DRAFT

NMP Lessons Learned

Restoration

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 restoration. 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

Three NMP projects focused on evaluating the effects of restoration on water quality and aquatic biota:

- Waukegan River, Illinois
- Walnut Creek, Iowa
- Upper Grande Ronde Basin, Oregon

The Waukegan River NMP project is demonstrating the effectiveness of stream restoration techniques implemented in a river draining a heavily urbanized watershed that has few measures to control stormwater quantity or quality. The project is evaluating changes in water quality, habitat, and stream biota in response to biotechnical streambank stabilization and installation of pool-and-riffle complexes and other habitat improvements in the stream.

The Walnut Creek NMP project is evaluating water quality response to conversion of row crop land to native prairie and restoration of riparian and upland wetlands. The effects of this restoration, combined with nutrient management and integrated pest management applied to remaining agricultural land, on stream chemistry (particularly nitrate) and stream biota are being evaluated using a paired-watershed approach as well as an above/below-watershed assessment.

The Upper Grande Ronde Basin NMP project is focused on loss of anadromous fish communities and degradation of aquatic habitat from elevated water temperature and loss of physical habitat as a result of riparian vegetation loss, timber harvest, road construction, and livestock production. The project redirected flow from a channelized stream to its historic channel, implemented streambank stabilization, and restored a wetland meadow complex to moderate stream temperature and restore habitat.

The Bottom Line: Water Quality Results

All three of these projects documented improvements in water quality; the Illinois and Oregon projects report improvements in stream habitat and biota.

The Waukegan River project documented significant improvements in macroinvertebrate and fish communities in response to habitat improvement. The number and abundance of fish species in the South Branch of the Waukegan River has more than doubled as a result of the stabilization and addition of pools/riffles. Index of Biotic Integrity (IBI) scores rose sharply from degraded to moderately degraded. A site downstream of the restoration contained more sensitive fish species and higher IBI scores than the upstream site in 1996-1999, but sustained improvement has been limited by undocumented stressors in the watershed.

The Walnut Creek project was able to document significant reductions in agrichemical inputs resulting from conversion of cropland to prairie and the imposition of nutrient and pesticide management on remaining cropland. Reductions in nitrate and pesticide levels in the stream were documented in response to these changes. Mean nitrate concentrations exceeded 10 mg/L in upper Walnut Creek and Squaw Creek (the control watershed), but averaged 6.6 mg/L in lower Walnut Creek where the restored prairie is located. Statistical analyses of total monthly export of NO_3-N, Cl and SO_4 indicated that lower Walnut Creek exported significantly less NO_3-

N and Cl than did upper Walnut Creek and Squaw Creek. Atrazine levels decreased by 26% but the reduction was not highly significant.

The Upper Grande Ronde Basin project used monitoring data to establish linkages between stream restoration BMPs and meaningful stream and biological characteristics. For example, correlation analysis of 50 variables indicated that channel and riparian characteristics and water quality variables indicative of disturbances were correlated to fish assemblage composition. Water temperature correlated most strongly with the composition of fish assemblages. Channel and riparian restoration yielded significant reductions in water temperatures and improvements in fish populations. Compared to the temperature of the water flowing into the restored section, maximum water temperatures measured in the middle of the reach were 3.0°C cooler in 1997 and 4.6°C cooler in 1998; diurnal temperature fluctuations were moderated in the relocated reach compared to channelized reaches. Existing willows grew quickly in the new riparian area and returning beavers built dams that created several large, deep pools and numerous smaller pools. Pool and backwater temperatures in the relocated channel were about 5.5°C cooler than in channelized segments. Snorkel surveys showed an increase in trout numbers in the restored section of the Creek.

Conclusions:

- Restoration of stream channel and riparian areas can yield significant improvements in aquatic habitat, water temperature, and stream biota.
- Efforts to restore aquatic biota should address water quality as well as habitat and temperature issues.
- Reductions in agrichemical inputs resulting from cropland conversion and implementation of nutrient and pesticide management can result in significant reductions of nitrates and pesticides at the watershed outlet.

