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Public Participation and Perceptions of Watershed Modeling

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Public participation in environmental management is increasingly common across many natural resource sectors. Environmental policies in the water resources sector, in particular, depend upon both computer-based watershed modeling activities and public participation in watershed management decisions, though the integration of participation in watershed modeling remains uncommon. Case studies of two watershed councils in Central New York offer differing perspectives on the effectiveness of public participation in modeling efforts as a mechanism for improving environmental conditions in watersheds. Although watershed modeling is improved from public input in the forms of local knowledge and data contributions, care must be taken at the outset to ensure that public participants appreciate what modeling can and cannot provide so that modeling activities are best able to inform watershed management decisions. A critical assessment of three A's of public participation in watershed modeling (e.g., model applicability, accessibility and accuracy) should be undertaken prior to model development.

Keywords environmental management, focus-group interviews, participatory watershed management, stakeholder involvement

Participatory approaches to environmental management increasingly incorporate stakeholder involvement in watershed-scale issues and the application of watershed-scale assessment tools such as watershed modeling. Watershed modeling, in which physical and chemical processes of hydrology and water quality are represented in a computer simulation, is often employed by hydrologists and environmental scientists to evaluate potential impacts from changes in land use or climatic conditions. While the use of watershed modeling in support of local environmental policy decisions is increasing (Dietz et al. 2004), public participation in modeling activities remains relatively uncommon.

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Table 1. Criteria and indicators of good practice for public involvement in watershed modeling efforts

Criteria	Indicator
Transparent modeling process	Watershed model is user-friendly and well documented with easily understandable outputs including potential uncertainties.
Continuous involvement	Process involves the public throughout, with modelers providing feedback about the public's substantive impact at each stage.
Appropriately representative involvement	Modeling involves participation from the full range of interests of those directly and indirectly impacted by watershed management.
Influence on modeling decisions	Participants' values and knowledge have bearing on decisions made in the modeling process.
Clear role of modeling in watershed management	Model results affect watershed management decisions.

Note. Adapted from Korfmacher (2001).

Within the last decade, however, several national and international environmental management approaches have called for the incorporation of stakeholder input into modeling activities, including the Watershed Analysis and Management Guide for States and Communities (U.S. EPA 2003) and the European Union (EU) Water Framework Directive (Kallis and Butler 2007). While these policy initiatives acknowledge that integration of public participation in modeling is needed, it is often not clear how it should best be implemented and promoted (Castelletti and Soncini-Sessa 2006).

Effective participation by the public in watershed modeling and management is complicated by disparities between sociocultural boundaries and watershed boundaries (Rhoades 2000; Nelson and Weschler 2001), discrepancies in time frames between when stakeholders would like to have information and when modelers are able to provide it (Maguire 2003), and differences between the spatial scales for which stakeholders and local officials often request information and those that modelers are able to provide (Dietz et al. 2004). Although geographies of biophysical watersheds and their corresponding institutional landscapes are rarely the same, stakeholder participation in watershed-related decisions is needed since human society both degrades watershed resources and derives economic and ecosystem services from watershed-scale processes (Rhoades 2000).

The social goals of public participation in modeling activities include the incorporation of public values into decisions and contributing to the resolution of conflicts (Beierle and Cayford 2002). It is also increasingly recognized that local knowledge not only can provide valuable data for model design, but also can serve to qualitatively evaluate the validity of model predictions (Arnold and Fernandez-Gimenez 2007). To what extent

such participation is effective, however, depends upon the level of transparency and the range of involvement of representative actors (Korfmacher 2001).

This article examines the experiences of two watershed councils in central New York relative to their engagement with watershed modeling: the Irondequoit Creek Watershed Collaborative and the Cayuga Lake Watershed Network. I evaluate these cases using Korfmacher's (2001) framework to assess the relative effectiveness of public participation in modeling as a mechanism for improving environmental conditions in watersheds. The Korfmacher (2001) framework presents guidelines for "good practice" in participatory modeling efforts, and is summarized in Table 1.

The watershed councils examined here are hybrids of citizen-based and agency-based collaboratives, or "mixed partnership" types of watershed group (Moore and Koontz 2003), which is the most common organizational form for watershed organizations (Griffin 1999). Three focus-group interviews were conducted by the author with the Cayuga Lake Watershed Network in addition to participation by the author in hydrologic modeling efforts and meetings and conversations with the Irondequoit Creek Watershed Collaborative.

