Comprehensive Chemical Agent Tactical Guidebook for Consequence Management

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DISCLAIMER

PARTICIPANTS

The Chemical Warfare Agent (CWA) National Preparedness Work Group consists of United States Environmental Protection Agency (EPA) On-Scene Coordinator (OSC) representatives from all 10 Regions as well as representatives from the National Homeland Security Research Center (NHSRC), Environmental Response Team (ERT), and Consequence Management Advisory Division (CMAD). The goal of the WG was to develop an operational guide, or playbook to provide a national approach to respond to a CWA incident. The result is this Comprehensive Chemical Agent Tactical Guidebook for Consequence Management (Guidebook). Additional guides, checklists, or appendices were developed or used in support of this Guidebook. CSS-Dynamac, the Decontamination Analytical & Technical Service (DATS) contractor for CMAD, assisted with preparation of this Guidebook. The following project team individuals also contributed their time and expertise to writing this Guidebook:

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AAMP	Ambient Air Monitoring Plan
AC	Chemical warfare agent hydrogen cyanide
ACGIH	American Conference of Government Industrial Hygienists
AEGL	Acute Exposure Guideline Level
AEL	Airborne exposure limit
AIHA	American Industrial Hygienists Association
APF	Assigned protection factor
APR	Air-purifying respirator
ARAR	Applicable or relevant and appropriate requirement
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
BROOM	Building Restoration Operations Optimization Model
CAD	Computer-aided design
CAP	Common Alerting Protocol
CAS	Chemical Abstract Services
CBRN	Chemical, biological, radiological, and nuclear
CBRNE	Chemical, biological, radiological, nuclear, and high-yield explosives
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
CG	Chemical warfare agent phosgene
CJR	Combined judgmental and random
CK	Chemical warfare agent cyanogen chloride
CMAD	Consequence Management Advisory Division
COC	Chain-of-custody
CWA	Chemical warfare agent
CWC	Chemical Weapons Convention
DHHS	Department of Health and Human Services
DHS	Department of Homeland Security
DMP	Data Management Plan
DOD	Department of Defense
DOE	Department of Energy
DOT	U.S. Department of Transportation
DQO	Data quality objective
ECC	Environmental Clearance Committee
ECD	Electron capture device
EDD	Electronic data deliverable
EOC	Emergency Operations Center
EPA	United States Environmental Protection Agency
ERLN	Environmental Response Laboratory Network
ERPG	Emergency Response Planning Guideline
ERRS	Emergency Rapid Response Services
ERT	Environmental Response Team
ESF	Emergency Support Function
EU	Environmental Unit (a unit of the Planning Section of a Unified Command)
FSP	Field Sampling Plan
FEMA	Federal Emergency Management Agency

FNR	False-negative rate
GA	Chemical warfare nerve agent tabun
G agents	Class of chemical warfare nerve agents, including tabun, sarin, soman, and cyclosarin
GB	Chemical warfare nerve agent sarin
GC	Gas chromatography
GD	Chemical warfare nerve agent soman
GF	Chemical warfare nerve agent cyclosarin
GIS	Geographic information system
GPL	General population limit
GPS	Global positioning system
Guidebook	Comprehensive Chemical Agent Tactical Guidebook for Consequence Management
H	Sulfur mustard
HA	Health Advisory
HASP	Health and Safety Plan
HAZMAT	Hazardous material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HD	Distilled (purified) sulfur mustard
HEPA	High-efficiency particulate air
HMTA	Hazardous Materials Transportation Act
HSPD-5	Homeland Security Presidential Directive-5
HVAC	Heating, ventilation, and air conditioning
IAP	Incident Action Plan
IC	Incident Commander
IC/UC	Incident Command/Unified Command
ICP	Incident Command Post
ICS	Incident Command System
IDLH	Immediately dangerous to life or health
IDQTF	Intergovernmental Data Quality Task Force
ISO	International Organization for Standardization
JFO	Joint Field Office
JIC	Joint Information Center
LC	Liquid chromatography
LCt50	Lethal concentration and time 50 percent
LD50	Lethal dose 50 percent
LLNL	Lawrence Livermore National Laboratory
LNO	Liaison Officer
MCL	Maximum Contaminant Level
mg/m^3	Milligram per cubic meter
MS	Mass spectrometry
MS/MS	Tandem mass spectrometry
mVHP	Modified vaporous hydrogen peroxide
NAS	National Academy of Sciences
NAU	Negative air unit (also known as negative air machine [NAM])
NCEH	National Center for Environmental Health
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NELAC	National Environmental Laboratory Accreditation Conference
NFPA	National Fire Protection Association
NHSRC	National Homeland Security Research Center

