Indiana Water Resources Research Center

Annual Technical Report

FY 2000

Introduction

The IWRRC has established a strong foundation and infrastructure for continuing to adapt modern information technologies in support of water resources research, decision-making, and general communication. Our goal for the future is to play a leadership role in this emerging area at all levels; local, state, and within the National Institutes for Water Resources at the federal level.

Research Program

Basic Information

Title:	Fiscal Year 2000 Annual Institute Program for Indiana: Program Development & Administration
Project Number:	01-2000
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	program administration
Lead Institute:	Purdue University
Principal Investigators:	Jeff R. Wright

Publication

1. None.

Fiscal Year 2000 Annual Institute Program for Indiana: Program Development & Administration

The administration plan for the Indiana Water Resources Research Center during FY 2000 has been focused on trying to survive as a research center at Purdue University. A discussion during the summer of 2000 with the vice president for research at Purdue made it clear that the modest level of state support being provided by Purdue for the operation of the center was in jeopardy because of state budget concerns. As a result, it was assumed that this level of support would not continue past July, 2001.

The response to this impending problem was to identify other sources of support for the administrative assistant employed by the center, and to reorient the program of the IWRRC to providing ongoing information systems support to the National Institutes for Water Resources. consequently, the focus of our program has been to develop an infrastructure that would allow our program to continue providing this level of support for at least the FY2001 period.

It has recently been announced that the director of the IWRRC will be leaving Purdue university, and the associate director—Professor Ronald Turco, Director of Purdue's Environmental Science and Engineering Institute (ESEI)—will be taking over leadership of the center starting March 1, 2002. The ESEI will thereafter provide administrative support for the IWRRC, and the provision of state support as in the past will remain uncertain.

Basic Information

Title:	Design and Implementation of a Distributed Water Resources Information System (continuation)
Project Number:	02-2000
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	electronic web-based system, distributed information system, database
Lead Institute:	Purdue University
Principal Investigators:	Jeff R. Wright

Publication

1. None.

Problem and Research Objectives

This system has been developed using the client/server compute architecture of the global Internet, but accessible only by users authorized by the National Institutes of Water Resources (NIWR). This system is most properly viewed as a distributed intranet. Using this system, the institutes that comprise the NIWR are able to accomplish such things as:

Develop and manage consistent databases of NIWR project profiles including research projects, technology transfer and educational outreach projects, and institute administration. Develop consistent databases of human resources affiliated with each institute including research faculty and graduate student personnel, state professional personnel and water resources practitioners, institute staff, and other members of the water resources community within the state and region served by a particular institute. Maintain financial information about projects of the institute. Electronically construct and submit a variety of institute reports including periodic review and evaluation reports, annual technical reports, and annual applications for recurring federal support.

The ultimate goal is for these systems and functions to provide a comprehensive framework for communication within and among the NIWR institutes that will greatly extend the impact of individual institute initiatives. As a result of this enhanced virtual interconnectivity among the institutes, our program should become considerably more valuable to the water resources community within each state, to the university research communities within each state, and to water resources “stakeholders” at large. A natural extension of this system could extend to state USGS offices, and to other appropriate governmental agencies.

Methodology

A principal strength of the national network is access to the latest water resources information through the clearing house resources of all institutes that can provide easy connection between water resources needs and expertise/research. That access might entail the latest research reports, ongoing projects, talented student expertise for employment, knowledgeable and experienced faculty, and connections to state and regional efforts. In effect, the National Institutes for Water Resources is a series of networks, beginning with a national network and proceeding to many regional, state, and local networks; all can be accessed via the national network.

The data maintained by and administered through the NIWR intranet resides on a single host computer within an SQL-based relational database structure. The database is made up of five data subsystems, each with a “projects” perspective: 1) a project profile system, 2) a program finance system, 3) an institute personnel system, 4) a publications system, and 5)an institute profile system. Each of these subsystems are linked through data table relations so that reports can be generated quickly and efficiently, and with an appropriate degree of consistency among institutes. This expedites greatly the federal reporting obligations of each institute, and provides a more effective means of evaluating institute activities.

Data access is achieved using standard SQL query functionality making the system accessible by other (authorized) systems. Data may thus physically reside at multiple and dispersed locations consistent with the capabilities of each individual institute (which may change over time). This structure will also facilitate the upgrade of system support infrastructure (hardware and software over time, and in a manner that will be transparent to the community of users.

The database management system is configured as an Internet server with user access through any Web browser. Security and access control is achieved using standard client/server protocols, with an appropriate level of client-side functionality within reasonable standards. This will insure that the functionality of the system will be driven by user community needs and capabilities rather than by the state-of-technology as it grows over time.

