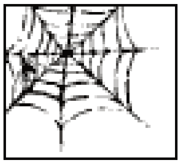
United States Environmental Protection Agency
Office of Water

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat



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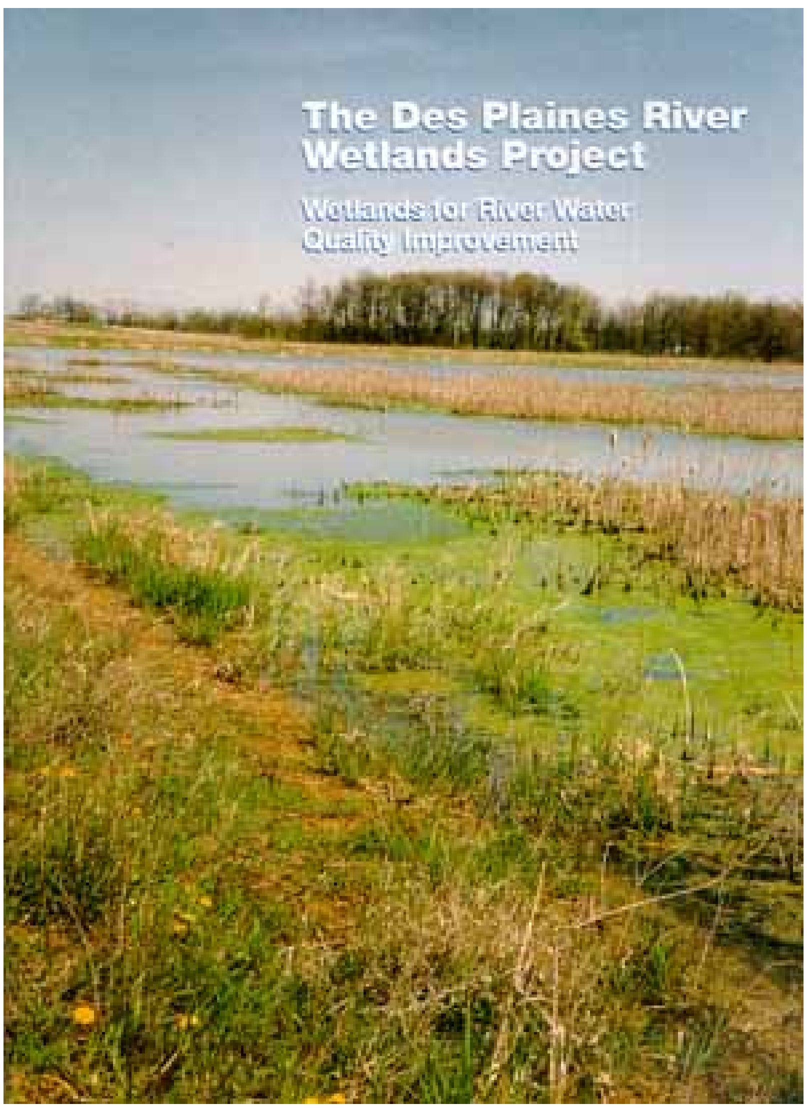
Des Plaines River, IL - The Des Plains River Wetlands Project: Wetlands for River Water Quality Improvement



System Description

The Des Plaines River Wetlands Demonstration Project is designed to produce the criteria necessary for rebuilding our river systems through the use of wetlands and for developing management programs for the continued operation of the new structures. The research program is assessing wetland functions through large-scale experimentation, controlled manipulation of flow rates and water depths, testing of soil conditions, and the employment of a wide variety of native plant communities.

Wetlands EW3 and EW4 are encircled by access roads, and bordered by US Highway 41 (bottom) and Wadsworth Road (left). Flow enters EW3 from the left, and enters EW4 from the bottom. Both discharge to a swale (top right), which is connected to the Des Plaines River. On this aerial infrared photo, water is black and cattails are dark red.

