CHAPTER 1

PROJECT DESCRIPTION AND SUMMARY OF THE RESEARCH ACCOMPLISHMENTS

EPA Agreement Number: R82-5759
Title: **Risk Based Urban Watershed Management-Integration of Water Quality and Flood Control Objectives**
Investigators: Primary Investigator: Vladimir Novotny, PhD, P.E.
Co-investigators: David Clark, PhD, Robert Griffin, PhD
Institution: Institute for Urban Environmental Risk Management
Marquette University, Milwaukee, WI 53201-1881
Research Category: US EPA/NSF/USDA STAR Watershed Program
Project Period: October 1, 1977 - September 30, 2001
EPA Project Officers: Barbara M. Levinson and Gina Perovich

Objectives of the research

The overall research objectives and goals of the project outlined in the proposal were:

(1) Develop statistical flow, loading and water quality models applicable to risk assessment;
(2) Develop objective and quantitative risk assessment procedures for estimating ecological risks of stormwater and subsurface discharges from urban and suburban watersheds;
(3) Develop methodology for assessment of flood control and water quality benefits and resolve conflicts between flood control and ecological preservation-restoration objectives;
(4) Develop benefits/cost models for urban watershed management to optimize both flood control and receiving water integrity;
(5) Research innovative financing of urban watershed management, identify key players, and assess the willingness to pay for different watershed resident groups; and examine homeowners' risk/benefit perceptions, values, effective responses to the risk, subjective norms, socio-cultural backgrounds, and use of communication in the willingness to pay for these different types of benefits.

The goal of the research was to examine urban water bodies along two different dimensions: the degree to which the urban development influences flooding risks, and the degree to which it influences the ecology of the water bodies as represented by the ecological risks. The research effort developed quantitative measures of the two risks that will enable public officials and stakeholders to assess the level of flood and ecological risks and develop priorities for control and urban stream (water body) improvements. It has been recognized that urban streams have multipurpose roles from which conveyance of floods and pollutants are most important. Additional uses of urban water bodies include water supply, recreation (both primary and secondary), and some less common uses such as navigation and hydropower production. These uses are interrelated and often conflicting. The team used willingness to pay concepts and extensive surveys to weight the two major risks and provide a quantitative information about the perceptions and attitudes of the citizens living within two pilot watersheds on the two issues: flood control and ecological restoration of urban streams.

Project Team

The project objectives and goals were addressed in an interdisciplinary fashion by the researchers from the following disciplines:

Environmental/Water Quality/Hydrology Engineering

Faculty:	Vladimir Novotny, PhD, P.E.
Post doctoral fellow:	Pavel Hajda, PhD, P.E.
Graduate assistants:	Alena Bartošová, MSc
	Sarah Alamilla, MSc
	Emre Alp, MSc
	Phillip Blonn, MSc
	Joshua Kasun, MSc
	Neal O'Reily, MSc, PH

Economics and Environmental Ethics

Faculty:	David Clark, PhD
	Douglas Booth, PhD
Students:	Margarette Daun
	Kyra Taylor
	Mark Hutchinson
	Joseph Borchardt

Communications

Faculty:	Robert Griffin, PhD
Post doctoral fellow:	James Giese, PhD

Aquatic Biology

Faculty:	Robert Anderson, PhD, Wisconsin Lutheran College

Public survey:	Lina Gusman
	John Stevenson, University of Wisconsin Survey Center

The work has brought together teams from these disciplines. The teams very rapidly established communications among themselves and with stakeholders from the community. The intermediate results were communicated to the stakeholders (representatives of the communities, non governmental organizations, other researchers). The project provided educational and research opportunities and partial funding to three post doctoral fellows (from United States, Italy and Japan), two PhD candidates and eight MSc candidates. In addition to the US EPA STAR Watershed Program support, funds to conduct the watershed research were also received from Marquette University (co-share and development of the GIS laboratory) and Wisconsin Foundation for Independent Colleges (S.C. Johnson foundation). The project also provided opportunity to two undergraduate students in a form of summer internship.

Selection of Pilot Watersheds

The methodology developed in this research was applied to two watersheds: the mostly rural but rapidly urbanizing Oak Creek watershed (Table 1.1) and the Menomonee River watershed representing already

developed watersheds (Table 1.2). Figure 1.1 shows the map of the greater Milwaukee, including the locations of the watersheds investigated in this study.