Table 1. Restoration

State	Treatment	Chemistry		Biology				Temperature	Riparian vegetation	Other	Notes
		N	Pesticides	Bacteria	Invertebrates	Fish	Habitat				
IL	Stream restoration				↑	↑	↑				
IA	Cropland conversion to native prairie	↓	↓	⇔	⇔	⇔				↓ turbidity	1
OR	Stream channel restoration					↑	↑	↓	↑		2
Range of % change		10-45%	26%								

1. Project documented impacts of BMPs on nutrient/pesticide loading rates to watershed. N applications decreased from 11-37%. Pesticide reductions are estimated to be 28%.
2. Project data established that channel and riparian characteristics and water quality variables indicative of disturbances are correlated to fish assemblage composition

Table explanation and caveats:

- 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.

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**:
  - By characterizing annual and seasonal dynamics of sediment transport, including observations of cyclic patterns of sediment movement through streams, the Walnut Creek project demonstrated the need for more intensive sediment sampling (i.e., daily) in some critical seasons.
  - Work in the Upper Grande Ronde project provided data to test rapid Proper Functioning Condition (PFC) assessment method against more intensive monitoring techniques to determine a stream's channel stability and identify management practices that need changing to improve channel conditions.
- **Design of treatments for nonpoint sources**:
  - The Waukegan River project generated important lessons on the design and installation of lunkers, a-jacks, stone weirs, and other elements of in-stream practices
  - Results from the Waukegan River project underscored the need to take a holistic look at problems and needs, specifically the need for pools and riffles to supplement streambank stabilization. The project also noted that chemical water quality may need to be considered in fishery restoration efforts because chemical stressors may inhibit fishery improvements resulting from changes in physical habitat.
- **Significant water quality response to land treatment**:
  - The Waukegan River project documented significant improvements in macroinvertebrate and fish communities in response to habitat improvement in a heavily impacted urban stream
  - The Walnut Creek project documented changes in nutrient and pesticide inputs in response to strict agricultural management practices
  - The Walnut Creek project documented significant reductions in nitrate and atrazine levels in response to prairie restoration and increases in stream nitrate levels in response to increases in row crop land in the control watershed
  - Channel and riparian restoration in the Upper Grande Ronde project yielded significant reductions in water temperatures and improvements in fish populations.

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

The projects reported no special efforts 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 other projects has showed that, in general, projects such as those in Illinois and Iowa that are run within state agencies generally have better opportunities to communicate their results and lessons learned into state policies than did projects operated mainly outside of state government. The Confederated Tribes of the Umatilla Indian Reservation

(CTUIR) has been the lead agency in planning and implementation of restoration in the Oregon project, but Oregon Department of Environmental Quality (ODEQ) has led the monitoring effort.

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

The Waukegan harbor Citizens Advisory Group (CAG) is expanding its attention/activities into the watershed due to the Waukegan River NMP project. The NMP project was looking for a way to extend and continue its work, while CAG sought to continue its restoration efforts after completing a contaminated sediment remediation in the harbor itself. The park renovated by the NMP project attracted attention and personal contact between project staffs got the ball rolling. Education efforts (e.g., efforts directed toward homeless population, signage for kids, BMP workshops for volunteers, clean-up days, etc.) and local government actions (e.g., *E. coli* monitoring, sewage interceptor repair) have continued the attention on the stream and watershed.

Restoration and monitoring in the Upper Grand Ronde project has generated interest in small scale effectiveness monitoring, and managers elsewhere in the state are using the lessons in TMDL efforts. The rate of change measured in the Walnut Creek project helped guide expectations for other projects in Iowa.

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 three restoration projects in these and related areas are discussed below to aid future projects. Note that some design criteria such as critical area selection and land treatment monitoring may not fully apply to these projects because their design and function is distinct from that of the typical agricultural watershed project.

Project Design: Water quality problem characterization

> The Walnut Creek project stressed the importance of not just pollutants and sources but also of how pollutants are delivered to streams (e.g., runoff or baseflow) both in the design of treatments and the development of appropriate monitoring plans.

Restoration projects are highly dependent upon clear documentation of water quality problems at their study sites. 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. The Waukegan River project had documentation of severely eroded stream channels and impaired fish and macroinvertebrate habitat due to urban stormwater impacts. The Upper Grande Ronde project had extensive data on stream fisheries, habitat, and geomorphology collected by the state agency.

