

NRT Quick Reference Guide: Soman (GD)

Report any release of WMD to the National Response Center 1-800-424-8802
For References, Please See: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Nerve Agent CAS: 96-64-0 Description: Colorless liquid; generally odorless, possibly fruity. GD was manufactured as a warfare agent and is a lethal cholinesterase inhibitor. It has the same mechanism of toxicity as organophosphate insecticides but is much more potent. GD is considered to have low persistence; though it is less volatile than sarin (GB), it is much more volatile than persistent agents VX or sulfur mustard (HD). While considered relatively non-persistent, liquid GD could be present for hours to days if in large amounts, or in cold or enclosed environments. Breakdown/hydrolysis in water (especially treated water) is expected. Environmental breakdown products of GD are relatively nontoxic. Signs/symptoms of exposure to GD will occur within minutes or hours, depending on the dose. Even relatively low dose exposure to GD can be fatal; administration of antidotes within 2 minutes of exposure may be effective. (See First Aid/Decon below) Persistence: vapor: minutes-hours; liquid: hours to days depending on amount, temperature, rain or other weather conditions, and type of surface.				
	Molecular Weight: 182.18 g/mol Volatility: 3900 mg/m ³ 77°F Freezing point: -44°F Vapor Pressure: 0.4 mm Hg @ 77°F	Vapor Density: 6.33 (air = 1) Boiling Point: 388°F Flashpoint: 250°F Conversion Factors: 1ppm = 7.5 mg/m ³ ; °C = 0.56 × (°F – 32)	Aqueous Solubility: 21 g/L 68°F Soluble: organic solvents Specific Gravity: 1.02 g/ml 68°F		
Release Scenarios	Air Release: Because it is somewhat volatile, GD is not generally considered a “persistent” agent. GD is a plausible agent of concern for facilities or large outdoor areas. Liquid-contamination on surfaces could persist for hours or days in colder environments and areas protected from open weathering. Water: If released into water, GD would likely degrade from evaporation and hydrolysis, and be further broken down by dissolution and treatment processes, such as chlorination. Environmental and hydrolytic degradation products of GD are not significant toxic concerns. Facility: Due to its volatility, GD could feasibly be dispersed in a building or facility. Decontamination should focus on areas of liquid contamination. Breakdown products of GF are not significant toxic concerns. U.S. Munitions Stockpiles: U.S. munitions stockpiles of G-agent are/have undergone destruction/disposal in Utah, Oregon, Arkansas, Alabama, and Kentucky. State/local plans to address potential releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info).				
Health Effects	ONSET	Symptoms are dose dependent and may occur within seconds after exposure to vapors and within minutes or hours from exposure to liquid from.			
	SIGNS/ SYMPTOMS	Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficult breathing. Moderate: Increased miosis (to level of pinpointing of pupils), headaches, confusion, drowsiness, nasal congestion, tightness of chest, nausea vomiting diarrhea, cramps, generalized weakness, twitching of large muscle groups. Severe: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, and death.			
	EXPOSURE ROUTES	Inhalation: A primary exposure route; inhalation of very small concentrations can produce effects. Skin: Especially toxic from contact with liquid agent; usually moderate to severe localized effects (e.g., sweating) and systemic effects. Effects can also result from absorption of vapors through skin. Eyes: Eyes are the most sensitive target organs of nerve agent exposure: miosis (reduction in pupil size) will typically be the first sign of exposure. Ingestion: Overall systemic effects.			
	OTHER	Females appear to be more susceptible to nerve agent effects. Small percentages of general population have genetic traits that may increase susceptibility.			
Effect Levels	Air: Acute Exposure Guideline Levels (AEGs) (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents) for general population one-time exposure emergency scenarios for GD:				
	▼ AEGL Level AEGL 1: threshold mild effects: AEGL 2: potentially irreversible effects or impaired ability to escape: AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality: Occupational: IDLH = 0.05 mg/m ³ ; STEL = 5.0 x 10 ⁻⁵ mg/m ³ ; Worker Population Limit (WPL) [an 8-hour time-weighted average occupational value] = 3.0 x 10 ⁻⁵ mg/m ³ General Population Limit (GPL) [a 24-hour time weighted average lifetime chronic value] = 1.0 x 10 ⁻⁶ mg/m ³ .	exposure duration ► 10 min: 0.0035 mg/m ³ 0.044 “ 0.38 “	30min: 0.0020 mg/m ³ 0.025 “ 0.19 “	1 hr: 0.0014 mg/m ³ 0.018 “ 0.13 “	4 hr: 0.00070 mg/m ³ 0.0085 “ 0.070 “
Industrial Exposure Scenario = 32-41 mg/kg; Residential Exposure Scenario = 1.3-1.6 mg/kg. Drinking Water: Although G-agent contamination of large water sources is unlikely, there are military screening levels to determine if smaller, contained water supplies (e.g., water buffalo, tank truck) have been contaminated. Acceptable levels for troops drinking 5-15 L/day of a contaminated supply for 7 days are 4-12 µg/L. This level is a reasonable value to use for the general population since their consumption rate is considerably less.					
Personal Safety	SITE SPECIFIC CONCERNS	Check with the Health and Safety Officer regarding Personal Protective Equipment (PPE), Medical Surveillance, and Safety Plans. Level and type of PPE may vary depending upon the circumstances of the site and the incident. PPE levels below are general recommendations only.			
	MEDICAL SURVEILLANCE	Baseline: Annual physical and respiratory function exams and a baseline cholinesterase activity. During Incident: Conduct medical monitoring; use PPE designated by the Health and Safety (H&S) Plan; document PPE levels used; observe for any signs and symptoms and treat accordingly. Post-Incident: Monitor for signs/symptoms and treat accordingly.			
	FIRST AID/ DECON	Antidote: Nerve agent antidotes Atropine and (if more severe) 2-PAM Chloride injections are of limited effectiveness with GD – 2-PAM chloride must be given within 2 minutes of exposure for any antidote effect; atropine drops for eyes. Decon outer PPE with a dilute household bleach solution. Household bleach is 5% sodium hypochlorite. To create a dilute bleach solution, combine water to household bleach (add 1 part bleach to 9 parts water) yielding a 0.5% sodium hypochlorite solution. USE WARM SOAPY WATER INSTEAD OF DILUTE BLEACH FOR DECON OF BARE SKIN.			
	PPE	Hazard evaluation responders use NIOSH-approved chemical, biological, radiological, and nuclear (CBRN) self-contained breathing apparatus (SCBA) respirators when the types of inhalation hazards and their concentrations are unknown or expected to be high. The CBRN APR full-face respirator provides a lower level of protection than the SCBA and its use is generally allowed once conditions are understood and exposures are determined to be at lower levels. Outer suit: Tychem F, BR, LV, Responder, TK, or Reflector. Gloves: Butyl Rubber Goves, M3 and M4 Norton, or Chemical Protective Set. See: http://www2.dupont.com/Personal_Protection/en_US/assets/downloads/tychem/permguide82004.pdf . During decontamination operations there should also be PPE/respiratory measures to minimize potential exposures to associated chlorine vapors.			
Field Detection	Real-time field screening tools (results not confirmatory or quantified): Caution should be given to equipment that has not been properly evaluated. The following is a summary of screening tools procured by most EPA response teams. Other screening tools may be used by other agencies and responders some with similar capabilities and limitations. Hand-Held: 1) <i>APD-2000(CAM)</i> and <i>Improved Chemical Agent Monitor (ICAM)</i> : Hand-held vapor detection devices that identify presence of G-agents at concentrations ≥ 0.1 mg/m ³ within 10 seconds. This device is subject to false positives (e.g., perfumes, exhausts, diesel). It can specify type of nerve agent, which is an improvement over previous military monitors that could not distinguish among the nerve agents. 2) <i>AP2C</i> : A hydrogen flame spectrophotometer that detects phosphorous (contained in G, V agents) and sulfur (contained in HD, V agents). Identifies presence of G-agents at concentrations ≥ 0.03 mg/m ³ within 10 seconds. 3) <i>Dräger Detector Tube</i> : Glass detector tubes impregnated with an indicating agent. Reagent produces a colorimetric indication in the presence of a particular gas, vapor, or aerosol. Gross				

Soman GD (side 2)