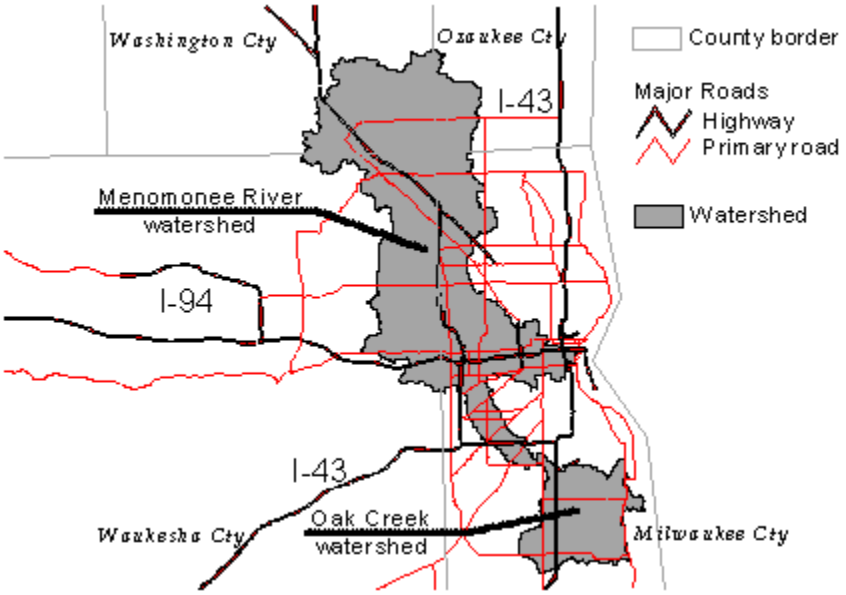

Figure 1.1. Location of pilot watersheds. Milwaukee, WI, area and suburban counties.

Table 1.1. Basic watershed characteristics of the Oak Creek watershed.

Area	69.8 km^2 (27.2 mi^2)
Percent urbanized	44.6%
Population	40,499 (1990)

The Menomonee River watershed discharges into the Milwaukee River about one and half km upstream from its confluence with Lake Michigan. The lower portion of the watershed is heavily urbanized.

Table 1.2. Basic watershed characteristics. Menomonee River watershed.

Area	350.7 km^2 (137 mi^2)
Percent urbanized	52.8%
Population	330,178 (1990)
	362,570 (1996)

Overall Accomplishments

Scientific results

1. Establishing of the GIS laboratory and development of analytical software for project analyses
The first task of the project was to develop and improve the capability to conduct the watershed spatial analyses with the Geographical Information Systems (GIS). Arc Info and Arc View software packages were acquired from ESRI along with several supplemental upgrades. The Institute for Urban Environmental Risk Management (the team conducting this project) rapidly developed the GIS laboratory and also included a permanent GIS upper division and graduate level course in the university environmental course program.

Several research tasks were developed in the GIS environment. These tasks included hedonic analyses of the effects of risks on values of residential properties, geocoding of the survey respondents, and analysis of the spatial distribution of the flooding and ecological risks.

2. Methodology for estimating the effect of urbanization high and low flows
A method originally published by McCuen (see Chapter 3) was used to modify the probability of urban high and low flows developed from long term flow series that include periods with different degrees of urbanization as affected by urbanization.

3. Development of methodology for quantitative enumeration of flood risks within the GIS
A methodology has been developed to facilitate evaluation of risk due to flooding. Flood risk is a spatial variable defined as a reciprocal of the flooding probability at a location within a flood plain. Flood risk at any given location is related to local topography, the distribution of flows in the river, the distance to the river and the distance to the floodplain relative to the width of the floodplain. Urbanization of the watershed changes the flow distributions. Thus, flood risk changes over time and is not a constant value.

The methodology was then expanded by developing a GIS-based relationship between the magnitude of flows with the specified recurrence interval and that spatial flood risk. First, flood risks has been evaluated for present watershed conditions. This has been done in two different ways: (1) flood risk has been evaluated on watershed wide basis, both for whole watershed and specific locations within the watershed (i.e., related to residential location); and (2) area flooded by flows of specified recurrence intervals, the floodplain has been delineated. Second, the effect of urbanization on flood risk has been assessed. Discharge-frequency curves for gage stations located within the watersheds have been adjusted to account for changes with watershed urbanization. Adjusted curves have been then used to evaluate flood risk for hypothetical development scenarios. The methodology has been applied to both Oak Creek and Menomonee River watersheds, with the exception of floodplain delineation (Oak Creek watershed only). Results have been presented with more detail given in individual technical reports.

4. Modification, development and application of methodology for ecological risk assessment
The existing methodology on assessing ecological risk due to water column contamination has been modified and expanded to evaluate the risk in its three components: (1) acute toxicity risk from contaminated water column, (2) chronic toxicity risk from contaminated water column, and (3) chronic toxicity risk from contaminated sediment.

5. Development of a GIS based urban watershed pollutant loading model
A model of wet weather nonpoint pollution has been developed and implemented in ArcView GIS. Generation of pollutants from urban and rural areas is modeled separately. Two approaches were calibrated and verified: (1) annual load, and (2) event based load. The evaluation of annual loads is useful for a quick

assessment of watershed development scenarios. An event-based approach enables more detail comparison of scenarios by comparing probabilistic distributions of ambient concentrations.

6. Data acquisition and monitoring

The retrieved data bases included demographic census data, US EPA's water quality data base STORET; USGS data bases and web sites; GIS and other data bases developed by the SEWRPC and Wisconsin DNR, data bases developed and gathered by consultants on the ongoing (Oak Creek) and completed (Lincoln Creek) watersheds; and information gathered by the Friends of the Menomonee River.

