassessments to ensure adequacy.
- Annual or more frequent analysis and reporting of monitoring data to ensure that the monitoring program is on track and capable of achieving its objectives.
- Annual reassessment of the monitoring program, with adjustments made as needed to ensure that monitoring objectives are achieved in the most cost efficient manner.

The monitoring timeline should include time to design the monitoring program, work with landowners and local experts to find and secure access to monitoring sites, construct the monitoring stations, and test the equipment before collection of real data. The experience of the Minnesota project suggests that this process could take several months or even years. For all monitoring designs it is necessary for project leaders to obtain the support for the study approach, monitoring site locations, and access to monitoring sites prior to initiating the project. In some cases, this may require that project leaders find local advocates to speak on their behalf to obtain approval.

Monitoring needs to be focused on the parameters most directly related to the water quality goals, the parameters most likely to be affected by the implemented practices, and explanatory variables that can be used to improve the resolution of statistical analyses. Additional monitoring stations, parameters, or samples may be needed to quantify unexpected inputs, This additional monitoring may be temporary or "permanent" depending upon project needs, and project planners should develop contingency plans for such flexibility. The Lake Pittsfield, IL project learned that maintaining temporary sub-watershed monitoring throughout the entire project time period would have been useful not just to further specify sources of sediment but also to recognize the possible negative feedbacks from installed designs.

Paired-watersheds are the best design for assessing effectiveness.

- Small watersheds are recommended (hundreds instead of thousands of acres); the Whitewater Creek, MN project learned that large watersheds (e.g., >6,000 ac) may be too big to realize sufficient treatments to detect change;
- Ability to direct land use and land management decisions in both treatment and control watersheds is necessary.
- Finding suitable pairs can be very difficult for a variety of reasons, including lack of a suitable match, distance between pairs, and lack of control over activities in the watersheds for the duration of the study;
- Land use and land management must be tracked in detail to provide opportunity for interpreting trends;
- Covariates such as discharge and precipitation must be tracked.

Upstream-downstream designs are also generally satisfactory for assessing effectiveness.

- Application of this design works best when the source isolated is a relatively large contributor of pollutants for which practices are expected to improve water quality dramatically;
- Pre- and post-implementation monitoring should be conducted, making this design essentially the same as a paired-watershed study with the exception that upstream contributions can be a concern.
- Land use and land management must be tracked in detail to provide opportunity for interpreting trends.
- Covariates such as discharge and precipitation must be tracked.

Single-station monitoring designs may be successful in assessing effectiveness, but only if conditions are ideal and appropriate covariates are tracked.

- This design should be a last resort and part of a longer-term trend monitoring effort to maximize the potential for usefulness of the data collected. Big changes in water quality must be anticipated if this design is used.
- Land use and land management must be tracked in detail to provide opportunity for interpreting trends.
- Covariates such as discharge and precipitation must be tracked.

In watersheds with significant sedimentation problems and highly variable discharge, site locations must be considered very carefully to avoid washouts. Stage-discharge relationships and storm-event monitoring are necessary in most cases for assessing the effectiveness of implementation with chemical parameters in a nonpoint source impacted watershed. Weekly composites of stage-triggered samples should be considered the minimum requirement for successful chemical monitoring when the pollutants of interest are transported via surface flow. Weekly composites reduce analytic costs compared to event-based sample collection, and weekly samples should be suitable for determining annual loads and the long-term effectiveness of practice implementation. Backwater can pose a problem when establishing stage-discharge relationships. Instruments such as Doppler flow meters may be helpful in addressing backwater, but their applicability effectiveness must be known. Grab sampling is insufficient for assessing effectiveness of practices when the pollutants of interest are transported via surface flow.

**Project Design: Land treatment and land use monitoring**

*Land use and land treatment tracking was generally more effective when conducted by the water quality monitoring project in a small watershed, rather than relying on an external agency in a larger basin.*

Land treatment/land use data can be obtained in a variety of ways including conservation plans, satellite imagery/aerial photography, and intensive field surveys. It is most important to track land use/land treatment variables that relate to the water quality problem and are expected to be impacted by the implementation of practices. Most of the projects in this group monitored land treatment and land use to some degree, although analysis of land use data and attempts to relate land treatment to water quality were not addressed aggressively. The Sycamore Creek, MI project reported that land use and land management information was useful for estimating nutrient and pesticide inputs, but noted that direct tracking of such parameters (e.g., nutrient applications) may be necessary, even though increased effort is required. The Michigan project also noted that relatively easy-to-track parameters such as percentage of land under no-till farming can be useful in water quality-land treatment data analyses.

