United States Environmental Protection Agency

Technical Fact Sheet – Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)

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At a Glance

- Highly explosive, white crystalline solid.
- Synthetic product that does not occur naturally in the environment.
- Has been used extensively in the manufacture of munitions and accounts for a large part of the explosives contamination at active and former U.S. military installations.
- Not significantly retained by most soils and biodegrades very slowly under aerobic conditions. As a result, it can easily migrate to groundwater.
- Not expected to persist for a long period of time in surface waters because of transformation processes.
- Classified as a Group C (possible human) carcinogen.
- Can damage the nervous system if inhaled or ingested.
- EPA plans to update its toxicity benchmarks and health risk assessment.
- Basic types of field screening methods include colorimetric and EXPRAY.
- Primary laboratory analytical methods include liquid and gas chromatography.
- Potential treatment technologies include in situ bioremediation, granular activated carbon treatment, composting, phytoremediation and incineration.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), including its physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers and field personnel who may address RDX contamination at cleanup sites or in drinking water supplies.

RDX is a secondary explosive[1] that is used extensively by the U.S. military in manufacturing explosives. Major manufacturing of RDX began in the United States in 1943 during World War II; RDX was produced in enormous quantities at the Government Owned-Contractor Operated (GOCO) Holston Army Ammunition Plant (AAP) in Kingsport, Tennessee, for use in military munitions in World War II and afterwards (U.S. AEHA 1985).

During the 1940s through the 1970s, Department of Defense (DoD) ammunitions plants and depots demilitarized off-specification, unserviceable and obsolete munitions using steam-out and melt-out processes to recover 2,4,6-trinitrotoluene (TNT) and TNT-containing explosive fillers such as Composition B (TNT/RDX mixture). These processes often generated significant quantities of explosives-contaminated wastewater. The untreated wastewater was discharged into unlined impoundments, lagoons, ditches and playas, which resulted in significant levels of soil and groundwater contamination. Groundwater contamination from RDX was first reported in the late 1980s (Spalding and Fulton 1988).

RDX is still widely used in U.S. military munitions and is present in munitions fillers such as Composition A, Composition B, Composition C and Cyclotols. With its manufacturing impurities and environmental transformation products, this compound accounts for a large part of the explosives contamination at active and former U.S. military installations (EPA 1999).

[1] *Secondary explosives are bursting and boostering explosives (used as the main bursting charge or as the booster that sets off the main bursting charge) (USACE 2005).*

What is RDX?

- RDX, also known as Royal Demolition Explosive, cyclonite, hexogen and T4, is a synthetic product that does not occur naturally in the environment and belongs to a class of compounds known as explosive nitramines (ATSDR 2012; CRREL 2006).
- Production of RDX in the United States has been limited to Army ammunition plants. It is currently manufactured at one facility in the United States, the GOCO Holston AAP in Kingsport, Tennessee (which has operated since 1943) (ATSDR 2012; HSDB 2013; U.S. AEHA 1985).
- RDX is not produced commercially in the United States; however, RDX is used both in military and commercial applications. Some U.S. companies import RDX from outside the United States for use in some commercial applications (ATSDR 2012; EPA 2010).
- RDX is one of the most powerful high explosives available and was widely used during World War II. It is present in more than 4,000 military items, from large bombs to very small igniters (DoD 2011).
- It is a highly explosive, white crystalline solid (in its pure form) that is often mixed with other explosives, oils or waxes to make military munitions and other products (DoD 2011).
- It is commonly used as an ingredient in plastic explosives and has been used as explosive “fill” in most types of munitions compounds (DoD 2011; MMR 2001).
- RDX can be used alone as a base charge for detonators or mixed with other explosives such as TNT to form Cyclotols, which produce a bursting charge for aerial bombs, mines and torpedoes (ATSDR 2012; Lewis 2000).
- RDX is commonly found at hand grenade ranges, antitank rocket ranges, bombing ranges, artillery ranges, munitions testing sites, explosives washout lagoons, demolition areas and open burn/open detonation (OB/OD) sites (CRREL 2006, 2007; EPA 2005, 2012d).