GIS coverages for the two test watersheds were downloaded from the US EPA web site as shape-files (*.shp, the ArcView format) for the Hydrologic Units 04040002 (Pike-Root River watershed; Oak Creek) and 04040003 (Milwaukee River watershed; Menomonee River and Lincoln Creek). Other maps were found on the Wisconsin DNR and USGS web sites and from the City of Oak Creek, Planning Department, including floodplain, sewer system, and subwatersheds.

The sampling program supplementing the existing data was carried out during the course of the study and included water quality monitoring (Oak Creek watershed only), sediment sampling, habitat evaluation, and fish and macroinvertebrate sampling.

7. Biologic monitoring surveys

Ecological integrity of investigated watersheds has been evaluated. A survey of fish and macroinvertebrate communities was conducted in the summer of 1999 and 2000. The fish IBIs indicate that both sampled water bodies have poor to very poor quality when compared to typical Wisconsin warm water streams. The macroinvertebrate IBIs indicated nearly all sampling locations were in the good to fair quality. It appears that fish IBIs reflect general land use trends that result in degradation of water quality and hydrology while the macroinvertebrate IBIs are more closely related to characteristics of instream habitat.

8. Surveys of residents in the pilot watersheds

The professional survey organization conducted eight focus groups sessions in Spring 1999 prior to the first survey, to help in the development of the survey instruments. A 25 minute telephone survey was then conducted at two points in time (1999-2000 and 2000-2001 winter periods) on approximately one thousand randomly selected adult residents of the two pilot watersheds, the Menomonee River and the Oak Creek.

In the first wave survey in the 1999-2000 period, respondents were asked the same set of questions and were rovided with a detailed description of the watershed project before being asked a series of questions designed to determine their willingness to pay either for the maintenance of flood risk or ecological risk improvement (stream restoration and preservation). The WTP questions were posed in terms of a hypothetical political referendum.

The objectives of the surveys were:

a. Find the extent and nature of physical and emotional connection to the water body;
b. Identify perceptions of the health of the water bodies;
c. Identify perceptions about flooding;
d. Assess the willingness to pay for the flood control and/or ecological risk reduction questions.
e. Identify salient beliefs about the water bodies and related issues;
f. Identify perceptions about the citizens' capacity to get information on this topic;
g. Identify beliefs about nature and quality of information about this topic from mass media;
h. Find the range of values placed on prevention of flooding and ecological improvement relative to other community issues.

i. Determine the community-wide benefits derived from each of the proposed projects.

Participants were drawn from a random sample of homeowners and residents of the two investigated watersheds. About 80 citizens participated in the focus group sessions. The purpose of the focus groups was to pretest wording of the comprehensive surveys that will follow and find the initial response to key issues. More than one thousand citizens living in the two watersheds were surveyed in a two-wave survey.

9. Willingness to Pay estimates - economic issues

The project focused on the factors that determine willingness to pay for expenditures on flood control and expenditures on ecological risk reduction. Although there are many contingent valuation studies, few of these studies evaluated the broad range of determinants considered in this project.

- Among the unique drivers considered in this project are spatial determinants of willingness to pay for flood control, including a flooding risk measure derived in a GIS environment that enabled researchers to consider and correlate the location and flood risk with the response of the respondents.
- This study also considered the importance of psychological drivers of willingness to pay for two projects described to respondents: (1) A project designed to hold the line against flooding, and (2) a project designed to improve the ecological health of the river. Specifically, based on Ajzen's Theory of Planned Behavior (see Chapter 7), the study determined that willingness to pay for both projects was significantly associated with a set of respondents' beliefs and outcome evaluations about paying for the described projects (termed "cognitive structure" in this report, but otherwise referred to as "indirect attitude"). A set of beliefs about non-economic outcomes (e.g., contributing to a long-term solution, feeling like one is doing something for the environment or for the community) had a stronger relationship to WTP than did economically-associated beliefs (personal affordability and effects on taxes). Subjective norms (felt social pressures from significant others) also had a consistent relationship with WTP across time and across projects. Attention to news about issues related to the projects was positively related to the non-economic cognitive structure dimension as well as to willingness to pay, although the relationship to non-economic cognitive structure was a bit stronger for the flood control project than for the ecological enhancement project, a result that suggests that further research might investigate apparent differences in media coverage of flood risk as compared to the more subtle trends related to the ecological health of the rivers which might account for this result. The Ajzen variables of subjective norms and especially cognitive structure were consistently among the strongest of all "predictors" of WTP across time and projects.
- Willingness to pay functions have been used to determine how support for the proposed projects (flood control and ecological restoration) vary over space by simulating the estimated functions for individual census block groups. This requires that individual characteristics be mapped to the characteristics of the census block group. This will give as estimate of financial support for the proposed actions throughout the watersheds.
- A new contribution is the use of the benefit transfer technique to map the benefits derived from the willingness to pay function from one area (i.e., Menomonee River) to another watershed (the Root River basin in Racine county). Since the mappings within the Menomonee River watershed are to the census block group, this permits the mapping of benefit estimates to be transferred to nearby geographical locations in which the census block group information can be identified.