NIOSH	National Institute for Occupational Safety and Health
NIMS	National Incident Management System
NIST	National Institute of Standards and Technology
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination Program
NRC	National Research Council
NRF	National Response Framework
NRS	National Response System
NRT	National Response Team
ORNL	Oak Ridge National Laboratory
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
OSTP	Office of Science and Technology Policy
OSWER	Office of Solid Waste and Emergency Response
PAL	Provisionary Advisory Level
P&T	Purge and-trap
PCB	Polychlorinated biphenyl
PDA	Personal data assistant
PEL	Permissible exposure limit
PHILIS	Portable High Throughput Integrated Laboratory Identification System
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIO	Public Information Officer
PNNL	Pacific Northwest National Laboratory
POTW	Publicly owned treatment works
ppbv	Part per billion by volume
PPE	Personal protective equipment
ppmv	Part per million by volume
pptv	Part per trillion by volume
QAPP	Quality Assurance Project Plan
QA	Quality assurance
QC	Quality control
QRG	Quick Reference Guide
QSAR	Quantitative structure-activity relationship
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
RRT	Regional Response Team
RSL	Regional Screening Level
SA	Chemical warfare agent arsine
SADA	Spatial Analysis and Decision Assistance
SAM	Selected Analytical Methods for Environmental Remediation and Recovery
SAP	Sampling and Analysis Plan
SCBA	Self-contained breathing apparatus
SEDD	Staged Electronic Data Deliverable
SME	Subject matter expert
SNL	Sandia National Laboratory
SO	Safety Officer
SOP	Standard operating procedure

SSC	Scientific Support Coordinator
START	Superfund Technical Assistance and Response Team
STEL	Short-term exposure limit
TAGA	Trace atmospheric gas analyzer
TDU	Thermal desorption unit
TEEL	Temporary Emergency Exposure Limit
TIC	Toxic industrial chemical
TLV	Threshold Limit Value
TOF	Time-of-effort
TWA	Time-weighted average
TWG	Technical Working Group
UC	Unified Command
UFP	Uniform Federal Policy
USACE	U.S. Army Corps of Engineers
USCHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USC	*United States Code*
USCA	*United States Code Annotated*
USCG	U.S. Coast Guard
VSP	Visual Sample Plan
VX	O-ethyl S-(diisopropylaminoethyl) methylphosphonthiolate
WMD	Weapon of mass destruction
WPL	Worker population limit

GLOSSARY

The references listed at the end of this glossary section provide the sources of definitions from other publications, agencies, and authorities. All other terms in this glossary are defined according to their specific use in this Comprehensive Chemical Agent Tactical Guidebook for Consequence Management (Guidebook).

Acute Exposure Guideline Level (AEGL): AEGLs represent federally endorsed guidance criteria for the assessment and management of single-exposure emergency events, such as accidents or intentional terrorist attacks. AEGLs, published by the National Research Council Committee on Toxicology, are threshold airborne concentrations of a chemical in the air above which health effects could begin to occur among members of the general public. There are three levels of AEGLs, AEGL-1, AEGL-2, and AEGL-3, which represent five exposure periods (10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours). Each level is distinguished by varying degrees of severity of toxic effects, with AEGL-3 being the most severe.

Agent: An agent is a chemical, physical, mineralogical, or biological entity that may cause deleterious effects in an organism after exposure (United States Environmental Protection Agency [EPA] 2002).