Four wetlands have been constructed near Wadsworth, Illinois, for purposes of river water quality improvement. The river drains an agricultural and urban watershed, and carries a non-point source contaminant load of sediment, nutrients and agricultural chemicals. The site is located 35 miles north of Chicago. It incorporates 2.8 miles of the upper Des Plaines River and 450 acres of riparian land. The river flows south, draining 200 square miles in southern Wisconsin and northeastern Illinois. Eighty percent of the watershed is agricultural and 20 percent urban. The river is polluted with non-point source contaminants from a variety of land use activities, and point source contaminants from small domestic treatment plants. In support of previous agricultural uses, low-lying portions of the site were drained by means of tiles. Past uses of the site included pasture and a Christmas tree farm which resulted in the demise of most of the original wetlands and associated fauna and flora.

Water is pumped from the river to the wetlands, from a point just south of Wadsworth Road. This energy intensive alternative was necessary because of site constraints, and because of the desire to explore a wide range of hydraulic conditions. Gravity diversion would be a preferred alternative in most applications of this technology. Water leaving the wetlands returns to the river via grassy swales.

Hydrology

The river is a "good old muddy midwestern stream." Shown here at average flow, it regularly floods a large amount of bottom land. In the summer of 1988, a severe drought caused it to dry to a disconnected string of pools.

The Des Plaines River enters the site from the north, passing under the Wadsworth Road bridge. It is relatively wide and shallow under normal flow conditions—100 feet wide and about 2 feet deep. This reach exhibits channel stability, primarily because of the low energy state of the river. Stream velocities average less than 1 foot per second. The gradient is 1.2 feet per mile.

About 15% of the variable stream flow is pumped to the wetlands, and allowed to return from the wetlands to the river through control structures followed by vegetated channels. Native wetland plants have been established, ranging from cattail, bulrushes, water lilies, and arrowhead to duckweed and algae. Pumping began in the 1989, and has continued during the ensuing spring, summer and fall periods. The experimental design provides for different hydraulic loading rates, ranging from 2 to 24 inches per week. Intensive wetland research began in late summer 1989, and continues to present.

The hydrology of the wetland complex has been studied extensively. Groundwater investigations showed a relatively complex local flow pattern, with some groundwater interactions with the river. Wetland EW5 leaks to groundwater, as does wetland EW5 to a minor extent. For WY 1990 (October 1989-September 1990), precipitation and evapotranspiration were equal.

Pumping occurred for all weeks in 1990, but was discontinued in winter in subsequent years. The pump is run on weekdays, for a prescheduled period. In WY 1990, it was run 10.5% of the time. Outflow from the wetlands is controlled by weirs. Thus the hydrologic regime is cyclic, with increasing water levels and flows during the few daily hours of pumping, followed by a lowering of water levels and a slowing of flows during the off hours.

Pumping creates a fountain effect at the inlet to each wetland.

WY1990 (cm/day)

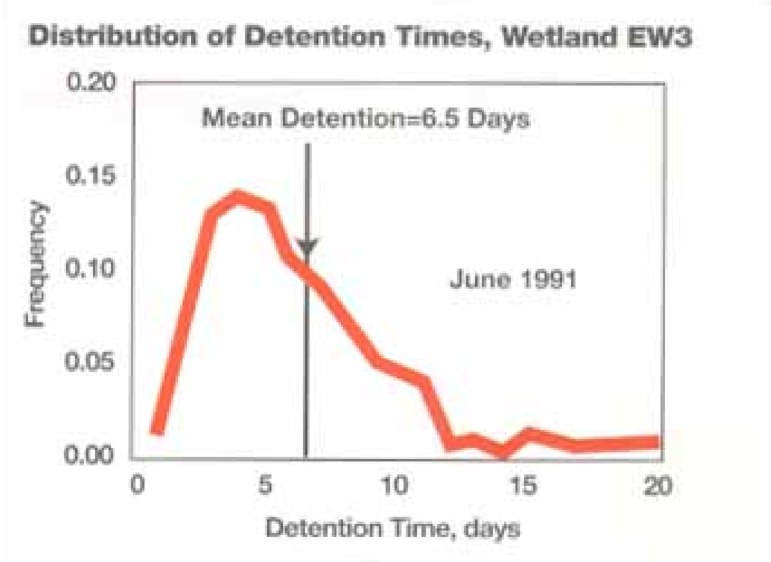
	EW3	EW4	EW5	EW6
Inflows				
Surface Inflow	5.36	1.46	5.01	2.78

