New Jersey Pinelands Commission

NEW JERSEY PINELANDS LONG-TERM ENVIRONMENTAL MONITORING PROGRAM

A FIVE-YEAR (2000-2004) REVIEW AND SUMMARY OF UPCOMING ACTIVITIES

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DECEMBER 2004

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INTRODUCTION

In the early 1990's, the Commission initiated a long-term environmental-monitoring program with the ultimate goal of evaluating the ecological consequences of the Comprehensive Management Plan. The main objectives of the program are to characterize the effect of existing land-use patterns on aquatic and wetland resources and to monitor long-term changes in these resources. This comprehensive progress report describes the work completed from January 2000 through December 2004, the current status of the monitoring program, and upcoming activities. A list of all environmental-monitoring program articles and reports completed by Commission scientists since 1992 is given in Appendix 1. Appendix 2 contains a list of current and completed federal grants.

MULLICA RIVER AND GREAT EGG HARBOR RIVER STREAM-DISCHARGE MONITORING PROGRAMS

The Commission and the U. S. Geological Survey (USGS) continued to implement two cooperative stream-gaging programs. The Camden County Municipal Utilities Authority (CCMUA) funded project is designed to determine whether wastewater transfers from the lower Camden County area are affecting stream discharge in portions of the Mullica River basin.

The analytical method used to assess trends in streamflow is based on the approach presented in a study, titled "Detecting base-flow impacts in Coastal Plain streams," that was conducted by Commission staff (Dow 1999) and published in the *Journal of the American Water Resources Association*. An initial trend analysis of streams in the Camden County study area revealed no changes in streamflow during the period 1991-1998. Staff completed a second trend analysis for the period April 1991 through September 2002 (Procopio 2003). Decreases in streamflows were detected within the study area and the changes appeared to coincide with an increase in wastewater flows to the Delaware River. However, for most of the study sites that showed a significant decrease in flow, the annual percentage decreases estimated through the analysis far exceeded the amount of water withdrawn.

Due to funding limitations, water-quality and groundwater-level monitoring programs were discontinued in 2002. In 2004, the agreement between the Commission and the CCMUA was amended to continue the stream-flow monitoring program through March 2008, at which time the need for a continuation of the program will be determined.

The Commission and the USGS are conducting a similar stream-gaging project at five stream stations in the Upper Great Egg Harbor River basin in cooperation with the Monroe Township Utilities Authority. Staff recently completed an analysis of stream-flow trends in this study area for the period 1991-2003. The results will be released in early 2005.

MULLICA RIVER BASIN AND RANCOCAS CREEK BASIN STUDIES

The Mullica River basin was the initial focus of the long-term environmental monitoring program. A comprehensive report describing the results of the Commission's landscape, water-resources, and wetland-community monitoring program in the basin was released in December 2001 (Zampella et al. 2001). Water-resources and wetland-communities studied included water quality, stream discharge, wetland groundwater levels, Atlantic white cedar wetlands, stream and pond vegetation, fish communities, and anuran (frog and toad) assemblages. Several published studies (Zampella 1994, Lathrop et al. 1997, Zampella and Lathrop 1997, Zampella and Laidig 1997, Zampella and Bunnell 1998, Dow 1999, Bunnell and Zampella 1999, Laidig and Zampella 1999, Zampella et al. 1999, Dow and Zampella 2000, Zampella and Bunnell 2000, Bunnell et al. 2001, Laidig et al. 2001) contributed to the completion of the comprehensive study of the Mullica River basin.

A second report describing the ecological status of surface waters in the Rancocas Creek basin was released in 2003 (Zampella et al. 2003). Most of the Rancocas Creek monitoring sites were co-located with the NJDEP AMNET (Ambient Biomonitoring Network) and IBI (Index of Biotic Integrity) monitoring sites.

The data presented in the Mullica River and Rancocas Creek reports clearly demonstrated a relationship between aquatic and wetland resources and land-use related watershed disturbances. In both studies, the surface-water quality and biological communities found in forested stream basins contrasted with those attributes found in basins with a high percentage of altered land (developed land and upland agriculture). Acid waters and typical Pinelands biological communities characterized survey sites in forest-dominated stream basins. Elevated pH and specific conductance and nonnative plant and animal species were associated with stream basins with a high percentage of altered lands.

Although the results of the two basin studies were similar, differences in geology, geography, and land-use patterns were given greater consideration when interpreting the Rancocas Creek data. In addition to the Cohansey Formation, which dominated the Mullica River Basin, the Kirkwood Formation and several Inner Coastal Plain formations (primarily the Vincentown Formation and the Manasquan Formation) outcrop in the Rancocas Basin. To account for the greater geologic diversity in the Rancocas Creek Basin, variations in surficial geology were included in the assessment of Rancocas Creek water-quality variables.

Unlike the Mullica River Basin, where upland agriculture is a dominant or a co-dominant altered-land use, upland agriculture is a minor land use in a majority of the drainage basins associated with Rancocas Creek Basin monitoring sites. Thus, the relationship between water quality and biological-community gradients and altered land in the Rancocas Creek Basin was due largely to variations in the extent of developed land. Overall, the effect of land-use on water-quality appeared to overshadow that of geology.