Basic Information

Title:	Restoration of Indiana Streams: A Comparison of Restoration Strategies at a Statewide Level
Project Number:	03-2000
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Biological Sciences
Focus Category:	Ecology, Surface Water, Water Quality
Descriptors:	Stream restoration, surface water quality, channelization, fish, geomorphology, hydrology, habitat, siltation
Lead Institute:	Purdue University
Principal Investigators:	Gary A. Lamberti

Publication

1. Moerke, A.H. and G.L. Lamberti. Changes in fish community structure after reconstruction of two Indiana streams. In preparation to Freshwater Biology.
2. Moerke, A.H., J. Latimore, and G.L. Lamberti. Evaluation of an Indiana stream restoration using an ecosystem-level approach. In preparation to Environmental Management.

PROBLEM AND RESEARCH OBJECTIVES:

Land-use activities such as agriculture and urbanization have extensively modified the structure and function of midwestern streams. In the last century, an increased need for agricultural, commercial, and residential development has contributed to surface water pollution, draining of wetlands, and channelization; all of which result in stream habitat losses and impairment of water uses such as drinking, fishing, and swimming.

Many state and federal agencies have attempted habitat improvement projects on streams affected by anthropogenic disturbances. Projects have involved installation of in-stream structures, revegetation of the riparian zone, addition of gravel in riffle habitats to aid in salmonid spawning, and fish stocking. Stream restoration is an accepted practice in the western U. S., where streams are impacted by logging, and in the Northeast, where streams are affected by acid rain. But, few examples of stream restoration can be found in the Midwest, and even fewer have been evaluated. The Committee on Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy recommends a target of 400,000 stream and river miles be restored by approximately the year 2012 (NRC 1992). In order for restoration of midwestern streams to succeed, stream restoration methods, adequate monitoring programs, and the cost-effectiveness of current restoration practices need to be evaluated.

In fall 1997, a channelized 1-km reach of Juday Creek (South Bend, IN) was reconstructed by adding two meanders, which included pools and riffles, and adding in-stream habitat improvements such as gravel and logs. A second, less construction-intensive stream restoration was carried out on Potato Creek (near North Liberty, IN), also in fall 1997, which mostly involved diversion of flow into historical meanders. Both restoration projects involved restoring reaches of similar lengths in cool-water streams, but differed in cost, construction intensity, instream habitat improvement structures, water quality manipulation, and revegetation and stabilization of banks.

The stream restorations have provided a unique opportunity that will enable us to evaluate the efficacy of current restoration methods on midwestern streams. The restorations can also serve as large-scale "experiments" to study important concepts in community ecology, such as succession, recovery, and factors determining assemblage structure. The major objectives of this study were to: (1) compare geomorphic, hydraulic, and biological features of restored and unrestored reaches of these streams, before and after the restorations, with an emphasis on fish community response, (2) monitor longevity of habitat structures in the restored reaches, (3) identify biological criteria useful for evaluating the short-term success of other low-order stream restoration projects in the Midwest, and (4) compare the Potato Creek restoration and the Juday Creek restoration to determine the more effective approach to restoring midwestern streams.

Our basic experimental design was to sample physical, chemical, and biological variables in Juday and Potato Creek. Restored stream reaches were compared to upstream, unrestored reaches and when possible, replicate samples were taken. Pre-restoration data has been collected for both streams and post-restoration evaluation has been carried out for 3 years. Variables were chosen to assess both stream structure and function, and biological responses were evaluated at the population, community, and ecosystem levels.

PRINCIPAL FINDINGS AND SIGNIFICANCE:

Juday Creek

Prior to the restoration, Juday Creek was divided into 3 reaches for monitoring purposes: lower unrestored (U1), middle restored (MID), and upper unrestored (U2) reference. Post-restoration, the study area was divided into 4 reaches: U1, lower restored (R1), upper restored (R2), and U2. Habitat improvement techniques were only applied to R1 and R2. U2 is the only reach upstream of all modifications, including the sediment retention basin.

Prior to the restoration a habitat survey of all reaches found that runs were abundant but pool and riffle habitats were sparse (Table 1). Nine months post-restoration, the reconstruction of Juday Creek resulted in an increase in the number of habitat units available to the stream biota, and the pool-riffle ratio increased dramatically due to the addition of created pool and riffle habitat units. Over all post-restoration habitat survey dates, the total number of habitat units, pool-riffle ratios, and the percentage of stream length comprised of run habitat have remained similar. However, 21 months post-restoration, the amount of pool habitat in R2 seems to be declining, and this trend also was observed for surveys conducted 33 months post-restoration. Although habitat diversity remains greater in the restored reaches, current trends indicate a decline in R2, which is most likely due to continued sedimentation in the upper reach.

Table 1. Habitat parameters of Juday Creek before and after restoration.