Field Detection (cont'd)	<p>levels can be read directly from the discoloration on the tube's printed scale; for confirmatory agent identification the tubes must be sent to an appropriate lab for further analysis. Tubes identify presence of G-agents at concentrations $\geq 0.025 \text{ mg/m}^3$. 4) M256 Kit: Air sample detector that identifies presence of G-agents at concentrations $\geq 5.0 \times 10^{-3} \text{ mg/m}^3$ within 15 minutes. 5) M8 and M9 papers: Presence/absence colorimetric detector strips for liquid G-agent on surfaces. M8 has an indefinite shelf life. 6) M272 Water Test Kit: Colorimetric test kits that can detect G-agents at concentrations $\geq 0.02 \text{ mg/L}$ within 7 minutes. Can be used for raw or treated water with minimal interferences.</p> <p>Advanced Field Monitoring: EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA): A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect G-agent vapors at concentrations as low as $4.9 \times 10^{-6} \text{ mg/m}^3$ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams.</p> <p>Note: Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</p>
<p>THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION</p>	
Sampling for Confirmatory Results	<p>Sample Locations and Planning: Initially consider atmospheric sampling to "delineate the plume area," followed by targeted sampling and analysis to identify "hot spots" and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because GD is generally not persistent, sampling to "clear areas" where no liquid deposition is expected vs. identifying potential hot spots of liquid contamination and should be emphasized in the sampling plan. Note: These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze GD, particularly in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI investigative unit to ensure chain-of-custody.</p> <p>Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p> <p>Types of Samples: Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and a significant public health concern. Air sampling can be performed to answer, "Has the plume passed? Is liquid deposition off-gassing?" and to "prove a negative." Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis. Water: As previously indicated, G-agents are unlikely to persist in water. If analysis is performed, standard EPA volatile water sampling methods should be used. Soil: For localized "hot spot" areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was pored on ground. Wipes: Wipe samples are often desired to indicate absence of G-agents on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding type of wipe pads or extraction solvent to use. Scabbling/Cores: For hot spot areas where liquid G-agent deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis. Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>
Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for GD because access to G-agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-put is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>
Decontamination/Cleanup	<p>Decon/Cleanup Planning: Once site controls have been established, develop a specific decon/cleanup plan. Significant areas of lasting GD contamination is relatively unlikely due to high volatility of GD. Except where immediate decontamination of liquid-contaminated hotspots is necessary to reduce the spread of G-agent or to immediately clear an area for use (e.g., hotzone entry/egress), determine whether additional "decon" actions are necessary or whether natural attenuation can adequately reduce or eliminate the hazard within an acceptable amount of time (typically will require hours to days and is a preferred option for large open areas). Determine when sampling can be conducted to "clear" areas that are not likely to be contaminated. For areas requiring use of decon materials (see methods below), consider the following: localized liquid (surface) contamination versus vapor/aerosol deposition of large areas; impacts to sensitive surfaces; whether some materials (e.g. carpeting, furniture, etc) are best removed for disposal, and how to collect/test waste materials/solutions for possible classification as hazwaste.</p> <p>Decon/Cleanup Methods: Effective and readily available non-proprietary* decon methods for G-agents include FOR LARGE AREAS: 1) Natural attenuation/degradation is recommended for vapor plume contamination or low concentration G-agent in large open areas; efficacy typically can be achieved in hours to days with no waste generated and no adverse impacts to sensitive items. 2) Water, seawater, dilute household bleach/chlorinated water (e.g., 0.5% sodium hypochlorite, swimming pool water,) are generally effective for low level contamination but require waste-water collection/sampling/possible hazwaste disposal and may damage sensitive items; efficacy typically achieved between 0.5-4 hrs after 2-15 minute rinse depending on level of contamination. FOR BUILDINGS/HVACS: Recommended options for G-agents include use of hot air ventilation (efficacy in hours) or ammonia gas and steam (efficacy achieved in less than an hour. FOR LIQUID CONTAMINATED SURFACES: 1) Household bleach solution (5.0% sodium hypochlorite); efficacy achieved between 0.5-4 hours with contact time of 15 minutes; however, very damaging (corrosive) to surfaces and should be rinsed; 2) High-pH solutions less corrosive than bleach (e.g., ammonia solutions, sodium bicarbonate solutions/slurries, or sodium borate hydrate/"Borax"); efficacy similar to that of bleach. 3) Reactive adsorbent clay (e.g., fullers earth) is useful for absorbing and neutralizing liquid agent; efficacy on the order of hours; 4) Chlorinated lime is best for high concentration liquid in localized areas; efficacy on the order of hours. *Proprietary decon materials (e.g. gels and foams) have been undergoing testing and are not officially endorsed though may have certain specific application benefits. Note: Decon products may have unique safety/ PPE requirements (e.g., bleach results in chlorine vapors).</p> <p>Verification of Decon/Cleanup: Cleanup levels will be determined based on site-specific factors and multi-agency agreements. An example of a multi-agency verification sampling plan (developed during TOPOFF 2005 for sulfur mustard, and may be applicable for this agent) included a tiered approach involving prioritized multi-media samples. This exercise approach ensured: Air results < 8 hour AEGL 1 value Water samples < 15 L/day drinking water value Soil samples < soil screening levels Wipe samples — presence-absence approach; laboratory detection capability, which will vary per laboratory</p> <p>Note: Some established effect levels (e.g., WPLs and GPLs) may be below the analytical detection limits of some laboratories.</p>
Waste Disposal	<p>While not a "Federally-listed" waste, GD is more toxic than most RCRA listed chemicals and is a "listed" hazardous waste in some states where stored in military stockpiles. Though GD is somewhat volatile and actual liquid contaminated waste will likely be limited, perception/politics may suggest management of all response wastes as hazardous. However, extreme caution should be given to sample and segregate wastes sampling to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated and containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. Wastewater solution from decon should be analyzed to ensure no residual agent is present. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include "head space" (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility, such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent is present. It is likely that the solution will not contain residual agents and therefore not need to be classified as a hazardous waste but sampling must be used to verify. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>

NRT Quick Reference Guide: Cyclosarin (GF)

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For References, Please See: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Nerve Agent CAS: 329-99-7 Description: Colorless liquid, generally odorless. GF was manufactured as a warfare agent and is a lethal cholinesterase inhibitor. It has the same mechanism of toxicity as organophosphate insecticides, but is much more potent. GF is considered to have moderately low persistence as it is less volatile than GB (sarin), but is more volatile than persistent agents such as VX or HD (sulfur mustard). While considered relatively non-persistent, liquid GF could be present for hours to days if in large amounts or in cold or enclosed environments. Breakdown/hydrolysis in water (especially treated water) is expected. Environmental degradation/breakdown products of GF are relatively nontoxic. Signs/symptoms of exposure to GF will occur within minutes or hours depending on the dose received. Even a relatively low dose exposure to GF can be fatal, though immediate administration of an antidote (see First Aid/Decon below) can be lifesaving. Persistence: vapor: minutes to hours; liquid: hours to days depending on amount, temperature, rain or other weather conditions, and type of surface.																					
	Molecular Weight: 180.2 g/mol Volatility: 581 mg/m ³ 77°F Freezing point: -22°F Vapor Pressure: 0.044 mm Hg @77°F	Vapor Density: 6.2 (air = 1) Boiling Point: 462°F Flashpoint: 201°F Conversion Factors: 1ppm = 7.4 mg/m ³ ; °C = 0.56 x (°F – 32)																				
Release Scenarios	Air Release: Because it is somewhat volatile, GF is not generally considered a “persistent” agent. Though less so than GB, GF is a plausible agent of concern within facilities or large outdoor areas. Liquid-contaminated surfaces could persist for hours or days in colder environments and areas protected from open weathering. Water: If released into water, GF would likely degrade from evaporation and hydrolysis, and be further broken down by dissolution and treatment processes, such as chlorination. Environmental and hydrolytic degradation products of GF are not a significant toxic concern. Facility: GF could potentially be dispersed in a building or facility. Decontamination should focus on areas of liquid contamination. Breakdown products of GF are not significant toxic concerns. U.S. Munitions Stockpiles: U.S. munitions stockpiles of G-agent are/have undergone destruction/disposal in Utah, Oregon, Arkansas, Alabama, and Kentucky. State/local plans to address potential releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info)																					
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	EXPOSURE ROUTES	Inhalation: A primary exposure route; inhalation of very small concentrations can produce effects. Skin: Especially toxic from contact with liquid agent; usually moderate to severe localized effects (e.g., sweating) and systemic effects. Effects can also result from absorption of vapors through skin. Eyes: Eyes are the most sensitive target organs of nerve agent exposure: miosis (reduction in pupil size) will typically be the first sign of exposure. Ingestion: Overall systemic effects.																				
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Soil: Industrial Exposure Scenario = 5.2-8.2 mg/kg; Residential Exposure Scenario = 0.22–0.31 mg/kg.																						
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Cyclosarin (GF) (side 2)

Field Detection <i>(cont'd)</i>	<p>within 15 minutes. 5) M8 and M9 papers: Presence/absence colorimetric detector strips for liquid G-agent on surfaces. M8 has an indefinite shelf life. 6) M272 Water Test Kit: Colorimetric test kits that can detect G-agents at concentrations ≥ 0.02 mg/L within 7 minutes. Can be used for raw or treated water with minimal interferences. Advanced Field Monitoring: EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA): A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect G-agent vapors at concentrations as low as 4.9×10^{-6} mg/m³ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams. Note: Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</p>
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THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION

