

5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

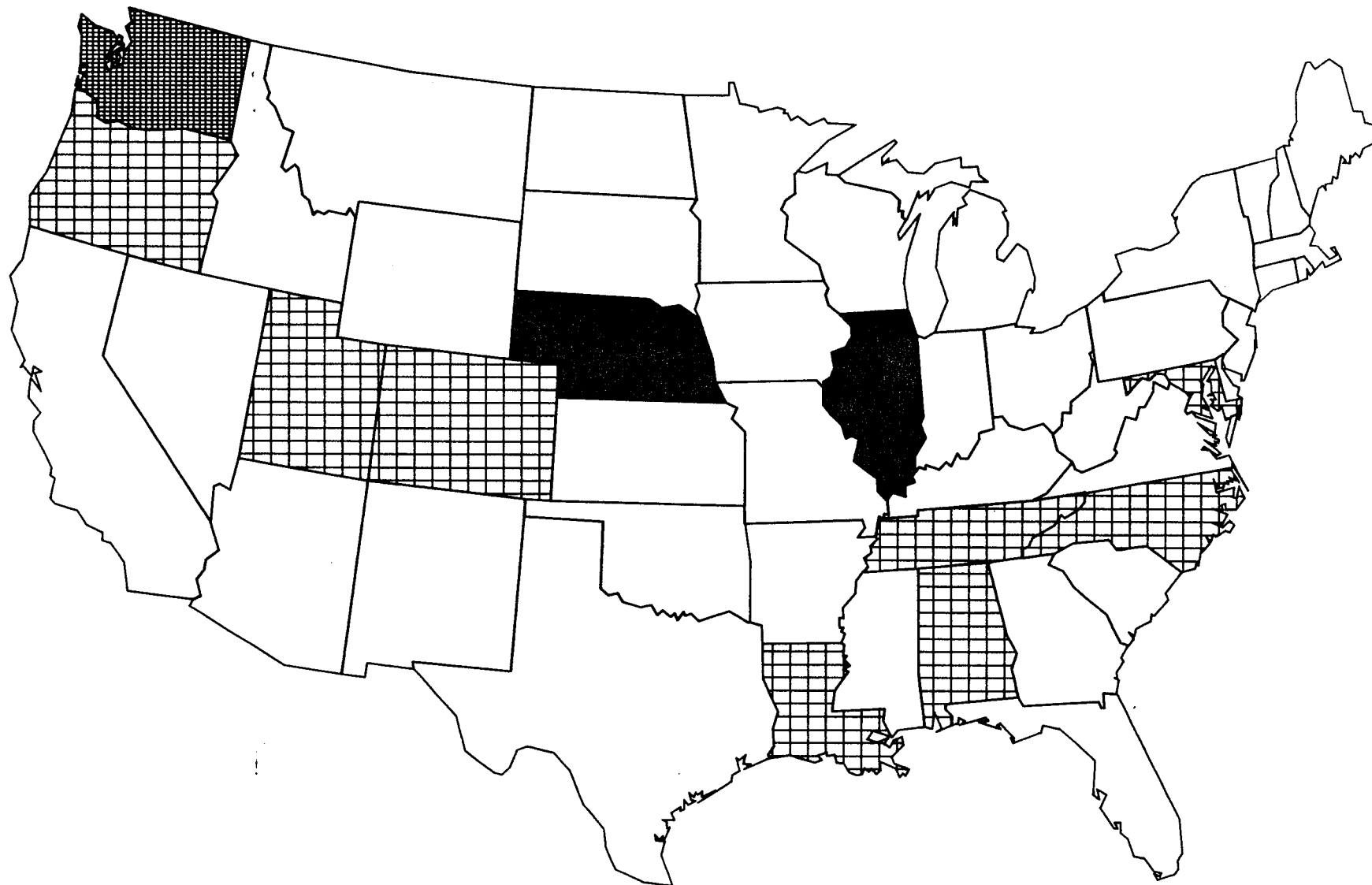
RDX is a widely used military explosive. It is a synthetic compound and is not known to exist in nature. Effluents and emissions from Army ammunition plants are responsible for the release of RDX into the environment. When released to the atmosphere, RDX may be removed by reaction with photochemically generated hydroxyl radicals (half-life = 1.5 hours). When released to water, RDX is subject to photolysis (half-life = 9-13 hours). Photoproducts include formaldehyde and nitrosamines. RDX undergoes biodegradation in water and soil under anaerobic conditions. Its biodegradation products include hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine; hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX); hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX); hydrazine; 1,1-dimethyl-hydrazine, 1,2-dimethyl-hydrazine; formaldehyde; and methanol. RDX is mobile in soil and can leach into groundwater, and can be transported from soils to plants.

