Health Consultation

Evaluation of Pesticide Residuals in Soil
Underneath the Shirley Base Housing Complex

FORT DEVENS

AYER, MIDDLESEX COUNTY, MASSACHUSETTS

CERCLIS NO. MA7210025154

SEPTEMBER 29, 1999

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:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
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Introduction

Summary

The town of Shirley, Massachusetts, asked the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the residual pesticide contamination in soils beneath the foundations of the now unoccupied Shirley Base Housing located adjacent to the main post area of Fort Devens. The Town of Shirley is considering the base housing area as the site of a future school.

In July 1999, ATSDR released a draft public health assessment for Fort Devens which evaluated the potential public health impacts of exposures to chemicals released during operations at Fort Devens. During construction of the Shirley Base Housing facility, pesticides were applied to the soil before the concrete foundation slab was poured to prevent termite infestation. At the time the public health assessment was being prepared, exposure to soil containing pesticides was not considered to be a potential public health threat because the soil is underneath the concrete foundation of the existing base housing, and no one has been or is currently coming into contact with the soil.

If the buildings are demolished and the concrete foundations removed, there is a possibility that someone may come into contact with the pesticides in the soil during construction of a future school, or if the soil is left in place and the area is converted into a school playground. Because of concerns expressed by members of the Shirley community, ATSDR evaluated the soil sampling data and estimated the potential exposures to harmful substances to determine the possibility of adverse health effects from contact with soils containing pesticide residues.

In this document, ATSDR focuses on two issues:

> Could children playing in a future schoolyard on the site of the former housing area be exposed to harmful levels of pesticides in soil?
>
> Could utility workers excavating soil in the area of the former base housing during construction of a future school be exposed to harmful levels of pesticides?

ATSDR staff met and spoke with representatives of the town of Shirley, MassDevelopment, the U.S. Army, and the Massachusetts Department of Environmental Protection. ATSDR relied on the quality of the information and soil sampling data obtained by agencies involved with the remediation and development of Fort Devens in its determination of the likelihood of adverse health effects associated with exposure to pesticides in soil under the base housing area.

ATSDR considers that, under plausible, site-specific conditions of exposure, the pesticide residues that may remain in soil at the proposed new school site will be *too low to produce any adverse health effects in humans*, including young children. This is based upon an evaluation of the data

and estimated exposures to individuals who may come into contact with contaminated soil either through construction of a future school building or recreational use of a school playground.

Regulatory agencies involved with the cleanup of contamination have established standards that guide remedial activities at Fort Devens. These regulatory requirements will be applied to the contamination in the soils at the former Shirley Base Housing, and may necessitate remedial actions, possibly including removal of contaminated soils. ATSDR believes it is good public health practice to prevent potential exposures, and supports any regulatory decisions and work practices that would prevent or mitigate exposures to hazardous substances.

Background and Statement of Issues

Fort Devens is a former military base located 35 miles northwest of Boston, Massachusetts. The base area covers approximately 9311 acres in the towns of Ayer, Harvard, Lancaster, and Shirley. In 1989, the USEPA placed Fort Devens on the National Priorities List of Superfund sites. Currently the South Post area is used for military training exercises, while the remainder of the base is undergoing environmental investigations and cleanup. The Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the public health implications of the chemical contamination at Fort Devens and documented their findings in a public health assessment draft released for public comment in June 1999 (ATSDR 1999).

In 1996, large areas of the base identified as the Main and North Posts were transferred to the local redevelopment and reuse authority, MassDevelopment, for development as a commercial and industrial center under the Devens Reuse Plan (Vanasse Hangen Brustlin, Inc. 1994).

The Town of Shirley is in the process of identifying locations to build a new school. The site of the former Shirley Base Housing area at Fort Devens is being considered as a potential school location (Figure 1). The former Shirley Base Housing area is located to the west of the Main Post, adjacent to the Shirley gate base entrance. The housing area covers approximately 50 acres and contains 22 two-story multi-family dwellings. During construction of the Shirley Base Housing, to prevent infestation with termites the pesticides aldrin, chlordane and DDT were apparently applied to the soil prior to laying the concrete foundations. From the limited information and sampling data available, ATSDR is not able to determine whether the pesticides applied to the soil under the Shirley housing area were applied in a manner consistent with manufacturers' guidelines. Currently, the buildings are vacant and have not been demolished. No one is currently being exposed to pesticides in soil at the Shirley housing area because the soil containing pesticide residues are covered by concrete foundation slabs.