Projects can successfully use regional or generic information to establish water quality impairments, pollutants, and sources. The Walnut Creek project, for example, was supported by extensive information relating row cropland with stream nitrate levels in Iowa and elsewhere in the Midwest. The project observed that it is important to consider not just pollutants and sources but also how pollutants are delivered to streams (e.g., runoff or baseflow) both in the design of treatments and the development of appropriate monitoring plans.

Project Design: Nonpoint source control objectives

The NPS control objectives of all three of the projects in this group were directed not toward quantitative load reduction targets or water quality standards but were rather focused on demonstrating the effects of restoration efforts on water quality and aquatic life. The principal objectives of both the Illinois and Oregon projects were to improve aquatic communities by restoring habitat quality through restoration work in the stream channel itself. In the Iowa project, objectives were to measure water quality response to essentially complete restoration of watershed land to native prairie.

Project Design: Identification of critical areas

The identification of critical areas in the traditional sense of watershed contributions to NPS pollution was not applied to the two in-stream restoration projects (IL and OR), where critical areas were defined as the degraded streams themselves. In urban settings such as the Waukegan River project area where storm runoff is the major contributor to degraded stream habitat, critical area definition that includes the drainage area as well as the damaged stream reaches would seem appropriate. Failure to manage storm runoff and water quality could result in temporary rather than long-term improvements in stream biology. The Walnut Creek project identified all row crop land in the watershed as critical area needing treatment (i.e., conversion to prairie) because of the positive association between row crop land and elevated stream nitrate levels.

Project Design: Land treatment plan

In both the Waukegan River and the Upper Grande Ronde projects, the project land treatment plan was tightly focused on restoration of a specific stream reach. In the Waukegan River project, the state Water Survey designed biotechnical and other practices to resist high velocity runoff while increasing riparian habitat for stream fisheries within the stream channel. However, because the full range of needs to restore the fishery was not assessed in the beginning, the initial land treatment plan did not address all important issues. However, the project maintained enough flexibility to adapt to new knowledge that insufficient pool depth and the lack of pools and riffles were important impairments, and later added pool-and-riffle sequences to the restoration program. Even so, the project pointed out that untreated chemical stresses may still impair the fishery. In the Oregon project, the land treatment plan was a multi-year, multi-partner effort to restore a stream reach to as near natural conditions as possible with accompanying beaver marsh, meandering stream channels, and palustrine emergent wetlands. The complex plan was developed in several phases by a number of cooperating agencies.

The Walnut Creek project had an unusually controlled land treatment plan because most agricultural land in the treated watershed was owned or controlled by the U.S. Fish and Wildlife Service (USFWS) Refuge. Land treatment planners were therefore able to designate the land to be converted to prairie and to impose controls on agrichemical applications on remaining crop land.

Important lessons for land treatment plans from the restoration projects include:

- In restoration projects, as in urban projects, project staff had a great deal of control over BMP selection and design throughout a single stream reach or area of limited land ownership. As a result, implementation of the land treatment plan was simpler and more efficient than in projects in agricultural settings in which each farm has a unique plan.
- Both the Iowa and Oregon projects learned that it is important that BMP selection and design are not based solely on sources and pollutants but also are carried out with full consideration of pollutant pathways and interactions among practices, pollutants, and habitat characteristics.
- Flexibility and continuous interpretation of monitoring data are key to achieving NPS control and water quality goals 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 a biological response will be dependent upon both obvious and masked problems.

Project Design: Water quality monitoring

Both of the stream restoration projects (Illinois and Oregon) employed physical and biological monitoring with an above/below-watershed design, which is highly appropriate for evaluating the effects of a restoration effort occurring on a particular stream reach. The Walnut Creek project, which focused on land restoration, used both an above/below-watershed and a paired-watershed monitoring approach.

