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## LOCAL GOVERNMENT AND GROUNDWATER QUALITY MANAGEMENT

By

David J. Allee and John Powell

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Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

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## Introduction and Summary

We want to touch on some aspects of several topics related to contamination of groundwater. First, how might we think about local governments in groundwater management? One argument concludes they play an integral role in the development of problems by politically fragmenting the landscape. Whether that is true or not, they have major opportunities in the prevention and correction of groundwater problems. Whether those opportunities are seized will depend upon how state and federal agencies make use of the opportunity to extend and multiply their own capabilities by working through local governments. Contamination of groundwater is the problem considered here, but many of the arguments apply to quantity problems, as well.

Second, regulation is a favorite strategy in resource management to correct spillovers from private activity. For groundwater problems, land use controls are often cited as the long run solution -- presumably because infiltration and recharge rates are highly variable over the landscape and high risk land users have little incentive to consider this without controls.[1] It makes sense to locate higher risk activities over the lower risk sites and/or impose risk reducing conditions on the high risk land uses. Land use controls traditionally are a local function. However, states and to some extent the Federal Government have introduced a variety of overlay arrangements that affect land uses and their regulation. Groundwater management involves interactions between land users, each of which may be highly localized initially, but which can happen over wide chunks of landscape and over long periods of time many sources of contamination provide a ubiquitous threat. The many different federal and state statutes provide some degree of control for each of these sources. All of these potentially come together at the local level.

Regulation is attractive as a management tool in part because it puts the direct burden of cost on the perpetrator of the problem, not those affected by the problem. But it is a bargaining process where regulator and regulatee are the most constant and stable participants. Other actors come and go, but these two participants have to find a way to get along. Success of regulation depends as much upon education and technical assistance as it does on the threat of sanctions. Reformers regularly decry the rare use of sanctions and the narrow scope of the problem. Comprehensive coverage of a broad complex problem depends upon a mosaic of many duplicative programs and overlapping levels of government. Closing the last gaps and coordinating all the others involved

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**Professor of Resource Economics and graduate student in Department of Natural Resources, respectively; both at Cornell University, Ithaca, N.Y.

is a role that falls to local governments. If anyone is really to be in charge of managing groundwater, that is who it will be. Of course, some cynics aren't sure there is anyone in charge of anything in the governance of complex societies.

We will review four examples of local arrangements that are illustrated in New York, namely water supply source protection rules and regulations, modifications of local zoning ordinances, the use of the state's environmental impact review procedures and the potential role of Soil and Water Conservation Districts -- the only one of the group to have full coverage of the state. We suspect close parallels in other states.

We argue that rural areas call for special attention and that a broad upgrading of water supply management in rural areas is a strategy to be considered. A small part of all groundwater is known to be contaminated, and at this point, most rural areas are probably in better shape. Many toxic dumps and some major uses of toxic chemicals are found in rural areas, however. And it is commonplace to observe that urbanization takes place, frequently, where governments are structured to deal with rural and not urban problems. Two approaches should be considered to prepare for the groundwater management opportunity. Householders that now depend upon wells should have more support services available. Encouraging only a small proportion to manage their own supply with more sophistication in treatment and monitoring would provide a kind of early warning system and a nucleus of people who will understand the need for more stringent measures. Second, a program to upgrade the many small municipal systems would pay similar dividends. Many have significant problems now and in addressing them we see an opportunity to build management capacity.

We have stressed management approaches that lend themselves to low information, low administrative capacity situations. While the early use of these measures can be carried out with volunteers and part-time officials, they can effectively utilize more resources as risks expand. Cooperative approaches between several governments are important. Support from county and state levels for activities by towns, cities and villages can help. While thorough characterizations of all groundwater in the nation and sophisticated monitoring of chemical constituents would be desirable, they are so expensive that we doubt they are likely, and perhaps not even necessary. For example, the analysis of one water sample tested for all of the more than a hundred toxics now being considered for drinking water standards would cost about $1000. Information gathered from a number of laboratories revealed that costs of analysis for the 129 EPA priority pollutants are in the range $800-$1500 per water sample. A single sample mixed with difficult background chemicals could cost as high as $10,000. In any case, potential contaminants are so ubiquitous in our society that good community housekeeping for toxics is surely worthwhile regardless of the precision of the information on which that housekeeping is based.