	Total # of habitat units	Pool:Riffle	% Runs	LWD abundance per 100 m
Pre-restoration	8	1:13	89 %	13.7
9 mo. Post-restoration	21	1:2.5	41 %	7.5
21 mo. Post-restoration	19	1:2.8	39 %	15.5
33 mo. Post-restoration	20	1:1.5	42 %	19.6

The restoration did not immediately increase the abundance of large woody debris (LWD) per 100 m stream length (Table 1), however by 33 months post-restoration LWD abundance increased from 7.5 to 19.6 pieces per 100 m. Thirty-three months post-restoration, the volume of LWD per 100 m was nearly significantly greater in the restored reaches, with 2.8 m^3, than the unrestored which only had 1.8 m^3 of woody debris ($p=0.075$). Data from the woody debris surveys suggest that most of the LWD structures have been retained within the reaches, and recruited riparian trees are replacing those that are lost downstream.

Two weeks after the restoration, percent substrate embeddedness was higher in the unrestored reaches, at about 80%, than in the restored reaches, at approximately 18% embeddedness. Percent substrate embeddedness remains higher in the unrestored reaches 33 months after, but embeddedness has increased to nearly 40% in R1 and 60% in R2, while remaining the same in the unrestored reaches. Approximately 2 and 3 years after restoration, substrate cores were taken in each reach to determine if the abundance of fine sediments was accumulating in the restored reaches. Two years after restoration, the unrestored reaches contained 106.6 ± 10.8 kg of fine sediment (<2mm) per m^2, whereas the restored reaches only contained $5.8 + 3.1$ kg/m^2. By 3 years after restoration, the restored reaches contained significantly more fines (18.9 + 5.7 kg/m2; p=0.070) than the previous year, and no difference was found in the unrestored reaches between 2 and 3 years after restoration. This data indicates that fine sediments are continuing to accumulate in the restored reaches and may be leading to a decline in habitat diversity.

Percent canopy also illustrates differences between unrestored and restored reaches, with the unrestored reaches possessing a denser canopy than the restored reaches. In 2000, estimates of fish cover suggest that the restored reaches have a lower percentage of the total area providing cover for fish, but since the restoration increased stream length, it also increased the abundance of fish cover. However, on an individual habitat unit basis, the percentage of area that acts as cover is slightly greater in the unrestored reaches (20%) than in the restored reaches (approximately 13%). The most notable difference in fish cover is the dominant type of cover present in the unrestored versus restored reaches. Overhanging vegetation, debris dams, and undercut banks provide the majority of cover in the unrestored reaches, while boulders and large woody debris create the bulk of fish cover in the restored reaches.

Short-term retention of organic matter (OM), a valuable energy source, was assessed in the restored and unrestored reaches of Juday Creek to determine if all reaches had equivalent retentive capacities. Measurements of short-term retention allow us to monitor changes in a stream process that reflects ecosystem structure. Retention of gingko leaves and wood dowels was measured in all reaches before the restoration, 10 months, 22 months, and 34 months after the restoration. We hypothesized that increased reach complexity and substrate roughness in the restored reaches would lead to greater OM retention compared to the unrestored reaches.

The data suggest that percent retention of wood dowels and gingko leaves varies spatially and temporally in Juday Creek. Pre-restoration data indicate that approximately 30%, 50%, and 51% of the gingko leaves were retained in U1, MID, and U2 respectively. Ten months after the restoration, U1, R1, R2, and U2 retained 70%, 18%, 18%, and 21%, respectively. By 22 and 34 months post-restoration, retentive capacity was also greater in the unrestored reaches than the restored. Although restored reaches retained a lower percentage of gingko leaves, retention structures in the restored reaches were more diverse than in unrestored reaches. Backwater, roots, bank, and wood debris were the most important retention structures of leaves in restored reaches, whereas wood and vegetation were the primary retention structures in unrestored reaches. However, overhanging vegetation became a more dominant retention structure in the restored reaches by 34 months after restoration, which suggests that riparian areas are becoming more vegetated over time. Patterns found for wood dowel retention were similar to leaf retention. In contrast to our expectations, streambed roughness did not seem to be an important retention structure in any of the reaches. Overhanging vegetation and debris dams appear to be the main factors responsible for the higher rates of OM retention in the unrestored reaches. However, debris dam development has continued in all reaches with the addition of large woody debris to the stream channel. Bank vegetation also has become more established in the restored reaches. Early on, grasses dominated the riparian vegetation, however, shrubs and small trees are starting to develop on the stream banks. With time, successional processes should aid in establishing more effective retention structures in the constructed reaches.

Snorkeling surveys were conducted approximately 3 to 4 times per year from 2 weeks to 38 months following the restoration. Approximately 2 weeks after the restoration mean fish abundance in the unrestored reaches was three-fold greater than restored reaches. However, mean fish abundance quickly peaked in the restored reaches 9 months after the restoration and was two-fold greater than the unrestored abundance. Since the 9-month snorkeling survey, mean fish abundance in the restored reaches has continued to decline and converge with the unrestored reaches (35 months after restoration: unrestored=117 fish per 100 m, restored=115 fish per100 m).