Members of the selectmen of the town of Shirley requested that ATSDR evaluate soil sampling data collected underneath the building foundations to determine if there is any potential for health hazards from contact with the soils if the buildings are demolished, the slabs removed, and the soil exposed.

In July 1999, ATSDR representatives toured the Shirley Base Housing areas and met with officials of the Town of Shirley, Mass Development, the U.S. Army, and the Massachusetts Department of Environmental Protection (MADEP). The purpose of the meeting was to obtain information about the planned use of the base housing, to collect sampling data for the soils underlying the buildings and to hear community concerns expressed of behalf of the Shirley selectmen.

This document will evaluate the existing soil sampling data to determine the likelihood of adverse health effects from exposure to pesticide residues in soil. This health consultation will attempt to

answer two issues:

1. Could children playing in a future schoolyard on the site of the former housing area be exposed to harmful levels of pesticides in soil?

2. Could utility workers excavating soil during construction of a future school be exposed to harmful levels of pesticides?

Soil sampling at the Shirley Base Housing Area

In 1996, Haley and Aldrich, Inc., under contract with MassDevelopment, arranged for soil sampling to be performed at the Shirley Base Housing area to support their evaluation of the extent of potential contamination below and around the foundations of base housing areas under the jurisdiction of the local redevelopment authority (Maguire Group Inc. 1996).

Eighteen housing buildings are encompassed by the area intended as a future school site. The soil under two buildings was sampled. A total of twenty eight soil samples were taken by drilling through the concrete foundation either in the center or at the edge of each slab. Soil samples were taken at one foot intervals from 0-1 foot, 1-2 feet, 2-3 feet and 3-4 feet. The samples were analyzed in a laboratory for a range of pesticides in accordance with EPA method 8080. Aldrin, dieldrin and DDT were detected in soils, with aldrin present at the highest concentrations. Chlordane was not detected in any of the soils within one foot of the surface, but was detected in the deeper soil samples.

A summary of the sampling results is presented in Tables 1 and 2. Table 1 contains sampling data from 0-1 foot, considered representative of what a child might contact on a school playground. Table 2 contains the sampling data averaged over 0-4 feet, considered representative of the range of pesticide levels a construction worker may contact during excavation.

Contaminants of interest

The results of the soil sampling were compared with ATSDR's environmental media evaluation guidelines (EMEG) for specific pesticides in soil. The soil concentrations for aldrin and dieldrin exceeded the EMEG values for long term oral exposure in children, and were evaluated further as contaminants of interest. The other contaminants were below the EMEG values for both children and adults and were not considered further, as potential adverse health effects from exposure to these substances at the identified soil levels were too low to produce any adverse health effects in humans, including young children. It is important to note that these comparison values are extremely conservative and contain many safety factors to ensure protection to sensitive individuals.

Discussion

Exposure evaluation and health assessment methodology

In this section, ATSDR evaluates whether community members have been exposed in the past, are currently being exposed, or could be exposed in the future to harmful levels of pesticides in the soil underneath the Shirley Base Housing. If exposures are possible, ATSDR then considers whether the chemicals present are at levels that might be harmful to people. ATSDR does this by screening the maximum contaminant concentrations in the soil to health-based comparison values. These comparison values are derived from information in the scientific literature that identify concentrations in soils that would be unlikely to result in adverse health effects to people. If the maximum concentrations are above the screening value, then a more detailed analysis is performed.

ATSDR takes a conservative, health protective approach in evaluating the potential health implications from exposures to the contaminants in the Shirley Base Housing soil. The reader of this report should keep this in mind when interpreting ATSDR's analysis. It is important to note that comparison values are extremely conservative and contain many safety factors to ensure protection of sensitive individuals. These comparison values are not intended as thresholds for toxicity, but are used to identify chemicals for further toxicological evaluation.

To determine the likelihood of adverse health effects, are identified, the potential magnitude of the exposure to chemicals of interest is estimated using conservative assumptions regarding how someone may be exposed. ATSDR then compares this exposure estimate with information obtained from the scientific literature on the health effects of chemical exposures.