Exhibit 1: Physical and Chemical Properties of RDX
(ATSDR 2012; HSDB 2013; Major and others 2007)

Property	Value
Chemical Abstracts Service (CAS) Number	121-82-4
Physical Description (physical state at room temperature)	White Crystalline Solid
Molecular weight (g/mol)	222.26
Water solubility at 25^{o}C (mg/L)	59.7
Octanol-water partition coefficient (Log K_{ow})	0.87
Soil organic carbon-water coefficient (Log K_{oc})	1.80
Boiling point (^{o}C)	Decomposes
Melting point (^{o}C)	204 to 206
Vapor pressure at 20^{o}C (mm Hg)	1.0 x 10^{-9} (ATSDR 2012); 4.0 x10^{-9} (HSDB 2013)
Specific gravity at 20 ^{o}C (g/mL)	1.82
Henry’s Law Constant at 25^{o}C (atm-m^3/mol)	2.0 x10^{-11}

Abbreviations: g/mol – grams per mole; mg/L – milligrams per liter; ^{o}C – degrees Celsius; mm Hg – millimeters of mercury; g/mL – grams per milliliter; atm-m^3/mol – atmosphere - cubic meters per mole.

What are the environmental impacts of RDX?

- RDX can be released to the environment through spills, firing of munitions, disposal of ordnance, open incineration and detonation of ordnance, leaching from inadequately sealed impoundments and demilitarization of munitions. The compounds can also be released from manufacturing and munitions processing facilities (ATSDR 2012).
- As of 2007, RDX had been identified at more than 30 sites on the EPA National Priorities List (NPL) (HazDat 2007).
- In the atmosphere, RDX is expected to exist in the particulate phase and settles by wet or dry deposition (ATSDR 2012; HSDB 2013).

What are the environmental impacts of RDX? (continued)

- Low soil sorption coefficient (K_{OC}) values indicate that RDX is not significantly retained by most soils and can migrate to groundwater. However, the rate of migration depends on the composition of the soil (ATSDR 2012; EPA 2005).
- RDX can migrate through the vadose zone and contaminate underlying groundwater aquifers, especially at source areas that have permeable soils, a shallow groundwater table and abundant rainfall (CRREL 2006; EPA 2012d).
- RDX dissolves slowly in water because of its slow rate of dissolution from the solid phase and does not evaporate from water readily as a result of its low vapor pressure (CRREL 2006; EPA 2005).
- Phototransformation of RDX in soil is not significant; however, it is the primary physical mechanism that degrades RDX in aqueous solutions. Consequently, RDX is not expected to persist for a long period of time in surface waters (ATSDR 2012; CRREL 2006; HSDB 2013).
- Based on its low octanol-water partition coefficient (K_{OW}) and low experimental bioconcentration factor, RDX has a low bioconcentration potential in aquatic organisms (ATSDR 2012; EPA 2005).
- Results from a study indicate that RDX may bioaccumulate in plants and could be a potential exposure route to herbivorous wildlife (CRREL 2006; EPA 2005; Harvey and others 1991).

What are the routes of exposure and the health effects of RDX?

- Potential exposure to RDX could occur by dermal contact or inhalation exposure; however, the most likely route of exposure at or near hazardous waste sites is ingestion of contaminated drinking water or agricultural crops irrigated with contaminated water (ATSDR 2012).
- The EPA has assigned RDX a weight-of-evidence carcinogenic classification of C (possible human carcinogen) based on the presence of hepatocellular adenomas and carcinomas in female mice that were exposed to RDX (EPA IRIS 1993).
- The American Conference of Governmental Industrial Hygienists (ACGIH) has classified RDX as a Group A4, not classifiable as a human carcinogen (ACGIH 2011).
- RDX targets the nervous system and can cause seizures in humans and animals when large amounts are inhaled or ingested. Human studies also revealed nausea and vomiting after inhalation or oral exposure to unknown levels of RDX (EPA 2005; HSDB 2013; Ketel and Hughes 1972).
- Potential symptoms of overexposure include eye and skin irritation, headache, irritability, fatigue, tremor, nausea, dizziness, vomiting, insomnia and convulsions (HSDB 2013; NIOSH 2010).
- Animal studies found that the ingestion of RDX for 3 months or longer resulted in decreased body weight and slight liver and kidney damage in rats and mice (ATSDR 2012).
- EPA plans to update its toxicity benchmarks and health risk assessment for RDX in its database of chemical risk values, the Integrated Risk Information System (IRIS). RDX was included as part of EPA's 2012 IRIS agenda and the assessment is under way (EPA 2012c).
- Limited information is available regarding the effects of long-term, low-level exposure to RDX (ATSDR 2012).

Are there any federal and state guidelines and health standards for RDX?

