# Health Consultation

PUBLIC HEALTH IMPLICATIONS OF 1,4-DIOXANE-CONTAMINATED GROUNDWATER AT THE DURHAM MEADOWS SITE

DURHAM, CONNECTICUT

EPA FACILITY ID: CTD001452093

MARCH 28, 2005

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.


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Prepared by:
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## BACKGROUND AND STATEMENT OF ISSUES

The purpose of this health consultation is to examine the recent data on 1,4-dioxane in groundwater at the Durham Meadows site, and assess the public health implications of long-term exposure to the residents nearby to the Merriam Manufacturing and Durham Manufacturing properties. The conclusions and recommendations of this health consultation are based on the data and information made available to the Connecticut Department of Public Health (CT DPH) and the Agency for Toxic Substances and Disease Registry (ATSDR). The CT DPH and the ATSDR will review additional information relevant to this health consultation, should it become available.

In 1988, the site currently identified as the "Durham Meadows Superfund Site" (Durham, Connecticut) was defined by the contamination located at and emanating from the Merriam and Durham manufacturing facilities and also included the areas between, adjacent to and near the Durham premises and the Merriam premises. The Durham Meadows Superfund Site was added to the National Priorities List ("NPL") on October 4, 1989, because the Connecticut Department of Environmental Protection (CT DEP) had, in 1982, identified groundwater contamination in the vicinity. Since that time, these two manufacturing facilities have been the primary focus of investigation. Merriam Manufacturing Company is located at 281 Main Street, while Durham Manufacturing Company is located at 201 Main Street. About 68 private wells are nearby. These wells are located near the center of town in a generally north-south transect parallel to Main Street (Route 17). Most of the wells serve private residences, though there is one non-transient, non-community public well (Strong School). A diagram of the site is included in Attachment A.

The Merriam Manufacturing Company produces metal boxes. The company operated from 1851 at its Main Street location until March 1998, when it was almost completely destroyed by fire and relocated to Middletown, Connecticut. The Durham Manufacturing Company also produces metal boxes and has operated since 1922. Durham Manufacturing has used chlorinated solvents for cleaning and degreasing from approximately 1947 to the present. It began with trichloroethylene (TCE), then switched to 1,1,1-trichloroethane (TCA) in 1967, which it continued to use until 1980. Durham also used methylene chloride from 1976 until 1997. As part of its manufacturing operations, Merriam Manufacturing used TCE as its primary parts cleaner from 1940 until 1953. From 1953 to 1978, Merriam cleaned parts using a water-based cleaner that did not contain chlorinated compounds. Merriam began using TCE in a small parts washer from 1974 to 1986 and methylene chloride in its larger degreaser from 1978 to 1986. Both washers were converted to TCA in 1986. Merriam used TCA from 1986 to 1993.

At the Merriam premises, two lagoons were used for the disposal of waste products from approximately 1973 to 1982. The wastes received by the lagoons included, but were not limited to, paint booth wash water and alkaline wash and rinse water, which may have contained volatile organic compounds from the various chlorinated solvents used by Merriam over the years. At the Durham premises, through the 1980's, Durham discharged well water used for cooling into an unlined holding pond on its property. It also discharged wastewater from its wet paint booths and paint stripping tanks into a ditch on the property, and later to a leaching field. Floor drains in the painting area and near the degreaser also drained into the tank and then into the cooling pond. These drains occasionally collected solvents spilled in connection with use of the degreaser.

Investigations at Durham Manufacturing confirmed three contaminant source areas; a former solvent storage and handling area, the former wastewater treatment lagoons, and the septic system leach field. Source areas at the Merriam Manufacturing premises are near its former loading dock and drum storage area. The extent of groundwater contamination is not fully characterized. A 1995 U.S. Geological Survey Administrative Report prepared for the U.S. Environmental Protection Agency (EPA) on the *Geohydrology and Water Quality of The Durham Center Area, Durham, Connecticut*, stated that "neither the details of the ground-water flow paths nor the nature of the aquifer system can be resolved without additional data." The principle contaminants found in this study were TCE and TCA. The report concluded that the transport of contaminants, which was affected by the structural features of the sedimentary bedrock, was generally to the south and southwest of the purported source areas and that the groundwater flow and transport of the organic compounds were also affected by pumpage from the numerous bedrock wells in the area.