Participation in Watershed Modeling: The Irondequoit Creek Watershed Collaborative

The Irondequoit Creek watershed is a mixed land-use basin with agriculture and forested areas in its headwaters and suburban and urban areas located downstream, including a portion of Rochester, NY. The Irondequoit Creek Watershed Collaborative (IWC) formed as a coalition of municipal agencies in 1994 out of interest in resolving watershed-wide water quality concerns, and to examine potential alternatives to a prior U.S. Army Corps of Engineers proposal to mitigate flooding in the central New York State watershed that was beginning to move toward implementation.[1] Community members and elected officials were concerned about increased flooding and water quality impacts that could result from poorly planned suburban development. A U.S. Geological Survey (USGS) proposal to model runoff and water quality in the watershed using a computer-based simulation model for scenarios selected by the IWC was subsequently funded in 2000 (Bugliosi et al. 2000).

The IWC operates as a coalition of municipal agencies with review and jurisdictional authority over stormwater management projects. Public participation in the watershed modeling project was organized jointly by IWC and the USGS and included local governmental agency personnel from Departments of Public Works, Soil and Water Conservation Districts and municipal planning departments representing 10 municipalities and 2 counties. The IWC representatives to the modeling effort were involved in defining modeling objectives and provided input toward the construction and application of the model. The IWC was also responsible for selecting specific sites for model-based analysis of the impact of detention basins on flood risk, water quantity, and water quality. After model development and application by watershed modelers associated with the USGS (Johnson et al. 2003; Coon and Johnson 2005), the future operation of the model was designed to be turned over to water resources professionals affiliated with the IWC. A detailed users' manual was prepared that included examples of model runs that could be modified "to create scenarios that reflect hypothetical or proposed changes in a basin and to view, analyze, and compare the output from two or more scenarios" (Coon 2003).

The IWC participation in watershed modeling exhibits several attributes that are considered positive indicators of participation in watershed modeling according to Korfmacher's (2001) evaluation framework. Democratic principles dictate that the public should have a voice in issues that affect its interests, which is reflected by the participation in the IWC by representatives from local governments. Second, the idea that the substance of the modeling effort would be improved by inclusion of public input regarding flood scenarios has also been shown valid in this case. Knowledge of local hydrologic conditions, including flood-prone areas and wetland locations, was augmented through public participation during model application. However, the pragmatic justification for public involvement, which argues that a more participatory public would better support initiatives based on model results, is less certain in the Irondequoit Creek case. The IWC determined the locations in the watershed for model-based analysis of the impact of potential detention basins. Local governmental representatives to the IWC appeared to act more upon their local mandates as public officials of a political-geographic area than upon their membership in a hydro-geographic area by lobbying for the analysis of particular detention sites on the basis of their political jurisdiction, rather than ranking the range of available sites by flood risk or other criteria. As such, some of the impetus to "work as a watershed," which was anticipated by the modelers to provide synergy in realizing the potential to resolve numerous local flood-prone areas, did not translate into coordinated planning, and the model-based analysis proved less fruitful for scenario evaluation than anticipated.

The Irondequoit Creek modeling project also faced difficulties relating to the costs of increased time and resources expended on nonexpert participation in the early stages of model development. Significantly, IWC project expectations required periodic restatement and clarification. The lack of watershed modeling expertise of both the citizens and water resources professionals from public agencies involved in the IWC required significant training, including the preparation and publication of a users' manual with training CD (Coon 2003). Unfortunately, IWC dissatisfaction with model accessibility and complexity has severely limited its use, and without identification of and funding for specific users of the model, the model has "died a slow death" (W.F. Coon personal communication 2007).

In the case of the IWC, model development took about 4 years between funding and delivery of the model and training CD. Although extended time frames for model development are not uncommon, examples in the literature demonstrate that modeling delays have resulted in diminished stakeholder confidence in the modeling, and have prevented stakeholders from being able to incorporate model results in decision making within anticipated time frames (Maguire 2003).

Evaluation of the outcomes of the IWC modeling involvement using the Korfmacher (2001) framework (Table 1) shows that citizen participation in the project could have been improved. Since the resulting watershed model was not viewed as user-friendly by the nonmodelers, the modeling process cannot be viewed as transparent and accessible. Continuous involvement was difficult to maintain as the model employed (Hydrological Simulation Program-FORTRAN [HSPF]; Bicknell et al. 1997) demanded significant data preprocessing and other modeling tasks that contributed to the lengthy period between participant provision of input for the model and the model delivery. Finally, the overall dissatisfaction of the participants with the model usability precluded the use of the model in ways that were able to affect watershed management decisions in the future.