10. Environmental ethics study

We included a series of questions for respondents on basic environmental attitudes in the watershed survey questionnaire. Included were questions designed specifically to capture beliefs about the effects of humanity of the ecosystem (and vice-versa), the idea of a duty to restore the health of urban rivers, and valuation of urban rivers for their own sake. A biocentric valuation of the natural world is premised on the notion that nature is valuable for its own sake apart from human interests. The basic hypothesis that was tested

employing multivariate regression analysis was that environmental attitudes affect specific beliefs and values (cognitive structure) about WTP for urban watershed restoration and that these beliefs and values in turn affect WTP. It was found that a broad measure of environmental beliefs, the Awareness of Consequences Scale (AC), explains a significant portion of variation in cognitive structure and that cognitive structure affects significantly the Willingness to Pay. Moreover, including specific measures of environmental attitudes in addition to the AC scale, such as the degree to which respondents hold biocentric attitudes toward urban rivers and believe they have a duty to share in the cost of urban river restoration, adds to the explanatory power of the cognitive structure regression equation. In short, this means that the extent to which respondents believe that the natural world is valuable in its own right has a positive impact on WTP. To the extent that biocentric attitudes are becoming more widespread, support for restoration of urban rivers in the form of willingness to pay will increase.

11. Transfer of the results to a neighboring watershed

Using additional funding the results of the research were extrapolated to a neighboring urbanizing watersheds of the Root River. The watershed of the Root River is similar to the Menomonee River, however, the degree of urbanization if less. The idea behind these projects is to carry out and test transfer of finding and application of methodologies to another urbanizing watershed. The tasks will be completed in 2002. The following subprojects sponsored by a Grant from the S.C. Johnson Foundation and Foundation for Wisconsin Independent Colleges are carried out by the Institute for Urban Environmental Risk Management:

1. Effect of urbanization of high and low flows
2. Evaluation of benefits of and willingness to pay for reduction of flood and ecological risks.
3. USE of GIS in urban watershed planning

Other Accomplishments

1. Presentations to local policy makers and stakeholders

The members of the team held two half-day workshops with stakeholders from the local governments and agencies in which the survey methodology and intermediary results were presented. Typically, over 50 representatives of local communities, planning agencies, flood control agencies, consultants, representatives of the Southeastern Wisconsin Regional Planning Commission and the Department of Natural Resources attended the workshop.

2. Tour of the watersheds

The members of the research team toured Lincoln Creek, Menomonee River, and Oak Creek watersheds to examine the land use, watershed and channel character and status, water quality, and habitat conditions of the systems being studied.

3. Literature reviews

Each team prepared literature reviews and position articles on the topics and methodologies relevant to the projects. The reviews include: (a) Urban best management practices and their flood control and ecological benefits; (b) modeling pollutant loads in the GIS environment; and c) risk assessment surveys and models.

Publications

V. Novotny (1999) Integrating Diffuse/Nonpoint Pollution Control and Water Body Restoration into Watershed Management, *Journal AWRA* **35**(4):717-727

Griffin, R.J., D. Booth, D. Clark, J. Giese, and V. Novotny (1999) Public Perception of Urban River Flood Risks and Ecological Quality: Focus Group Insights, *Proc. Society for Risk Analysis Ann. Meeting,* Atlanta, GA, December 5-8

A. Bartošová, D.E. Clark, V. Novotny, K.S. Taylor (1999): Using GIS to Evaluate the Effects of Flood Risk on Residential Property Values. *Proc. Environmental Problem Solving with Geographical Information Systems: A National Conference*, U.S. EPA, September 22-24, 1999, Cincinnati, Ohio.

R. J. Griffin, D. Clark, D. Booth, V. Novotny, J. Giese (2000) Risk Communication and Public Willingness to Pay for Flood and Ecological Improvement in River Watersheds. *Proc. Society for Risk Analysis Annual Convention,* December 2000. To be published in a special issue of the *Journal of Risk Analysis*

V. Novotny, D. Clark, R.J. Griffin and D. Booth (2001) Risk Based Urban Watershed Management under Conflicting Objectives, *Water Sci. & Technol.* **43**(5):69-78

V. Novotny, D. Clark, R.J. Griffin, and A. Bartošová (2001) Balancing Flood Control and Ecological Preservation/restoration of Urban Streams. In *Advances in Urban Stormwater and Agricultural Runoff Source Controls* (J. Marsalek, J.F. Sieker, E. White, E. Zeman, and H. Sieker, eds.) Kluver Academic Publishers, Dordrecht, The Netherlands.