For the general population, exposure to RDX is limited to areas around Army ammunition plants where it is manufactured, converted to munitions, packed, loaded, or released through the demilitarization of antiquated munitions. The most likely route of exposure is ingestion of contaminated drinking water. Inhalation exposure of contaminated particulate matter produced during incineration of RDX-containing waste material is also a possible route of exposure. Occupational exposure to RDX can occur when workers handle RDX at Army ammunition plants. According to the National Occupational Exposure Survey (NOES) of 1981-1983 conducted by NIOSH, the estimated number of workers potentially exposed to RDX in the United States was 488 (NOES 1990).

RDX has been identified in 16 of the 1,397 hazardous waste sites that have been proposed for inclusion on the National Priorities List (NPL) (HazDat 1994). The frequency of these sites within the United States can be seen in Figure 5-1.

Since RDX releases are not required to be reported under SARA Section 313, there are no data on RDX in the Toxics Release Inventory (TRI 1993).

FIGURE 5-1. FREQUENCY OF NPL SITES WITH RDX CONTAMINATION *



FREQUENCY



1 SITE
3 SITES

2 SITES

*Derived from HazDat 1994

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5.2 RELEASES TO THE ENVIRONMENT

5.2.1 Air

RDX can enter the air through the release of contaminated particulate matter formed during the incineration of RDX-containing mixtures (Army 1984a). RDX can also enter the air through evaporation from aquatic effluent streams or waste storage lagoons (Army 1984a).

5.2.2 Water

RDX can be released to water in waste discharge effluents from Army ammunition production, formulation, manufacturing, loading, assembly, and packing, and through the demilitarization of antiquated munitions (Army 1980a, 1984a, 1984f).

5.2.3 Soil

Manufacturing, packing, and use of RDX have often resulted in contamination of soil. RDX can enter soil by leaching from waste lagoons and from improper disposal of contaminated sludge (Army 1984a). RDX can also enter the soil from spills during manufacture, transportation, and storage. Releases can also occur from the settling of airborne particulates from manufacturing and incineration onto soil surfaces (Army 1984a).

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

RDX has a vapor pressure of 1.0×10^{-6} mm Hg (Army 1987a). It may exist in both the vapor phase and particulate phase in the atmosphere (Eisenreich et al. 1981). The solubility of RDX in water is low to negligible (Merck 1989; HSDB 1994). However, the following water solubility values have been reported: 21.8-21.9 mg/L at 10 °C, 38.4-38.9 mg/L at 20 °C, and 66.7-67 mg/L at 30 °C (Army 1983b). RDX is slightly soluble in methanol, ether, ethyl acetate, and glacial acetic acid (Merck 1989). The Henry's law constant for RDX (1.2×10^{-5} atm-m³/mol) (McKone and Layton 1986)

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indicates that RDX tends to partition equally between the atmosphere and water (Eisenreich et al. 1981) and that volatilization is a slow transport process (Lyman et al. 1982).