Sample Locations and Planning:	<p>Initially consider atmospheric sampling to “delineate the plume area,” followed by targeted sampling and analysis to identify “hot spots” and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because GF is generally not persistent, sampling to “clear areas” where no liquid deposition is expected vs. identifying potential hot spots of liquid contamination and should be emphasized in the sampling plan. Note: These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</p>
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Sampling Concerns:	<p>Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze GF, particularly in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI investigative unit to ensure chain-of-custody.</p>
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Sample Packaging and Shipping:	<p>The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p>
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Types of Samples:	<p>Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and a significant public health concern. Air sampling can be performed to answer, “Has the plume passed? Is liquid deposition off-gassing?” and to “prove a negative.” Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis.</p> <p>Water: As previously indicated, G-agents are unlikely to persist in water. If analysis is performed, standard EPA volatile water sampling methods should be used.</p> <p>Soil: For localized “hot spot” areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was pored on ground.</p> <p>Wipes: Wipe samples are often desired to indicate absence of G-agents on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding type of wipe pads or extraction solvent to use.</p> <p>Scabble/Cores: For hot spot areas where liquid G-agent deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis.</p> <p>Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>
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Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for GF because access to G-agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-put is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>
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Decontamination/Cleanup	<p>Decon/Cleanup Planning: Once site controls have been established, develop a specific decon/cleanup plan. Significant areas of lasting GF contamination is relatively unlikely due to high volatility of GD. Except where immediate decontamination of liquid-contaminated hotspots is necessary to reduce the spread of G-agent or to immediately clear an area for use (e.g., hotzone entry/egress), determine whether additional “decon” actions are necessary or whether natural attenuation can adequately reduce or eliminate the hazard within an acceptable amount of time (typically will require hours to days and is a preferred option for large open areas). Determine when sampling can be conducted to “clear” areas that are not likely to be contaminated. For areas requiring use of decon materials (see methods below), consider the following: localized liquid (surface) contamination versus vapor/aerosol deposition of large areas; impacts to sensitive surfaces; whether some materials (e.g. carpeting, furniture, etc) are best removed for disposal, and how to collect/test waste materials/solutions for possible classification as hazwaste.</p>
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Decon/Cleanup Methods:	<p>Effective and readily available non-proprietary* decon methods for G-agents include FOR LARGE AREAS: 1) Natural attenuation/degradation is recommended for vapor plume contamination or low concentration G-agent in large open areas; efficacy typically can be achieved in hours to days with no waste generated and no adverse impacts to sensitive items. 2) Water, seawater, dilute household bleach/chlorinated water (e.g., 0.5% sodium hypochlorite, swimming pool water,) are generally effective for low level contamination but require waste-water collection/sampling/possible hazwaste disposal and may damage sensitive items; efficacy typically achieved between 0.5-4 hrs after 2-15 minute rinse depending on level of contamination. FOR BUILDINGS/HVACS: Recommended options for G-agents include use of hot air ventilation (efficacy in hours) or ammonia gas and steam (efficacy achieved in less than an hour. FOR LIQUID CONTAMINATED SURFACES: 1) Household bleach solution (5.0% sodium hypochlorite); efficacy achieved between 0.5-4 hours with contact time of 15 minutes; however, very damaging (corrosive) to surfaces and should be rinsed; 2) High-pH solutions less corrosive than bleach (e.g., ammonia solutions, sodium bicarbonate solutions/slurries, or sodium borate hydrate/“Borax”); efficacy similar to that of bleach. 3) Reactive adsorbent clay (e.g., fullers earth) is useful for absorbing and neutralizing liquid agent; efficacy on the order of hours; 4) Chlorinated lime is best for high concentration liquid in localized areas; efficacy on the order of hours. *Proprietary decon materials (e.g. gels and foams) have been undergoing testing and are not officially endorsed though may have certain specific application benefits. Note: Decon products may have unique safety/ PPE requirements (e.g., bleach results in chlorine vapors).</p>
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Verification of Decon/Cleanup:	<p>Cleanup levels will be determined based on site-specific factors and multi-agency agreements. An example of a multi-agency verification sampling plan (developed during TOPOFF 2005 for sulfur mustard, and may be applicable for this agent) included a tiered approach involving prioritized multi-media samples. This exercise approach ensured:</p> <p style="margin-left: 20px;">Air results < 8 hour AEGL 1 value Water samples < 15 L/day drinking water value Soil samples < soil screening levels Wipe samples — presence-absence approach; laboratory detection capability, which will vary per laboratory</p> <p>Note: Some established effect levels (e.g., WPLs and GPLs) may be below the analytical detection limits of some laboratories.</p>
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Waste Disposal	<p>While not a “Federally-listed” waste, GF is more toxic than most RCRA listed chemicals and is a “listed” hazardous waste in some states where stored in military stockpiles. Though GF is somewhat volatile and actual liquid contaminated waste will likely be limited, perception/politics may suggest management of all response wastes as hazardous. However, extreme caution should be given to sample and segregate wastes sampling to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated and containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. Wastewater solution from decon should be analyzed to ensure no residual agent is present. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include “head space” (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility, such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent is present. It is likely that the solution will not contain residual agents and therefore not need to be classified as a hazardous waste but sampling must be used to verify. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>
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NRT Quick Reference Guide: Sulfur Mustard (H/HD/HT)

Report any release of WMD to the National Response Center 1-800-424-8802
For References, Please See: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Blister (Vesicant) Agent Description: Despite the common term "mustard gas," H/HD/HT (sulfur mustard) is an oily liquid and not a "gas," unless heated or exploded. H/HD/HT was developed as a warfare agent to cause severe injuries to the skin, eyes, and respiratory tract. It was manufactured in three forms of purity: 1) The nearly pure (distilled) substance, HD; 2) Agent H, which contains 20-30% impurities; and 3) HT, a mixture of 60% HD with thickening material to reduce freezing point. It is colorless when pure, but is typically a yellow to brown oily liquid with a slight garlic or mustard odor. Because of its high freezing point, H/HD/HT can persist for decades if significant quantities are buried in the soil or when stored in munitions. Large liquid spills will persist in cooler temperatures. Bulk liquid can settle in water and remain for years if undisturbed. If released in air as small aerosolized droplets or as a vapor, the residual deposition of small droplets on surfaces can last hours to days depending on weather conditions (heat and moisture increase agent breakdown). Vapors/droplets can settle in cooler/low-lying areas and may persist for days. Environmental breakdown products of H/HD/HT are relatively nontoxic. Health effects from H/HD/HT are delayed until hours after the exposure—so those exposed may not be aware. The effects caused by H/HD/HT are not typically fatal, but can require substantial supportive medical care as there is no antidote. Immediate decontamination is only means to minimize effects. High concentration exposures (especially direct liquid contact), can cause severe effects to include blistering of the skin and permanent eye and respiratory tract damage; lesser airborne concentrations may just cause temporary eye irritation. Long-term effects of high concentration exposures to H/HD/HT include scarring of skin, eye damage, and possibly cancer.																													
	Molecular Weight: (H/HD) 159 g/mol, (HT) 263 g/mol Volatility: (H) 610 mg/m ³ @ 68°F; (H/HD) 920 mg/m ³ @ 86°F, (HT) 831 mg/m ³ @ 77°F Freezing Point: (H/HD) 57°F, (HT) 89°F Vapor Pressure: (H/HD) 0.072 mm Hg @ 68°F, (HT) 0.077 mm Hg @ 68°F																													
Release Scenarios	CAS: (H/HD) 505-60-2; (HT) 63918-89-8 Vapor Density: (H/HD) 5.4, (HT) 6.9 (air=1.0) Boiling Point: (H/HD) ~422°F, (HT) >442°F Flashpoint: (H/HD) 223°F, (HT) 227-237°F Conversion Factors: (H/HD) 1 ppm=6.5 mg/m ³ °C=0.56 x (°F - 32)																													
	Aqueous Solubility: (H/HD) practically insoluble (HT) slightly soluble Soluble: (all) organic solvents, oils, fats Specific Gravity: (H/HD) 1.27g/cm ³ @ 77°F (HT) 1.26 g/cm ³ @ 77°F																													
Health Effects	Sulfur mustard is unique in that its freezing point is -57°F, so that in cooler temperatures it will be in a very thick, viscous form that will not volatilize. Air Release: Though vapors and even aerosol droplets can be largely broken down by physical and chemical processes (e.g., volatilization, oxidation, dilution), temperature and climate condition (e.g. rain) will determine the likelihood of some residual surface hazards. Cooler, dry environments and low-lying areas would be areas of greatest concentration/persistence. Water: If vapor/droplets contact large water surfaces, hydrolysis is expected to break down agents rapidly. Water movement/mixing further facilitate breakdown/hydrolysis processes. Chlorination/water treatment processes will also facilitate degradation of agents. If a large quantity of H/HD/HT liquid is directly poured into a small, untreated water source with limited agitation, there is potential for "globules" of agent to settle out. Facility: Due to its low volatility, VX would be difficult to distribute effectively throughout a building or facility from a point source. Possible localized areas of liquid contamination. U.S. Munitions Stockpiles: H/HD is undergoing destruction in Utah, Maryland, Arkansas, Alabama, Oregon, Kentucky, and Colorado. State/local plans to address potential vapor plume releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info).																													
	ONSET	H/HD/HT produce effects by entering cells of the skin, eyes or mucous membranes (including respiratory tract), causing DNA damage/cell death in seconds (this is not like an acid burn). Despite the immediate DNA damage, actual signs/symptoms are DELAYED 1-48 HOURS AFTER EXPOSURE. Time of onset and severity of effects depend on dose, duration, and route of exposure (not all signs/symptoms may develop).																												
	SIGNS/ SYMPTOMS	Mild: Effects are delayed 2-48 hours: Eye irritation (tearing, grittiness); runny nose, sneezing, nosebleed, hoarseness, hacking cough. Moderate: Effects are delayed 2-24 hours: Above plus reddening, swelling of eyelids, severe cough, shortness of breath, reddening of skin. Severe: Effects are delayed 1-24 hours: Upper respiratory/lung damage may occur at high concentrations and longer exposure durations. While high concentration H/HD/HT exposure is not generally lethal, without medical treatment infections from open blisters/respiratory tissue damage could be fatal. High concentration exposures that produce visible symptoms could later result in cancer. Inhalation: Vapor exposure is absorbed through the mucous membranes (nose, mouth, throat, and lungs) and inhaled. Injury develops slowly and intensifies over time. High concentration can cause lung damage. Skin: Direct contact with H/HD/HT liquid can cause redness or blisters in two to 24 hours. Warm and sweaty skin areas (underarms, groin) most susceptible. Eyes: Eyes are the most sensitive to H/HD/HT injury; effects noted 1-12 hours; irritation, burning, gritty feeling, itching, weeping, reddening, lid swelling, light-sensitivity, pain, and corneal injury. High concentration effects extremely painful and generally require extended medical treatment. Ingestion (rare): Consumption of contaminated food or drink could cause nausea and vomiting.																												
EXPOSURE ROUTES	Inhalation: H/HD and HT can be heated or otherwise released as vapor/aerosol and inhaled. Injury develops slowly and intensifies over several days. Vapor exposure is absorbed through the mucous membranes (eyes, mouth, throat, and lungs) and induces DNA damage/cell death within seconds. Skin: Direct contact with H/HD/HT can cause effects in one or more hours. H/HD/HT produce effects by entering cells of the skin, eyes or mucous membranes (including respiratory tract), causing DNA damage/cell death in seconds. Eyes: Greatly affected by vapor hazard; symptoms occur in an hour or more with direct liquid contact. Ingestion (rare): Consumption of contaminated food or drink could cause local effects.																													
Effect Levels	Air: Acute Exposure Guideline Levels (AEGs) (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents) for general population one-time exposure emergency scenarios for H/HD/HT: <table border="1"> <thead> <tr> <th>▼ AEG Level</th> <th>exposure duration ►</th> <th>10 min:</th> <th>30min:</th> <th>1 hr:</th> <th>4 hr:</th> <th>8 hr:</th> </tr> </thead> <tbody> <tr> <td>AEGL 1: threshold mild effects:</td> <td></td> <td>0.40 mg/m³</td> <td>0.13 mg/m³</td> <td>0.067 mg/m³</td> <td>0.017 mg/m³</td> <td>0.0080 mg/m³</td> </tr> <tr> <td>AEGL 2: potentially irreversible effects or impaired ability to escape:</td> <td></td> <td>0.60 "</td> <td>0.20 "</td> <td>0.10 "</td> <td>0.025 "</td> <td>0.013 "</td> </tr> <tr> <td>AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality:</td> <td></td> <td>3.9 "</td> <td>2.7 "</td> <td>2.1 "</td> <td>0.53 "</td> <td>0.27 "</td> </tr> </tbody> </table> Occupational: IDLH = 0.7 mg/m³; STEL = 3.0 x 10⁻³ mg/m³; Worker Population Limit (WPL) [an 8-hour time-weighted average occupational value] = 4.0 x 10 ⁻⁴ mg/m ³ General Population Limit (GPL): [a 24-hour time weighted average lifetime chronic value] = 2.0 x 10 ⁻⁵ mg/m ³ .		▼ AEG Level	exposure duration ►	10 min:	30min:	1 hr:	4 hr:	8 hr:	AEGL 1: threshold mild effects:		0.40 mg/m ³	0.13 mg/m ³	0.067 mg/m ³	0.017 mg/m ³	0.0080 mg/m ³	AEGL 2: potentially irreversible effects or impaired ability to escape:		0.60 "	0.20 "	0.10 "	0.025 "	0.013 "	AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality:		3.9 "	2.7 "	2.1 "	0.53 "	0.27 "
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Soil: Industrial Exposure Scenario = 0.3-14 mg/kg (10-4 cancer risk); Residential Exposure Scenario = 0.01-0.55 mg/kg (10-5 cancer risk). Drinking Water: Although H/HD/HT contamination of large water sources is unlikely, there are military screening levels to determine if smaller, contained water supplies (e.g., water buffalo or tank truck) have been contaminated. Acceptable levels for troops drinking 5-15 L/day of a contaminated supply for 7 days are 47-140 µg/L. This level is a reasonable value to use for the general population since their consumption rate is considerably less.																														
Personal Safety	SITE SPECIFIC CONCERNS	Check with the Health and Safety Officer regarding Personal Protective Equipment (PPE), Medical Surveillance, and Safety Plans. Level and type of PPE may vary depending upon the circumstances of the site and the incident. PPE levels below are general recommendations only.																												
	MEDICAL SURVEILLANCE	Baseline: Annual physical and respiratory function exams. During Incident: Conduct medical monitoring; use PPE designated by the Health and Safety (H&S) Plan; document PPE levels used; observe for any signs and symptoms and treat accordingly. Post-Incident: Monitor for signs/symptoms and treat accordingly.																												
	FIRST AID/ DECON	THERE IS NO ANTIDOTE. The only way to minimize effects is to perform immediate and thorough decon. Decon outer PPE with a dilute household bleach solution. Household bleach is 5% sodium hypochlorite. To create a dilute bleach solution, combine water and household bleach (add 1 part bleach to 9 parts water) yielding a 0.5% sodium hypochlorite solution. USE WARM SOAPY WATER INSTEAD OF DILUTE BLEACH FOR DECON OF BARE SKIN. Use water or saline eye rinse for eyes. Antihistamines and corticosteroids may relieve skin and eye irritation and guard against infection. Follow burn regimen for blisters. To administer first aid or cardiopulmonary resuscitation, ensure the victim is decontaminated first.																												
PPE	Hazard evaluation responders use NIOSH-approved chemical, biological, radiological, and nuclear (CBRN) self-contained breathing apparatus (SCBA) respirators when the types of inhalation hazards and their concentrations are unknown or expected to be high. The CBRN APR full-face respirator provides a lower level of protection than the SCBA and its use is generally allowed once conditions are understood and exposures are determined to be at lower levels. Outer suit: Tychem F, BR, LV, Responder, TK, or Reflector. Gloves: Butyl Rubber Goves, M3 and M4 Norton, or Chemical Protective Set. See: http://www2.dupont.com/Personal_Protection/en_US/assets/downloads/tychem/permguide82004.pdf . During decontamination operations there should also be PPE/respiratory measures to minimize potential exposures to associated chlorine vapors.																													