## Some Economic Thinking About Local Government

Perhaps an apology will serve as a needed reminder. To characterize the world of governments as consisting of three kinds -- federal, state and local -- is to do a great injustice to a marvelously complex set of organizations. It is necessary to simplify to communicate, but much is lost in the translation. One example -- if you examine the total dollars

spent by state and local government in New York and Vermont, you see a surprising difference. Where in New York, local governments spend about three-quarters of the total, in Vermont they spend one-quarter. But remember in many ways Vermont is smaller than some New York counties. Difference in size affects how you do business. Note that in this case the result is for New York to appear more decentralized in its spending, but is it?

Sizes of governments often suggest a cause of inefficiency based upon the logic of economics of scale -- bigger is presumed better. Economic engineering techniques can be used to create estimates of the cost of public services per capita. They show that many services, particularly sewer and water that come in expensive lumps, are less expensive per capita the more total capitas there are to divide those fixed costs. But that is much harder to show with observed expenditure data. Smaller governments have a host of ways to keep out-of-pocket costs manageable. They often spend in cash even less per capita than large governments. Expensive machines can be rented or borrowed instead of purchased; volunteers are used more; services can be offered in more varied levels of quality, or omitted altogether where everyone agrees it's too expensive, and it's easier to get agreement.

Perhaps the more important point about organizational size is not its effect on supply, but on the ability to discover demand. Some preferences are easier to express face to face. Small governments may be much better at reflecting some preferences than large. Efficiencies in demand discovery are as potentially important as efficiencies in supply. Much less study and thought has been given to the demand side, however. This may be because we copy the economist's mental trick of separating supply decisions from demand decisions. The market brings them together. For services provided by government, these decisions are made together in the budget process -- not separately as in the market. Small governments may be better at providing face to face and other categories of services because they can do a better job of either one or both sides of the supply and demand equation. There is some evidence for education, some social services, security patrols and some kinds of regulation.[2,3,4] We should consider where this is true in groundwater management, and encourage those activities at the local level.

People turn to larger governments -- state and federal -- to obtain the advantages of scale on both counts -- both supply and demand advantages. Spillovers and alternative access are two interesting cases that should apply to groundwater management.[5]

Indeed, why would anyone turn to a state or federal government if you could get what you want at the same price from a local supplier? Local governments should be able to provide just enough of what you and your neighbors want. State and federal agencies may be likely to provide too much or too little or have side conditions you don't like, but that risk is frequently worth taking. Luckily, state and federal governments maintain local outlets to facilitate their doing business, as well. Often, perhaps too often, it seems worth it to do business with state or federal suppliers because the cost will be shared over more people and thus be less noticeable. Some public services are overused as a result. Government services almost always seem like something for nothing, but the more so when larger units pay for them. But then some services, like education, are underutilized even when free.

When someone does something to bother a neighbor, the neighbor is apt to turn to government for relief. When local governments lack the capacity or will to provide that relief, larger governments are called in, sometimes with the local officials acting to represent their constituents, sometimes not. This is often useful in environmental problems like groundwater management.