Agent GA: Agent GA represents chemical warfare agent (CWA) tabun, the chemical ethyl N,N-dimethylphosphoramidocyanidate, Chemical Abstracts Services (CAS) Registry No. 77-81-6. Agent GA is a nerve agent with the chemical formula $C_5H_{11}N_2O_2P$.

Agent GB: Agent GB represents CWA sarin, the chemical isopropyl methylphosphonofluoridate, CAS Registry No. 107-44-8. Agent GB is nerve agent with the chemical formula $C_4H_{10}FO_2P$.

Agent GD: Agent GD represents CWA soman, the chemical pinacolyl methylphosphonofluoridate, CAS Registry No. 96-64-0. Agent GD is a nerve agent with the chemical formula $C_7H_{16}FO_2P$.

Agent GF: Agent GF represents CWA cyclosarin, the chemical O-cyclohexyl methylfluorophosphonate, CAS Registry No. 329-99-7. Agent GF is a nerve agent with the chemical formula $C_7H_{14}FO_2P$.

Agent H: Agent H commonly is known as sulfur mustard and less frequently is referred to as Levinstein mustard, CAS Registry No. 505-60-2. Agent H is a blister agent with the chemical formula $C_4H_8C_{l2}P$.

Agent HD: Agent HD is distilled (purified) sulfur mustard, CAS Registry No. 505-60-2. Agent HD is a blister agent with the chemical formula $C_4H_8C_{l2}P$.

Agent VX: Agent VX represents the chemical O-ethyl S-(diisopropylaminoethyl) methylphosphonthiolate, CAS Registry No. 50782-69-9. Agent VX is a nerve agent with the chemical formula $C_{11}H_{26}NO_2PS$.

Airborne Exposure Limit (AEL): AEL is a general term used by the Centers for Disease Control and Prevention (CDC) and the U.S. Army to refer to a set of exposure standards specifically developed for CWAs (nerve and blister agents). AELs are expressed in milligrams per cubic meter (mg/m^3) of air for various exposure frequencies and durations. AELs include occupational and general population standards used to monitor, assess, and prevent unacceptable exposures associated with operations at U.S. Army CWA stockpile sites and laboratories. AELs are similar to other federal industrial, occupational, and general population standards. For workplaces where agents are regularly processed or routinely

near workers, the AELs include the following: immediately dangerous to life and health (IDLH) limits, short-term exposure limit (STEL), and chronic-exposure time-weighted-average (TWA) worker population limits (WPL). The general population limit (GPL) is an atmospheric concentration level (in mg/m^3) at which no adverse effects would occur in the general population, including sensitive subpopulations, assuming a continuous, daily (24-hour-a-day, 7-day-a week) chronic (lifetime) exposure (Mioduszewski et al. 1998; Department of Health and Human Services [DHHS] 1988, 2002, and 2003). The CDC points out the AELs are not precise thresholds of potential human toxicity.

Air sampling: Air sampling refers to the procedure of collecting an air sample for chemical analysis. If the expected concentration of a chemical in air is high, air sampling can be performed by directly transferring air into a container, such as a Tedlar bag or canister. If the expected concentration of a chemical in air is low, the sample can be collected as a large volume of air passed through a medium, such as XAD resin or Tenax, to which the chemical sorbs but through which air passes without retention, thus allowing the chemical to be concentrated so that it can be detected when the medium later is extracted and analyzed in the laboratory.

Ambient air: In this Guidebook, ambient air is the air outside a contaminated facility.

Ambient Air Monitoring Plan (AAMP): The AAMP is a written plan for monitoring ambient air, and the monitoring approach is designed to detect any escape of a gas (such as a fumigant and any agent of concern) from a facility at concentrations that may pose a hazard to the surrounding population. Appendix 3 of this Guidebook discusses air monitoring instrumentation.

