HEALTH CONSULTATION

Indoor Air Exposure Investigation

LINCOLN CREEK GROUNDWATER PLUME
(a.k.a. DANIEL WEBSTER MIDDLE SCHOOL)

MILWAUKEE, MILWAUKEE COUNTY, WISCONSIN

AUGUST 4, 2004

Prepared by

Wisconsin Department of Health and Family Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary

An indoor air investigation was conducted at Daniel Webster Middle School, Milwaukee, Wisconsin, to determine whether solvents in shallow groundwater may be entering the school building and posing a health concern for students and staff. Neither the July 2000 nor December 2000 rounds of indoor air sampling found any volatile organic compounds (VOCs) at levels that were a human health concern. On the basis of the two rounds of indoor air sampling at Webster Middle School, vapor migration and intrusion may be occurring but currently poses a *no apparent public health hazard* and is not likely to change in the future. No further indoor air investigations or actions are needed at the school. As a precautionary measure, the Wisconsin Department of Health and Family Services (DHFS) and the Agency for Toxic Substances and Disease Registry (ATSDR) recommend the installation of a radon mitigation system when unfinished rooms at the school are renovated.

Background

In May 2000, DHFS evaluated environmental sampling data that reported elevated concentrations of volatile organic compounds (VOCs) in shallow groundwater near Daniel Webster Middle School (Webster Middle School) at 6850 North 53rd Street, Milwaukee, Wisconsin. Given the high concentrations of certain VOCs in groundwater on the Webster Middle School property (Table 1), *cis*-1,2-dichloroethylene and vinyl chloride were indicated as having potential for release from groundwater in a vapor form, migrating through soils, infiltrate the indoor air at Webster Middle School, and reaching levels that could pose an inhalation health concern (DHFS 2000).

In response, DHFS conducted an indoor air investigation at the school in July 2000 to determine whether VOCs in groundwater could be migrating through soils, entering the school building, and posing an inhalation concern for students and staff (ATSDR 2000a). The July 2000 round of indoor air sampling found no VOCs above their respective health-based comparison values (CVs) (Table 2). Although some VOCs were found in air inside Webster Middle School, all VOCs were at extremely low levels and did not pose a human health concern. DHFS concluded that VOCs in the indoor air of Webster Middle School did not pose a human health concern. Seasonal weather changes can alter conditions that can increase the potential for soil vapor migration and intrusion, such as frozen soil cover and decreased indoor air exchanges associated with heating can increase the migration of VOCs vapors through soils and infiltration into the building. Consequently, DHFS recommended a second round of air sampling during the winter to determine whether atmospheric and seasonal conditions increased indoor air concentrations of VOCs.

In early 2001, DHFS evaluated data from the second round of sampling. DHFS provided oral communications to the School officials that concluded VOCs in the indoor air of Webster Middle School did not pose a health concern. In 2004, DHFS was requested to formally evaluate

the data and prepare a written report. This written health consultation is the response to this 2004 request.

Methods

The winter phase of the indoor air investigation at Webster Middle School occurred on December 27, 2000. Indoor air samples were collected only from the three undeveloped rooms with dirt floors (UF1, UF6, and UF44) because the potential for vapor migration and intrusion is greater in a room with a dirt floor than in a room with a finished concrete floor. Therefore, the indoor air in these rooms was viewed as having the highest risk for impact by vapor migration and intrusion.

During this winter sampling round, one air sample was collected from the indoor of each of the three unfinished rooms of Webster Middle School (Sigma 2001). Samples were collected over an approximately 60-minute period using specially prepared, evacuated 6-liter SUMMA® canisters. Samples were shipped overnight to Air Toxics Ltd, in Folsom, California, for laboratory analysis. Samples were analyzed with the US Environmental Protection Agency (EPA) TO-14S method using gas chromatographic/mass spectroscopy instrumentation (EPA 1999). The TO-14S method was chosen because of the low detection limits of the targeted VOCs.