The relative toxicity of a chemical is important, but ATSDR also considers how the human body responds to a chemical exposure. How someone responds to exposure is determined by many factors including the concentration of the chemical in the environment, how the chemical enters the body, how often and how long an individual is exposed. Individual characteristics such as age, sex, body weight, genetics, and overall health status contribute to how a chemical behaves in the body. A unique combination of many factors will determine an individual's response to a chemical and the adverse health effects that may be experienced as a result of this exposure.

ATSDR methodology is consistent with the approach used by other public health agencies in estimating exposures. To be more concise for the general public, detailed explanations of exposure assumptions, calculations used to estimate exposures and estimated exposure levels are not presented in this document, but are available upon request.

Appendix A contains information about the toxicity of aldrin and dieldrin obtained from the scientific literature.

Exposure Pathways Evaluation and Public Health Implications

Could children playing in a future schoolyard on the site of the former housing area be exposed to harmful levels of pesticides in soil?

Table 1 shows the levels of pesticides detected in the top one foot of soil, which is most relevant from the standpoint of soil contact during recreational use. From a comparison with the pesticide levels to the EMEG values in Table 3, aldrin and dieldrin concentrations exceeded the EMEG values for a child ingesting soils on a daily basis, and were evaluated further. Figure 3 contains the ATSDR comparison values that were used to screen the sampling data and identify substances for further evaluation. Table 4 describes the elements of the exposure pathways to environmental contamination at the Shirley Base Housing. All elements must be complete for there to be exposure and the possibility of adverse health effects.

The next step in the evaluation was to estimate potential exposure levels of these compounds for children playing on bare soil containing aldrin and dieldrin residues. The exposure estimates considered the ways that the chemicals could enter the body, either by ingestion, skin contact, or inhalation of dust. To estimate exposure levels, assumptions were made regarding the frequency, duration, and intensity of contact with the soil contamination. These assumptions likely overestimate true exposure levels, but ATSDR chose to make conservative estimates of how someone might be exposed in order to be protective of human health.

Combining all exposure routes (oral inhalation and skin contact), the estimated average daily exposures to aldrin and dieldrin were more than two times below the conservative minimal risk level (MRL) published in the toxicological profile for aldrin and dieldrin (ATSDR 1993). An MRL is an estimate of the daily human exposure to a chemical that is likely to be without appreciable risks of adverse noncancer health effects.

Additionally, the exposure levels are three times below the WHO acceptable daily intake for aldrin and dieldrin (WHO, 1975) applicable to both adults and children. From studies in animals receiving exposure levels much higher than what would be estimated to occur at the Shirley Base Housing, a lowest adverse health effect level (LOAEL) of 0.025 mg/kg/day was identified for the most sensitive health effect at the lowest dose in a long-term study involving rats fed aldrin and dieldrin daily in food (Fitzhugh et al. 1964). The dose estimated for the Shirley Base Housing area was over 500 times lower than the LOAEL identified in this animal study. Levels of exposure to volunteers exposed for 18 months (the equivalent of 2 school years) where no adverse health effects were noted were at least 60 times higher than those estimated for children at a future school site using conservative exposure assumptions.

Furthermore, making an assumption about the density of the soil, a 5-year-old child would need to eat more than 2 tablespoons of soil at the maximum concentration detected per day to equal the dose level identified as the LOAEL which the MRL was based upon. Additionally, due to the

chemical properties of the soil and pesticides, the contaminants in soil may be less well absorbed through the gastrointestinal tract compared to the contaminants in the feed used in the animal studies.

Based upon an evaluation of potential exposure levels in relation to information in the scientific literature about exposure to aldrin and dieldrin and possible health effects, ATSDR believes the levels of pesticides in soil would not result in a public health hazard to children playing on a future school playground.

It is important to note that no past or current exposure is possible because the contaminated soils are under concrete slabs and are inaccessible. Future exposure is unlikely as contaminated soils will require further study and possible remediation under state regulatory requirements.

Could utility workers excavating soils in the area of the former base housing during construction of a future school be exposed to harmful levels of pesticides?