In both the Mullica River and Rancocas Creek basins, pH and specific conductance increased in relation to the percentage of altered land (developed land and upland agriculture) in a drainage basin. Nitrate concentrations were also higher in the more heavily altered basins. The composition of stream-fish assemblages varied along a watershed-disturbance gradient characterized by increasing in pH, specific conductance, and the percentage of altered land in a basin. The percentage of native species decreased and the percentage of nonnative species increased along this disturbance gradient. Similar changes in impoundment-fish assemblages were associated with variations in pH.

Conditions at sites where native anuran species were heard contrasted with those observed at sites that supported only bullfrogs. Compared with carpenter frogs, bullfrogs were found at impoundments with elevated pH and specific conductance and a high percentage of altered land in the associated drainage basin.

Similar stream-vegetation patterns were observed in the Mullica River and Rancocas Creek basins. Variations in stream-vegetation patterns, represented by a decrease in the percentage of Witmer Stone's Pine Barrens District species, an increase in the percentage of non-Pinelands species (primarily species associated with Stone's Middle District), and an increase in the percentage of disturbance-indicator plant species, were associated primarily with increasing pH, specific conductance, and the percentage of developed land in a basin. However, establishing a clear relationship between land-use disturbance and non-Pinelands or disturbance-indicator plants in the Rancocas Creek Basin was complicated because, unlike the Mullica River Basin, a significant portion of the Rancocas Creek Basin is located within or near the approximate boundary of the Middle District. Regardless, Middle District plants were generally associated with waters characterized by elevated pH.

The results of the Mullica River basin study provide a sound scientific foundation for the Commission's watershed-planning efforts in the Mullica River basin. In 2004, the planning staff used the relationships between land use, water quality, and biological communities to characterize the current and future condition of water resources in the basin. The results of the Mullica River basin study also established the protocols for evaluating the status of other Pinelands stream systems.

The Mullica River and Rancocas Creek basin data were invaluable in revising the New Jersey Department of Environmental Protection's (NJDEP) Integrated List of Waterbodies, which rates streams and lakes throughout the state. Commission staff ranked Mullica River and Rancocas Creek waterbodies based on the composition of biological communities, and the NJDEP used these ranks to classify Pinelands streams.

A paper, based on the landscape chapter in the Mullica River basin report and titled "Landscape changes in the Mullica River Basin of the Pinelands National Reserve, New Jersey, USA," was published in the journal *Environmental Management* (Bunnell et al. 2003). In this study, we prepared detailed, land-cover maps within randomly selected aerial-photograph plots for a major watershed in the Reserve. We used these land-cover maps to quantify changes in landscape composition and structure (i.e., patch size, patch area, and number of patches) and characterize land-cover transitions in the basin between 1979 and 1991. Because the study period represented the first 12 years of the regional-planning effort in the Reserve, we evaluated the relationship between land-cover transitions and Commission management-area designations that permit different land-use intensities. Although landscape composition was similar in 1979 and 1991, we found an increase in the total area and number of developed-land, managed-grassland, and barren-land patches. An increase in the number of patches and a decrease in the total area and patch size for forest and for all patches regardless of cover type indicated fragmentation of forest and the landscape as a whole occurred during the study period. The major land-cover transitions that occurred during the period were the loss of forest to development and associated cover types and the conversion of one agricultural type to another. Overall, land-cover transitions during the period were found to be consistent with the Commission management-area designations, which indicated that the regional-planning effort has been successful in directing human activities to appropriate areas of the basin.

A second published study was based on a Pine Barrens treefrog habitat-characterization study completed as part of the Mullica River basin assessment (Laidig et al. 2001). The study, titled "Functional equivalency of natural and excavated coastal plain ponds," appeared in *Wetlands* (Zampella and Laidig 2003). In this study, we compared hydrologic, water-quality, and vegetation-composition characteristics of nine natural ponds with those of four small, well-established excavated basins that are at least 50 years old. Based on water-depth-fluctuation patterns and the similarity of most hydrologic indices, including high-water pond area, mean water depth, area of exposed substrate (drawdown), and the presence of a clay lens, the excavated ponds were similar to the natural reference wetlands. However, steeper bank slopes found at most of the excavated ponds affected nearshore water depths and resulted in the absence of plant zonation that characterizes coastal plain ponds. Water-quality, represented by pH, specific conductance, and total organic carbon, differed between pond types. The pH and specific conductance of the excavated ponds were higher and total organic carbon concentrations were lower compared with the natural ponds. These differences may be attributed to landscape setting, reflected by adjacent vegetation and contrasting plant zonation. Both total and herbaceous species richness were greater in the excavated ponds. Although overall species composition differed between the two pond types, the flora of the created wetlands was similar to that of coastal plain ponds found in other regions and other areas of the Pinelands. The major difference in vegetation composition between ponds was both the lack of distinct vegetation zonation due to steeper slopes and lower patch-type diversity in the excavated ponds. Most importantly, the excavated ponds supported a native Pinelands species composition.

A third scientific paper, titled "Using multiple indicators to evaluate the ecological integrity of coastal plain streams," was recently submitted to *Environmental Monitoring* for publication (Zampella et al., in review). In this paper, we demonstrate the use of multiple indicators to characterize the ecological integrity of Pinelands streams in relation to human-induced watershed alterations. The individual indicators include pH, specific conductance, stream vegetation and stream-fish, impoundment-fish, and anuran assemblages. We evaluated and compared the utility of the individual and multiple environmental and biological indicators and present a relatively straightforward method for ranking sites. Specific conductance and pH measured at eighty-eight monitoring sites varied in relation to the percentage of altered land (developed land and upland agriculture) within the associated watersheds. With the exception of impoundment fish, the association between altered land and the multiple-indicator scores based on the two water-quality indicators and the four biological indicators was stronger than that displayed by any of the individual variables.