Results and Discussion

In December 2000, three VOCs were measured in indoor air slightly above CVs, but none posed an inhalation health concern at Webster Middle School. These three VOCs were methylene chloride, *cis*-1,2-dichloroethylene, and vinyl chloride (Table 3). The highest amounts of VOCs measured in these rooms would not be of health concern even if the rooms were regularly occupied, which they are not.

When evaluating the human health implications of these VOCs in the indoor air of Webster Middle School, it is important to take into account how often students and staff are in these unfinished rooms. Staff and students are reported to not regularly enter or use these unfinished rooms. This results in a reduced exposure to indoor air VOCs found in these rooms than in the rest of the school. Staff, teachers, and students probably average 10 hours per day, 250 days per year in classrooms, hallways, and meeting rooms of a school. Conversely, the standard inhalation CVs used to screen indoor air VOC concentrations (Tables 2 and 3) rely on exposure factors based on a residential setting: a person is present in a home for 24 hours per day, 365 days per year, and for 70 years. Although residential-based CVs can be useful to initially screen indoor air sampling data from Webster Middle School, further assessment needs to account for likely exposures.

For Webster Middle School, DHFS used CVs that are based on a residential setting. The use of occupational inhalation guidelines is not appropriate for evaluating VOC concentrations in

indoor air of homes and schools because of the gap between occupational and public health standards. Occupational standards are designed for exposures of workday duration to healthy, non-pregnant adults. Public health standards and guidelines account for longer exposures and sensitive individuals (young children and older adults). In some cases, public health standards can be extrapolated from occupational standards; in other cases, they are based on separate experimental models. CVs trigger steps to further evaluate and maintain residential air quality; occupational standards are designed for air management decisions in the breathing zone of healthy workers. The direct use of occupational threshold limit values does not sufficiently protect public health when air around or inside of homes or schools is evaluated.

Methylene Chloride

Methylene chloride was detected above its CVs only in Room UF6. In December 2000, each of the three unfinished rooms with dirt floors was targeted for follow-up sampling. However, since December 2000, Room UF6 has been completely renovated, with a concrete slab, and is now a classroom for the school's technology center. Before renovation and pouring of the concrete slab on the floor in Room UF6, a passive radon mitigation system was installed. Radon mitigation systems are very effective in correcting known indoor air quality problems from vapor migration and intrusion. Although sampling did not indicate a need for such a system in this room to address a potential vapor intrusion concern, the installation of the mitigation system was an appropriate proactive and precautionary measure. Methylene chloride concentrations in shallow groundwater on the Webster Middle School property were not widespread and, where present in groundwater, were near or lower than Wisconsin Groundwater Enforcement Standard of 5.0 micrograms per liter (μg/L). Recent U.S. EPA guidance on vapor intrusion suggests that such a level of methylene chloride in shallow groundwater has a low likelihood of significantly impacting the indoor air of a nearby structure (EPA 2002b).

The highest level of methylene chloride measured in the indoor air of Room UF6 was 14.0 $\mu g/m^3$, which was above its inhalation CV of 3.8 $\mu g/m^3$, but this concentration of methylene chloride is not a health concern to students, staff, or teachers at Webster Middle School.

EPA classifies methylene chloride as a probable human carcinogen because laboratory studies of the chemical have found a significantly increased number of liver cancers in rats and mice. However, occupational studies of people exposed over many years to very high levels of methylene chloride did not find a significant increase of any cancers in workers (ATSDR 2000c).

The inhalation CV for methylene chloride for indoor air derives from the cancer slope factor assigned by EPA. CV for methylene chloride of 3.8 $\mu g/m^3$ is based on a theoretical one in one million lifetime excess risk forcancer. The theoretical risk can be interpreted that if one million people inhaled 3.8 $\mu g/m^3$ methylene chloride in air, every day for 70 years, one additional excess case of liver cancer may occur. This theoretical risk projects an estimated four excess cases of liver cancer if one million peopled inhaled a concentration of methylene chloride at 14.0 $\mu g/m^3$ every day over their entire lives. Such an increased lifetime excess risk of developing liver cancer is extremely low and not a health concern. Finally, in the July 2000 indoor air

investigation, methylene chloride was not detected above its CV. Overall, the presence of methylene chloride above its CV appears to be intermittent at Webster Middle School. As a result, methylene chloride in the indoor air of Room UF6 was not a health concern. Since the installation of the radon mitigation system, the potential has been eliminated for soil vapors containing methylene chloride to reach the indoor air of Room UF6.