The calculated soil sorption coefficient (K_{OC}) values for RDX range from 63.1 (Army 1987a) to 270 (Army 1983b). These K_{OC} values are indicative of medium-to-high mobility in soil (Swarm et al. 1983); therefore, RDX can be expected to leach into groundwater. Experimental data have shown that RDX is not readily bound or retained in soil as evidenced by its early breakthrough in column leachates (Army 1985a). A lysimeter study of the migration of RDX in soil showed that RDX was found in leachate from the soil columns (Navy 1982). Based on these K_{OC} values and the experimental data, adsorption to sediment and particulate matter in the aquatic environment should not be significant (Army 1980a). Although RDX does not significantly adsorb to sediment, greater adsorption occurs with an increase in organic matter or clay content (Army 1980a). However, the clay content seems to be more important than organic matter content in influencing the amount of RDX adsorbed (Army 1980a). In a later study sponsored by the U.S. Army Medical Research and Development Command (USAMRDC), the adsorption rate constant of RDX in soil was found to be low (k_d of <1 mg/g). The adsorption constant was linearly correlated with a combination of soil properties, such organic carbon and clay content, pH, and cation exchange capacity (Ainsworth et al. 1993). It appears that sorption of RDX in soils is not solely the result of hydrophobic partitioning of RDX to the organic carbon phase of the soils.

The logarithm of the octanol/water partition coefficient ($\log K_{OW}$) is a useful preliminary indicator of potential bioaccumulation of a compound. The $\log K_{OW}$ for RDX was estimated to be 0.87 (HSDB 1994), indicating RDX is not very lipid soluble and therefore has a low potential for bioaccumulation. Experimental bioconcentration factors in edible tissue for bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), and fathead minnow (*Pimephales promelas*) were 1.9-6.4, 1.2-5.5, and 1.4-5.9, respectively (Army 1984a). These factors indicate that bioaccumulation in aquatic organisms is not an important fate process.

Data indicate that RDX can be taken up by plants (Army 1990a; Harvey et al. 1991). Studies of bean plants grown in 10 ppm RDX hydroponic solutions and exposed for 1 or 7 days indicated that uptake of RDX readily occurred. Following uptake, translocation of the compounds to the aerial tissue occurred, resulting in foliar concentrations of 20 ppm and 97 ppm for the 1 and 7 day exposures, respectively. Metabolism of RDX to polar metabolites was observed in plants exposed for 7 days

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(Harvey et al. 1991). Additional studies of hydroponic plant-culture systems indicated that RDX (1-10 ppm) was also absorbed by the roots of brome and wheat and that plant absorption was concentration-dependent (Army 1990a). In a later study, plants were grown in soils containing 10 ppm RDX for a period of 60 days, and the extent of plant uptake was found to be dependent both on soil type and plant species (Cataldo et al. 1993). RDX was transported unchanged from soils to plants and the plant uptake increased as the organic matter content of soil decreased. In bush bean plants, RDX was mostly concentrated in leaves and seed, but less in roots, stems and pods. In case of wheat and brome, RDX mostly concentrated in leaves and roots, but very little or none in seeds (Cataldo et al. 1993). After plant uptake, RDX in storage tissues of plants (i.e., roots and stems) mostly metabolized to unidentified polar metabolites or non-extractable products, while RDX remained mostly unchanged (>50%) in leaves and seed tissues (Cataldo et al. 1993).

5.3.2 Transformation and Degradation

5.3.2.1 Air

When released to the atmosphere, RDX is degraded by reacting with photochemically generated hydroxyl radicals (Atkinson 1987; HSDB 1994). The half-life for this reaction in the vapor phase was estimated to be 1.5 hours (Atkinson 1987; HSDB 1994). No data were located on photolysis of RDX in the atmosphere. However, it is expected that photolysis of RDX is an important fate process in the atmosphere since RDX absorbs ultraviolet wavelengths between 240 and 350 nm (Army 1986e) and it undergoes rapid photolysis in water (Army 1980a).

5.3.2.2 Water

In a hydrolysis study of RDX in seawater (pH 8.1) at 25 °C, 11.6% of initial RDX hydrolyzed in 112 days (Hoffsommer and Rosen 1973). Other data found that RDX was stable to hydrolysis in an aqueous solution at a pH range normally found in natural waters (Army 1980a). Therefore, hydrolysis is not expected to significantly influence the environmental fate of RDX.