GREAT EGG HARBOR RIVER WATERSHED MANAGEMENT AREA STUDY

Water-quality (pH and specific conductance) sampling at 61 sites in the Great Egg Harbor River Watershed Management Area, which includes the Great Egg Harbor River, Tuckahoe River, Absecon Creek, and Patcong Creek, was completed in March 2003. During 2002, fish were surveyed at 33 stream sites and 11 stream impoundments, frog-vocalization surveys were completed at 44 stream impoundments, and stream vegetation was sampled at 40 stream sites. In 2004, fish were sampled a second time at several stream sites. Data analysis has been completed and a report describing the results of this assessment will be completed in early 2005.

TOMS RIVER BASIN STUDY

Water quality, stream vegetation, fish, and anurans of the Toms River Basin and other Barnegat Bay drainage systems were surveyed in 2003. Monthly pH and specific conductance measurements were completed at 65 stream stations from January 2003 through December 2003. Fish were surveyed at 42 stream sites and 17 stream impoundments, frog-vocalization surveys were completed at 46 stream impoundments, and stream vegetation was sampled at 49 stream sites. A report will be completed in 2005.

CRANBERRY AGRICULTURE AND WETLANDS

In 1999, the Commission received a Wetlands Development Grant from the U. S. Environmental Protection Agency (USEPA) to conduct a study of the potential effect of past and present cranberry agriculture on selected landscape features and aquatic communities in the Mullica River and Rancocas Creek basins. Monitoring was initiated in October 2000. In 2002, water-quality sampling, stream-habitat characterizations and fish, macroinvertebrate, and vegetation surveys were completed and diatoms (algae) were sampled at 17 streams on two occasions. In 2003, a second round of diatom sampling was conducted and streamflow monitoring was concluded. Draft reports describing the preliminary results of the macroinvertebrate, diatom, and stream and landscape patterns studies were submitted to the USEPA in December 2004.

LITTORAL COMMUNITIES

In 2001, the Commission received a Wetlands Development Grant from the USEPA titled, "Monitoring the ecological integrity of Pinelands wetlands: the effect of watershed disturbance on the littoral communities of stream impoundments." The results of this study of littoral (near-shore) biota will allow the existing baseline inventory of Pinelands vegetation, fish, and anuran communities to be expanded to include impoundments and help to refine previously developed land-use/ecological relationship models. To date, growing-season water quality (pH and specific conductance) has been measured at 47 sites from April to October and fish, vegetation, and selected environmental features were surveyed at twenty impoundments.

WATER-LEVEL MONITORING: FORESTED WETLANDS AND COASTAL PLAIN PONDS

Monitoring of growing-season water levels at five pitch pine lowland reference sites continued for the seventeenth year. With the exception of one year, these sites have been monitored continuously since 1987. Growing-season water levels were monitored at 14 coastal plain ponds for the ninth consecutive year (1996-2003). The results of these monitoring programs have been applied directly towards development of the Kirkwood-Cohansey Project work plan (see below) and to preparation of two studies relating hydrology to vegetation (Zampella et al. 1992) and soils (Zampella 1994).

A third, more recent study, titled "Using reference sites and simple linear regression to estimate long-term water levels in coastal plain forests," was published in the *Journal of the American Water Resources Association* (Zampella et al. 2001). In this study, we evaluated the use of simple linear regression and long-term (10 years) stream-gaging and pitch pine lowland water-level data sets to estimate long-term hydroperiods at lowland test sites using short-term (two years) records. Measured and predicted test-site growing-season water levels were similar. Although the results based on the stream gaging site data were similar, the difference between measured and estimated growing-season water levels was greater when stream flows were used to predict forest groundwater levels.

USING MULTIPLE REGRESSION TO RELATE WATER QUALITY TO LAND-USE PATTERNS

Water-quality data collected through the Camden County Municipal Utilities Authority and National Parks Service funded studies of the Mullica River basin were used in an USEPA funded project to quantify the effect of land use on surface-water quality and aquatic communities in the Mullica River basins (Zampella et al. 2002). The same water-quality data were used in a cooperative Rutgers University-Commission study titled "Remotely Sensed Indices of Land-use Intensity for Watershed-level Monitoring." Funding for the Rutgers study was provided by the National Oceanic and Atmospheric Agency's Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) Program.

In the first study, we used 1986 and 1995 NJDEP land-use data, 1995 satellite-derived Landsat Thematic Mapper (TM) land-use data, and multiple regression to relate water quality attributes (pH, specific conductance, calcium, magnesium, chloride, and sulfate) at 25 Mullica River basin stream sites to both the extent and position of all the major land uses in the associated basins. We addressed two primary questions. First, does the position of a land use within a watershed influence the relationship between land use and water quality or land use and aquatic-community composition? Second, do temporal factors influence the relationship between land use and water quality? To assess temporal effects on water quality, we analyzed land-use data from two different time periods (1986 and 1995). We also investigated the effects of using land-use data from different sources and analyzing median versus flow-weighted water-quality data on the relationships between land use and water quality. The study demonstrated that land use is a good predictor of Pinelands water-quality conditions and that the relationships between water quality and land use in the Pinelands are generally not influenced by the land-use data source used, the position of a land use within a watershed, or stream flow conditions. The analyses revealed that the simplest and most practical approaches represent extremely effective predictive tools.