Characterization: In the context of this Guidebook, characterization refers to the process of obtaining information about a CWA or toxic industrial chemical (TIC) attack to determine further action. Characterization includes two distinct activities: (1) assessing the physical nature of the chemical of concern (its identity, formulation, toxicological properties, persistence, and other physical properties) and (2) assessing the degree of contamination of a facility. Such information is used to estimate the potential for exposure to the chemical of concern and to decide locations, items, and methods of decontamination. Facility characterization generally occurs after the first response phase and before decontamination. Characterization of the agent of concern occurs as early as possible during the overall response.

Characterization sampling: Environmental characterization sampling is intended to assess the identity and extent (location and quantity) of contamination of an area or items and to provide information needed to decide if decontamination is required and if so, locations, items, and methods of decontamination. Characterization sampling occurs after the first response phase and before decontamination.

Chemical warfare agent (CWA): A CWA is a chemical intended for military use (or used by terrorists in the context of this Guidebook) with lethal or incapacitating effects on people. The classes of CWAs are (1) nerve agents, (2) blister agents, (3) choking agents, (4) blood agents, and (5) vomiting agents, all of which cause incapacitation, serious injury, or death.

Chemicals of concern: This Guidebook focuses on the nerve agents tabun, sarin, soman, cyclosarin, and VX, and the blistering agents sulfur mustard, Lewisite, nitrogen mustard, and mustard Lewisite. Collectively, the nine chemicals are referred to as EPA chemicals of concern.

Clearance: Clearance is the process of determining that a clearance goal has been met for a specific chemical of concern in or on a specific site or item. Clearance generally occurs after cleanup and before re-occupancy.

Clearance criteria or clearance decision criteria: These criteria are conditions that must be met as part of a defined process for determining if clearance goals have been achieved. The clearance process should include ensuring that exposure guidelines are met with a level of confidence acceptable to stakeholders.

Clearance (cleanup) goal: This goal refers to an amount of contamination for a specific chemical of concern in or on an area or item that provides acceptable protection to human health and the environment. A clearance (cleanup) goal specifies measurable criteria for determining the success of decontamination and for permitting unprotected reentry (Department of Homeland Security [DHS] and EPA 2009).

Clearance sampling: Environmental clearance sampling is conducted after decontamination and is intended to provide a basis for determining if a clearance goal is met for a specific chemical of concern in an area or on items.

Clearance Sampling and Analysis Plan (SAP): The clearance SAP is a formal written plan that describes how clearance sampling will be conducted, including the rationale for the clearance sampling design. The clearance SAP specifies clearance decision criteria, including how clearance sampling results will be used to determine if clearance goals have been met. The clearance SAP is a companion to the Remedial Action Plan (RAP) and is required before the RAP is executed.

Consequence management: This management function includes measures to protect public health and safety; restore essential government services; and provide emergency relief to governments, businesses, and individuals affected by terrorism. Consequence management can include measures to identify the cause, location, and extent of contamination (characterization); clean up the contamination (decontamination); ensure that all health and environmental issues are addressed (clearance); and permit recovery (re-occupancy). The requirements of consequence management and crisis management (see definition below) are combined in the *National Response Framework* (DHS 2008).

Containment: In the context of this Guidebook, containment includes actions or measures to prevent (1) the spread of a chemical of concern (in this Guidebook, a CWA or TIC) from a particular zone or (2) the movement of a chemical of concern within a zone. Containment should not be confused with isolation (see definition below). Containment is a term defined differently by different agencies.

Contamination reduction zone: This zone is a transition area between the exclusion and support zones where responders enter and exit the exclusion zone and where decontamination of responders occurs. The contamination reduction zone also is called the warm zone (EPA 2004).

Crisis management: Predominantly a first responder and law enforcement function, crisis management includes measures to identify, acquire, and plan the use of resources needed to anticipate, prevent, or resolve a threat or act of terrorism. In the context of this Guidebook, crisis management includes predominantly first responder and law enforcement functions to resolve the immediate threat or act of terrorism. The requirements of consequence management (see definition above) and crisis management are combined in the *National Response Framework* (DHS 2008).