Since the identification of groundwater contamination (in 1982), both the Merriam Manufacturing Company and the Durham Manufacturing Company have been involved in private well water treatment and monitoring programs. Currently, treatment systems consist of two-stage granular activated charcoal (GAC) filters. In 1989, ATSDR issued a Preliminary Public Health Assessment for the Durham Meadows site. This health assessment concluded that exposure to volatile organic compound in groundwater used for domestic purposes was a public health concern.

In April 1995, the CT DPH wrote a health consultation regarding the results of private well water testing. At that time, it was concluded that some residents living in homes fitted with only the single GAC filter unit were exposed to low levels of TCE when the activated charcoal filters were no longer effective at removing the volatile organic compounds. These exposures occurred for short periods of time prior to the replacement of the filters. These wells received a second GAC unit in October of 1994 which theoretically addressed the concern of exposure following breakthrough. Following the release of the April 1995 health consultation, the CT DPH delivered fact sheets to homeowners that had GAC units to emphasize the importance of monitoring and timely replacement of filters.

As part of the April 1995 health consultation, the CT DPH concluded that filter changing had not always occurred on a timely basis and recommended that EPA consider an evaluation of all the private wells around the two manufacturing facilities to determine if all the wells that needed to be monitored were part of an existing monitoring program. Private well sampling was conducted by EPA in April 1998, and September/October, 1998. CT DPH reviewed these two rounds of private well sampling, and concluded that low levels of TCE were identified in some of the private wells that currently do not have any treatment systems (ATSDR, 1999). In that 1999 health consultation, CT DPH recommended that two additional wells needed treatment systems, and at least two additional rounds of private well water sampling should be considered for all wells, to ensure an adequate understanding of the private well water in and around the groundwater contamination area.

In December 2003 through December 2004, a limited number of residential drinking water wells were sampled by CT DEP. Results indicated that 1,4-dioxane was present in raw water at concentrations up to 27 micrograms per liter (ug/L). Results further indicated that sometimes this contaminant was by-passing the filter’s adsorbent material and getting into finished water. The discovery of 1,4-dioxane in groundwater was a result of an improvement in the analytical methodology used to quantify its concentration in water. In the past, the detection limits for this compound were relatively high (40 ug/L). New analytical methodologies are now available to reliably quantify 1,4-dioxane at a concentration of 2 ug/L. In response, EPA (in collaboration with CT DPH and CT DEP) issued a Community Update (i.e.; fact sheet) on the 1,4-dioxane sampling results in March of 2004.

## DISCUSSION

1,4-dioxane is a manmade compound primarily used as a stabilizer that prevents the breakdown of chlorinated solvents to acids during degreasing operations. It is added to chlorine-based degreaser formulations usually at a concentration of less than 5%. 1,4-dioxane has also been detected in ethylene glycol-based antifreeze coolants at concentrations of 0.1 -22 milligrams per liter (mg/L) (Hartung, 1989). Because it is a by-product of the manufacturing process, 1,4-dioxane is also present in ordinary household products like shampoos (0.005-0.03%), liquid/dishwashing soap (0.0002-0.007%), baby lotion (0.001%), hair lotions (0.005-0.01%), bath foam (0.002-0.004 %) and other cosmetic products. As a result of its presence in a variety of consumer products, 1,4-dioxane has been shown to be a contaminant of sewage effluent (Abe, 1999).

In their previously cited report on the local hydrology, the US Geological Survey (USGS, 1995) presented a conceptual model of the movement and fate of organic contaminants through the highly complex hydrogeochemical system found in the vicinity of the site. The USGS's conceptual hydrogeologic model includes the likely possibility that nonaqueous phase primary contaminants (e.g., TCE, TCA) are retained near their source by the diffusion of these nearly insoluble contaminants into open pores in the soil/rock matrix (USGS, 1995). Thus, even though contamination presumably ceased about 15 years ago, the low water solubility of the primary contaminants may be keeping a significant fraction in storage above the water table. This low mobility contrasts with that for 1,4-dioxane, which because of its infinite solubility, can be presumed to be equal to that for water.