The primary physical mechanism that degrades RDX in aqueous solutions is photolysis (Army 1986e). The range of ultraviolet wavelengths that causes photolytic reactions with RDX is generally between 240 and 350 nm (Army 1986e). RDX in waste water (23.9 mg/L) exposed to ultraviolet radiation

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decomposed with a half-life of 3.7 minutes (Burrows et al. 1984). Photolysis of an aqueous solution of RDX in natural sunlight is fairly rapid with an experimental half-life of 9-13 hours. Consequently, RDX is not expected to persist for a long period of time in surface waters (Army 1980a). Formaldehyde and nitrosamines were identified as photoproducts. Nitrosamines may be of environmental importance because of their potential mutagenicity/carcinogenicity. Conversion to this product, however, occurs only to a limited extent since the product itself is photoreactive (Army 1980a). The rate constants for photolytic transformation of RDX in the waste-water lagoon of a Louisiana Army ammunition plant were determined as 0.016 cm/day in the winter and 0.076 cm/day in the summer (Army 1983b). The half-life of RDX was estimated to range from over 2,000 days in winter to 456 days in summer in a lagoon 50 cm deep (Army 1983b). The slow photolysis rate can be attributed to the high absorptivity of light by surface water of the lagoon, which allowed little light to penetrate deeper into the lagoon water (Army 1983b).

The biodegradation of RDX has been studied under aerobic and anaerobic conditions. RDX did not undergo aerobic biodegradation using a variety of inocula and nutrients (Osmon and Klausmeier 1973). However, microbial degradation studies were carried out using water and sediment samples collected from the Holston River and the waste-water effluents from the Holston Army ammunition plant showed some degradation (Army 1980a). Only the addition of river sediments appeared to stimulate the aerobic biodegradation of RDX in samples of river water containing either 5.5 or 11.5 ppm of RDX. The half-life for the disappearance of RDX in water samples supplemented with sediment was approximately 7 days. A lag period of 2-3 weeks was observed before a noticeable degradation of RDX occurred. The results showed that biodegradation of RDX leads to mineralization of the molecule (Army 1980a). No degradation of RDX was observed during a 90-day aerobic experiment with RDX in the lagoon water alone, with added yeast extract, or with 1% of bottom sediment (Army 1983b). Concentrations of RDX remained unchanged when cultures were inoculated with aerobic activated sludge and incubated aerobically. No RDX disappeared in uninoculated controls (McCormick et al. 1981).

Data are available indicating that biodegradation of RDX occurs under anaerobic conditions (Army 1984f; McCormick et al. 1981; Walker and Kaplan 1992). RDX (50 or 100 $\mu\text{g/mL}$) disappeared rapidly from nutrient broth cultures inoculated with anaerobic sewage sludge and incubated anaerobically. Biodegradation of RDX was complete after 4 days (McCormick et al. 1981). The disappearance of RDX was accompanied by the appearance of several products identified as the

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mono-, di-, and trinitroso derivatives of RDX formed by sequential reductions of the nitro groups to nitroso groups (McCormick et al. 1981; Walker and Kaplan 1992). Anaerobic biodegradation products included hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine (MNX); hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX); hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX); hydrazine; 1,1-dimethyl-hydrazine; 1,2-dimethyl-hydrazine; formaldehyde; and methanol. The nitroso intermediates are known to be hazardous. Both 1,1- and 1,2-dimethylhydrazine, as well as hydrazine, are known mutagens and/or carcinogens (McCormick et al. 1981), but may be found naturally in the environment (e.g., certain mushrooms).

After an incubation period of 5 days, 97% of RDX was anaerobically degraded by a mixed population of purple photosynthetic bacteria of the genera *Chromatium*, *Rhodospirillum*, and *Rhodopseudomonas*, and possibly others (Navy 1973). Sixty percent of RDX was anaerobically degraded by *Chromatium* alone (Navy 1973). These photosynthetically active cultures, which do not release oxygen, were supplemented with sodium acetate and ammonium chloride. It was hypothesized that RDX was not actually metabolized, but rather was being reduced and modified as a result of the active electron transfer brought about by the anaerobic photosynthetic activity of the organisms.