One way to think of this response is partly captured in the word federation. Often the natural resource unit doesn't fit the political unit. There is a boundary problem. Even if the local government is willing and able to provide homeowners with protection from a neighbor contaminating their wells, the aquifer may extend into the next jurisdiction. Boundary problems come in many other forms. For example, some of the skills needed to police some contaminants may only be needed occasionally in each jurisdiction. Jurisdictions may be federated together to deal with many kinds of boundary problems. Occasionally they jointly provide themselves a service without involving a larger government. More often the higher jurisdiction is brought in, or instigates the grouping. What the higher jurisdiction provides is some resources to make the federation possible -- indeed, the federated jurisdictions may not even think of themselves as tied together by, say, a health department employee that services them all. The point is that whether there is a formal organization to reflect the federation or not, thinking about problems in this way points out the partnerships, the shared roles, the complementarities between units of government. The result is a very flexible conceptual system; able to group and regroup to deal with a constantly shifting mix of problems. Indeed, rigid regional organizations, when they need to be changed, may take more organizational effort than was needed to put them there in the first place.

Sometimes when higher levels of government get into a problem area, some local officials breath a sigh of relief and pull out of it. The result can be less net capacity to deal with the problem than might be expected.

Two considerations come to mind if local governments are not yet involved in solving or avoiding a problem. First, it may be easier for the different parts of the local government to work together if there is an internal advocate for the problem. And without an internal advocate, external advocates are less effective. Second, stronger local governments may end up with more attention, shifting the problem to areas with less capacity to resist and/or less capacity to get help in time.

Finally, we feel compelled to point out that governments are always complex and fragmented. For all the discussion about it, coordination is very difficult. Presidents and Governors have never proven very able to focus the resources of their governments on the problems of your town -- your mayor may be able to coordinate them better. Local officials spend a goodly share of their time improving the communication between and within federal and state agencies. Local legislature representatives of the larger governments do, too. After all, they have the motivation to do so. Maybe it's their job? In any case, they may obtain more rewards from successful local coordination than anyone in the executive branches of the higher governments.

## Regulation as a Tool in Environmental Management

Successful regulation -- and does it ever come up to the expectations of those who feel the need of protection -- depends upon widespread understanding of the problem involved. Otherwise, those charged with the role will not have enough support. Actions needed have to be accepted by those regulated. There is never enough capacity to police more than a small minority. Local governments have some advantages in administering regulations that complement the disadvantages of state and federal agencies and vice versa. The trick is how to organize the partnership.

First, we need to get some perspective on intergovernmental relationships. Too many expectations are built on the notion of a chain of command. Somebody must be in charge -- or if they aren't, they should be!! Somebody must be able to tell somebody else to go do what is right and proper. But organizations provide members with some protection from outsiders telling them what to do. And political organizations may be designed more for that purpose than others. Thus, governments relate to each other, and to constituents of each other, in some particular ways.

As noted, bargaining and exchange characterize many of the relationships. Local people and their local governments provide support for authority and budget while state and federal agencies provide program elements in exchange. Chain of command expectations are replaced by the reality of independence, or perhaps more accurately, by partial interdependence.

But what are those program elements that the state and federal agencies have to offer? Money, information, expertise, authority, legitimacy... in short, the resources that are needed to make things happen. To coerce, to bribe or to organize for internalization of spillovers or for delivery of a service, or to deliver compensation. The same things that local governments have, but with different boundaries and resource endowments. Local governments use many of these state and federal resources to make things happen. Regulation of environmental problems is no exception.

On the smallest scale, regulation is heavily education and technical assistance. Social pressure works. The raised eyebrow, the explanation often are enough. But as a social system grows, those protected and those regulated grow further apart. Sanctions and authority are more important. There are frequent calls to separate the technical assistance function and public education function from the regulatory activity. Let the regulator just be the policeman, but only the regulators can be the final arbiters of the technology involved. They usually end up spending most of their time at technical assistance. No one else's word counts. Water quality and public health officials take pride in their engineer-to-engineer, problem solving approach in their respective domains of water quality enforcement. Sanctions are the exception -- not the rule. Most elected officials seem to prefer it that way.[6] Conflict is destabilizing.

There are advantages of a three tiered, partially independent approach to environmental regulation. Reformers can enter at more points. But of course when they do, they feel that they can't achieve as much as fast as if there were fewer tiers. Layers of government make for a more torturous process of reform, but hopefully when changes do move through the system, there has been more innovation, testing, understanding, compensation and support. It should be a more stable system than with more consolidation.