Precipitation	0.26	0.26	0.26	0.26
Outflows				
Discharge	5.36	1.46	4.80	0.35
Evapotranspiration	0.26	0.26	0.26	0.26
Seepage	0.00	0.00	0.21	2.43

River enters the site from the north, passing under the Wadsworth Road bridge. It is relatively wide and shallow under normal flow conditions 100 feet wide and about 2 feet deep. This reach exhibits channel stability, primarily because of the low energy state of the river. Stream velocities average less than 1 foot per second. The gradient is 1.2 feet per mile.

System Performance

The wetland internal flow patterns are not ideal in any sense of the word. The nominal detention times in the wetlands range from one to three weeks under moderate to high flow conditions. Some of the pumped water moves quickly toward the outlet, and reaches it in about one days time. Other portions of the pumped water are trapped in the litter and floc near the wetland bottom. Still other portions are slowed by plant clumps, or blown off course by the wind. The net effect is that some water takes three times as long as the average to find its way out of the wetland.

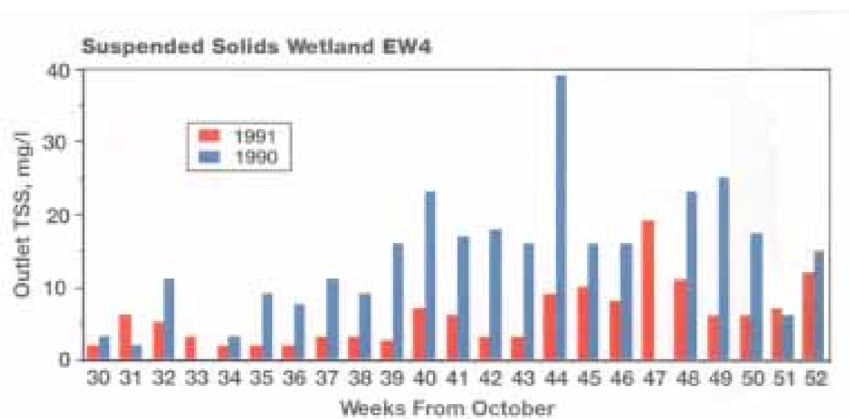


Tracer studies have been run at Des Plaines, using lithium chloride as the tracer material. A sudden dump of dissolved lithium is made into the wetland inflow. The outflow is then analyzed for the lithium, which appears at varying concentrations and at various times after the dump. These tests have established that the degree of mixing within the wetlands is higher than expected. But surprisingly, there is not a great deal of difference between wetlands, even though they differ in shape.

Suspended Solids In and Out of the Des Plaines Wetlands (mg/l)

	Inlet	EW3	EW4	EW5	EW6
FA89	8.0	2.0	2.4	2.6	3.0
WI89	7.1	5.0	3.6	4.2	3.0
SP90	24.2	5.5	4.5	2.9	3.3
SU90	47.7	5.7	14.9	4.3	13.9
FA90	50.1	10.8	7.4	5.4	4.4
SP91	63.9	5.8	7.4	2.4	6.2
SU91	123	6.0	6.8	3.2	7.8
FA91	66.0	10.8	6.7	25.8	NF
AVG	**48.8**	**6.5**	**6.7**	**4.9**	**6.1**
% Removal		**87%**	**86%**	**90%**	**87%**

