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WASHINGTON
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August 29, 1998

VIA FEDERAL EXPRESS

Ms. Ruth Scharr (3HS21)
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Re: Keystone Sanitation Landfill

Dear Ms. Scharr:

The purpose of this letter is to submit comments on behalf of Keystone Sanitation Company, Inc. and Mr. and Mrs. Kenneth Noel (hereinafter collectively "Keystone") in response to the United States Environmental Protection Agency's ("EPA's") Proposed Plan to Amend the Operable Unit One Record of Decision ("Proposed Plan") for the Keystone Sanitation Landfill site located in Union Township, Adams County, Pennsylvania (the "Site"). The Proposed Plan was originally issued on July 1, 1998 with a public comment period ending July 31, 1998. EPA extended the public comment period until August 31, 1998.

Keystone hereby reserves its rights to supplement these comments as a result of comments submitted by other parties or if EPA makes significant changes from the Proposed Plan in its selected remedy for the Site. In addition, Keystone hereby requests EPA to respond fully to comments submitted on its behalf prior to the 60-day comment period which began on July 1, 1998, including, without limitation, my July 16, 1996 and July 24, 1996 letters to Mary Rugala, (Attachments 1 and 2) and a January 2, 1997 report prepared by Professor Edward J. Bouwer of Johns Hopkins University entitled "Evaluation of Chemical Constituents in Groundwater in the Vicinity of the Keystone Sanitation Landfill." (Attachment 3). All attachments to this letter are submitted for purposes of inclusion in the administrative record file for the Site.

A. Incorporation of Comments by Waste Management of Pennsylvania, Inc.

31 R.S. Keystone hereby incorporates and adopts certain comments set forth in an August ~~28~~, 1998 letter submitted by Stephen Joyce on behalf of Waste Management of Pennsylvania, Inc. ("Waste Management"). In particular, Keystone concurs with and requests EPA's review and full response to the following Waste Management comments:

1. The Proposed Plan incorrectly includes iron and manganese as site-related constituents in several off-site residential wells.
2. The Proposed Plan incorrectly includes iron and manganese as site-related constituents when calculating Hazard Indices for off-site residential wells.
3. U.S. EPA has inappropriately indicated that vinyl chloride detected in off-site residential well RW-57 is related to the landfill, and has incorrectly characterized the associated risk.
4. U.S. EPA has inappropriately characterized the contribution of other sources to the calculated risks.

Keystone does not take a position on Waste Management's "Alternative Remedy" comments at this time because it has participated in recent technical discussions between Waste Management and EPA concerning the "Alternative Remedy."

B. EPA Has Not Demonstrated that Volatile Organic Compounds Detected in Certain Monitoring and Residential Wells are Attributable to the Landfill

The Proposed Plan states that several volatile organic compounds ("VOCs") detected in groundwater beyond the landfill boundaries in monitoring and residential wells are attributable to groundwater migration from the landfill. See Proposed Plan at p. 7. In this regard, the Proposed Plan identifies 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE), tetrachloroethene (PCE), associated degradation products, and 1,4-dichlorobenezene as detected VOCs attributable to the landfill. The Proposed Plan, however, fails to consider other sources of these VOCs, including their presence in septic tank effluent from individual residences. The attached technical journal article entitled "Trace Organics in Septic Tank Effluent" (Attachment 4) reports on several studies which confirm that tetrachloroethene (PCE), trichloroethene (TCE) and numerous other chlorinated organic solvents have been found in septic tanks servicing individual homes. In fact, the article cites an EPA report in which all of the aforementioned VOCs that have been attributed to the landfill are predicted by EPA to be the most frequently occurring organic compounds of products used and discharged into domestic individual wastewater treatment systems. See Attachment 4 at Table I. The article identifies a number of common household products that are often dumped down the drain -- including toilet bowl cleaners, drain pipe cleaners, septic tank cleaners, stove and oven cleaners, tile and tub cleaners, rug and upholstery cleaners, paint brush cleaners and thinners, and cosmetics -- and which contain the very same VOCs that EPA has attributed to the landfill. Another study conducted by professors at the University of Connecticut demonstrates that VOCs of the type reported in residential wells near the Site make their way into the groundwater from on-site sewage disposal systems. See Attachment 5. Moreover, some of these same VOCs have been detected in residential wells located south of the stream valley of the tributary to Piney Creek in areas EPA has acknowledged are not capable of receiving groundwater affected by the landfill.

In the Remedial Investigation for OU-1, EPA recognized that residential well data might be influenced by other factors such as nearby "septic systems" and even conducted a preliminary well survey to identify land uses (including septic tanks) that could impact groundwater quality). See Attachment 6. Despite the presence of such obvious other sources of VOCs and other chemical constituents, EPA made no effort in the OU-2 Remedial Investigation ("RI") to evaluate the affects of septic tanks or other on-site residential sources of groundwater contamination. In addition, EPA has made no attempt in the Proposed Plan or elsewhere to corroborate other landfill leachate indicator parameters such as sodium, sulfates and chlorides in order to ascertain whether the reported detections of a limited number of VOCs are more likely due to on-site household sources instead of being associated with the landfill. As Waste Management's comments indicate, an analysis using sodium does not support EPA's contention that RW-1, RW-3 or RW-61 have been impacted by the landfill. These serious omissions now preclude EPA from finding that the VOCs detected in residential and monitoring wells beyond the landfill boundaries are attributable to groundwater migration from the landfill.

C. EPA Has Not Appropriately Calculated the Risk for Individual Wells and Areas

The Proposed Plan presents its calculation of potential human health risks for residential wells in two off-site areas (i.e. Area 1 east of the landfill and Area 2 north, west and south of the landfill). See Proposed Plan at p. 9. The Proposed Plan attempts to assign "Site-related" and "total" groundwater risks for these areas, as well as individual residential wells based on those contaminants it believes are "site-related." In addition to the problems discussed above (i.e. EPA's failure to consider other sources for contaminants which have been detected at the landfill), the calculations for cancer and non-cancer risks for residential wells are based upon overly conservative assumptions which exaggerate the actual risk. For example, EPA uses a concentration of 0.765 ug/L (parts per billion) as the "representative concentration" for calculating the risk associated with RW3. See RI Appendix L at Table L-3. However, when the analytical results for RW3 are probed, the following data points are found:

Date of Sample	PCE Concentration (ug/L)
1/1/94	Not Detected
6/1/94	1.0
1/1/95	Not Detected
10/1/95	0.4J
3/1/96	Not Detected
6/1/96	0.3J
10/1/96	0.6J

See RI at Appendix A, Table A-5. Several observations are worth noting. First, the "J" qualifier is described by EPA to mean "reported value may not be accurate or precise." Second, if the "J" values are excluded, there is only one detection (and three non-detections) for PCE, which raises the question of how EPA could assume that 0.765 ug/L is a "representative concentration." Third, even if the "J" values are assumed to be correct, the average concentration for these seven samples collected over a period of 34 months is 0.328 ug/L. Fourth, EPA has made no attempt to determine whether the concentrations for RW3 or other wells are increasing or decreasing. Instead, EPA has used the maximum value reported, even though it appears to be an outlier, to dominate the calculation of risk. Since EPA's risk calculations for groundwater are based on 30 years of exposure to the "representative concentrations," the overestimation of "representative concentrations" is a significant problem and calls into question EPA's attempt to quantify risk in residential wells.

D. EPA's Assessment of Risk Associated with RW43 Appears to be Inappropriate

RW43 is the residential well used by Mr. and Mrs. Noel. It is reportedly more than 600 feet deep and is already serviced by an activated carbon filter. The RI acknowledges that risk calculations for RW43 are based only upon one sample which adds uncertainty to the "representative concentration" used to estimate the risk. See RI at p. 7-29. In addition, it is believed that the one RW43 sample was collected from the upstream side of the filter so that it does not represent the actual risk to consumers of water on the Noel's premises. Field notes or other documents in the possession of EPA should be able to confirm whether the sample in question was indeed collected from the raw (as opposed to treated) water side of the filter. It is ironic that EPA's Proposed Plan includes the installation of filters on residential wells to reduce the risk to human to acceptable levels and yet does not appear to recognize the existence of a filter installed many years ago on the Noel's well.

E. The Proposed Plan Overstates the Risk to Groundwater Because it Relies Upon Well Samples Which Appear not to have been Field-Filtered

As EPA is aware, failure to filter groundwater samples in the field prior to preservation with acid will result in contaminant concentrations which are often over estimated. See e.g. EPA Region III, QA Directives "Field Filtration Policy for Monitoring Well Groundwater Samples Requiring Metals Analysis" (April 23, 1990) (Attachment 7). It is unclear whether all of the samples used by EPA to calculate the risk for residential wells were field-filtered. The RI indicates that some samples were filtered while others were not. See RI at Appendix C ("Sample Logs"). It is believed that field notes taken by the sample collectors may confirm whether monitoring well and residential well samples were in fact appropriately filtered. To the extent unfiltered samples were used to calculate "representative concentrations" or to otherwise characterize groundwater contamination attributable to the landfill, EPA should so state in the RI and Proposed Plan and recalculate alternative risk factors using only filtered samples.

F. The Proposed Plan Does Not Demonstrate That the OU-1 Remedy is Necessary to Protect Human Health and the Environment

The Proposed Plan concludes that the impermeable cap remedy selected by EPA in September, 1990 in the OU-1 Record of Decision, in combination with the preferred alternative described in the Proposed Plan, are necessary in order to protect public health, welfare and the environment from actual or threatened releases from the Site to groundwater. See Proposed Plan at p. 9. However, neither the Proposed Plan, nor the RI or Focused Feasibility Study, contain any analysis of whether groundwater concentrations of contaminants of concern are increasing, decreasing or remaining stable as a result of the final soil cover and vegetative layer placed on the Keystone Landfill when it closed in accordance with its permit requirements in 1990. Because the OU-1 Record of Decision and the studies leading up to it occurred at a time when conditions associated with the closed landfill could not be evaluated, the OU-2 studies and the Proposed Plan should have reevaluated the need for a cap. EPA's conclusion that the OU-1 impermeable cap is still needed is not supported by any current technical data or analysis and is therefore not defensible.

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Thank you for the opportunity to comment upon EPA's Proposed Plan. A detailed written response to each of the points raised above is requested.

Very truly yours,

Wm. Roger Truitt

WRT/cak
Attachments 1 - 7
cc: Mr. and Mrs. Kenneth Noel (w/enclosures)
John E. Griffith, Jr., Esquire (w/enclosures)
Mary Rugala, Esquire (w/enclosures)

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WASHINGTON
NEW YORK
PHILADELPHIA
EASTON

July 16, 1996

<u>VIA FACSIMILE AND REGULAR MAIL</u>

Mary E. Rugala, Esquire
Sr. Assistant Regional Counsel
U.S. EPA, Region III
841 Chestnut Building
Mail Code 3RC22
Philadelphia, PA 19107

Re: Keystone Sanitation Landfill Site - OU-2 Sampling

Dear Mary:

Enclosed please find copies of articles from the June 13, 1996 Baltimore Sun (Carroll County edition) and the July 10, 1996 Gettysburg Times recently forwarded to me in which Chris Corbett is quoted as saying that Keystone Sanitation Landfill OU-2 sampling has shown "additional homes that have been impacted by contaminates (sic) that are related to the landfill," that "[t]hose homes are near the landfill, and a direct connection to the Superfund site is likely, because those contaminates (sic) were found at the landfill," and that "[i]t's a direct correlation . . .[between] contaminants in the off-site wells (and) the on-site wells." Mr. Corbett's comments apparently were based upon the latest round of residential well sampling which, according to the summary information you forwarded to me on June 27, indicated one residential well with a very low level of vinyl chloride and two other residential wells showing trace amounts of pentachlorophenol ("PCP"). Mr. Corbett apparently believes that these data suggest "mounting evidence that contamination [has] moved off-site."

My clients and I were very surprised and dismayed to read these press accounts. I understand that on July 11, 1996 Mr. Corbett personally advised [redacted] the Noels' tenants and the occupants of the home with the well reported by EPA to exhibit the highest level of PCP, that a re-test two weeks earlier showed no trace of PCP in their well. Mr. Corbett reportedly told [redacted] that their drinking water was fine and that they could discontinue using the bottled water he had recommended after the March 1996 sample indicated the presence of PCP. Despite this apparent acknowledgment that there was no PCP problem at the [redacted] residence, Mr. Corbett either forgot to mention this important piece of information to the Gettysburg Times reporter or was misquoted. In either event, the article is very misleading, and I respectfully request that EPA provide a full explanation to my client and to the Gettysburg Times so that this apparent misinformation will not alarm the public and create unwarranted anxiety for my clients.[1]

In addition, Mr. Corbett apparently stated to the media that PCP had been found by EPA in groundwater at the Keystone Sanitation Landfill in earlier testing. I have carefully reviewed the July, 1990 Remedial Investigation ("RI") and the September 30, 1990 Record of Decision for the Keystone site and find no reference to pentachlorophenol or PCP in any residential or monitoring well even though at least 42 wells were tested as part of the RI, nor was it identified as a contaminant of concern at the site. Please advise what other data, if any, EPA has collected "from the landfill" that shows PCP to be originating from waste contained at the site so that my clients can better understand Mr. Corbett's concerns and take any necessary action with regard to their tenants' wells.

It is interesting that neither of the enclosed newspaper articles mentions that the one well located nearly one-half mile from the landfill in which vinyl chloride was reportedly detected in the March 1996 sampling round is: (1) side-gradient to the documented direction of ground water flow (southwest to northeast); and (2) more distant from the landfill than at least three intervening residential wells (RW-04, RW-11 and RW-07), that apparently did not have any detections of vinyl chloride. See enclosed Halliburton NUS chart entitled "Keystone Landfill Residential Wells Sampled During October 1995 - December 1995 and March 1996 Sampling Events." Moreover, according to the summary information you forwarded to me on June 27, not one of the

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[1] Although the Baltimore Sun article briefly notes that "[t]he chemicals did not appear in detectable levels in follow-up tests," it and Mr. Corbett's statements focus upon the March 1996 test results which Mr. Corbett apparently believed had been superceded when he recommended that the [redacted] discontinue their use of bottled water on June 11.

other 67 residential wells tested during five rounds of sampling data collected over the past two years has indicated elevated levels of vinyl chloride. This one detection, apparently not replicated in follow-up sampling, appears to be an anomaly and may be related to any plastic well casing or piping that is associated with this new residence. Please explain how EPA could report to the press that "a direct connection to the Superfund site is likely" (emphasis added) from this one sample, when so much more evidence contradicts this conclusion.

Your June 27 letter provided certain information about EPA's OU-2 residential sampling, including results from the March 1996 sampling round which reported PCP in [redacted] well (RW-13). Although we understand that Mr. Corbett advised the [redacted] more than two weeks earlier (on June 11, 1996) that confirmatory sampling had demonstrated that the water was safe to drink, your letter makes no mention of that very relevant piece of information. In addition, your letter did not transmit the "original laboratory data" that I had requested earlier by telephone. Please advise whether all laboratory information, which would include original laboratory data sheets, duplicate and field blank sample results and data validation reports, are available in the community repositories and distributed at the Task Force meetings, as your June 27 letter implies. Please note that I have been advised that the Keystone Remediation Committee's consultant (EA Engineering, Science and Technology) was not present at the July 11 Task Force meeting and therefore did not hear Mr. Corbett's remarks and did not receive the residential well sampling information you forwarded on June 27. If the "original laboratory data" is not available at the repository, I hereby request that all such information regarding the three residential well samples discussed in the enclosed newspaper articles, including the March 1996 sampling round and all follow-up or confirmatory samples analyzed for these wells, be provided to me as soon as possible. If necessary, please treat this request under the Freedom of Information Act. Please call to advise where and when this data can be reviewed and/or picked up.

As I think you will agree, my clients have cooperated with all of EPA's requests to sample their tenants' residential wells, the Buchart-Horn wells and your recent request to sample the "K" wells, all of which on the Noels' property. It is my understanding that your June 27 letter agrees to release the results of these recent sampling efforts to me, on behalf of my clients, at the same time as they are provided to the Task Force. If this information does not include the original laboratory materials, including data validation reports, I request that such information be provided simultaneously so that our consultants can quickly evaluate its validity and be prepared to respond to EPA's characterizations of the data as it is presented to the Task Force and/or the media. Moreover, I think it is only fair that when well monitoring data or other technical information is supplied to the Task Force or media by Agency personnel, all currently available and relevant information (including sample results tending to contradict the proposition being presented) be provided so that the recipient can properly evaluate and draw informed conclusions about the meaning of all of the data. Please confirm that the Agency will follow this practice in the future and place my name on EPA's notification list for all future meetings of the Task Force.

I took the time to write this letter because of the gravity of this matter, and because I could not reach you or Joseph Donavan (your supervisor identified in your June 27 letter) by telephone. I look forward to receiving copies of the original laboratory data requested above and written assurances that the information in the enclosed articles will be clarified by the Agency in written communications to the Task Force and the affected media. Thank you in advance for your assistance.

Very truly yours,

Wm. Roger Truitt

WRT/edf
Enclosures
cc: Joseph Donovan, Esquire
Mr. and Mrs. Kenneth Noel
Mr. Timothy Saylor
John E. Griffith, Jr., Esquire

GETTYSBURG TIMES, WEDNESDAY, JULY 10, 1996

Landfill clean-up will include some residential areas

BY ROBERT HOLT
Times Staff Writer

SILVER RUN, Md. – Even as a cleanup design was reviewed Tuesday night for the Keystone Sanitation Co. landfill Superfund site in Adams County, a federal official said he will recommend some cleanup plan for surrounding residential areas.

Christopher Corbett, the Environmental Protection Agency's KSC project engineer, said after a landfill task force meeting that officials confirmed in 1990 there was off-site contamination.

"It's more of a continuation. I think the operable unit one record of decision they made the statement there was off-site contamination," Corbett said.

"What we've seen through the sampling of operable unit two is additional hits, additional homes that have been impacted by contaminates that are related to the landfill," he said.

The latest rounds of sampling showed a home with levels of vinyl chloride, and two homes showed new off-site traces of Pentachlorophenol (PCP) at two homes.

Those homes are near the landfill, and a direct connection to the Superfund site is likely, because those contaminates were found at the landfill, he said.

The PCP levels at homes around the landfill is new, suggesting mounting evidence that contamination moved off-site, Corbett said.

The EPA engineer said he is not sure what will be recommended in the clean-up plan that will be released in January or February.

"When the proposed plan comes out we'll have a cleanup plan outlined," he said.

Final sampling in residential areas around the landfill, which has been going on for more than a year, should be done in August.

Corbett said draft reports should be finished by late November or early December.

The cleanup plan will include recommendations for protection of groundwater and residents in Pennsylvania and Maryland.

"There will be various alternatives that will be evaluated," he said.

But even if the final report comes out as planned early next year, it could be some time before any action occurs if the process goes at the pace as cleanup at the landfill.

The KSC task force members got their first look at the design for a treatment plant that will purge contaminates from water at the landfill

Peter Pellissier, project manager for E.A. Engineering, Science and Technology in Sparks, Md., showed the task force plans for a pump and treatment system that EPA officials want in operation by December 1997.

Corbett said the public comment period for the design runs through Aug. 19, with a public meeting to explain the plans in September or October.

He said the public meeting on the construction plans should not be held until the company that wins the bid is available to outline plans.

That drew objections from task force members, who say the meeting will be too late for public input.