*Exposure Pathways*

To evaluate the public health implications of exposure to 1,4-dioxane at this site, CT DPH considered the available environmental data and how people might become exposed to this chemical. If there is no potential for exposure, then it can be concluded that there is no threat to public health. Where exposure is possible, either by drinking, breathing, or contact with skin, CT DPH compared maximum concentrations of 1,4-dioxane with health-protective comparison values. This approach screened out exposures that have little likelihood of causing adverse health effects. When contaminant concentrations are in excess of comparison values, likely exposure amounts were evaluated to determine if they may be significant enough to cause adverse health effects.

Because 1,4-dioxane is miscible with water, it is not expected to leave water and bind to soil or volatilize to a significant amount. Exposure via direct contact with soil or through indoor air is therefore expected to be minimal. Dermal absorption from 1,4-dioxane-contaminated bath/shower water is also minimal because of the relatively short contact time, and because 1,4-dioxane in water does not easily penetrate the skin. The primary means of exposure to dioxane in contaminated groundwater is therefore via oral ingestion.

*1,4-dioxane toxicology*

Effects seen in humans from repeated short-term exposure to high amounts of

1,4-dioxane include central nervous system (CNS) effects, kidney and liver damage, convulsions, coma and death. Exposures levels associated with these adverse effects are uncertain but vastly greater than exposure levels that would occur through contaminated drinking water. Case reports of fatalities from industrial exposure indicate that toxicity included inhalation and skin absorption components.

Limited and inconclusive human data exist with respect to associations between chronic 1,4-dioxane exposure and incidence of cancer. In a retrospective mortality study of 165 workers exposed to a range of 1,4-dioxane air concentrations from less than 25 parts per million (ppm) to 75 ppm during manufacture and processing, the observed cancer deaths (3) were not significantly different from the expected number (1.7) (Buffler et al., 1978). Cancer deaths were reported as carcinoma of stomach, and alveolar and mediastinal tumors. A death from chronic hepatitis/cirrhosis was also reported. Results were inconclusive according to study authors for a number of reasons but primarily because of the small sample size and relatively short exposure duration.

Laboratory animal studies have demonstrated that 1,4-dioxane can, at high doses and over long exposure times, cause damage to the liver. While such liver damage may lead to tumor formation, 1,4-dioxane does not damage the liver cells DNA. As tumor formation seems to follow cytotoxicity, there is little reason to expect that 1,4-dioxane could cause cancer at the relatively low levels of exposure possible from drinking 1,4-dioxane-contaminated water.

The reproductive toxicity of 1,4-dioxane has not been evaluated directly; the only study involving 1,4-dioxane was in combination with TCA. In this study, no effects on fertility were reported in OCR Swiss mice given 1,1,1-trichloroethane containing 3% 1,4-dioxane during a 2-generation drinking water study. When pregnant rats were dosed with 1,4-dioxane by gavage at doses that caused the mothers to lose weight, there were no significant differences between control and treated groups of offspring (Giavini et al.,1985).

*A comparison value for 1,4-dioxane*

EPA sets the federal standard (MCL) for drinking water contaminants in public water. However, in this instance, there is no federal drinking water standard and other health-based guidance from EPA is dated. Additionally, other federal agencies (e.g., ATSDR), and other states, have not issued relevant health-based guidance for 1,4-dioxane in drinking water.

At the present time, the most comprehensive guidance is available in an Australian government report (NICNAS, 1999) and a draft document from The World Health

Organization (WHO, 2003). CT DPH used both of these resources in their recent review of the 1,4-dioxane toxicology database (CT DPH, 2004). This review describes the basis for derivation of a 1,4-dioxane comparison value of 20 ug/l in drinking water.

The CT DPH evaluated 1,4-dioxane's toxic effects and exposure potential with respect to the general population and vulnerable groups (e.g., young children). The comparison value (20 micrograms per liter (ug/L)) is intended to be protective against possible cancer and non-cancer health effects over a lifetime's worth of exposure. CT DPH believes that this comparison value provides a large margin of safety relative to the threshold where toxic effects may begin to be seen.