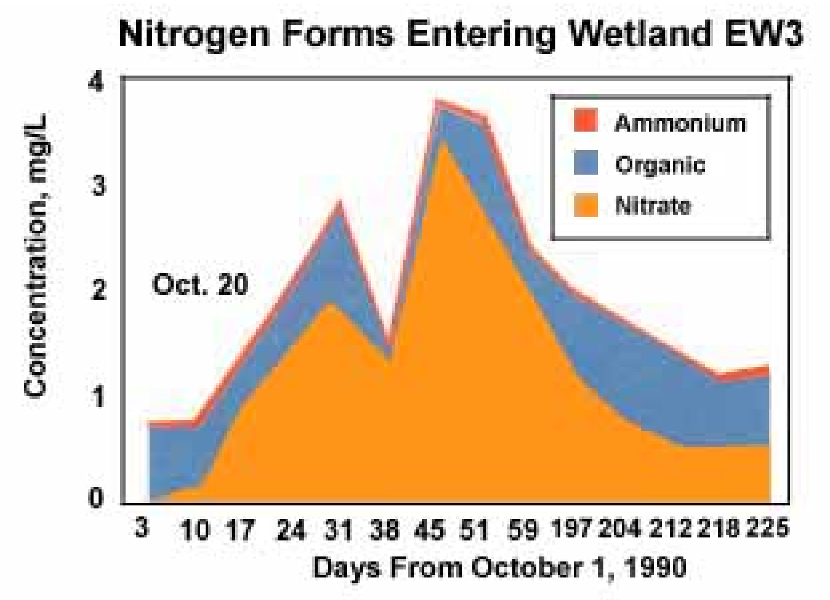
The primary water quality problem of the river is associated with turbidity. With a mean concentration of 59 parts per million, over 5,000 tons of suspended solids enter the site per year via the Des Plaines River and Mill Creek. Seventy-five percent of these solids are inorganic and 95 percent are less than 63 microns in size. Sediment removal efficiencies ranged from 86-100% for the four cells during summer, and from 38-95% during winter.

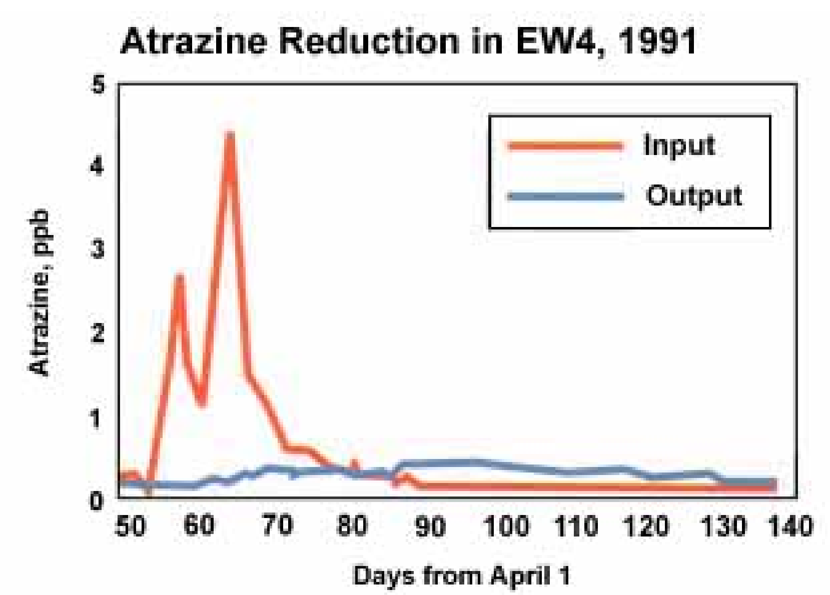


A fish story developed in 1990. The solids in the wetland effluents were steadily increasing with each passing week. The source of the problem was found: a large number of carp were growing up in the wetlands. These fish foraged in the wetland sediments, causing resuspension of solids. They entered as fry in the pumped water, and grew to 8-10 inches over the first two years of the project. The solution was to draw down the wetland water levels, in winter 1990-91, and freeze out the carp. Solids removal returned to the previous high levels of efficiency.