In the second study, we used multiple regression to relate water-quality at Pinelands stream sites to the extent of agriculture, urban land, and impervious surface and lawns associated with urban land. Separate models were developed using four different sets of land-use data including: 1) NJDEP urban land, upland agriculture, and wetland agriculture land uses; 2) NJDEP estimated impervious surface, upland agriculture, and wetland agriculture; 3) TM based impervious surface and lawn and NJDEP upland agriculture and wetland agriculture cover; and 4) TM based impervious surface + lawn and NJDEP upland agriculture and wetland agriculture. We addressed two related questions. First, which land-cover/land-use class explains a greater percentage of the variance in water-quality data? Second, do the components of urban land (impervious surface and lawn cover) provide greater explanatory power than that of the broader urban-land designation? The water-quality models based on NJDEP land-use data (urban land, upland agriculture, and wetland agriculture) were generally best. However, all four model types accounted for a high percentage of the variation in water-quality and for each water-quality variable there was no significant difference in the actual minus predicted values between any of the model types.

COASTAL PLAIN PONDS

Commission staff participated in a study of coastal plain ponds conducted by the NJDEP Office of Natural Lands Management. The study, which was funded by the USEPA, builds upon the Commission's ongoing coastal plain ponds investigations and will contribute to both the Commission's long-term environmental-monitoring program and the Kirkwood-Cohansey Project. Commission staff conducted anuran and vegetation surveys and monitored water-levels at fifteen ponds. The study concluded in 2004 and the NJDEP is preparing a report for submission to the USEPA.

THE KIRKWOOD-COHANSEY PROJECT

New Jersey Public Law 2001, Chapter 165 directed the Pinelands Commission to assess and prepare a report on the key hydrologic and ecological information needed to determine how the current and future water-supply needs within the Pinelands area may be met while protecting the Kirkwood-Cohansey aquifer system and avoiding any adverse ecological impact on the Pinelands area. The aquifer assessment is to be implemented in cooperation with the NJDEP, Rutgers University, the U. S. Fish and Wildlife Service (USFWS), and the USGS. The legislation appropriated $5,500,000 from the Water Supply Fund for the preparation of the assessment by the Pinelands Commission. While not a component of the long-term environmental-monitoring program, the results of the Kirkwood-Cohansey Project will contribute to the achievement of the goals and objectives of the program.

Scientists from the cooperating agencies and institutions completed a work plan for the Kirkwood-Cohansey Project that underwent peer review. The Commission approved the work plan In October 2003. The work plan addresses two major research questions. First, what are the probable hydrologic effects of groundwater diversions from the Kirkwood-Cohansey aquifer on stream flows and wetland water levels? Second, what are the probable ecological effects of reduced stream-flow and groundwater-level changes on aquatic and wetland communities? In 2004, inter-agency agreements were executed and the Commission and cooperating agencies began implementing the work plan. An October 29, 2004 summary of the status of the Kirkwood-Cohansey Project activities is attached to this progress report (Appendix 3).

TIMBER RATTLESNAKE STUDY

As part of a settlement agreement between the Commission, Main Line Realty Group, and Evesham Township, the Commission and the NJDEP Endangered and Nongame Species Program jointly initiated a three-year program to monitor the movement of timber rattlesnakes (*Crotalus horridus*) in a section of Evesham Township. The purpose of the study, which was begun in 2001 with funding from Main Line Reality Group, was to assess the movements of transmitter-implanted snakes relative to the constructed portion of a development and to evaluate the effectiveness of measures intended to direct snakes away from the development.

Progress reports describing the study methodology and results of the first and second years of snake monitoring were released in April 2002 and April 2003, respectively. Field work for the third year of the study was completed in October 2003 and a final report titled, "Assessing timber rattlesnake movements near a residential development and locating new hibernacula in the New Jersey Pinelands," was released in 2004 (Laidig and Golden 2004).

During the three-year study, five male and four female timber rattlesnakes representing a range of sizes were radiotracked for various time periods. Telemetry data indicated that these rattlesnakes used extensive areas of forested uplands and wetlands within a 1500-ha area in and around the development. The two largest males had the largest activity ranges. Both snakes had total round-trip travel-distances of greater than 11 km in both years when they were tracked for the entire active season. A pregnant female traveled the shortest distance from the hibernaculum and was characterized by a reduced activity range. Core activity areas for several timber rattlesnakes, including an area intensively used by pregnant snakes, were located in areas that may be developed in the future. Fences, constructed to direct the rattlesnakes away from the development, did not prevent any of the transmitter-equipped timber rattlesnakes from entering constructed portions of the development. Culverts, installed to allow snakes to move beneath a road to the forest east of the development, were used by two timber rattlesnakes

OYSTER CREEK WATERSHED REPORT

Science staff prepared a report on the natural resources of Oyster Creek watershed in Ocean County. The objective of the report is to provide information that will allow the Commission to reevaluate the existing land-management designations in the watershed. The primary question that the report addresses is whether the Oyster Creek watershed displays the essential character of the Pinelands, a major criterion used to designate Forest Areas. Much of the information presented in the report was collected as part of the long-term environmental monitoring program.