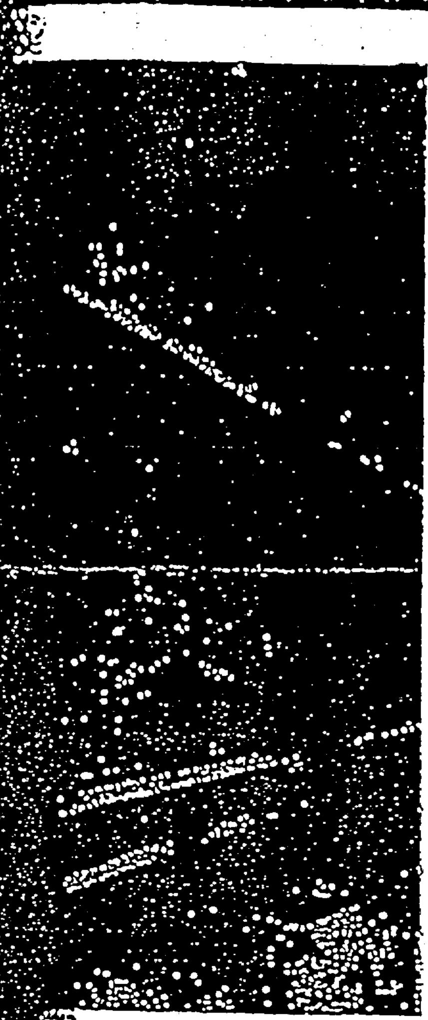
But Corbett said some plans can be adjusted to accommodate public concerns.

At the same time, the task force is opposing efforts by the landfill owners to eliminate plans to cap the site.

The task force is planning to send EPA officials a letter today saying they will agree to a plan to delay capping the site.

But for that agreement, they want the landfill owners and EPA will to provide alternative water sources such as filters and bottled water and a buffer zone for protecting residential areas.

Corbett said the best the landfill owners can hope for is a delay of capping the site, because a cap on the landfill is required by Pennsylvania environmental laws.



SUN STAFF

and her late husband's sur-
a neighboring boutique.

e

next door, will expand into the second and third floors of the Nyborgs' building. Nyborg will retain ownership of the property.

"Our store is growing, and we thought about opening a second one in Georgetown," said Steve Appel, a partner in Nouveau, which for 10 years has trafficked in quality kitsch. "But we decided to commit to Charles Street. The rents are reasonable and the landlords here are glad to have you. In Georgetown, you're lucky if they take you."

The expanded Nouveau will display more bedding and bigger pieces of furniture.

[See Nyborgs, 11B]

Carroll County

Carcinogens in wells tied to landfill

EPA tests indicate first direct link to Superfund site

'A pretty strong argument'

Keystone, now closed, is just across state line in Pa.

BY A SUN STAFF WRITER

Cancer-causing chemicals that were found in residential wells near Keystone Sanitation Landfill may have provided the first direct link between toxic chemicals buried at the Superfund cleanup site and neighboring water supplies.

High levels of vinyl chloride turned up in one well and pentachlorophenol in two others in March tests on about 70 residential wells that the federal Environmental Protection Agency has monitored regularly since February 1994. The chemicals did not appear in detectable levels in follow-up tests two weeks ago, but experts say such an erratic pattern is not uncommon.

Both chemicals have been present in the past at even higher levels in monitoring wells at the closed landfill, said Christopher J. Corbett, the EPA's project manager for the site.

Keystone, a private operation in Adams County, Pa., across the border from Carroll County, was added to the EPA's Superfund list in 1987.

"The vinyl chloride and PCP in wells close to the landfill, to me that makes a pretty strong argument that they are from the landfill," Corbett told a Keystone task force at its meeting Tuesday. The group of local government officials and residents monitors the cleanup effort.

In the

[See Landfill, 6B]

Modell defends stadium design

Ex-Oriole architect

Carcinogens in Pa. wells linked to closed landfill

[Landfill, from Page 1B]

past, the EPA and Pennsylvania and Maryland health officials have said that contaminants in wells near Keystone could have come from other sources.

With the recent findings, Corbett said, "It's a direct correlation. We're seeing contaminants in the off-site wells that are in the on-site wells."

The contaminated wells are in Pennsylvania. EPA officials would not identify the property owners. Corbett said the homeowners had been notified of the test results.

Vinyl chloride, a solvent used in making plastics, was present in amounts five times higher than the EPA's "action level" in a well at a house Corbett described as "fairly new construction." The house is within 2,500 feet of the landfill.

When a contaminant reaches the action level in samples taken from a public water supply, the EPA requires the municipality to reduce the amount of the contaminant to safe levels for drinking.

Pentachlorophenol, which is used in wood preservatives, was present in another well at 25 times the level that the EPA rates as risky for tap water. That well is near the landfill's eastern edge.

At a third well, near the landfill's northern border, pentachlorophenol was detected at nearly double the risk level, which EPA considers a less-serious concern.

The government doesn't regulate private water supplies the way it regulates public systems.

"You put the person on notice, give him sufficient information that he can make a reasonable decision, which may be to treat the water or may be to bring in bottled water," said Charles L. Zeleski, assistant director of environmental health for the Carroll County Health Department.

The high levels of the chemicals would have prompted the EPA to supply the affected homeowners with bottled water or well filters if follow-up tests had shown the same results, Corbett said.

"It's not surprising with a site like the Keystone landfill, that is such a nonhomogenous source, that you don't see contaminants at the same time at the same wells," Corbett said. "I think the important thing when you see contaminants out in residential wells is to look back at the landfill and see if the landfill is a potential source ... and also to look at the potential for transport. ... I think the case for these two is very strong."

EMILY HOLMES : SUN STAFF

School board rejects video, 2 pamphlets

[Board, from Page 1B]

pamphlets also presume sexual activity, he said. For example, the pamphlet for boys says to always assume your girlfriend is not using birth control.

"There's a presumption of the sex act," Stone said.

Ballard said she voted against the pamphlets because she thought they were too strong for middle school. The pamphlets were proposed for seventh grade.

Mish said he was less concerned about the pamphlets, because they are not as powerful as a video, but he supported Stone's

provide information on preventing pregnancy and disease.

"Obviously there are kids who are going to be sexually active," Mish said. "But I don't think we need to make them the focus of the program."

At the board's request, Gary Dunkleberger, assistant superintendent, drafted the abstinence policy in 1988 when he was director of curriculum.

"We cannot choose to teach abstinence only," Dunkleberger said. "We are required by [Maryland state law] to go beyond that. That's really what our policy says. If you look at it."

The policy reads: "While the in-

to students as the most appropriate choice." In addition to the parent panel, all parents are notified when new materials come up for review and can view them before the school board votes.

State law requires that parents be notified of family life unit classes and allows them to exclude their children. But in Carroll, parents must request that their children participate in the classes and sign a permission form. Nearly 100 percent of students take the courses, Dunkleberger said.

Hamps

Council backs
of surplus fund:

BY A SUN STAFF WRITER

The Hampstead
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for the first time in
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improvement plan.

The four-year $1
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pairs, water sys
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facilities.

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and we're in a go
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Hampstead Mayo
M. Nevin said at T
Council meeting.

Commissi
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This month's H
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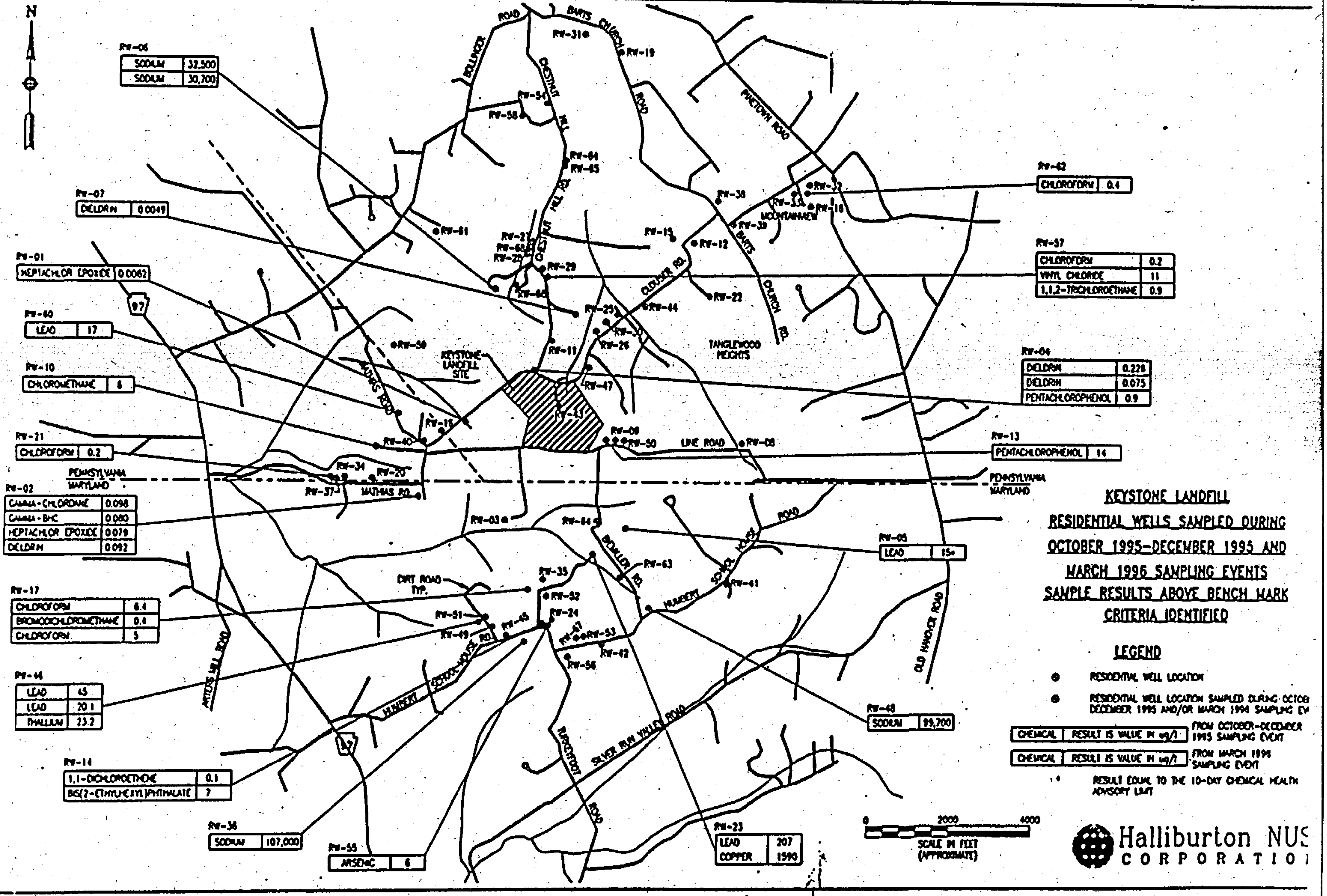
meeting has been r

The commissio
p.m. Tuesday, inst
at Town Hall, 1034

Information: 23

Church news

Lazarus Un
Christ: Father'



KEYSTONE LANDFILL
RESIDENTIAL WELLS SAMPLED DURING OCTOBER 1995–DECEMBER 1995 AND MARCH 1996 SAMPLING EVENTS SAMPLE RESULTS ABOVE BENCH MARK CRITERIA IDENTIFIED

LEGEND

● RESIDENTIAL WELL LOCATION

● RESIDENTIAL WELL LOCATION SAMPLED DURING OCTOB DECEMBER 1995 AND/OR MARCH 1996 SAMPLING EV

CHEMICAL	RESULT IS VALUE IN ug/l	FROM OCTOBER–DECEMBER 1995 SAMPLING EVENT
CHEMICAL	RESULT IS VALUE IN ug/l	FROM MARCH 1996 SAMPLING EVENT

* RESULT EQUAL TO THE 10-DAY CHEMICAL HEALTH ADVISORY LIMIT

Halliburton NUS
CORPORATIO

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WASHINGTON
NEW YORK
PHILADELPHIA
EASTON

July 24, 1996

FACSIMILE AND U.S. MAIL

Mary E. Rugala, Esquire
U.S. EPA, Region III
841 Chestnut Building
Mail Code 3RC22
Philadelphia, PA 19107

Re: Keystone Sanitation Landfill Site -- OU-2 Sampling

Dear Mary:

As a follow-up to my July 16, 1996 letter, I have enclosed a copy of a July 22, 1996 memorandum from Tim Saylor, a professional geologist who I believe has more relevant technical training and actual site experience than anyone else who has studied groundwater conditions at and near the Keystone Sanitation Landfill. He has reviewed the information discussed in my July 16 letter and concluded that EPA's reported detection of vinyl chloride and pentachlorophenol cannot be associated with the landfill based on the evidence presented. For your convenience, I also have enclosed copies of References 3 and 4 in Mr. Saylor's memorandum, as well as a relevant excerpt from ANSI/NSF Standard 14-1990 (Plastics Piping Components and Related Materials), which help explain why residual vinyl chloride in PVC piping could be the cause of any vinyl chloride detected in residential wells.

Please include my July 16, 1996 letter as well as this letter, and its enclosures, in EPA's administrative record for Operable Unit 2. I await your response to the questions asked and information requested in my July 16 letter.

Very truly yours,

Wm. Roger Truitt

WRT/tsc
Enclosures
cc: Joseph Donovan, Esquire
Mr. and Mrs. Kenneth Noel
Mr. Timothy E. Saylor
John E. Griffith, Jr., Esquire

MEMORANDUM

TO: Wm. Roger Truitt, Esquire
Piper & Marbury

FROM: Timothy E. Saylor, P.G. TES
Buchart-Horn, Inc.

DATE: July 22, 1996

REFERENCE: Pentachlorophenol and Vinyl Chloride Findings
Keystone Sanitation Co., Inc. Landfill Site

In response to our discussions, I have reviewed the information and associated news clippings concerning the reported findings of pentachlorophenol at two residences "in the vicinity" of the Keystone landfill as well as vinyl chloride at another "nearby" residence. I have also conducted a brief investigation on the uses of pentachlorophenol as well as the generation of vinyl chloride in water wells which have been constructed with PVC pipe and cements. In addition I also visited the three sites in question on Thursday, July 18, 1996.

PENTACHLOROPHENOL

Pentachlorophenol (PCP) is commercially produced for use as a bactericide, fungicide, and slimicide for preservation of wood. Because it is a chlorinated hydrocarbon its biological characteristics have also resulted in its being used as an herbicide, insecticide, and molluscicide. Contamination can result as a point source water contamination at wood preservation sites and as non-point source through water runoff where PCP has been used.

It is manufactured as PCP, penechlorol, Dowicide EC-7, Dowicide G, Monsanto Penta, and Santobrite.

VINYL CHLORIDE

Vinyl chloride is used as a vinyl monomer in the production of polyvinyl chloride and other resins. Vinyl chloride levels ranging from nearly non-detect to high concentrations have been found in drinking water, beverages, food, cosmetics, and other consumer products.

A number of studies have been conducted concerning migration of vinyl chloride into water in contact with polyvinyl chloride pipe. A library search turned up the following:

1. Berens, A.R., and Daniels, C.A. (1976) Prediction of Vinyl Chloride Monomer Migration from Rigid PVC Pipe: Polymer Eng. and Sci. Vol. 16, No. 8, pages 552 - 558 (August)

2. Dressman, R.C., and McFarren, E.F. (1978) Determination of Vinyl Chloride From Polyvinyl Chloride Pipe Into Water: Journal of the American Water Works Association, Vol. 70, No.1, pages 29 - 30 (January)

3. Ando, M. and Sayato, Y. (1984) Studies on Vunyl Chloride Migrating Into Drinking Water From Polyvinyl Chloride Pipe and Reaction Between Vinyl Chloride and Chlorine: Water Research Vol. 18, No. 3, pages 315 - 318

4._______ (1988) News of the Field - NSF Recalls PVC Pipe Made by Pioneer International: Journal of the American Water Works Association, Vol. 80, No.11, page 84 (November)

The basic conclusion reached by researchers has been that there is some migration of vinyl chloride into water from PVC pipe. The levels are not high. In fact in five systems investigated by Dressman and McFarren, the levels ranged from 0.03 to 1.4 lg/l (a unit believed to be the equivalent of parts per billion, but it could not be substantiated) in four. It was also determined that the highest level occurred in the newest pipe, and gradually diminished over about nine years. Some years ago, I recall reading an article on the release of vinyl chloride into water by the use of resin glues manufactured for cementing PVC casing pipe in water well construction. That article have not been able to find.

POTENTIAL ORIGINS IN THE FIELD - PENTACHLOROPHENOL

First it would appear that the one time only finding of pentachlorophenol in the March, 1996 round of sampling is probably attributable to either field or laboratory QA/QC error. On July 18, 1996 I reviewed the two properties where the PCP was allegedly found in the ground water. In the case of the [redacted] property (USEPA RW-13), there was no evidence of any PCP containers or activities that would have been reason for use of PCP. I also looked at the groundwater mapping shown in the USEPA RI/FS reports (as well as ours). The groundwater divide that lies roughly parallel to Line Road would preclude any of the contaminates (real or alleged) from reaching this property based on the preferred SW-NE flow directions of ground water. Indeed it would even be difficult to achieve by flow over the surface of the ground!

At the [redacted] (sp?) property on the northwest corner of Clouser and Chestnut Hill Roads, anything is possible. The well, according to Ken Noel. is a very shallow, hand dug well. It is located midway between Clouser Road and the house, which is only about 30 to 40 feet away from Clouser Road. The property is poorly maintained. A York Waste trash compactor truck was parked along the west side of the house. Some out buildings also are located to the west of the house. Between Clouser Road and these out buildings are parked a number of pieces of farm equipment. Ken Noel also related that this gentlemen is always using more insecticdes, pesticides, and fertilizers than necessary on the fields he farms. He also washes down his equipment along Chestnut hill Road next to the house! Finding almost anything in the way of contaminates would not be a surprise. To relate almost any contamination in the well to the landfill would be difficult.

POTENTIAL ORIGINS IN THE FIELD - VINYL CHLORIDE

On the same day I examined the other two properties in the field, I also looked the residence located just south of USEPA RW-29, on Chestnut Hill Road. It appeared to be a new residential structure constructed approximately 100 feet east of Chestnut Hill Road. The well was very visible from the road and was located about 25 to 35 northwest of the northwest corner of the house. I did not examine the property in detail because no one appeared to be home. The well was drilled by William W. Reichert, Inc., Hanover, PA. If vinyl chloride was present, it was most likely from the new well construction. The distance of this residence from the landfill (approximately 2500 feet), the preferred direction of groundwater flow (SW/NE), and the rate at which ground water flows, makes it virtually impossible for any contaminates that may be present to have originated from the landfill. The fact that the finding of vinyl chloride was not repeatable on the subsequent sampling event, makes this moot.

CONCLUSIONS

1. Although pentachlorophenol could occur as a contaminate in the ground water anywhere in the area, it would be very difficult to relate its occurrence to the land fill, because of its usage in farming chemicals.

2. The geologic structure and the groundwater system in the landfill area would virtually preclude the migration of this chemical compound (PCP) to the well on the [redacted] property.

3. The management of chemicals and the poor housekeeping practices coupled with the shallow well used for water supply on the [redacted] property, would make it very difficult to relate almost any contamination found to the landfill. Analysis of the groundwater is almost meaningless.

4. The occurrence of vinyl chloride in the new water well on the property south of USEPA RW.29 would most likely been attributable to the fact that the well was only recently constructed. The distance of the property, the rate of groundwater flows in the area, the geologic structure, and groundwater flow in a preferred SW-NE direction would make it impossible for the landfill to be a source.

5. The fact that these findings in the March 1996 sampling round were not repeated in the subsequent June 1996 round, makes any conclusions as to what was present and why moot. It most likely could be attributed to either a field or laboratory QA/QC error.

