



THE NEED FOR WELL-HEAD PROTECTION

An example of the pollution of a water-supply aquifer in the State of New Jersey, U.S.A.

by Gil Osofsky

Abstract: Groundwater pollution can often be attributed to the lack of a well-head protection area around a water supply well. Polluted domestic and municipal supply wells are an increasing problem in the State of New Jersey, U.S.A. Pollutants are being introduced into aquifers from industrial facilities such as chrome manufacturing plants, pharmaceutical plants, metal shops and electronic manufacturing. Pollution of such a nature has affected the Township of East Hanover, Bergen County, New Jersey. East Hanover Township relies entirely on groundwater for their water supply, and pollution in the area can be attributed to the rapid growth of industry/residential developments and to the lack of well-head protection. The sites which are a potential hazard to the groundwater are within the capture zone of municipal and domestic supply wells.

Background and nature of the problem

Polluted domestic and municipal supply wells are an increasing problem in the State of New Jersey, USA. Many communities, which rely completely on domestic and municipal supply wells for their water supply, have been forced to abandon their existing water systems or add treatment.

East Hanover Township is located in Eastern Morris County, New Jersey on the western edge of New York City's metropolitan area. It has a population of approximately 10000 and an area of about 9 square miles. The Township is predominantly residential, but locally has concentrations of light industry. This includes electronics, metal working and finishing, pharmaceuticals, specialty chemicals, and auto-repair facilities. Additionally, there are several landfills which exist within the Township. These landfills accepted industrial and commercial wastes, and septage. East Hanover Township relies entirely on groundwater for their water supply.

Based on a review of historical aerial photographs, most industries within the Township began production in the late 1950's and early 1960's. Within the same time period, residential development also began. Zoning restrictions were lax allowing industrial zones and residential zones to be intermingled or adjacent.

Many of the industries in the Township manufacture, store and/or handle hazardous substances. These industries used lagoons and septic systems for waste disposal. Public sewerage did not become available until 1984. Many of the industries disposing of hazardous substances are adjacent to residential areas dependent on domestic-well water. In fact, East Hanover municipal well no 2 is located within 50 yards of several industries which used septic systems for their waste disposal. Wastes, which include volatile-organic compounds, have infiltrated from the disposal systems to the underlying soil and groundwater. The pumping of domestic and municipal supply wells has accelerated the spread of pollutants.

Leaks from underground storage tanks have also contributed to groundwater pollution in East Hanover. Most tanks installed during the past 40 years were constructed of plain steel; they were largely unprotected from corrosion, and lacked any monitoring system or cathodic protection. Many tanks have leaked, allowing pollutants to migrate to the groundwater. Underground tanks in East Hanover have stored

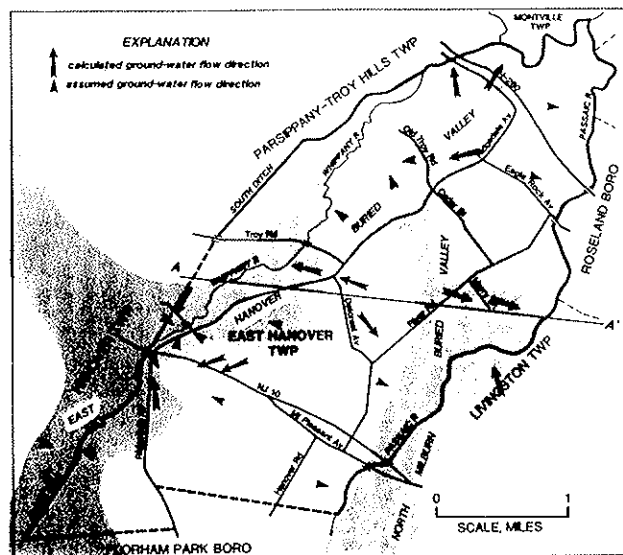


Fig 1 : Delineation of Buried Valley Aquifers in East Hanover Township.

gasoline, fuel oils and industrial solvents. In addition, the improper handling of wastes, the burial of hazardous waste drums and possible "midnight dumping" of hazardous materials have also added pollutants to the groundwater.

Analyses of groundwater from domestic, municipal and monitor wells indicate that at least five plumes containing volatile-organic compounds exist within the township. [Fig 1 & 3] The plume with the highest concentrations emanates from near the intersection of Ridgedale Avenue and Deforest Avenue; the source area includes site nos 8 - 17. A second plume emanates from the vicinity of Merry Lane; it includes site nos 23 - 26. Based on analysis of groundwater samples from domestic and monitor wells, plumes emanating from these two known source areas have been delineated.