SCIENCE COMMITTEES

The Commission established two committees to advise the Science Office and the Commission on the role of science in achieving the goals of the Comprehensive Management Plan. A Science Advisory Committee (SAC) was established in 2000. Committee members are Drs. John Dighton, Joan Ehrenfeld, Richard Lathrop, Anthony Navoy, and Peter Oudemans. Dr. Lathrop was named chairperson. A second committee, composed of Commissioners, was established in 2001 to provide a forum for discussion of ongoing Science Office activities.

Important accomplishments of the Science Advisory Committee included a review of the Mullica River and Rancocas Creek basin reports before release of the final documents, a meeting with the full Commission regarding the Commission research program to discuss future research priorities for the Science Office, completion of a detailed survey of Pinelands research priorities, and an ongoing review of the Science Office activities. The last SAC meeting was held in July 2004.

Since its first meeting in June 2002, the Science Committee developed a statement of purpose, reviewed a Science Advisory Committee survey of Pinelands research priorities, evaluated prior Commission research projects to determine how to improve Pinelands land-use and environmental policies, and reviewed the Kirkwood-Cohansey Project work plan. The Committee also considered a strategy, developed by Planning staff and based on Science Office research, to identify existing and potential future conditions in Pinelands watersheds.

COORDINATION AND OUTREACH

Staff coordinated with or participated in other environmental-monitoring programs, including NJDEP Endangered and Nongame Species Program projects (e.g., Delphi process of ranking the status of New Jersey fish and amphibian species) and the NJDEP biological monitoring programs (e.g., Index of Biotic Integrity and AMNET programs). Over the five-year period staff scientists made numerous presentations on various environmental-monitoring related topics at several public events, including presentations on the timber rattlesnake study, the Mullica River Basin and Rancocas Creek Basin studies, and the effect of land use on aquatic resources. Presentations on frogs and toads of the Pinelands and the history of the Pinelands acquisition program were given at the annual Pinelands short courses. The research staff also conducted staff workshops on the results of different studies and provided technical assistance on several major permitting and planning projects.

UPCOMING ACTIVITIES
(JANUARY 2005 - DECEMBER 2005)

The anticipated work program over the next four years is outlined in Table 1. In the upcoming year, Science Office staff will complete the Great Egg Harbor River and Toms River assessment reports. An updated streamflow trend analysis of Mullica River streams will be conducted and the Monroe stream analysis will be released. The cranberry/wetlands study will be completed. The third and final year of fieldwork for the littoral-community study will be conducted and data analysis will be initiated. To calibrate the pH and specific conductance measurements completed in different years in the four major study basins, we will conduct a water-quality survey of selected reference sites in each basin. Science Office staff and Rutgers cooperators will complete a comprehensive report relating land-use to water quality that is based on the results of the Mullica River Basin, USEPA, and CICEET studies.

Commission scientists will continue to cooperate with the NJDEP on the development of an appropriate Integrated List of Waterbodies for the Pinelands using data collected as part of the Commission's long-term environmental monitoring program. Science staff will also work with the Natural Resource and Conservation Service and New Jersey Conservation Foundation to establish permanent plots in areas targeted for restoration at the Franklin Parker Preserve.

Although not a component of the long-term environmental-monitoring program, the Science Office will continue to implement the Kirkwood-Cohansey Project. In addition to managing and participating in studies conducted by USGS, Rutgers University, and USFWS scientists, Commission scientists are primarily responsible for conducting studies on palustrine wetlands, intermittent pond-vegetation, and anurans. The Science Office will also work with the Commission, Commission Science Committee, and Science Advisory Committee to determine research and monitoring priorities. The Science Office will play a lead role in the development of a electrical-transmission right-of-way management plan for the Pinelands and provide major support to the preparation of a regional threatened and endangered species protection program.

Table 1. Schedule for long-term environmental-monitoring program.

Topic	1/05 - 12/05	1/06 - 12/06	1/07-12/07	1/08-12/08
Surface-water Quality[1] and Stream Discharge	Complete the Great Egg Harbor River and Toms River assessment reports. Conduct a water-quality survey of selected reference sites in each of four major study basins to calibrate pH and specific conductance measurements. Complete a comprehensive report relating land-use to water quality.	Compile a comprehensive water-quality data set for the four major study basins and complete a region-wide ranking of stream sites. Evaluate the results of the Pinelands watershed assessment programs and determine the need to resurvey sites.	Based on the results of the program evaluation, conduct necessary repeat surveys.	Conduct necessary repeat surveys.
		Develop a five-year environmental-monitoring program plan.	Implement the five-year environmental-monitoring program plan.	Implement the five-year environmental-monitoring program plan.
	Complete streamflow trend analysis updates for CCMUA streams and release the MMUA streamflow trend analysis.	Complete a streamflow trend analysis updates for CCMUA and MMUA streams	Complete a streamflow trend analysis updates for CCMUA and MMUA streams.	Complete a streamflow trend analysis updates for CCMUA and MMUA streams.
Wetland Plant and Animal Communities[2]	Complete the Great Egg Harbor River and Toms River assessment reports.	Compile a comprehensive biological-community data set for the four major study basins and complete a region-wide ranking of stream sites. Evaluate the results of the Pinelands watershed assessment programs and determine the need to resurvey sites.	Based on the results of the program evaluation, conduct necessary repeat surveys.	Conduct to conduct necessary repeat surveys.
		Develop a five-year environmental-monitoring program plan.	Implement the five-year environmental-monitoring program plan.	Implement the five-year environmental-monitoring program plan.
	Continue to monitor forested wetlands and frog breeding ponds.	Continue to monitor forested wetlands and frog breeding ponds.	Continue to monitor forested wetlands and frog breeding ponds.	Continue to monitor forested wetlands and frog breeding ponds.