ANSI/NSF 14 - 1990

PLASTICS PIPING COMPONENTS AND RELATED MATERIALS

American National Standard/
NSF *International* Standard

ANSI/NSF 14 - 1990

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6.1.2 CALCIUM STEARATES: Calcium stearates shall comply with the applicable requirements of NSF Standard 61 when tested in PVC pipe or fittings formulated to contain the ingredient at the maximum use level.

6.1.3 HYDROCARBON WAXES: Hydrocarbon waxes shall comply with Title 21, (food and drugs) CFR-178.3710 and the applicable requirements of NSF Standard 61 when tested in PVC pipe or fittings formulated to contain the ingredient at the maximum use level.

6.1.4 OXIDIZED POLYETHYLENE WAXES; Oxidized polyethylene waxes shall comply with Title 21, (food and drugs) CFR-172.260 OR CFR-177.1620 and the applicable requirements of NSF Standard 61 when tested in PVC pipe or fittings formulated to contain the ingredient at the maximum use level.

6.1.5 TITANIUM DIOXIDES: Titanium dioxides shall comply with Title 21, (food and drugs) CFR 73.575, and/or shall comply with the applicable requirements of NSF Standard 61 when tested in PVC pipe or fittings formulated to contain the ingredient at the maximum use level.

SECTION 7. MONITORING REQUIREMENTS FOR POTABLE WATER PLASTICS PIPING SYSTEM COMPONENTS AND RELATED MATERIALS

7.0 MONITORING: Plastics piping system components and related materials shall be monitored at least once each calendar year for the chemical extraction parameters in Table 1. Only antimony containing products shall be monitored for antimony. Only copper containing products shall be monitored for copper. The levels of substances in the low pH extractant water shall not exceed the maximum permissible levels (MPLs) in Table 1 after the third exposure. The extractant waters may also be analyzed for additional substances based on the formulation information, and shall not exceed levels of toxicological significance.

7.1 TOTAL TRIHALOMETHANES: The maximum permissible level of total trihalomethanes in the organic extractant water after exposure to CPVC pipe shall not exceed 0.10 mg/L.

7.2 RESIDUAL VINYL CHLORIDE MONOMER (RVCM): The maximum permissible level of RVCM in PVC and CPVC piping products shall not exceed 3.2 mg/kg.

7.3 EXTRACTION TESTING: Plastics piping system components and related materials shall be extraction tested in accordance with the following procedures for monitoring.

7.3.1 EXPOSURE CONDITIONS: Exposure of samples shall be conducted using the multiple exposure procedure; except that dip tubes, shall be tested using the single exposure procedure. Pans and tanks shall be filled with the extractant water and exposed using the multiple exposure procedure.

SINGLE EXPOSURES: (DIP TUBES ONLY)
72 ± 4 HOURS AT 99 ± 0.5° C

MULTIPLE EXPOSURES:
COLD APPLICATIONS
1. 24 ± 1 HOUR AT 37 ± 0.5° C
2. 24 ± 1 HOUR AT 37 ± 0.5° C
3. 72 ± 4 HOURS AT 37 ± 0.5° C

HOT APPLICATIONS:
1. 1 HOUR AT 82 ± 0.5° C
2. 1 HOUR AT 82 ± 0.5° C
3. 0.5 HOUR AT 82 ± 0.5° C AND
72 ± 4 HOURS AT 37 ± 0.5° C

TABLE 1. MAXIMUM PERMISSIBLE LEVELS FOR CHEMICAL SUBSTANCES

SUBSTANCES	MPL mg/L	Action Levels mg/L
Antimony	0.05	
Arsenic	0.050	
Cadmium	0.005	
Copper	1.3	
Lead	0.020	
Mercury	0.002	
Phenolic Substances		0.05[3]
Tin	0.05	
TOC		5.0[3]
TTHM	0.10	
RVCM*	3.2	2.0[4]

*In the finished product ppm (mg/kg).

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[3] This is an action level. If the level is exceeded, further review and/or testing shall be initiated to identify the specific substance(s), and acceptance or rejection shall be based on the level of specific substances in the water.

[4] Additional samples shall be selected from inventory and tested to monitor for conformance to the MPL.

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STUDIES ON VINYL CHLORIDE MIGRATING INTO DRINKING WATER FROM POLYVINYL CHLORIDE PIPE AND REACTION BETWEEN VINYL CHLORIDE AND CHLORINE

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(*Received June* 1983)

Abstract—To determine the conditions for the migration of vinyl chloride monomer (VCM) into water from polyvinyl chloride (PVC) pipes and to examine the reaction between VCM and the chlorine present in drinking water, we studied the migration of VCM into water. It was found that migration of VCM into water from PVC pipes (containing 29.5 ppm VCM) could only be detected by using an apparatus that prevented volatilization of VCM and increasing the surface area of the pipe wall in contact with the water. The amount of VCM which could undergo action of the chlorine in the water decreased markedly with the age of the pipes and when the pH was lowered. VCM occurred in the water was converted to chloroacetaldehyde, chloroacetic acid, etc., by its reaction with chlorine, while the amounts of these reactants varied with pH of the solution was changed.

Key words—vinyl chloride, polyvinyl chloride pipe, chlorine, chloroacetaldehyde, chloroacetic acid, reaction of VCM with Cl_2, migration, VCM migrating into drinking water from PVC pipe, VCM, PVC

INTRODUCTION

One of the first reports on the adverse effects to human health was the discovery of neoplasia, or tumor formation, linked to vinyl chloride monomer (VCM), by Viola *et al.* (1971). Shortly thereafter Maltoni and Lefemine (1971) reported on malignant changes in animals, including angiosarcoma of the liver. Creech and Johnson (1974) supported this observation in their report on angiosarcoma of the liver.

VCM is used extensively as a basic material to make polyvinyl chloride (PVC) and other plastics which are used in such manufactured products as pipes, containers, transparent sheeting, etc. In recent years, PVC has been widely used in public drinking water systems, and amounts of the production and installation of such pipes is increasing in Japan. Because such materials are now commonly used, it is obvious that people are in daily contact with PVC. Residual VCM from PVC materials have been reported as hazardous to human health. Thus, it has become an important problem to solve, despite the apparent hazards to health, only few studies have been made on the migration of VCM from PVC pipes. Although chlorine is used to purify drinking water in Japan, there has been little research on the reaction, or chemical recombination, of VCM with chlorine in water.

The discovery that chloroform and other trihalomethanes are produced in chlorinated drinking water (Rook, 1974; Bellar *et al.*, 1974) has attracted much attention. Although it is known that organic compounds present in water interact with chlorine, no evidence has thus far been revealed on the reaction between VCM and chlorine. This paper reports a study of the actual conditions under which VCM migrates into water from PVC pipes and the reaction of VCM with chlorine in water.

MATERIALS AND METHODS

Migration of VCM into water from PVC pipes

Method I. Migration of VCM into water from PVC pipes was studied by sealing water in sections of PVC pipe. The PVC pipes (length 1 m × 20 mm, i.d.) were sealed with silicone rubber stoppers at one end. The solutions used to migrate VCM from PVC were 0.1 M phosphate buffer solutions (pH 5, 7 and 9) and deionized water. The PVC pipes were filled to overflowing with the solutions, and silicone rubber stoppers were slid over the top in such a way as to preclude any air space forming during sealing. These were then allowed to stand for a number of days (1, 2, and 3 day periods) at 20°C. In this experiment, the surface area of the PVC pipe in contact with the solution was $0.8\ cm^2\ ml^{-1}$.

Method II. Another method of migrating VCM from PVC was carried out by sealing a few pieces of PVC pipe and water in a serum vial. Eight pieces of PVC pipe (length 2.5 cm, width 0.5 cm, thickness 0.3 cm) whose surface area had previously been calculated were placed in a 10 ml serum vial (Fig. 1). The solutions used to migrate VCM were the same as those used in Method I. Each serum vial was filled to overflowing with the solutions, then sealed with an aluminium cap lined with Teflon septa so that no air space remained. They were then allowed to stand for a number of days (1, 2 and 3 day periods) at 20°C. In this experiment, the surface area of the PVC pipe in contact with the solution was $8.8\ cm^2\ ml^{-1}$.

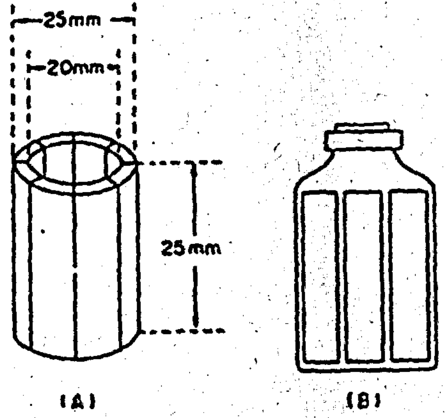

Fig. 1. Method II—Migration method of vinyl chloride from polyvinyl chloride pipe. (A) polyvinyl chloride pipe. (B) pieces of polyvinyl chloride pipe sealed in the vial of water.

The solutions migrated by Method I and Method II allowed to stand for 1, 2 and 3 day periods were directly injected into a gas chromatograph to determine the VCM.

Reaction between VCM and chlorine in water

Several serum vials were filled to overflowing with deionized water, sealed with an aluminium cap lined with Teflon septa so that no air space remained, then a gas containing VCM was injected into each of the sealed vials. Various concentrations of sodium hypochlorite was injected into the sealed vials containing water and VCM. For periods of varying hours, the water in the vials was injected directly into the gas chromatograph to determine the VCM and the reactants of VCM and chlorine.

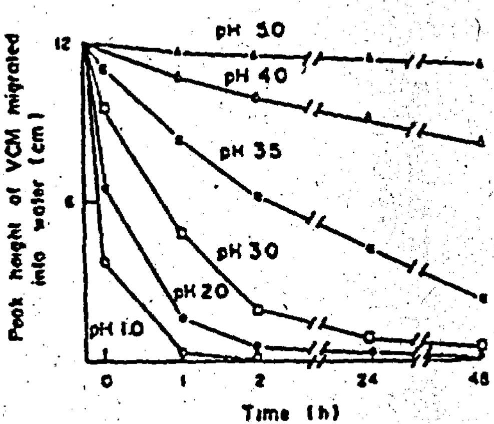

Fig. 2. Time course variation of vinyl chloride in water with chlorine. Vinyl chloride = 10 ppm; chlorine = 30 ppm.

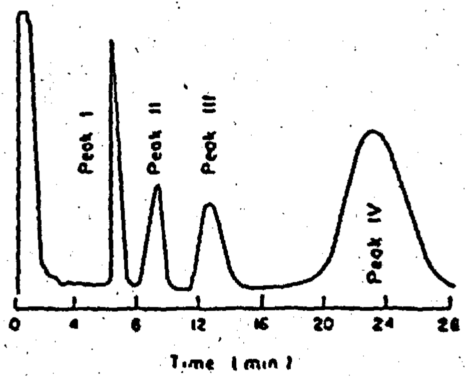

Fig. 3. Gas chromatogram of vinyl chloride treated with chlorine. Vinyl chloride = 10 ppm; chlorine = 30 ppm. pH = 5.8, reaction time = 24 h.

Gas chromatography conditions

The gas chromatograph used to determine VCM was equipped with a flame ionization detector and a 1 m × 3 mm i.d. glass column containing Chromosorb 104 on 60–80 mesh. The analysis was made under the following conditions: column temperature, 120 C; detector temperature, 120 C; and nitrogen carrier gas, 30 ml min^{-1}. The analysis of the reactants in the solution produced by the reaction between VCM and chlorine was made under the following conditions: the gas chromatograph was fitted with an electron-capture detector and a 1 m × 3 mm i.d. glass column containing Chromosorb 101 on 60–80 mesh. The conditions for analysis were as follows: column temperature, 155 C; injection port temperature, 200°C; detector temperature, 280 C; and nitrogen carrier gas 30 ml min^{-1}.

Gas chromatograph–mass spectrometry

The products formed by the reaction between VCM and chlorine were identified by combined gas chromatograph–mass spectrometry (GC-MS). A peak identifier fitted with a 1 m × 3 mm i.d. glass column containing Chromosorb 101, was used to elute each compound. Each mass spectrum was recorded, then identified by comparing its spectra with those of authentic specimens.

RESULTS AND DISCUSSION

To elucidate the existing conditions for the migration of VCM into water from PVC pipes, a migrating experiment for VCM was conducted by Method I and Method II (see Fig. 1). Table 1 gives the results of the analysis of VCM migrating into water from PVC pipes. With Method I, it was not possible to show that VCM migrated into water of the different solvents and days of the test. With Method II, in which a few pieces of PVC pipes were

Table 1. Migration of vinyl chloride into the water from polyvinyl chloride pipe

	Vinyl chloride in polyvinyl chloride pipe	Eluting time (day)					
		Method I			Method II		
Eluting solution	(ppm)	1	2	3	1	2	3
pH 5.0	29.5	ND	ND	ND	0.060	0.085	0.125
pH 7.0	29.5	ND	ND	ND	0.065	0.094	0.125
pH 9.0	29.5	ND	ND	ND	0.035	0.090	0.120
Distilled water	29.5	ND	ND	ND	0.060	0.085	0.120

ND—non detectable.

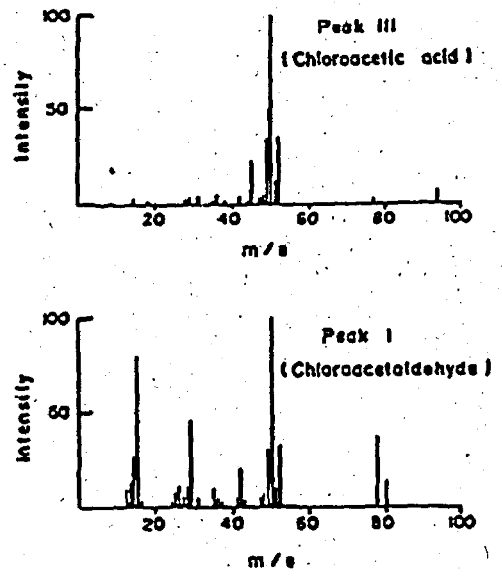

Fig. 4. Mass spectrum of gas chromatograph effluent peak I and peak III.

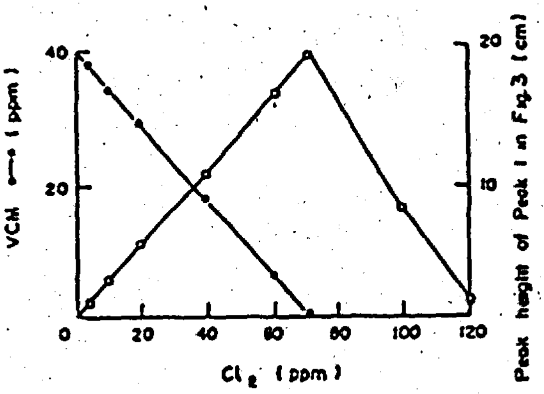

Fig. 6. Effect of chlorine concentration on the formation of peak I from vinyl chloride. Vinyl chloride = 10 ppm; pH = 2.8; reaction time = 2 h.

sealed in with the water, migration of VCM into water was determined to be more than 50 ppm. The FDA (1975) has already pointed out that since water pipes made of hard PVC are rigid and relatively thick walled, migration of VCM into water from such pipes would probably not have a potential for higher levels. The data in Table 1 shows that we were able to detect VCM migrating into water from PVC pipes only by using an apparatus that prevents volatilization of VCM and by increasing the surface area of the pipe wall in contact with the water.

It was necessary to study the reaction between VCM and the dissolved substances in water. Since the most commonly used purification agent is chlorine, the reaction between VCM and chlorine was studied. The amount of VCM in the water decreased markedly with age, or with a lowering pH and, at the same time, the VCM was converted into other compounds by the action of the chlorine (see Fig. 2).

The reacted solution was directly injected into a gas chromatograph to analyse compounds that were converted from VCM. Under this gas chromatograph condition (Chromosorb 101, ECD), the chromatogram of the reacted solution indicated 4 peaks at the 6.77, 9.36, 13.04 and 23.56 minute positions (see Fig. 3).

The compounds of peaks I and III were identified by gas chromatograph–mass spectrometry. Figure 4 shows the mass spectrum of peak I and indicates chloroacetaldehyde with an *m/e* of M^+ as 78. Peak III was given an *m/e* of M^+ at 94 and coincides with that of chloroacetic acid.

The producing results of peak I, according to the pH differences and the time course, are shown in Fig. 5. It was found that the height of peak I increased markedly within 2 h, with the solution at a pH of 1 or 2. But peak I did not rise beyond the 2 h. In addition, the amount of peak I decreased as the reacted solution was neutralized. The change in the amount of the compound produced at peak I and the

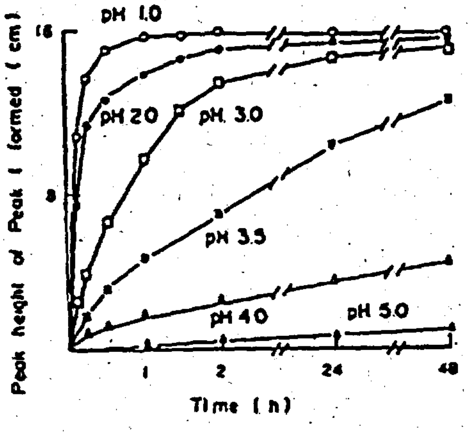

Fig. 5. Changes of peak I in the solution of vinyl chloride treated with chlorine. Vinyl chloride = 10 ppm; chlorine = 30 ppm.

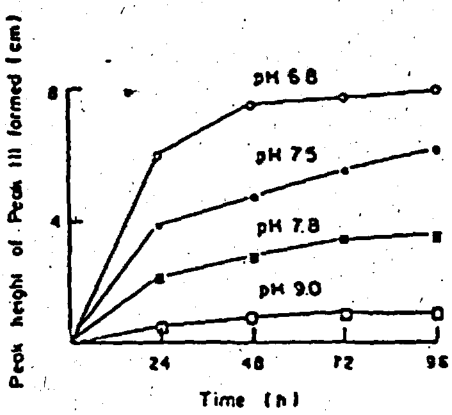

Fig. 7. Time course variation of peak III formation of vinyl chloride treated with chlorine. Vinyl chloride = 10 ppm; chlorine = 30 ppm.

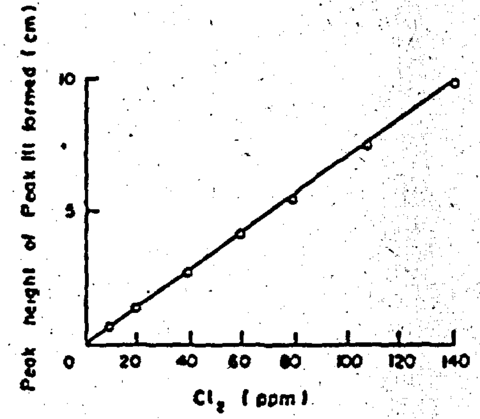

Fig. 8. Effect of chlorine concentration on the formation of peak III from vinyl chloride. Vinyl chloride = 10 ppm; pH = 6.8; reaction time = 24 h.

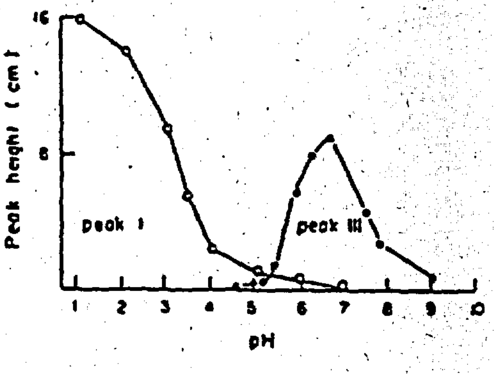

Fig. 9. Influences of pH on peak I and peak III formation. Vinyl chloride = 10 ppm; reaction time: peak I = 2 h; peak III = 24 h.