Decontamination: Decontamination is the process of inactivating, reducing, or removing a chemical of concern in or on buildings, humans, animals, plants, food, water, soil, air, areas, and other items through physical, chemical, or other method, which can include monitored natural attenuation, to meet a clearance goal. For the purposes of this Guidebook, decontamination focuses on buildings and their contents and includes waste disposal. The term also refers to decontamination of personnel and equipment in the contamination reduction zone. This term is defined differently by federal agencies and other entities.

Decontamination reagent: A decontamination reagent reacts chemically with a CWA or TIC to reduce its toxicity. An effective decontamination reagent reduces the concentration of CWA or TIC on humans, animals, plants, inanimate surfaces, or other media. An example decontamination reagent is 5 percent sodium hypochlorite (household bleach).

Decontamination zone or area: The decontamination zone or area is a discrete section or subsection of a contaminated site that can be isolated with respect to other areas and then decontaminated as a unit.

Disposal: Disposal is the transfer or placement of any solid or hazardous waste on or in the land or water.

Emergency Operations Center (EOC): The EOC is the physical location where the coordination of information, communications, and resource allocation and tracking to support domestic incident management activities normally occurs. An EOC may be a temporary facility or a central or permanently established facility, perhaps at a higher level of organization within a jurisdiction. EOCs may be organized by major functional disciplines (fire, law enforcement, and medical services), by jurisdiction (federal, state, regional, county, city, or tribal), or by some combination thereof (DHS 2008).

Environmental sampling: Environmental sampling for a chemical of concern is conducted on inanimate surfaces or in air, water, or soil. After a CWA or TIC release, indoor sampling may include bulk sampling of porous materials or elastomeric (rubber-like) compounds and sealants (such as silicone caulk). In the context of this Guidebook, environmental sampling includes characterization sampling, clearance sampling, and sampling to support public health or medical treatment decisions.

Environmental Unit (EU): This unit is within the Incident Command System (ICS) Planning Section responsible for tasks such as recommending response priorities, developing sampling plans, characterizing the extent and effects of site contamination, and developing cleanup plans. The EU prepares environmental data for the Situation Unit and coordinates with other units and sections within the ICS structure to enable effective decision support to the Incident Commander (IC) or Unified Command (UC) (Federal Emergency Management Agency [FEMA] 2008).

Exclusion zone: Per the Hazardous Waste Operations and Emergency Response standard, the exclusion zone is an area where contamination is known to be present or the potential exists for exposure to a chemical of concern. Entry into the exclusion zone is permitted only for persons wearing appropriate personal protective equipment (PPE). The exclusion zone is equivalent to a hot zone, red zone, or restricted zone.

Exposure guideline: EPA defines exposure as contact between a chemical, physical, or biological agent and the outer boundary of an organism (such as the skin, lungs, or gut). Exposure is quantified as the amount of an agent available at the exchange boundaries of the organism (EPA 2005b). This Guidebook defines an exposure guideline as an amount (such as in mg/m^3) of a particular chemical of concern (such

as sarin) that provides protection against an undesired health effect for a particular exposure pathway (inhalation, ocular, dermal, or ingestion) in a specified population (for example, transit passengers) over a specified interval (for example, 8 hours). An AEGL (see definition above) is an example of an exposure guideline.

First responder: First responders primarily include local police, fire, and emergency personnel who, during the early stages of an incident, are responsible for protecting and preserving life, property, evidence, and the environment. First responders include emergency response providers as defined in Section 2 of the Homeland Security Act of 2002 (Title 6 of *United States Code* [USC] 101) as well as emergency management, public health, clinical care, public works, and other skilled personnel who provide immediate support services.

First response: First response refers to actions taken immediately after notification of an incident or release involving an agent of concern. In addition to search and rescue, scene control, and law-enforcement activities, first response includes initial site containment, initial environmental sampling and analysis, and personnel decontamination. The first response phase follows the notification phase of a response.