Table 1. Schedule for long-term environmental-monitoring program.

Topic	1/05 - 12/05	1/06 - 12/06	1/07-12/07	1/08-12/08
	Continue to apply monitoring data to the development of an appropriate Integrated List of Waterbodies for the Pinelands.			
	Cooperate with the NRCS and NJCF to establish permanent plots in areas targeted for restoration at the Franklin Parker Preserve.	Cooperate with the NRCS and NJCF to establish permanent plots in areas targeted for restoration at the Franklin Parker Preserve.		
Cranberry Bog Study	Complete final reports.			
Littoral Community Study	Complete the biological surveys and habitat characterizations and initiate data analysis.	Complete final report.		

[1] pH and specific conductance unless noted otherwise.

[2] Stream vegetation, fish, and anurans.

TABLE 2. COSTS ASSOCIATED WITH THE ENVIRONMENTAL MONITORING PROGRAM.

EXPENSES	**1/03 - 12/03**	**1/04 - 12/04**	**1/05 - 12/05**
PERSONNEL	230,000	240,000	
PROFESSIONAL SERVICES (1)	30,000	25,000	
SUPPLIES AND EQUIPMENT	20,000	20,000	
OTHER (2)	2,750	2,600	
TOTAL	282,750	287,600	

(1) INCLUDES USGS WATER RESOURCES MONITORING AND OTHER CONSULTANT SERVICES.
(2) INCLUDES TRAINING, TRAVEL, MEALS, AND OTHER MISCELLANEOUS EXPENSES.

APPENDIX 1. LITERATURE CITED AND OTHER ENVIRONMENTAL MONITORING AND RESEARCH REPORTS (1992-2004). THE REPORTS ARE ORDERED CHRONOLOGICALLY

Laidig, K. J. and D. M. Golden. 2004. Pinelands timber rattlesnake study: final report. Pinelands Commission, New Lisbon, NJ.

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APPENDIX 2. SUMMARY OF CURRENT AND COMPLETED FEDERAL GRANTS.

National Park Service funding approved for the Pinelands long-term environmental-monitoring program.

1994 Cooperative Agreement CA4000-4-3016	$150,000
1995 Amendment to Cooperative Agreement CA4000-4-3016	$143,375
1996 Amendment to Cooperative Agreement CA4000-4-3016	$164,455
1997 Amendment to Cooperative Agreement CA4000-4-3016	$216,855
1998 Amendment of Cooperative Agreement CA4000-4-3016	$232,908
1999 Cooperative Agreement CA4000-9-9023	$197,784
2000 Amendment of Cooperative Agreement CA4000-9-9023	$202,886
2001 Amendment of Cooperative Agreement CA4000-9-9023	$162,300
2002 Amendment of Cooperative Agreement CA4000-9-9023	$152,300
2003 Amendment of Cooperative Agreement CA4000-9-9023	$62,300

Classification, Protection and Monitoring of Significant Wetland Communities: Coastal Plain Pond Communities. EPA Wetland Protection Grant funds provided through an agreement with the NJ Department of Environmental Protection: $37,794. Project was completed December 2004.

Remotely Sensed Indices of Land Use Intensity for Watershed-level Monitoring. National Oceanic and Atmospheric Agency's CICEET Program funds provided through an agreement with Rutgers University: $6,750. Project was completed July 2003.

Monitoring the ecological integrity of Pinelands wetlands: the effect of cranberry agriculture on wetland landscapes, stream hydrology, and aquatic communities. EPA Wetland Protection Grant approved in 1999. Federal funds approved: $199,363. Project is ongoing.

Development of an empirically based model to quantify land-use impacts on surface-water quality and associated wetland communities in the New Jersey Pinelands. EPA Wetland Protection Grant approved in 1998. Federal funds approved: $107,595. Project was completed February 2002.

Monitoring the ecological integrity of Pinelands wetlands: the effect of watershed disturbance on the littoral communities of stream impoundments. EPA Wetland Protection Grant approved in 2001. Federal funds approved: $138,619. Project is ongoing.

Monitoring wetland dependent vertebrates in the New Jersey Pinelands. EPA Wetland Protection Grant approved in 1997. Federal funds approved: $129,677. Project was completed December 2001.

Monitoring the long-term ecological integrity of forested wetland plant and animal communities in the New Jersey Pinelands. EPA Wetland Protection Grant approved in 1994. Federal funds approved: $90,092. Project was completed December 1997.

Monitoring the integrity of stream vegetation along watershed disturbance gradients in the New Jersey Pinelands. EPA Wetlands Protection Grant approved in 1996. Federal funds approved: $102,646. Project was completed December 1996.

Monitoring the effect of watershed disturbance on the long-term biological integrity of aquatic bed and emergent wetland communities in the New Jersey Pinelands. EPA Wetland Protection Grant approved in 1993. Federal funds approved: $53,583. Project was completed December 1996.

Long-term sustainability of Atlantic white cedar swamps in the Pinelands Biosphere Reserve. National Science Foundation grant submitted through the U. S. Man and the Biosphere Program approved in 1992. Federal funds approved: $47,000. Project was completed June 1996.