Sites 60 m in length were electroshocked once prior to restoration and 2 times per year (June and August) following restoration in all reaches. At the onset of the study, representative electroshocking sites were chosen in each study reach, and all sites remained the same throughout the study years. Approximately 33 months following reconstruction of Juday Creek, total fish catch per 100 m stream length in reaches U1 and R1 declined from their 21-month levels, whereas R2 and U2 exceeded previous levels (Table 2). In U1 and R2, total fish biomass per 100 m stream length declined from 9 months to 33 months after restoration. Total biomass in R1 and U2 increased from 9 months to 21 months and then declined at 33 months after restoration. However, R1 had the greatest fish biomass over all sampling dates, and R2 often had the lowest fish biomass. Our data suggest that by 33 months after restoration, the mean individual size of fish was greatest in R1 and often lowest in R2.

Thirty-three months after restoration, calculated salmonid abundances in all reaches (range: 3-10 fish per 60 m) declined below all abundances calculated from 21-month samples (range: 12-24 fish per 60 m). Salmonid abundances from the 33-month survey even decline below abundances calculated for 9 months after restoration. Trout recruitment 33 months after restoration did not appear to be as successful as 21 months after restoration. At 21 months, approximately 20% of U1 and R1's total catches were comprised of salmonids. Approximately 40% of salmonids made up R2's total catch, and 30% of salmonids made up U2's total catch. However, at 33 months, the relative abundance of salmonids was lower in all reaches. No salmonids were recorded in U1, and only 2% and 8% of R2 and U2’s catches were comprised of salmonids. R1 contained the highest percentage of salmonids, with only 17%.

Table 2. Catch-per-unit-effort (CPUE) and total biomass of fishes in unrestored and restored reaches at 9, 21, and 33 months after restoration.

Reach	CPUE (fish per 100 m)			Total Biomass (kg/100 m)		
	9 mo.	21 mo.	33 mo.	9 mo.	21 mo.	33 mo.
U1	73	72	28	3.03	1.75	0.48
R1	62	97	67	7.38	17.52	9.63
R2	35	47	64	1.62	1.27	0.95
U2	52	105	160	4.45	6.56	3.74

Fish species richness was similar between U2 and the restored reaches. However, species diversity in U1 declined to only 3 species, with almost the entire sample comprised of creek chubs. Creek chubs are tolerant, omnivorous minnows that can take advantage of adverse habitat conditions. Species diversity in reach H-16, a site that runs through a golf course fairway and is void of all riparian vegetation, increased from 3 species 21 months after to 5 species 33 months after restoration, but this site still contains a depauperate fish community (only 18 fish per 100 m), which is most likely made up of transient fish migrating through the reach in search of more suitable habitat. Fish community structure in the two restored reaches has diverged even more since our 21-month surveys. At 33 months after restoration, creek chubs had a strong presence in both R1 and R2, whereas white suckers were dominant in R1 but absent in R2. Additionally, blacknose dace and mottled sculpin were not found in R1, but were relatively abundant in R2. Community structure in the unrestored reaches also differed considerably. U2 was dominated by creek chubs and blacknose dace, while mottled sculpin and white suckers also were relatively abundant. However, in U1 only creek chubs were abundant. U1 and R2 continue to lack slow, deep-water habitat that is preferred by white suckers and adult salmonids, and an overall decline in abundances of large fish may suggest that habitat is deteriorating in R1 and U2 as well.

Anadromous salmonids continue to spawn in the restored reaches. In late fall of 1997 (approximately 2 months after restoration), 26 redds were counted in the restored reaches, and 4 were observed in H-16, which received minor habitat improvements. No redds were observed in the unrestored reaches. Redd locations indicated that salmonids preferred 3-to-1 to spawn in R2 versus R1. Twenty-five redds were counted in the restored reaches 14 months after restoration, and again, no redds were found in the unrestored reaches. However, salmonids preferred 2-to-1 to spawn in R2 versus R1. At 38 months after restoration, 22 salmonid spawning redds were found, which is similar to the past three years, but it appears that salmonids now prefer 1-to-3.4 to spawn in R2 versus R1. This reversed trend of increased spawning activity in R1 compared to R2 suggests that habitat quality in R2 is deteriorating. The data presented on increased fines in R2 (reported above) supports our redd findings, and indicates that accumulating fine sediments in R2 may be deterring salmonids from spawning in this reach.