Perceptions of Watershed Modeling: The Cayuga Lake Watershed Network

Stakeholder groups in the neighboring Cayuga Lake watershed located in central New York have also begun to explore the potential use of watershed models to accomplish water quality goals. The Cayuga Lake Watershed Network was formed in 1997 by a group of citizens concerned about lake water quality, and it has since grown to a community organization of citizens, businesses, and local governments. The public membership organization has over 650 members, while the partnering intermunicipal coalition represents 4 counties and 46 municipalities. I conducted a series of focus-group interviews over 3 months with about 40 representatives from several of the groups actively involved in the development of a watershed management plan: the Technical Advisory Committee (TAC; $n = 15$ participants), the Intergovernmental Organization (IO; $n = 19$), and the Agricultural Committee (AC, $n = 4$). The TAC and IO focus-group interviews were conducted in conjunction with regular meetings of those groups, and as such comprised broad participation of these groups with more than two-thirds of members participating. The AC interview was scheduled and the invitations issued by the county extension service. As such participants in the AC interview were self-selected, and represented less than half of members of the AC. Participants in the IO focus group interview were primarily individuals involved as representatives of local towns in the watershed. While the IO membership includes individuals who also serve on the TAC, the focus-group interview excluded these individuals.

The focus-group interviews were conducted to assess the base knowledge level of watershed modeling by the groups, to explore ideas for potential applications of watershed modeling, and to begin a discussion of modeling issues that may inform any subsequent modeling activities carried out by the group. Each interview consisted of open- and closed-ended questions. Participants in the TAC interview included a number of social and physical scientists, some of whom had previous exposure to (and even personal experience with) models of different types. As such, the TAC offers recommendations to the IO, which members of the TAC and the IO agree are likely to be accepted uncritically by the IO.

In discussing watershed models and modeling, Technical Advisory Committee members described models as providing a means to synthesize information and processes to illustrate the impacts of public policy on environmental quality. Participants in the TAC focus group also discussed the utility of a watershed model in explaining to the public what a watershed is and how it works. Their suggested uses for watershed models included a sediment study for the southern end of the lake, TMDL development for specific water quality parameters, use as a planning tool to limit urban sprawl, and to evaluate the contribution of septic system to phosphorus loadings and transmission of viruses to the lake.

The data collection and model development requirements to support the analyses suggested by the TAC participants were considerable and costly, a factor discussed in depth by the Intergovernmental Organization group, whose members, as political representatives of local towns, had a less developed understanding of what comprises a watershed model. When asked to define a watershed model, IO participants responded by asking for an example of one. After a general discussion of watershed models and modeling, the group offered a general consensus that models could be a good educational tool for watershed residents and would encourage compliance with environmental regulations. Nevertheless, for a model

to be viewed as credible and useful by participants in the IO focus group, it must be both scientifically based and understandable by the layperson. Interest was expressed in using modeling to explore soil erosion from farms and the phosphorus contribution of both urban and rural land uses to water bodies. While the potential utility of a model was generally accepted, participants stated that any funds required for data collection to support modeling are not likely to come from town boards, and should come from agencies involved in the watershed such as the USGS or the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). If not, grant funding would have to be obtained by local watershed groups.

The Agricultural Committee focus-group interview began with a discussion of models and modeling that quickly became focused on the lack of confidence in models expressed by the focus group participants. The discussion also explored ways in which modeling could benefit and/or restrict agricultural interests. Participants conveyed a pervasive impression that agriculture is frequently blamed as an environmental scapegoat, and that modeling could serve to illustrate agriculture's true contribution to pollution in the watershed. Participants also expressed caution that further examination might lead to increasingly restrictive regulations affecting the economic return of farms in the watershed. The reluctance of many farmers to participate in data collection and sampling was explained from this perspective.

Results from the Cayuga Lake watershed focus group interviews meet a number of the Korfmacher (2001) indicators of good practice for participation in watershed modeling (Table 1), which include a transparent modeling process, continuous involvement, and appropriately representative involvement. Continuous involvement is probable in the case of Cayuga Lake, as many interested parties have been involved in the process for several years (Genesee/Finger Lakes Regional Planning Council 2001). Finally, representative involvement is a goal of the Cayuga Lake group, and efforts have been made both to bring in the general public and to involve special interest groups in the watershed.[2]

The Cayuga Lake focus-group interviews also highlight several concerns regarding the role of modeling in watershed management. Potential tasks identified for modeling are both difficult and expensive to achieve since models are developed, applied, and tested using data that must be either publicly available or collected with funds that tend to be scarce. Furthermore, for modeling results to be meaningful, they must both be understandable and have the confidence of the public. A transparent modeling process (Korfmacher 2001) is essential to achieve this confidence, which was confirmed by the focus group participants as a prerequisite to successful outcomes of any future modeling activities.

