UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF NEW YORK

	:	CV 97-2154
UNITED STATES OF AMERICA,	:	**GERSHON, J.**
	:	**GOLD, M.J.**
Plaintiff,	:	
-and-	:	
	:	**AFFIDAVIT**
STATE OF NEW YORK *et ano,*	:	Paul S. Makiewicz, Ph.D.
	:	
Plaintiff-Intervenors,	:	
	:	
- against -	:	
	:	
CITY OF NEW YORK *et ano,*	:	
	:	
Defendants,	:	
-and-	:	
	:	
CROTON WATERSHED CLEAN WATER COALITION, INC.; *et* al,	:	
	:	

Paul S. Mankiewicz, Ph.D., being duly sworn, deposes and says:

1. I am a developmental biologist and ecological engineer with expertise in biophysics, hydrostatics, fluid dynamics, and research interests in the development of ecological systems. I am Executive Director of the Gaia Institute, an environmental research, development, and education center located in New York City.

Qualifications

2. I have worked on over a hundred wetland, ecological engineering, water treatment, and bioremediation projects including the Oakland Ravine storm water treatment project with the New York City Department of Environmental Protection (DEP) and New York City Department of Parks and Recreation, directed research at the ecologically based Solar Aquatic wastewater treatment facility in Providence, Rhode Island, directed the Pelham Bay Landfill Wetlands Investigation with the NYC DEP, and many others.

3. My doctoral work on water holding capacity and resistance to water loss on the part of plant communities, peats, and soils, conducted over three field seasons, was done in the Catskill, Delaware, and Croton watersheds.

4. I was retained by the law offices of John Klotz, on behalf of its client, the CWCWC, to investigate various alternatives to filtration for the Croton Watershed. Specifically, I have investigated the quality of Croton water vis a vis public health standards, changes in water quality over the course of specific sampling regimes, and the feasibility of watershed enhancement to improve water quality.

Fox affidavit.

5. I have read the affidavit of Kim Fox submitted by the United States Environmnteal Protection Agency (EPA).

6. Mr. Fox provides a standard textbook description of how turbidity, disinfection, and filtration can be effective in public health protection, (paragraphs 4 through 6), but it addresses none of the issues raised by the specific problems and potentials of the Croton water supply. Paragraph 8 may not be relevant, since it points out no densities of *Cryptosporidium* oocysts which need to be removed from the Croton water. This is because, from available sampling data, *Cryptosporidium* does not appear to be a problem in the Croton system.

7. Mr. Fox states in paragraph 9 that: "While watershed protection is also desirable, watershed protection cannot prevent all pathogens from entering surface water sources". He goes on to state that filtration is beneficial because it can remove much pathogenic material, but that adding filtration makes disinfection more efficient. Mr. Fox then asserts that a multibarrier approach which incorporates watershed protection, filtration and disinfection "...provides the greatest protection from microbiological contamination and other public health risks".

8. Mr. Fox is apparently unaware of the fact that watersheds, wetlands, and water column food webs are themselves filters which functionally decontaminate water supplies and thus protect human health. There is no argument that filtration could be helpful if it were warranted by the circumstances. For the Croton system, however, there is no indication that filtration would protect human health from *Cryptosporidum* in the Croton water supply since no evidence has been

produced that *Cryptosporidium* is a problem in the Croton water supply. Neither has anyone else in EPA provided such evidence. Nor have the responsible State or City agencies produced any evidence that *Cryptosporidum* can survive predation and/or biogeochemical filtration in the biologically diverse food webs in the Croton water supply system.

9. The Milwaukee episode was the largest outbreak of waterborne disease in the United States in modern times. Milwaukee has a filtered water system. Remarkably, other recent events of unusual *Cryptosporidium* contamination in this country (and also in England) all relate to filtered water systems.