Potato Creek

Potato Creek monitoring sites were defined as M1, the lower manipulated reach, M2, the upper manipulated reach, and REF, the upstream reference reach. A beaver dam was constructed a few months following the restoration and it was abandoned and destroyed approximately one year later. Due to logistical constraints associated with the beaver dam, sampling efforts were reduced in Potato Creek. Habitat and woody debris surveys of Potato Creek were conducted 2 weeks prior to restoration, and 10, 22, and 34 months after restoration. The data illustrate large changes in channel morphology and current velocity in the restored and reference reaches. Mean pre-restoration depth in the REF reach was less than 0.2 m with a maximum depth of 0.4 m, whereas the mean post-restoration depth was 0.8 m, and 1.15 m was recorded as the maximum depth at base flow. Mean active channel width (ACW) prior to restoration was 6.0 m, but following restoration M1 had a mean ACW of 4.3 m and M2 had a mean ACW of 15.25 m. Mean current velocity, measured at base flow was approximately 0.24 m/s, before restoring Potato Creek. Ten months after, mean current velocity declined to 0.1 m/s in M1, and 0.01 m/s in M2 and REF. A decrease in the number of habitat units after the restoration was also evident. The entire study unit consisted of 10 habitat units prior to the restoration and 10 months following, the study reach only consisted of 5 units. At 34 months post-restoration only 4 habitat units existed in the study reach, and one long pool dominated the study area. Total LWD abundance also decreased 10 months after the restoration. The number of debris dams and logs present pre-restoration had declined by at least 50% by the 10-month survey. However, total LWD abundance 34-months post-restoration exceeded all previous levels. Beaver activity and low flows most likely could account for the observed increases in LWD abundance. Our data suggest that the stream does not possess enough stream power to define its channels, which has created deep, stagnant waters upstream.

During the summer of 2000 (approximately 34 months after restoration), recorded temperatures reached 19^{o}C and dissolved oxygen measurements ranged between 3.0 and 6.8 mg/L. The lowest dissolved oxygen readings were recorded in upstream reaches that were stagnant pools with large accumulations of organic matter. Conductivity and pH remained relatively constant at 670 μS and 7.6, respectively. Meanders were constructed in heavily forested areas, therefore 34 months after the restoration, percent canopy cover in the restored reaches was comparable to the reference reach and previous surveys, with about 70% canopy cover. M1 had slightly lower values of about 40%, which were similar to pre-restoration values for percent canopy cover in a corresponding reach.

In Potato Creek, fish were sampled 2 weeks prior to restoration, and 10, 22, and 34 months following restoration. During the 22- and 34-month fish surveys, water levels were too high to electroshock the REF reach with a backpack electroshocker. Stream banks were electroshocked, but no individuals were captured. Therefore, no data were obtained for REF during these two sampling periods. At 10 and 22 months after restoration, fish densities in M1 were similar to pre-restoration, with approximately 40 fish per m^2. Densities in M1 increased 3-fold by 34 months after restoration, but the fish community was dominated by central mudminnows. Central mudminnows are extremely tolerant to low dissolved oxygen conditions, which allows them to persist in this stream. Unlike M1, fish densities in M2 and REF declined dramatically over all sampling dates after the restoration. At 10 months after restoration, 31 fish per m^2 were found in M2, but by 34 months only one fish was found in this reach. A similar trend existed in REF. Along with the declines in fish densities came changes in community structure. Individuals less tolerant to silt and low dissolved oxygen conditions, such as the brook lamprey, were present prior to restoration but disappeared following restoration. More tolerant individuals such as central mudminnows replaced these sensitive species. In addition, generalist or slow-water species replaced species that preferred fast-flowing riffle areas. For example, blacknose dace were abundant prior to restoration but they were not found after restoration; however, green sunfish became more dominant with the development of stagnant waters. In general, our habitat and fish data suggest that the Potato Creek restoration resulted in a wider and deeper channel, which is leading to declines in fish density and alterations of community structure in all reaches surveyed.

Retention of gingko leaves and wood dowels was not measured at 22 and 34 months after restoration because extremely low current velocities and an abundance of large woody debris would have most likely led to retention near 100%. At 10 months post-restoration, the conditions were similar to 22 and 34 months post-restoration and many of the leaves in M2 and REF were considered retained because they were moving too slowly to reach the block net by the end of the retention experiment. Wood, debris dams, and stagnant water were the dominant means of retaining gingko leaves and wood dowels in the 10-month post-restoration retention experiments.

The Potato Creek and Juday Creek restorations attempted to recreate historical channel sinuosity, as well as to restructure the channel to increase habitat complexity and thus biotic diversity. However, the two restorations involved vastly different degrees of geomorphic manipulation, which likely produced the different fish community responses. In general, fish population and community metrics for Juday Creek suggested nearly complete colonization by 9 months after restoration, although metrics seldom exceeded the levels of unrestored, channelized reaches. In contrast, the Potato Creek restoration led to dramatic geomorphic changes that resulted in low fish densities, altered community structure, and domination by slow-water, silt-tolerant species. In both restorations, fish community characteristics appeared to be linked to habitat complexity, but neither restoration increased fish community integrity (e.g., IBI scores) in the restored reaches.

The Juday Creek restoration suggested that sedimentation is a chronic problem in the stream, and that restoration may only be achieved if sediment input is controlled at the watershed level. In Potato Creek, simple reconnection of the stream to historical channels, without attention to geomorphology and hydrology, may be insufficient to achieve restoration. Both restorations suggest that basic research is needed on geomorphic and ecological responses to current stream restoration practices, and that site-specific projects may be ineffective if watershed conditions are ignored. In addition, this study demonstrated that a single suite of metrics may not be appropriate for evaluating all restorations, but rather that metrics must be chosen to fit the specific restoration. For example, current velocity guilds detected fish community changes in Potato Creek because the reconstruction dramatically altered flow, whereas no changes were detected in Juday Creek using this metric. Furthermore, the use of multiple population- and community-level metrics to evaluate biotic response allowed conclusions to be drawn that would not have been possible had only a few population-level variables been evaluated.