This three tiered, partially interdependent, approach also means that gaps in the system can be closed, at least for some states and some localities. But where support and capacity do not exist, a mobile problem may concentrate in those vulnerable spaces.

Regulators under pressure from the regulated and in the face of never enough support from those protected always define their scope in terms that are smaller than the problem as seen by those who feel the need of protection. As the Office of Technology Assessment has shown, 33 categories of sources of groundwater contamination are to some degree covered by 16 federal authorities (most in EPA).[7] Do these add up to the full range of protection needed everywhere? Does everywhere and everyone need the same degree of gap filling? We never consolidate in one organization all regulators or public programs to deal with all aspects of one major problem of any kind. Even in national defense, we achieve comprehensiveness from multiple layers of overlapping and apparently duplicative but usually complementary organizations. The urge to advocate simplistic consolidation of environmental management activities should be resisted not only as naive but as counterproductive. We will end up with less capacity, not more.

More mundane but also more effective concepts for reformers to consider include more funds for regulator expertise to bargain with the regulatees more effectively -- more people, of higher status backed up with more specialists and research capacity. Change the rules to give more advantage to the regulator in the bargaining. The technology standards of PL 92-500 did that for water quality regulation.

Overlay agencies focus more resources and support on particular problem areas. Examples relevant to groundwater include Coastal Commissions in California, Water Management Districts in Florida, the Adirondack Park Agency in New York, the Pinelands Commission in New Jersey, the Natural Resource Districts in Nebraska, the Conservancy Districts in Ohio, etc., etc. Another tactic is to strengthen the organizations that provide complementary research information and technical assistance. Examples include the U. S. Geological Survey, Soil and Water Conservation Districts, university research and extension programs.

Some more subtle problems exist. While the three tiered system lends itself to varying the resources to match the problem, it can also end up varying those resources in favor of those jurisdictions who are already in the strongest position to help themselves. Several approaches suggest themselves. First, the main line Federal organizations could differentiate their efforts so that states and local governments with less capacity receive special attention. In particular, organizational capacity building could be emphasized. For example, those states and local governments who do not have capacity commensurate with the problems they face might be eligible for extra training and organizational support. "Who like us had a problem like ours and how did they solve it?" is the question to answer. It is harder to answer well than it might seem. Help to share capacity is another area of opportunity.

Perhaps more likely is the expansion of the program of some other agency that is particularly well placed to provide compensatory services. Good examples are the programs for Indians and rural areas that appear to duplicate other programs but in fact usually serve quite different clientele.

## Some Program Examples from New York

New York divides its state level groundwater protection activities primarily between the Departments of Environmental Conservation (DEC) and Health (DOH). Booth and Bronson of the Cornell Center for Environmental Research developed a critical analysis of their programs in 1982 that called for more resources, more coordination and more aggressive outreach into the communities of the state, and stricter use of their several enforcement powers.[8]

DEC's primary controls are through their role in implementing most of the federal environmental programs. In addition, they administer a unique and highly innovative program of cost sharing for operation and maintenance of public waste treatment plants. Usually, there has been a DEC program that preceded a federal version. Pesticide controls is an older relevant example.[9] Underground storage tanks is a current example.

While DEC emphasizes source control, DOH emphasizes management of drinking water systems. Counties can have delegated to them various parts of the process with some cost sharing and other support as an inducement to develop the local capacity needed to carry out the delegated activities. Besides the implementation of the federal 1974 drinking water act, DOH has a full complement of public health activities.

Recent legislation has formalized cooperative efforts to develop regional water supply strategies. DEC and DOH have complemented each other's water activities for many years. Major water supply developments, contaminant abatement, organizational changes, or planning activities only proceed with the involvement of both. The following descriptions of local actions to manage the risk of groundwater contamination do not spell out all of the relationships between and within DEC, DOH and local governments. And in particular, the inspection and enforcement roles of the two agencies are not dwelt upon. Suffice it to be said that those provide important reinforcement to the local activities. There is more complementarity and coordination than we shall describe, albeit less than many would like to see. Perhaps future research will show where some synergism can be achieved by more resources devoted to coordination. Another act of the legislature has called for a water resources commission that might well address such a topic.