In looking at the soil data to evaluate the potential health hazards to construction workers, ATSDR based its analysis on the levels in the top four feet of soils (Figure 2). The pesticide concentrations in the soil samples taken from the former Shirley housing area were below ATSDR's EMEG comparison values for the detected pesticides in soil, indicating that adverse health effects in adults from exposure to soil during utility and construction activities are highly unlikely. Furthermore, the infrequent and short duration of contact with the soil limits potential exposures and subsequent adverse health effects.

ATSDR's Child Health Initiative

ATSDR recognizes that infants and children may be more sensitive than adults to environmental exposure in communities faced with contamination of their water, soil, air, or food. This sensitivity is a result of many factors, including the following: (1) due to their play activities, children are more likely to be exposed to certain media like soil when they play outdoors; (2) children are shorter than adults, and therefore may be more likely to breathe dust, soil, and vapors close to the ground; and (3) children are smaller than adults and therefore may receive a higher level of chemical exposure relative to their size and body weight. Children also can experience permanent damage if exposed to toxic substances during critical growth and development periods. As part of the Child Health Initiative, ATSDR is committed to evaluating children's unique vulnerabilities to environmental contaminants.

Aldrin and dieldrin are metabolized in the liver. In the very young, the biological systems responsible for this metabolism operate less efficiently than those in adults (Calabrese 1978). Because of the decreased ability to metabolize aldrin and dieldrin, the very young may experience increased toxicity due to the decreased rates of elimination of these chemicals from the body. Similarly, persons with impaired liver function may also experience increased toxicity because of

their limited ability to fully metabolize aldrin or dieldrin.

Persons suffering from compromised immune function may demonstrate an increased susceptibility to infections because aldrin and dieldrin may impair the immune system (Krzystyniak et al. 1985). Young children may also be susceptible because the human immune system does not reach maturity until 10 to 12 years of age (Calabrese 1978).

ATSDR reviewed the scientific literature mentioned above regarding special sensitivities of children to aldrin and dieldrin. The MRLs for aldrin and dieldrin are intended to protect more sensitive populations. The exposures estimated for children were below these protective values.

Conclusions

ATSDR has determined that the soil contamination below the Shirley Base Housing poses no apparent public health hazard from contact during school-related playground activities if a future school is built upon the site of the former Shirley Base Housing.

ATSDR believes that, under plausible, site-specific conditions of exposure, the pesticide levels under the Shirley Base Housing area are too low to produce any adverse health effects in humans, including sensitive populations such as children. This is based upon exposure estimates that account for child-specific exposure factors and incorporate conservative assumptions about exposures that likely overestimate true exposure levels. The estimated exposure levels at the Shirley Base Housing area were below the ATSDR minimal risk levels for aldrin and dieldrin.

ATSDR believes the soil presents no apparent public health hazard to construction and utility workers excavating the soil during construction and maintenance projects at a future school. Detected levels of pesticides in the soil underlying building foundations were below comparison values applicable to adult workers. Additionally, the exposure of the workers to contaminants in the soil is limited by the short and infrequent contact associated with excavation activities.

Currently no one is being exposed to pesticides in soil under the Shirley Base Housing area because the contaminated soil is covered by concrete slabs and the base housing is vacant. Past exposure was also not likely due to the soil being covered by the slabs and is inaccessible.

ATSDR's focus is on the potential public health impacts of exposure to hazardous substances, and serves only in an advisory capacity. Regulatory agencies involved with the cleanup of contamination have established standards that guide remedial activities at Fort Devens. These regulatory requirements will be applied to the contamination in the soil at the former Shirley Base Housing area, and may necessitate remedial actions, possibly including removal of contaminated soil. ATSDR believes it is good public health practice to prevent potential exposures, and supports decisions and work practices that would prevent or mitigate exposure to hazardous substances.

ATSDR recognizes that uncertainties exist in sampling data and scientific information about the adverse health effects from exposure to hazardous substances. To account for this uncertainty, ATSDR incorporated conservative assumptions about how people may be exposed and incorporates several safety factors in deriving comparison values such as EMEGs and MRLs. As additional information and data become available, ATSDR will further evaluate the potential for adverse health effects as needed.

Recommendations

ATSDR believes it is good public health practice to minimize potential exposures to hazardous substances. To support this principle, ATSDR makes the following recommendations for the Shirley Base Housing site:

1. If a decision to remediate soils contamination is made, post-remedial confirmatory sampling of the area intended for the school site should be performed to determine that unexpected and unacceptable levels of pesticides do not exist in exposed soil.