Although efforts to restore sinuosity to straightened streams have occurred predominantly in Europe (Kondolf 1996), large-scale restorations such as for the Kissimmee River in Florida (Dahm et al. 1995) are introducing this approach to North America. Stream restorations provide unique opportunities to assess our current understanding of stream ecosystem structure and function, and to test our abilities to successfully restore degraded ecosystems. In addition, stream restorations can be viewed as large-scale experiments to test ecological theory. Linkages between habitat complexity and community structure may be an especially profitable area of research.

A website has been created to keep the public informed on the Juday and Potato Creek restorations. Background information on the restorations, ongoing research, general results, and progress reports are available on the website. The website can be viewed best with Internet Explorer at www.nd.edu/~strmeco. In addition, this research has been presented at regional and international scientific meetings (i.e., North American Benthological Society 1999, 2000, 2001; Midwest Fish and Wildlife Conference 2000; Society for Ecological Restoration 1999).

Basic Information

Title:	Utilization of a Constructed Wetland to Improve Water Quality in a Suburban Setting
Project Number:	04-2000
Start Date:	3/1/2000
End Date:	2/28/2001
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Surface Water
Descriptors:	Urban water quality monitoring, nonpoint source pollution management
Lead Institute:	Purdue University
Principal Investigators:	Ronald F Turco, Zac Reicher

Publication

1. Poole, Vickie L., Jonathan M. Harbor, Ronald F. Turco Jr., Zachary J. Reicher. 2000. Water quality management of a golf course using constructed wetlands: in Abstracts with Programs, 34th Annual Meeting of the North-Central Section of the Geological Society of America, April 6-7, 2000, vol. 32, no. 4.
2. Stofleth, John, Vickie L. Poole, Jon S. Harbor. 2000. In Abstracts with Programs, 34th Annual Meeting of the North-Central Section of the Geological Society of America, April 6-7, 2000, vol. 32, no. 4.
3. Poole, Vickie L., Zac Reicher, Ron Turco, and Jon Harbor. 1998. Impact of a mixed-use constructed wetland on managing non-point source pollution: in Proceedings of the 1998 Environmental Symposium of the Environmental Sciences and Engineering Institute, September 24, 1998, p. 39 (html), Purdue University, West Lafayette, IN

Problem and Research Objectives:
Prior to reconstruction of Purdue's Kampen Golf Course, untreated runoff from the adjacent commercial and residential neighborhood was piped under the old course through drainage tiles directly to the Celery Bog, a recovering natural wetland and nature area. As part of the reconstruction of the course runoff from the urban area was re-directed, along with golf course tile drainage, through a series of constructed wetlands on the golf course. The major objective of this study is to determine the effectiveness of the constructed wetland system in improving the quality of water entering and exiting the golf course system. Additionally, the regeneration of water supplies for golf course use will be evaluated.

Methodology

Water Quality Monitoring
After construction of the Kampen Course was finished in 1998, automatic water samplers were installed at six points throughout the wetland system. The samplers were located to track the progress of water as it enters the east edge of the course, travels through the wetland system, and exits the far northwest edge of the course (sites 1 through 6, Figure 1). The water is continuously measured during non-freezing weather for temperature, pH, dissolved oxygen, and conductivity using a YSI Model 600R multiparameter probe connected to each sampler.

