Health Consultation

RENVILLE COUNTY GROUNDWATER CONTAMINATION SITE

CITY OF OLIVIA, RENVILLE COUNTY, MINNESOTA

JUNE 2, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

RENVILLE COUNTY GROUNDWATER CONTAMINATION SITE

CITY OF OLIVIA, RENVILLE COUNTY, MINNESOTA

Prepared by:

The Minnesota Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

FOREWORD

This document summarizes public health concerns related to a landfill in Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

- *Evaluating exposure:* MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out the quantity of pollutants emitted from a facility, where they go from the site, and how people might be exposed to them. Usually, MDH does not collect its own environmental sampling data. Rather, MDH relies on information provided by the Minnesota Pollution Control Agency (MPCA), the US Environmental Protection Agency (EPA), and other government agencies, private businesses, and the general public.

- *Evaluating health effects:* If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. MDH's report focuses on public health— that is, the health impact on the community as a whole. The report is based on existing scientific information.

- *Developing recommendations:* In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.

- *Soliciting community input*: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

Please write to: Community Relations Coordinator
Site Assessment and Consultation Unit
Minnesota Department of Health
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OR call us at: (651) 201-4897 *or* 1-800-657-3908
(toll free call - press "4" on your touch tone phone)

On the web: http://www.health.state.mn.us/divs/eh/hazardous/index.htmls

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Summary

The site is located in Henryville Township is located approximately 7 miles southwest of Olivia, Minnesota (Figure 1). The Renville County Sanitary Landfill (SLF) is located in the northeast quarter of section 23, at 32877 County Road 4. The affected residential well is located approximately one mile south of the landfill, in section 26, south of 740th Ave. To encompass both the residential property and the landfill, for the purposes of this report the "site" is considered to be the eastern half of Henryville Township.

This report has two purposes: 1) to provide information on the groundwater contamination for residents of Henryville Township; and 2) to provide a technical review of the site as a basis for discussion by state and local agencies regarding what additional work may be needed.

The Minnesota Department of Health (MDH) was contacted by Renville County public health staff on October 3, 2003 regarding a private well sample collected by a Henryville Township resident in which vinyl chloride was detected. On October 10, 2003, the affected well owner petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct a public health assessment at the site.

MDH staff contacted staff at the Minnesota Pollution Control Agency (MPCA) and requested that they collect a confirmation sample at the residence, sample other residences nearby, and evaluate whether the Renville County Sanitary Landfill might be a source of the contamination. The latter request was made because vinyl chloride and other chlorinated precursor chemicals (i.e. compounds that degrade to vinyl chloride) have been detected in groundwater samples collected from monitoring wells at the landfill.

Sampling by the MPCA confirmed the presence of vinyl chloride in the residential well, but did not detect volatile organic compounds in any other wells in the area. A granular activated carbon (GAC) filter system was installed at the affected home in November 2003 and monthly monitoring of the filtered and unfiltered water was commenced.

A limited groundwater investigation on the affected property determined that the contamination is present in a buried sand aquifer located approximately 210-220 ft. below ground surface. A new well was drilled for the resident to provide clean drinking water from a buried sand aquifer located approximately 88-95 ft. below ground surface. Additional investigation will be needed to determine the source of the contamination. This report reviews the environmental data available for the affected residential well and the Renville County Sanitary Landfill, evaluates the public health risk, and makes recommendations regarding additional work needed to refine this evaluation.

Studies of animals exposed to very high levels of vinyl chloride in air show the chemical can damage the liver, lungs, kidneys, and heart. People exposed in the workplace to high levels of

vinyl chloride in the air may show changes in the liver, nerve damage, immune system effects, reproductive effects, blood flow problems, and a rare type of liver cancer, angiosarcoma. Some published studies also suggest a possible link to brain cancer. Based on these studies, vinyl chloride has been classified as a known human carcinogen.

There have been no human studies of the potential adverse health effects from exposure to low levels of vinyl chloride in drinking water. However, the types of adverse health effects associated with occupational exposure to high levels in air do not seem likely to occur at common environmental exposure levels in water.

The current Health Risk Limit (HRL) for vinyl chloride in drinking water is 0.2 micrograms per liter (ug/L or parts per billion), and is based on the potential for an increased incidence of cancer in an exposed population. The overall cancer rate in the Minnesota population is approximately 40 to 50 percent, meaning nearly 1 out of every 2 people will have some form of cancer in their lifetime. The HRL based on an incremental cancer risk of 1 additional case of cancer in a population of 100,000 people exposed at that concentration, a risk that is considered very low or negligible. A life-time exposure to vinyl chloride at the concentrations detected in the residential well would be estimated to result in a rate of 1 additional cancer in 10,000 people exposed to it. This is still an extremely low additional risk above the background cancer rate, but is sufficient to trigger action to prevent further exposures.