10. The purpose of downstream filters is to concentrate particles, including infective agents. Because they concentrate solids, filters need to be backwashed, resuspending materials. Materials with lower charge to mass ratios, including *Cryptosporidium* oocysts, viruses, and other infective agents would be held less tightly to the surrounding materials. The more efficient the filter, the more frequent the backwashing. The more efficient the filter, the more infective agents which can be resuspended. Because infection is more or less proportional to the quantity of infective agents, the greater the concentration of infective agent, the greater the potential risk to human health.

11. Thus filtration by its very nature creates the potential for intensifying episodes of contamination when the system is poorly maintained or overwhelmed by transient events such as torrential rains.

12. Mr. Fox's account of the Milwaukee *Cryptosporidium* event provides no verifiable means for comparing his account with other accounts. He offers no comparative means for eliminating the contribution of filtration itself to the public health protection failure of this event. Mr. Fox described the measured turbidity ranges at the time of the outbreak, and the increase in coliform levels. He asserts that because turbidity was reduced, and because coliform bacteria were reduced by the plant, "the HWTP did provide significant protection and treatment during the outbreak" (Fox Affidavit, para. 15). He offers no evidence to support this conclusion for Cryptosporidium. He states "The primary reason for the outbreak was the unusually high and rapidly changing levels of particulate matter, including Cryptosporidium". Mr. Fox does not appear to be aware of the fact that the cell wall properties of *Cryptosporidium* would lead to different behavior in a wastewater treatment context from that of coliform bacteria.

13. Since Mr. Fox provides no analysis of backwashing and differential resuspension, no comparative epidemiological data on the number of oocysts necessary to effectively infect the impacted population, no comparative quantities of *Cryptosporidium* oocysts in raw water compared to filter cake, no density or charge to mass ratios data or hypotheses which might effect the behavior of the specific filtration system at the HWTP in relation to *Cryptosporidium* concentration, we are left with assertions which cannot be corroborated or refuted based on available data.

Description of Watershed

14. The New York Water supply occupies about 2,000 square miles. The East of Hudson Croton Reservoir system (presently about 350 square miles), was put on line in 1842 by John Jervis, arguably the greatest engineering feat of its time. While John Jervis had planned for the growth which New York City has undergone, and scaled the Croton system accordingly, he could not plan for a technological innovation, the flush toilet, imported to the US in the 19th Century. This greatly increased waste demand, and necessitated the building of the West of Hudson Catskill and then Delaware systems, which were constructed and put on line in a series of projects spanning several decades. Annexed hereto as Exhibit C is a map of the watershed prepared by the NYC DEP.

15. While Mr. Fox and others at EPA have noted that violation of color standards is a problem with Croton water, neither EPA nor NYS DOH nor DEP have presented any credible measures of the distribution of iron or manganese release from sediments. Overall measures of color in the water column at various depths have been documented since around the turn of the century, as indicated in DEP's "Color Raw Water Monthly Samples at Croton Gatehouse", data contained in the "Croton Water Supply System: Citizens Advisory Committee Meeting" handout at the June 19, 1997 in Valhalla. However, since the mass balance of iron and manganese solubilization has apparently not been characterized in terms contribution by different basins, the problem can only be addressed 'at the end of the pipe', through filtration, which may be the most costly, least sustainable means of addressing the problem.

16. Color can be controlled by aerating sediments, as indicated in the well researched US EPA document, Lake and Reservoir Restoration Guidance Manual (2nd ed., August 1990. Mr. Fox fails

to indicate this, or that the problem of color can also be solved by the much less costly approach of hypolimnetic aeration. He also fails to investigate how much biochemical oxygen demand (BOD) could be removed by such an approach. He also provides no analyses of relative costs in the context of water quality improvement per dollar spent. These omissions constitute a breach in the public trust, since public funds were utilized to develop the low cost, sustainable approaches to water quality improvement and public health protection described in EPA's, Lake and Reservoir Restoration Guidance Manual, and this body of research was apparently not considered, and never publicly discussed, for the Croton water supply.

Quality of Croton Watershed

17. Croton water quality is described as degrading over time by filtration proponents. No evidence has been advanced supporting this hypothesis as of yet by EPA. In fact, what evidence there is points towards water quality improvements over the past several decades.