## Water Supply Source Protection Rules and Regulations

A request to the NYS Department of Health (DOH) for suggestions as to what a locality might do to protect its groundwater will elicit information on an approach that has been on the books since 1885.[10] Bacteriological contamination was the concern then, but disinfection and other treatment proved less expensive, more convenient and quite effective. Prevention through sanitary surveys and related technical assistance and sanctions was de-emphasized. As long as the number and type of toxics encountered remain manageable and public attention is minimal, this situation can be expected to continue. But if there is support to link a prevention strategy to the water supply agency, this approach has much to commend it.

As usually implemented, the owners of a water supply system (public or private) petition the DOH proposing rules and regulations to fit its

present and prospective sources. Note that system protection can extend across political boundaries. Jurisdictions other than the owner normally are only represented informally through DOH, and/or the County Health agency, if it is included. Land uses may be prohibited within specified distances of wells or recharge areas. Particular activities may be permitted if they follow prescribed risk reduction measures. Regular inspections -- sanitary surveys -- may or may not be performed by the owner. If violations are identified, enforcement proceedings are carried forward jointly by the owner and DOH. Proceedings have been characterized as time consuming, expensive and locally unpopular.

In a recent study[11] of the Water Supply Rules and Regulations program Robert Hennigan of Syracuse University identified three options -- continue the present ineffective program, replace the program with state controls or, and most likely, incrementally strengthen the present approach. He presented a number of strengthening changes tailored to the present situation of ubiquitous toxic risk including adopting rules and routes for the transport of chemicals.

Of the almost 1100 larger primary systems in the state -- they develop sources for more than a trailer park -- about 200 have rules. Most large surface water systems have them. A significant number who don't have them draw from lakes and streams whose watersheds are beyond their means to regulate -- opportunities for federation with state help exist. Many have not been updated or enforced in years.

DOH has developed modern model regulations. The City of Schenectady is serving as a test case. A concern has been the use of grandfather clauses. When zoning ordinances are put in place, it is common to provide nonconforming uses with limited or even unlimited dispensation to continue. But should public health rules allow for such exceptions? If the danger is significant enough to deserve this category of rule making, then shouldn't those who pose a present danger be removed as well as future dangers prevented? Is it justifiable to simply seek no increase in risk while at the same time bestowing a property right to run the risk of polluting? This debate is an important version of the perennial arguments over who will bear the costs and how safe is safe.

It is one thing to have a set of modern concepts, sensitive to groundwater as a drinking water source and embodied in model language. It is another to have the capacity to carry out the inspections and follow up needed to turn them into effective controls. To date no proposals have been put forward to stimulate more effort on the part of local water suppliers to engage in such self-protection. New York's cost-sharing for operation and maintenance of sewerage treatment plants is an interesting precedent as is the cost-sharing for local public health programming.

## Modifying Traditional Land Use Control

Watershed rules and regulations miss many hundreds of small systems. Indeed, the number of systems with only a few connections may run into the thousands. Modifying traditional land use control, operated by the lowest level of government, will provide some protection for systems that cannot be expected to conduct some version of the sanitary survey. The traditional land use control modified to reflect risk of groundwater contamination can complement the water supply rules and regulations approach. They are probably not substitutes.

Traditional land use had the advantage of catching development before it begins. Most contractors and developers and even private citizens are accustomed to getting a building permit and to complying with zoning requirements. The special permit approach is widely understood if not always applied. While the primary emphasis of the control is at the time of a change in use, zoning activities have a poor record of monitoring and, of course, have a great deal of difficulty influencing problems systematically across jurisdictional lines. They do have the advantage of a tradition of grandfathering existing land uses which, as we have seen, causes some consternation in public health oriented water supply rules and regulations. On Long Island, modifications of traditional land use control have been combined with density reduction as a means of reducing risk.[12] More generally, the approach is to require a special permit for those activities which pose a special risk of groundwater contamination.