VCM, according to the concentration of chlorine, is shown in Fig. 6. On the other hand, VCM decreased linearly as chlorine was added, then disappeared at a level of 70 ppm chlorine, while the amount of compound produced at peak I increased linearly. Subsequently, at a concentration of more than 70 ppm chlorine, peak I decreased markedly and finally disappeared at 120 ppm.

The results of peak III, showing an opposite tendency, are shown in Fig. 7. The formation of peak III took a long time, with the solution in pH range from 6.5 to 7.8. Figure 8 shows the effect of the chlorine concentration to form the peak III compound from VCM. The amounts of the compound produced at peak III was found to show a linear increase up to 24 h.

Figure 9 summarizes the rate at which peak I and peak III were formed in relation to the pH value of the solution. It was found that peak I was easy to produce in the acidic region, but peak III occurred in the neutral pH region.

From these facts, if water pipe was made of PVC, it suggested that VCM migrated into water from the pipe and that the VCM in the water was converted into chloroacetaldehyde, chloroacetic acid, etc (peak II and IV), as the VCM reacted with the chlorine.

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AWWA Journal
Nov. 1988

NSF Recalls PVC Pipe Made by Pioneer International

Under the direction of the National Sanitation Foundation (NSF), Pioneer International (GA) Inc. of Greensboro, Ga., in September initiated a recall of its polyvinyl chloride (PVC) pipe for potable drinking water.

The recalled pipe may not comply with the maximum level of 2.0 mg/L of residual vinyl chloride permitted under NSF Standard 14 and may leach vinyl chloride monomer to water in excess of the 2.0 mg/L federal standard.

The pipe being recalled (all sizes) was made on March 24, 25, and 28 of this year. Production dates can be determined by codes printed on the pipe; e.g., the code for pipe produced on March 24 is 032488, in which the first two numbers designate the month, the middle two numbers designate the day, and the last two numbers designate the year.

To obtain further details or to inform NSF of any pipe already in service, telephone Earl D. Dietz, NSF vice-president of operations, at (313) 769-8010.

Amended Fluoride Standard Proposed for Bottled Water

The US Food and Drug Administration (USFDA) has proposed amending its quality standard for fluoride in bottled drinking water (Sept. 16, 1988, *Federal Register*). Maximum permissible concentrations of fluoride under the proposed rule would be 2.0 mg/L for bottled water containing only naturally occurring fluoride and 1.3 mg/L for bottled water containing any amount of added fluoride.

The proposal additionally calls for analysis of fluoride concentrations to be conducted using the potentiometric ion selective electrode method identified as 413B Electrode Method in the 16th Edition of *Standard Methods for the Examination of Water and Wastewater*.

The USFDA noted that the changes were being proposed in response to the US Environmental Protection Agency's (USEPA's) 1986 revision of the 1975 interim federal drinking water standard for fluoride. In that controversial action, which was upheld in federal court, USEPA replaced the interim standard, which varied from 1.4 to 2.4 mg/L depending on an area's average maximum air temperature, with two standards—a primary standard (maximum contaminant level) of 4.0 mg/L and a secondary standard of 2.0 mg/L.

Current USFDA standards for fluoride in bottled water, set in 1973, limit naturally occurring fluoride levels in bottled water to 1.4–2.4 mg/L and added fluoride levels to 0.8–1.7 mg/L, both being dependent on air temperatures. Bottled water not complying with the standards is required to be labeled to that effect. In its proposal, the USFDA adopts USEPA's rationale for abandoning the temperature-related standards and accepts the USEPA's secondary standard as appropriate for naturally occurring fluoride in bottled water.

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January 2, 1997

VIA FEDERAL EXPRESS

Mary E. Rugala, Esquire
U.S. EPA, Region III
841 Chestnut Building
Mail Code 3RC22
Philadelphia, PA 19107

Re: Keystone Sanitation Landfill Site -- OU-2

Dear Mary:

Pursuant to the concerns expressed in my July 16, 1996 and July 24, 1996 letters to you concerning EPA's characterization of residential well sampling results conducted under OU-2, I am submitting herewith ten copies of a report prepared by Dr. Edward J. Bouwer entitled "Evaluation of Chemical Constituents in Groundwater in the Vicinity of the Keystone Sanitation Landfill."

Dr. Bouwer is a professor of environmental engineering at Johns Hopkins University where he has taught and conducted research on groundwater contamination for the past 12 years. He has just completed a three-year research project for EPA's Office of Research and Development and has been awarded a new three-year research project by EPA's National Center for Environmental Research and Quality Assurance program to study transport and fate of toxic organic compounds in groundwater.

Dr. Bouwer has reviewed all of the available groundwater monitoring data relevant to the Keystone Sanitation Landfill, including that collected during the OU-1 RI/FS process and the OU-2 groundwater data released by EPA to date. He has analyzed groundwater flow direction and velocity, the absence of any pattern of groundwater contamination indicating a plume from the landfill and several published surveys of groundwater in similar rural areas showing comparable levels of the same constituents. Dr. Bouwer concludes that the Keystone Landfill is a highly improbable source for the sporadic detections of chemical constituents that have been observed in nearby residential wells.

On behalf of Keystone Sanitation Company, Inc. and Mr. and Mrs. Noel, we request that the enclosed report be placed into the administrative record for OU-2. In addition, we request that copies be sent to the Keystone Task Force members and the Keystone document repositories and made available at the January 14, 1997 public meeting. Please copy me on the transmittal of this report to the administrative record, the Task Force members and the document repositories so that we can track compliance with our request. If EPA needs additional copies of this report, please contact Gina Zawitoski at (410) 576-1792 or me to make appropriate arrangements.

Finally, if your client has questions or comments concerning the enclosed report, please direct them in writing to my attention as soon as possible.

Very truly yours,

Wm. Roger Truitt

WRT/kag

cc: Mr. and Mrs. Kenneth Noel (w/enc.)
Edward J. Bouwer, Ph.D. (w/o enc.)
John E. Griffith, Jr., Esquire (w/enc.)
Gina M. Zawitoski, Esquire (w/enc.)
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EVALUATION OF CHEMICAL CONSTITUENTS IN GROUNDWATER IN THE VICINITY OF THE KEYSTONE SANITATION LANDFILL

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ABSTRACT

This study was conducted to address the fate and transport of both organic and inorganic constituents in soil and groundwater at, under, and surrounding the Keystone Sanitation Landfill. The analysis is based on a review of the site hydrogeology and monitoring data, experience of the author with soil and groundwater contamination, and upon the cited references.

Several reasons exist for why the Keystone Landfill is not the source for the sporadic detections of chemical constituents that have been observed in several of the residential wells. A summary of each reason is listed below:

The groundwater flow originating from the Keystone site is generally to the northeast and the southwest because the groundwater will follow the lineations due to schistosity which run in the direction NE-SW. Many of the residential wells sampled are outside of the NE-SW corridor of groundwater flow. Furthermore, many of the wells are beyond major drainage swales and streams and are not likely to be hydraulically impacted by the site.

The groundwater flowing northeasterly and southwesterly from the Keystone site moves slowly with an estimated average linear velocity within the range of 2.9 and 21 feet per year. Using the highest estimate of groundwater velocity (21 feet/year), the maximum travel distance for the groundwater since operation of the landfill is 630 feet (21 feet/year x 30 years). Even if the Keystone Landfill were a potential source of contamination, the maximum travel distance of chemical constituents is estimated at less than 630 feet from the site. Many chemical constituents move much slower than groundwater because they partition/react with the soil.

The patterns in the monitoring data are not consistent with principles of constituent movement and fate within a groundwater plume. As groundwater flows downgradient from a source, the processes of advection, dispersion, sorption, and reactions will cause the concentrations to decline in the direction of groundwater flow. It is highly improbable for distant wells to have substantially higher concentrations of a constituent in comparison to wells closer to the landfill. Also, if a contaminant plume were present downgradient from the Keystone Landfill, then wells that are relatively close together should exhibit similar concentrations of the constituent. At the Keystone

Landfill, the concentrations of constituents detected in some of the residential wells generally do not decline with distance away from the site and often a constituent is detected in one well and is not detected in nearby wells. This behavior is inconsistent with a contaminant plume coming from the Keystone Landfill.

Numerous studies of landfill leachate plumes have shown that the inorganic and organic chemicals in the leachate usually lead to the development of different oxidation-reduction (redox) environments in the plume. The monitoring data do not indicate the typical changes in geochemical parameters known to occur from landfill leachate plumes, such as the presence of organic acids, methane, hydrogen sulfide, reduced iron, and reduced manganese downgradient from the site, and depletion of oxygen. Furthermore, metabolites of chlorinated solvent transformations have not been conclusively detected in sampled groundwater.

Several published surveys of rural drinking water wells have yielded similar types of chemicals and concentrations as observed in the residential wells surrounding the Keystone Landfill. The monitoring experience of sporadic constituent detections in the residential wells surrounding the Keystone Landfill agrees with the incidence of detecting volatile organic chemicals in drinking water supply wells in rural areas. These published surveys indicate there are many possible diffuse sources for the constituents detected at low levels in groundwater, all of which are unrelated to the landfill itself.

Based on the local geology and hydrology, residential well sampling results to date, and studies of rural groundwater in other locations that are described above, other sources are the most probable cause of chemical constituents reported in the groundwater in the vicinity of the Keystone Landfill. These other sources must be evaluated and ruled out before considering the Keystone Landfill a potential source of the chemical constituents reported in off-site wells.

INTRODUCTION

The author has studied the Keystone Sanitation Landfill (Keystone Landfill or Keystone site) from the perspective of analyzing the fate and transport of both organic and inorganic chemical constituents in soil and groundwater at, under, and surrounding the facility. The author has reviewed documents and reports that provide background information, a description of the site hydrogeology, and available monitoring data for OU-1 and OU-2. A listing of the documents appears in Appendix A. The author has visited the site on Tuesday, November 12 and was able to observe the present condition of the closed Keystone Landfill, the topography surrounding the site, the location of many of the monitoring wells, the location of several topographic swales and streams in the area, and the location of many of the residences in the area. The conclusions set forth below are based on the author's review of the data, his experience in studying soil and groundwater contamination, and upon the cited references.

The author is a Professor of Environmental Engineering in the Department of Geography and Environmental Engineering of the Johns Hopkins University in Baltimore, Maryland where he has taught environmental engineering and conducted research on groundwater contamination for the past 12 years. The author holds a Ph.D. in Environmental Engineering and Science from Stanford University, and his primary field of expertise is soil and groundwater contamination. In September 1996 the author completed a 3-year research project for the U.S. Environmental Protection Agency's (EPA) Office of Research and Development on biodegradation of hydrocarbons for application to site remediation. The author has just been awarded a new 3-year research project from U.S.E.P.A.'s National Center for Environmental Research and Quality Assurance program to study the transport and fate of toxic organic compounds in groundwater. A full description of his qualifications and publications appears in the attached Curriculum Vitae (Appendix B).

1. Groundwater at the Keystone site tends to flow toward the northeast (NE) and the southwest (SW). Therefore, residential wells located to the northwest (NW) and southeast (SE) of the site and beyond major streams are unlikely to be hydraulically impacted by the site.

The elevation of the Keystone site represents a "local high" point, so there is a groundwater divide that is centered along the former landfill. Because of the groundwater divide, groundwater will flow in two directions from the Keystone site. The groundwater flow originating from the groundwater divide is generally to the northeast and the southwest because the groundwater will follow the lineations due to schistosity which run in the direction NE-SW (Figure 4, 1990 EPA ROD). The NE-SW direction of groundwater movement is confirmed by the potentiometric surface map for the site (Figure 5, 1990 EPA ROD). Therefore, wells that are located outside of this NE-SW corridor from the site are unlikely to be hydraulically linked to the groundwater flowing from the Keystone Landfill. For example, the cluster of wells located along Chestnut Hill Road corridor designated as RW-07, RW-61, RW-27, RW-68, RW-28, RW-29, RW-57, RW-06, and RW-66 lie due north of the site and do not fall along the groundwater flow lines as reflected by the potentiometric surface map and the NE-SW lineations due to schistosity (see site map in Appendix C for locations of these wells).

There are drainage swales (i.e., surface depressions) and intermittent streams between the Keystone site and several of the residences in the area. The approximate locations appear on a site map prepared by Halliburton NUS Corporation (Appendix C). The presence of the drainage swales and intermittent streams likely serve as boundaries for the groundwater flow. For the Keystone site area, there is a large intermittent stream south of Line Road that prevents hydraulic connection of the groundwater to the residences along Humbert School House Road. Some of the specific wells that are unlikely to be hydraulically connected to the Keystone site for this reason are RW-17, RW-46, RW-14, RW-36, RW-55, RW-23, RW-05, and RW-48. Similarly, the distant wells NE of the Keystone site, such as RW-62, RW-12, RW-15, RW-38, and RW-39, are on the other side of a major drainage swale. Groundwater from the Keystone site probably cannot impact these wells.

Because of the NE-SW groundwater flow direction and presence of major swales and intermittent streams to drain the groundwater in the basin, many of the residential wells that have been sampled and that have shown sporadic detections of chemical constituents above bench mark criteria are unlikely to be impacted by groundwater from the Keystone site. Therefore, sources other than the Keystone Landfill must be responsible for the constituents detected in these wells.

2. Groundwater moves slowly at the site, so the travel distance of constituents in the groundwater that may have leached from the landfill is estimated to be less than 630 feet.

Available field pump test data for wells located along the eastern boundary of the Keystone site indicated a Darcy velocity ranging between 1.1 and 8.0 feet per year (Buchart-Horn, 1990). The actual average linear velocity for the groundwater is determined by dividing the Darcy velocity by the porosity of the formation. In the Remedial Investigation Report (EPA, 1990), EPA uses a porosity of 0.38. Using this value of porosity, the groundwater flowing northeasterly from the Keystone site moves slowly with an estimated average linear velocity within the range of 2.9 and 21 feet per year. The Keystone Landfill began operations in 1966, which is 30 years ago. Using the highest estimate of groundwater velocity (21 feet/year), the maximum travel distance for the groundwater since operation of the landfill is 630 feet (21 feet/year x 30 years). Therefore, dissolved chemical constituents in the groundwater that do not react with the soil, such as chloride and sodium, could only have migrated a maximum of 630 feet under the most conservative of assumptions. Many of the constituents that have been sporadically detected in the groundwater sampled from residential wells, such as chlorinated solvents, pesticides, and certain metals, move slower than the groundwater. This is because the constituents "react" with soil surfaces which retards their movement relative to water (Bouwer et al., 1988). Some of the important reaction processes in soils are sorption, ion exchange, chemical hydrolysis, and biodegradation (Bedient et al., 1994). Sorption and ion exchange simply retard (or impede) the constituent movement. Chemical hydrolysis and biodegradation can destroy the constituent. The retardation of the constituents means that even if the groundwater has moved 630 feet, the chemicals would not have traveled as far. Typical retardation factors for chlorinated solvents in soils range from 2.0 to 5.0 (Bedient et al., 1994). This translates to a maximum travel distance of between 126 feet and 315 feet for chlorinated solvents if the groundwater has moved 630 feet over 30 years. It is highly improbable that the constituents detected in the residential wells located more than 630 feet from the landfill could have come from the groundwater originating at the landfill.

3. The behavior and patterns of constituents detected in the residential wells surrounding the Keystone Landfill indicate that the landfill is not the source of reported contamination.

There have been several rounds of sampling in the residential wells located within one mile radius of the Keystone Site under EPA's Operable Unit 2 (termed OU-2). In most of the samples, the constituents are below the detection limits. However, some of the wells exhibit an occasional detection of one or more constituents above benchmark criteria (the constituents and concentrations recently detected are located on two site maps that appear in Appendix C). In many instances, the detection of a constituent is not repeated in a subsequent round of sampling. The patterns in the monitoring data indicate that the landfill is not the source for the following reasons: (a) landfill leachate plumes have well-characterized geochemical signatures that are not evident from the data collected at the site, (b) if the landfill is the source, the constituent concentrations should decline with distance away from the landfill because of dispersion and attenuation processes in the groundwater as it moves through the subsurface, (c) often a constituent is detected in one well and is not detected in nearby wells, and (d) metabolites of chlorinated solvent transformations have not been conclusively detected in the sampled groundwater. Additional discussion of each of these four points appears below.

a. Numerous studies of landfill leachate plumes have shown that the inorganic and organic chemicals in the leachate usually lead to the development of different oxidation-reduction (redox) environments in the plume (Baedecker and Back, 1979: Reinhard et al., 1984; Back et al., 1993; Bjerg et al., 1995). Landfill leachate normally contains biodegradable organic matter which causes the groundwater to become anaerobic. Because the anaerobic microbial processes are generally competitive, a distribution of redox zones develops downgradient of the landfill. Close to the landfill there will be a methanogenic/sulfate reducing zone where both methane and hydrogen sulfide are produced and are obvious indicators of anaerobic microbial activity. As the leachate plume moves away from the landfill, less reducing conditions are present in the form of iron-reducing, manganese-reducing, and nitrate-reducing zones. The leading edge of the plume becomes aerobic as the leachate mixes with the native groundwater. These anaerobic processes cause marked changes in the chemistry within the plume which can be easily detected with groundwater monitoring. For example, the leachate plume is established by the presence of organic acids (part of the dissolved organic matter), methane, hydrogen sulfide, reduced iron, reduced manganese, and no oxygen. The concentrations of these major chemical species that typically delineate a landfill leachate plume will be in the mg/L (ppm) range. Detection of these major chemical species is relatively easy. Based on the monitoring data provided, there is no indication that these constituents are present in the groundwater sampled at and near the Keystone Landfill. There are no data to suggest that a significant landfill leachate plume has developed at the Keystone site. Furthermore, the anaerobic conditions will be very noticeable from the perspective of causing taste and odors in the drinking water.

b. When contaminants enter groundwater, there are several processes which influence the movement and fate of the chemical constituents. The movement of non-reactive (conservative) dissolved contaminants is controlled by advection, mechanical dispersion, and molecular diffusion (Bouwer et al., 1988; Bedient et al., 1994). These processes will cause a spreading (or dilution) of the chemical constituents, so that the concentrations in the groundwater decline as the groundwater travels downgradient from the source. For reactive contaminants, such as chlorinated solvents, hydrocarbons, pesticides, and certain metals, additional processes of sorption/desorption, chemical transformation, and biotransformation affect transport (Bouwer et al., 1988; Bedient et al., 1994). With these processes, the plume of the reactive contaminant will expand more slowly and the groundwater concentration will change more slowly than that of an equivalent nonreactive contaminant. What has been observed for landfills is that the dissolved plume for specific organic contaminants (e.g. benzene, toluene, and chlorinated solvents) is embedded or contained within the main leachate plume that is defined by the various anaerobic redox zones as discussed in point "3a" above (Reinhard et al., 1984; Rügge et al., 1995).