G agent: G agents are a class of chemical warfare nerve agents that include Agents GA (tabun), GB (sarin), GD (soman), and cyclosarin (GF) (see definitions above).

Hazardous material: A hazardous material (HAZMAT) is a substance or material determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce and designated at Title 49 of the *Code of Federal Regulations* (CFR) 171.8.

Health and Safety Plan (HASP): The HASP is a written plan required under the Occupational Health and Safety Administration's (OSHA) HAZWOPER standard (29 CFR 1910.120). This standard requires a written HASP that identifies site hazards and appropriate controls to protect employee health and safety (National Response Team [NRT] 2005). The HASP describes known physical, chemical, and biological hazards at a site; the establishment of hot (contaminated), cold (uncontaminated), and warm (intermediate or contamination reduction) zones; PPE; personal decontamination procedures; and emergency procedures to be used by sampling and decontamination personnel.

Hot zone: The hot zone, also known as the exclusion zone (see definition above), is a contaminated area.

Immediately dangerous to life and health (IDLH): The IDLH concentration represents the maximum level of a chemical from which an individual could escape within 30 minutes of exposure without escape-impairing symptoms or irreversible health effects (EPA 2002).

Incident: An incident is an occurrence or event, natural or human-caused, that requires emergency response to protect life or property. Incidents can include major disasters, emergencies, terrorist attacks, terrorist threats, wild land and urban fires, floods, HAZMAT spills, nuclear accidents, aircraft accidents, earthquakes, hurricanes, tornadoes, tropical storms, war-related disasters, public health and medical emergencies, and other occurrences requiring emergency response (DHS 2008).

Incident Action Plan (IAP): The IAP is an oral or written plan containing general objectives reflecting the overall strategy for managing an incident. The IAP may include the identification of operational

resources and assignments. It also may include attachments that provide direction and important information for managing the incident during one or more operational periods. In the context of this Guidebook, the RAP and the Sampling and Analysis Plan (SAP) are implemented through a series of IAPs.

Incident Commander (IC): The IC is responsible for all incident activities, including the development of strategies and tactics and the ordering and release of resources. The IC has overall authority and responsibility for conducting incident operations and is responsible for managing all incident operations at the incident site (FEMA 2008; DHS 2008).

Incident Command Post (ICP): As defined by the National Incident Management System (NIMS) and National Response Framework (NRF), the ICP is the field location where primary, tactical-level, on-scene incident command functions and management organizations are located (FEMA 2008; DHS 2008). The ICP may be collocated with the incident base or other incident facilities and normally is identified by a green rotating or flashing light.

Incident Command System (ICS): The ICS is a standardized, on-scene, emergency management system specifically designated to provide for the adoption of an integrated organizational structure that reflects the complexity and demands of single or multiple incidents without hindrance from jurisdictional boundaries. The ICS is the combination of facilities, equipment, personnel, procedures, and communications operating with a common organizational structure designed to aid in managing resources during incidents.

Integrated Risk Information System (IRIS): The IRIS is an EPA compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects. The IRIS initially was developed for EPA staff in response to a growing demand for consistent information on substances for use in risk assessments, decision-making, and regulatory activities. The information in IRIS is intended for those without extensive training in toxicology but with some knowledge of health sciences. The IRIS is available at http://www.epa.gov/iris/index.html.

Isolation: For the purposes of this Guidebook, isolation refers to action taken to seal a site or portions of a site to permit gas- or vapor-phase decontamination and to prevent release of gas- or vapor-phase decontamination reagent. Isolation also can refer to an action to exclude a chemical of concern from critical equipment, such as enclosing a baggage scanner with a tent. Isolation should not be confused with containment (see definition above). The term isolation is used differently by various agencies. Isolation also can refer to enclosing or encapsulating objects (such as sensitive equipment or valuable property) in a protective material to protect it from a gas- or vapor-phase reagent during decontamination.

Judgmental sampling: Environmental judgmental sampling locations are determined by professional judgment. Generally, judgmental sampling is based on incident-specific information, such as a known release location, visible evidence of contamination, or facility-specific information (including airflow patterns).