Hydrogeology

The surficial aquifers in East Hanover Township occupy the East Hanover and the North Millburn Buried Valleys as shown in Fig 1 [Nichols, 1968]. The valley fill is the result of the advance and retreat of two sublobes of the Wisconsin ice sheet which covered Northern New Jersey. The valley fill is

as much as 200 feet thick; thinner deposits flank the valley walls [Fig 2]. The valley-fill deposits consist largely of stratified drift, but include substantial volumes of till. The stratified drift consists of sand and gravel interbedded with clay. These deposits are the principal aquifers in the Township. Till may occur above and below the aquifers in both valleys and it may act as a confining or semi-confining layer. Sublacustrine fan deposits are identified outside and between the two buried valleys. These deposits consist of interbedded stratified drift and till.

Aquifer-pumping tests indicate that hydraulic conductivities range from 2,7 to 167 ft/day in the stratified drift aquifers [R E Wright Associates, 1986; Geraghty & Miller, 1985]. The pumping tests also indicated that the hydraulic connection between the aquifers and the Whippany River is limited. Based on data obtained from numerous pollution investigations, groundwater flow velocities were determined and ranged from 0,5 to 3,0 ft/day. Groundwater flow directions are shown in Fig 1. Bedrock exists beneath the glacial deposits. Bedrock consists of the Jurassic-age Boonton Formation ⇒ 27

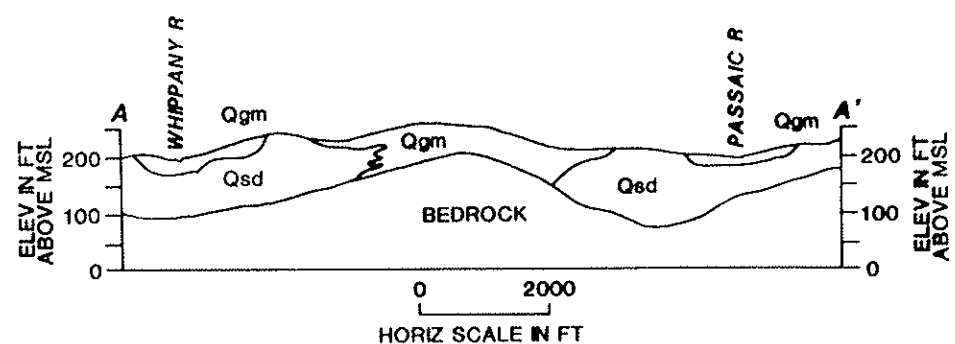


Fig 2 : Geologic cross-section from Fig 1

which is part of the Brunswick Supergroup. The Boonton consists of red, highly-fractured, interbedded siltstones, sandstones and shales. The Boonton is a highly productive aquifer in Northern New Jersey. Because of high yields in the glacial deposits, wells installed into bedrock are less common in East Hanover. However, bedrock wells do exist.

The need for well-head protection

Groundwater pollution can often be attributed to the lack of a well-head protection program. A well-head protection area is the surface and subsurface area surrounding a water supply well through which pollutants are reasonably likely to move toward and reach such well [United States Environmental Protection Agency 1987]. Most communities in New Jersey have not passed ordinances regulating the types of industries allowed within well-head protection areas.

The first aspect of a well-head protection program is the delineation of the capture zone of water supply wells. The portion of the aquifer affected by pumping which actually yields water to the well is defined as the capture zone [Keely and Tsang, 1983]. Methods to calculate a capture zone are described in Javendel and Tsang [1986], Keely and Tsang [1983] and Keely [1984]. A well-head protection program consists of:

1. Delineation of the capture zone of a water supply well[s] or wellfield;
2. Identification of all existing sources of groundwater pollution within the capture zone/protection area;
3. Remediation of the above pollution sources; and
4. Regulating industries which generate and/or dispose of hazardous substances within the capture zone/protection area.

Regulations to be established within a protection area may include some or all of the following:

1. Zoning restrictions to prevent the discharge to groundwater of hazardous substances;
2. Requirements on waste disposal practices;
3. Requirements on transport and storage of hazardous substances;
4. Installation of groundwater monitoring systems, periodic inspections of industrial facilities; and
5. Possible prohibition of certain industries or waste disposal practices.

These regulations must be established by governmental or municipal authorities.