RDX (13 ppm) in lagoon waste water at the Louisiana Army ammunition plant did not undergo anaerobic degradation for approximately 90 days with yeast extract repeatedly added as a nutrient (Army 1983b). The RDX concentration dropped to 2.9 ppm at day 90 and to 1.4 ppm at day 92. The authors reported that the repeated addition of yeast extract acclimated RDX-utilizing organisms. The RDX-acclimated organisms then degraded 9.1 ppm of RDX 93% after 5 days of anaerobic incubation (Army 1983b).

5.3.2.3 Sediment and Soil

Three soils containing 0.5%-7.2% organic matter were amended with 60 ppm (mg/kg) RDX and incubated for 60 days under aerobic conditions (Cataldo et al. 1993). After 60 days, >95% were extractable and remained unchanged as parent RDX; only <2% remained non-extractable in the soils. No significant transformation products of RDX were observed in the soils. These results indicate that RDX may not be easily amenable to aerobic biodegradation in soils. However, significant biotransformation may occur under certain conditions. The degradation of pink water compounds in soil was studied (Army 1985a). Pink water is a generic term used for colored waters that may contain

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some explosive compounds, including RDX. A simulated pink water containing RDX (30 mg/L) was continuously applied to a series of soil columns at different flow rates, with and without carbon supplementation. The columns were inoculated with combined samples of microorganisms from activated sludge, anaerobic sludge digest, and garden soil. Concentrations of RDX and biotransformation products were monitored on a weekly basis. There appeared to be a significant decrease in RDX recovery in the leachate of the column with slow and fast flow with carbon supplement, indicating microbial activity. The mononitroso derivative (MNX) and the dinitroso derivatives of RDX were identified in the leachate of the column with fast flow (100 ml/day) and carbon supplement (2.0 g/L glucose). MNX was also identified in the leachates from the columns with slow flow (40 ml/day) with and without carbon supplement (Army 1985a). Since the nitroso derivatives are intermediates in the anaerobic biodegradation of RDX in aqueous systems (Walker and Kaplan 1992), it is likely that the observed products resulted from anaerobic biodegradation of RDX. The authors reported that land treatment or land farming of pink water should not be considered as a treatment option for pink water. Hazardous biotransformation intermediates and unchanged concentrations of some of the pink water compounds would contaminate groundwater and soil.

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

5.4.1 Air

No data are available regarding levels of RDX in outdoor air. However, indoor air samples collected at Holtson Army ammunition plant in Kingsport, Tennessee in 1974 contained RDX levels ranging from not detected ($<0.5 \text{ mg/m}^3$ [4.5 ppm]) to 60 mg/m^3 (546 ppm) (Army 1975). A more recent study found that RDX was detected at a concentration of 0.032 mg/m^3 (0.29 ppm) in the particulate fraction of one indoor air sample taken from the incorporation area of Holtson Army ammunition plant in 1986 (Bishop et al. 1988).

5.4.2 Water

Seawater samples taken in 1971 from a munitions dumping area 85 miles west of Cape Flattery, Washington, and similar samples taken 172 miles south-southeast of Charleston, South Carolina, were analyzed for RDX (Navy 1972). No RDX was found in any of the samples examined (detection limit of 5 ppt). RDX was found on-site at the Savanna Army Depot in Illinois in surface water samples at

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a maximum reported concentration of 36.9 ppm (ATSDR 1989c). The Savanna Army Depot is on the NPL. It is an Army munitions plant engaged in munitions renovation, loading, demolition, and burning. On-site groundwater sampling at the Milan Army ammunition plant in Tennessee identified RDX at concentrations ranging from not detected to 11.24 ppm (detection limit not reported) (ATSDR 1989b). Maximum concentrations of RDX detected in water at the Cornhusker Army ammunition plant (Nebraska) were 0.307 and 0.371 ppm from on-site and off-site wells, respectively (ATSDR 1989a). A plume of RDX-contaminated groundwater, which stretched 6.5 km, was found near the Cornhusker Army ammunition plant. The concentrations ranged from 9 to >100 µg/L (Spalding and Fulton 1988). The Louisiana Army ammunition plant is a shell manufacturing and explosives load, assembly, and pack facility (Army 1988). From 1951 to 1980, waste waters were trucked to and discharged into a series of artificial leaching pits, which resulted in contamination of soil, sediments, and groundwater. Levels of RDX measured in groundwater at the Louisiana Army ammunition plant ranged from 1.3 to 14,100 µg/L (Army 1988).

