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SUMMARY OF AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY ACTIONS  
AT CAMP LEJEUNE MCB CAMP LEJEUNE NC  
1/1/2005  
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY



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## **Summary of ATSDR actions at Camp Lejeune**

### **1. Site Background**

The United States Marine Corps (USMC) Base at Camp Lejeune, North Carolina began operations during the 1940s. Currently, the base is home to an active duty, dependent, retiree, and civilian employee population of nearly 150,000 people. About 43,000 are active military personnel and their dependents total about 53,500. About 42,000 are retired and about 4,900 are civilian employees. The base has a relatively young population with almost two-thirds of the active military personnel and their dependents under the age of 25. There has been considerable in- and out-migration from the base. For example, ATSDR was told by staff of the Camp Lejeune Naval Hospital that an estimated one-third of mothers receiving prenatal care at the hospital during the 1970s and 1980s were transferred from Camp Lejeune before delivery.

Base housing for enlisted personnel, officers, and their families are located in 15 different areas on the base. During the 1970s and 1980s, the base's drinking water was extracted from over 100 wells, treated at eight treatment plants, and distributed to its residents through a network of distribution pipes. Three water distribution systems provided water for Camp Lejeune's base housing areas: the Tarawa Terrace, Holcomb Boulevard, and Hadnot Point systems. The Hadnot Point system was constructed in the 1940s, the Tarawa Terrace system was constructed in 1954, and the Holcomb Boulevard system was constructed in 1972.



During the 1940s and 1950s, underground storage tanks were installed at Hadnot Point and used to store waste degreasing solvents. In 1954, ABC One-Hour Cleaners, a dry cleaning firm, began operation near the base. In 1958, a supply well for the Tarawa Terrace family housing units was installed near the septic tank system of the dry-cleaning operation. During the period 1980-1985, a sampling program of the supply wells and water distribution systems at the base found that some of the wells in the Hadnot Point and Tarawa Terrace systems were contaminated with volatile organic compounds (VOCs). However, the contamination of these wells likely began many years before contamination was detected. An important feature of the contamination of these two drinking water systems at Camp Lejeune was its intermittent nature. Each system had many more wells than were necessary to supply water on any given day. Wells were rotated in and out of service and contamination levels in the drinking water distribution system varied depending on the wells being used at a particular time. In each system, water from all the wells in use was mixed before treatment and distribution.

The base began sampling the Hadnot Point system in October 1980 for trihalomethanes (THMs), a chlorination disinfectant byproduct. The analysis of the sample at Hadnot Point indicated the presence of VOCs other than THMs. Samples taken in 1981 also indicated the presence of VOCs other than THMs in the Hadnot Point system. In April 1982, the base began using a different laboratory for the analyses of drinking water samples. This laboratory noted difficulty in measuring THMs in the Hadnot Point system and the Tarawa Terrace system because of interference by unidentified VOCs. Reanalysis of the samples from Hadnot Point and Tarawa Terrace were conducted in May 1982. At Hadnot Point, trichloroethylene (TCE) was detected at 1,400 ppb and tetrachloroethylene (PCE) was



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detected at 15 ppb, slightly above its detection limit of 10 ppb. At Tarawa Terrace, PCE was detected at 80 ppb. No action was taken at the time because water quality standards had not been established for these VOCs in 1982.

The possible sources of contamination of the Hadnot Point system were leaking underground storage tanks, spills, and other waste disposal practices. It is unknown when the contamination of the Hadnot Point system wells began, but the contamination could have started back in the 1950s. In July 1982, TCE was detected at levels around 20 ppb, very much lower than the level detected in the sample taken a few months before. THM samples taken at Hadnot Point in November 1982 and in 1983 were found to be contaminated with TCE and PCE. In November 1984, the base received results of samples taken in July 1984. In one well at Hadnot Point, both TCE and benzene were detected. Among the contaminated wells at Hadnot Point and finished water at one building served by the Hadnot Point system, TCE levels ranged from 5 ppb to 1,600 ppb. In December 1984, some of the Hadnot Point wells were shut down or placed offline.