The site is currently considered an indeterminant public health hazard. While vinyl chloride is present at concentrations in excess of the HRL in the groundwater, it is unclear whether any completed exposure routes now exist. The residents at the affected property did have a completed exposure pathway, through the water supply well, and they were exposed to vinyl chloride at concentrations above the HRL of 0.2 ug/L. The maximum level of vinyl chloride detected was 2.2 ug/L. Residents living at the affected property reportedly have used the water there for up to 20 years, but it is unknown when vinyl chloride may have first been present in the well at that property. Moreover, sampling of the well suggests that vinyl chloride may not always be present, reducing the overall “dose” the residents have received.

Installation of a GAC filter system at the affected residence to remove the vinyl chloride eliminated the exposure. A new well has been drilled on the property and appears to be uncontaminated. If additional testing confirms this, the new well could provide a permanent safe drinking water source for the residence.

At this time, it does not appear that other residents have been exposed to vinyl chloride in their drinking water. However, the complexity of the buried sand aquifers in this area and the lack of information regarding the extent and magnitude of contamination that is present in these aquifers, make it difficult to state with any assurance that other private wells in the area will not become contaminated in the future. For this reason, additional investigation of the contaminant plume is recommended.

I. Site Background and History

A. Site Visit

On September 16, 2004, MDH staff visited the property where the affected residential well is located (R-1 on Figure 2). The property is located approximately 7 miles southwest of Olivia, in gently rolling hills and surrounded by agricultural fields. The property slopes to the south and southeast, toward Beaver Creek, which provides the main drainage for eastern half of Henryville Township. Immediately south of the property, County Ditch Number 117 enters Beaver Creek. There is a house and several out-buildings at the property. According to the owner, a previous owner burned trash in a small pit located approximately 100 meters southwest of the house, in a wooded area. The well that supplies water to the property is located approximately 10 meters east of the house (designated as R-1 on Figure 2 and in Table 1). Near the garage (and approximately 10 feet from the water supply well) a 40 ft. deep dry well had been identified. According to one neighbor, the dry well may have been used by a previous owner for disposal of unknown materials, but there is no information available to confirm this. The dry well was sealed with concrete by the MPCA prior to the site visit. MDH staff visited the affected residence again on March 28, 2006 to collect a water sample from a new well installed by the MPCA.

MDH staff did not visit the landfill. According to records at the MPCA, the landfill property covers approximately 94 acres. About 15 acres in the northwest corner of the property, referred to as the Former Disposal Area, had been used for un-lined disposal of municipal solid waste. The Current Disposal Area covers an area of approximately 10 acres and consists of two lined cells. Several acres in the southeast corner are used for demolition debris disposal, approximately 10 additional acres are proposed for landfill expansion, and the balance of the property consists of former sand and gravel excavation pits and property and compliance boundary setbacks. The West Fork of Beaver Creek borders the southern boundary of the unlined fill area; approximately one-quarter mile south of the landfill it joins the East Fork of Beaver Creek and then flows south and southeast as Beaver Creek (Figure 2).

B. Geology and Hydrogeology

The surficial geology of Renville County consists of approximately 200 to 300 feet of glacial till and outwash deposits that thin to the south and west towards the Minnesota River. The glacial deposits overlie approximately 100 feet of Cretaceous shale and sandstone. These in turn are underlain by Precambrian granitic bedrock (Figure 3).

The site is located in an area designated as the Olivia Till Plain (Wright, 1972), which was formed during the Wisconsinan glacial period. The deposits left by the advancing glaciers in this area are non-stratified till composed of clay, silt, sand, gravel, and bolders. The till is intersected by sand lenses deposited by streams of melt-water that cut into the till during the glacier’s advance and retreat. These stream deposits are composed of layered sand and gravel with variable amounts of clay and silt, and are found at varying depths within the till.

During the final retreat of the glaciers, melt-water carved deep channels into the surface of the till. These channels were then filled with sand and gravel, leaving linear deposits of sand and gravel outwash within the till (Donohue, 1989). The sand and gravel layers in the glacial drift deposits, although usually thin and discontinuous, provide the majority of drinking water in the region. The Cretaceous sedimentary formations below the glacial deposits generally have only thin sandstone lenses, but are also used to provide drinking water locally (Van Voast, et. al., 1972).

Ground water flow directions, regionally, are to the south and southwest toward the Minnesota River (Figure 3). However, shallow ground water flow directions are strongly influenced locally by two factors: the orientation of buried stream channels and other sand layers within the glacial till and the extensive network of drainage ditches and tile-lines that transect the agricultural fields in this area (Van Voast, et. al., 1972).

During the process of siting the Renville County SLF (Figure 4), several investigations of the geology and hydrogeology were conducted. These studies found there are four principal geologic units in the glacial deposits underlying the site: 1-2 ft. of topsoil; 1-20 ft. of outwash sands that thickens toward the south; 3-20 ft. of brown to brownish-gray, sandy clay till with discontinuous seams or lenses of clayey or silty sand; and a gray sandy clay till, also with seams and lenses of clayey or silty sand, extending to an unknown depth (Donohue, 1989).