5.4.3 Sediment and Soil

Ocean floor sediment samples taken in 1971 from a munitions dumping area 85 miles west of Cape Flattery, Washington, and similar samples taken 172 miles south-southeast of Charleston, South Carolina, were analyzed for RDX (Navy 1972). No RDX was found in any of the sediment samples analyzed. RDX was found on-site at the Savanna Army Depot in Illinois in soil samples at a maximum concentration of 12.3 ppm (ATSDR 1989c). RDX was found at the Louisiana Army ammunition plant in soil and drainage sediments at concentrations ranging from <5 to 602 mg/kg (Army 1988).

5.4.4 Other Environmental Media

Ocean floor fauna samples (rat tail fish and sea cucumbers) taken in 1971 from munitions dumping areas in the Atlantic and Pacific oceans contained no RDX residues (detection limit of 0.123 µg/kg) (Navy 1972).

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5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

For the general population, exposure to RDX is most likely limited to areas around Army ammunition plants where RDX is manufactured, converted to munitions, or released through the demilitarization of antiquated munitions (Army 1980a, 1984a, 1984f). The most likely route of exposure for populations living in the vicinity of Army ammunition plants is ingestion of contaminated drinking water. Inhalation exposure of contaminated particulate matter produced during incineration of RDX-containing waste material is a possible route of exposure. However, since no monitoring data were located regarding levels of RDX in air, the extent of exposure by this route is not known. Dermal contact with contaminated soil is also a possible route of exposure. However, since no absorption data following dermal exposure to RDX were located, the extent of exposure by this route is also not known.

Occupational exposure to RDX can occur when workers handle RDX in explosive plants (Hathaway and Buck 1977; Kaplan et al. 1965). Inhalation exposure of workers to RDX has occurred as a result of release of dust into the workroom air, principally during dumping of dried RDX powder, screening and blending, and clean-up of spilled material (Kaplan et al. 1965). Exposure to RDX can also occur through dermal contact during manufacture, handling, and clean-up of RDX (Kaplan et al. 1965). RDX was detected at a concentration of 0.052 mg/m^3 (0.47 ppm) in the particulate fraction of one indoor air sample taken from the incorporation area of Holston Army Ammunition Plants in Tennessee in 1986 (Bishop et al. 1988). Based on the observed concentration, the authors considered the potential for exposure to RDX to be very low.

According to the NOES (1981-1983), the estimated number of workers potentially exposed to RDX in the United States was 488 (NOES 1990)

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Workers involved in the production and use of RDX at Army ammunition plants constitute a group at risk because of the potential for occupational exposure. Persons living near Army ammunition plants or hazardous waste sites may have a higher risk of exposure to RDX resulting from inhalation of dusts or fumes, ingestion of contaminated drinking water, or contact with contaminated soil.

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5.7 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of RDX is available. where adequate information is not available, ATSDR, in conjunction with NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of RDX.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that, if met, would reduce or eliminate the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda may be proposed.

5.7.1 Identification of Data Needs

Physical and Chemical Properties. The physical and chemical properties of RDX are sufficiently characterized to permit estimation of its environmental fate (Army 1986e, 1987a; HSDB 1994; Merck 1989; McKone and Layton 1986).

Production, Import/Export, Use, Release and Disposal. RDX is not produced commercially in the United States (HSDB 1994). Production in the United States is limited to Army ammunition plants such as Holston Army Ammunition Plants in Kingsport, Tennessee, which has been operating at 10-20s capacity (Army 1986e). Several Army ammunition plants also handle and package RDX such as Louisiana (Shreveport, Louisiana), Lone Star (Texarkana, Texas), Iowa (Middletown, Iowa), and Milan (Milan, Texas) (Army 1986e). Current import/export data for RDX are not available. RDX is primarily used as a high explosive, although it has been used occasionally as a rat poison or for civilian uses, such as in fireworks or as heating fuel for food rations (Merck 1989; HSDB 1994; Turley and Brewster 1987). RDX is primarily found in water, groundwater, and soil around Army ammunition plants (Army 1988; ATSDR 1989a, 1989b, 1989c; Spalding and Fulton 1988). Data on the most commonly used disposal methods are sufficient (Army 1986a, 1986c; Hoffsommer and Rosen

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1972); however, more data on the amounts of RDX being disposed of and on alternative disposal methods would be useful. RDX wastes produced in manufacturing and processing are classified as hazardous wastes and are subject to EPA regulations (EPA 1990a).