Sulfur Mustard (H/HD/HT) (side 2)

Field Detection	<p>Real-time field screening tools (results not confirmatory or quantified): Caution should be given to equipment that has not been properly evaluated. The following is a summary of screening tools procured by most EPA response teams. Other screening tools may be used by other agencies and responders some with similar capabilities and limitations. Hand-Held: 1) <i>APD-2000/(CAM)</i> and <i>Improved Chemical Agent Monitor (ICAM)</i>: Hand-held vapor detection devices that identify presence of H/HD/HT at concentrations ≥ 0.1 mg/m³ within 10 seconds. This device is subject to false positives (e.g., perfumes, exhausts, diesel). 2) <i>AP2C</i>: A hydrogen flame spectrophotometer that detects phosphorous (contained in G, V agents) and sulfur (contained in HD, V agents). Identifies presence of H/HD/HT at concentrations ≥ 0.1 mg/m³ within 10 seconds. 3) <i>Dräger Detector Tube</i>: Glass detector tubes impregnated with an indicating agent. Reagent produces a colorimetric indication in the presence of a particular gas, vapor, or aerosol. Gross levels can be read directly from the discoloration on the tube's printed scale; for confirmatory agent identification the tubes must be sent to an appropriate lab for further analysis. Tubes identify presence of H/HD/HT at concentrations ≥ 0.15 mg/m³. 4) <i>M256 Kit</i>: Air sample detector that identifies presence of H/HD/HT at concentrations ≥ 2.0 mg/m³ within 15 minutes. 5) <i>M8 and M9 papers</i>: Presence/absence colorimetric detector strips for liquid H/HD/HT on surfaces. M8 has an indefinite shelf life. 6) <i>M272 Water Test Kit</i>: Colorimetric test kits that can detect H/HD/HT at concentrations ≥ 2.0 mg/L within 7 minutes. Can be used for raw or treated water with minimal interferences.</p> <p>Advanced Field Monitoring: <i>EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA)</i>: A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect H/HD/HT vapors at concentrations as low as 1.1×10^{-4} mg/m³ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams.</p> <p>Note: <i>Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</i></p>
<p>THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION</p>	
Sampling for Confirmatory Results	<p>Sample Locations and Planning: Initially consider atmospheric sampling to "delineate the plume area," follow by targeted sampling and analysis to identify "hot spots" and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because H/HD/HT is a persistent liquid, sample priorities should include surfaces that are potentially contaminated with aerosol/liquid (e.g., release site, low lying areas) and which humans are likely to contact or where vegetation is used as food). Note: <i>These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</i></p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze H/HD/HT in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI) investigative unit to ensure chain-of-custody.</p> <p>Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p> <p>Types of Samples: Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and significant public health concern. Air sampling can answer, "Has the plume passed? Is liquid deposition off-gassing?" and to "prove a negative." Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis. Water: In large volumes of water, H/HD/HT is expected to dissipate via breakdown, hydrolysis, and dilution. Standard EPA semi-volatile water sampling methods apply. Soil: For localized "hot spot" areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was pored on ground. Wipes: Wipe samples are often desired to indicate absence of H/HD/HT on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding type of wipe pads or extraction solvent to use. Scabble/Cores: For hot spot areas where liquid H/HD/HT deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis. Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>
Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for H/HD/HT because access to CW agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-pot is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>
Decon/Cleanup	<p>Decon/Cleanup Planning: Once site controls have been established, develop a specific decon/cleanup plan. Significant areas of lasting H/HD/HT contamination is relatively unlikely due to high volatility of H/HD/HT. Except where immediate decontamination of liquid-contaminated hotspots is necessary to reduce the spread of H/HD/HT to immediately clear an area for use (e.g., hotzone entry/egress), determine whether additional "decon" actions are necessary or whether natural attenuation can adequately reduce or eliminate the hazard within an acceptable amount of time (typically will require hours to days and is a preferred option for large open areas). Determine when sampling can be conducted to "clear" areas that are not likely to be contaminated. For areas requiring use of decon materials (see methods below), consider the following: localized liquid (surface) contamination versus vapor/aerosol deposition of large areas; impacts to sensitive surfaces; whether some materials (e.g. carpeting, furniture, etc) are best removed for disposal, and how to collect/test waste materials/solutions for possible classification as hazwaste.</p> <p>Decon/Cleanup Methods: Effective and readily available non-proprietary* decon methods for H/HD/HT include: FOR LARGE AREAS: 1) Natural attenuation/degradation is recommended for vapor plume contamination or low concentration H/HD/HT in large open outdoor areas; efficacy typically can be achieved in days with no waste generated and no adverse impacts to sensitive items. 2) Water, seawater, dilute household bleach/chlorinated water (e.g., 0.5% sodium hypochlorite, swimming pool water,) are generally effective for low level contamination but require waste-water collection/sampling/possible hazwaste disposal and may damage sensitive items; efficacy typically achieved between 0.5-4 hrs after 2-15 minute rinse depending on level of contamination. FOR BUILDINGS/HVACS: Potential options for H/HD/HT include use of hot air ventilation, steam, ammonia gas and steam (efficacy achieved in hour(s)). FOR LIQUID CONTAMINATED SURFACES: 1) Household bleach solution (5.0% sodium hypochlorite); efficacy achieved between 0.5-4 hours with contact time of 15 minutes; however, very damaging (corrosive) to surfaces and should be rinsed; 2) High-pH solutions less corrosive than bleach (e.g., ammonia solutions, sodium bicarbonate solutions/slurries, or sodium borate hydrate/"Borax"); efficacy similar to that of bleach. 3) Reactive adsorbent clays (e.g., fullers earth) is useful for absorbing and neutralizing liquid agent; efficacy on the order of hours; 4) Chlorinated lime is best for high concentration liquid in localized areas; efficacy on the order of hours. *Proprietary decon materials e.g. gels and foams have been undergoing testing and are not officially endorsed though may have certain specific application benefits.</p> <p>Note: <i>Decon products may have unique safety/ PPE requirements (e.g., bleach results in chlorine vapors).</i></p> <p>Verification of Decon/Cleanup: Cleanup levels will be determined based on site-specific factors and multi-agency agreements. An example of a multi-agency verification sampling plan (developed during TOPOFF 2005 for H/HD/HT) included a tiered approach involving prioritized multi-media samples. This exercise approach ensured: Air results < 8 hour AEGL 1 value Water samples < 15 L/day drinking water value Soil samples < soil screening levels Wipe samples — presence-absence approach; laboratory detection capability, which will vary per laboratory</p> <p>Note: <i>Some established effect levels (e.g., WPLs and GPLs) may be below the analytical detection limits of some laboratories.</i></p>
Waste Disposal	<p>While not a "Federally-listed" waste, H/HD/HT is more toxic than most RCRA listed chemicals and is a "listed" hazardous waste in some states where stored in military stock-piles. Because H/HD/HT is difficult to disperse, hazardous waste can be minimized with proper segregation. While perception/politics may suggest management of all response wastes as hazardous, extreme caution should be given to sample and segregate wastes to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated and then containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include "head space" (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent is present. It is likely that the solution will not contain residual agent and therefore may not need to be classified as a hazwaste, but sampling must be used to verify this. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>