Figures 5 through 8 illustrate the geology beneath the landfill. Although the sand lenses within the tills appear to be discontinuous in the cross-sections, they may be inter-connected in three dimensions. The sand lenses appear to be more elongated along a north-south axis (Figures 7 and 8). This could provide a preferential flow direction to the groundwater within the tills, although any groundwater flow pattern is likely to be very complicated, due to the discontinuous nature of the sand lenses. Understanding the path followed by the groundwater is critical to understanding the movement of contaminants away from the landfill.

Water level measurements in wells at the Renville County landfill indicate that shallow groundwater within the upper outwash sand flows to the south-southwest (Figure 9). Shallow groundwater flowing beneath the landfill likely discharges to the West Fork of Beaver Creek, which defines the southwest boundary of the landfill property. Groundwater can move not only horizontally, but vertically. Comparison of water levels in some of the wells (26-OWA and 26-OWB) in the outwash sand near the creek indicate either very little vertical flow or upward flow in the outwash sand. This makes sense as shallow groundwater would be expected to moving upward to discharge into Beaver Creek in this area.

Groundwater flow directions in the till also appear to be to the south and southwest. However, flow directions in the buried sand lenses within the till have not been defined, as only one well (P-108-B) was completed in a sand lens (all other deep wells at the site are completed in the clay till). Comparison of water levels between wells in the outwash sand and in the till (24-OWA / P-24-B; OW-201A / P-201-C; and OW-202A / P-202-B), generally shows an upward gradient from the till to the outwash sand. But comparison of water levels between wells in the outwash sand and in a buried sand lens (OW-108A / P-108-B, see Figure 7), generally shows a downward gradient from the outwash sand to the buried sand lens. Water level "gradients" simply indicate the "potential" for groundwater flow either up or down, but the low permeability of the clay till may significantly slow or even prevent the vertical flow of groundwater at the site. However, these limited results suggest the possibility of groundwater and contaminant migration downward from the outwash sand into the buried sand lenses beneath the landfill. Groundwater in at least some of the buried sand lenses likely does not discharge to Beaver Creek, but instead would migrate beneath the stream channel.

C. Site History

The Renville County landfill began accepting municipal solid waste in 1972. Wastes at that time were disposed in the unlined portion of the landfill. Prior to this time, portions of the landfill property were used for agricultural purposes, as well as sand and gravel excavation. The first lined cell (Cell 1) began accepting waste on June 1, 1994; Cell 2 was constructed in 1999. Two additional lined cells have been constructed to accept waste in the future.

A number of actions have been taken by the landfill operator to control runoff and discharge from the landfill. In 1996, a sedimentation pond was constructed. Gradient control trenches were also installed upgradient of the lined landfill area, to limit groundwater intrusion into the landfill. In 2000, an artificial wetland was constructed along the southwestern boundary of the unlined Former Disposal Area to provide a form of natural attenuation of contaminants migrating from the landfill toward the West Fork of Beaver Creek. The objective is to allow shallow groundwater to migrate through the wetland where vegetation and wetland biochemical and geochemical reactions attenuate and remove contaminants from the water (Earth Tech, 2003).

A series of hydrogeologic assessments of the landfill property were conducted between 1985 and 1992. These are discussed in detail in reports by Donohue & Associates (Donohue, 1986; 1988; 1989; and 1991) and Rust Environmental, Inc. (REI, 1993). A total of 27 soil borings, 9 test pits, X piezometers (to measure water levels), and 34 monitoring wells have been installed at the site. Twelve of the monitoring wells were abandoned because they did not meet state well code requirements. The well locations are shown on Figure 4.

In 2003, a resident living approximately 1 mile south of the landfill collected a sample from the private well on their property (R-1 on Figure 2) for analysis for volatile organic compounds by a laboratory in Duluth, Minnesota. The resident collected the sample because the water had developed an unusual odor and the resident was concerned it might be unhealthy. The analysis detected 1 ug/L (microgram per liter, or part per billion) of vinyl chloride. The resident notified Renville County public health staff, who contacted MDH staff on October 3, 2003. MDH staff contacted the resident to discuss the situation, and then contacted staff at the MPCA to request that they investigate.

MPCA contracted with Minnesota Valley Testing Laboratories, Inc. (MVTL) to collect a sample from the private well on October 16, 2003. This sample confirmed the presence of vinyl chloride above the MDH Health Risk Limit (HRL) of 0.2 ug/L (see section IIIB, page 13). On October 24, 2003, MVTL collected samples at three additional residences, but did not detect any volatile organic compounds in those wells (designated as wells R-2, R-3, and R-4 on Figure 2).

In November 2003, the MPCA contractors installed a whole-house, point-of-entry, granular activated carbon (GAC) filter system at the affected residence. GAC filters have been used effectively to remove volatile organic compounds from water in residential settings. Following installation of the system, monitoring of the filtered and unfiltered water at the residence began on a monthly basis, continuing until the present. The results are presented in the next section of this report. Vinyl chloride continued to be intermittently detected in R-1, (however, see discussion of detection limits in section IIA, page 10).