- EPA assigned RDX a chronic oral reference dose (RfD) of 3×10^{-3} milligrams per kilogram per day (mg/kg/day) (EPA IRIS 1993).
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.2 mg/kg/day for acute-duration oral exposure (14 days or less), 0.1 mg/kg/day for intermediate-duration oral exposure (15 to 364 days) and 0.1 mg/kg/day for chronic-duration oral exposure (365 days or more) to RDX (ATSDR 2012).
- The EPA has assigned an oral slope factor for carcinogenic risk of 0.11 mg/kg/day, and the drinking water unit risk is 3.1×10^{-6} micrograms per liter (µg/L) (EPA IRIS 1993).
- EPA risk assessments indicate that the drinking water concentration representing a 1×10^{-6} cancer risk level for RDX is 0.3 µg/L (EPA IRIS 1993).

Are there any federal and state guidelines and health standards for RDX? (continued)

- The EPA has established drinking water health advisories for RDX, which are drinking water-specific risk level concentrations for cancer (10^{-4} cancer risk) and concentrations of drinking water contaminants at which noncancer adverse health effects are not anticipated to occur over specific exposure durations (EPA 2012a).
  - The EPA has established a lifetime health advisory guidance level of 0.002 milligrams per liter (mg/L) for RDX in drinking water. The health advisory for a cancer risk of 10^{-4} is 0.03 mg/L.
  - EPA also established a 1-day and 10-day health advisory of 0.1 mg/L for RDX in drinking water for a 10-kilogram child.
- For RDX in tap water, EPA has calculated a screening level of 0.61 µg/L (EPA 2013).[1],[2]
- EPA has calculated a residential soil screening level (SSL) of 5.6 milligrams per kilogram (mg/kg) and an industrial SSL of 24 mg/kg. The soil-to-groundwater risk-based SSL is 2.3×10^{-4} mg/kg (EPA 2013).
- EPA has not established an ambient air level standard or screening level for RDX (EPA 2013).
- EPA included RDX on the third Contaminant Candidate List, which is a list of unregulated contaminants that are known to or may occur in drinking water and may require regulation under the Safe Drinking Water Act (EPA 2012b).
- The National Institute for Occupational Safety and Health (NIOSH) established a recommended exposure limit of 1.5 milligrams per cubic meter (mg/m^3) as the time-weighted average (TWA) over a 10-hour work exposure and 3 mg/m^3 as the 15-minute, short-term exposure limit for airborne exposure to RDX (NIOSH 2010).
- The ACGIH has set a threshold limit value of 0.5 mg/m^3 as the TWA over an 8-hour work exposure for airborne exposure to RDX (ACGIH 2011).
- Numerous states have established regulations on explosives for air quality control, solid waste disposal, storage, manufacture and use. Regulatory agencies in states such as Colorado and New York have specified RDX cleanup levels for water of less than 1 part per billion (ppb) (DoD ESTCP 2008).
- Massachusetts has established a reportable concentration of 0.001 mg/L for the GW-1 category (based on the use of groundwater as drinking water) and 50 mg/L for the GW-2 category (based on the potential for volatile material to migrate into indoor air). For soil, Massachusetts established a reportable concentration of 1 mg/kg for the S-1 category (based on sensitive uses of the property and accessible soil) and 60 mg/kg for the S-2 category (based on property uses associated with moderate exposure and accessible soil) (Mass DEP 2008).
- The Department of Transportation has many regulations on the transportation of RDX (DOT 1989).

[1] Screening Levels are developed using risk assessment guidance from the EPA Superfund program. These risk-based concentrations are derived from standardized equations combining exposure information assumptions with EPA toxicity data. These calculated screening levels are generic and not enforceable cleanup standards but provide a useful gauge of relative toxicity.

[2] Tap water screening levels differ from the IRIS drinking water concentrations because the tap water screening levels account for dermal, inhalation and ingestion exposure routes; age-adjust the intake rates for children and adults based on body weight; and time-adjust for exposure duration or days per year. The IRIS drinking water concentrations consider only the ingestion route, account only for adult-intake rates, and do not time-adjust for exposure duration or days per year.

What detection and site characterization methods are available for RDX?