Carp rooted up sediments and impaired sediment removal efficiency. They were frozen out and removed.

Water Quality Responses





Other observed river water quality problems included violations of the state water quality standards for iron, copper, and fecal coliforms. These pollutants are found only occasionally, and not in dangerously high concentrations. Although not detected in amounts exceeding the federal Food and Drug Administration's criteria, dieldrin, DDT and PCBs have been found in fish flesh samples. DDT, DDE and PCBs were also found in low concentrations in the river borne sediments. The

Suspended Solids In and Out of the Des Plaines Wetlands (mg/l)

	Inlet	EW3	EW4	EW5	EW6
FA89	0.052	0.018	0.013	0.014	0.018
WI89	0.073	0.053	0.030	0.058	0.024
SP90	0.057	0.044	0.015	0.017	0.023

old pesticides are pervasive everywhere else in the environment, and so will be in these wetlands. The river bears a significant nutrient load, as evidenced by nitrate and phosphorus. These fertilizers peak seasonally, corresponding to runoff timing and land use practices within the watershed. Agricultural practices within the basin produce pollution with atrazine, at concentrations which peak in excess of the federal drinking water standard. According to the results of benthic surveys, the stream is classified as semi-polluted.

SU90	0.117	0.038	0.055	0.035	0.062
FA90	0.131	0.024	0.007	0.017	0.011
SP91	0.089	0.003	0.002	0.001	0.002
SU91	0.119	0.010	0.010	0.010	0.009
AVG	**0.091**	**0.027**	**0.019**	**0.022**	**0.021**
% Removal		**65%**	**78%**	**73%**	**75%**

Phosphorus removal efficiencies average 65–80%. However, efficiency is lower in winter and higher in summer. That is partly because the riverine concentrations of phosphorus are very low in winter, and partly because biological processes slow in the cold temperatures. Winter runoff in the watershed is overland, over frozen soils or ice and snow. The result is low phosphorus in the river in winter.

Most phosphorus enters the wetlands associated with mineral suspended solids. These solids settle quickly, and may not freely exchange their phosphorus with the wetland waters. In addition, there is a large biotic cycle of growth, death and decomposition at work, which leaves a residual of organic sedimentary material. The deposition from this cycle exceeds the deposition of incoming river solids by a wide margin. Both processes immobilize phosphorus in these wetlands. During the early years, phosphorus is also tied up in the new biomass associated with these developing ecosystems.

Nitrate Nitrogen Reduction, (mg/l)

	Inlet	EW3	EW4	EW5	EW6
FA89	2.46	1.46	0.04	1.27	0.08
WI89	2.15	0.67	0.17	1.51	0.25
1990	1.87	0.54	0.24	0.53	0.32
1991	1.22	0.23	0.10	0.18	0.18
AVG	**1.80**	**0.61**	**0.15**	**0.70**	**0.22**
AVG %		**66%**	**92%**	**61%**	**88%**

There are a variety of nitrogen forms in the river water. About 0.6 mg/l of organic nitrogen enter the wetlands, and the same amount leaves. Very low ammonium nitrogen concentrations are found in both river and wetland waters: about 0.05 mg/l. Nitrate varies seasonally in the river, in response to urban and agricultural practices. High spring and fall concentrations are echoed by similar variations in the nitrate content of the wetland effluent waters. However, in the warm seasons, a considerable amount of the incoming nitrate is removed, presumably due to denitrification. This microbially mediated process appears to be more efficient in the wetlands with lower hydraulic loading rate, which is equivalent to increased detention time since depths are comparable. Thus the overall effect of the wetlands is to control the nitrate in the water when sufficient contact time is available.