Monitored natural attenuation: This term refers to a decrease in the concentration of a hazardous substance, including CWAs and TICs, to less hazardous concentrations through natural environmental mechanisms (such as heat, light, or volatilization), together with verification through a defined monitoring process. Natural mechanisms can reduce or eliminate a chemical hazard and should be considered as a decontamination option. The associated term “degradation” as used in this Guidebook

refers to a transformation caused by chemical reactions with environmental species, such as water or hydroxyl radicals in the atmosphere.

National Incident Management System (NIMS): The NIMS is a nationwide template enabling federal, state, local, and tribal governments and private-sector and non-government organizations to work together effectively and efficiently to prevent, prepare for, respond to, and recover from domestic incidents regardless of cause, size, or complexity. The NIMS provides a core set of doctrines, concepts, terminology, and organizational processes to enable collaborative incident management at all levels (FEMA 2008).

National Response Framework (NRF): The NRF is an all-discipline, all-hazards document that establishes a single, comprehensive framework for managing domestic incidents. The NRF provides the structure and mechanisms for coordinating federal support to and exercising direct federal authorities and responsibilities for such incidents (DHS 2008).

Negative air unit (NAU): A NAU subjects an area to a slightly negative pressure relative to surrounding areas to ensure that a chemical of concern (and decontamination reagent) remains in the contaminated area. An NAU often consists of an air handling unit and a high-efficiency particulate air (HEPA) filter, chemical scrubber, demister, carbon bed, fan, and stack. Air in a contaminated area is exhausted through the unit at a rate sufficient to create a slightly negative pressure.

Nerve agent: Nerve agents include several organic esters of phosphoric acid used as chemical warfare nerve agents because of extreme toxicity. Nerve agents include Agents GA (tabun), GB (sarin), GD (soman), cyclosarin (GF), and VX (see definitions above). All are potent inhibitors of the enzyme acetylcholinesterase, which is responsible for the degradation of acetylcholine in neuronal synapses or myoneural junctions.

On-Scene Coordinator (OSC): The OSC is the federal official predesignated by the EPA or the U.S. Coast Guard to coordinate responses under Subpart D of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) or the government official designated to coordinate and direct removal actions under Subpart E of the NCP (DHS 2008).

Operations Section: This ICS section is responsible for all tactical incident operations.

Percutaneous absorption: This term refers to the absorption of a chemical of concern through unbroken skin.

Permissible exposure limit (PEL): The PEL is expressed as TWA. OSHA, the National Institute for Occupational Safety and Health (NIOSH), and regulatory and compliance standards use the PEL for occupational settings. The PEL is a concentration of a substance to which most workers can be exposed without adverse effects averaged over a normal 8-hour workday or 40-hour work week as defined in the *Federal Register*, Vol. 57, No. 114, June 12 1992, pp. 26539, 26556, 26572, 26573, and 26590. The PEL for a chemical agent is comparable to the WPL (see definition of Worker Population Limit [WPL] below).

Planning Section: This ICS section is responsible for collecting, evaluating, and disseminating operational information related to an incident and for preparing the IAP. The Planning Section maintains information on the current and forecasted situation and on the status of resources assigned to the incident.

Quality Assurance (QA): QA is an integrated system of activities involving planning, quality control (QC), quality assessment, reporting, and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence (EPA 2002). For the purposes of this Guidebook, QA refers to data quality.

Quality Assurance Project Plan (QAPP): The QAPP is a formal document describing in comprehensive detail the necessary QA, QC, and other technical activities that must be implemented to ensure that the data quality objectives (DQO) are met. The QAPP documents how QA and QC are applied to an environmental data collection operation to ensure that the results obtained satisfy the stated performance criteria (EPA 2005a).

Quality Control (QC): QC refers to the overall system of technical activities to measure and control the quality of a product or service so that it meets user needs. The aim of QC is to ensure that the quality of a product or service is satisfactory, adequate, dependable, and economical (EPA 2005a). For the purposes of this Guidebook, QC refers to data quality.