On January 27, 1985, a fuel pump broke at the Holcomb Boulevard system and water from Hadnot Point was supplied to the Holcomb Boulevard service area while repairs were made. On January 31, 1985, buildings in the Holcomb Boulevard service area that were temporarily receiving water from Hadnot Point were sampled and high contamination was found at the Berkeley Manor Elementary School (1,148 ppb TCE and 407 ppb 1,1-Dichloroethene [DCE]), an Officers club (890 ppb TCE and 332 ppb DCE), the Married Officers Quarters (1,041 TCE), and two Berkeley Manor Housing Units



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(905 ppb and 981 ppb TCE, 335 ppb and 369 ppb DCE). All contaminated wells in the Hadnot Point system were closed in early February 1985.

The likely source of the Tarawa Terrace system wells contamination was the dry cleaning operation. Since a supply well for Tarawa Terrace was drilled in close proximity to the dry cleaner's septic tank and the soil at the base was highly permeable, it is likely that the well was contaminated soon after it was installed in 1958. In July 1982, PCE levels at Tarawa Terrace ranged from 76 ppb to 104 ppb. THM samples taken at Tarawa Terrace in November 1982 and in 1983 were found to be contaminated with PCE. In early February 1985, a tap water sample detected 215 ppb PCE, 8 ppb TCE, and 12 ppb DCE. The contaminated wells were shut down on February 8, 1985. Both Camp Lejeune and ABC One-Hour Cleaners were listed as United States Environmental Protection Agency (US EPA) National Priority List (NPL) "Superfund" sites in 1989.

## **2. 1997 ATSDR Public Health Assessment (PHA)**

The Agency for Toxic Substances and Disease Registry (ATSDR) is required by law to conduct a public health assessment (PHA) at each NPL site. The aim of each assessment is to determine whether the population residing around a particular site might have been exposed to any toxic substance and also to assess whether there might have been any adverse health effects resulting from this exposure. Known health effects are documented in these assessments and public health recommendations are made accordingly. Potential health effects are also identified and referred to ATSDR scientists for additional investigation.



In 1997, ATSDR completed a PHA for Camp Lejeune (ATSDR 1997). The assessment determined that the estimated drinking water VOC exposures at Camp Lejeune were several thousand times lower than levels of concern in animal studies. They were also hundreds of times lower than levels linked to adverse health effects found in workplace studies. ATSDR concluded that both cancer and non-cancer health effects were unlikely in adults exposed to VOC-contaminated drinking water at Camp Lejeune based on worst-case estimates. However, because of the limited information available in the scientific literature on how these chemicals might affect a fetus or child, it was suggested that an epidemiological study be performed at Camp Lejeune to evaluate whether mothers exposed during pregnancy to chlorinated solvents (e.g., PCE and TCE) in drinking water had a higher risk of giving birth to a child with a birth defect or a childhood cancer.

### 3. 1998 ATSDR study of adverse birth outcomes

As a first step in following up the PHA recommendation to conduct an epidemiological study, ATSDR utilized available databases to evaluate whether associations existed between potential maternal exposure to the drinking water contaminants at the base and preterm birth (<37 weeks gestational age), small for gestational age (SGA), and mean birth weight deficit (ATSDR 1998; Sonnenfeld et al. 2001). SGA was determined as <10<sup>th</sup> percentile weight by gestational week using published sex-specific growth curves for whites in the state of California. The study was completed and published as an ATSDR report in August 1998.



The study obtained electronic birth certificate information for 12,493 live births born during the period January 1, 1968 through December 31, 1985 to women who resided in base family housing at time of delivery. After exclusions for poor data quality, 11,970 live births were included in the analyses. The year 1968 was chosen as the starting point of the study because that was the year that North Carolina began computerizing its birth records. Information from the birth certificate was used to determine birth weight and gestational age.

Birth certificates were linked to the base's family housing records on mother's address at delivery and, in most cases, father's name. The housing records contained dates of occupancy and military pay grade for the family member assigned to the unit (i.e., the active duty person). This information was used to estimate the dates during pregnancy when the mother resided in the base housing unit. The study estimated that the mothers of 6,117 births resided at Tarawa Terrace for at least one week before birth occurred. These births were considered exposed to PCE. Mothers of 31 births that resided at Hospital Point (served by the Hadnot Point system) for at least one week before birth occurred were considered having "long-term" exposure to TCE. Mothers of 141 births that resided in housing units supplied briefly in 1985 by the Hadnot Point system when the Holcomb Boulevard system was down (due to a fuel pump failure) for at least one week before birth occurred were considered having "short-term" exposure to TCE. Mothers of 5,681 births (nearly half of the total number of births on base during the study period) resided in housing units that were not served by either the Hadnot Point or Tarawa Terrace systems and were therefore considered unexposed to VOCs in drinking water.