18. Inspection and investigation of water body margins indicate substantial erosion along the edges of virtually all of the Croton Reservoirs. Recent erosion events have also occurred following major rain storms in the Cat/Del Reservoir System. These events are known to be major causes of pollution in the Croton and in the whole water supply. Attempts to evaluate effects of filtration before these major non-point pollution problems are addressed may be a gross misuse of public funds, since major sources of pathogens, turbidity, and nutrients hundreds to many thousands of times the pollution loads which could ever be removed by filtration are contributed by these events.

19. Water quality has probably varied inversely with agricultural use of the Croton Watershed, especially dairy farming, since cows and calves create pathways to existing water bodies, disturb vegetation, and also produce pathogens. It is unlikely that farming practices of decades back would have protected water quality.

20. While the population in the Croton Watershed roughly doubled between 1900 and 1940, again between 1940 and 1960, and a third time between 1960 and 1990[1], over the same period, turbidity decreased by a factor of five. Turbidity is an index of non point pollution, eutrophication,

[1] DEP handout, Croton Water Supply System: Citizens Advisory Committee Meeting, June 19, 1997.

and/or erosion. Clearer water is both less likely to be a source of pathogens, and easier to treat for pathogenic agents.

21. The five-fold decrease in turbidity while population was increasing eight-fold, implies that buffering capacities of ecosystems in the region developed, coinciding with a decline in intensive farming and animal husbandry, and the redevelopment of biogeochemical buffers around waterbodies.

22. The US Environmental Protection Agency (EPA) has asserted that Croton water has decreased in quality, but has provided no coherent data on this matter since none exists. Historical information indicates that the Croton Watershed was intensively farmed on settlement by Europeans, and then gradually left fallow as farming and animal husbandry moved West. This would lead us to expect that water quality would improve as farming diminished, and as natural buffers developed around receiving bodies of water.

Environmental costs of filtration.

23. Upstream biogeochemical filtration mechanisms capture and degrade infective agents. While the half life or life expectancy of *Cryptosporidium, Giardia, Rotaviruses*, in soil, wetland, and water column ecosystems is not precisely known, in general, the more biological activity, the shorter the life expectancy of pathogens outside of their hosts.

24. The US EPA has provided no documentation as to how overall environmental quality will be protected by the Croton filtration plant, nor could any be provided, since the proposed filtration plant will necessarily degrade overall environmental quality, while improving limited, specific water quality parameters. Electricity to run the plant, and especially to produce ozone would run several to many millions of dollars each year, costing each New York City citizen hundred of tax dollars each decade. Environmental costs of standard coal fired electrical plants include the annual production of hundreds of millions of cubic feet of carbon dioxide, further contributing to global warming, together with hundreds of pounds of smog, soot, ash and sulfur dioxide annually, contributing to respiratory problems, acid rain, and destruction of water shed quality and filtration capacity elsewhere.

25. The EPA or NYS Department of Health (DOH) or NYC DEP have yet to provide a publicly verifiable account of how color is added differentially by various components of the Croton water delivery system. The "Color Raw Water Monthly Samples at Croton Gatehouse" presented at Valhalla by DEP on June 19, 1997, shows that color at the Croton Gatehouse varied between 10 and 35 units in June, 1991. Graph 6, from the "Review of Croton System Water Quality, Summer 1994, indicates that, for July of the same year, at Jerome Park Reservoir Site 32, Color units varied between about 25 and 110 color units. This suggests that the aqueduct itself may be contributing between three to tenfold the color, thus pushing water quality beyond regulatory limits. This implies that a much less expensive, much more cost effective approach to improving Croton water quality may be addressed by improving the aqueduct.

Natural processes.