2. A health and safety plan should be in place prior to excavation projects to reduce exposures to workers.

3. Dust control measures should be in place and followed during construction activities in the area of the former Shirley Base Housing area.

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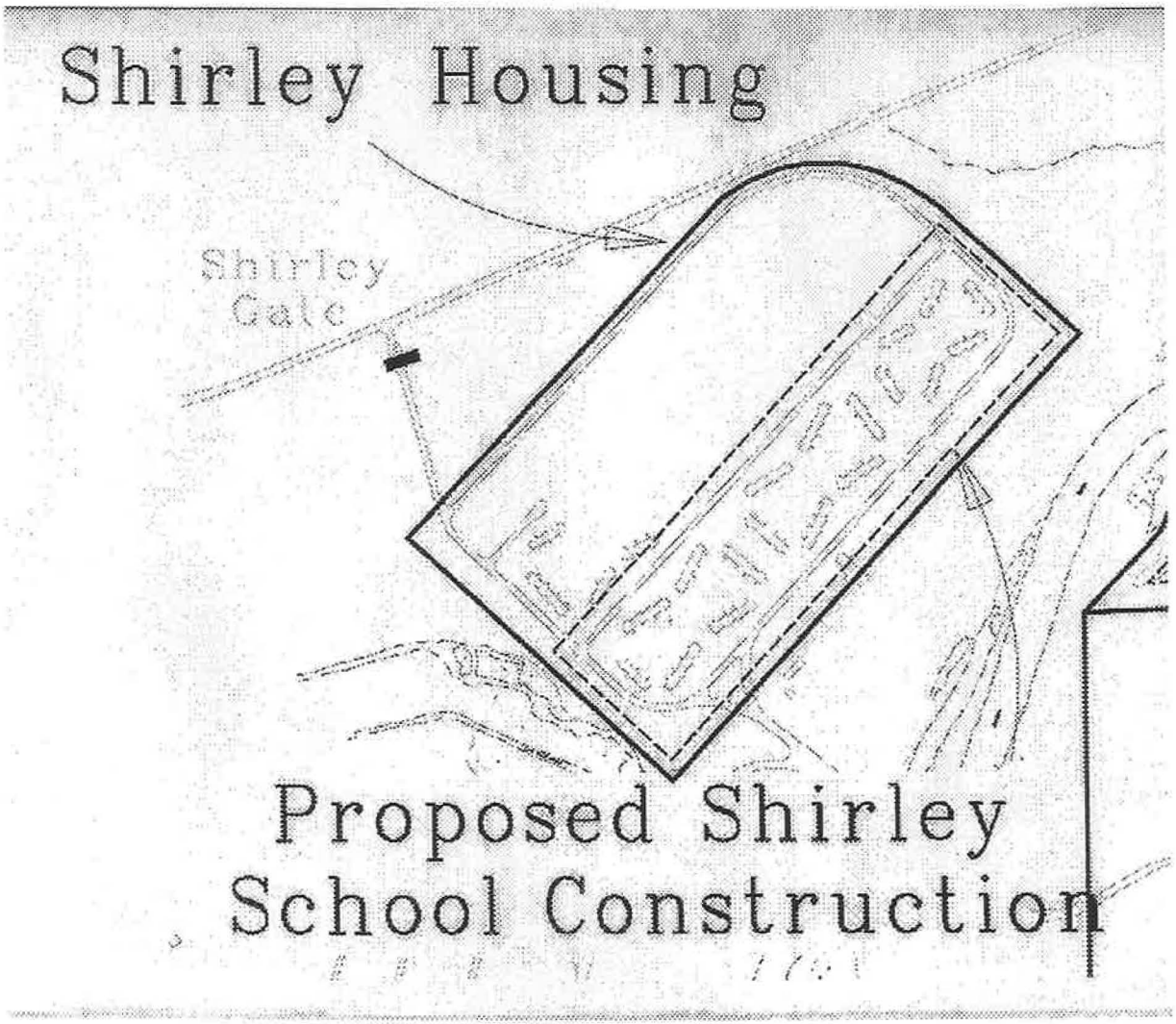
Figure 1. Proposed Shirley School construction area.