The study showed that “long-term” TCE exposure from Hadnot Point water was associated with an elevated risk for SGA (OR=3.9, 90% CI: 1.1, 11.9) only among male infants (ATSDR 1998). Exposure to PCE from Tarawa Terrace water was associated with elevated risk for SGA among infants born to mothers aged >35 years (adjusted OR=2.1, 90% CI: 0.9, 4.9) and among mothers with two or more prior fetal losses (adjusted OR=2.5, 90% CI: 1.5, 4.3) (Sonnenfeld et al. 2001). The following potential confounders and effect modifiers were included: sex of infant, maternal and paternal ages, maternal race, maternal and paternal education, military pay grade, maternal parity, adequacy of prenatal care, marital status, and year of birth.

An attempt was made to evaluate fetal deaths that occurred on base during the study period, but was abandoned for several reasons. First, the total number of fetal deaths identified through the computerized state database was small (N=83). Second, the cause of death was missing for most of the fetal deaths. Finally, the number of fetal deaths in the computerized database likely constituted an under ascertainment of the true occurrence of fetal death on base because the race-specific rates of fetal deaths were considerably lower than expected based on US rates.

#### 4. Current ATSDR epidemiological study of specific birth defects and childhood leukemia

##### A. Introduction



Because the adverse birth outcome study relied on birth certificate information, it could not evaluate birth defects or childhood cancers. In order to evaluate these adverse childhood outcomes in an epidemiological study, ATSDR initiated a multi-step process. First, a review of the scientific literature was conducted to narrow the focus of potential adverse outcomes to study. Second, a telephone survey was conducted to identify potential cases of the selected adverse childhood outcomes among the births occurring during the period 1968-1985 to mothers residing at the base anytime during their pregnancy.

The next step was to verify the diagnoses of the cases ascertained by the survey. This work is ongoing and a progress report was issued in July 2003. In July 2003, work began to develop a study protocol. The protocol received approval from the CDC Institutional Review Board and the US Office of Management and Budget in 2004. Work is now proceeding on the epidemiological study. The expected completion date of the study is 2007.

## **B. Literature review**

In order to narrow the focus of the epidemiological study to adverse childhood outcomes that might be related to the drinking water exposures on base, ATSDR reviewed the toxicological and epidemiological literature. Based primarily on the evidence from the epidemiological studies of VOC-contaminated drinking water, the following adverse childhood outcomes were selected for further evaluation: neural tube defects (NTDs), oral cleft defects, conotruncal heart defects (i.e., tetralogy of Fallot, D-transposition of the great arteries, truncus arteriosus, pulmonary valve atresia with ventricular septal defect, and double outlet right ventricle), choanal atresia, childhood leukemia and childhood non-Hodgkin's lymphoma. In



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some of these studies, the drinking water was contaminated by a mixture of VOCs that included TCE and/or PCE.

The studies that evaluated birth defects were recently reviewed (Bove et al 2002). Neural tube defects and oral cleft defects were found to be associated with TCE in a NJ drinking water study (Bove et al. 1995). Major heart defects were associated with exposure to TCE-contaminated drinking water in a study conducted in Tucson (Goldberg et al. 1990). A decision was made to focus on conotruncal heart defects because these defects are pathogenetically similar and they were associated with maternal residential proximity to toxic waste sites in a California study (Croen et al. 1997). A cluster of choanal atresia was associated with drinking water primarily contaminated with TCE in the Woburn Environmental and Birth study (Bove et al 2002). A drinking water study at Woburn also found an association with childhood leukemia (Costa et al 2002). A New Jersey study found an association between childhood leukemia in females and TCE-contaminated drinking water (Cohn et al 1994). A study of drinking water contaminated with TCE, PCE, and a styrene-acrylamide trimer in Dover Township, NJ found an association with childhood leukemia among females (New Jersey Department of Health and Senior Services. 2003). Associations between non-Hodgkin's lymphoma and drinking water contaminated with TCE and with PCE were found in the NJ study, but the finding was not limited to children (Cohn et al 1994). Nevertheless, it was decided to include childhood non-Hodgkin's lymphoma in the list of selected adverse outcomes for further evaluation.