V. Novotny, D. Clark, R.J. Griffin, A. Bartošová, and D. Booth (2001) Hydrological Impact of Urbanization - Balancing Flood Risks, Ecological Preservation and Socio-Economic Aspects. *Paper presented at the 11th Stockholm Water Symposium*, August 10-15, 2001

J. Kasun, A. Bartošová, and V. Novotny (2001) Combined ecological risk assessment of contaminated sediment and water column. *Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15, considered for publ. in *Wat. Sci. & Technol.*

D.E. Clark, V. Novotny, R. Griffin, D. Booth, A Bartošová, M.C. Daun and M. Hutchinson (2001) Willingness to pay for flood and ecological risk reduction in an urban watershed. *Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15, accepted for publ. in *Wat. Sci. & Technol.*

S. Alamilla, V. Novotny, and A. Bartošová (2001) GIS based approach to urban river corridor delineation. *Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15, considered for publ. in *Wat. Sci. & Technol.*

D. E. Booth (2001) Biocentric environmental values and support for the ecological restoration of urban watersheds, *Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15, considered for publ. in *Wat. Sci. & Technol.*

Additional publications are being prepared and will be submitted shortly after the completion of the final report.

Conference presentations

In additions to the publications listed in the preceding section, researchers made the following conference presentations that did not yield a publication (the presentations was selected based on the abstract that was published in the conference proceedings):

A. Bartošová, S. Alamilla, and V. Novotny (2001) Using GIS to Evaluate the Effect of Urbanization on Floodplain Expansion in Oak Creek Watershed, *Abstract in Proceeding, 2001 Wisconsin AWRA Conference, March 29, 2001, Green Lake, WI*

R. Griffin, D. Clark, D. Booth, V. Novotny and James Giese (2001) Psychological and Information-processing Predictors of Public Willingness to Pay for Flood Control and Ecological Improvements in Urban River Watersheds, *Abstract published in Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15

P. Blonn (2001) A GIS Based Model of Diffuse Pollution in the Oak Creek and Menomonee River Watersheds, *Abstract published in Proc. 5th IWA International Conf. On Diffuse Pollution and Watershed Management,* Milwaukee, WI, June 10-15

D. E. Clark, M.C. Daun, M. Hutchinson, D. Booth, R. Griffin, V. Novotny and A. Bartošová (2001) Flood Risk, Ecological Risk and Willingness to Pay: an Interdisciplinary Approach to Urban Watershed Management. *Paper pres. at the Western Regional Science Association Annual Meeting,* Palm Springs, CA, February 2001

Books

The results of the research and methodologies developed in the research were incorporated into several chapters of a book by Dr. Vladimir Novotny entitled: WATER QUALITY: Diffuse Pollution and Watershed Management that will be published by the J. Wiley and Sons, Publishers in 2002 (anticipated publication in September 2002).

Reports

The details of the research and development of the methodologies, models and syntheses of data and literature is contained in the technical report listed below. Each report represent a detailed analysis of a topic related to the objectives of the research. The key findings are then summarized in the chapters of the final report.

Report # 1
A. Bartošová, D. Clark, V. Novotny, and K. Taylor (1999) *Using GIS to Evaluate the Effects of Flood Risk on Residential Property Values*

Flooding causes more property damage in the United States than any other type of natural disaster. Urbanization causes flood to enlarge, increase the flood risk in the areas around the urban streams and rivers. Hedonic modeling techniques can be used to estimate the relationship between residential housing prices and flood risks. One weakness of hedonic modeling has been incomplete control for locational characteristics influencing a given property.

GIS was used to provide more accurate measurements of flood risks and a more thorough accounting of the locational features in the community. An interpolation scheme to evaluate the level of flood risk was developed and applied to the Menomonee River watershed. Together with a wide range of other locational attributes, flood variables were matched ro geocoded properties to investigate impacts on housing prices. The findings supported the hypothesis that increases in flood risk decreases the values for residential properties within the 100-year floodplain. Unlike other studies which conclude that there is an uniform impact within the floodplain, it was find that the effects are declining with reduced risk. Evidence also suggested that flooding events heighten sensitivity to such risks and raise the property premium associated with a give level of flood risks. Negative impacts beyond the 100 year floodplain were not found.

Report #2
N. O'Reilly and V. Novotny (1999) *Water Quality, Ecological, and Flood Risks to Receiving Waters due to Urban Runoff and Urbanization*

An extended literature review of the risks caused by urbanization has been performed. The report addresses the hydrologic/morphological changes of streams due to urbanization, importance of the stream corridor, and ecological impact of stormwater. References of impacts on aquatic habitat, biotic communities, water quality impact, and elimination of riparian vegetation were synthesized and comparatively assessed in a form of impact matrices.

Report # 3
N. O'Reilly and V. Novotny (1999) *Water Quality, Ecological, and Flood Control Benefits of Urban Stormwater Management Practices*

Implementation of stormwater management practices reduces the potential impact of stormwater runoff. The degree of benefits produced by a stormwater practice is dependent on the ratio of watershed area controlled by the practice to the total watershed area. The stormwater control practices covered in the report are divided into the following categories: Source Control BMPs; Flow Volume Reduction BMPs, and Stormwater Storage and Treatment Alternatives. The report evaluates BMPs based on the water quality, ecological and flood control impacts. Each BMPs was evaluated and included into a multi parameter matrix. Cross-referencing between the matrices enables to select BMPs that will provide the highest water quality, ecological and flood control benefits.