NRT Quick Reference Guide: VX

Report any release of WMD to the National Response Center 1-800-424-8802
For References, Please See: Key References Cited/Used* in National Response Team
(NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Nerve Agent CAS: 50782-69-9 Description: Odorless, oily, yellow/amber colored liquid when pure. VX was developed as a warfare agent and is a lethal cholinesterase inhibitor. It has the same mechanism of toxicity as organophates insecticides but in much more potent—in fact is the most potent of the nerve agents. However, VX has a very low vapor pressure and is difficult to maintain or disperse as vapor in air (unlike nerve agent GB). Liquid VX is relatively persistent on surfaces and can last for days to weeks if in large amounts or in cold environments. Under certain conditions, VX breakdown can result in the presence of compound EA-2192, which is considered almost as equally toxic as VX through ingestion (EA 2192 is a solid and thus not an inhalation hazard). Signs/symptoms of exposure to VX will occur within minutes or hours depending on the dose received. Even extremely low dose exposure to VX can be fatal, though immediate administration of an antidote (see First Aid/Decon below) can be lifesaving. Persistence: vapor: hours-day; liquid: hours-months depending on amount, temperature, rain or other weather conditions, and type of surface.																					
	Molecular Weight: 267.38 g/mol Volatility: 10.5 mg/m ³ @ 77°F Freezing Point: < -38 °F Vapor Pressure: 7 x 10 ⁻⁴ mm Hg @ 77°F	Vapor Density: 9.2 (air = 1) Boiling Point: 568°F Flashpoint: 318°F Conversion Factors: 1ppm= 11 mg/m ³ ; °C = 0.56 x (°F - 32)	Aqueous Solubility: 30g/L @ 77°F Soluble: organic solvents Liquid Density: 1.008 g/ml @ 68°F																			
Release Scenarios	Air Release: VX is very difficult to disperse in air due to low volatility, however it may be possible to disperse VX as a vapor/aerosol plume if an appropriate heat/explosive device is employed. The low volatility of VX would limit the size and extent of plume dissipation (significantly less than what would be expected of G-agents, such as GB). Droplets from a VX plume would likely settle near the initial point of release, posing localized surface hazards. Liquid contaminated surfaces will likely need decontamination due to liquid VX persistence (several days, weeks, or longer especially in colder environments and areas protected from open weathering). Water: If released into water, VX is expected to degrade from hydrolysis and be further broken down by dissolution and treatment processes, such as chlorination (high pH). Warm temperatures also hasten degradation. During environmental or hydrolytic degradation of VX, the breakdown product EA 2192 may be a potential oral toxic concern. Facility: Due to its low volatility, VX would be difficult to distribute effectively throughout a building or facility from a point source. Possible localized areas of liquid contamination. U.S. Munitions Stockpiles: U.S. munitions stockpiles of VX are undergoing destruction in Kentucky, Oregon, Arkansas, Alabama, Indiana, and Utah. State/local plans to address potential vapor plume releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info).																					
Health Effects	ONSET	Symptoms are dose dependent and may occur within seconds after exposure to vapors and within minutes or hours from exposure to liquid from.																				
	SIGNS/ SYMPTOMS	Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficult breathing. Moderate: Increased miosis (to level of pinpointing of pupils), headaches, confusion, drowsiness, nasal congestion, tightness of chest, nausea vomiting diarrhea, cramps, generalized weakness, twitching of large muscle groups. Severe: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, and death.																				
	EXPOSURE ROUTES	Inhalation: A primary exposure route; inhalation of very small concentrations can produce effects. Skin: Especially toxic from contact with liquid agent; usually moderate to severe localized effects (e.g., sweating) and systemic effects. Effects can also result from absorption of vapors through skin. Eyes: Eyes are the most sensitive target organs of nerve agent exposure: miosis (reduction in pupil size) will typically be the first sign of exposure. Ingestion: Overall systemic effects.																				
	OTHER	Females appear to be more susceptible to nerve agent effects. Small percentages of general population have genetic traits that may increase susceptibility.																				
Effect Levels	Air: Acute Exposure Guideline Levels (AEGLs) (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents) for general population one-time exposure emergency scenarios for VX: ▼AEGL Level exposure duration ► <table style="display: inline-table; border: none;"> <tr> <td>10 min:</td> <td>30min:</td> <td>1 hr:</td> <td>4 hr:</td> <td>8 hr:</td> </tr> <tr> <td>AEGL 1: threshold mild effects:</td> <td>0.00057 mg/m³</td> <td>0.00033 mg/m³</td> <td>0.00017 mg/m³</td> <td>0.00010 mg/m³</td> </tr> <tr> <td>AEGL 2: potentially irreversible effects or impaired ability to escape:</td> <td>0.0072 "</td> <td>0.0042 "</td> <td>0.0029 "</td> <td>0.0015 "</td> </tr> <tr> <td>AEGL 3: threshold for severe/incapacitating effects, medical needs:</td> <td>0.029 "</td> <td>0.015 "</td> <td>0.010 "</td> <td>0.0038 "</td> </tr> </table>		10 min:	30min:	1 hr:	4 hr:	8 hr:	AEGL 1: threshold mild effects:	0.00057 mg/m ³	0.00033 mg/m ³	0.00017 mg/m ³	0.00010 mg/m ³	AEGL 2: potentially irreversible effects or impaired ability to escape:	0.0072 "	0.0042 "	0.0029 "	0.0015 "	AEGL 3: threshold for severe/incapacitating effects, medical needs:	0.029 "	0.015 "	0.010 "	0.0038 "
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Occupational: IDLH= 0.003 mg/m ³ ; STEL= 1.0 x 10 ⁻³ mg/m ³ ; Worker Population Limit (WPL) [an 8-hour time-weighted average occupational value] = 1.0 x 10 ⁻⁶ mg/m ³ ; General Population Limit (GPL) [a 24-hour time weighted average lifetime chronic value] = 6.0 x 10 ⁻⁷ mg/m ³ . Soil: Industrial Exposure Scenario = 1.1-1.2 mg/kg; Residential Exposure Scenario = 0.042-0.047 mg/kg.																						
Drinking Water: Although VX contamination of large water sources is unlikely, there are military screening levels to determine if smaller, contained water supplies (e.g., water buffalo, tank truck) have been contaminated. Acceptable levels for troops drinking 5-15 L/day of a contaminated supply for 7 days are 4-12 µg/L. This level is a reasonable value to use for the general population since their consumption rate is considerably less.																						
Personal Safety	SITE SPECIFIC CONCERNS	Check with the Health and Safety Officer regarding Personal Protective Equipment (PPE), Medical Surveillance, and Safety Plans. Level and type of PPE may vary depending upon the circumstances of the site and the incident. PPE levels below are general recommendations only.																				
	MEDICAL SURVEILLANCE	Baseline: Annual physical and respiratory function exams and a baseline cholinesterase activity. During Incident: Conduct medical monitoring; use PPE designated by the Health and Safety (H&S) plan; document PPE levels used; observe for any signs and symptoms and treat accordingly. Post-Incident: Monitor for signs/symptoms and treat accordingly.																				
	FIRST AID/ DECON	Effective Antidote: Atropine and (if more severe) 2-PAM Chloride injections; atropine eye drops. Decon outer PPE with a dilute household bleach solution. Household bleach is 5% sodium hypochlorite. To create a dilute bleach solution, combine water and household bleach (add 1 part bleach to 9 parts water) yielding a 0.5% sodium hypochlorite solution. USE WARM SOAPY WATER INSTEAD OF DILUTE BLEACH FOR DECON OF BARE SKIN.																				
	PPE	Hazard evaluation responders use NIOSH approved chemical, biological, radiological, and nuclear (CBRN) self-contained breathing apparatus (SCBA) respirators when the types of inhalation hazards and their concentrations are unknown or expected to be high. The CBRN APR full-face respirator provides a lower level of protection than the SCBA and its use is generally allowed once conditions are understood and exposures are determined to be at lower levels. Outer suit: Tychem F, BR, LV, Responder, TK, or Reflector. Gloves: Butyl Rubber Goves, M3 and M4 Norton, or Chemical Protective Set. See: http://www2.dupont.com/Personal_Protection/en_US/assets/downloads/tychem/permguide82004.pdf . During decontamination operations there should also be PPE/respiratory measures to minimize potential exposures to associated chlorine vapors.																				
Field Detection	Real-time field screening tools (results not confirmatory or quantified): Caution should be given to equipment that has not been properly evaluated. The following is a summary of screening tools procured by most EPA response teams. Other screening tools may be used by other agencies and responders some with similar capabilities and limitations. Hand-Held: 1) <i>APD-2000(CAM)</i> and <i>Improved Chemical Agent Monitor (ICAM)</i> : Hand-held vapor detection devices that identify presence of VX at concentrations ≥ 0.03 mg/m ³ within 10 seconds. This device is subject to false positives (e.g., perfumes, exhausts, diesel). Can specify type of nerve agent, which is an improvement over previous military monitors that could not distinguish between the nerve agents. 2) <i>AP2C</i> : A hydrogen flame spectrophotometer that detects phosphorous (contained in G, V agents) and sulfur (contained in HD, V agents). Identifies presence of VX at concentrations ≥ 0.03 mg/m ³ within 10 seconds. 3) <i>Dräger Detector Tube</i> : Glass detector tubes impregnated with an indicating agent. Reagent produces a colorimetric indication in the presence of a particular gas, vapor, or aerosol. Gross levels can be read directly from the discoloration on the tube's printed scale; for confirmatory agent identification the tubes must be sent to an appropriate lab for further analysis. Tubes identify presence																					