> Habitat and biological monitoring should be part of any monitoring program in which in-stream practices are implemented

Both the Waukegan River and the Upper Grande Ronde projects demonstrated that biological and habitat monitoring provide valuable information regarding in-stream impacts and in-stream benefits of stream restoration. It is clear that habitat and biological monitoring should be part of any monitoring program in which in-stream practices are implemented. The Upper Grande Ronde project concluded that chemical sampling may not be needed if water chemistry is clearly not part of the problem; however, the Waukegan River project noted that chemical stressors not evaluated through monitoring may have suppressed the response to treatment.

Whereas feedback between monitoring and land treatment is important in all nonpoint source projects, it is particularly critical to in-stream restoration projects. The pattern of response by habitat, macroinvertebrate, and fish parameters can be used successfully to indicate the success of practices and suggest the need for additional practices, as shown in the Waukegan River project's addition of pool-and-riffle treatments. It is important to keep an open mind when interpreting apparently conflicting chemical, physical, habitat, and biological data because the information content may be far beyond what is apparent after initial data review.

Project Design: Land treatment and land use monitoring

> Even in projects tightly focused on restoration of specific sites, land use monitoring should extend outward through the contributing watershed. Failure to do so may compromise the ability to interpret water quality/habitat/biological data to either explain response to treatment or fine-tune land treatment designs.

All three projects in this group monitored their land treatments in detail. In the Walnut Creek project, Landsat satellite imagery and tracking of prairie planting areas and locations of cooperative farmer rental ground by USFWS personnel documented conversion of crop land to prairie. Combined with information on farm rental land that allowed estimation of changes in nutrient and pesticide inputs, these activities provided a comprehensive picture of land treatment in the Walnut Creek watershed.

In the two stream restoration projects, however, land treatment/land use monitoring was perhaps too focused on the restoration sites themselves. While the Upper Grand Ronde project documented their channel restoration work extensively with photo points and measures of habitat condition, project staff believe that their ability to document biological response would have been improved by collection of data from a reference site so that treatment site conditions could be compared to best attainable conditions.

In the Waukegan River project, all in-stream implementation was tracked in detail, but no information on land use and land management activities in the contributing watershed was collected. Project staff from now conclude that contributing watershed information should be collected before or during the project planning stage when stream restoration is undertaken to ensure that the full range of practices needed to achieve water quality goals is applied. Failure to track land use and land treatment in the contributing watershed may compromise the ability to interpret water quality/habitat/biological data collected as part of projects in which in-stream practices are installed. For example, it appears that tracking of land management activities in the contributing watershed may have helped identify the causes of fish kills reported in 1998 and 1999 in the Waukegan River. Further, more complete knowledge of activities in the watershed may have enabled the project to identify additional controls needed beyond the in-stream measures to restore the fishery.

Project Design: Evaluation and reporting plan

> Priority and time need to be given to effective evaluation, reporting, and communication of project results.

Only the Waukegan River project attempted to use USEPA's NPSMS software and/or STORET to report their monitoring data. It is not clear that any of the projects had a specific evaluation and reporting plan. As for similar projects in other groups, project staff for these projects noted 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 these things.

It is also recommended that required elements and organization of project final reports be specified in advance and established as a requirement for participation in the NMP program.

Land treatment implementation: Treatment levels achieved

> Flexibility in land treatment implementation is important and the ability to make changes/adjustments to make practice(s) work benefits the project.

All three of the restoration projects were able to achieve their goals for land treatment. Achievement of planned treatment level was fairly straightforward for the Waukegan River and Upper Grande Ronde projects because of their direct focus on the stream corridor itself; treatment in Walnut Creek was greatly facilitated by the ownership of much of the watershed land by the USFWS Refuge. Thus, in these restoration projects, voluntary landowner participation was less of an issue than in most other NMP projects.

The experience of several projects demonstrated that flexibility in land treatment implementation is a benefit and that the ability to make changes/adjustments to improve practice effectiveness benefits the project. The Waukegan River project added stone weirs to provide pools and riffles after it was determined that stream stabilization alone was insufficient to restore the fishery. Channel diversion was implemented in the Upper Grande Ronde project after previous efforts of livestock exclusion fencing had failed. The Walnut Creek project was able to adapt their monitoring design to increases in cropland in the control watershed to show the effects of increases as well as decreases in row crop land on stream nitrate levels.

Land treatment implementation: Incentives and technical assistance

Incentives and assistance for land treatment implementation were not important elements for the projects in this group.