Report # 4
P. Hajda, A. Bartošová, and V. Novotny (1999) *Estimating Effects of Urbanization on the Discharge Frequency Relationship of the Menomonee River and Oak Creek.*

A technique originally developed and proposed for removal of urbanization effects from historical flood records was extended to estimate the impact of urbanization on discharge/frequency relationship. To estimate the impact of urbanization in the watershed the method requires two values of the overall watershed imperviousness: (1) the imperviousness describing the watershed in the period of flow records on which the discharge-frequency curve is based, and (2) the imperviousness describing the watershed in a condition of interest (i.e., future). These two quantities are easily estimated from historical, existing, or planned land use data. The procedure revealed that land use changes affect the more frequent floods more extensively than they do the rarer (larger magnitude) floods.

Report # 5
J. Giese, R. Griffin, and D. Clark (2000) *Survey of Attitudes and Willingness to Pay for Flood Control and Water Body Restoration* (including *Focus Group Report,* University of Wisconsin Survey Center)

Eight focus groups were conducted with a random sample of adult residents of the Menomonee River and Oak Creek watersheds. The purpose of these focus groups was to help the research team develop questions for the "Willingness to Pay" telephone survey conducted in the winter of 1999-2000 and 2000-2001 in the same watersheds. In some focus groups participants were asked about perceptions of flood risk whereas other groups focused on the ecological health of the watersheds. The objectives and key results were as follows: 1: Examine the extent and nature of feeling physically and emotionally connected to the river and creek; 2: Examine perceptions of the health of the river and creek. Most participants felt that the health the river and creek could be improved and that it had worsened over time; 3: Examine perceptions about flooding;4: Examine understanding of "Willingness to Pay" questions; 5: Examine salient behavioral beliefs about providing money for projects designed to hold the line on flooding and improve ecological quality of the river/creek; 6: Examine perceptions about their capacity to get information on this topic; 7: Examine beliefs about nature and quality of information about this topic from the mass media; 8: Examine the value placed on the prevention of flooding and ecological improvement relative to other community issues.

There is great variance in people's connectedness to the river or creek. Emotionally, some expressed anger at local agencies perceived as responsible for flooding/environmental quality problems. Participants from Menomonee River groups perceived a much greater risk of flooding than respondents from Oak Creek, the latter often responding quizzically to questions posed to them about Oak Creek flooding. Oak Creek residents had a hard time providing a WTP dollar amount because they did not believe the creek was flooding and did not see a creek flooding problem developing in their community.

Most participants placed the prevention of floods and the environmental improvement of the river/creek as a medium to high priority for their community. Most participants disagreed with the notion that only those who live in the flood plain should be required to pay the cost of flood control. Most participants agreed that we have an obligation to protect nature even if there are not human benefits. Information from the groups was used to identify issues and concerns that residents near the watershed have, as well as their experiences with the two bodies of water.

The report also contains the questionnaire and a transcript of the focus group report by the survey organization.

Report #6
D. Clark, J. Borchardt and M. Daun - *Flood Risk and Contingent Valuation Willingness to Pay Studies: A Methodological Review and Applied Analysis*

Watershed management objectives can address both the objectives of flood control and ecological risk reduction .This report surveys the theory and empirical application of the Contingent Valuation Model (CVM) and examines the relevant issues as they relate to valuation of flood control and ecological risk reduction. Among the issues considered are the use of WTP (willingness to pay) versus WTA (willingness to accept compensation) in the structuring of the survey questionnaire; the use of open-ended vs. discrete choice approaches in the survey; starting from biases; the treatment of protest votes, the issues of embedding in survey responses; and the modeling of ecological and flood risks; and the economic issues in estimation. After addressing these issues, the empirical estimation of separate WTP functions for flood control and ecological risk reduction is derived from a two-wave panel designed survey. The finding suggest that WTP for flood control and ecological risk reduction depends on demographic characteristics of the respondent, attitudinal drivers related to political philosophy, subjective norms, perceived behavioral control, and other economic and noneconomic factors; the individual flood risk faced by the survey respondent, and ecological risk factors in the closest branch of the river to the respondent. These estimated functions are then used to derive benefits estimates for the two watersheds in the Milwaukee metropolitan area.

Report # 7
A. Bartošová, V. Novotny, and P. Hajda (2000) *Evaluation of Water Quality and Ecological Risks*.

This report contains in the first part detailed descriptions of the pilot watersheds of the Menomonee River and Oak Creek. Both watersheds can be characterized as urban or urbanizing however, they differ, in character. The Menomonee River watershed can be divided essentially into two halves, the upper watersheds that is rapidly urbanizing and the lower watershed that is fully urbanized. The downtown portion of the watershed was not considered in the research because the river is detached from the community and located in a formerly industrial/rail yard brown field area. The Oak Creek watershed contains a commercial transportation land use clustered along the Interstate 94 in the upper part and fully urbanized City of South Milwaukee in the lower part. The middle is mostly rural and rapidly urbanizing. The focus of the research was the community of Oak Creek and upstream community of Franklin that are presently mostly rural/suburban and rapidly urbanizing.