Lessons Learned

Indications of success and notes of caution regarding public participation in watershed modeling are evident based on the experiences of these watershed councils in New York State. United in their efforts to provide local input into watershed problems, participants in the Irondequoit Creek watershed nevertheless missed opportunities for synergies by maintaining a focus on local political-geographic perspectives rather than a watershed focus for selection of model evaluation points. In the Cayuga Lake watershed example, the desire of all stakeholder communities to capitalize on the educational potential of watershed models was balanced by the pragmatic recognition of the municipal officials that modeling costs money, which

would need to be sought from granting agencies or other sources. If the educational potential and future planning possibilities are to be derived from modeling activities, significant funds will need to be budgeted to reflect this, as was the case for the IWC. Otherwise, efforts of the watershed modeler will inevitably focus on model development and application, and what may result in a well-performing watershed model from the modeler's perspective could be an inaccessible scientific product from the perspective of the participants.

Since watershed groups will almost always have to look outside for funding of modeling activities, as was the case for both New York watershed councils described here, the need for transparency and open discussions on anticipated benefits of watershed modeling activities cannot be overlooked. Writing grants to solicit external financial support is a long process that requires significant efforts. It also creates opportunities for frustration that can try the nerves of participants from different stakeholder groups who may even hold differing views of what constitutes "taking action" (Bonnell and Koontz 2007).

Watershed collaboratives that have formed in recent years are seeking to facilitate more collaborative approaches to natural resource management (Bonnell and Koontz 2007). As state, national, and international agencies continue to promote stakeholder involvement in watershed approaches to water resources issues (cf. the US EPA Watershed Approach: U.S. EPA 2007), this study demonstrates that there is a need to focus not only on how to improve participation (Castelletti and Soncini-Sessa 2006), but also on how to improve the dialog between scientists and stakeholder participants.

In the two cases presented here, local participants expressed interest in obtaining model results at a level of detail not readily achievable with the current spatial scale at which watershed models are applied and evaluated. This spatial disjuncture in public interest and watershed model applicability is not uncommon (Dietz et al. 2004). One potential way forward is in the use of cooperative modeling activities, in which modelers and stakeholders work together to develop the model (Cockerill et al. 2006). Cooperative model development differs from the IWC case, where an existing watershed simulation model was applied to a local watershed.

Broadly, efforts to incorporate public participation in watershed modeling activities need to consider model (1) applicability, (2) accessibility, and (3) accuracy. These three A's of public participation in watershed modeling suggest that the scope of the problem for which a model will be utilized needs to be jointly defined (e.g. model applicability), the importance of direct end-user interaction with a watershed model needs to be considered prior to model development, and the trade-offs between model applicability and its accessibility to end-users on model accuracy need to be evaluated and understood by both modelers and the participating public.

There are clearly also pitfalls that need to be avoided when watershed modeling incorporates public participation. The choice of a model needs to be limited to those with the potential to be viewed as a user-friendly model from the perspective of nonmodelers, bearing in mind that this also limits the choice of available watershed models to those that are both technically applicable and relatively easy for a nonmodeler to engage. Given that gathering and incorporating data into a watershed model can take a significant period of time, steps need to be taken to ensure that involvement from the participants does not suffer from long time gaps during which interest could wane. The continuity of participants is fundamental to maintaining a fluid, iterative modeling process, just as involving participants from

the full range of interest groups is needed to maintain representative involvement. Finally, if the model is well chosen, and the public participation is continuous, transparent, and representative, then the final indicators for good practice in watershed modeling efforts (participants' views and knowledge impact the modeling efforts, and the modeling efforts affect watershed management decisions) are more likely to be met. In the first example presented in this article, a lack of transparency (e.g., the model viewed as not user-friendly) ultimately impacted the quality and substance of subsequent public engagement with the watershed model, as reflected by the evaluative indicators of Table 1. In the second example presented, the broad engagement of technical specialists, governmental representatives, and land managers in a coordinated watershed management plan suggests that participatory modeling by that group is likely to prove useful, as long as the participants involved engage in the process in an open and reflexive manner such as that suggested by the Kormacher (2001) guidelines.