Also in November 2003, the MPCA and their contractors began to evaluate whether there were sources on the affected property that may have contributed to the contamination in well R-1. It was determined that well R-1 was improperly constructed of black polyvinyl chloride (PVC) perforated at two levels, approximately 90 and 200 feet below the ground surface. No record of the well construction is available from the Minnesota Geologic Survey and it is likely the well was built before the Minnesota well construction code went into effect. The dry well on the property, located approximately 10 ft. from well R-1, was cleaned out but no water entered the well to allow a sample to be collected, so it was sealed in accordance with state well regulations. Although waste was reportedly disposed and burned in a shallow pit southwest of the house, this was determined to be an unlikely potential source because groundwater most likely flows to the south and southwest in this area, which would place R-1 upgradient of the burn pit.

In June 2005, eleven private wells near the landfill (including the three sampled previously in October 2003) were sampled for VOCs. These wells are designated as R-2 through R-12 on Figure 2. No VOCs were detected.

In September 2005, the MPCA installed two new wells at the affected residence. The wells were screened at 90-95 feet and 202 - 212 feet below grade, to determine whether vinyl chloride was present at one or both of these horizons in the subsurface. Vinyl chloride was detected in the deeper well, which has been retained as a monitoring well (MW-1 on Figure 2). No VOCs were detected in the shallower well (R-NEW on Figure 2), which will be used as the water supply well for the residence once additional sampling confirms the absence of VOCs. The pre-existing water supply well is slated for abandonment after testing of the new well confirms the absence of vinyl chloride.

II. Environmental Data

Groundwater sampling has occurred at least annually at the Renville County Sanitary Landfill since 1987. Private well sampling and GAC filter system monitoring has occurred monthly at the affected residence since November 2003, and other private wells in the area have been sampled. The results are presented below.

A. Private Wells

Table 1 presents the sample results from the thirteen residential wells sampled as part of the groundwater investigation of this area. All of the samples were analyzed for the full suite of 68 Safe Drinking Water Act VOCs, but the table shows only those compounds that have been detected at least once in any of the wells.

Vinyl chloride in R-1 has ranged from not detectable to 2.2 ug/L. Although vinyl chloride was often not detected, the detection limit used by MVTL was 0.5 ug/L, which exceeds the HRL for vinyl chloride. MDH staff collected split samples with MVTL in September 2004 and March 2006, which were analyzed with a lower detection limit (0.25 ug/L) and no vinyl chloride was detected. This suggests that some, if not all, of MVTL's reported "non-detect" results may be correct, but it is not possible to say this with any certainty. Toluene was detected once in R-1. No VOCs have been detected in the new, shallower well, R-NEW. The monitoring well (MW-1 on Figure 2) installed on the same property as R-1 has had up to 1.2 ug/L of vinyl chloride.

One other private well, R-2 had detections of five VOCs in January 2004. However, the well had recently been repaired and chlorinated. The compounds detected were consistent with the glues and solvents typically used in well repair and the by-products of chlorination. A second sample collected from that well in January 2004 showed significantly lower concentrations of the VOCs, and a third sample collected in June 2005 did not have detectable VOCs. As noted above, the detection limit for vinyl chloride for all of the residential samples exceeded the HRL.

Table 2 presents the GAC filter system monitoring results from the affected residence. While the GAC filter effectively removed vinyl chloride from the water entering the home, tetrahydrofuran was frequently detected at concentrations ranging up to 12.9ug/L in the system effluent samples. The source of the tetrahydrofuran is not certain, but appeared to be coming from either the filter canisters or fittings, or from the carbon itself. MDH recommended that the carbon canisters be replaced, but it is unclear whether this was ever done. The concentrations of tetrahydrofuran never exceeded the Health Based Value (HBV) of 100 ug/L.

It is our understanding that MPCA intends to install two additional deep monitoring wells to evaluate the buried sand aquifer and further delineate the vinyl chloride plume. The wells are to be installed north and east of the R-1 property, although the exact locations have not been determined.

B. Renville County Sanitary Landfill

Table 3 presents a summary of the sampling results from monitoring wells at the landfill. Groundwater samples from the monitoring wells were analyzed for 20 inorganic compounds (primarily metals) and 71 VOCs. Some samples were also analyzed for Base Neutral Extractable compounds, pesticides, and polychlorinated biphenyls (PCBs). Only those organic compounds ever detected at the landfill are shown in the table.

Forty-two VOCs typical of municipal solid waste landfills have been found in monitoring wells at the Renville County landfill. These generally include solvents (such as acetone), petroleum constituents (such as benzene, toluene, and xylenes), and chlorinated compounds (such as dichloroethane, trichloroethane, tetrachloroethane, and vinyl chloride). Only two base neutral extractables, bis(2-ethyl-hexyl)phthalate and butyl benzyl phthalate, and two pesticides, dichloroprop and dicamba, have been detected. Table 3 shows the wells in which these chemicals were detected and the maximum concentrations detected.