The Lake Pittsfield, IL, Sycamore Creek, MI, and Elm Creek, NE projects relied mainly on reporting by other agencies that were directing land treatment, with mixed success. The Sycamore Creek project had some success with measuring implementation progress as percent no-till in the monitored sub watersheds through the standard USDA Natural Resources Conservation Service (NRCS) tracking activities; annual tracking of tillage practices through direct observation allowed effective tracking beyond the initial implementation period. In contrast, the Elm Creek project relied on tracking of cropping patterns and BMP implementation in the broad HUA project for a separate AGNPS modeling effort that was later abandoned. It is generally more feasible and effective to monitor land use and land treatment in smaller study areas, compared to large river basins.

In general, none of the projects expended enough effort in tracking the operation and maintenance of practices after they were installed.

**Project Design: Evaluation and reporting plan**

Most projects attempted to use USEPA's NPSMS software and/or STORET to report their monitoring data. There is, however, no evidence that annual or final data summaries provided by the projects (either through NPSMS, STORET, or otherwise) have ever been evaluated or used. Centralized housing and management of data did not happen as envisioned by USEPA. Most NMP projects, however, followed USEPA's guidance for the paired-watershed design in developing their plans for evaluation of project monitoring data.

*Reporting often ends up taking a back seat to more pressing issues, especially in state agencies with high workloads. Priority and time needs to be given to effective evaluation, reporting and communication of project results.*

Projects agreed that it is important to keep the farm community apprised of project results and to provide feedback to the planners as to the success or failure of the practices.

Project annual and final (where available) reports are of widely varying depth, scope, and availability. Some, for example, focus exclusively on water quality monitoring data and lack any information on other aspects of the project. Some of this is due to limits on agency responsibility and available time or funding. Some projects stated that reporting often ends up taking a back seat to other more pressing issues, especially in state agencies with high workloads. Priority and time needs to be given to effective evaluation, reporting and communication of project results. In the future, required elements and organization of project final reports may need to be specified in advance and established as a requirement for participation in the NMP program.

**Land treatment implementation: Treatment levels achieved**

Most NMP projects were able to achieve planned levels of land treatment; however in many cases, this was not obvious from project publications that often failed to state specific objectives for land treatment. Implementation of treatment was most challenging when applied to large watershed areas based on voluntary participation in a changing economic/social environment. The Whitewater Creek, MN project stated that difficulties in implementation can be reduced by improving deliberate communication with the land operators in a proactive approach to get the operators to manage the land as desired for the project. A "laid back/it will work out" is not likely to be effective. The Minnesota project also learned that a formal contract approach with landowners for their land management activities helps ensure things are done as planned. The information, education, and persuasion needed to obtain such a contract are themselves important ingredients to project success.

External forces such as changes in agricultural management, land use, land ownership, cost-share structure, commodity programs, regulation, and legislation may significantly affect practice adoption and implementation progress.

The experience of several projects demonstrated that flexibility in land treatment practice design is a benefit and that the ability to make changes/adjustments to make practice(s) work benefits the project. The Lake Pittsfield, IL project, for example, added stone weirs as a practice to control channel erosion after sediment basins were constructed. The Sycamore Creek, MI project added streambank stabilization practices after monitoring data showed that streambank erosion was an important source of sediment.

**Land treatment implementation: Incentives and technical assistance**
In most projects, technical assistance was provided by NRCS, often through the local soil and water conservation district (SWCD). Land treatment in both the Michigan and Nebraska projects was handled through the larger ongoing HUA projects. Landowner participation in all projects was voluntary, with cost-share incentives from USDA programs such as HUA, Environmental Quality Incentives Program (EQIP), and WQIP (Water Quality Improvement Program) and support from CWA Section 319(h) funds.

**Land treatment implementation: Scheduling of land treatment with water quality monitoring design**

*Failure to schedule land treatment to fit the water quality monitoring design significantly undermines the effectiveness of the paired-watershed design*

As discussed under Project Design, scheduling of land treatment to fit the monitoring design is absolutely essential to successful project evaluation; scheduling and directing land treatment are critically needed for the paired-watershed design to ensure that no implementation occurred in the control watershed and that data were obtained from distinct pre- and post-treatment periods. Coordination of land treatment and water quality monitoring was extremely difficult when implementation was done by a separate agency or organization. The Michigan project reported that lack of control meant that conservation tillage was implemented in the control watershed at about the same rate as in treatment watersheds, preventing the effective application of the paired-watershed design. The South Dakota project experienced similar problems, with conservation work occurring in both watersheds requiring the project to adopt a before/after design. The Minnesota project had the opposite problem; achieving implementation even in the treatment watershed was especially difficult in the absence of formal contracting agreements with landowners and the numerous land use changes that affected the study.

As noted earlier for the Lake Pittsfield, IL project, coordination of land treatment with water quality monitoring presents opportunities to use monitoring data to fine-tune or redirect implementation.