Notes

1. U.S. Army Corps of Engineers. 1982. Irondequoit Creek Watershed New York, Final Feasibility Report and Environmental Impact Statement. Report accession number ADA115849.
2. See for example Appendix B "Public Participation" of the Cayuga Lake Watershed Restoration and Protection Plan (Genesee/Finger Lakes Regional Planning Council 2001).

References

Arnold, J. S. and M. Fernandez-Gimenez. 2007. Building social capital through participatory research: An analysis of collaboration on Tohono O'odham tribal rangelands in Arizona. *Society Nat. Resources* 20(6):481–495.

Beierle, T. C. and J. Cayford. 2002. *Democracy in practice: Public participation in environmental decisions*. Washington, DC: Resources for the Future.

Bicknell, B. R., J. C. Imhoff, J. L. Kittle, Jr., A. S. Donigian, Jr., and R. C. Johanson. 1997. Hydrological Simulation Program—FORTRAN: User's manual for version 11. Athens, GA: U.S. Environmental Protection Agency, National Exposure Research Laboratory.

Bonnell, J. E. and T. M. Koontz. 2007. Stumbling forward: The organizational challenges of building and sustaining collaborative watershed management. *Society Nat. Resources* 20(2):153–167.

Bugliosi, E. F., W. F. Coon, and D. A. Sherwood. 2000. Irondequoit Creek Watershed gets a model. *Monroe County Environmental Health Laboratory and U.S. Geological Survey Newsletter* 6(Summer):1–2.

Castelletti, A. and R. Soncini-Sessa. 2006. A procedural approach to strengthening integration and participation in water resource planning. *Environ. Model. Software* 21(10):1455–1470.

Cockerill, K., H. Passell, and V. Tidwell. 2006. Cooperative modeling: Building bridges between science and the public. *J. Am. Water Resources Assoc.* 42(2):457–471.

Coon, W. F. 2003. Simulating land-use changes and stormwater-detention basins and evaluating their effect on peak streamflows and stream-water quality in Irondequoit Creek basin, New York—A user's manual for HSPF and GenScn. Ithaca, NY: USGS.

Coon, W. F. and M. S. Johnson. 2005. *Effects of land-use changes and stormflow-detention basins on flooding and nonpoint-source pollution, in Irondequoit Creek basin, Monroe and Ontario Counties, New York—Application of a precipitation-runoff model*. Washington, DC: U.S. Geological Survey.

Dietz, T., J. Tanguay, S. Tuler, and T. Webler. 2004. Making computer models useful: An exploration of expectations by experts and local officials. *Coastal Manage.* 32(3):307–318.

Genesee/Finger Lakes Regional Planning Council. 2001. *Cayuga Lake watershed restoration and protection plan*. Genesee/Finger Lakes Regional Planning Council: Rochester, NY.

Griffin, C. B. 1999. Watershed councils: An emerging form of public participation in natural resource management. *J. Am. Water Resources Assoc.* 35(3):505–518.

Johnson, M. S., W. F. Coon, V. K. Mehta, T. S. Steenhuis, E. S. Brooks, and J. Boll. 2003. Application of two hydrologic models with different runoff mechanisms to a hillslope dominated watershed in the Northeastern U.S.: A comparison of HSPF and SMR. *J. Hydrol.* 284(1):57–76.

Kallis, G. and D. Butler. 2007. The EU water framework directive: measures and implications. *Water Policy* 3(2):125–142.

Korfmacher, K. S. 2001. The politics of participation in watershed modeling. *Environ. Manage.* 27(2):161–176.

Maguire, L. A. 2003. Interplay of science and stakeholder values in Neuse River total maximum daily load process. *J. Water Resources Plan. Manage-ASCE* 129(4):261–270.

Moore, E. A. and T. M. Koontz. 2003. A typology of collaborative watershed groups: Citizen-based, agency-based, and mixed partnerships. *Society Nat. Resources* 16(5):451–460.

Nelson, L. S. and L. F. Weschler. 2001. The watershed as a focus for public administration: Conventional and bioregional approaches. *Admin. Theory Praxis* 23(1):10–24.

Rhoades, R. E. 2000. The participatory multipurpose watershed project: Nature's salvation or Schumacher's nightmare? In *Integrated watershed management in the global ecosystem*, ed. R. Lal, 327–344. Boca Raton, FL: CRC Press.

U.S. Environmental Protection Agency. 2003. *Watershed analysis and management (WAM) guide for states and communities*. Washington, DC: EPA Office of Water.

U.S. Environmental Protection Agency. 2007. *A watershed approach 2007*. Available from http://www.epa.gov/owow/watershed/approach.html (accessed 4 September 2007).