Of the forty-six chemicals detected, only nine (acetone, benzene, chloromethane, 1,4-dichlorobenzene, dibromomethane, 1,2-dichloropropane, tetrahydrofuran, vinyl chloride, and bis(2-ethyl-hexyl)phthalate) were found at concentrations exceeding drinking water standards:

Compound	Maximum Concentration (in ug/L)	Location of Maximum Concentration	Drinking Water Criteria (ug/L)
acetone	1,010	25-OWA	700
benzene	113	27-OWA	10
chloromethane	54	29-OWA	30
1,4-dichlorobenzene	19	25-OWA	1,000
dibromomethane	140	29-OWA	0.004
1,2-dichloropropane	46	25-OWA	5
tetrahydrofuran	219	29-OWA	100
vinyl chloride	49	28-OWA	0.2
bis(2-ethyl-hexyl)phthalate	124	29-OWA	20

The full sampling history of these nine contaminants are shown in Table 4. Only those wells that had detectable concentrations are included in Table 4; the following wells had no detections of VOCs, base neutral extractables, or pesticides in any of their samples: 33-OW, 34-OWA, OW-113-A, OW-116-A, P-202B.

The only wells in which contaminants were found at concentrations exceeding state drinking water standards were those located to the south and southwest of the closed, unlined portion of the landfill. This would be expected, as the groundwater beneath the landfill flows to the south-southwest, toward the affected wells. No VOCs have been detected in the wells located downgradient of the demolition debris landfill, and only low concentrations of VOCs have been detected in wells in and near the new, lined portion of the landfill. The only exception is well OW-202A, in which vinyl chloride exceeded its drinking water standard once; however, it is located at the southeast corner of the unlined portion of the landfill and may occasionally detect contaminants from the unlined cell. In general, all of the wells at the site have shown decreasing concentrations of VOCs, likely as a result of closure and capping of the unlined landfill, gradient control activities, and leachate collection and treatment in the new, lined portion of the landfill.

Deeper monitoring wells completed within the till beneath the site (wells P-24B, OW-113A, P-201C, and P-202B) have had only rare detections of low concentrations of VOCs and no detections of vinyl chloride. However, none of these deeper wells are located downgradient (i.e. south or southwest) of the closed, unlined portion of the landfill. Well P-202B is the only deeper well located near the unlined portion of the landfill, but it is located near its southeast corner, placing it "side-gradient" to the groundwater flow. P-108-B was the only well completed in a sand lense within the till, but it was never sampled and was sealed prior to construction of the lined portion of the landfill. At this time, it is impossible to say whether contaminants from the unlined portion of the landfill are migrating downward to buried sand aquifers beneath and downgradient of the landfill.

Since 1987, surface water samples have been collected from two locations in the West Fork of Beaver Creek; one located upstream of the landfill (SS-1 on Figure 2) and the other (SS-2 on Figure 4) near the southwest boundary of the landfill property, approximately 300 ft south of the unlined portion of the landfill. The samples have been analyzed for pH, dissolved oxygen, a variety of physical parameters, metals and other inorganic compounds. The results indicate no significant difference between the upstream and downstream sampling locations, suggesting that the chemicals detected in the water were from sources located upstream of the landfill (EarthTech, 2005). The stream apparently is not sampled for volatile organic compounds.

III. Discussion

A. Exposures

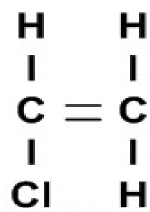
Twelve private wells, located within 2.5 miles south and southwest of the Renville County Landfill, and numerous monitoring wells at the landfill, have been sampled for volatile organic compounds (VOCs). While a large number of contaminants are present in the shallow groundwater at the landfill, only nine were found to exceed state drinking water standards at the landfill. Of these, only vinyl chloride has been detected in one residential well (R-1) approximately one mile south of the landfill and can be attributed to groundwater contamination. Tetrahydrofuran was also detected at that residence, but not in samples from the well, only in samples collected after the carbon filter system. Five other VOCs were detected in another residential well (R-2), but were attributed to well repair and decontamination activities and have since disappeared.

The R-1 residence did have a completed exposure pathway, through the water supply well at that property, and the residents were exposed to vinyl chloride at concentrations above the HRL of 0.2 ug/L. The duration of the residents' exposure reportedly was, at most, 20 years (although the time when vinyl chloride first appeared in their well water is unknown), and sampling of the well suggests that vinyl chloride may not always be present in the water, reducing the overall "dose" the residents received. Installation of a GAC filter system at the affected residence to remove the vinyl chloride eliminated that exposure pathway. A new well drilled on the property appears to be uncontaminated and may provide a permanent clean drinking water source.

B. Contaminant of Concern

The chemical of concern for the site is vinyl chloride. Vinyl chloride is a man-made colorless gas at normal room temperature (ATSDR 1997). Most of the vinyl chloride manufactured today is used in producing polyvinyl chloride (PVC), a common plastic used in many commercial products including water pipes. It can also be produced in the environment from the degradation of other chlorinated solvents such as trichloroethene (TCE) and tetrachloroethene. Vinyl chloride has been detected in smoke from cigarettes and small cigars, in the range of 5.6-27 ng (nanogram) per cigarette (Hoffman, et. al., 1976).