The rationale for this comparison value is detailed in CT DPH's 2004 review. In summary; 1,4-dioxane is clearly hepatocarcinogenic at 1,000 milligrams per kilogram per day (mg/kg/day) and above; somewhat hepatotoxic and possibly carcinogenic at 100 mg/kg/day; also a slight suggestion of carcinogenic response at 25 mg/kg/day in rats. No tumors or toxicity in liver at 10 mg/kg/day in rats. Therefore, 10 mg/kg/day appears to be a chronic cancer no observed adverse effect level (NOAEL). This NOAEL was also protective for other toxic effects, and it is 17,500 times greater than the daily dose derived from drinking 2 liters of water contaminated with 20 ug/L of 1,4-dioxane.

*Extent of chronic exposure within the community*

Well water was surveyed for 1,4-dioxane four times in the recent past. A total of 75 different wells were sampled one or more times within 1 year. Wells from all nearby streets were included in the survey. Results (Table 1) indicate that contamination (i.e.; 1,4-dioxane concentration greater than the detection limit of 2 ug/L) is limited to about half the wells on Main Street. The number of individuals chronically exposed to 1,4-dioxane through contaminated well water is therefore approximately 80 (20 wells times four individuals per well). Because the data do not exist, it is not known if past exposure potential was greater or smaller than it is presently. As investigative work at other sites has shown that 1,4-dioxane is often present with TCA (or its breakdown products), exposure could have begun as early as 1967, when TCA was first used at Durham Manufacturing. Exposure duration therefore could be as long as 38 years.

**Table 1:** Results from past surveys for 1,4-dioxane in well water from homes within the Durham Meadows Superfund Site.

| **1,4-dioxane in Durham wells** | | |
|---|---|---|
| **Street** | *Not detected* (number)* | *Detected ** (number)* |
| Maple Avenue | 21 | 0 |
| Maiden Lane | 8 | 0 |
| Wallingford Road | 2 | 0 |
| Brick Lane | 1 | 0 |
| Main Street | 23 | 20 |
| **Total** | 55 | 20 |

* The detection limit for 1,4-dioxane was 2 ug/L.

** Detected in one or more samples from surveys conducted in December of 2003; June, September, October, or December of 2004.

Results of the last year's sampling efforts indicate that contamination levels on Main Street have exceeded the comparison value (20 ug/L) in a minority of the homes sampled. The results of the surveys are presented in Table 2. The relative frequency at which exceedences of the Comparison Value occurred is less than ten percent of all detections. Of the 92 instances when 1,4-dioxane was detected, there were eight instances when the contamination levels were at 20 ug/L or greater. The highest concentration detected was 27 ug/L. In raw (untreated water), the 1,4-dioxane concentration was greater than the comparison value in two of 33 instances (6%). In treated water, the 1,4-dioxane concentration was greater than the comparison value in five of 31 instances (16%). The cause of this increased frequency of exceedences in treated water over raw water may be the treatment system. In all five instances when 1,4-dioxane concentrations in the treated water was at or above 20, the concentration in raw water was less than 20. It is not clear why treatment was associated with higher levels of 1,4-dioxane, but results (Table 2) indicate that it has occurred in four different Main Street wells. Conversely, treatment decreased 1,4-dioxane concentrations in only two wells.

**Table 2:** Results of surveys for 1,4-dioxane contamination in Durham drinking water wells between December 2003 and December 2004. All wells were located on Main Street. Addresses have been removed to respect confidentiality of results. (< = less than; ND = Not Detected)