- RDX is commonly deposited in the environment as discrete particles with strongly heterogeneous spatial distributions. Unless precautions are taken, this variability causes highly variable soil data, which can lead to confusing or contradictory conclusions about the location and degree of contamination. As described in SW-846 Method 8330B, proper sample collection (using an incremental field sampling approach), sample processing (which includes grinding) and incremental subsampling are required to obtain reliable soil data (EPA 2006).
- RDX, manufactured in the United States using the Bachmann process at Holston AAP, contains octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) (also commonly known as octogen or High Melting Explosive) as a manufacturing impurity of RDX at a level of approximately 10 percent. Therefore, some experts recommend that sites potentially containing RDX or RDX-containing explosives fillers (such as Composition B) be analyzed for HMX (HSDB 2013; U.S. AEHA 1985).
- Both RDX and HMX are analytes included for EPA SW-846 Methods 8330 (high-performance liquid chromatography (HPLC) – ultraviolet (UV) detector) and 8095 (gas chromatography (GC)–electron capture detector [ECD]) (EPA 2007a, b).
- HPLC and high-resolution gas chromatography (HRGC) have been paired with several types of detectors, including mass spectrometry (MS), thermal energy analyzer (TEA), electrochemical detection (ED), ECD and UV detector to analyze for RDX and related contaminants (ATSDR 2012).
- EPA SW-846 Method 8330 is the most widely used analytical approach for detecting RDX in soil. The method specifies using HPLC with a UV detector. It has been used to detect RDX and some of its breakdown products at levels in the low ppb range in water, soil and sediment (EPA 2005, 2007b, 2012d).
- Another method commonly used is EPA SW-846 Method 8095, which employs the same sample processing steps as EPA SW-846 Method 8330, but uses capillary column GC - ECD for detection of explosives in water and soil (EPA 2005, 2007a, 2012d).
- EPA SW-846 Method 8321, which uses HPLC-MS, may be modified for the determination of RDX in soil. Since RDX is not a target analyte for this method and the sample processing steps are not appropriate for use with energetic compounds, this method is commonly modified for RDX to employ different sample processing steps, such as those identified in Method 8830 (EPA 2012d).
- Specific field screening methods for RDX include EPA SW-846 Method 4051 to detect RDX in soil by immunoassay and EPA SW-846 Method 8510 to detect RDX and HMX using a colorimetric screening procedure (U.S. Army 2009; USACE 2005).
- EPA Method 529 used solid phase extraction and capillary column GC and MS for the detection of RDX in drinking water (EPA 2002).
- Colorimetric methods generally detect broad classes of compounds such as nitroaromatics or nitramines. As a result, these methods are able to detect the presence of the target analytes and also respond to many other similar compounds. Immunoassay methods are more compound specific (EPA 2005).
- The EXPRAY is a simple colorimetric screening kit that can be used for qualitative tests for RDX and related compounds in soil. It is also useful for screening surfaces and unknown solids. The tool's detection limit is about 20 nanograms (EPA 2005; USACE 2001).
- Prototype biosensor methods for RDX have been field-tested and are emerging methods for explosives analysis in water (EPA 1999).
- Tested field-screening instruments for RDX include FAST 2000, which uses antibodies and fluorescence, and GC-IONSCAN, which uses ion mobility spectrometry (IMS) (EPA 2000a, b).

What technologies are being used to treat RDX?

- Bioreactors, bioslurry treatments and passive subsurface biobarriers have proven successful in reducing RDX concentrations (CRREL 2006; EPA 2005; DoD ESTCP 2010).
- Composting has been successful in achieving cleanup goals for RDX in soil at field demonstrations (EPA 2005).
- In situ chemical remediation can also be used to treat RDX. Fenton oxidation and treatment with iron metal (FeO) has been used to remediate RDX-contaminated soil and water but has not been used as a stand-alone, full-scale treatment technology (EPA 2005; EPA NCER 2013).
- In a recent pilot-scale demonstration, in situ chemical reduction using buffered sodium hydrosulfite effectively reduced RDX concentrations in soil (Luo and others 2012).

What technologies are being used to treat RDX? (continued)

- Phytoremediation of RDX-contaminated water and soil is being evaluated as a potential treatment technology (Lamichhane and others 2012; Panz and Miksch 2012).
- A recent study was conducted to evaluate the transformation of RDX in plant tissues. Research results indicated that the concentration of chlorophyll in leaf tissues affects RDX concentration in the plants. When the chlorophyll concentration is low, then RDX degrades quickly and does not accumulate (CRREL 2013).
- Other methods of treating waters contaminated with RDX include activated carbon, UV radiation and in situ bioremediation (ATSDR 2012).
- The Department of Defense's Strategic Environmental Research and Development Program (SERDP) is conducting a field-scale demonstration at the Umatilla Chemical Depot to assess the application of bioaugmentation to enhance RDX biodegradation in groundwater under aerobic conditions. The project is anticipated to be complete in 2015 (DoD SERDP 2012).