Tables

Table 1. Pesticide levels in soil, 0-1 foot (mg/kg).

Pesticide	# detects/samples	Minimum	Maximum	Average	Maximum location
Aldrin	7/7	0.93	10.60	3.09	939B
Dieldrin	7/7	0.59	8.25	2.86	939B
Chlordane	0/7	ND (.007)	ND (.007)	ND (.007)	----
DDT	4/7	ND (.007)	6.07	0.92	939B

ND(0.007): Compound was not detected at a method detection limit of 0.007 mg/kg.

Table 2. Pesticide levels in soil, 0-4 foot (mg/kg).

Pesticide	# detects/samples	Minimum	Maximum	Average	Maximum location
Aldrin	14/28	ND (.007)	10.60	0.80	939B
Dieldrin	15/28	ND (.007)	8.25	0.75	939B
Chlordane	4/28	ND (.007)	0.48	0.03	939B
DDT	18/28	ND (.007)	7.39	0.83	939B

ND(0.007): Compound was not detected at a method detection limit of 0.007 mg/kg.

Table 3. Comparison values for pesticides detected in soil.

Pesticide	EMEG (mg/kg) adult, chronic oral	EMEG (mg/kg) child, chronic oral	MRL (mg/kg/day)	Do pesticide concentrations exceed comparison values?
Aldrin	20	2	0.00003	Y
Dieldrin	40	3	0.00005	Y
Chlordane	400	30	0.0006	N
DDT	400	30	0.0005	N

Table 4. Pathways of exposure to pesticide residuals in soil.

Pathway Name	Chemical Compound	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	Comment
Excavation for future school site	Aldrin Dieldrin	Soil (0-4 ft.)	Excavation of soils during utility work.	Inhalation Ingestion Skin contact	Utility workers	ATSDR believes that the low levels of pesticides in soils would not result in adverse health effects because of short and infrequent exposure to aldrin and dieldrin. No past or current exposure is possible because the contaminated soils are under concrete slabs and are inaccessible. Future exposure is unlikely as contaminated soils will likely need to be cleaned-up under State regulations.
Future School Playground	Aldrin Dieldrin	Soil (0-1 ft.)	Recreational use of school playgrounds.	Inhalation Ingestion Skin contact	Children	ATSDR believes that exposures to low levels of aldrin and dieldrin in soils would not result in adverse health effects to children. No past or current exposure is possible because the contaminated soils are under concrete slabs and are inaccessible. Future exposure is unlikely as contaminated soils will likely need to be cleaned-up under State regulations.

Appendix A: Literature search on the toxicity of aldrin and dieldrin.

Use and human exposure potential

Aldrin and dieldrin are two closely related compounds in the organochlorine class of pesticides. Aldrin and dieldrin are no longer used, but from the 1950s until 1970, they were used widely as insecticides on crops such as corn and cotton. The U.S. Department of Agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved aldrin and dieldrin as a pesticide for eradicating termites. The use of aldrin and dieldrin to control termites continued until 1987. In 1987, manufacturers voluntarily canceled the registration for use in controlling termites (ATSDR 1993).

Aldrin and dieldrin are still present in the environment from these past uses. Sunlight and bacteria in the environment can change aldrin to dieldrin. As a result, dieldrin is typically found in areas where aldrin was originally released. Dieldrin in soil or water breaks down slowly. Aldrin and dieldrin stick to soil very strongly and may stay there unchanged for many years. Background levels of dieldrin in soil are about 0.001 part per million (ppm) (ATSDR 1993). To provide some perspective on the units of concentration, one ppm is equivalent to one inch in 16 miles.

The major source of general population exposure to aldrin and dieldrin is through the diet. The 1982-1984 estimated daily intake from food was approximately 1 nanogram per kilogram body weight per day (ATSDR 1993). One nanogram is one billionth of a gram. In order to establish limits on aldrin residues in foods, the World Health Organization (WHO) has recommended that 0.0001 mg aldrin/kg body weight is an acceptable daily intake that is unlikely to result in adverse health effects over a lifetime of daily exposure (WHO 1975).

Toxicity

Aldrin and dieldrin both exert their effects in insects and other animals by interfering with the nervous system. At low levels typical of human exposures to environmental contamination, these chemicals can have effects on different organ systems.