Atrazine, a triazine herbicide, exists in many streams in the upper midwestern part of the United States, including the Des Plaines River, due to use patterns in the watershed. The atrazine-wetland interaction is very complex, including removal from the area by convection in the water, loss of chemical identity by hydrolysis to hydroxytriazine and dealkylation, and sorption on wetland sediments and litter. Atrazine transport, sorption and identity loss were studied at the site, and in accompanying laboratory work. Sorption was effective for soils and sediments, but the more organic materials, such as litter, showed a stronger affinity for atrazine than the mineral base soils of the wetland cells at Des Plaines.

Atrazine was found to degrade on those sediments according to a first order rate law. Therefore, outflows from the Des Plaines wetland cells contained reduced amounts of atrazine compared to the river water inputs. During 1991, atrazine peaked in the river due to two rain events. Only about 25% of the incoming atrazine was removed in wetland cell EW3, but 95% was removed in wetland cell EW4. The explanation is that the detention time in EW4 is longer than in EW3.

Vegetation Responses

Water clarity is generally excellent at the wetland outflow.

Efforts at vegetation establishment were initially thwarted by the extreme drought conditions of 1988. The planting of white water lily (*Nymphea odorata*) showed small success, and American water lotus (*Nelumbo lutea*) did not survive.

The development of the macrophyte plant communities has been monitored from project startup. Sixteen 2m x 2m permanent quadrats were established in each wetland cell. Data were acquired on species composition and biomass for all plants in each quadrat. Plants were individually measured, and a correlation between dry weight and leaf size was developed. Thus biomass could be determined non-destructively. There was an overall increase in species as volunteer wetland vegetation replaced the terrestrial vegetation of pre-pumping.