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### C. Telephone survey

An important objective of the survey was to determine whether an epidemiological study of these adverse outcomes was feasible. In particular, several questions needed to be answered: Could a high percentage of the population be identified and contacted? Could most of the cases of these adverse outcomes in the population be reliably ascertained and verified? Would there be sufficient numbers of cases to study? The telephone survey began in September 1999 and was completed in January 2002.

The survey sought information on all children who were born to mothers who were pregnant while living in base housing during the period 1968-1985. This included births at the base and births that occurred after the mother was transferred off the base. If the survey was successful in obtaining information on a high percentage of these children, and if a sufficient number of cases of each of the adverse childhood outcomes could be ascertained and verified, then an epidemiological study could proceed. The survey was necessary because: (1) data from NC cancer and birth defect surveillance systems were not available before 1985, and (2) a number of mothers who were pregnant while residing at Camp Lejeune were transferred off the base prior to delivery and gave birth outside NC.

ATSDR attempted to locate and contact the parents of each eligible child to elicit information on the child's health as well as to confirm that the mother was a resident at the base at some point during the pregnancy. Eligible children were identified in two ways. First, the survey used the birth certificate information from the previous Camp Lejeune study of SGA (ATSDR 1998). A total of 12,493 birth



certificates were obtained for children born from 1968 through 1985 to mothers who lived in base housing at the time of delivery.

Second, children born from 1968 through 1985 to mothers whose pregnancies occurred while they lived in base housing but who lived off the base at the time of delivery were identified primarily by word-of-mouth (e.g., parent groups), by referrals from other parents during their interviews, or by parents prompted by media information about the survey to contact ATSDR or the USMC. The number of these births occurring off the base is unknown. However, staff of the Camp Lejeune Naval Hospital estimated that about one third of mothers receiving prenatal care at the hospital were transferred from Camp Lejeune before delivery. Based on this information, ATSDR estimated that between 3,500 and 4,500 mothers were transferred from Camp Lejeune before delivery. Therefore, an estimated total of 16,000 to 17,000 births occurred among women who were pregnant while living at Camp Lejeune during the study period (ATSDR 2003).

ATSDR surveyed the parents of 12,598 eligible children, representing an overall participation rate of between 74% and 80% depending on the estimate used for births that occurred off base. Of the 12,493 births that occurred on base, the survey was able to obtain information on 80.4%. Of the children born after the mother transferred off the base, information was obtained from 2,558. Assuming a total number of off-base births ranging from 3,500 to 4,500, this represented a participation rate of 64% to 73%. The survey demonstrated that an epidemiological study of this population could have high participation rates. Parents were asked if the child had had a birth defect or had developed a childhood



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cancer. Sufficient numbers of cases of NTDs, oral clefts, and childhood leukemias were ascertained to move forward with a study of these adverse outcomes.

#### D. Progress on the epidemiological study

Verification of the NTD, oral cleft, and childhood leukemia cases is ongoing. All verified cases and a random sample of non-cases will be selected for inclusion in the epidemiological study. Detailed interviews will be administered in Spring 2005 to parents in order to obtain data on maternal water consumption habits, residential history, and maternal and paternal risk factors. In order to provide a quantitative estimate of exposure, an historical exposure reconstruction approach will be taken, consisting of the modeling of the water distribution system at Camp Lejeune and the ground water contamination plumes. The method of historically reconstructing the water distribution system at Camp Lejeune will be similar to the approach taken in the Dover Twp, NJ study (Maslia et al. 2001; New Jersey Department of Health and Senior Services. 2003). Using water-distribution system modeling, it is possible to estimate quite accurately the proportional contribution of water from a water source to any location serviced by the water-distribution system. This technique can also provide the relative concentrations of specific contaminants in the water delivered to study subject residences. Work has begun on the modeling of the ground water contamination plumes and the water distribution system.



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