Where can I find more information about RDX?

- Agency for Toxic Substances and Disease Registry (ATSDR). 2012. "Toxicological Profile for RDX." www.atsdr.cdc.gov/toxprofiles/tp78.pdf
- American Conference of Governmental Industrial Hygienists (ACGIH). 2011. "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices." Cincinnati, OH.
- Harvey, S.D., Fellows, R.J., Cataldo, D.A. and R.M. Bean. 1991. "Fate of the Explosive Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in Soil and Bioaccumulation in Bush Bean Hydroponic Plants." Environmental Toxicology and Chemistry. Volume 10. Pages 845 to 855.
- Hazardous Substance Data Bank (HSDB). 2013. Cyclonite. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
- HazDat. 2007. RDX. Database. ATSDR's Hazardous Substance Release and Health Effects Database. Atlanta, GA: Agency for Toxic Substances and Disease Registry.
- Ketel, W.B. and J.R Hughes. 1972. "Toxic Encephalopathy with Seizures Secondary to Ingestion of an Explosive Material Composition C-4: A Clinical and Electroencephalographic Study." Neurology. Volume 22. Pages 871 to 876.
- Lamichhane, K.M., Babcock, R.W., Turnbull, S.J., and S. Schenc. 2012. "Molasses Enhanced Phyto and Bioremediation Treatability Study of Explosives Contaminated Hawaiian Soils." Journal of Hazardous Materials. Volume 243. Pages 334 to 339.
- Lewis, R.J. 2000. Sax's Dangerous Properties of Industrial Materials. 10th Edition. New York, NY: John Wiley & Sons, Inc.. Pages 1050 to 1051.
- Luo, C., O'Niell, W., and V. Nzengung. 2012. "Pilot-Scale Demonstration of In Situ Chemical Reduction Technology at a Formerly Used Defense Site." Water, Air, & Soil Pollution. Volume 223 (9). Pages 5807 to 5815.
- Major, M., Reddy, G., and G. Leach. 2007. "Reevaluation of the Toxicity and Carcinogenicity of RDX within the Guidelines of Modern Risk Assessment." Health Effects Research Program. 2007 JSEM Conference.
- Massachusetts Department of Environmental Protection (Mass DEP). 2008. "Massachusetts Contingency Plan." 310 CMR 40.0000. www.mass.gov/eea/agencies/massdep/cleanup/regulations/site-cleanup-regulations-and-standards.html
- Massachusetts Military Reservation (MMR). 2001. "Impact Area Groundwater Study Program. Chemical Fact Sheet – RDX." Fact Sheet 2001-04.
- National Institute for Occupational Safety and Health (NIOSH). 2010. NIOSH Pocket Guide to Chemical Hazards: Cyclonite. www.cdc.gov/niosh/npg/npgd0169.html
- Panz, K. and K. Miksch. 2012. "Phytoremediation of Explosives (TNT, RDX, HMX) by Wild-Type and Transgenic Plants. Journal of Environmental Management." Volume 113. Pages 85 to 92.
- Spalding, R. and J. Fulton. 1988. "Groundwater Munition Residues and Nitrate near Grand Island, Nebraska, USA." Journal of Contaminant Hydrology. Volume 2 (2). Pages 139-153.
- U.S. Army. 2009. Military Munitions Response Program. "Munitions Response Remedial Investigation/Feasibility Study Guidance." www.aec.army.mil/Portals/3/restore/Guidance_MMRP_RIFS_2009.pdf
- U.S. Army Corps of Engineers (USACE). 2001. "Field-Based Analytical Methods for Explosive Compounds." Clu-In Seminar. August 28, 2001. www.clu-in.org/conf/tio/explosives_082801/prez/aug01BW.pdf

Where can I find more information about RDX? (continued)