**Land treatment implementation: Tracking of installed land treatments**

*Tracking of the operation and maintenance of land treatments after implementation generally received inadequate attention from all the projects.*

Coordination of land treatment and water quality monitoring is best accomplished when monitoring personnel have direct control over implementation; otherwise, coordination is extremely difficult when implementation is done by a separate agency or organization. For monitoring projects such as those in the NMP, more specific and intensive land treatment tracking is necessary than is generally done in large, broad-scale projects. In general, tracking of participation in land treatment implementation was fairly superficial in the cases of large watershed areas; the most common approach was through NRCS or SWCD farm plan files or other records. Projects that included intensive studies focused on subwatersheds or intensive treatment areas did a better job of tracking participation and implementation within those limited areas. Tracking of the operation and maintenance of land treatments after implementation generally received inadequate attention from all the projects.

Where watershed-level tracking was done effectively, it was generally accomplished by direct observation by monitoring personnel through frequent visits to the project area or through personal contact with landowners. Poor institutional cooperation and lack of accountability can seriously impair the ability to track land treatment implementation and operation in cases where monitoring and land treatment are very separate activities.

**Project management: Agency participation, roles and responsibilities**
NRCS was a frequent participant in projects, typically in the role of technical assistance for land treatment, and county and local SWCDs played a strong role in project interactions with landowners. State natural resource agencies and universities were commonly in charge of water quality monitoring and data analysis.

**Project management: Coordination methods, success, and failure**
Coordination among different agencies with different missions is essential to project success. Mechanisms to achieve coordination must be built into the project from the beginning. Effective coordination looks easy and seamless; failure of coordination can have disastrous results. The Minnesota project, for example, experienced difficulties developing coordinated implementation assistance from all necessary parties, particularly from NRCS and the SWCD in the larger watershed project. The NMP project was not seen as a complete part of the overall project.

Some findings from the NMP projects are:

- Advisory committees that bring in a wide range of interests, including local stakeholders, are an effective way to accomplish project coordination.

- Coordination between small NMP projects and larger watershed projects such as Demonstration projects or HUAs can be especially difficult as project objectives and procedures may be very different.

- Local SWCDs are an effective means to link state and local activities and concerns.

- Annual funding is not a good way to run a 10-year project.

**Project management: Stakeholder involvement**
For most projects, stakeholders like state and federal agencies were highly involved in project design and operation. Producer, landowner, and public involvement were typically addressed through demonstrations, field days, and one-on-one contact with project personnel.

Stakeholder involvement is more than publicizing the project or “educating” landowners; stakeholders should be aware of and contribute to the project from the beginning. For most projects, stakeholder involvement was limited to I&E efforts. The effectiveness of stakeholder involvement efforts should be considered as well as the efforts projects expended in involving stakeholders

**Project management: Information and education**
Most projects included some I&E activities, which typically included newsletters, field demonstrations, meetings, and media releases. However, most projects did not fully document such activities in their reports. Projects like Michigan's Sycamore Creek and Nebraska's Elm Creek that took place within larger HUA project activities tended to have vigorous I&E programs, but these tended not to be specific to the NMP project. Illinois' Lake Pittsfield project produced videos as part of the final project I&E effort.

Information and education activities need to be evaluated in terms of their effectiveness and their contribution to project success.

**Water quality response: Documented water quality improvements**
Water quality response was measured at several scales using a range of parameters and study designs (See Table 1 above). Water chemistry reductions presented in this report are the result of statistical analyses performed by project personnel and are typically but not always values that have been adjusted using data collected at control sites. Year to year variations in precipitation and runoff, for example, can have enormous influence on measured nonpoint source pollutant loads; these variations are accounted for in the paired-watershed design. For this reason, an 80% reduction in phosphorus load, for example, may not be an actual 80% reduction in the stream but rather an 80% reduction *compared* to the control site used in the analysis. These reductions, however, show the generally strong capability NMP projects had to measure changes that could then be related to the implementation of practices.

**Water quality response: Relating water quality improvements to land treatment**
Some projects found it difficult to relate changes in water quality to land treatment because of implementation of diverse practices, implementation of incorrect practices, lack of land use/land treatment monitoring, or an inadequate or corrupted control watershed. In large watersheds where multiple BMPs are implemented at multiple sites, it is extremely difficult to relate changes in water quality to land treatment, especially without land use/land treatment monitoring and a solid experimental design. Projects taking place in small watersheds with clearly defined BMPs, appropriate monitoring designs, and effective land use/land treatment tracking (including operation and maintenance) stand the best chance of clearly relating water quality response to land treatment. Sub-studies of specific treatment-related phenomena within treated watersheds can help corroborate inferences with regard to cause and effect.

**Water quality response: Interpretation and presentation of results**
Some projects such as Sycamore Creek did a reasonably good job interpreting and presenting their results in technical reports, but either did not present results to other (non-technical) audiences or did not report such efforts. While technical reports from the Lake Pittsfield project are lacking in statistical and graphical presentation of results, the project has presented results to broader audiences in other ways.

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