cis-1,2-Dichloroethylene

Vinyl chloride and *cis*-1,2-dichloroethylene were detected in indoor air above their respective CVs only in Room UF44, which remains unfinished and with a dirt floor. Once used for storage, Room UF44 is no longer used for any purpose, and staff does not regularly enter the room. Although VOCs coming from soil vapors may occasionally be present in the indoor air of Room UF44 at Webster Middle School, potential inhalation exposures are infrequent.

The highest concentration of *cis*-1,2-dichloroethylene was 150 $\mu g/m^3$, which is above its CV of 37 $\mu g/m^3$, but this concentration of *cis*-1,2-dichloroethylene does not pose a health concern to students, staff, or teachers of Webster Middle School. The CV for *cis*-1,2-dichloroethylene derives from a provisional EPA *reference dose* (RfD[1]) for chronic health effects, which is 0.01 milligram per kilogram body weight per day (mg/kg/day). This provisional RfD is based on a *no observed adverse effect level* (NOAEL[2]) of 32 mg/kg/day for effects on blood observed in an unpublished 90-day gavage study in rats (EPA, 2002a). Hematocrit and hemoglobin levels decreased in rats when their ingestion dose approached 97 mg/kg/day. The provisional RfD derives from this NOAEL and accounts for an uncertainty factor of 3,000 (10 for use of a subchronic study, 10 to extrapolate from rats to humans, 10 to protect sensitive individuals, and three for database limitations).

If an adult and a child inhaled *cis*-1,2-dichloroethylene at 150 $\mu g/m^3$ all day, their daily inhalation dose to would be 0.04 mg/kg/day and 0.12 mg/kg/day, respectively. These doses are 100 times lower than the NOAEL of 32 mg/kg/day. Neither adult nor child is likely to develop an adverse health effect from this exposure. Furthermore, *cis*-1,2-dichloroethylene was detected at much lower levels during the July 2000 round of sampling, below the its CV. The presence of *cis*-1,2-dichloroethylene above its CV appears to be intermittent. A continued presence in Room UF44 is likely to result in an exposure to *cis*-1,2-dichloroethylene even lower than 150 $\mu g/m^3$.

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[1] Reference Dose (RfD): An EPA established value that estimates, with built-in safety factors, the maximum daily, lifetime exposure to a chemical that is <u>not</u> likely to cause harmful health effects.

[2] No Observed Adverse Effect Level (NOAEL) - The highest dose of a chemical in a study or group of studies that did not cause harmful health effects in people or animals.

Webster Middle School staff and students do not regularly enter or use Room UF44, so inhalation exposures are minimal to *cis*-1,2-dichloroethylene in indoor air in this room. The typical amount of time that staff, teachers or students typically spend time at Webster Middle School is probably similar to other middle schools: an average 10 hours per day, 250 days per year. They spend even less time in Room UF44. As a result, the probable potential inhalation exposures to *cis*-1,2-dichloroethylene in the air from Room UF44 is far below exposures in a residential setting. Assuming a student or staff member spends no more than 1 day per week in Room UF44, the potential long-term exposure would result in a lower exposure dose than described in the above paragraph, resulting in an even lower likelihood of developing an adverse health effect.

Vinyl Chloride

The highest level of vinyl chloride measured in the air of Room UF44 was 0.5 $\mu g/m^3$, which was above the CV of 0.1 $\mu g/m^3$. This concentration of vinyl chloride does not pose a health concern to students, staff, or teachers at Webster Middle School.