Environmental Fate. RDX released to the environment partitions into air, water, and soil (Army 1980a, 1983b, 1987a; Eisenreich et al. 1981; Lyman et al. 1982). RDX is transported in soil, surface water, and groundwater (Army 1983b, 1985a; 1986e, 1987a; Swann et al. 1983). Volatilization is expected to be a slow transport process (Lyman et al. 1982). No data were located in the literature regarding atmospheric transport of RDX. RDX is degraded in the atmosphere by reacting with photochemically generated hydroxyl radicals (half-life = 1.5 hours) (Atkinson 1987; HSDB 1994). Experimental data are needed regarding photolysis of RDX in the atmosphere. Photolysis is the primary mechanism of RDX degradation in water (half-life = 9-13 hours) (Army 1980a, 1986e). Biodegradation of RDX occurs in water and soil, principally under anaerobic conditions (Army 1984f, 1985a; McCormick et al. 1981; Osmon and Klausmeier 1973). Biodegradation half-life data for RDX and its breakdown products in water and soil are needed. This information will be helpful in better identifying the most important pathways of human exposure to RDX.

Bioavailability from Environmental Media. Absorption data regarding dermal exposure in humans are not available. Very limited data indicate that RDX is absorbed following inhalation exposure (Kaplan et al. 1965). RDX is absorbed through the gastrointestinal system following ingestion of the compound (Hollander and Colbach 1969; Ketel and Hughes 1972; Merrill 1968; Stone et al. 1969). The oral and dermal routes of exposure may be of concern to humans because of the potential for RDX to contaminate drinking water and soil. More information regarding all absorption routes, particularly on the absorption of RDX following ingestion of contaminated drinking water and soil or plants grown in contaminated environments, is needed to better characterize the bioavailability of RDX.

Food Chain Biotaccumulation. Based on a low log K_{ow} and a low experimental BCF, RDX has a low bioconcentration potential in aquatic organisms (Army 1984a; HSDB 1994). Limited data were located regarding bioaccumulation of RDX in plants (Harvey et al. 1991). No data were located regarding bioconcentration potential in animals. Data are needed regarding bioconcentration/ biomagnification potential in terrestrial food chains.

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Exposure Levels in Environmental Media. RDX has been detected in surface water, groundwater, and soil at Army ammunition plants (ATSDR 1989a, 1989b, 1989c; Spalding and Fulton 1988). Data are needed regarding levels of RDX in ambient air and occupational air. No data were located regarding human intake estimates for each media. Reliable monitoring data are needed for levels of RDX in contaminated media at hazardous waste sites. The information on RDX levels in the environment and the resulting body burden of RDX can be used to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Exposure Levels in Humans. Very limited data indicate that RDX has been found in human cerebrospinal fluid, plasma, urine, and feces (Woody et al. 1986). Biological monitoring data are needed for occupationally exposed populations and populations living in the vicinity of Army ammunition plants and hazardous waste sites. This information is necessary for assessing the need to conduct health studies on these populations.

Exposure Registries. No exposure registries for RDX were located. This substance is not currently one of the substances for which a subregistry has been established in the National Exposure Registry. The substance will be considered in the future when chemical selection is made for subregistries to be established. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to the exposure to this substance.

5.7.2 Ongoing Studies

The Department of Energy is sponsoring a project to study plant physiology. The process by which plant cells take up, degrade, or modify certain explosive compounds (i.e., RDX, TNT, and HMX) will be investigated. This work is being performed at the Los Alamos National Laboratory by P.J. Jackson (FEDRIP 1994).