APPENDIX 3. SUMMARY OF THE STATUS OF THE KIRKWOOD-COHANSEY PROJECT

MEMORANDUM

To:	Members of the Commission
From:	Robert A. Zampella, Chief Scientist
Subject:	Kirkwood-Cohansey Project Year-1 Progress Report
Date:	October 29, 2004

On October 14 I briefed the Commission on the status of the Kirkwood-Cohansey Project activities. I am providing you with a written summary of progress made during the first year of the project.

HYDROLOGY (USGS)

LEAD INVESTIGATORS: ROBERT NICHOLSON AND RICHARD WALKER

THE CENTRAL QUESTIONS TO BE ADDRESSED BY THE VARIOUS HYDROLOGIC INVESTIGATIONS ARE:

1. What are the hydrologic-system controls on hydrologic regimes?
2. What are the relations among components of the hydrologic budget?
3. How do the aquifer, wetlands, and streams interact hydrologically and how are these relations affected by pumping stress?
4. How are wetland water levels and stream flows affected by pumping stress?
5. What is the relative contribution of various land cover/natural-vegetation community types to the regional water demand through the process of evapotranspiration (ET)?
6. How can evapotranspiration (ET) be estimated at the watershed scale?

Hydrologic activities initiated by the U. S. Geological Survey during year 1 of the Kirkwood-Cohansey Project focused on the characterization of a hydrologic framework and the establishment of networks to monitor groundwater and surface-water flow, depth to water in wetlands, interactions between groundwater, wetlands, and surface waters, and evapotranspiration The data collected will be used to develop models to quantitatively evaluate the response of the aquifer system in selected study areas to hydrologic stresses, including seasonal changes in recharge, drought, climatic change, and groundwater withdrawals. Year 1 tasks and accomplishments are described below.

Task

Characterize the hydrogeologic framework and prepare a hydrostratigraphic model of each study area.

Accomplishments

- Obtained borehole geophysical logs in 7 new boreholes.
- Completed 28 miles of ground-penetrating radar (GPR) surveys.
- Obtained 10 borings for GPR ground truth.
- Conducted slug tests and well performance tests on 16 new wells.
- Initiated processing of geophysical data, boring logs, and geologic data.
- Developed preliminary hydrogeologic framework concept for each study area

Task

Characterize stream flows in support of hydrologic and ecological tasks.

Accomplishments

- Operated 7 continuous stream gages with satellite telemetry in the project study areas :
  - Pump Branch (new)
  - Albertson Brook (new)
  - Morses Mill Stream (new)
  - McDonalds Branch (existing)
  - Batsto River (existing)
  - Mullica River (existing)
  - E. Branch Bass River (existing)

Real-time stream data are available on-line at http://nj.usgs.gov (stage only for new gages until they are rated)

- Installed 10 new staff gages:
  - Batsto River (8)
  - Pump Branch (1)
  - Albertson Brook (2)

Task

Characterize water levels in support of hydrologic and ecological tasks.

Accomplishments

- Initiated an inventory of existing observation wells.
- Completed installation of 16 cluster wells and 5 upland wells.
- Initiated continuous water-level monitoring in a total of 25 wells.
- Selected 15 hydrologic transect locations.
- Installed 11 shallow hydrologic transect piezometers.

Task

Monitor evapotranspiration in the field and use the ET measurements to develop a method for determining ET at the watershed scale.

Accomplishments

- Selected initial ET monitoring site in McDonalds Branch basin.
- Tested instrumentation.
- Constructed 24-meter tower.

STREAM FISH AND MACROINVERTEBRATES (USGS)

LEAD INVESTIGATOR: DR. JONATHAN KENNEN

Question

How do stream fish and macroinvertebrate assemblages respond to changes in streamflow regimes?

Accomplishments

- Selected eight discharge-type stream reaches in the Batsto River basin for model development.
- Selected 30 Batsto River sampling reaches.
- Initiated selection of sampling reaches in Morses Mill Stream, Pump Branch/Albertson Brook, and Bass River for model validation (8 reaches selected so far).
- Completed high-flow aquatic-invertebrate surveys at 30 Batsto River sites and 2 West Branch Bass River sites.
- Initiated low-flow aquatic-invertebrate surveys (12 sites completed so far)
- Initiated high-flow fish surveys, but sampling was postponed until 2005 due to July flood event.
- Completed installation of all staff gages associated with selected sampling sites and will measure the gages on a regular basis beginning this month.
- Commission staff completed four rounds of water-quality sampling at all selected stream sites.

WETLAND-FOREST COMMUNITY GRADIENTS (PINELANDS COMMISSION)

LEAD INVESTIGATOR: DR. ALLISON BROWN

Question

How do wetland-forest plant species, communities and the boundaries between communities respond to changes in water regime (e.g., seasonal water-level patterns, mean and extreme water levels)?

Accomplishments

- Established 201 study plots, representing nine different vegetation types, in the five study basins.
- Recorded the location of 196 plots with a GPS.
- Installed and developed 201 water-level observation wells.
- Collected monthly water-level measurements from March through October 2004.
- Measured soil Moisture in a subset of 46 plots from June – September. Will make a final measurement for 2004 season this month.
- Completed vegetation cover and height measurements for 70 plots in the McDonalds Branch basin.

POND VEGETATION (PINELANDS COMMISSION AND NJDEP)

LEAD INVESTIGATOR: KIM J. LAIDIG

Question

How do intermittent-pond plant species, plant communities, and plant zones respond to changes in water regime (e.g., seasonal water-level patterns, mean and extreme water levels)?