Vinyl chloride is a known human carcinogen; occupational studies have found a greater than expected incidence of a rare type of cancer (angiosarcoma of the liver) among workers exposed over many years to very high concentrations of vinyl chloride (ATSDR 1997a). The CV for vinyl chloride for indoor air derives from the cancer slope factor assigned by EPA. The CV for vinyl chloride of 0.1 $\mu g/m^3$ is based on a theoretical one in one million lifetime excess risk for cancer. For a vinyl chloride level in air of 0.5 $\mu g/m^3$, the theoretical risk predicts that if one million people inhaled 0.5 $\mu g/m^3$ vinyl chloride in residential air, every day for a lifetime, about three additional cases of angiosarcoma may occur. Such an increased lifetime excess risk of developing angiosarcoma is extremely low and not a health concern.

Vinyl chloride was detected in the January 2000 indoor sample only in Room UF44. Webster Middle School teachers, staff, and students do not regularly enter or use Room UF44, so inhalation exposures to indoor air in this room are minimal. Staff, teachers, or students probably spend the same amount of time at Webster Middle School as do staff, teachers, and students at other middle schools: an average 10 hours per day, 250 days per year. As a result, the potential inhalation exposures to vinyl chloride in the air from Room UF44 are much less than in a residential setting. Assuming a student, teachers, or staff members spends no more than one day per week in Room UF44, excess lifetime cancer risk are even less than one in one million, even lower than extrapolated above.

<u>Potential for Vapor Migration and Intrusion at Webster Middle School</u>

Although the levels of methylene chloride, *cis*-1,2-dichloroethylene, and vinyl chloride are not health concerns in the air of two unfinished rooms at Webster Middle School, VOCs in shallow

groundwater and their presence in the indoor air of Webster Middle School may be related. Two of these VOCs in groundwater (*cis*-1,2-dichloroethylene and vinyl chloride) were above their respective EPA target groundwater concentrations for worst-case partitioning from groundwater to indoor air (EPA 2002b).

Webster Middle School's indoor air VOCs data are higher than what is typically found in a residential setting. The highest concentrations of methylene chloride and vinyl chloride (14.0 and 0.5 $\mu g/m^3$, respectively) in the December round of indoor air sampling at Webster Middle School are somewhat higher concentrations than observed in the indoor air of unaffected private homes. In an 2001 investigation of background levels of chlorinated VOCs in indoor air of 282 homes in Denver, Colorado, vinyl chloride concentrations averaged 0.01 $\mu g/m^3$, a 95^{th} upper confidence level concentration of 0.023 $\mu g/m^3$, and a maximum concentration of 0.5 $\mu g/m^3$ (Kurtz and Folkes, 2002). For methylene chloride, this investigation also found a mean concentrations of 1.28 $\mu g/m^3$, with a 95^{th} upper confidence level concentration of 16.0 $\mu g/m^3$, and a maximum concentration of 180.0 $\mu g/m^3$ Even though these homes were close to a groundwater plume of chlorinated solvents, their indoor air was determined to not be impacted by vapor migration and intrusion. These background levels of methylene chloride also were similar to background indoor air concentrations in a 2004 investigation of selected homes in Minneapolis/St. Paul (Sexton et al, 2004); the mean methylene chloride level was 7.8 $\mu g/m^3$, with a 90^{th} upper confidence level concentration of 11.5 $\mu g/m^3$. This investigation did not provide indoor air background data for either vinyl chloride or *cis*-1,2-dichloroethylene. Unfortunately, no data are available of indoor air background concentrations for *cis*-1,2-dichloroethylene. Data are also not available for the typical background VOC concentrations in the indoor air of a school.

When Webster Middle School data are compared against outdoor levels of background air, they suggest vapor migration and intrusion at Webster Middle School. The December 2000 indoor air levels for methylene chloride are higher than those in Milwaukee outdoor air (Tables 2 and 3) (DNR 1999a; DNR 1999b). Conversely, the indoor air level of methylene chloride was less than that reported by ATSDR for other urban areas (whether the ATSDR data represents residential, commercial, or industrial areas, or a mixture is not known). For *cis*-1,2,-dichloroethylene, levels detected in indoor air at Webster Middle School were well above levels in ATSDR's outdoor air data, but no comparative Milwaukee outdoor air data exists for this VOC. Vinyl chloride was present in indoor air at Webster Middle School but not in outdoor air background levels. The absence of vinyl chloride in outdoor air may be due to its absence or to higher detection limits of the sampling method used for the outdoor air investigations. Yet, vinyl chloride detected in the indoor air sampling at Webster Middle School also could result form another source, possibly vapor migration and intrusion from contaminated groundwater.