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

Scheduling of land treatment was not a relevant issue for the two stream restoration projects. The Walnut Creek project had no difficulty scheduling land treatment in the treatment watershed because of the ownership of land by the USFWS Refuge. However, the project did experience challenges due to conversion of CRP land to row crop land in their control watershed. The project successfully responded to this challenge in two ways. First, they were able to alter their monitoring design from a paired-watershed to a gradual change (trend) design. Second, the project was able to use data from the new crop land acreage in the control watershed to strengthen the relationships between land use and water quality, showing that increasing crop land acreage led to higher stream nitrate levels at the same time as reducing row crop acreage helped decrease nitrate levels.

Land treatment implementation: Tracking of installed land treatments

> The restoration projects did good job tracking installed land treatments because of their focus on well-defined areas and/or strong control of their treatment areas

Tracking of the operation and maintenance of land treatments after implementation in these three projects was quite different from tracking in other NMP projects. Whereas tracking of installed treatments generally received inadequate attention from most watershed-scale projects, the restoration projects were able to focus on either very specific limited areas under project control (Waukegan River and Upper Grande Ronde) or on land that was closely controlled by a single entity (Walnut Creek).

Project management: Agency participation, roles and responsibilities
The Illinois and Iowa projects included participation by a number of agencies and were led by state agency personnel. Land treatment planning and implementation in the Oregon project has been a cooperative effort involving the landowners, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Natural Resource Conservation Service (NRCS), Oregon Department of Fish and Wildlife (ODFW), ODEQ, and USEPA; ODEQ has led the monitoring effort.

Project management: Coordination methods, success, and failure
None of the three projects reported any particular difficulties or failures with regard to coordination.

Project management: Stakeholder involvement
None of the three projects reported any unusual efforts at stakeholder involvement. The Upper Grande Ronde project the McCoy Meadows Restoration Project included a working group with landowners, the Confederated Tribes of the Umatilla Indian Reservation, state agencies, and federal agencies. Results of the Waukegan River project contributed to a broad community environmental group, the Waukegan harbor Citizens Advisory Group.

Project management: Information and education (I&E)
The Waukegan River project incorporated a national workshop into its objectives; more than 120 people from across the U.S. participated in the Illinois EPA's National Nonpoint Pollution Monitoring Conference in Chicago. The project also developed an urban stream restoration manual and videos of the biotechnical streambank restoration activities were developed. The State Water Survey plans to create two educational/informational productions at the close of the project.

The Walnut Creek project took advantage of the USFWS Wildlife Refuge's role as an educational/demonstration center to carry out their I&E efforts.

Water quality response: Documented water quality improvements
Water quality response was measured using biological and habitat metrics in or below the restoration sites in the Waukegan River and Upper Grande Ronde projects. Improvements in aquatic biota and habitat were generally related to upstream untreated reaches or control sites. The Walnut Creek project focused on stream chemistry at several scales including subwatersheds and main watershed outlets using a range of parameters, and also included biological parameters. The use of a gradual change model in trend analysis in the Walnut Creek project allowed direct evaluation of changes in stream nitrate levels; the project was also successful in relating these

changes to changes (both decreases in the treated watershed and increases in the control watershed) in watershed row crop land. The water quality improvements documented by the restoration projects 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

The projects in this group were more successful than most other NMP projects in relating observed water quality improvements to land treatment. For the Waukegan River and Upper Grande Ronde projects, this was because the in-stream treatments were thoroughly documented. The Waukegan River project did however have difficulty explaining some of the measured back sliding in biological conditions because there were significant gaps in land treatment and water chemistry monitoring. Tight control over land treatment and agricultural management, as well as good documentation of decreases and increases in row crop land helped the Walnut Creek project relate observed changes in stream nitrate levels to changes in row crop acreage.

Water quality response: Interpretation and presentation of results

The Waukegan River project has issued annual reports of biomonitoring data and interpretation and has developed educational materials including an urban stream restoration manual and video of the biotechnical streambank restoration. The Upper Grande Ronde project has produced numerous state agency reports on invertebrates, fish, and temperature monitoring results. Final reports from the Walnut Creek project are in progress.

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