26. A storm delivering an inch of rain to the ground surface over a village of a hundred acres contributes about 3,000,000 million gallons of surface runoff. Three inches so delivered in the duration of a storm would contribute about a million cubic feet of water. This water could carry high loads of suspended solids, pathogens, and nutrients. All such runoff should be filtered by enhanced wetland, meadow, and vegetated buffers in and around upstate communities. About a hundred acres of such buffers with inch per hour holding capacity would be able to capture the stormwater described. This could add value to the real estate, filter the water before it enters the drinking water supply, thus protecting the quality of our surface waters and public health, the intent of the Surface Water Drinking Rule.

27. The building of a filtration plant should be compared to the acquisition or enhancement of 100 acres of forested buffer zone, where forest growth removes some 300,000 lbs of carbon from the atmosphere, thousands of pounds of nitrogen and phosphorus per year from the soils[2] , and adds a buffering, water holding, or non-point pollution prevention capacity in the millions to millions of gallons per storm event.

[2] Figures adapted from Lieth, H, & R.H. Whitaker, eds. 1975. The Primary Productivity of the Biosphere. Springer-Verlag, NY; Tamm, C.O. 1991. Nitrogen in Terrestrial Ecosystems. Springer-Verlag

Gaia Institute involvement in watershed controversy,

28. The Gaia Institute has been involved in environment protection and public health protection in NYC Watershed for the past decade. On May 5, 1989, the Bronx Council for Environmental Quality sponsored a meeting at Bronx High School of Science where I presented the biogeochemical (ecological) systems responsible for maintaining water quality in the Croton System to the audience, including the Deputy Commissioner of DEP and engineers of the Croton system. Scanning electron micrographs, taken by myself and staff members at Lehman College, of diatoms, diatomaceous earth, peat, humic matter, soils, and forest floor plant communities from the Croton watershed environment were presented. Comparisons were presented of the filtration capacity of a diatomaceous earth based filter, as well as physical and economic rationales for enhancing within-watershed filtration instead of building a filtration plant. Beyond any internal memos which may have been generated on marginal points raised in my presentation, DEP did not respond publicly, perhaps because the agency was at that time woefully understaffed in the several disciplines of ecology, liminology, and biogeochemistry, and in no way focused on enhancing ecological systems to protect human health and well being.

29. On December 13, 1993, Dr. Julie A. Mankiewicz, a developmental biologist with the Gaia Institute with expertise in the evolution of water conduction and lignin biochemistry, read a statement she and I had generated commenting on the draft scope of work of the EIS for the Croton filtration plant at Jerome Park Reservoir. She stated:

> "The reason filtration has not been necessary to date in the Croton and Catskill watersheds is because the natural ecological systems in the watersheds and around the reservoirs have filtered and purified the water ..the woodlands, the soil, and the wetlands...these natural systems take up nitrates, detoxify pesticides, and consume human pathogens. They always have. We have only to put these natural systems back, or where that is not possible, to engineer analogous systems, and we will not have to build an ozone-diatomaceous earth filtration plant at Jerome Park or anywhere else.
>
> "The Croton Reservoir System was arguable the greatest public works engineering accomplishment of its time. It is sad indeed to see this achievement diminished by coupling it with fast becoming out of date

> costly filtration technologies based on pump-and-treat methods of past decades. Environmental and ecological engineering methods are moving beyond ozone-diatomaceous earth and other high capital, high operating cost approaches to producing fine drinking water.

30. After describing how modeling, monitoring, and ecological engineering could be coupled to develop a hypothesis driven, scientific approach to filtration avoidance, she ended her statement with the following:

> "...we would be happy to supply a selective bibliography to illustrate these methodologies, as well as other information that might enable DEP to knowledgeably assess the relative merits of these vital biological and ecological engineering methods.

31. We were not taken up on this offer in 1993, and, while DEP has hired impressive modelers, limnologists, and geologically trained staff to date, no Ph.D. level ecological engineers trained in physiological, forest, or systems ecology, or wetlands biology have yet to join the staff to our knowledge. In other words, DEP is not yet capable of evaluating biogeochemical regulation on the part of the watershed.