Animal studies

It is important to note that the health effects seen in animal studies involved much higher exposure levels than what is anticipated to occur from contact with soils at the former Shirley Base Housing area.

In similarity with studies of human exposure, animal studies show effects of aldrin and dieldrin on the nervous system and on the kidneys. Studies in animals, however, show that mice that eat large doses of aldrin or dieldrin daily over a lifetime develop liver tumors. Animal studies also show that exposure to moderate levels of aldrin and dieldrin for a short time causes decreased

ability to fight infections. Study result in animals give conflicting information about whether aldrin and dieldrin causes birth defects. Studies in animals also give conflicting information about whether aldrin and dieldrin make it more difficult for male animals to reproduce (ATSDR 1993). There is conflicting information in animal studies that show species and sex differences in response to exposure. We do not know whether these effects also occur in people.

Human studies

Most of the studies involving human exposures to organochlorine pesticides such as aldrin and dieldrin involve accidental poisonings, intentional exposures during suicide attempts, or occupational studies of workers who had been exposed during the process of manufacturing pesticides. The levels of exposure to aldrin and dieldrin in these studies were higher and for longer periods of time than the exposures that were estimated for children coming into contact with contaminated soils at the former Shirley Base Housing area.

From human studies and case reports, aldrin and dieldrin seem to cause similar adverse health effects. Short-term exposures to 26.5 mg/kg resulted in convulsions and kidney damage to an adult who attempted suicide by ingesting aldrin (Spiotta 1951). Dieldrin given to volunteers daily for 18 months at doses as high as 0.003 mg/kg/day showed no adverse effects on nervous system activity (Hunter and Robinson 1967). Some sensitive people develop a condition in which aldrin or dieldrin causes the body to destroy its own blood cells (ATSDR 1993). We do not know whether aldrin or dieldrin affects the ability of men to father children. We also do not know whether aldrin or dieldrin cause birth defects or cancer in people.

The International Agency for Research on Cancer has determined that aldrin and dieldrin are not classifiable as to their carcinogenicity to humans (IARC 1974a; IARC 1974b). From animal studies, EPA has determined that aldrin and dieldrin are probable human carcinogens (ATSDR 1993). Human studies do not support a conclusion that these compounds are carcinogenic in humans.

A study was conducted to investigate the occurrence of long-term health effects in humans exposed to aldrin and dieldrin. A group of 570 workers employed from 1954 to 1970 in a pesticide production facility were followed up for mortality until 1993. Data from industrial hygiene and biological monitoring for aldrin and dieldrin were available for most of the workers. From this data, individual estimates of total dieldrin and aldrin intake were made. No increase in mortality from liver cancer was observed in the study population. An analysis by job title did not show any excess cancer in any particular job. Overall, this study did not support a carcinogenic effect of exposure to dieldrin and aldrin in humans (de Jong et al. 1997).

In another study, causes of death were assessed for a group of 232 workers engaged in the manufacturing and formulation of aldrin, dieldrin, endrin and telodrin. This group is part of the total exposed population that was selected for follow up due to the high exposures in the initial

years of manufacturing and formulation and of the long exposure (mean 11 years) and observation (mean 24 years) periods. Although in this group the exposures were high and exposure and observation periods were long enough for meaningful evaluation, this study revealed no indication of carcinogenic activity of aldrin or dieldrin in the workers (Ribbens et al. 1985)

Pesticide workers in a Shell plant in Holland had occupational exposure to dieldrin over periods of up to 12.3 years with an average of 6.6 years. 223 long term workers were involved in this study and no permanent adverse health effects (including cancer) on the workers' health were observed (Versteeg 1973).

Thirteen volunteers were given dieldrin by mouth for 18 months; in 9 of them the daily dose ranged from 0.00014 to 0.003 milligrams per kilogram (mg/kg) body weight (assuming a 70 kg adult body weight). None showed evidence of ill health and results of clinical and lab investigations remained within the normal range and showed no significant change (Reynolds 1982; Hunter and Robinson 1967).

No adverse effect level doses to these volunteers exposed for 18 months (the equivalent of 2 school years) were at least 60 times higher than those estimated for children at a future school site using conservative exposure assumptions.