The most important aspect of a well-head protection program is the remediation of existing groundwater pollution sources. A groundwater pollution source is an accumulation of pollutants within the saturated or unsaturated zone. The establishment of environmental regulations is not sufficient to protect a drinking water aquifer. A concentrated effort must be made by industry and government to identify and clean up past discharges of contaminants within the protection area. Polluted groundwater must be hydraulically controlled. Pollution in the unsaturated zone must be removed or remediated. Inaction on the part of industry and government will allow pollution to spread through the aquifer causing groundwater cleanups to become much more difficult and expensive to complete.

Well-head protection is a new concept in the United States. Well-head protection programs have been implemented in Western Europe since the 1960's [USEPA, 1987], but have only begun recently in this country.

A well-head protection program has never been implemented in East Hanover Township. Many communities throughout the world are impacted by pollution problems similar to those discovered in East Hanover. The implementation of well-head protection is essential to the preservation of an underground water supply.

As of 1989, over thirty groundwater pollution sources have been identified within or adjacent to East Hanover Township. Groundwater pollutants will continue to migrate and spread

through the aquifers of East Hanover until remediation of pollutant sources and remediation of affected groundwater are initiated. Over thirty individual groundwater cleanups must be conducted soon. The cost of these cleanups may amount to hundreds of millions of dollars. The implementation of well-head protection in East Hanover would have prevented many of these pollution problems or at least reduced their severity.

Groundwater pollution investigations

The New Jersey Department of Environmental Protection [NJDEP] is the state regulatory agency which has been addressing the pollution problems in East Hanover. Following the discovery of pollutants in a municipal supply well in 1981, septic-tank and seepage-pit wastes were sampled by the Department as part of a Township wide industrial survey. Numerous subsurface disposal systems were found to contain volatile-organic compounds [VOCs]. As of 1989, monitor wells have been installed at 25 of these sites.

In early 1984, NJDEP and the local East Hanover Health Department began collecting water samples from domestic wells near site no 14. Analysis of the samples disclosed pollution by volatile-organic compounds at concentrations above the drinking water standards. Additional domestic wells were later sampled in a phased approach as part of the delineation process. It soon became clear that groundwater in the surficial aquifers throughout the Township is polluted by VOCs. The VOCs consist predominantly of trichloroethylene [TCE], tetrachloroethylene, trans-1,2-dichloroethylene and 1,1,1-trichloroethane [TCA]. ⇒ 30

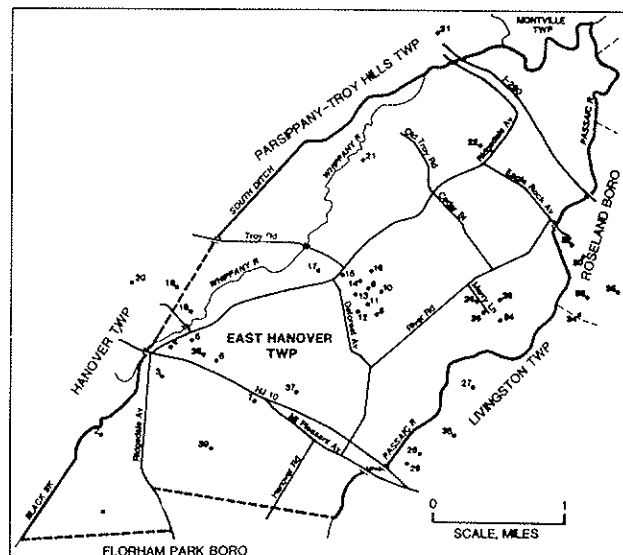


Fig 3 : Location of groundwater pollution investigations within East Hanover Township, 1989

Additionally, several groundwater samples disclosed high concentrations of base/neutral and acid-extractable organic compounds.

The most highly polluted well in the East Hanover Buried Valley Aquifer is at site no 14 [Fig 3 & 4].

Concentrations of VOCs in water from this well are shown in table 1.

Compound	Concentration [ppb]
Methylene chloride	2,0
Trans - 1,2 - dichloroethylene	31,0
Trichloroethylene	14,710,0
Tetrachloroethylene	130,0
1,1,1-Trichloroethane	1,700,0

Table 1 : Analysis of groundwater for volatile organic compounds from the most highly polluted well site no 14, East Hanover Township, New Jersey

Site no 14 operated several industrial cesspools and an unlined waste-water lagoon. The lagoon was closed in 1984 because local children were swimming in it. Drums containing hazardous wastes were also buried beneath the property. This pollution site is within 50 yards of several residences which operated domestic wells for their water supply. A plume consisting of predominantly trichloroethylene is emanating from the vicinity of site no 14. Over 50 domestic wells were polluted by this plume. Total VOC concentrations in groundwater from these wells were as high as 3000 ppb. Based on the analysis of groundwater samples from domestic wells, the plume is approximately 3000 feet in the longitudinal direction. The plume is as much as one mile wide [transverse direction]. The breadth of the plume may be attributed to multiple sources; there are several other suspected sources of pollution in the vicinity of site no 14.