Even if the Keystone Landfill were a source of contamination, the constituent concentrations in the groundwater should decline as one moves away from the landfill. It is highly unlikely for distant wells to have substantially higher concentrations of a constituent in comparison to wells closer to the landfill. An example of the opposite behavior is RW-26 and RW-30 from the 1/95 sampling event. Chloroform was not detected in the well closer to the landfill (RW-26), but was detected in RW-30 (9.5 µg/L) which is more distant from the Keystone site. In addition, the arsenic level in RW-30 (5.5 µg/L) was higher than that reported in RW-26 (2.3 µg/L). Furthermore, if a plume were coming from the landfill, then the concentrations would be continuous and should be detected in a series of downgradient wells that follow the flow direction of the groundwater. The monitoring data show sporadic detections of constituents with concentrations that do not typically decrease with distance away from the landfill. The same constituent is not detected in a series of residential wells along the direction of groundwater flow from the Keystone site. For example, chloroform (9.5 µg/L) was detected in RW-30 during the 1/95 sampling event, but was not detected in other wells along the NE direction of groundwater flow, such as RW-11, RW-26, RW-22, and RW-12. Similarly, dieldrin (0.092 µg/L) was detected in RW-02 during the 3/96 sampling event, but was not detected in other wells along the SW direction of groundwater flow, such as RW-16, RW-01, and RW-10. The observed conditions are not consistent with principles of contaminant movement and fate within a groundwater plume. In addition, the monitoring data are not steady with time. A constituent typically detected in one monitoring period is not detected in the next monitoring period. For example, 1,1-dichloroethene was detected in RW-04 (2 µg/L) in 6/94, but was not detected in the well in 2/94, 1/95, 10/95, 3/96, and 6/96. Similarly, pentachlorophenol was detected in RW-13 (14 µg/L) in 3/96, but was not detected in the well in 10/95 and 6/96. The absence of continuous constituent detection throughout the several sampling rounds in most of the wells is inconsistent with a contaminant plume coming from the Keystone Landfill.

c. If a contaminant plume were present downgradient from the Keystone Landfill, then wells that are relatively close together should exhibit similar concentrations of the constituent. This will especially hold for groups of wells that are thousands of feet downgradient from the landfill, because sharp constituent gradients are not possible due to longitudinal and lateral dispersion. Wells that are on the order of 500 to 1000 feet apart should not vary greatly in their response to contamination if the source is the landfill. This behavior is not evident from the monitoring data. When a constituent is detected in one residential well, the constituent is often below the quantitation limit in nearby residential wells. Examples from the 1/95 sampling event are the detection of chloroform (9.5 µg/L) in RW-30, but no detection of chloroform in RW-07 and RW-26 and the detection of chloroform (8.8 µg/L) in RW-20, but no detection of chloroform in RW-21. Similarly, examples from the October-December 1995 sampling event are the detection of chloroform (6.4 µg/L) in RW-17, but no detection of chloroform in RW-46 and RW-55, detection of lead (45 µg/L) in RW-46, but no detection of lead in RW-14 and RW-17, and detection of arsenic (6 µg/L) in RW-55, but no detection of arsenic in RW-14 and RW-17. Finally, examples from the March 1996 sampling event are the detection of vinyl chloride (11 µg/L) and 1,1,2-trichloroethane (0.9 µg/L) in RW-57, but no detection of vinyl chloride and 1,1,2-trichloroethane in RW-06 and RW-07 and detection of thallium (23.2 µg/L) in RW-46, but no detection of thallium in RW-17 and RW-36.

d. The anaerobic microbial processes within a landfill leachate plume (discussed in Point "3a" above) are conducive for transformation of certain chlorinated solvents (Bouwer, 1994; McCarty, 1994). The anaerobic transformation of chlorinated solvents produces chlorinated metabolites which will accumulate in the downgradient groundwater. The typical reaction is reductive dechlorination where a chlorine atom is replaced by a hydrogen atom to produce a compound with one less chlorine. As the number of chlorines on the molecule decreases, the reactivity toward reductive dechlorination decreases and the metabolite becomes more persistent. Examples of common reductive dechlorination reactions involving chlorinated solvents under anaerobic conditions include the conversion of tetrachloroethylene to trichloroethylene, trichloroethylene to dichloroethylenes, dichloroethylenes to vinyl chloride, 1,1,1-trichloroethane to 1,1-dichloroethane, and chloroform to methylene chloride (McCarty, 1994). If the parent compounds are initially present in the landfill (e.g. tetrachloroethylene, 1,1,2-trichloroethane, and chloroform), then the reductive dechlorination metabolites should be detected downgradient from the landfill. This is not the pattern that is revealed by the monitoring data for the Keystone Landfill. Generally if a parent chlorinated compound is detected, the corresponding metabolite from reductive dechlorination is not detected. For example, chloroform was detected in RW-17, but methylene chloride, its metabolite from reductive dechlorination, was not detected. 1,1,2-trichloroethane was detected in RW-57, but 1,2-dichloroethane (its metabolite from reductive dechlorination) was not detected. Finally, pentachlorophenol was detected in RW-13, but tetra- and tri-chlorophenols, its metabolites from reductive dechlorination, were not detected. This is further evidence that the landfill is not the source of the parent chlorinated compounds.

4. Many activities can lead to the occurrence of chemical constituents in groundwater. Therefore, several explanations exist that better account for the sporadic detection of constituents in the residential wells in the area around the Keystone Landfill.

The scientific literature contains extensive documentation of groundwater contamination from a variety of waste disposal activities: industrial impoundments, land disposal of solid wastes, septic tanks and cesspools, municipal wastewater disposal, land-spreading of wastes, exploitation of petroleum and other mineral resources, and deep well disposal (Pye et al., 1983; National Research Council, 1994; Pankow and Cherry, 1996). Other sources of groundwater contamination not intended for waste disposal include: accidental spills, leaking storage tanks, irrigation practices, and use of fertilizers and pesticides. In a rural setting like that surrounding the Keystone Landfill, it is not surprising to find occasional occurrences of chemicals in sampled groundwater.

Several published surveys of water supply wells have yielded similar types of chemicals and concentrations as observed in the residential wells surrounding the Keystone Landfill. One study involved the measurement of the concentrations of 56 toxic substances in samples of both groundwater (over 1000 different wells) and surface water (over 600 different sites) throughout New Jersey (Page, 1981). The sample locations were selected to include approximately the same number of sites in rural or undeveloped areas as those in heavily developed areas, including industrial areas and some in the vicinity of landfills. 1,1,1-trichloroethane (TCA) was detected in 835 out of 1071 samples with a median concentration of 2 µg/L. Similarly, trichloroethylene (TCE) was detected in 388 out of 669 samples with a median concentration of 0.3 µg/L. Some of the samples contained high concentrations of TCA (608 µg/L max.) and TCE (635 µg/L max.), but the majority contained concentrations of a few µg/L or less as evidenced by the median concentrations. The study by Page (1981) also compared data from the wells sampled in southern New Jersey with the data averaged for the whole state. The patterns of contamination for the more rural southern part of New Jersey were similar to the rest of the state.

A second study was conducted by EPA and is entitled the Ground Water Supply Survey (GWSS) (Westrick et al., 1984). Out of 500 randomly selected groundwater supply wells in the U.S., 230 were found to be contaminated with volatile organic compounds (VOCs) of the same type found in the vicinity of the Keystone Site. The groundwater supplies sampled covered a broad range of populations. The most pertinent to the Keystone Landfill area is the grouping of 80 wells that serve fewer than 100 people. In this set of wells sampled, 70 were below quantitation limit, 9 had concentrations up to 5 µg/L, and 1 had a concentration between 11 and 50 µg/L.

A third study was conducted by the U.S. Geological Survey and is geographically relevant to the Keystone site (Daley and Lindsey, 1996). As part of the National Water

Quality Assessment program, groundwater samples from six areas within the Lower Susquehanna River Basin that spanned portions of Pennsylvania and Maryland were analyzed for 60 volatile organic compounds (VOC's; chlorinated solvents, petroleum hydrocarbons, ketones, and ethers) with detection levels ranging from 0.05 to 0.2 µg/L. Five of the six sampling areas were classified as rural, and two of the rural areas contained a population density similar to the area surrounding the Keystone Landfill. In December 1995, EA Engineering reported that there were 44 homes within a 0.75 mile radius of the Keystone site and an additional 41 residences between 0.75 and 1.0 mile radius from the site. Thus, the number of homes per square mile is 108, and the population density is about 270 people per square mile (assuming 2.5 people per household). In the USGS groundwater sampling study, an agricultural area in the Great Valley with a population density of 290 per mi^2 had 4 wells out of 20 with at least one VOC detected (20% incidence rate for constituent detection). An agricultural area in the Piedmont Physiographic Province with a population density of 210 per mi^2 had 3 wells out of 10 (30% incidence) with at least one VOC detected. These incidence rates are comparable to the Keystone residential well data. For example, in Round 5 (3/96), only 6 wells out of 24 sampled (25% incidence rate) reported detections of VOCs or semi-volatile compounds.

Through the Iowa Groundwater Protection Act, many municipal systems and private rural wells have been sampled in Iowa since 1987 in order to establish a water quality data base with information on the characteristics and presence of chemical constituents in drinking water supplies. In a study entitled the Statewide Rural Well Water Survey conducted between April 1988 and June 1989, groundwater from 686 rural wells were sampled for various constituents, including pesticides, nitrate, and coliform bacteria (Libra et al., 1993). The monitoring data revealed that 44.8% of the wells exhibited the presence of coliform bacteria, 18% of the wells contained significant amounts of nitrate, and 13.6% of the private rural drinking water wells contained one or more pesticides. The most frequently detected pesticides were atrazine, metribuzin, pendamethalin, metolachlor, alachlor, and cyanazine.

The observations from these four published broad monitoring surveys are similar to the monitoring experience at the residential wells surrounding the Keystone Landfill. Most of the time the chemical constituents are below the quantitation limits, but there are occasional detections that cannot be attributed to a landfill leachate plume for the reasons described in the previous conclusions.

Some of the common sources for the chemical constituents that have been detected in the residential wells are given in Table 1. These other sources include septic tanks, agricultural practices, well casings and household plumbing, and household use of wood preservatives and solvents, all of which are commonly encountered in rural residential areas, such as the area surrounding the Keystone Landfill. This information indicates that there are many possible explanations for why certain constituents have been detected in some of the residential wells surrounding the Keystone site, all of which are unrelated to the landfill itself. Therefore, the potential sources identified in Table 1 must be evaluated and ruled out before considering the Keystone Landfill as a possible source for the sporadic detections of constituents reported in the residential wells. In addition, it is the author's experience that both chloroform and phthalates (e.g., bis(2-ethylhexyl) phthalate) are common laboratory contaminants. Several of the metals detected in the monitoring wells, such as arsenic, chromium, manganese, and cadmium, are commonly found in soils (naturally occurring) (Shacklette and Boernlen, 1984; Lindsay, 1979).

CONCLUSIONS

Several reasons support the author's conclusion that it is highly improbable that the Keystone Landfill is a source for the sporadic detections of chemical constituents that have been reported in residential wells located in the vicinity of the Keystone site. A summary of each reason is listed below:

- Many of the residential wells sampled are outside of the flow path of groundwater from the site due to either being outside of the NE-SW corridor of groundwater flow or being hydraulically disconnected from the Keystone site via drainage swales and streams.

- The groundwater flowing northeasterly and southwesterly from the Keystone site moves slowly, so that even if the Keystone Landfill were a possible source of contamination, the maximum travel distance of chemical constituents is estimated to be less than 630 feet from the site.

- The patterns in the monitoring data are not consistent with principles of constituent movement and fate within a groundwater plume. The concentrations of constituents detected in some of the residential wells generally do not decline with distance away from the Keystone site and often a constituent is detected in one well and is not detected in nearby wells.

- The monitoring data do not indicate the typical changes in geochemical parameters known to occur from landfill leachate plumes, such as the presence of organic acids, methane, hydrogen sulfide, reduced iron, and reduced manganese downgradient from the site, and depletion of oxygen. Furthermore, metabolites of chlorinated solvent transformations have not been conclusively detected in sampled groundwater.

- The monitoring experience of sporadic constituent detections in the residential wells surrounding the Keystone Landfill agrees with the findings of several published surveys of drinking water supplies in rural areas. These published surveys indicate there are many more probable sources unrelated to the Keystone site that need to be evaluated and ruled out before considering the Keystone Landfill as a possible source for the constituents detected at low levels in groundwater.

Table 1 Chemicals detected in the groundwater in residential wells surrounding the Keystone Landfill and possible sources.

Chemical	Possible Source**
chloroform	chlorination of water, solvent usage
bromodichloromethane	chlorination of water
dibromochloromethane	chlorination of water
carbon tetrachloride	solvent usage
vinyl chloride	solvent usage, leaching from new PVC pipe
1,1,2-trichloroethane	solvent usage, septic tank cleaner
1,1,2,2-tetrachloroethane	solvent usage, septic tank cleaner
dieldrin	pesticide usage
pentachlorophenol	wood preservative, creosote
1,1-dichloroethene	solvent usage, septic tank cleaner
bis(2-ethylhexyl) phthalate	common laboratory contaminant
heptachlor epoxide	pesticide usage
gamma-chlordane	pesticide usage
gamma-BHC	pesticide usage
Arochlor 1248	transformer oil, waste oils
chloromethane	solvent usage
sodium	road salt usage
lead	leaching from solder and water pipes
copper	leaching from water pipes
arsenic	pesticide usage
antimony	common in metal alloys
cadmium	Ni-Cd batteries, common in metal alloys
manganese	naturally occurring
thallium	rodenticide usage

**NRC, 1994; Pankow and Cherry, 1996; Merck & Co., 1989

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Page, G.W. 1981. Comparison of Groundwater and Surface Water for Patterns and Levels of Contamination by Toxic Substances. Environ. Sci. Technol., 15:12, 1475-1481.

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Pye, V.I., R. Patrick, and J. Quarles. 1983. Groundwater Contamination in the United States, Univ. Penn. Press, Philadelphia.

Reinhard, M., N.L. Goodman, and J.F. Barker. 1984. Occurrence and Distribution of Organic Contaminants in Two Landfill Leachate Plumes. Environ. Sci. Technol., 18:12, 953-961.

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Westrick, J.J., J.W. Mello, and R.F. Thomas. 1984. The Groundwater Supply Survey. J. Amer. Water Works Assoc., 76:5, 52-59.

Appendix A

List of Documents Reviewed

LIST OF SITE DOCUMENTS REVIEWED
BY DR. EDWARD BOUWER

- July 15, 1990 Report of Investigation and Remediation Design for Keystone Sanitary Landfill, by Buchart-Horn, Inc.
- July, 1990 Final Remedial Investigation Report, Keystone Sanitation Company Site.
- September 30, 1990 EPA Record of Decision for Keystone Sanitation Landfill site.
- February 10, 1994 Memorandum and Order and Judgment of Chief Judge Rambo in Brown v. Keystone Sanitation Company.
- OU-2 Keystone Residential Well data table and figures prepared by Halliburton NUS Corp., depicting results above benchmark criteria for sampling events of February, 1994; June, 1994; January, 1995; October, 1995; and December 1995.
- June 27, 1996 letter from EPA Senior Assistant Regional Counsel Mary Rugala, attaching tables and figure depicting residential wells sampled between October, 1995 and March, 1996 with results above benchmark criteria.
- November 1, 1996 letter from EPA Senior Assistant Regional Counsel Mary Rugala, attaching tables and figures depicting residential wells sampled between February, 1994 and June, 1996 with results above benchmark criteria.
- December 4, 1996 letter from EPA Senior Assistant Regional Counsel Mary Rugala, attaching table depicting residential wells sampled between February, 1994 and June, 1996 with results above benchmark criteria.

Appendix B

Curriculum Vitae for Dr. Bouwer

CURRICULUM VITAE

Edward J. Bouwer, Ph.D.

ADDRESS:	Geography and Environmental Engr. The Johns Hopkins University 34th and Charles St. Baltimore, MD 21218 (410) 516-7437	1115 Dulaney Gate Circle Cockeysville, MD 21030 (410) 628-6451

BIRTHDATE: December 5, 1955

EDUCATION:

Ph.D.	Stanford University Thesis Advisor: Dr. Perry L. McCarty Title: "Transformations of Trace Halogenated Organic Compounds in Biofilms"	1982	Environmental Engineering and Science
M.S.	Stanford University	1978	Environmental Engineering and Science
B.S.C.E.	Arizona State University	1977	Civil Engineering

PROFESSIONAL EXPERIENCE:

1992-Present	Professor of Environmental Engineering, The Johns Hopkins Univ. Teaching: Environmental Engineering, Engineering Microbiology, Biological Processes, Biofilms, and Hazardous Waste Management.
1988-1992	Associate Professor of Environmental Engineering, The Johns Hopkins Univ.
1985-1988	Assistant Professor of Environmental Engineering, The Johns Hopkins Univ.
1983-1984	Assistant Professor of Civil Engineering, University of Houston.
1984 (June) 1983 (July)	Research Advisorship, National Institute for Water Supply, The Netherlands. Project: "The Behavior of Organic Micropollutants in the Soil".
1978-1982	Graduate Student Research Assistant, Stanford University.
1981-1982	Acting Instructor, Department of Civil Engineering, Stanford University.
1976-1977	Research Assistant in Chemical Technology Division at Oak Ridge National Laboratory, Oak Ridge, Tennessee.

PROFESSIONAL ORGANIZATIONS

Association of Environmental Engineering Professors
American Society of Civil Engineers
American Water Works Association
Water Environment Federation
American Chemical Society
Assoc. of Ground Water Scientists & Engineers
International. Association. on Water Quality
Tau Beta Pi
Sigma Xi

PROFESSIONAL SERVICE

Task Group on Modelling of Biofilm Processes, International Association for Water Pollution Research and Control, 1985-1989.
Chesapeake Bay Project Scientific Technical Advisory Committee on Nutrient Control Strategy, 1985.
Project Advisory Committee on Biological Denitrification in Drinking Water Treatment, AWWA Research Foundation, 1987-1989.

Groundwater Committee, Water Pollution Control Federation, 1987-1991.
U.S.G.S. Committee on Water Resources Research, National Research Council, 1987-1989.
Executive Committee, Mid-Atlantic University Consortium on Subsurface Contamination, 1987-1988.
Awards Committee, Association of Environmental Engineering Professors, 1988-1991.
Project Advisory Committee on Microorganisms and GAC, AWWA Research Foundation, 1988-1990.
Vice-Chair, Workshop on Long-Term Water Quality Monitoring for U.S.G.S., 1988
Chair, Symposium on Groundwater Contamination, SETAC 9th Annual Meeting, 1988
Vice-Chair, Student Activities Committee, American Water Works Association, 1989-1991.
Project Advisory Committee on Ozonation/Biological Treatment, AWWA Research Foundation, 1989-1991.
Chair, AEEP Workshop on Biological Processes in Drinking Water Treatment, 1989.
Editorial Board, Biodegradation Journal, 1989-1996.
Chair, Abstract Review and Program Committee, 1990 ASCE National Conference on Environmental Engineering, 1989-1990.
Co-Chair, AWWARF Expert Workshop on Biological Treatment Research Needs, 1990.
Chair, Session on Biological Processing for Treatment of Xenobiotics, SETAC 11th Annual Meeting, 1990.
Editorial Board, J. Contaminant Hydrology, 1990-1996.
Project Advisory Committee on Factors Limiting Microbial Growth in the Distribution System, AWWA Research Foundation, 1991-1994.
Committee on Ground Water Cleanup Alternatives, National Research Council, 1991-1994.
Project Advisory Committee on Microbial Impacts of Biological Filtration, AWWA Research Foundation, 1993-1995.
Board of Directors and Secretary, Association of Environmental Engineering Professors, 1993-1995.
Chair, University Student Activities Subcommittee, American Water Works Association, 1993-1996.
Committee on Shipboard Pollution Control, Naval Studies Board, National Research Council, 1994-1996.
Project Advisory Committee on Advanced Oxidation/Biodegradation Processes for the Destruction of TOC and Disinfection By-Product Precursors, AWWA Research Foundation, 1995-1997.
USEPA/AAFC Environmental Fate and Effects Test Methods Workshop, March 25-26, 1996.
Steering Committee on Building an Environmental Management Science Program, Board of Radioactive Waste Management, National Research Council, 1996.
Managing Editor, Biodegradation Journal, 1996-Present

HONORS AND AWARDS:

National Science Foundation Graduate Fellowship, 1978-1982.
Engineering Science Inc./Association of Environmental Engineering Professors Award for the Best Doctoral Thesis Relevant to Environmental Engineering Practice for the 1982-1983 Academic Year.
Outstanding Teaching Award, College of Engineering, University of Houston, 1984.
National Science Foundation Presidential Young Investigator Award, 1985-1990.
First Prize in WPCF Student Paper Competition (awarded jointly to Ph.D. student Dennis Lew), 1988.
Paper Award, AWWA Chesapeake Section (awarded jointly to Ph.D. students G. Cobb and D. Lew), 1989.
Kappe Environmental Engineering Lecture, Penn State University, 1990.
Paper Award, AWWA Chesapeake Section (awarded jointly to Ph.D. student A. Leeson), 1990.
Pedagogical Lecture, Contaminants and Sediments, American Chemical Society, 1990.
Outstanding Doctoral Thesis Award, Engineering Science/Association of Environmental Engineering Professors (awarded jointly to Ph.D. student Gordon Cobb), 1990
Outstanding Doctoral Thesis Award, CH2M Hill/Association of Environmental Engineering Professors (awarded jointly to Ph.D. student Robert Martin), 1991
EERO Keynote Lecture, "Microbial Remediation: Strategies, Potentials, and Limitations," Maastricht, The Netherlands, 1992.