In Vestal, New York, they have adopted an aquifer district.[13] Their ordinance has been requested by many other jurisdictions and may act as something of a model for other villages and towns. An aquifer district map was developed based on work of the U. S. Geological Survey and political acceptability which was conditioned by some legal action over a spill that impacted the municipal system. The ordinance contains a definition of toxic or hazardous material and any man-made change to improved or unimproved real estate, construction of buildings, reconstruction, dredging, filling, grading, construction of tanks or other storage facilities, pumps, pumping stations, waste treatment facilities, dumping or landfill operations are required to apply for a permit. Also, any other activity which requires a permit from the State must also apply for a permit from the Town of Vestal. The applicant is required to submit a fair amount of descriptive information of the activity in question and details with respect to the use and storage of all toxic and hazardous materials. A public hearing is called for, and the town board is then to make a judgment as to whether it will grant the permit unconditionally or with stated conditions. The burden that this process will put on the capacity of the town board to make risk judgments can only be guessed at until we have more experience. We would suspect, however, that technical assistance from the other local government agencies such as the county boards of health and the state agencies will be required.

## State Environmental Quality Review Act

New York, like many states, gives local governments the authority to review proposed activities which may have environmental impacts.[14] Special adoption of ordinances and organization of boards and permit procedures

is kept to a minimum. Information required from the applicant can be voluminous or quite corsory. The sanctions that can be imposed other than public attention are, of course, rather minimal. Several areas have found this to be a useful tool in gaining time for more tailored and sophisticated response. It also provides a way for the public to gain information on the risks which they face. In one county where the potential toxic dump sites are numbered in the hundreds, and some 60 are quite sure to contain hazardous materials, the environmental review procedure has proven to be a way to discourage subdivisions over the old landfill sites. In many cases these are subdivisions that would be depending on groundwater in and around the landfill site.

Landfills and other potential contamination sources easily fit the definition of critical environmental areas and thus qualify for more rigorous review. In due course of time, it is hoped that all of the 60 hazardous sites with more and more toxic materials and such others as may prove to provide problems will be cleaned up under either the federal or the state Superfund. Meanwhile, people have bought land that they can't use and have been effectively discouraged through the environmental review procedure.

## Soil and Water Conservation Districts

Another device that covers most of the countryside are the districts that were founded in response to many years of federal encouragement and education. These soil and water conservation districts sign a cooperative agreement with the U. S. Department of Agriculture for technical assistance in conservation programming. During the recent review of nonpoint pollution under Section 208 of the Federal Water Quality Legislation, most soil and water conservation district participants became sensitized to water quality problems. Best management practices for most extensive land uses were identified and campaigns to achieve their voluntary adoption were made a part of their ongoing activities. Some cost-sharing has been available in some cases, but generally speaking, the practices adopted are either those that save money or represent relatively low costs and avoid needless and gratuitous results to the environment. Altruism does get things done at the local level.

But perhaps more important, the Soil and Water Conservation District activities have provided a sensitivity which may give us a basis for action on groundwater contamination. The Soil Conservation Service is attempting to develop technical capacity within its system to provide backstopping for groundwater problems.[15] They have a contract with Oklahoma University to provide a national assessment of existing groundwater problems and techniques being used to overcome them. The study is split into four areas:

1. Saltwater intrusion;
2. Recharge potential;
3. Pollution related to nutrients, eg., from agricultural fertilizers and animal wastes;
4. Pollution related to pesticides and herbicides.

This implies the capacity to give quick and dirty identification of high risk recharge zones somewhat similar to the work that was done in the

early development of high risk flood areas before detailed flood plain mapping became available through the flood insurance program.