A second plume emanates from the vicinity of site no 26. This site operated two industrial cesspools and also had discharges of solvents from a leaking underground storage tank. A plume consisting of predominantly 1,1,1-trichloroethane extends from the vicinity of site no 26 to the Passaic River. Four domestic wells were polluted by this plume. Several wells were also threatened and subsequently abandoned.

A third plume emanates from site no 22 which is a gasoline service station. Leakages from underground gasoline storage tanks caused up to 4 feet of product to exist floating on the water table in the surficial aquifer. A product and groundwater recovery well was installed to abate the migration of pollutants.

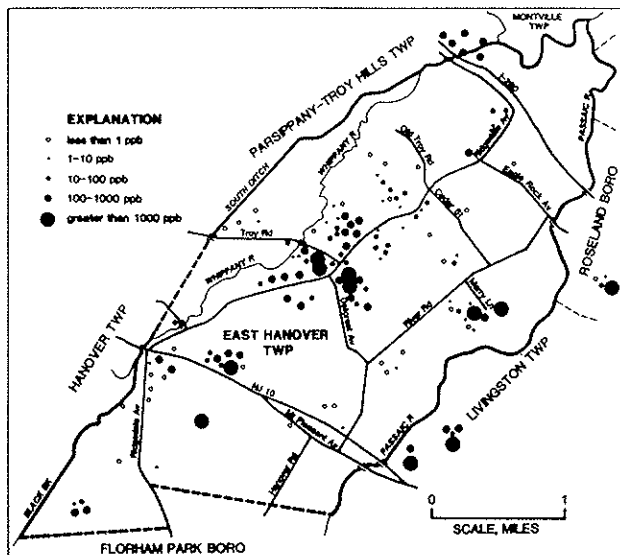


Fig 4 : Distribution of total volatile-organic compounds in groundwater of surficial aquifers in East Hanover Township.

Several monitor wells have been completed into the deep bedrock aquifer. For example, three bedrock monitor wells installed at site no 14. These wells have total depths of 113, 125 and 126 feet. Analysis of groundwater samples collected from these wells disclosed total VOC concentrations of 693 to 1 055 ppb. There are numerous additional point sources of pollution within the Township which have been identified. However, plumes emanating from these sources have not yet been delineated nor remediated. These plumes account for the many other domestic wells which have become polluted.

Conclusions

Groundwater pollution can be attributed to lax zoning restrictions in a recently industrialized community. These restrictions are often required when implementing a well-head protection program. This type of program has never been implemented in East Hanover, a community which relies entirely on groundwater for its water supply. To preserve groundwater quality in this and other communities, well-head protection must be implemented.



Millions of years to evolve, a few weeks to pollute - a lifetime to clean up !

[Photo: Courtesy of Department of Water Affairs]

References

- Geraghty & Miller, Inc 1985, Installation of Valley Road production well no 6 Consultants' report prepared for the Township of East Hanover.
- Javendel, I and Tsang, C, 1986, Capture-zone type curves: A tool for aquifer cleanup: Ground Water, v 24, no 5 p 616-625
- Keely JF 1984, Optimizing pumping strategies for contaminant studies and remedial actions: Ground Water Monitoring Review, Summer 1984 p 63-74.
- Keely JF and Tsang C 1983 Velocity plots and capture zones of pumping centers for ground water investigations: Ground Water v 21, no 6, p 701-714
- Nichols WD 1968, Bedrock Topography of Eastern Morris and Western Essex Counties, New Jersey, US Geological Survey Geologic Investigation, Map I-549
- RE Wright Associates, Inc 1986, Remedial Investigation and Feasibility Study Sharkey Farms Landfill Site Parsippany and Troy Hills Townships Morris County, New Jersey - July 1986 - Final Report, prepared for New Jersey Department of Environmental Protection.
- United States Environmental Protection Agency, 1987, Guidelines for the delineation of wellhead protection areas: Office of Groundwater Protection, Washington, DC

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Please note

This article represents an edited version and précis of the original article entitled "Pollution of a Water Supply Aquifer in the State of New Jersey, USA." The author was a fellow member of the NWWA July in Moscow 1989 conference. The article was specifically requested and edited by your editor to make the South African Groundwater Industry more aware of the potential threat of pollution, and the ramifications it will have for South Africa in the future.

PREVENTION IS EASIER THAN REMEDIATION.

LET'S START NOW! ♦