RESEARCH INTERESTS:

Environmental engineering processes, groundwater contamination, bioremediation for control of organic contaminants at waste sites, factors that influence biotransformation of organic contaminants, biofilm kinetics, interaction between biotic and abiotic processes, biological processes design in wastewater, industrial and drinking water treatment, and transport and fate of microorganisms in porous media.

PUBLICATIONS:

Refereed Publications (1980 to 1996)

Bouwer, E.J., M.Reinhard, T. Everhart, and P.L. McCarty, "Organic Material Formed through Decolorization of Coffee Wastewater with Chlorine and Chlorine Dioxide," in Water Chlorination-Environmental Impact and Health Effects Volume 3, Jolley, R.L., Brungs, W.A., and Cumming, R.B., Editors, Ann Arbor Science publishers, Ann Arbor, MI, pp. 315-323, 1980.

Bouwer, E.J., P.L. McCarty, and J.C. Lance, "Trace Organic Behavior in Soil Columns during Rapid Infiltration of Secondary Wastewater," Water Research, 15, 151-159, 1981.

Bouwer, E.J., B.E. Rittmann, and P.L. McCarty, "Anaerobic Degradation of Halogenated 1- and 2-Carbon Organic Compounds," Environ. Sci. Technol., 15:5, 596-599, 1981.

Bouwer, E.J. and P.L. McCarty, "Removal of Trace Chlorinated Organic Compounds by Activated Carbon and Fixed-Film Bacteria," Environ. Sci. Technol., 16:12, 836-843, 1982.

Bouwer, E.J. and P.L. McCarty, "Transformations of 1- and 2-Carbon Halogenated Aliphatic Compounds Under Methanogenic Conditions," Appl. Environ. Microbiol., 45:4, 1286-1294, 1983.

Bouwer, E.J. and P.L. McCarty, "Transformations of Halogenated Organic Compounds Under Denitrification Conditions," Appl. Environ. Microbiol., 45:4, 1295-1299, 1983.

Bouwer, E.J. and P.L. McCarty, "Effects of 2-Bromoethanesulfonic Acid and 2-Chloroethanesulfonic Acid on Acetate Utilization in a Continuous-Flow Methanogenic Fixed-Film Column," Appl. Environ. Microbiol., 45:4, 1408-1410, 1983.

Bouwer, E.J., P.L. McCarty, H. Bouwer, and R.C. Rice, "Organic Contaminant Behavior During Rapid Infiltration of Secondary Wastewater at the Phoenix 23rd Avenue Project," Water Research, 18:4, 463-472, 1984.

Bouwer, E.J. and P.L. McCarty, "Modeling of Trace-Organics Biotransformation in the Subsurface," Ground Water, 22:4, 433-440, 1984.

Bouwer, E.J., "Secondary Utilization of Trace Halogenated Organic Compounds in Biofilms," Environmental Progress, 4:1, 43-46, 1985.

Bouwer, E.J. and P.L. McCarty, "Ethylene Dibromide Transformation Under Methanogenic Conditions," Appl. Environ. Microbiol., 50:2, 527-528, 1985.

Bouwer, E.J. and P.L. McCarty, "Utilization Rates of Trace Halogenated Organic Compounds in Acetate-Grown Biofilms," Biotech. and Bioeng., 27:11, 1564-1571, 1985.

Bouwer, E.J. and G.D. Cobb, "Modeling of Biological Processes in the Subsurface", Wat. Sci. Tech., Vol. 19, No. 5-6, 769-780, 1987.

Bouwer, E.J., "Theoretical Investigation of Particle Deposition in Biofilm Systems," Water Research, 21:12, 1489-1498, 1987.

Bouwer, E.J. and J.P. Wright, "Transformations of Trace Halogenated Aliphatics in Anoxic Biofilm Columns," J. Contaminant Hydrology, 2, 155-169, 1988.

Bouwer, E.J., J. Mercer, M. Kavanaugh, and F. DiGiano, "Coping with Groundwater Contamination," J. Water Pollution Control Federation, 60:8, 1415-1427, 1988.

Bouwer, E.J. and P.B. Crowe, "Assessment of Biological Processes in Drinking Water Treatment," J. Amer. Water Works Assoc., 80:9, 82-93, 1988.

Bouwer, E.J., "Biotransformation of Aromatics in a Strip-Pit Pond," J. Env. Engr. Div., ASCE, 115:4, 741-755, 1989.

Cobb, G.D. and E.J. Bouwer, "Effects of Electron Acceptor on Halogenated Organic Compound Biotransformations in a Biofilm Column," Environ. Sci. Technol., 25:6, 1068-1074, 1991.

Martin, R.E., L.M. Hanna, and E.J. Bouwer, "Determination of Bacterial Collision Efficiencies in a Rotating Disk System," Environ. Sci. Technol., 25:12, 2075-2082, 1991.

Bouwer, E.J. and B.E. Rittmann, "Comment on: Use of Colloid Filtration Theory in Modeling Movement of Bacteria through a Contaminated Sandy Aquifer," Environ. Sci. Technol., 26:2, 400-401, 1992.

Pardieck, D.L., E.J. Bouwer, and A.T. Stone, "Hydrogen Peroxide Use to Increase Oxidant Capacity for In Situ Bioremediation of Contaminated Soils and Aquifers: A Review," J. Contaminant Hydrology, 9, 221-242, 1992.

Martin, R.E., E.J. Bouwer, and L.M. Hanna, "Application of Clean Bed Filtration Theory to Bacterial Deposition in Porous Media," Environ. Sci. Technol., 26:5, 1053-1058, 1992.

Bouwer, E.J., C.T. Chen, and Y.H. Li, "Transformation of a Petroleum Mixture in Biofilms," Water Science and Technology, 26:3-4, 637-646, 1992.

McGahey, C. and E.J. Bouwer, "Biodegradation of Ethylene Glycol in Simulated Subsurface Environments," Water Science and Technology, 26:1-2, 41-49, 1992.

Hozalski, R.M., S. Goel, and E.J. Bouwer, "Use of Biofiltration for Removal of Natural Organic Matter to Achieve Biologically Stable Drinking Water," Water Science and Technology, 26:9-11, 2011-2014, 1992.

Bouwer, E.J. and A.J.B. Zehnder, "Bioremediation of Organic Compounds--Putting Microbial Metabolism to Work," Trends in Biotechnology, 11:8, 360-367, 1993.

Rijnaarts, H.H.M., W. Norde, E.J. Bouwer, J. Lyklema, and A.J.B. Zehnder, "Bacterial Adhesion under Static and Dynamic Conditions," Appl. Environ. Microbiol., 59:10, 3255-3265, 1993.

Rifkin, E. and E.J. Bouwer, "A Proposed Approach for Deriving National Sediment Criteria for Dioxin," 28:9, 441A-443A, 1994.

Bouwer, E.J., N. Durant, L. Wilson, W. Zhang, and A. Cunningham, "Degradation of Xenobiotic Compounds In Situ: Capabilities and Limits," FEMS Microbiol. Rev., 15:2-3, 307-317, 1994.

Durant, N.D., L.P. Wilson, and E.J. Bouwer, "Microcosm Studies of Subsurface PAH-Degrading Bacteria from a Former Manufactured Gas Plant", J. Contaminant Hydrology, 17:3, 213-237, 1995.

Goel, S., R. Hozalski, and E.J. Bouwer, "Biodegradation of NOM: Characterization of Different Sources and Effect of Ozone Dose", J. Amer. Water Works Assoc., 87:1, 90-105, 1995.

Sturman, P.J., P.S. Stewart, A.B. Cunningham, E.J. Bouwer, and J.H. Wolfram, "Engineering Scale-Up of In-Situ Bioremediation Processes: A Review", J. Contaminant Hydrology, 19, 171-203, 1995.

Zhang, W., E.J. Bouwer, L. Wilson, and N. Durant, "Biotransformation of Aromatic Hydrocarbons in Subsurface Biofilms", Water Science and Technology, 31:1, 1-14, 1995.

Logan, B.E., D.G. Jewett, R.G. Arnold, E.J. Bouwer, and C.R. O'Melia, "Clarification of Clean-Bed Filtration Models", J. Environmental Engineering Division, ASCE, 121:12, 869-873, 1995.

Rijnaarts, H.H.M., W. Norde, E.J. Bouwer, J. Lyklema, and A.J.B. Zehnder, "Reversibility and Mechanism of Bacterial Adhesion," Colloids and Surfaces B: Biointerfaces, 4, 5-22, 1995.

Hozalski, R., S. Goel, and E.J. Bouwer, "TOC Removal in Biological Filters", J. Amer. Water Works Assoc., 87:12, 40-54, 1995.

Wilson, L.P. and E.J. Bouwer, "Biodegradation of Aromatic Compounds Under Mixed Oxygen/Denitrifying Conditions," J. Industrial Microbiology, in press.

Rijnaarts, H.H.M., W. Norde, E.J. Bouwer, J. Lyklema, and A.J.B. Zehnder, "Bacterial Deposition in Porous Media Related to the Clean Bed Collision Efficiency and to Substratum-Blocking by Attached Cells", Environ. Sci. Technol., 30:10, 2869-2876.

Rijnaarts, H.H.M., W. Norde, E.J. Bouwer, J. Lyklema, and A.J.B. Zehnder, "Bacterial Deposition in Porous Media: Effects of Cell Coating, Substratum Hydrophobicity, and Electrolyte Concentration", Environ. Sci. Technol., 30:10, 2877-2883.

Bouwer, E.J., W. Zhang, L.P. Wilson and N.D. Durant, "Biotreatment of PAH Contaminated Soils/Sediments," Annals of the NY Academy of Sciences, submitted for publication.

Bosma, T.N.P., E.J. Bouwer, M. de Gee, and A.J.B. Zehnder, "Modeling Transport and Radial Diffusion Limited Biodegradation of Organic Contaminants in Saturated Columns," Water Resources Research, submitted for publication.

Cobb, G.D., E.J. Bouwer, and L.M. Hanna, "Simulation of Steady-State Multiple Electron Acceptor Utilization and Organic Contaminant Biotransformation by Biofilms in Porous Media 1. Concepts," J. Environ. Engr. Div., ASCE, submitted for publication.

Cobb, G.D., E.J. Bouwer, and L.M. Hanna "Simulation of Steady-State Multiple Electron Acceptor Utilization and Organic Contaminant Biotransformation by Biofilms in Porous Media 2. Experiments," J. Environ. Engr. Div., ASCE, submitted for publication.

Book Chapters (1992 to 1996)

Bouwer, E.J., "Bioremediation of Organic Contaminants in the Subsurface," in Environmental Microbiology, R. Mitchell, Ed., John Wiley and Sons, Chapter 11, pp. 287-318, 1992.

Harvey, R.W. and E.J. Bouwer, "Limits on Quantitative Descriptions of Biocolloid Mobility in Contaminated Groundwater," in Manipulation of Groundwater Colloids for Environmental Restoration, J.F. McCarthy and F.J. Wobber, eds., Lewis Publishers, pp. 57-64, 1993.

Bouwer, E.J., "Microbial Remediation: Strategies, Potentials, and Limitations," in Integrated Soil and Sediment Research: A Basis for Proper Protection, H.J.P. Eijsackers and T. Hamers, Eds., Kluwer Academic Publishers, pp. 533-544, 1993.

Martin, R. E., E.J. Bouwer, and L. Hanna, "Cells and Surfaces in Groundwater Systems," in Manipulation of Groundwater Colloids for Environmental Restoration, J.F. McCarthy and F.J. Wobber, eds., Lewis Publishers, pp. 67-71, 1993.

Bouwer, E.J., "Microbial Remediation: Strategies, Potentials, and Limitations," in Integrated Soil and Sediment Research: A Basis for Proper Protection, H.J.P. Eijsackers and T. Hamers, Eds., Kluwer Academic Publishers, pp. 533-544, 1993.

Norris, R.D., R. Hinchee, R. Brown, P.L. McCarty, L. Semprini, J. Wilson, D. Kampbell, M. Reinhard, E.J. Bouwer, R. Borden, T. Vogel, M. Thomas, and H. Ward, Handbook of Bioremediation, Lewis Publishers, 1994.

Durant, N.D., L.P. Wilson, and E.J. Bouwer, "Screening for Natural In-Situ Subsurface Biotransformation of Polycyclic Aromatic Hydrocarbons at a Former Manufactured Gas Plant," In Bioremediation of Chlorinated and Polycyclic Aromatic Hydrocarbon Compounds. R.E. Hinchee, A. Leeson, L. Semprini, and S.K. Ong, Eds., Lewis Publishers, pp. 456-461, 1994.

Durant, N.D., C.A.A. Jonkers, L.P. Wilson, and E.J. Bouwer, "Enhanced Biodegradation of Naphthalene in MGP Aquifer Microcosms," In Intrinsic Bioremediation. R.E. Hinchee, J.T. Wilson, and D.C. Downey, Eds., Battelle Press, pp. 189-196, 1995.

Wilson, L.P., N.D. Durant, and E.J. Bouwer, "Aromatic Hydrocarbon Biotransformation Under Mixed Oxygen/Nitrate Electron Acceptor Conditions," In Microbial Processes for Bioremediation. R.E. Hinchee, F.J. Brockman, and C.M. Vogel, Eds., Battelle Press, pp. 137-144, 1995.

Zhang, W., E.J. Bouwer, A.B. Cunningham, and G.A. Lewandowski, "Influence of Sorption on Organic Contaminant Biuodegradation," In Microbial Processes for Bioremediation. R.E. Hinchee, F.J. Brockman, and C.M. Vogel, Eds., Battelle Press, pp. 315-322, 1995.

Bouwer, E.J., N. Durant, L. Wilson, and W. Zhang, "Design Considerations for In Situ Bioremediation of Organic Contaminants," In Biological Treatment of Hazardous Waste. G. Lewandowski and L. DeFilippi, Eds., John Wiley and Sons, in press.

Bouwer, E.J., W. Zhang, L.P. Wilson and N.D. Durant, "Biodegradation of Coal Tar Constituents in Aquifer Sediments," In Soil and Aquifer Pollution: Non-Aqueous Phase Liquids - Contamination and Reclamation. H. Rubin, N. Narkis and J. Carberry, Eds., Springer-Verlag, in press.

Selected Conference Proceedings (1990 to 1996)

Pardieck, D., E.J. Bouwer and A.T. Stone, "Hydrogen Peroxide as a Source of Oxidant Capacity for the Biotransformation of Benzene, Toluene, and Xylene in Biofilms," Proceedings of the ASCE 1990 National Conference on Environmental Engineering, pp. 374-381, Washington, D.C., July 1990.

Trizinsky, M.A. and E.J. Bouwer, "Biotransformation of Aromatic Compound Mixtures under Denitrifying Conditions," Proceedings of the ASCE 1990 National Conference on Environmental Engineering, pp. 921-922, Washington, D.C., July 1990.

McGahey, C. and E.J. Bouwer, "Biodegradation of Ethylene Glycol in Subsurface Environments," Proceedings of the ASCE 1990 National Conference on Environmental Engineering, pp. 903-904, Washington, D.C., July 1990.

Muralidharan, V., I.S. Hirsh, T.L. Peeples, R.M. Kelly, I. Suy, and E.J. Bouwer, "Mixed Cultures of High Temperature Bacteria: Prospects for Bioprocessing of Fossil Fuels," Proc. 2nd International Symposium on Biological Processing of Coal, Sponsored by EPRI and DOE, San Diego, CA, May 1991, 15 pages.

Bouwer, E.J., M.A. Trizinsky, and W. Zhang, "Influence of Redox Conditions on Organic Contaminant Biotransformation," Proc. of the In-Situ Bioremediation Symposium '92, Niagara-On-The-Lake, Ontario, Canada, September 20-24, 1992.

MacFarlane, I.D., G.D. McCleary, E.J. Bouwer, and P.J.S. Colberg, "Evidence for Natural In Situ Biodegradation of Aromatic Hydrocarbons," Proc. Innovative Solutions for Contaminated Site Management, Water Environment Federation, Miami, Florida, March 6-9, 1994.

Goel, S., R.M. Hozalski, R.M., and E.J. Bouwer, "Removal of Natural Organic Matter in Biofilters," Proc. Amer. Water Works Assoc. Annual Conference, New York City, NY, June 19-23, pp. 653-675, 1994.

MacFarlane, I.D., E.J. Bouwer, and P.J.S. Colberg, "Demonstrating the Feasibility of Intrinsic Bioremediation at a Former Manufactured Gas Plant," Proc. Symposium on Intrinsic Bioremediation of Ground Water, U.S.E.P.A., Denver, CO, pp. 181-182, Aug. 30- Sept. 1, 1994.

Bouwer, E.J., "In-Situ Bioremediation: Strategies, Capabilities, and Limits," Proc. 7th Annual Symposium of the Arizona Hydrological Society entitled "Approaching the Millennium, Evolving Perspectives in Water Resources", Scottsdale, Arizona, September 22-23, pp. 335-342, 1994.

Wilson, L.P., P.C. D'Adamo, and E.J. Bouwer, "Aromatic Hydrocarbon Biotransformation Under Mixed Oxygen/Nitrate Electron Acceptor Conditions," Proc. Symposium on Bioremediation of Hazardous Wastes: Research, Development, and Field Evaluations, U.S.E.P.A., Rye Brook, NY, pp. 22-23, 1995.

CURRENT RESEARCH FUNDING

"Bioremediation of BTEX, Naphthalene, and Phenanthrene in Aquifer Material Using Mixed Oxygen/Nitrate Electron Acceptor Conditions," U.S. E.P.A., October 1, 1993 to September 30, 1996; $295,497.

"Coal Tar Biodegradation at the Baltimore Gas and Electric Spring Gardens Facility", Baltimore Gas and Electric, October 1, 1991 to December 31, 1996; $508,000.

"In-Situ Bioremediation of Organic Compounds: Coupling of Mass-Transfer and Biodegradation," New Jersey Hazardous Substance Management Research Center, July 1, 1995 to June 30, 1997; $185,000; (Dr. Gordon Lewandowski Co-Principal Investigator).

"Effect of Phosphate-Based Corrosion Inhibitors and other Nutrients on Klebsiella Growth in Treated WSSC Water," Washington Suburban Sanitary Commission, August 1, 1995 to July 31, 1996; $49,207.

"Technical Support on Bioremediation," U.S. Army Corps of Engineers, September 25, 1995 to June 30, 1997; $12,000.