32. On March 8, 1994, I submitted comments to the US EPA on the Surface Water Treatment Rule, issued on December 30, 1993. Addressing the 12/30/93 Avoidance Determination, I pointed out that:

> "While many of these comments concern the structure and implementation of NY City's watershed protection programs, they are submitted to the US EPA based on the understanding that EPA has broad authority to direct the City to revise and enhance their current programs to ensure their success and effectiveness at protecting water quality.

And further:

> "These programs must be developed in cooperation with watershed communities, and should be designed to be implemented at the local community level to the greatest extent possible.

Failure of EPA to involve public in regulatory process.

33. While EPA has done a laudable job of involving the community in the regulatory process vis a vis water quality in other parts of the country, this has not yet occurred here. A serious case in point is stormwater and non-point source pollution, recognized as a major, if not the major cause of

the degradation of water quality in watersheds generally. Because of the predominance of surface flow in the Croton Watershed, this source of pollutants is probably even more important. This major source of pollutants and water quality degradation has yet to be addressed meaningfully by EPA or the State. DEP, on the other hand, has implemented the successful and fully voluntary Whole Farm Planning program which addresses pathogen and non-point contributions from farming operations in the watershed.This model supports and strengthens economic well being in watershed communities, while addressing specific non-point source pollution problems at their source, not at a centralized facility. As stated in my 1994 testimony:

> "Non-point source pollution from diverse activities in the watershed, which poses a real risk to water quality, will not be effectively controlled through "top-down" regulations, but instead will require cooperative, community-based programs. This partnership approach will require flexibility, improved relationships with watershed communities, and timely demonstrations of good faith by the City, steps which will be challenging but critical for the DEP and other City agencies to achieve.

Failure of NYC DEP to understand natural filtration.

34. The one model that is working was established by the City directly with economic interests in the watershed. Because the funding is tied to performance criteria, the necessary feedback between regulations, pollution control, and financial input is forged. No such feedback can exist in the building of one large filtration plant for the Croton system. Also, since non-point source pollution could dwarf the capacity of the mandated filtration plant, the absence of a systematic non-point source pollution program undermines any rational plan for designing and building any filtration facility to match potential pollution loadings of the system. This is underscored by the fact that recent storms have dwarfed prior inputs of sediments and pollutants into the reservoir system. Intense storms demonstrate how the filtration mandate of the Surface Water Drinking Rule, as applied to the Croton water supply, is a regulation which requires funds to be spent on centralized end-of-pipe facilities to solve problems which can only be addressed in the watershed and in collaboration with watershed communities. This has been pointed out to EPA and to DEP, but neither agency is capable of representing the law together with environmental and economic dimensions of the public good.

35. In May of 1989, DEP was unaware of specific biogeochemical contributions to water quality on the part of forested uplands, soil systems, wetlands, and water column and benthic communities. I can say this because , representatives of DEP indicated this to me in the course of discussion in a program we were jointed party to at the Bronx High School of Science.

36. Because of this, DEP was unable to responsibly represent the case for filtration avoidance for the Croton to EPA by December 31, `1991. In fact, since no consideration was given to the natural systems conservation, preservation, and enhancement, neither DEP nor EPA could address the scientific prerequisites for appropriately scaling such a filtration system, or maximizing water quality per capital investment.

37. EPA has multiply burdened the Citizens of New York City, thus breaching the public trust. Huge quantities of public funds are obligated to technological fixes which have not been adequately compared to the ecologically based approaches identified by EPA and ecologically informed watershed/reservoir evaluations. EPA has provided no performance criteria to evaluate water quality protection and enhancement technologies, greatly diminishing or eliminating the value of this expenditure of public funds for New York City or other municipalities in NY State, the region, or the nation.

Dated: New York, New York
July 20, 1997

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PAUL S. MAKIEWICZ, Ph.D.

Sworn to before me this ___ day of July, 1997

_____
JOHN C. KLOTZ
Notary Public, State of New York
No. 02KL5048350
Qualified in Bronx County
Commission Expires August 21, l997