The second part of the report contains evaluation of water quality of both pilot water bodies and several reference streams. The analyzed data included historic data retrieved from STORET and agencies (Wisconsin Department of Natural Resources and Milwaukee Metropolitan Sewerage District and data obtained by the Marquette University team during the period of study. It was found that both rivers have relatively fair water quality with exception of dissolved oxygen that is poor at Oak Creek. The Menomonee River quality is better than that of Oak Creek for DO but worse for metals. Violations of the water quality standards were found to be frequent and included dissolved oxygen A dramatic improvement in present concentrations of lead from those measured before the ban on the use of lead in gasoline. Traditional approach to water quality evaluation revealed possible chronic toxicity problems with cadmium and past lead in both watersheds. The ecological effect quotients are close to 1.0 for copper at several monitoring sites on Menomonee River, both for acute and chronic toxicity. The acute toxicity standard for zinc was exceeded on at one site on Menomonee River.

The third part of the report presents the evaluation of the ecological risks. The acute and chronic risks were calculated using the modified methodology developed by the Water Environment research Foundation (WERF). The chronic toxicity estimation does not include the effect of contaminated sediments, only the water column contamination.

Report # 8
D. Booth (2000) *Biocentric Environmental values and Support for the Ecological Restoration of an Urban Watershed*

The primary goal of this portion of the research project was to estimate the extent to which ethical evaluations of the environment affect the public's willingness to pay (WTP) for the ecological restoration of urban watersheds. This was accomplished by including a series of questions for respondents on basic environmental attitudes and values in the watershed survey questionnaire. Questions designed specifically to capture the ideas of a duty to restore the health of urban rivers and valuation of urban rivers for their own sake were included as well. A biocentric valuation of the natural world is premised on the notion that nature is valuable for its own sake apart from human interests. The basic hypothesis to be tested employing multivariate regression analysis was that environmental attitudes affect specific beliefs and values (cognitive structure) about WTP for urban watershed restoration and that these beliefs and values in turn affect WTP. Regression analysis indicates that a broad measure of environmental attitudes, the Awareness of Consequences Scale (AC), is a statistically significant explanatory variable in a regression equation for cognitive structure and that cognitive structure is in turn a statistically significant explanatory variable in a regression equation for WTP. The magnitude of the regression coefficients indicate that a change in AC at the margin has a substantial effect on WTP. Moreover, including specific measures of environmental values in addition to the AC scale, such as the degree to which respondents hold biocentric attitudes toward urban

rivers and believe they have a duty to share in the cost of urban river restoration, adds to the explanatory power of the cognitive structure regression equation. In short, this means that the extent to which respondents believe that the natural world is valuable in its own right has a positive impact on WTP. To the extent that biocentric values are becoming more widespread, support for restoration of urban rivers in the form of willingness to pay will increase.

Report #9
E. Alp, R.L Shresta and V. Novotny (2001) *Hydrologic Impact of Urbanization on the Root River in Racine*

The Root River watershed located in the east-central portion of the Southeastern Wisconsin region is rapidly urbanizing. The urbanization may create significant damages because of increased flooding and deteriorating water quality. In this research sponsored primarily by the Wisconsin Foundation for Independent Colleges (S.C. Johnson Foundation), the methodology developed during this EPA sponsored project (Report #4) was successfully applied to another watershed. This report examined the impact of urbanization on the Root River discharge-frequency relationship as it could be impacted by the urbanization pressures. Results have shown that as the imperviousness increases the discharge-frequency curve shifts. The 2-year flood flow could be expected to increase 1.6 times, 100-year flood 1.4 times, and the current 100-year flood flow could become a 4-year flow if the watershed is fully urbanized.

Report # 10
S. Alamilla, V. Novotny and A. Bartošová (2001) *GIS based Approach to Floodplain Delineation and Flood Risk Estimation Applied to the Oak Creek Watershed*

The extent of the flood plain is typically estimated from FEMA insurance maps that are often outdated and do not present the current state. The methodology described in this paper greatly simplifies calculations comparing to the traditional hydrologic-hydraulic modeling. GIS based methodology was developed (1) to estimate the flood risk for any given location, and (2) to estimate the change of floodplain with urbanization. Flood risks for specific location was interpolated from risk at 100-year floodplain fringe and risk of channel overtopping. The methodology was implemented in ArcView in two different ways: (1) watershed-wide estimates using Spatial Analyst (raster approach), or (2) location-specific using custom scripts (vector approach).

Probabilistic distributions of floods were developed for several urbanization levels. The flow of given recurrence interval and urbanization level was used to estimate floodplain width through simple regression based on channel geometry. Custom developed scripts then draw the floodplain in ArcView.

Report # 11
P. Blonn (2001) *GIS-based Model of Diffuse Pollution in the Oak Creek and Menomonee River Watershed*

This report describes a GIS based model for estimating diffuse pollution inputs from urban and urbanizing watersheds. The model that is connected to the GIS shell is based on the Natural Resources Conservation Service TR-55 watershed hydrology model, the Universal Soil Loss Equation, and sediment delivery and enrichment of the runoff by soil and urban/highway particulate pollutants. Runoff contamination from urban and highway zones can be related to traffic density or calculated from the National Urban Runoff Project statistical data. The model can calculate annual and storm event loads.