While this level of detail may not be fit for the more rigorous requirements of public health oriented regulation, it may be quite sufficient for modifications of traditional land use controls. And it's the kind of information that will certainly provide a basis for public education.

## Some Final Comments

Upgrading water management in general in rural areas is an important strategy in achieving capacity to handle the groundwater contamination problems, both latent and potential. We must help solve the problems of today and develop capacity for tomorrow. Rural areas are the locations for many of our dumps, formal and informal. They are also the site of the use of tons of agricultural chemicals. All urban areas were once rural. And urbanization regularly takes place within a governmental context that was developed to serve very different kinds of problems.

The National Statistical Assessment of rural water conditions carried on in 1978 by staff of Cornell University and others for the EPA Office of Drinking Water surveyed 2,654 households.[16] These were selected from 22 million rural households and information was generated on quantity, quality, affordability and reliability of water supplies. Around half of these households received water from municipal type systems. Fifteen percent of rural households -- that is 3.3 million -- face significant water born health problems. Seven hundred thousand households face severe quantity problems; 3.6 million face moderate quantity problems. If we can raise the management capabilities of these households, we will have gone far to providing a vigorous base for responding to the groundwater contamination problem.

## References


1. Huffmire, Madelyn M. and Larry Frankel. 1982. Regulation of Land Use Practices for Areas Surrounding Aquifers. In: The Impact of Waste Storage and Disposal on Groundwater Resources. A Northeast Conference at Cornell University, Ithaca, NY, sponsored by USGS and Center for Environmental Research, Cornell. Co-sponsored by EPA, New York State Department of Environmental Conservation and Department of Health.

2. Ostrom, Elinor and Dennis C. Smith. 1976. On the Fate of "Lilliputs" in Metropolitan Policing. Public Administration Review 32(2):192-200.

3. Ostrom, Vincent. 1975. Alternative Approaches to the Organisation of Public Proprietary Interests. Natural Resources Journal 15(4): 165-89.

4. Mehay, Stephen L. and Rodolfo A. Gonzalez. 1985. Economic Incentives Under Contract Supply of Local Government Services. Public Choice 46(1):79-86.

5. Ostrom, Vincent and Elinor Ostrom. 1977. A Theory for Institutional Analysis of Common Pool Problems. In: Managing the Commons. Garrett Hardin and John Baden (eds.). W. H. Freeman and Co., San Francisco.

6. New York State Department of Health. November 1984. Personal communication.

7. Office of Technology Assessment. 1984. Protecting the Nation's Groundwater from Contamination. OTA-0-233.

8. Booth, Richard and Albert Bronson. 1983. Major Institutional Arrangements Affecting Groundwater in New York State. Center for Environmental Research, Cornell University. (Unpublished report)

9. Petroleum Bulk Storage Law, 1983. Ch. 613 of the New York State Laws; Article 27 of Environmental Conservation Law.

10. Ch. 543 of the New York State Laws, 1885.

11. Hennigan, Robert D. 1981. Water Supply Source Protection Rules and Regulations Project. SUNY College of Environmental Science and Forestry, Syracuse, New York.

12. Koppelman, Lee, Edith Tanenbaum and Carole Swick. 1984. Non-point Source Management Handbook. Long Island Regional Planning Board, Hauppauge, New York.

13. Town of Vestal Zoning Ordinance. 1983. Ordinance requires aquifer permits for building or remodelling where costs exceed $50,000 or where any substances likely to contaminate groundwater are to be used or stored.

14. State Environmental Quality Review Act. 1975. Article 8 of the Environmental Conservation Law. Ch. 612 of Laws of New York State, 1972.

15. Soil Conservation Service, Washington, DC. June 1985. Personal communication.

16. Francis, Joe D., Bruce L. Brower and W. F. Graham. 1982. National Statistical Assessment of Rural Water Conditions. Report prepared for Office of Drinking Water of U. S. Environmental Protection Agency.