"Optimizing Filtration in Biological Filters", AWWA Research Foundation, January 1, 1996 to December 31, 1997; $75,000.

"Bioavailability of Aromatic Hydrocarbons in Saturated Porous Media: The Effects of Chemical Aging and Mass Transfer", U.S. E.P.A. National Center for Environmental Research and Quality Assurance, December 5, 1996 to December 4, 1999; $439,725.

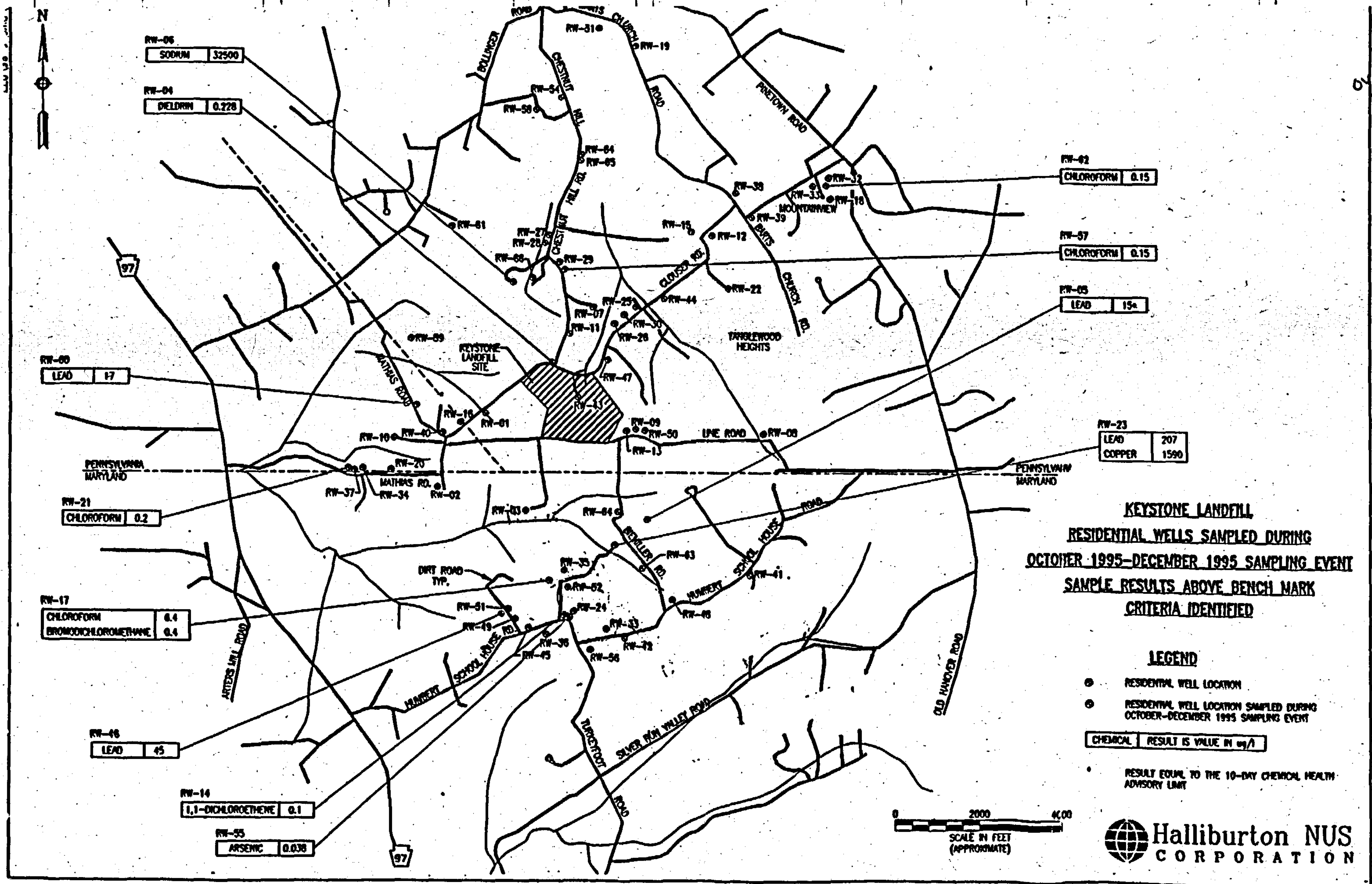
CONSULTING

"Biological Treatment of a Hazardous Waste Impoundment for RCRA Site Closure," A.J. Weigand, Inc., 1984-1986.
"Groundwater Contamination by Chlorinated Solvents," Woburn, MA, Unifirst Corporation/ Goodwin, Procter, and Hoar, 1985-1986.
"Degradation of Halogenated Solvents in Groundwater," IBM, 1986-1987.
"Groundwater Contamination by Halogenated Aliphatics," Groundwater Sciences Corporation, 1987
"Transport and Fate of Pesticides and Nutrients at the Caves Valley Project," Piper and Marbury, 1988-1989
"Single-Sludge Denitrification for City of Fredericksburg," Whitman, Requardt and Associates, 1989
"Fate of Formaldehyde at the Oroville Plant," Louisiana-Pacific, 1989
"Assessment of Subsurface Microbial Processes," IBM, 1989-1990.
Technical Advisory Committees for James M. Montgomery
    "Arkansas Eastman Company Wastewater Treatment Process Development," 1989-1990.
    "Mesa Water District/Orange County Water District Production Demonstration Facility," 1990.
    "Biofiltration Process Study at Water Treatment Plant No. 8, Palm Beach County, Florida," 1990.
"Partitioning of Dioxin to Wastewater Solids and to Ocean Particulates," Rifkin and Associates, 1990.
"Assessment of Pulaski Incinerator Wastewater and Treatment," Whiting-Turner Contracting Company, 1990.
"Geochemical Factors Influencing Organic Contaminant Biotransformation in the Subsurface," IBM, 1990.
"Biological Nutrient Removal Wastewater Treatment Plant Design for BARC-East," KCI Technologies, 1991.
"Bioremediation of Chlorinated Solvents using Alternate Electron Acceptors," U.S.E.P.A., 1992.
"Subsurface Remediation Modeling - A State of the Art Review", DuPont, 1992-1993.
"Biodegradation of Organic Contaminants," Sonnenschein Nath & Rosenthal, 1993.
"Dover Air Force Base Bioreactor Study," EA Engineering, 1992-1994.
"Transport and Fate of Dioxin in Aquatic Systems," Rifkin and Associates, 1991-present.
"Evidence for Intrinsic Bioremediation of Vinyl Chloride at the Ekotek Site", RUST E. & I., 1994-1995.
"Hampstead Wastewater Treatment Plant Expansion", Anderson, Coe, and King, 1995.
"Intrinsic Remediation at the Chem-Solv Site", Rare Earth Envirosciences, Inc., 1995.
"Potential for Groundwater Contamination from the PST Landfill", Anderson, Coe, and King, 1995.
"Attenuation of Thiophenes at the McColl Superfund Site", ENVIRON, 1995.
"PCE Contamination at Westview Mall, Baltimore, MD", Weinberg & Green, 1995-1996.
"Groundwater and Soil Contamination at the Athens, AL Facility of MagneTek, Inc.", Sonnenschein Nath & Rosenthal, 1996.
"Fate and Transport of Contaminants in the Vicinity of the Keystone Sanitation Landfill", Piper and Marbury, 1996.

Appendix C

Site Maps prepared by Halliburton NUS Corporation.

over sized



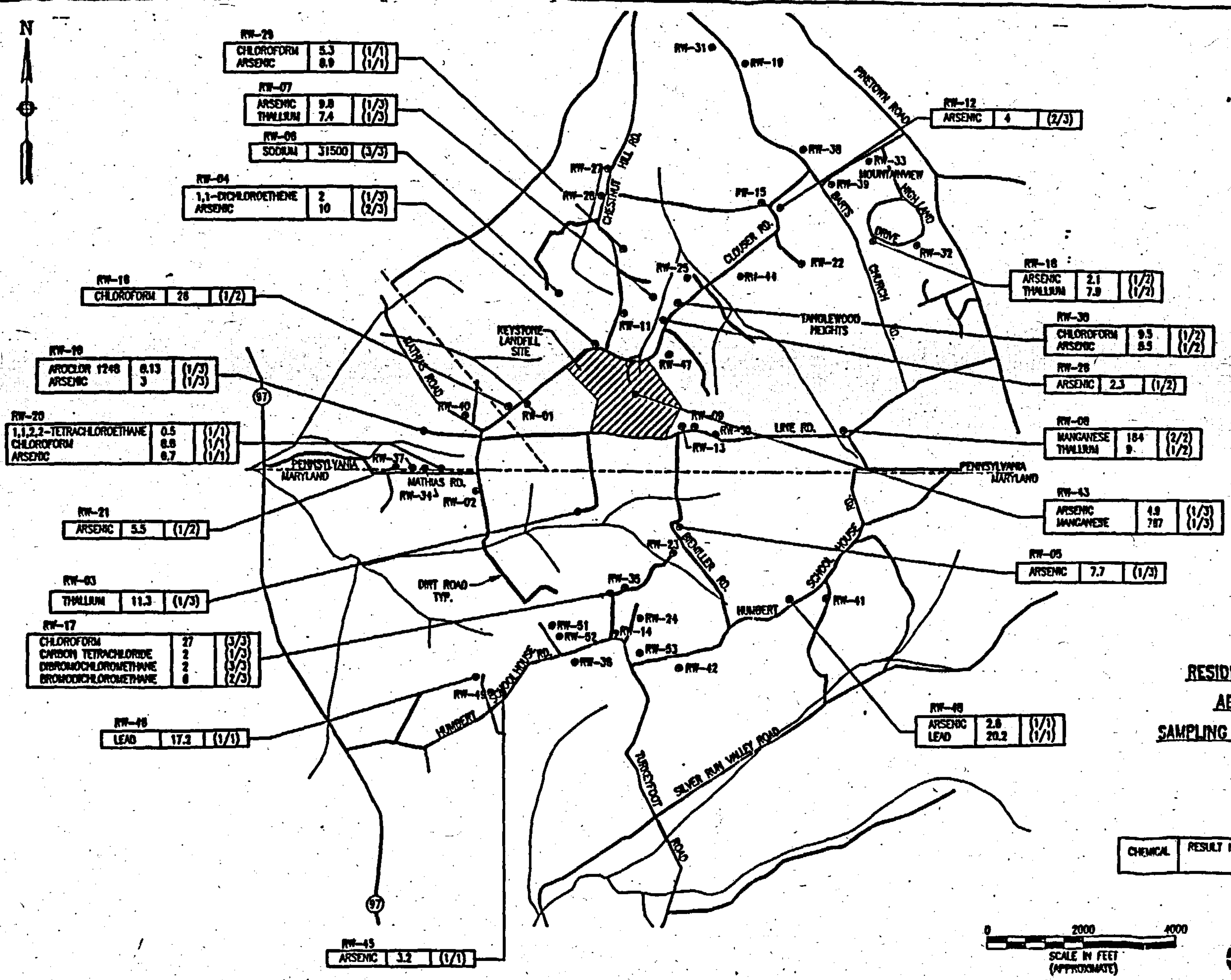
KEYSTONE LANDFILL
RESIDENTIAL WELLS SAMPLED DURING
OCTOBER 1995-DECEMBER 1995 SAMPLING EVENT
SAMPLE RESULTS ABOVE BENCH MARK
CRITERIA IDENTIFIED

LEGEND

- ● RESIDENTIAL WELL LOCATION
- ● RESIDENTIAL WELL LOCATION SAMPLED DURING OCTOBER-DECEMBER 1995 SAMPLING EVENT
- CHEMICAL | RESULT IS VALUE IN ug/l
- * RESULT EQUAL TO THE 10-DAY CHEMICAL HEALTH ADVISORY LIMIT

Halliburton NUS
CORPORATION

over sized



KEYSTONE LANDFILL
RESIDENTIAL WELL SAMPLE RESULTS
ABOVE BENCHMARK CRITERIA
SAMPLING EVENTS (2/94, 6/94 AND 1/95)

LEGEND

● RESIDENTIAL WELL SAMPLE LOCATION

CHEMICAL	RESULT IS THE MAXIMUM OF ROUNDS VALUE IN ug/l	(FREQUENCY OF DETECTION)

Halliburton NUS CORPORATION

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TRACE ORGANICS IN SEPTIC TANK EFFLUENT

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Abstract. This paper reviews the available information and presents the results of a study undertaken to estimate the presence and level of certain trace organics in wastewater samples collected from a septic tank in an individual household, from a lift station, and from a waste treatment lagoon near Regina, Canada. Out of 11 priority pollutants analyzed, 6 priority pollutants – chloroform, bromodichloromethane, toluene, benzene, methylene chloride and tetrachloroethylene – were detected in the samples. Benzene and bromodichloromethane were dominant. Methylene chloride and tetrachloroethylene could not be quantified at the low concentrations present. Chloroform was present in the lagoon effluent sample once at a concentration of 0.03 $\mu g \ L^{-1}$. Toluene was not present either in the septic tank effluent or in the lagoon effluent. Benzene was present in the septic tank effluent (max. value 450 $\mu g \ L^{-1}$) and in the lagoon effluent (max. value 120 $\mu g \ L^{-1}$). Bromodichloromethane was present in the septic tank effluent and lagoon effluent at concentrations lower than 1.10 $\mu g \ L^{-1}$. The trace organics in the septic tank effluent and lagoon effluent at these comparatively low concentrations may not pose any significant risk either to aquatic life or to public health, taking into account the attentuation capacity of the soil and the dilution usually available.

1. Introduction

Most of the previously published studies have only characterized the septic tank effluent with respect to biochemical oxygen demand (5 day, 20 °C) (BOD), chemical oxygen demand (COD), suspended solids (SS), N, P and similar parameters. Only recently has some attempt been made to measure the trace organics present in septic tank effluent. There is very little published information on the subject at present.

The basic objective of this study was to characterize the septic tank effluent with respect to certain trace organics.

2. Review of Literature

2.1. General

In most areas, homeowners can buy septic tank cleaning fluids, most of which contain trichloroethylene (TCE), benzene, or methylene chloride. TCE and other chlorinated organic solvents may reach and spread with the groundwater. Many of these compounds such as TCE are known animal carcinogens (Council on Environmental Quality, 1981). Widespread use of such solvents has led to the closure of many public and private drinking water wells (Council on Environmental Quality, 1981). The monitoring data from both federal and state studies in U.S.A. on affected groundwater supplies showed that of all the groundwater supplies collected and analyzed, trichloroethylene (TCE), an industrial solvent and degreaser, was detected more frequently and in the highest concentration and that tetrachloroethylene ranked second in frequency

Water, Air, and Soil Pollution 28 (1986) 299–308.

2.2. TRACE ORGANICS IN SEPTIC TANK EFFLUENT AND SEPTAGE

DeWalle *et al.* (1980) measured several volatile organics in the influent and effluent of a community septic tank serving 91 homes in a subdivision located south of Tacoma, Pierce County, Washington State during a week of intense sampling in September 1980. Their data showed the presence of five priority pollutants – toluene, dichloromethane, chloroform, tetrachloroethene and ethylbenzene – in the raw wastewater. These compounds showed essentially no removal during the one to two days detention in the septic tank as indicated in Table III.

TABLE III

Volatile organics in septic tank influent and effluent (averaged over 7 d 24 h composites) (from DeWalle *et al.*, 1980)

Organics	Concentration ($\mu g\ L^{-1}$)			
	Influent	Effluent	Scum	Solids Accum.
Toluene	34.6	38.8	0.7	0.02
Dichloromethane	3.6	3.4	0.9	0.25
Chloroform	1.7	0.76	0.1	0.06
Tetrachloroethene	0.76	0.28	5.8	7.6
Ethylbenzene	0.1	0.1	6.9	6

These priority pollutants showed higher levels in the weekend probably reflecting increased domestic activity. Most of the other volatile compounds were reported to be hydrocarbons and their removal by septic tank generally decreased with increasing molecular weight. Several organosulfur compounds showed a substantial increase in concentration as a result of anaerobic digestion process in the septic tank.

Six additional samplings were carried out by the researchers at the University of Washington during 1980–1982 and further analysis of these and earlier data were reported in 1982 (DeWalle *et al.*, 1982). These results indicated that dichloromethane was found in all samples, followed by toluene in frequency of detection. These compounds were also found in the water collected from a 40 m deep monitoring well located adjacent to the drainfield. The volatile organic fraction typically contained 40 to 50 compounds at a concentration greater than 1 $\mu g\ L^{-1}$; however, only five were identified as priority pollutants as discussed earlier.

Tomson *et al.* (1981) studied the trace organic removal efficiency of a rapid infiltration system treating secondary sewage effluent. A broad spectrum monitoring of trace organics in the secondary sewage effluent applied to the rapid infiltration site was compared to a similar broad spectrum analysis of groundwater beneath the site. Overall removal efficiency was found to be about 92%. Classes of organic compounds exhibited removal efficiencies ranging from 70 to 100%. The 'dampening' effects of groundwater

TABLE IV

Sample details and locations

Date	Day of the week	Sample details					
		Individual household				Lif station	Lagoon
		Raw wastewater	Septic tank effluent	Septic tank sludge	Septic tank scum	Wastewater	I cell effluent
84-08-15	Wednesday		x			x	x
84-08-16	Thursday		x	x	x	x	x
84-08-17	Friday	x	x	x	x	x	x
84-08-18	Saturday	x	x	x	x	x	x
84-08-19	Sunday		x			x	x
84-08-20	Monday		x			x	x
84-08-21	Tuesday		x			x	x

collected at 7 p.m.; samples on August 18 and 19 were collected at 2 p.m. Samples were collected in plastic buckets and transferred to glass bottles immediately at the site. These samples were then sent to Saskatchewan Research Council laboratory at Saskatoon, 240 km away, by bus in two batches. Samples were stored at 5 °C before being shipped to the laboratory. Out of 29 samples sent, 27 samples were analyzed due to breakage of two sample bottles. Samples were analyzed for trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane and bromoform), toluene, benzene, methylene chloride (dichloromethane), carbon tetrachloride, trichloroethylene, tetrachloroethylene and 1-2-dichloroethane. All the organic compounds belong to the category of priority pollutants designated by the U.S. EPA. Samples were preserved at 5 °C before analysis. Samples were analyzed using a gas chromatograph (Hewlett-Packard, Model 5730A) by a headspace technique. The halomethanes were determined with an electron capture detector. The other compounds were determined using a flame ionization detector. Standards obtained from the U.S. EPA were used for calibration. It is highly unlikely that the presence of other organics have any interfering effects. Some samples of septic tank effluent, lift station wastewater and lagoon effluent were analyzed for BOD and SS.

4. Results and Discussion

4.1. RESULTS

Benzene, toluene and bromodichloromethane present in the 27 samples collected are shown in Table V. Methylene chloride (dichloromethane) was detected in samples of septic tank effluent on August 16, sludge on August 17 and scum on August 16, but could not be quantified at low levels. Tetrachloroethylene was detected in lift station wastewater on August 15 and 20. Chloroform was detected once only in the effluent of

TABLE VI

BOD and SS of samples

Sample description	Average concentration (mg L^{-1})	
	BOD	SS
Septic tank effluent	152	116
Lift station wastewater	140	125
Lagoon I cell effluent	123	108

TABLE VII

Occurrence of trace organics in samples (%)

No.	Compound	Raw wastewater $N = 2$	Septic tank effluent $N = 5$	Septic tank sludge $N = 3$	Septic tank scum $N = 3$	Lift station wastewater $N = 7$	Lagoon I cell effluent $N = 7$
1	Chloroform	0	0	0	0	0	14
2	Bromodichloromethane	100	100	67	100	100	66
3	Dibromochloromethane	0	0	0	0	0	0
4	Bromoform	0	0	0	0	0	0
5	Toluene	100	0	0	0	14	0
6	Benzene	50	60	33	67	71	43
7	Methylene Chloride (Dichloromethane)	0	20	33	33	0	0
8	Carbon Tetrachloride	0	0	0	0	0	0
9	Trichloroethylene	0	0	0	0	0	0
10	Tetrachloroethylene	0	0	0	0	29	0
11	1-2-dichloroethane	0	0	0	0	0	0

Detection limit is 10 μg L^{-1} benzene, 15 μg L^{-1} for toluene and 0.02 μg L^{-1} for $CHCl_2Br$.
N = number of samples.