The model was applied to the Menomonee River and Oak Creek watersheds. The calibration output of the model was found to be within 10 % of the measured values with the exception of sediment for the Menomonee River (±30%) and copper and lead for the Oak Creek (±45% and ±20 %, respectively).

Report # 12
E. Alp, D. Clark and V. Novotny (2002) *Application of Benefit Transfer with Contingent Valuation Method on the Root River Watershed*

The model of Willingness to Pay developed for the Menomonee River and Oak Creek was extended to the neighboring Root River watershed. The report contains the demographic evaluation of the Root River watershed and a comparison to the two studied watersheds. Although the Root River is larger geographically, it is more sparsely populated than the two studied watersheds. Nevertheless, most of the statistical variables were similar and the Root River watershed was judged to be sufficiently similar to apply the benefit transfer. The demographic information was obtained from the last census data. The estimated flood control benefits were small, ecological benefits of water body preservation and restoration were ten times greater.

Report # 13
A. Bartošová, V. Novotny, and R. Anderson (2002) *The Effect of Habitat on Biological Integrity of Oak Creek and Menomonee River*

A model based on risk (probability of damage to the benthic biota) propagation from the causative habitat impairment factors and chemical/pollution risks to in water and sediments was developed for the Menomonee River and Oak Creek . The model relates the risks to the most important taxa of the benthic IBI and finally to the IBI itself. For the two studied watersheds, the sediment risk appeared to have the most important single effect. This out the importance of the sediment toxicity evaluation along with the chemical assessment of the water column.

The combined evaluation of all risks accounted for 99.5 % variability of the measured IBIs for the two watersheds. Extrapolating of the methodology using a regional/state wide data base was not as close, most likely due to the lack of information on key parameters in the risk propagation model.

Memorandum # 1
A. Bartošová and V. Novotny (2000) *Statistical Considerations in Aquatic Ecological Risk Calculations.*

The accuracy and magnitude of the ecological risk estimation that based on the concept of the probability of a harm to the most sensitive genera depends on the selection of the probability distribution selected to represent the genus dose response curve. Several probability distributions were investigated and it was found that for common ranges of toxic chemical in aquatic environment the differences in calculated risks can be more than one order of magnitude. The study also evaluated the effect of probability distribution of hardness on the risk caused by metals. It was found that using average hardness instead of instantaneous hardness is acceptable for risk estimation by metals and errors are small.

Memorandum # 2
Robert Anderson (2001) *Biological Evaluation of Menomonee River and Oak Creek.*

Fish and macroinvertebrate samples collected at representative sites throughout the Menomonee River and Oak Creek have been analyzed. Using multimetric assessments based on fish and macroinvertebrate species composition as well as a within stream and regional comparison approach provided a unique perspective for evaluation of selected streams. Historical fish collections in the Menomonee River compared to recent sampling show there has been some reduction in species diversity indicating a reduction of quality.

Fish collections in the Menomonee river and Oak Creek watersheds resulted in very poor biotic integrity ratings at all but one station when compared to a composite of warm-water streams in Wisconsin. Macroinvertebrate multimetric indices of biotic integrity based on the Donges Bay Road reference site in the upper Menomonee River watershed indicated nearly all sampling locations were in the good to fair quality categories. In the study, the composition of fish community (fish IBI) reflects general land use trends that result in degradation of water quality and hydrology. On contrary, the composition of macroinvertebrate community (macroinvertebrate IBI) is more closely related to characteristics of instream habitat.

International Cooperation

The institute/research team has established a cooperation with scientists in Japan from Ritsumeikan University in Kyoto and with scientists from the Universities of Padova, Pavia and Breccia in Italy. Ritsumeikan University is the largest private university in Japan. After the visit of the primary investigator to the Ritsumeikan University in October 1999 and a visit of Professor Yamada to Marquette University, a visiting research scientist from Ritsumeikan spent the 2000 - 2001 academic year (plus summer) at Marquette University. Dr. Atsushi Ichiki participate on the closing phases of this research. Professor Alessandro Muraca from the University of Breccia (Italy) spent the summer of 2001 in the Institute for Urban Environmental Risk Management

Supplemental Keywords:

Flooding, Urbanization, Urban economics, Hydrological modeling, Water quality modeling, Urban drainage, Property damages, Probabilistic models, Public opinion, Watershed, Risk assessment, Ecological effects, Land ethics, Chemicals, Toxics, PAHs, Heavy metals, Nitrogen, Phosphorus, Restoration, Habitat, Integrated assessment, Decisionmaking, Cost benefit, Contingent valuation, Willingness to pay, Geographical information systems, Great Lakes, EPA Region 5, Environmental Ethic, Biocentric values

Relevant Web Site: www.marquette.edu/environment/Research.htm

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