VX (side 2)

Field Detection <i>(cont'd)</i>	<p>of VX at concentrations ≥ 0.025 mg/m³. 4) M256 Kit: Air sample detector that identifies presence of VX at concentrations ≥ 0.02 mg/m³ within 15 minutes. 5) M8 and M9 papers: Presence/absence colorimetric detector strips for liquid VX on surfaces. M8 has an indefinite shelf life. 6) M272 Water Test Kit: Colorimetric test kits that can detect VX at concentrations ≥ 0.02 mg/L within 7 minutes. Can be used for raw or treated water with minimal interferences. Advanced Field Monitoring: EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA): A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect VX vapors at concentrations as low as 7.7×10^{-5} mg/m³ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams.</p> <p>Note: Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</p>
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THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION

Sampling for Confirmatory Results	<p>Sample Locations and Planning: Initially consider atmospheric sampling to "delineate the plume area," follow by targeted sampling and analysis to identify "hot spots" and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because VX is a persistent liquid, sample priorities should include surfaces that are potentially contaminated with aerosol/liquid (e.g., release site, low lying areas) and which humans are likely to contact or where vegetation is used as food).</p> <p>Note: These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze VX (or its breakdown product EA 2192), in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI investigative unit to ensure chain-of-custody.</p> <p>Sample packaging and shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p> <p>Types of Samples:</p> <p>Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and significant public health concern. Air sampling can answer, "Has the plume passed? Is liquid deposition off-gassing?" and to "prove a negative." Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis.</p> <p>Water: In large volumes of water, VX is expected to dissipate via breakdown, hydrolysis, and dilution. To rule out contamination concerns, particularly in smaller bodies of water, however, analyses should include the breakdown product EA-2192. Standard EPA semi-volatile water sampling methods apply.</p> <p>Soil: For localized "hot spot" areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was pored on ground.</p> <p>Wipes: Wipe samples are often desired to indicate absence of VX on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding type of wipe pads or extraction solvent to use.</p> <p>Scabble/Cores: For hot spot areas where liquid G-agent deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis.</p> <p>Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>				
Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for VX because access to CW agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-put is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>				
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Waste Disposal	<p>While not a "Federally-listed" waste, VX is more toxic than most RCRA listed chemicals and is a "listed" hazardous waste in some states where stored in military stockpiles. Because VX is difficult to disperse, hazardous waste can be minimized with proper segregation. While perception/politics may suggest management of all response wastes as hazardous, extreme caution should be given to sample and segregate wastes to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated and then containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include "head space" (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent or degradation products, like EA-2192, is present. It is likely that the solution will not contain residual agent and therefore may not need to be classified as a hazwaste, but sampling must be used to verify this. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>				

NRT Quick Reference Guide: Tabun (GA)

Report any release of WMD to the National Response Center 1-800-424-8802
For References, Please See: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Nerve Agent CAS: 77-81-6 Description: Colorless to brown liquid; generally odorless, though possibly fruity. GA was manufactured as a warfare agent and is a lethal cholinesterase inhibitor. It has the same mechanism of toxicity as organophosphate insecticides but is much more potent. GA is considered to have moderately low persistence as it is less volatile than GB (sarin), but it is much more volatile than persistent agents, such as VX or HD (sulfur mustard). Liquid GA could be present for hours to days if present in large amounts, or in cold or enclosed environments. Breakdown/hydrolysis in water (especially treated water) is expected. Environmental degradation/breakdown products of GA are relatively nontoxic. However, liquid agent GA reaction with high-pH decon solutions (e.g., household bleach) may produce toxic intermediate products (e.g., cyanide gas). Signs/symptoms of exposure to GA will occur within minutes or hours depending on the dose. Even relatively low dose exposure to GA can be fatal, though immediate administration of an antidote can be lifesaving (see First Aid/Decon below). Persistence: vapor: minutes to hours; liquid: hours to days depending on amount, temperature, rain or other weather conditions, and type of surface.																													
	Molecular Weight: 162.13 g/mol Volatility: 610 mg/m ³ @ 77°F Freezing point: -58°F Vapor Pressure: 0.07 mm Hg @ 68°F	Vapor Density: 5.63 (air = 1) Boiling Point: 446-473°F Flashpoint: 172°F Conversion Factors: 1ppm = 6.6 mg/m ³ ; °C = 0.56 × (°F - 32)	Aqueous Solubility: 73 g/L 68°F Soluble: organic solvents Specific Gravity: 1.08 g/ml @ 77°F																											
Release Scenarios	Air Release: Because it is somewhat volatile, GA is not considered a "persistent" agent. Though less so than GB, GA is a plausible agent of concern for facilities or large outdoor areas. Liquid contaminated surfaces could persist for hours or days in colder environments/areas protected from open weathering. Water: If released into water, GA would likely degrade from evaporation and hydrolysis, and be further broken down by dissolution and treatment processes such as chlorination. Environmental and hydrolytic degradation products of GA are not significant toxic concerns. Facility: GA could potentially be dispersed in a building or facility. Decontamination should focus on areas of liquid contamination. Breakdown products of GA are not significant toxic concerns however, liquid GA reaction with high-pH decon solutions may produce cyanide gas. U.S. Munitions Stockpiles: U.S. munitions stockpiles of G-agents are/have undergone destruction/disposal in Utah, Oregon, Arkansas, Alabama, and Kentucky. State/local plans to address potential releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info).																													
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	EXPOSURE ROUTES	Inhalation: A primary exposure route; inhalation of very small concentrations can produce effects. Skin: Especially toxic from contact with liquid agent; usually moderate to severe localized effects (e.g., sweating) and systemic effects. Effects can also result from absorption of vapors through skin. Eyes: Eyes are the most sensitive target organs of nerve agent exposure: miosis (reduction in pupil size) will typically be the first sign of exposure. Ingestion: Overall systemic effects.																												
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Field Detection (cont'd)	<p>of G-agents at concentrations ≥ 0.025 mg/m³. 4) M256 Kit: Air sample detector that identifies presence of G-agents at concentrations $\geq 5.0 \times 10^{-3}$ mg/m³ within 15 minutes. 5) M8 and M9 papers: Presence/absence colorimetric detector strips for liquid G-agent on surfaces. M8 has an indefinite shelf life. 6) M272 Water Test Kit: Colorimetric test kits that can detect G-agents at concentrations ≥ 0.02 mg/L within 7 minutes. Can be used for raw or treated water with minimal interferences. Advanced Field Monitoring: EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA): A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect G-agent vapors at concentrations as low as 4.9×10^{-6} mg/m³ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams.</p> <p>Note: Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</p>
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THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION

Sampling for Confirmatory Results	<p>Sample Locations and Planning: Initially consider atmospheric sampling to “delineate the plume area,” followed by targeted sampling and analysis to identify “hot spots” and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because GA is generally not persisting, sampling to “clear areas” where no liquid deposition is expected vs. identifying potential hot spots of liquid contamination and should be emphasized in the sampling plan. Note: These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze GA, particularly in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI investigative unit to ensure chain-of-custody.</p> <p>Sample packaging and shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p> <p>Types of Samples: Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and a significant public health concern. Air sampling can be performed to answer, “Has the plume passed? Is liquid deposition off-gassing?” and to “prove a negative.” Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis. Water: As previously indicated, G-agents are unlikely to persist in water. If analysis is performed, standard EPA volatile water sampling methods should be used. Soil: For localized “hot spot” areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was poured on ground. Wipes: Wipe samples are often desired to indicate absence of G-agents on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding type of wipe pads or extraction solvent to use. Scabble/Cores: For hot spot areas where liquid G-agent deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis. Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>
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Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for GA because access to G-agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-put is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>
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Decontamination/Cleanup	<p>Decon/Cleanup Planning: Once site controls have been established, develop a specific decon/cleanup plan. Significant areas of lasting GA contamination is relatively unlikely due to high volatility of GA. Except where immediate decontamination of liquid-contaminated hotspots is necessary to reduce the spread of G-agent or to immediately clear an area for use (e.g., hoizone entry/egress), determine whether additional “decon” actions are necessary or whether natural attenuation can adequately reduce or eliminate the hazard within an acceptable amount of time (typically will require hours to days and is a preferred option for large open areas). Determine when sampling can be conducted to “clear” areas that are not likely to be contaminated. For areas requiring use of decon materials (see methods below), consider the following: localized liquid (surface) contamination versus vapor/aerosol deposition of large areas; impacts to sensitive surfaces; whether some materials (e.g. carpeting, furniture, etc) are best removed for disposal, and how to collect/test waste materials/solutions for possible classification as hazwaste.</p> <p>Decon/Cleanup Methods: Effective and readily available non-proprietary* decon methods for G-agents include the following though it is cautioned that liquid GA reaction with high pH solution (e.g. bleach) can produce toxic intermediate products (e.g. cyanide gas). Hazard can be minimized through excess use of bleach. FOR LARGE AREAS: 1) Natural attenuation/degradation is recommended for vapor plume contamination or low concentration G-agent in large open areas; efficacy typically can be achieved in hours to days with no waste generated and no adverse impacts to sensitive items. 2) Water, seawater, dilute household bleach/chlorinated water (e.g., 0.5% sodium hypochlorite, swimming pool water) are generally effective for low level contamination but require waste-water collection/sampling/possible hazwaste disposal and may damage sensitive items; efficacy typically achieved between 0.5-4 hrs after 2-15 minute rinse depending on level of contamination. FOR BUILDINGS/HVACS: Recommended options for G-agents include use of hot air ventilation (efficacy in hours) or ammonia gas and steam (efficacy achieved in less than an hour. FOR LIQUID CONTAMINATED SURFACES: 1) Household bleach solution (5.0% sodium hypochlorite); efficacy achieved between 0.5-4 hours with contact time of 15 minutes; however, very damaging (corrosive) to surfaces and should be rinsed 2) High-pH solutions less corrosive than bleach (e.g., ammonia solutions, sodium bicarbonate solutions/slurries, or sodium borate hydrate/“Borax”); efficacy similar to that of bleach. 3) Reactive adsorbent clay (e.g., fullers earth) is useful for absorbing and neutralizing liquid agent; efficacy on the order of hours; 4) Chlorinated lime is best for high concentration liquid in localized areas; efficacy on the order of hours. *Proprietary decon materials (e.g. gels and foams) have been undergoing testing and are not officially endorsed though may have certain specific application benefits.</p> <p>Note: Decon products may have unique safety/ PPE requirements (e.g., bleach results in chlorine vapors).</p> <p>Verification of Decon/Cleanup: Cleanup levels will be determined based on site-specific factors and multi-agency agreements. An example of a multi-agency verification sampling plan (developed during TOPOFF 2005 for sulfur mustard, and may be applicable for this agent) included a tiered approach involving prioritized multi-media samples. This exercise approach ensured: Air results < 8 hour AEGL 1 value Water samples < 15 L/day drinking water value Soil samples < soil screening levels Wipe samples — presence-absence approach; laboratory detection capability, which will vary per laboratory</p> <p>Note: Some established effect levels (e.g., WPLs and GPLs) may be below the analytical detection limits of some laboratories.</p>
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Waste Disposal	<p>While not a “Federally-listed” waste, GA is more toxic than most RCRA listed chemicals and is a “listed” hazardous waste in some states where stored in military stockpiles. Though GA is somewhat volatile and actual liquid contaminated waste will likely be limited, perception/politics may suggest management of all response wastes as hazardous. However, extreme caution should be given to sample and segregate wastes sampling to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated, containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. Wastewater solution from decon should be analyzed to ensure no residual agent is present. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include “head space” (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility, such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent is present. It is likely that the solution will not contain residual agents and therefore not need to be classified as a hazardous waste but sampling must be used to verify. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>
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NRT Quick Reference Guide: Sarin (GB)

Report any release of WMD to the National Response Center 1-800-424-8802
For References, Please See: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents.

Agent Characteristics	Agent Classification: Chemical Warfare Nerve Agent CAS: 107-44-8 Description: Colorless to brown liquid; generally odorless, but may have fruity odor if impure. GB was manufactured as a warfare agent and is a lethal cholinesterase inhibitor. It has the same mechanism of toxicity as organophosphate insecticides only it is much more potent. GB is the most volatile of all nerve agents, with volatility similar to that of water. While easier to disperse in air it is less likely to persist in the environment than persistent agents such as VX or HD (sulfur mustard). While considered non-persistent, liquid GB could be present for hours to a day or more if in large amounts or in cold or enclosed environments. Breakdown/hydrolysis in water (especially treated water) is expected to be fairly rapid. Environmental degradation/breakdown products of GB are relatively nontoxic. Signs/symptoms of GB exposure will occur within minutes or hours depending on dose received. Even relatively low dose exposure to GB can be fatal, though immediate administration of an antidote can be lifesaving (see First Aid/Decon below). Persistence: vapor: minutes-hours; liquid: 2-24 hours depending on amount, temperature, rain or other weather conditions, and type of surface. Molecular Weight: 140.10 g/mol Vapor Density: 4.86 (air = 1) Volatility: 22,000 mg/m ³ @ 77°F Boiling Point: 316°F Freezing Point: -69°F Flashpoint: > 280°F Vapor Pressure: 2.94 mm Hg @ 77°F Conversion Factors: 1ppm = 5.7 mg/m³; °C = 0.56 x (°F - 32) Aqueous Solubility: miscible with H₂O Soluble: organic solvents Specific Gravity: 1.09 g/ml @ 68°F																								
	Release Scenarios	Air Release: GB is one of the more easily generated nerve agents (an impure version of GB was the agent used in the 1995 Tokyo subway event). Because it is volatile (liquid droplets or aerosols evaporate about as quickly as rain), it is not considered a "persistent" agent. Its volatility makes it easier to disperse as a vapor than other agents, thus GB is a plausible agent of concern for facilities or large outdoor areas. Since relatively non-persistent, GB will degrade in environment fairly rapidly; however liquid on surfaces could persist for hours or days in colder environments. Water: If released into water, GB will likely degrade from evaporation and hydrolysis, and be further broken down by dissolution and treatment processes, such as chlorination. Environmental and hydrolytic degradation products of GB are not significant toxic concerns. Facility: Due to its volatility, GB could potentially be dispersed in a building or facility. Decontamination should focus on areas of liquid contamination. Breakdown products of GB are not significant toxic concerns U.S. Munitions Stockpiles: U.S. munitions stockpiles of GB are/have undergone destruction/disposal in Utah, Oregon, Arkansas, Alabama, and Kentucky. State/local plans to address potential releases from Army properties are in place at these sites. These sites provide potential local subject matter experts (SMEs) and pertinent plans (go to http://www.cma.army.mil/csepp.aspx for more info).																							
Health Effects	ONSET	Symptoms are dose dependent and may occur within seconds after exposure to vapors and within minutes or hours from exposure to liquid from.																							
	SIGNS/ SYMPTOMS	Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficult breathing. Moderate: Increased miosis (to level of pinpointing of pupils), headaches, confusion, drowsiness, nasal congestion, tightness of chest, nausea vomiting diarrhea, cramps, generalized weakness, twitching of large muscle groups. Severe: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, and death.																							
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Sarin (GB) (side 2)