Toluene occurred at an average concentration of 225 μg L^{-1} in the houshold wastewater while none was detected in the septic tank effluent, sludge and scum. Toluene was present in one sample at a concentration of 30 μg L^{-1} taken from the lift station which collects the effluent from the various septic tanks in the community. This is in sharp contrast to the University of Washington study results which showed that toluene was most prevalent in raw wastewaster and septic tank effluent (Table III). Benzene concentrations in septic tank effluent, lift station wastewater and in lagoon I cell effluent were much higher than in raw wastewater, whenever it was detected. The average concentrations of bromodichloromethane in raw wastewater and septic tank effluent were 0.30 μg L^{-1} and 0.46 μg L^{-1}, respectively, showing no removal through the septic tank; the average concentrations in lift station wastewater and lagoon (I cell) effluent were 0.62 μg L^{-1} and 0.16 μg L^{-1}, respectively, showing approximately 74%

such as phenol, 2,4,6-trichlorophenol, 2-chlorophenol, 1-2-dichlorobenzene, 1,4-dichlorobenzene, 1,1,1-trichloroethane, naphthalene, diethyl phthalate and dimethyl phathalate;

(2) laboratory column studies with different soil types to understand about the behavior of trace organics through the soil;

(3) field studies to monitor the presence and quantity of trace organics downstream of existing and experimental septic tile systems in different soil environments; and

(4) regular groundwater monitoring for trace organics in areas where there is a relatively high density of septic tank systems to assess the long-term effects of such systems on groundwater quality.

Acknowledgment

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the External Research Program. The views expressed are those of the authors and do not represent the official views of the Corporation.

The authors would like to express their thanks to G. Yue and A. Ayyaswami who were involved in the initial phase of the project, especially sample collection. Thanks are due to Fran Mollard for her excellent typing assistance.

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Sites selected for the study were four single family dwellings located in Coventry, CT; three condominiums: Stony Hill Villages in Brookfield, CT, Northbrook Condominiums in Monroe, CT, and Stone Pond Condominiums in Tolland, CT; a business-residential complex in Chester, CT; and a community on-site sewage disposal system designed to serve 43 single family homes. At the latter site, each home's septic tank connected to a gravity sewer system going to the community soil absorption field area.

Except for the Coventry location site, selection was done in cooperation with the State of Connecticut Department of Environmental Protection Water Compliance Unit. This was an attempt to provide a mix of site conditions representative for the state. A second important consideration in the site selection process was the availability of on-site sewage disposal system design information and the system installatin practices followed.

A RUCK denitrification system located in Mansfield, CT, was used to evaluate techniques for determining the movement and concentration of constituents in the household wastewater discharge as it moves through the on-site sewage disposal system. This installation was designed for experimental use and consisted of a number of sampling points within the system including a capability for on-site column studies. The system was developed by Laak, one of this study's principal investigators, and researched by Costello (1984). The water supply for the residence came from a 40 meter (131 feet) deep drilled well located upstream about 35 meters (115 feet) from the sewage disposal system.

For the Coventry, CT site, each single family dwelling was on a 0.4 ha (1 acre) plot and had a conventional septic tank-leaching system for sewage disposal. These systems had been in place for about twenty years. The soils at this site were underlain by a compact basal till and the soil drainage characteristics ranged from good to poor. Ground water monitoring wells utilized were those installed earlier by Luce and Welling (1983) in a study of the movement of nitrates, phosphates, and fecal coliform bacteria from these soil leaching field areas.

The ground water monitoring wells at the Chester and Tolland condominium sites were already in place. The latter wells were installed at the time of condominium construction to satisfy the requirements of the State of Connecticut Department of Environmental Protection.

Ground water monitoring wells were installed at the Brookfield, Monroe and Somers sites. The Monroe and Somers wells were placed a little less than one meter (three feet) into the existing water table at the time of well boring. At the Brookfield site, this practice was followed only in the leach field area because of the difficult well boring conditions encountered in the glacial till for the equipment being used.

At the Somers location, a parallel set of wells were installed to observe leachate flow similarities or differences coming from the soil absorption field. Paired wells were used at three locations. Two piping materials, polyvinyl chloride (PVC) and stainless steel, were used to

The constituent concentration for ground water at the condominium site in Monroe and for the residential housing complex at Somers are shown in Tables 2 and 3. At Monroe, the drinking water supply was also analyzed. Emphasis at Somers was for a more in-depth evaluation of the constituent movement from the soil absorption field into the ground water and away from the site. The distance between wells A and D was approximately 38 meters (124 feet); for wells H to E, the approximate linear distance was 41 meters (133 feet).

Summary

Volatile organic compounds and hydrocarbons were found to make their way into the groundwater area near the on-site sewage disposal system. Further groundwater studies near on-site sewage disposal sites are recommended.

Acknowledgement

Dr. Harvey D. Luce of the Plant Science Department was a principal investigator during the first year of this study. Dr. James Stuart of the Chemistry Department provided assistance with the purge and trap concentrator prcoedures used and invaluable consultation during the latter stage of this study.

The importance of the people that do the ground water sample analyses in the laboratory cannot be over-emphasized. Special recognition is given to the staff at the South Central Connecticut Regional Water Authority in New Haven, CT. At the University of Connecticut, individuals deserving recognition are Mr. Albert Kind, Research Assistant in Microchemistry, Mr. Shi-Li Liu, a doctoral candidate in Chemistry; and Ms. Sarah Heminway, Institute of Water Resources Graduate Research Assistant and graduate student in Plant Science.

The study cooperators were represented by a Mr. Darrell Smith, Laboratory Manager, of the South Central Connecticut Regional Water Authority and a Mr. Randy May, Principal Sanitary Engineer, with the state of Connecticut Department of Environmental Protection (DEP) Water Compliance Unit. A Mr. Brian Curtis, Senior Sanitary Engineer, of the DEP was also of assistance to the project during the site selection process.

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Table 2. (Cont.)

M1	M2	M3	H
1,1,1-trichloroethane 2	Toluene 2 M-Xylene 3 P-Xylene 3 Unknown RTs at 21.17 24.50 and 32.38		Toluene 4 1,1,1-trichloroethane 1
Fluorotrichloromethane 2.4×10^2 Chloroform 4×10^2 Toluene 1 Unidentified RT @ 7.30 10.28 (vs Bromodichloromethane)	Chloroform 53, 70	Chloroform 18, 52	
1,1-dichloroethane 4 1,1,1-trichloroethylene 25		Toluene 2	Toluene 3
Chloroform 9 1,1-dichloroethane 4, 5 1,1,1-trichloroethane 14, 14 Toluene <1	Chloroform 28, 2, 7 1,1,1-trichloroethane 3, 3, 3	Chloroform 62, 7 Toluene <1 (thrice)	Chloroform 18 Toluene 1
1,1-dichloroethane 2 1,1,1-trichloroethylene 5 Chloroform 2	1,1,1-trichloroethylene 5	ND	ND

RT - Retention time in minutes ND - Not detectable

(1) Each data grouping shown is for a different ground water sampling event.

Table 1.

Chemicals Detected in Ground Water Samples Taken from Observation Wells at Brookfield, Chester, and Coventry, CT.

Site Location	Chemicals Detected
Brookfield, CT (6)	Except for one instance, and then only one well, no water found in any of the three perimeter wells; chloroform at 34 ppb. 10 ppb toluene in sample taken from the soil leaching field area.
Chester, CT (7)	----------
	1 to 3 ppb trichloroethylene
	----------
	4 ppb methylene chloride 7, 9 ppb chloroform 4 ppb dichloroethane
	----------
	Unidentified peaks at GC retention times of 3.22, 5.13 and 8.77 minutes. 120 ppb fluorodichloromethane 5 ppb trans-1,2-dichloroethane 3 ppb trans-1,3-dichloropropane
	----------
	Methane present but not quantified

	Unidentified peaks at retention times (RT) of 5.10, 8.34 and 5.13; RT's of 5.25 and approximately 8.30 similar to ethyl alcohol and acetone, respectively.
Coventry, CT (8)	----------
	Ethyl benzene present but not quantified.
	----------
	10 ppb ethyl benzene

	Unidentified peak at GC RT of 3.25; 7, 4 ppb trans-1,2-dichloroethene. Unidentified peak or ethyl benzene <1 ppb (twice)

Number in ( ) is the number of sampling events; different sampling event chemical detections are separated by ----.
RT - Retention Time; Time is in minutes.

Table 3. Volatile Organic Compounds and Hydrocarbons detected in Groundwater Samples taken from Somers, CT in ug/l.

	E	F	G	H
1985				
07-10	Chloroform <1.0	Carbon tetrachloride <1.0 Tetrachloroethylene <1.0 Trichloroethylene <1.0	Carbon tetrachloride <1.0 Tetrachloroethylene <1.0	Tetrahydrofuran 800
08-13	Unidentified RTs @ 14.20, 14.90 and	ND	Unidentified RTs @ 7.17, 11.37 and 18.88	Tetrahydrofuran 32 Unidentified peaks @ 5.19 and 8.32
09-21	ND	Unidentified RTs @ 5.98, 9.44 and 21.15	ND	1,1-dichloroethylene 5 1,1,1-trichloroethylene 5
10-19	ND	ND	Unidentified RT @ 12.63	ND
12-08	BDL	Unidentified RT @ 9.05	BDL	
1986				
01-24,25	ND Chloroform 48	Unidentified RT @ 3.34 (possibly methylene chloride)		Fluorotrichloromethane 10 ND
03-19	ND	ND	ND	ND

ND - Not detectable

BDL - Below detectable limit

williams-russell and johnson, inc.

REM V PROGRAM

REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES

FINAL

REMEDIAL INVESTIGATION REPORT
KEYSTONE SANITATION COMPANY SITE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
PHILADELPHIA, PENNSYLVANIA

JULY 1990

EPA CONTRACT NO. 68-01-7403

AEPCO, INC. ● C. C. JOHNSON & MALHOTRA, P.C. ● GEOSCIENCE CONSULTANTS, LTD.
CDM FEDERAL PROGRAMS CORPORATION ● ICF, INC.

pumping. Most other wells showed a significant increase in water levels during pumping, attributable to the rainfall. Appendix D contains the raw data for both drawdown and residual drawdown.

One of the objectives of the test was to determine whether or not the K1 area is hydraulically connected to the [redacted] Spring area. Since the data were distorted due to rain events, it was not possible to determine this hypothesis by the pumping test. However, the hydraulic connection is expected given the topographic and potentiometric relation shown in the cross section on Figure 4-16. The figure shows that the ground surface intersects the water table (potentiometric surface) on the northeast end of the cross section in the [redacted] Spring area.

4.8 RESIDENTIAL WELL SURVEY

The results of the residential well survey are presented in Table 4-5. Residents in the Keystone Site vicinity obtain water from shallow springs and wells hundreds of feet deep. Most well systems have a 20 to 30 gallon holding tank, and some have a filtering or water treatment unit.

Several residents indicated water was restricted to household uses other than drinking. Water with an odor was reported at RW-8 and RW-11. Both locations have shallow water sources and septic systems nearby. Water which caused black or grey-black stains was reported at RW-13 and RW-15.

Several factors may influence the CLP chemical analysis results. These include depth and type of water source, well design, and land use. Most residential wells were also located near cultivated fields and septic systems.

TABLE 4-5
RESIDENTIAL WELL SURVEY
KEYSTONE SANITATION COMPANY SITE
LITTLESTOWN, PENNSYLVANIA
REM V

WELL	SOURCE	USAGE	LAND USE
RW-1	500-foot deep, 6-inch diameter cast iorn well with water softner and charcoal filter	All household uses	Onsite, septic tank norteast of well
RW-2	Shallow spring source with 25 gallon holding tank	Washing and bathing only	Well 85 feet northeast of septic tank
RW-3	120-foot deep steel well with Amway filtering system and about 35 gallon holding tank	All house hold uses	Septic tank north west of well no farming activities
RW-4	10 inch diameter well	N/A	Well 20 feet north of house
RW-5	8 inch diameter well with 20 gallon holding tank and filter	All household uses	Crops grown near well
RW-6	Shallow spring source, no water treatment	All household uses, watering livestock	Crops grown near spring
RW-7	30-foot deep well with 20-gallon holding tank no water treatment	All household uses, watering livestock, crop irrigation	Well 30 feet west of house, crops grown near well

TABLE 4-5 (Continued)

RESIDENTIAL WELL SURVEY

KEYSTONE SANITATION COMPANY SITE
LITTLESTOWN, PENNSYLVANIA
REM V

WELL	SYSTEM	USAGE	LAND USE
RW-8	Very old, (mid 1800's) 35-foot deep, stone well with water treatment	Washing only, water has rotten egg smell.	Crops grown near well, septic system
RW-9	N/A	All household except drinking	Septic tank crops grown nearby
RW-10	140 foot deep, 8 inch diameter well with no water treatment	All household uses, watering livestock	Crops grown near well septic system south of well
RW-11	Spring source with 30 gallon holding tank	All household uses except cooking and drinking, water has odor	Septic tank about 90 feet northeast of spring, drain field north of house
RW-12	Well with treatment system	All household uses	Crops grown near well, well about 20 feet south of house.
RW-13	About 435 foot deep well with holding tank and no treatment system.	All household uses except drinking water, causes grey-black stains.	Septic tank about 100 feet soth east of house crops grown near well.
RW-14	N/A	N/A	N/A
RW-15	10 inch diameter well with 25 gallon holding tank	All house hold uses except drinking. Water causes blank stains	Septic tank about 75 feet east of well. Crops grown near well.

ESD

EPA
REGION III
QA DIRECTIVES

HWMD

Bulletin No. QAD009 Date: April 23, 1990

FIELD FILTRATION POLICY FOR MONITORING WELL GROUNDWATER SAMPLES REQUIRING METALS ANALYSIS

The objectives of this directive are: (1) to formally state Region III RCRA and CERCLA policy which requires both filtered and unfiltered groundwater samples for metal analyses; (2) to outline appropriate exceptions to the stated policy; and (3) to provide technical direction for the field filtration procedure.

REMINDER: A single copy of this directive is provided to the individual designated to represent the contractor. It is the responsibility of that individual to distribute the directive within the contractor organization to appropriate project managers and field personnel.

Concentrations of metal contaminants measured in unfiltered groundwater represent the total metals present in the sample. Filtered samples represent dissolved metals concentration and are often more representative of mobile contamination (see exceptions below). Monitoring wells sometimes produce turbid water (water containing suspended solids). The turbidity can be due to disruption of the adjacent geologic formations during well purging or poor design and initial development of the well. When particles containing metal species are suspended into the groundwater and are not removed, they dissolve when the sample is preserved to a pH <2. High levels of aluminum, manganese, and iron in unfiltered samples often indicate the presence of these particles. Without filtration, concentrations of this mobile metal contamination in the groundwater are often over estimated. Therefore, it is necessary to take both filtered and unfiltered samples to fully characterize the distribution of metals at a given site. Since acid (low pH) may distort the distribution of metals between particulate and dissolved species, preservation for dissolved metals samples must be performed after filtration. Because the oxidation state affects the solubility of metals, filtration must occur immediately after sampling.

The exceptions to the policy requiring both filtered and unfiltered samples are:

1. Site specific geologic conditions where groundwater may transport large particulates and only unfiltered samples are representative of mobile groundwater quality (for example, karst terrain or clean gravel facies). These site conditions must be fully discussed and documented in the Quality Assurance Project Plan (QAPjP).

2. When there is sufficient historical data (a minimum of four consecutive quarters) from the same monitoring wells that are to be sampled, then these wells may fall into one of the following exception categories:

   a. If the historical information shows that the purging and sampling methods are the same as the methods to be used at future sampling events, then either filtered or unfiltered samples is appropriate to the historical data are acceptable for future sampling in these wells.

   b. If the historical information shows inconsistency between the filtered and unfiltered data, and high levels of aluminum are present in the unfiltered data, only filtered samples are needed.

NOTE: Extrapolation of historical data from a limited number of wells to all the wells at the site is not acceptable without a clearly justified rationale. All deviations from taking BOTH filtered and unfiltered groundwater samples for metals must be fully described and justified in the QAPjP.

TECHNICAL GUIDANCE FOR FILTRATION OF MONITORING WELL SAMPLES FOR METALS ANALYSIS

1. Designate an area in which the filtration process is to take place. This area must have an element and dust-free environment. When filtration apparatus is not in use, keep it covered to protect from airborne particles. Use either a glass or plastic filtering apparatus. Stainless steel is unacceptable since it can contaminate the samples.

2. Filtration must be initiated immediately after sample collection. Record both the time of sample collection and time of filtration in the field notebook. Filtration must be completed before preservation to a pH <2.

3. A 0.45 micron filter is the required pore size for filtration. Other pore-size filters may be appropriate for site specific conditions. However, deviations from the 0.45 micron pore size must be justified and documented in the QAPjP and field notebook. The polycarbonate membrane type is recommended. For highly turbid water, a clean glass fiber filter may be used as a "pre-filter". When a pre-filter is used, place it on top of the 0.45 micron filter, then filter the sample using the normal procedure. Dispose of the pre-filter and record a general description of the turbidity of the sample in the field notebook.

4. Each filter and filtration apparatus must be prepared before use since they often contain trace amounts of metals. Filtration with approximately 20 ml of a 25% nitric acid (HNO_3) solution (3 parts water and 1 part acid) followed by three 20 ml rinses of trace metal free deionized (DI) water is required to remove any trace amounts of metals. The filtered liquid is then discarded before filtering each sample. Use the same DI water and dilute nitric acid solution (i.e., prepared from the same source, lot number and/or batch) to prepare the filters for all samples and the field blanks.

5. Both a filtered and an unfiltered blank must accompany samples to the lab(s) for analysis unless only unfiltered samples are collected and submitted for analysis. A duplicate filtered and unfiltered sample is also recommended.

6. All water samples, including surface water, filtered and unfiltered groundwater, and blanks must be preserved to a pH <2 with HNO_3. Use a high quality acid such as Baker Instra-Analyzed or equivalent. NOTE: Reagent grade acid is not acceptable. Verify that the pH of each sample is <2 with narrow range (0 to 2) pH paper.

7. Document the lot number and manufacturer of the acid, the deionized water, and the filters in the field notebook. This documentation will facilitate tracing the source of contamination when the data indicates the possibility of a contamination problem.

Monitoring wells with a very high concentration of solids (evidenced by a slow filtration rate) should be noted in the field notebook. This may indicate an improperly installed monitoring well.

DATA INTERPRETATION

The concentration of a dissolved metal (filtered sample) should not exceed its concentration as a total metal (unfiltered sample). If the dissolved fraction exceeds the total fraction by a small amount, it may be attributable to analytical variability. Typical problems and their possible causes are listed below.

1. The dissolved concentration is higher than the total:

   - When dissolved iron, zinc, aluminum, and copper are higher, then the filters may be a source of contamination. Investigate the rinsing procedure used for filters.

   - When nearly all dissolved metals are higher, then sample mislabeling is a possible source of error. Investigate the sample labeling procedure.

2. If the sample results are erratic, investigate the time lapse from sampling to filtration.