In water, most people begin to taste vinyl chloride only at levels higher than about 3.4 milligrams per liter, or 3.4 parts per million (ATSDR 1997). A molecule of vinyl chloride consists of two carbon atoms linked by a double bond, three hydrogen atoms, and a chlorine atom, as shown below:



Vinyl Chloride

Vinyl chloride is easily absorbed via inhalation or ingestion, but absorption through the skin is negligible. Once absorbed, vinyl chloride rapidly enters the bloodstream where it is metabolized by the liver, and the metabolites eventually excreted by the kidneys. The metabolites of vinyl chloride, some of which can damage DNA, are likely responsible for the adverse health effects associated with it.

Studies in animals exposed to very high levels of vinyl chloride in air show that the chemical can damage the liver, lungs, kidneys, and heart (ATSDR 1997). People exposed on the job to high levels of vinyl chloride in air may show changes in the liver, nerve damage, immune system effects, reproductive effects, and blood flow problems (Bolt 2005). These types of high workplace exposures generally occurred in the past and are uncommon today, and adverse health effects have not been seen from exposures outside the workplace. The very low concentrations of vinyl chloride detected in the affected residential well at this site are not likely to have resulted in non-cancer adverse health effects.

Vinyl chloride has been shown to cause cancer in laboratory animals. Based on epidemiological studies in humans, it is classified by the U.S. EPA as a known human carcinogen (EPA 2005, Bolt 2005). Studies in test animals and in workers exposed on the job to high levels of vinyl chloride in the air indicate a relation between exposure to high levels of vinyl chloride and angiosarcoma, a rare type of liver cancer. Published data also suggest a possible relation between exposure to vinyl chloride and brain cancer. The adverse effects of exposure to high levels of vinyl chloride on the liver may be exacerbated by concurrent exposure to ethanol or infection by the hepatitis virus (Mastrangelo et al 2004). There have been no human studies of the potential adverse health effects from exposure to low levels of vinyl chloride in drinking water. However, the types of adverse health effects associated with occupational exposure to high levels in air do not seem likely to occur at common environmental exposure levels in water.

The existing HRL for vinyl chloride (0.2 μg/L) was promulgated in 1994. It is based on cancer as the health effect of concern, using the assumptions that a 70-kilogram (approximately 154 pound) adult is drinking two liters (just over ½ gallon) of water per day over a lifetime. The excess incremental lifetime cancer risk used in deriving HRLs is 1×10^{-5}, or one excess case of cancer per 100,000 exposed persons. MDH considers this a very low amount of risk. Because of their inherent conservatism, MDH believes that the existing HRLs are also protective of other populations, such as children, the elderly, and those with compromised immune systems.

In 2000, EPA issued new estimates of the carcinogenic potency of vinyl chloride (EPA 2005). Instead of issuing one new cancer potency slope factor for all exposures, they issued two – one for adult exposure and one for exposure from birth. The new cancer slope factor for adult exposure is 0.72 per mg/kg-day; the new cancer slope factor for exposure from birth is 1.4 per mg/kg-day. Both are lower than the previous slope factor, indicating that vinyl chloride is considered less potent than previously thought – even if exposure occurs from birth.

In 2002, the Minnesota Legislature enacted a law that directed MDH to more transparently account for children's exposure to contaminants when water quality standards for environmental contaminants are established or revised (MN Stat. § 144.0751). MDH is currently revising the HRL rule. This is a formal process, with several opportunities for public input. As a part of this process, MDH has posted the proposed HRLs, including proposed HRLs for vinyl chloride, on the MDH web site at http://www.health.state.mn.us/divs/eh/groundwater/hrlgw/index.html. The current proposed HRL rule uses a factor (of three) to account for the relative higher intake of water by children. Another factor (of two) is proposed to account for the possible increased sensitivity of children to carcinogens. The proposed HRL for vinyl chloride, based on carcinogenic effects is 0.08 μg/L. It is still based on a calculated incremental lifetime cancer risk of 1×10^{-5}, or one excess case of cancer per 100,000 exposed persons.

C. Child Health Considerations

ATSDR and MDH recognize that the unique vulnerabilities of infants and children make them of special concern to communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are smaller than adults, so they breathe dust, soil, and heavy vapors close to the ground. Children also weigh less, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

At the Renville Groundwater Contamination Site, it does not appear that infants or young children have been or currently are exposed to the contaminated groundwater. There were older children (now grown) in the affected home in the past, but it is unknown if vinyl chloride was present in the water at the time that they lived in the home.