Finally, the indoor air sampling at Webster Middle School indicates that an inhalation health concern from vapor intrusion is very unlikely. However, the long-term future relationship between groundwater contamination and indoor air is difficult to predict. The installation of a passive radon mitigation system during future improvements of the two currently unfinished

rooms is relatively inexpensive. Therefore, as a precautionary measure, DHFS recommends installing such a mitigation system to rooms UF44 and UF6.

The VOC levels detected in the indoor air of Webster Middle School, empirical toxicological data, and potential conditions affecting inhalation exposures, indicate that the highest levels of methylene chloride, *cis*-1,2-dichloroethylene and vinyl chloride in the December 2000 indoor air sampling do not pose human health concerns, even if the rooms were regularly occupied. On the basis of both the results of the initial July 2000 and follow-up December 2000 indoor air investigation of Webster Middle School, the potential for vapor migration and intrusion into the indoor air at Webster Middle School poses a *no apparent human health hazard.*

Child Health Considerations

DHFS evaluated the likelihood that children who attend Webster Middle School might inhale VOCs released from groundwater at levels that pose a health concern. DHFS did not identify any situations in which those students were likely to be exposed to and breathe levels of VOCs associated with adverse health effects.

Conclusions

1. A second round of indoor air sampling in December 2000 at Webster Middle School found several compounds apparently from vapor intrusion from VOC-contaminated groundwater beneath the school, but the levels detected were very low and of *no apparent public health hazard*. The highest levels of VOCs in the tested rooms would not be of health concern, even if the rooms were occupied regularly, which they are not.

2. On the basis of two rounds of indoor air sampling at Webster Middle School, vapor migration and intrusion may be occurring but currently poses a *no apparent public health hazard* and are not likely to change in the future.

Recommendations

1. No further indoor air investigations or actions are needed at Webster Middle School.

2. As a precautionary measure, DHFS recommends installation of a passive radon mitigation system if either of the two unfinished rooms is renovated.

Public Health Action Plan

1. DHFS will continue to consult with Milwaukee Public Schools, Milwaukee Health Department, and the Wisconsin Department of Natural Resources to address concerns and questions about indoor air quality at Webster Middle School.

2. If requested and as needed, DHFS will provide health education about this indoor air investigation to the students, parents, teachers, and staff of Webster Middle School.

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Table 1: Groundwater Contamination
Webster Middle School
Milwaukee, Wisconsin
1998 and 1998
All concentrations in micrograms per liter (μg/L)

Chemical	Highest Level Detected	Lowest Level Detected	Frequency of Detection	Wisconsin Groundwater Enforcement Standard	Comparison Value	EPA Target Groundwater to Air Partitioning Concentration
Petroleum-Based Volatile Organic Compounds (VOCs)						
toluene	1.0	-	1/10	343.0	700.0[a]	1,500
xylenes	4.6	-	1/10	620.0	7,000.0[a]	n/a
Chlorinated VOCs						
chloroform	1.1	-	1/10	6.0	400.0[b]	80
cis-1,2-dichloroethylene	3,200.0*†	18.0	10/10	70.0	10,000.0[a]	210
trans-1,2-dichloroethylene	11.0	1.7	4/10	100.0	7,000.0[a]	180
1,1-dichloroethylene	11.0	0.8	7/10	850.0	300.0[b]	190
methylene chloride	7.2*	1.0	2/10	5.0	2,000.0[c]	58
vinyl chloride	1,600.0*†	110.0*†	10/10	0.2	0.7[b]	2

* - exceeds Wisconsin Groundwater Quality Public Health Enforcement Standard (NR140)
† - exceeds EPA Target Groundwater Concentration for worst case partitioning from groundwater to indoor air (EPA 2002b).
a - ATSDR Intermediate Adult EMEG
b - ATSDR Chronic Adult EMEG
c - U.S. EPA's reference dose