- USACE. 2005. Military Munitions Center of Expertise. Technical Update. "Munitions Constituent (MC) Sampling." http://uxoinfo.com/blogcfc/client/enclosures/MC%20Tech%20Update%20Final_USACEMar05Sampling.pdf
- USACE Cold Regions Research and Engineering Laboratory (CRREL). 2006. "Conceptual Model for the Transport of Energetic Residues from Surface Soil to Groundwater by Range Activities." ERDC/CRREL TR-06-18. www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA472270
- USACE CRREL. 2007. "Protocols for Collection of Surface Soil Samples at Military Training and Testing Ranges for the Characterization of Energetic Munitions Constituents." ERDC/CRREL TR-07-10.
- USACE CRREL. 2013. "RDX in Plant Tissue: Leading to Humification in Surface Soils." ERDC/CRREL TR-13-4.
- U.S. Army Environmental Hygiene Agency (AEHA). 1985. "Water Pollution Aspects of Explosive Manufacturing." Technical Guide No. 140.
- U.S. Department of Defense (DoD). 2011. Emerging Chemical and Material Risks. Chemical and Material Risk Management Program. www.denix.osd.mil/cmrmd/ECMR/RDX/TheBasics.cfm
- DoD Environmental Security Technology Certification Program (ESTCP). 2008. "Treatment of RDX and/or HMX Using Mulch Biowalls (ER-0426)."
- DoD ESTCP. 2010. "Passive Biobarrier for Treating Comingled Perchlorate and RDX in Groundwater at an Active Range (ER-201028)."
- DoD. Strategic Environmental Research and Development Program (SERDP). 2012. "Bioaugmentation for Aerobic Bioremediation of RDX-Contaminated Groundwater." Fact Sheet. SERDP Project ER-201207.
- U.S. Department of Transportation (DOT). 1989. "Hazardous Materials Table and Hazardous Materials Communications Regulations." Code of Federal Regulations. 49 CFR 172.101.
- U.S. Environmental Protection Agency (EPA). 1999. Office of Research and Development. Federal Facilities Forum Issue. "Field Sampling and Selecting On-site Analytical Methods for Explosives in Water." EPA-600-S-99-002. www.epa.gov/osp/hstl/tsc/Crockett1999.pdf
- EPA. 2000a. Office of Research and Development. Barringer Instruments. "GC-IONSCAN." Environmental Technology Verification Report. EPA/600/R-00/046.
- EPA. 2000b. Office of Research and Development. Research International, Inc. "FAST 2000." Environmental Technology Verification Report. EPA 600-R-00-045EPA.
- EPA. 2002. Method 529. "Determination of Explosives and Related Compounds in Drinking Water by Solid Phase Extraction and Capillary Column Gas Chromatography/Mass Spectrometry (GC/MS)." Revision 1.0. www.epa.gov/microbes/documents/m_529.pdf
- EPA. 2005. "EPA Handbook on the Management of Munitions Response Actions." EPA 505-B-01-001 http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100304J.txt
- EPA. 2006. SW-846. Method 8330b. "Appendix A: Collecting and Processing of Representative Samples for Energetic Residues in Solid Matrices from Military Training Ranges." www.epa.gov/osw/hazard/testmethods/pdfs/8330b.pdf
- EPA. 2007a. SW-846. Method 8095. "Explosives by Gas Chromatography." www.epa.gov/osw/hazard/testmethods/sw846/pdfs/8095.pdf
- EPA. 2007b. SW-846. Method 8330a. "Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)." Revision 1. www.epa.gov/osw/hazard/testmethods/sw846/pdfs/8330a.pdf
- EPA. 2010. "Non-Confidential 2006 IUR Records by Chemical, Including Manufacturing, Processing and Use Information." Inventory Update Reporting.
- EPA. 2012a. "2012 Edition of the Drinking Water Standards and Health Advisories." water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf
- EPA. 2012b. Drinking Water Standards. "Contaminant Candidate List 3 – CCL." water.epa.gov/scitech/drinkingwater/dws/ccl/ccl3.cfm
- EPA. 2012c. "Integrated Risk Information System (IRIS); Announcement of 2012 Program." Federal Register. Volume 77 (88). Pages 26751 to 26755. www.gpo.gov/fdsys/pkg/FR-2012-05-07/html/2012-10935.htm

Where can I find more information about RDX? (continued)

- EPA. 2012d. "Site Characterization for Munitions Constituents." EPA Federal Facilities Forum Issue Paper. EPA-505-S-11-001. www.epa.gov/fedfac/pdf/site_characterization_for_munitions_constituents.pdf
- EPA. 2013. Regional Screening Level Summary Table. www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
- EPA. Integrated Risk Information System (IRIS). 1993. "Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (CASRN 121-82-4)." www.epa.gov/IRIS/subst/0313.htm
- EPA. National Center for Environmental Research (NCER). 2013. "Final Report: Fate and Transport of Munitions Residues in Contaminated Soil." http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5251/report/F

Contact Information

If you have any questions or comments on this fact sheet, please contact: Mary Cooke, FFRRO, by phone at (703) 603-8712 or by email at cooke.maryt@epa.gov.