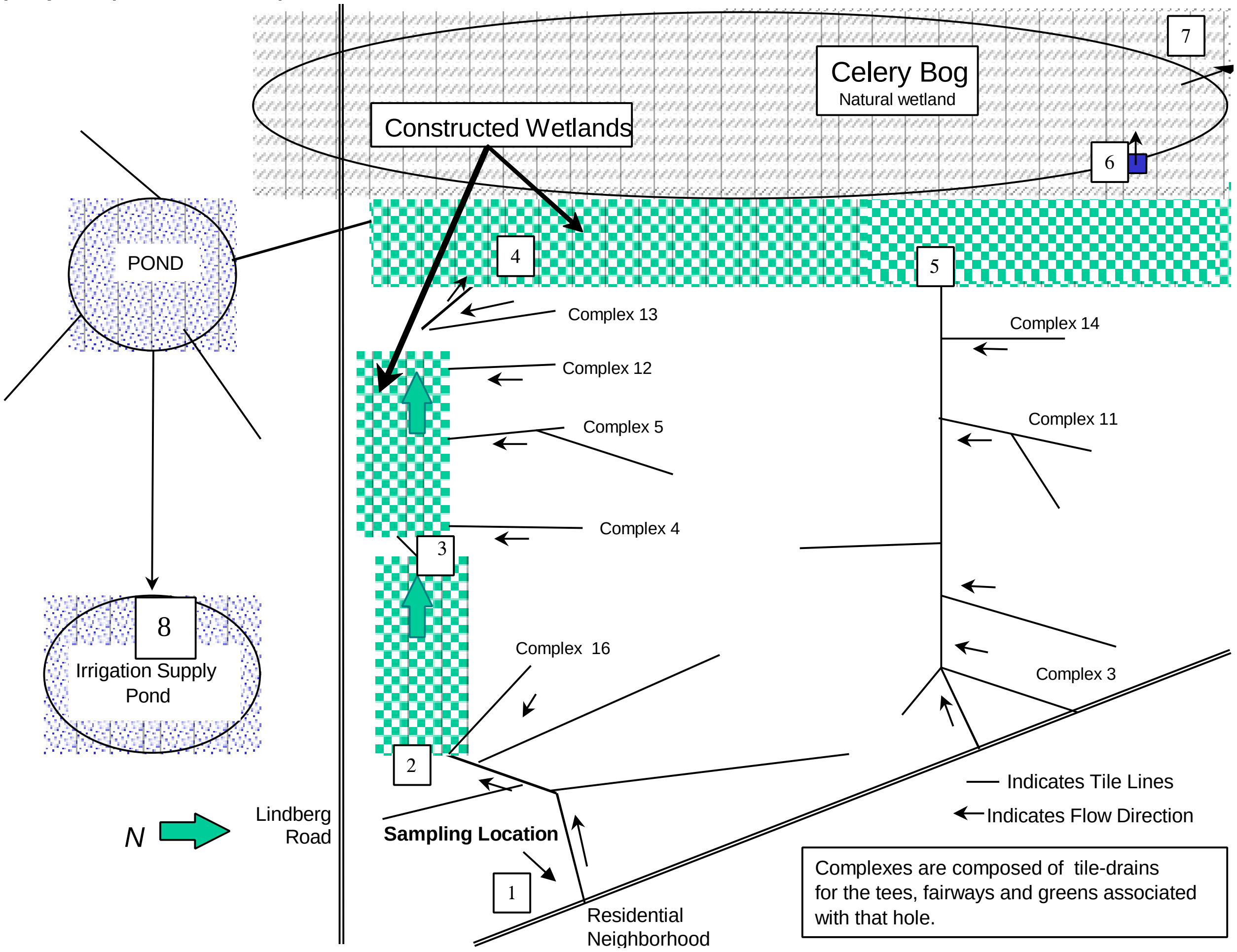
The water quality sampling design is a continuation of monitoring efforts begun in 1999. The major emphasis in this study is on typical nonpoint pollutants including nutrients and suspended solids that may be reduced by the establishment of BMPs such as constructed wetlands. ISCO samplers (ISCO 6700) are used to log data and collect samples during significant storm events and during base flow times.

Throughout 1999 and 2000, the focus of water sampling was storm-based, following the thought that the highest concentration of potential pollutants is washed from surfaces and appears in the "first flush" of stormwater runoff. The ISCO samplers were used to collect water samples representing the entire storm hydrograph. Selected storm hydrograph samples were analyzed by staff of the Limnology Laboratory, Dept. of Forestry and Natural Resources, for total suspended solid (TSS), total phosphorus, total Kjeldahl nitrogen (TKN), hardness, anions (chloride, fluoride, sulfate, nitrate, nitrite, etc.), and cations (ammonia, calcium, magnesium, potassium, etc.). Additionally, "first-flush" storm samples from selected events were collected and transported to Heritage Environmental Labs, Inc. in Indianapolis for more detailed chemical analysis. These samples were analyzed for cations, anions, 13 organophosphate pesticides such as the dinitrioaniline preemergence herbicides (pendimethalin), 27 organochlorine pesticides such as dieldren, 6 chlorinated herbicides like 2,4-D, and other potential contaminants such as nutrients, pesticides, salt, metals, petroleum products, etc.

Beginning in April 2001, the focus of water sampling has shifted to include detailed monitoring of base-flow water quality. During storm events, the volume of urban runoff dominates the constructed wetland system and residence time is considerably shorter than during times of base-flow. This data will allow us to compare the functioning of the wetland system under "normal" flow conditions as well as during special flow events.

In fiscal year 2000, five storms were chosen for storm hydrograph sample analysis (from June to December), and two were chosen for detailed analysis by Heritage Labs, Inc. (summer and fall). Two non-storm based samplings have taken place in April and June of 2001. Results have not yet been received for the June sampling.