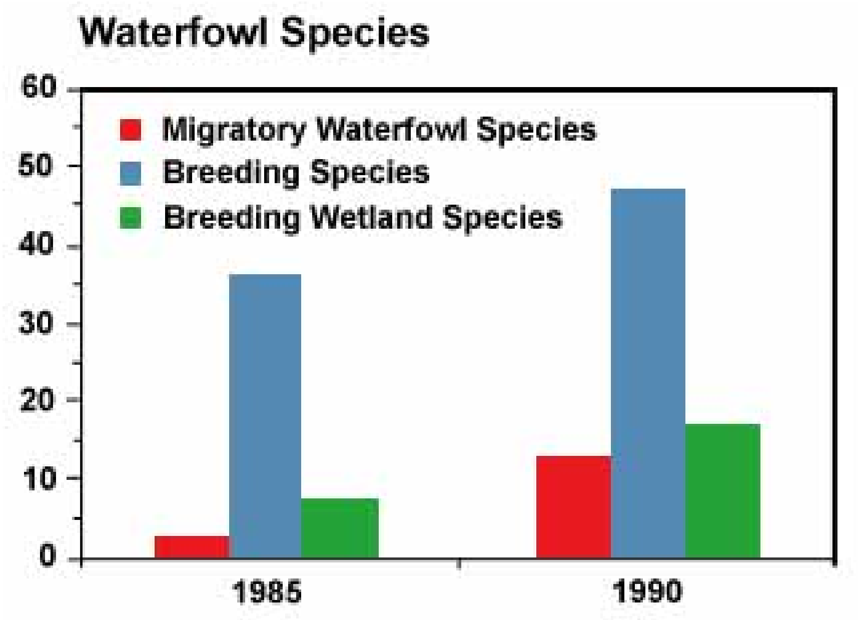
Number of Species of Wetland Plants

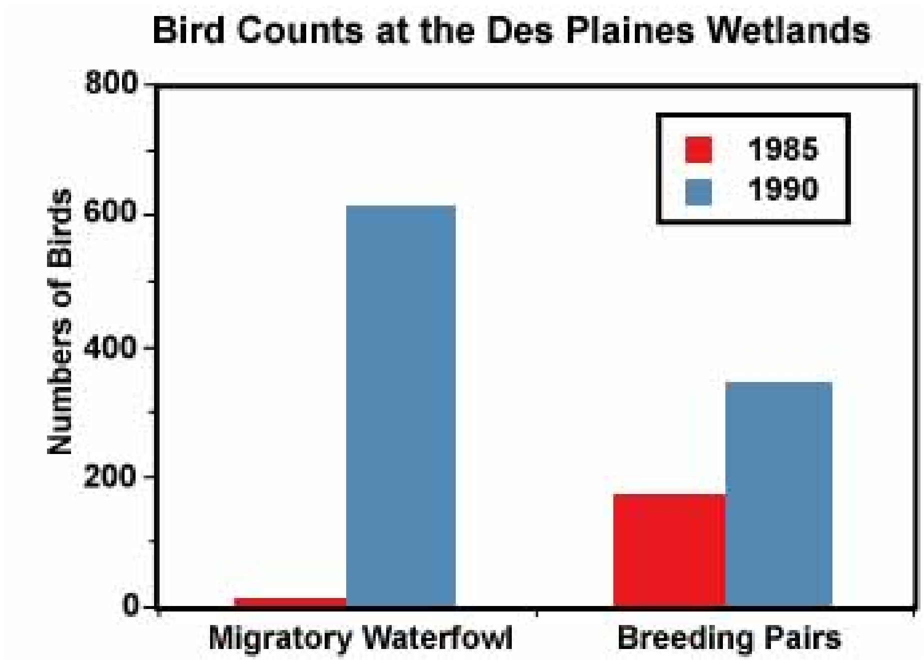
	EW3	EW4	EW5	EW6
1988	2	21	22	29
1989	9	19	14	17
1990	26	28	20	26
1991	25	33	22	27

Fourteen species were observed in 1990 that were not present in 1989, and ten species from 1989 did not reappear; these later being mostly upland species.

The first year of inundation caused the death of many upland species, such as cottonwood (Populus deltoides). The growing seasons of 1989, 1990 and 1991 all displayed an increase in the amount of cattail (Typha spp.). Productivity increased from 200-400 dry grams per square meter in 1989 to 600-800 in 1990. The growing season of 1990 produced extensive blooms of macrophytic algae, predominantly Cladaphora.

Wildlife Use





Bird populations have grown much larger than in the pre-wetlands period for the site. For migratory waterfowl, there has been a 500% increase in the number of species, and a 4500% increase in the number of individuals from 1985 to 1990. Forty-seven species of birds nested on the site in 1990, a 27% increase over preproject numbers.

The fall 1990 bird survey turned up a number of interesting species, including the state endangered pied-billed grebe and black-crowned night heron, and also the great egret, American bittern, and the sharp-shinned hawk. The state-endangered yellow-headed blackbird and least bittern nest successfully at the site.

Muskrats have moved in, and constructed both dwelling houses and feeding platforms. And, beaver are now resident in the wetlands. They chewed off quadrat corner posts—most of the 256 posts initially placed. They attempted to dam the wetland EW3 outflow nearly every night in 1992.

Acknowledgements

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ISPE Outstanding Engineering Achievement of 1991: The Des Plaines River Wetlands Demonstration Project

Ecological Society of America: Special Recognition Award, 1993

Research Groups

Project research has been conducted by several organizations:

College of Lake County
Wetlands Research, Inc.
Iowa State University
M. C. Herp Surveys
North Dakota State University
Northeastern Illinois Planning Commission
Northern Illinois University
Northwestern University
The Illinois State Water Survey
The Illinois Institute of Technology
The Illinois State Geological Survey
The Morton Arboretum
The Ohio State University
The University of Michigan
Western Illinois University

Blue horizon marker particles just after placement. As sediments accumulate, these marker particules become buried. The amount of overlying sediment may then be determined at later times.

For the project bibliography, project reports or other information, contact the not-for-profit coordinating organization:

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