| | December-03 | | | June-04 | | September-04 | | October-04 | | December-04 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Address Code | pre-filters | between filters | post-filters | pre-filters | post-filters | pre-filters | post-filters | pre-filters | post-filters | pre-filters | between filters | post-filters |
| A | <20 | <20 | <20 | <20 | <20 | - | - | - | - | - | - | - |
| B | <20 | <20 | ND | <20 | ND | - | - | - | - | - | - | - |
| C | - | - | - | <20 | ND | - | - | - | - | - | - | - |
| D | - | - | - | ND | <20 | - | - | - | - | - | - | - |
| E | - | - | - | <20 | <20 | <20 | <20 | - | - | - | - | - |
| F | - | - | - | <20 | <20 | <20 | <20 | - | - | - | - | - |
| G | - | - | - | <20 | <20 | <20 | **24** | - | - | <20 | <20 | ND |
| H | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | **26** | - | - | - |
| I | - | - | - | <20 | ND | <20 | <20 | - | - | - | - | - |
| J | <20 | <20 | <20 | <20 | ND | <20 | <20 | **27** | <20 | <20 | <20 | <20 |
| K | - | - | - | <20 | ND | - | - | <20 | <20 | - | - | - |
| L | - | - | - | <20 | ND | <20 | ND | - | - | - | - | - |
| M | - | - | - | <20 | ND | <20 | <20 | - | - | - | - | - |
| N | <20 | <20 | <20 | <20 | <20 | <20 | <20 | - | - | - | - | - |
| O | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | **20** | - | - | - |
| P | **24** | **25.5** | <20 | <20 | <20 | <20 | **22** | - | - | <20 | <20 | **27** |
| Q | - | - | - | ND | <20 | - | - | - | - | - | - | - |
| R | - | - | - | <20 | ND | <20 | <20 | - | - | - | - | - |
| S | <20 | <20 | <20 | ND | ND | - | - | - | - | - | - | - |
| T | <20 | <20 | <20 | <20 | ND | - | - | - | - | - | - | - |

*Public health significance*
Some treated wells had post-filter concentrations of 1,4-dioxane in excess of the comparison value (20 ug/L). However, because the level of contamination was only slightly above the comparison value, and because the great majority of detections were below this value, CT DPH does not believe these exposures are likely to cause adverse health effects. This is because CT DPH believes that the exposure potential is well below the threshold where adverse effects could be expected to occur. Through our review of the toxicology database, we have determined that the comparison value-equivalent exposure represents (depending on how much 1,4-dioxane exposure there may be from other sources) a 8,000 to 40,000-fold safety factor over exposures that may be associated with the development of cancer in certain laboratory animals. While it may be presumed that 1,4-dioxane contamination was greater in the past (possibly in proportion to the TCA contamination), the relative significance of the public health threat posed by other contaminants such as TCE was likely much greater, and any proportionate increase in 1,4-dioxane exposure would not significantly decrease the margin of safety. Adverse health effects are therefore not expected to occur in residents of Main Street drinking 1,4-dioxane contaminated water under current or past exposure scenarios.

## CONCLUSIONS

1) Evidence indicates that the treatment system is not effectively removing 1,4-dioxane from drinking water.

2) There are some wells with 1,4-dioxane levels greater than the health-based comparison value of 20 ug/L. However, because these exceedances occurred in a minority of the wells sampled, and because the magnitude of the excess was marginal, the doses received through drinking water are not significant enough to lead to adverse health effects. CT DPH therefore does not believe that current or future exposures could lead to adverse health effects in the exposed population.

3) ATSDR has a categorization scheme whereby the level of public health hazard at a site is assigned to one of five conclusion categories. CT DPH has concluded that, under current conditions, the site poses a no apparent public health hazard because exposure doses and risks are well below the threshold where adverse health effects (caused by exposure) could reasonably be deduced as possible.

4) Because data on past 1,4-dioxane contamination levels does not exist, it is not possible to adequately infer what the exposure levels were in the past.

## RECOMMENDATIONS

1) Future efforts by CT DEP should focus on improving the efficacy of the treatment systems with respect to 1,4-dioxane removal.

2) Until the adequacy of treatment systems can be demonstrated, CT DPH recommends that CT DEP provide bottled water to residents of homes with wells impacted by 1,4-dioxane.

## PUBLIC HEALTH ACTION PLAN

1) CT DPH will facilitate CT DEP's efforts to improve the treatment plan.

2) CT DPH will produce a fact sheet summarizing the results of this health consultation, and distribute it to the residents of Durham Center.

## REFERENCES

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## CERTIFICATION

The Health Consultation for the Durham Meadows Superfund Site was prepared by the Connecticut Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with its findings.

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**Attachment A:** Map of Durham, Connecticut, center showing local roads and locations of Merriam and Durham Manufacturing on Main Street (Route 17).