Figure 1. Schematic of water sampling sites in Kampen Course water monitoring project (not to scale)



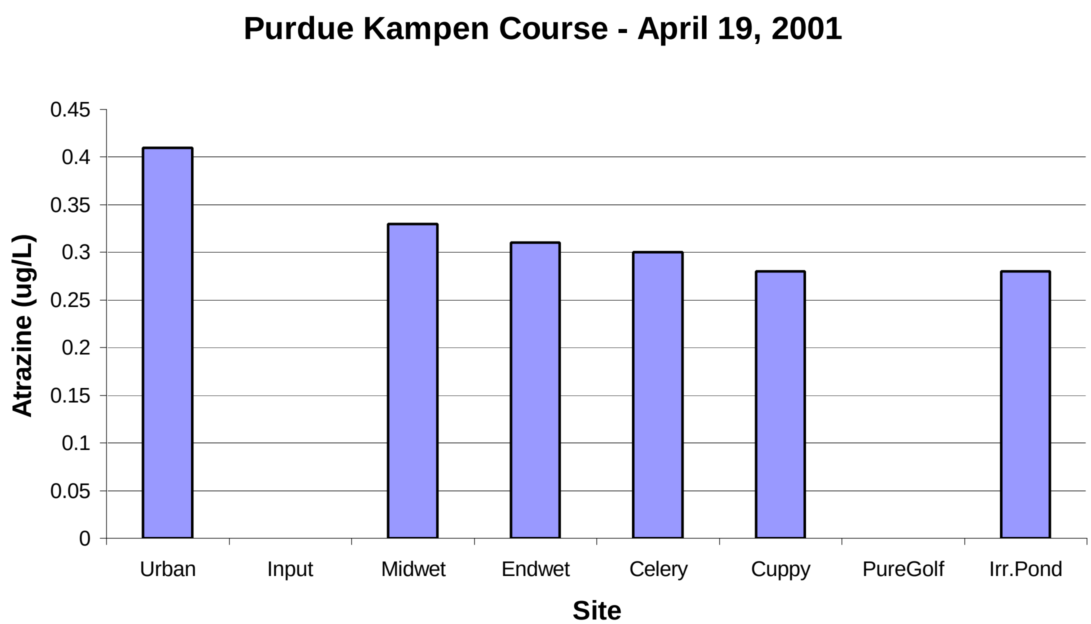
Principal Findings and Significance

As to be expected, there is a great deal of variability in the system due in part to the season and to the effects of storm-flow. In essence, concentration trap efficiencies in the summer and fall of 2000 mirrored those of 1999 in that there were more parameters with negative trap efficiencies in the late fall than in the summer. Nutrients continue to have positive trap efficiencies until vegetation dies out. Concentration trap efficiencies from the April 2001 non-storm based sampling were almost uniformly positive; the principal exceptions were sulfate, magnesium and total organic carbon. Sulfate and magnesium are the only parameters that have exhibited consistently negative concentration trap efficiencies, regardless of when samples are collected. Further analysis is necessary to determine the mechanism of these parameters production/release.

No unusually high levels of any of a wide array of potential pollutants, including pesticides and metals were detected at the golf course sampling sites. Surprisingly, even from the urban runoff there has been no measurable oil and grease. Heavy metals of concern, such as mercury and lead, are below detection limits in all samples. However, low levels of Atrazine were detected in water entering the golf course system from the urban area in June of 1998 and April 2001.

The April 2001 sampling represents the first widespread detection of very low concentrations of an herbicide in the golf course system and Cuppy-McClure watershed. Previous reports of Atrazine were single uncorrelated detections at the urban input site (Site 1, Fig. 1) and at the mouth of the watershed (Cuppy site) in previous years. The April 2001 sampling is the earliest detailed sampling to take place and the first non-storm based one. Results indicate that low concentrations of Atrazine have entered the golf course system from the adjacent commercial/urban area. Concentrations of Atrazine decrease as the urban input water (Site 1, Urban) moves through the constructed wetland system (Site 2 - Input; Site 3 – Midwet, Site 4 – Endwet, Site 5 – Celery) and is mixed with golf course tile drainage (Figure 2). This indicates that the golf course is not the source of the Atrazine found in the watershed this spring, and that the golf course wetland system is functioning to decrease levels of the herbicide entering it from the urban area. It is emphasized that the concentrations of Atrazine detected in these samples (0.41 to 0.3 μg/L) are far below the Office of Drinking Water short term HALs for atrazine of 100 μg/L.

Figure 2. Concentrations of Atrazine reported from spring non-storm based sampling. Detection limit for Atrazine is 0.1 μg/L



Information Transfer Program

The Indiana Water Resources Research Center does not sponsor a separate information transfer program. Rather, our efforts in designing and implementing the intranet of the National Institutes for Water Resources (NIWR) are focused towards moving the organization forward in the use of advanced information technologies. To the extent that our innovation in this area can assist the other water institutes in expanding their influence within the professional and academic water resources communities, our service in this dimension is well represented.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	0	0	0	0	0
Ph.D.	0	0	0	1	1
Post-Doc.	0	0	0	0	0
Total	0	0	0	1	1

Notable Awards and Achievements

The Indiana Water Resources Research Center received a plaque honoring their involvement in the development of the NIWR Intranet System. This award was presented to Jeff Wright at the National Institutes for Water Resources Annual Meeting.

Publications from Prior Projects