Accomplishments

- Selected 15 ponds in the vicinity of Brendan T. Byrne State Forest for study.
- Identified major plant communities (zones) at each pond.
- Conducted monthly floristic surveys from May through September.
- Installed staff gages and measured bimonthly water-levels from April through October.
- Installing wells as the ponds draw down.
- Installed a continuous recorder at a single pond.
- Measured water-quality (pH, SC, DO, temperature) monthly and stage biweekly from April through October in 15 ponds.

FROG STUDIES (PINELANDS COMMISSION)
LEAD INVESTIGATOR: JOHN F. BUNNELL

Question

How is anuran-larval development and recruitment success related to intermittent-pond hydrology?

Accomplishments

- ✍✍Conducted monthly night time anuran vocalization surveys at 21 ponds from March through June to determine breeding phenology for each species present.
- ✍✍Collected southern leopard frog egg masses in three ponds and hatched tadpoles
- ✍✍Installed duplicate transects of enclosures representing 10 different water depths in four ponds and stocked enclosures with tadpoles.
- ✍✍Pond-water depth was drawing down until the July 12^{th} storm flooded out the enclosures. The project was cancelled for 2004.

SWAMP PINK (USFWS AND PINELANDS COMMISSION)
LEAD INVESTIGATORS (CARLO POPOLIZIO AND KIM J. LAIDIG)

Question

What hydrologic regimes (e.g., seasonal water-level patterns, mean and extreme water levels) are associated with *Helonias bullata* colonies and how does the plant respond to natural and simulated changes in the depth, duration, and frequency of saturation and flooding?

Accomplishments

- ✍✍Selected Shinns Branch and Cooks Branch populations for study.
- ✍✍Established transects through each population to map the distribution of swamp pink and associated vegetation.
- ✍✍Installed staff gages and water-level observation wells at each transect and began bimonthly water-level measurements in June.
- ✍✍Completed data collection on rosette location and size, distance from rosettes to the water table, and canopy cover at Cooks Branch.
- ✍✍Plan to complete plant data collection at Shinn Branch in 2005.

ECOLOGICAL PROCESSES: INDICATORS OF PHYSIOLOGICAL STRESS (RUTGERS)
LEAD INVESTIGATORS: DR. MING XU AND DR. ERIC HAMERLYNCK

Question

How do variations in hydrologic regime affect the water relations and photosynthetic rates of wetland plants?

Accomplishments

- ✍✍Selected 12 wetland-forest community plots along dry – wet gradients.
- ✍✍In each plot, tagged three replicate individuals of each of four indicator species (fetterbush, dangleberry, sweet pepperbush, and highbush blueberry), for a total of 105 plants.
- ✍✍In July-August and October, stomatal conductance (transpiration) was measured and A/Ci curves (photosynthetic response) were generated for each of the tagged plants.
- ✍✍Pre-dawn and mid-day leaf water potentials (stress) were also measured on the same plants.

ECOLOGICAL PROCESSES: NITROGEN DYNAMICS (RUTGERS)

DR. JOAN EHRENFELD AND DR. J. C. CLEMENTS

Question

Will unsaturated conditions associated with lowered water-table levels promote increased nitrogen mineralization and nitrification, resulting in pulses of mineral nitrogen to wetland and aquatic systems?

Accomplishments

- ✍✍Obtained surface soils from hollows in two dry pine-lowlands, two wet pine-lowlands, and two cedar swamps.
- ✍✍Incubating the soil samples from the three types of wetlands in the laboratory under 100%, 60% and 30% saturation to observe the production of ammonium- and nitrate-nitrogen during long-term incubations.
- ✍✍The samples are leached biweekly, and the ammonium and nitrate in the leachate is measured. Cumulative nitrogen production is then analyzed to determine the rate of mineralization (ammonium production) and nitrification (nitrate production).
- ✍✍Results as of 45 days of leaching show very variable nitrate production, both between replicates of each wetland type and among wetland types.
- ✍✍Field incubations to measure actual ammonium and nitrate production will be implemented in the next phase of the research.

BUILD OUT (PINELANDS COMMISSION)

LEAD INVESTIGATORS: LARRY L. LIGGETT AND RUSSEL DAVIS

Question

What demand is placed on water supplies by residential, commercial, and agricultural land use, how will these patterns be expected to change in the future, and what is the implication for total future water demand within the Pinelands area?

Accomplishments

- ✍✍Created a methodology that will be used to derive lot status (e.g., vacant, developed, vacant-committed, and public lands) coverage using a GIS, database, and spreadsheet software.

- Completed pilot lot status coverage for one municipality.
- Currently documenting all of the assumptions used when deriving lot status coverage.
- Hired a consultant to parse (break out) tax assessment information from the State tax assessment database. This information will aid in reducing the number of steps used in the lot status methodology.

DATA MANAGEMENT AND DATA-ANALYSIS COORDINATION (USGS)

LEAD INVESTIGATOR: DR. STEVEN TESSLER

Task

Design and Implement a Kirkwood-Cohansey Project Database and Coordinate Data Analysis

Accomplishments

- Met with project leaders to discuss overall goals for the database.
- Established FTP file portal as a possible avenue for data exchange between cooperators and USGS.
- Met with Pinelands Commission staff to discuss database needs. Will meet with other subject area specialists and teams this fall.
- Database design is under construction.