D. Health Implications of Renville County Vinyl Chloride Contamination

The highest level of vinyl chloride detected in a private well in 2005 was 2.2 μg/L. Using the current HRL of 0.2 ug/L, if a resident at this location consumed two liters of water with that concentration of vinyl chloride everyday for a lifetime their corresponding calculated risk of developing cancer would be 11.0×10^{-5}, or 11 in 100,000. Using the proposed HRL of 0.08 ug/L in the same scenario, the corresponding calculated risk would be 27.5×10^{-5}, or just over 27 people in 100,000. Both are relatively small risks and represent an upper bound estimate of the potential risk. The true health risk is unknown and is likely to be lower, because the affected resident reportedly has used the affected water for only approximately twenty years and vinyl chloride appears to be present in the water only occasionally (Table 1), although the high detection limits may be masking the presence of lower concentrations of vinyl chloride that exceed the HRL.

These incremental lifetime cancer risks are in addition to the “background” cancer incidence rate in Minnesota residents. Nearly one in two Minnesotans will be diagnosed with cancer during their lifetimes. That corresponds to a background cancer risk of between 40,000 – 50,000 in 100,000.

Exposure to vinyl chloride may also occur through inhalation or skin contact during activities such as showering, bathing, or washing dishes. A recent study (Kerger et al 2000) using water and air measurements taken in actual home bathrooms estimated that the exposure through inhalation of volatile organics (such as vinyl chloride) from showering and bathing in contaminated water is less than the ingestion exposure by a factor of three to four. Some models developed by EPA also suggest that the levels of VOC metabolites formed by the body may be higher as a result of oral exposure than inhalation exposure (ATSDR, 1997). The toxic effects of exposure to VOCs are mainly due to the action of their metabolites within the body. This implies that for equal (low) doses, the ingestion of VOCs in water may be of greater consequence within the body than inhalation or dermal absorption because the relative exposure rate is greater and ingestion produces higher concentrations of toxic metabolites in a shorter amount of time. The studies related to inhalation and skin absorption are discussed in more detail in Appendix C.

At high doses, such as those found in workplace settings, vinyl chloride has been linked to a number of possible non-cancer adverse health effects, such as changes in the liver, nerve damage, immune system effects, reproductive effects, and blood flow problems (Bolt 2005). Generally, these effects were a result of inhalation of vinyl chloride at high concentrations. The low concentrations of vinyl chloride detected in the affected residential well could not result in similar high inhalation doses, and even ingested in drinking water would not likely result in non-cancer adverse health effects.

IV. Conclusions

The only contaminant detected in a residential well at the site that can be positively attributed to groundwater contamination is vinyl chloride. It was detected in one private well at concentrations exceeding the HRL. In addition, tetrahydrofuran was occasionally detected in filtered water at that residence, but appears to have been introduced by the GAC filter system on the water supply, as it was not detected in the unfiltered water from the well. Eleven other private wells were sampled, but vinyl chloride was not detected. Five VOCs were detected in one of those private wells, but appear to have been introduced by a recent repair and disinfection of that well.

The source of the vinyl chloride in the groundwater at the affected residence has not been definitively identified, but vinyl chloride and its chlorinated precursor chemicals (such as tetrachloroethene, trichloroethene, and dichloroethene) have been detected in shallow, downgradient monitoring wells at the Renville County Sanitary Landfill. The existing monitoring well network is not adequate to determine if these chlorinated contaminants are migrating downward into a buried sand aquifer that could act as a conduit for migration of vinyl chloride to the affected residence. No other known source for the vinyl chloride exists in the area. Additional work is needed to clarify whether the landfill is the source of the contamination in the residential well, and if so, the magnitude and extent of contamination.

If the landfill is the source of the contamination, the potential exists that other contaminants found in the groundwater beneath the landfill may eventually migrate to water supply wells in the area. Several actions have been taken by the landfill operator to limit migration of contaminated surficial groundwater. These include: capping of the unlined portion of the landfill, construction of an artificial wetland downgradient of the landfill, construction of gradient control trenches near the lined portion of the landfill, and removal and treatment of leachate from the lined portion of the landfill. Sampling results from the mainly shallow monitoring wells indicate that these actions have resulted in improved groundwater quality downgradient of the landfill. It is unknown whether these actions have been sufficient to prevent downward migration of contaminants into deeper aquifers, which may be used by nearby residential wells for drinking water.

The complexity of the buried sand aquifers in this area, and the lack of information regarding the extent and magnitude of contamination that is present in these aquifers, make it difficult to know whether or not other private wells in the area will become contaminated in the future.

The site is considered an indeterminant public health hazard. While vinyl chloride is present at concentrations in excess of the state Health Risk Limit (HRL) in the groundwater, it is unclear whether any completed exposure routes now exist. One residence did have a completed exposure pathway, through the water supply well at that property, and the residents were exposed to vinyl chloride at concentrations above the HRL of 0.2 ug/L. The duration of the residents' exposure reportedly was, at most, 20 years, and sampling of the well suggests that vinyl chloride may not always be present in the water, reducing the overall "dose" the residents received. Installation of a GAC filter system at the affected residence to remove the vinyl chloride eliminated that exposure pathway. A new well drilled on the property appears to be uncontaminated and may provide a permanent clean drinking water source, although some additional testing will be needed to confirm this.