Table 2: Indoor Air Sampling Results - Unfinished Rooms
Webster Middle School
Milwaukee, Wisconsin
July 10, 2000
All concentrations in micrograms per cubic meter ($\mu g/m^3$)

Chemical	Lowest Level Detected	Highest Level Detected	Frequency of Detection	Comparison Value	Levels Observed in Outdoor Air of Milwaukee 1996-1998[e]	Levels Observed in Outdoor Air of Other Urban Areas[f]
Petroleum-Based Volatile Organic Compounds (VOCs)						
toluene	3.0	8.0	9/9	80.0[a]	0.6 - 10.6	10.8
xylenes (total)	2.7	9.7	9/9	100.0[a]	0.7 - 6.5	0.7 -24
Chlorinated VOCs						
chloroform	nd	nd	0/9	0.04[b]	nd	0.2 - 14.7
cis-1,2-dichloroethylene	0.7	20.0	8/9	37.0[c]	n/a	<1.0
trans-1,2-dichloroethylene	nd	nd	0/9	73.0[d]	nd	<1.0
1,1-dichloroethylene	nd	nd	0/9	220.0[d]	n/a	<0.1
methylene chloride	0.6	1.4	7/9	3.8[b]	0.4 - 1.3	20 - 220
vinyl chloride	nd	nd	0/9	0.1[b]	nd	0

nd- Not Detected
n/a- not available
a- ATSDR's Chronic Environmental Media Evaluation Guide
b- Cancer Risk Evaluation Guide for 1 in 1,000,000 excess lifetime cancer risk
c- U.S. EPA's Provisional Peer-Reviewed Toxicity Value (Region III RBC Table 4/14/2004)
d- U.S. EPA's Oral Reference Dose
e- (DNR 1999a, 1999b)
f- (ATSDR 1994, 1995, 1997a, 1997b, 2000b, 2000c)
* - Exceeds comparison value

Table 3: Indoor Air Sampling Results - Unfinished Rooms
Webster Middle School
Milwaukee, Wisconsin
December 2000
All concentrations in micrograms per cubic meter ($\mu g/m^3$)

Chemical	Lowest Level Detected	Highest Level Detected	Frequency of Detection	Comparison Value	Levels Observed in Outdoor Air of Milwaukee 1996-1998[e]	Levels Observed in Outdoor Air of Other Urban Areas[f]
Petroleum-Based Volatile Organic Compounds (VOCs)						
toluene	4.8	36	3/3	80.0[a]	0.6 - 10.6	10.8
xylenes (total)	5.2	39	3/3	100.0[a]	0.7 - 6.5	0.7 -24
Chlorinated VOCs						
chloroform	nd	nd	0/3	0.04[b]	nd	0.2 - 14.7
cis-1,2-dichloroethylene	16	150.0*	2/3	37.0[c]	n/a	<1.0
trans-1,2-dichloroethylene	nd	9.1	1/3	73.0[d]	nd	<1.0
1,1-dichloroethylene	nd	nd	0/3	220.0[d]	n/a	<0.1
methylene chloride	0.8	14.0*	3/3	3.8[b]	0.4 - 1.3	20 - 220
vinyl chloride	nd	0.5*	1/3	0.1[b]	nd	0

nd- Not Detected
n/a- not available
a- ATSDR's Chronic Environmental Media Evaluation Guide
b- Cancer Risk Evaluation Guide for 1 in 1,000,000 excess lifetime cancer risk
c- U.S. EPA's Provisional Peer-Reviewed Toxicity Value (Region III RBC Table 4/14/2004)
d- U.S. EPA's Oral Reference Dose
e- (DNR 1999a, 1999b)
f- (ATSDR 1994, 1995, 1997a, 1997b, 2000b, 2000c)
* - Exceeds comparison value

CERTIFICATION

This Daniel Webster Middle School, Indoor Air Exposure Investigation Health Consultation was prepared by the Wisconsin Department of Health and Family Services 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 public health consultation was begun.

for BE

Technical Project Officer, SPS, SSAB, DHAC

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

for Chief, SPS, SSAB, DHAC, ATSDR