Field Detection (cont'd)	<p>levels can be read directly from the discoloration on the tube's printed scale; for confirmatory agent identification the tubes must be sent to an appropriate lab for further analysis. Tubes identify presence of G-agents at concentrations ≥ 0.025 mg/m³. 4) M256 Kit: Air sample detector that identifies presence of G-agents at concentrations $\geq 5.0 \times 10^{-3}$ mg/m³ within 15 minutes. 5) M8 and M9 papers: Presence/absence colorimetric detector strips for liquid G-agent on surfaces. M8 has an indefinite shelf life. 6) M272 Water Test Kit: Colorimetric test kits that can detect G-agents at concentrations ≥ 0.02 mg/L within 7 minutes. Can be used for raw or treated water with minimal interferences.</p> <p>Advanced Field Monitoring: EPA ERT Mobile Trace Atmospheric Gas Analyzer (TAGA): A vehicle-mounted Mass Spectrometry/Mass Spectrometry (MS/MS) laboratory that can reportedly detect G-agent vapors at concentrations as low as 4.9×10^{-6} mg/m³ (based on calibration with a surrogate agent). Quantified results may be obtained from other truck-mounted or fixed laboratory equipment used by other governmental response teams.</p> <p>Note: Final confirmatory quantified results can only be obtained from officially endorsed agent laboratories that use Gas Chromatography (GC)-MS.</p>
<p>THIS SECTION ADDRESSES THE COLLECTION OF SAMPLES FOR QUANTITATIVE CONFIRMATORY LABORATORY ANALYSIS FOR RISK ASSESSMENT AND CLEANUP VERIFICATION</p>	
Sampling for Confirmatory Results	<p>Sample Locations and Planning: Initially consider atmospheric sampling to "delineate the plume area," followed by targeted sampling and analysis to identify "hot spots" and agent flow paths. Additional biased or random sampling can be used to determine the extent of contamination or to verify efficacy of cleanup. More thorough sampling (e.g., grid, statistical approach) may be appropriate if there are large uncertainties about the area impacted or the amount released. Because GB is generally not persistent, sampling to "clear areas" where no liquid deposition is expected vs. identifying potential hot spots of liquid contamination and should be emphasized in the sampling plan.</p> <p>Note: These are general guidelines and do not replace need for a site-specific sampling plan. See reference list for sources of sampling guidance.</p> <p>Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., initial identification, extent of contamination, decon); and 4) specific laboratory requirements. Few laboratories have capability to analyze GB, particularly in all types of media. See LABORATORY ANALYSIS, below. For forensic sampling, ask the National Response Center (1-800-424-8802) to notify the appropriate Regional EPA Homeland Security Division (HSD)/FBI investigative unit to ensure chain-of-custody.</p> <p>Sample packaging and shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, and IATA. Consult the analytical laboratory receiving the samples to determine if they have additional packaging or shipping requirements.</p> <p>Types of Samples: Air: Air samples are used in all phases of response and typically comprise largest number of samples since air is a primary exposure pathway and a significant public health concern. Air sampling can be performed to answer, "Has the plume passed?" Is liquid deposition off-gassing?" and to "prove a negative." Air sampling is a good indicator of other pathways (e.g., off-gassing from soil) and is useful in risk analysis since it has health-based exposure limits. On-site and downwind sampling should be conducted within 6 inches above potentially contaminated surfaces/soil to assess any off-gassing hazard as well as at breathing zone level (e.g., 5 feet) to assess potential public health inhalation exposures. Appropriate solid phase sorbent medium (e.g., tubes, PUF samplers) and SUMMA canisters can be used for sample collection and subsequent laboratory analysis. Water: As previously indicated, G-agents are unlikely to persist in water. If analysis is performed, standard EPA volatile water sampling methods should be used. Soil: For localized "hot spot" areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was poured on ground. Wipes: Wipe samples are often desired to indicate absence of G-agents on non-porous surfaces. Concurrent air monitoring is recommended because there are currently no health-based effect levels to evaluate wipe sample data. Wipe sampling generally involves using synthetic gauze or cotton pads with a solvent to wipe a 10 cm x 10 cm area. Different labs may have specific requests regarding the type of wipe pads or extraction solvent to be used. Scabble/Cores: For hot spot areas where liquid G-agent deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis. Agricultural/Food: Currently, there are no validated methods for analysis of agricultural/food products; instead air, soil, and water sample results can be used as indicators.</p>
Laboratory Analysis	<p>There are very few labs within the U.S. that have confirmatory capability for GB because access to G-agent standards for laboratory calibration is limited. Of these labs, many may not be able to perform analysis on all matrices (e.g., wipes and soil). Most labs use their own specific methods, so caution is needed when comparing data sets from different labs. Sample thru-put is generally limited to 20-30 environmental samples in a 48 hour period; therefore, avoid overwhelming laboratories: planned sample prioritization (type and location) is critical.</p> <p>Laboratory Information: Chemical Agent Analyses Contract Vehicles for EPA emergency lab support. EPA has IAGs with Army (Aberdeen and Dugway) for Analytical Lab Support During a WMD response; for access please contact the ERT 24hr number: 732-321-6660.</p>
Decontamination/Cleanup	<p>Decon/Cleanup Planning: Once site controls have been established, develop a specific decon/cleanup plan. Significant areas of lasting GB contamination is relatively unlikely due to high volatility of GB. Except where immediate decontamination of liquid-contaminated hotspots is necessary to reduce the spread of G-agent or to immediately clear an area for use (e.g., hotzone entry/egress), determine whether additional "decon" actions are necessary or whether natural attenuation can adequately reduce or eliminate the hazard within an acceptable amount of time (typically will require hours to days and is a preferred option for large open areas). Determine when sampling can be conducted to "clear" areas that are not likely to be contaminated. For areas requiring use of decon materials (see methods below), consider the following: localized liquid (surface) contamination versus, vapor/aerosol deposition of large areas; impacts to sensitive surfaces; whether some materials (e.g. carpeting, furniture, etc) are best removed for disposal; and how to collect and test waste materials and solutions for possible classification as hazwaste.</p> <p>Decon/Cleanup Methods: Effective and readily available non-proprietary* decon methods for G-agents include: FOR LARGE AREAS: 1) Natural attenuation/degradation is recommended for vapor plume contamination or low concentration G-agent in large open areas; efficacy typically can be achieved in hours to days with no waste generated and no adverse impacts to sensitive items. 2) Water, seawater, and dilute household bleach/chlorinated water (e.g., 0.5% sodium hypochlorite, swimming pool water) are generally effective for low level contamination but require waste-water collection/sampling/possible hazwaste disposal and may damage sensitive items; efficacy typically achieved between 0.5-4 hrs after 2-15 minute rinse depending on level of contamination. FOR BUILDINGS/HVACS: Recommended options for G-agents include use of hot air ventilation (efficacy in hours) or ammonia gas and steam (efficacy achieved in less than an hour). FOR LIQUID CONTAMINATED SURFACES: 1) Household bleach solution (5.0% sodium hypochlorite); efficacy achieved between 0.5-4 hours with contact time of 15 minutes; however, very damaging (corrosive) to surfaces and should be rinsed; 2) High-pH solutions less corrosive than bleach (e.g., ammonia solutions, sodium bicarbonate solutions/slurries, or sodium borate hydrate/"Borax"); efficacy similar to that of bleach; 3) Reactive adsorbent clay (e.g., fullers earth) is useful for absorbing and neutralizing liquid agent; efficacy on the order of hours; 4) Chlorinated lime is best for high concentration liquid in localized areas; efficacy on the order of hours. *Proprietary decon materials (e.g. gels and foams) have been undergoing testing and are not officially endorsed though may have certain specific application benefits.</p> <p>Note: Decon products may have unique safety/PPE requirements (e.g., bleach results in chlorine vapors).</p> <p>Verification of Decon/Cleanup: Cleanup levels will be determined based on site-specific factors and multi-agency agreements. An example of a multi-agency verification sampling plan (developed during TOPOFF 2005 for sulfur mustard, and may be applicable for this agent) included a tiered approach involving prioritized multi-media samples. This exercise approach ensured: Air results < 8 hour AEGL 1 value Water samples < 15 L/day drinking water value Soil samples < soil screening levels Wipe samples — presence-absence approach; laboratory detection capability, which will vary per laboratory</p>
Waste Disposal	<p>While not a "Federally-listed" waste, GB is more toxic than most RCRA listed chemicals and is a "listed" hazardous waste in some states where stored in military stockpiles. Though GB is fairly volatile and actual liquid contaminated waste will likely be limited, perception/politics may suggest management of all response wastes as hazardous. However, extreme caution should be given to sample and segregate wastes sampling to minimize hazwaste disposal costs which can far exceed all other response related costs. Grossly liquid-contaminated materials should be decontaminated and containerized and labeled in accordance with DOT and EPA requirements as a hazwaste. Wastewater solution from decon should be analyzed to ensure no residual agent is present. The National Response Plan, ESF-3 designates USACE as the primary agency to manage contaminated debris. USACE and DOD typically use safety procedures prior to transport that include "head space" (off gas) monitoring around containers prior to shipment to ensure no leakage/off-gassing. Typically waste will be transported in accordance with state requirements to a designated disposal facility, such as an RCRA-permitted hazardous waste facility (typically an incinerator). Wastewater solution from decon will be analyzed to ensure no residual agent is present. It is likely that the solution will not contain residual agents and therefore not need to be classified as a hazardous waste but sampling must be used to verify. Chlorinated wastewater may need to be treated/neutralized prior to disposal.</p>

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* Several sources were used in developing the QRGs. Because most references are considered “secondary” sources, comparisons among multiple sources helped to verify information. When conflicting information was found between listed references, a determination was made as to what was more correct and up-to-date, based on publication date and level of peer-review.

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APD2000: Smiths Detection — Danbury, 21 Commerce Drive, Danbury, CT 06810; www.sensir.com; (ph) 203-207-9700, Toll Free: 888-473-6747; (fax) 203-207-9780; danbury@smithsdetection.com; For technical problems or questions during normal business hours email support.danbury@smithsdetection.com.

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