The exposures at the affected residence may result in an incremental increase in the lifetime risk of some cancers, but likely were too low to result in any non-cancer adverse health effects. The somewhat limited duration of the exposures, and the fact that the concentrations of vinyl chloride may not have been above the HRL during that entire time, would further reduce the potential for any health risks associated with this site.

V. Recommendations

1. Deeper monitoring wells should be installed to the south and southwest of the closed, unlined portion of the landfill to determine if contaminants have migrated into the buried sand aquifers and may be acting as the source of the contamination in the groundwater at residential well R-1.

2. The West Fork of Beaver Creek should be sampled for VOCs, not just inorganic compounds, to determine if any landfill related contaminants are entering the stream. If possible, these samples should be collected beneath the ice in late winter and from the middle or lower portion of the water column, to obtain samples least affected by volatilization and photodegradation.

3. The new clean well at the affected residence should be connected to the home as the drinking water supply well. The old well, which is not constructed according to the Minnesota well code, should be properly sealed. Regular sampling of the drinking water at the residence should continue until additional investigation work indicates there is no potential for vinyl chloride or other contaminants to enter the well.

4. All private wells located to the south and southwest of the landfill that have not yet been sampled should be sampled. Private wells previously sampled with a detection limit of 0.5 ug/L for vinyl chloride should be re-sampled and analyzed using a lower detection limit (no more than 0.25 ug/L).

5. The VOC analytical methods should achieve at least 0.25 ug/L method detection limit for vinyl chloride and report any peaks detected below the method detection limit.

6. Well 25-OWA had high concentrations of VOCs that abruptly "disappeared" when the well apparently was replaced with 25-OWR. Well 25-OWR should be evaluated to determine if samples from it are truly representative of the water quality in that portion of the landfill.

VI. Public Health Action Plan

MDH's Public Health Action Plan for the site consists of continued consultation with MPCA and Renville County staff regarding groundwater sampling and analysis, communication of the results to residents near the site, and participation in any planned public outreach activities.

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CERTIFICATION

This Renville County Groundwater Contamination Site Health Consultation was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

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ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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APPENDIX C: EXPOSURE TO VINYL CHLORIDE THROUGH PATHWAYS OTHER THAN INGESTION

Exposure to VOCs, such as vinyl chloride, in drinking water may also occur through inhalation or skin contact during activities such as showering, bathing, or washing dishes. The ratio of inhalation uptake versus direct ingestion of contaminated water was estimated to be as high as six to one (McKone 1989) or as low as less than one to one (Lindstrom and Pleil 1996). A more recent study (Kerger et al 2000) using water and air measurements taken in actual home bathrooms estimated that the exposure through inhalation of volatile organics (such as vinyl chloride) from showering and bathing in contaminated water is less than the ingestion exposure by a factor of three to four. Older studies typically used laboratory or simulated shower facilities, which tend to be smaller than standard home showers and less well ventilated, resulting in higher estimates of exposure through inhalation.

A large number of variables are involved in assessing inhalation exposure from drinking water sources, making accurate estimates very difficult. These variables include such things as water temperature, size of the shower enclosure, the type of shower head used, length of time spent in the shower, and ventilation. One study (Lee et al 2002) identified the contaminant level and the time spent in the shower as the key variables that determine the level of exposure. Several studies have demonstrated that simply ventilating the shower stall can greatly reduce the estimated exposure to VOCs in shower air (McKone and Knezovich 1991; Aggarwal 1994).

Estimates of additional exposure through skin contact with contaminated water are generally thought to be less than for inhalation exposure, and have been estimated to be in the range of one to one or less (McKone 1989). One study (Lee et al 2002) estimated that intake through dermal absorption would account for only about 2% of the total intake through inhalation and dermal contact while showering. This is especially true for vinyl chloride due to its high volatility.

The route of exposure, however affects the rate at which VOCs are absorbed and metabolized by the body: even if the same dose is received via different routes (i.e., ingestion, inhalation, or skin contact) the resulting toxicity may be different (Weisel and Jo 1996). A review of studies by ATSDR suggests that absorption of vinyl chloride through the gastro-intestinal tract as a result of oral exposure is “rapid and virtually complete.” While absorption of inhaled vinyl chloride in human lungs is “rapid,” on average only 42% of inhaled vinyl chloride is retained in the body, at least at higher concentrations (ATSDR, 1997).

Some pharmacokinetic models developed by EPA also suggest that the levels of VOC metabolites formed by the body may be higher as a result of oral exposure than inhalation exposure (ATSDR 1997). For instance, small amounts of VOCs that are ingested are often quickly metabolized by the liver, while small amounts of VOCs that are inhaled or absorbed through the skin are typically distributed throughout the body prior to metabolism by the liver, and are therefore metabolized more slowly. The toxic effects of exposure to VOCs are mainly due to the action of their metabolites within the body. This implies that for equal (low) doses the ingestion of VOCs in water may be of greater consequence within the body than inhalation or dermal absorption because ingestion produces higher concentrations of toxic metabolites in a shorter amount of time.