Random sampling: Environmental random sampling locations are chosen with some degree of randomness. Such sampling is based on the idea that choosing locations at random ensures both representative and reproducible results.

Recovery: Recovery involves the development, coordination, and execution of service and site restoration plans for impacted communities and the reconstitution of government operations and services through individual, private-sector, non-government, and public assistance programs (DHS 2008).

Remediation: Remediation is the process of characterizing, decontaminating, and clearing a contaminated site or items, including waste disposal. Remediation generally occurs after the first response phase and before the restoration phase. Remediation also can by a synonym for cleanup.

Remedial Action Plan (RAP): The RAP is a formal plan that describes actions to remove, reduce, or eliminate chemical of concerns at a site. In the context of this Guidebook, the RAP is a written, incident-specific plan that includes details on (1) facilities and areas requiring decontamination, (2) materials and structural components requiring *in situ* decontamination or removal for treatment and either reused or disposed of, (3) the extent of decontamination for removed items before disposal and the location and disposal of such items, (4) decontamination technologies to be used, (5) personnel and teams responsible for decontamination tasks, and (6) the types of wastes produced and their treatment and disposal.

Renovation: This process involves reconstructing or refurbishing a facility before allowing re-occupancy (see definition of restoration below).

Re-occupancy: Re-occupancy requires renovating a facility, monitoring restoration personnel, and deciding when to permit re-occupation. Generally, re-occupancy occurs after a facility has been cleared but before occupants are allowed to return.

Residual contamination: Residual contamination is any amount of contamination remaining in an area or on an item after decontamination or monitored natural attenuation.

Response: Response activities address the short-term, direct effects of an incident, such as immediate actions to save lives, protect property, and meet basic human needs. Response includes emergency operations and incident mitigation activities designed to limit loss of life, personal injury, property damage, and other unfavorable outcomes (DHS 2008).

Restoration: Restoration is the process of renovating or refurbishing a facility, bringing it back to an unimpaired or improved condition, and making a decision to allow re-occupancy. Generally, restoration occurs after a facility has been cleared but before occupants are allowed to return.

Risk: In the context of human health, risk refers to the probability of adverse effects resulting from exposure to an environmental agent or mixture of agents (EPA 2005b).

Risk communication: Risk communication refers to process of providing information about the expected type and magnitude of an outcome, particularly in the context of environmental health. Risk communication often is a discussion about an adverse outcome and the probability of that outcome occurring (Reynolds 2002).

Risk assessment: In the context of human health, risk assessment is the evaluation of scientific information on the hazardous properties of environmental agents (hazard characterization), the dose-response relationship (dose-response assessment), and the extent of human exposure to these agents (exposure assessment). The product of risk assessment is a statement regarding the probability that exposed populations or individuals will be harmed and to what degree (risk characterization) (EPA 1989 and 2005b).

Sampling and Analysis Plan (SAP): The SAP describes the methods, strategies, and analyses for environmental sampling. A characterization SAP is a plan for characterization sampling, a clearance SAP is a plan for clearance sampling, and so forth.

Scientific Support Coordinator (SSC): The SSC is a technical specialist defined in the NCP (40 CFR 300.145) as the principal advisor to the IC for scientific issues. The SSC is charged with gaining consensus on scientific issues affecting the response and ensuring that differing opinions within the scientific community are communicated to the IC (EPA 2007).

Short-term exposure limit (STEL): The STEL is the concentration to which workers can be exposed continuously for a short time without suffering from irritation; chronic or irreversible tissue damage; or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency (American Conference of Government Industrial Hygienists [ACGIH] 2007). The ACGIH often develops STELs. However, the CDC developed the STELs for CWAs.

Source reduction: In the context of this Guidebook, source reduction refers to activities designed to decrease the quantity of a CWA or TIC in a contaminated facility before the main decontamination activities. Source reduction can include the removal of contaminated materials and items from a building to make decontamination easier or the removal of items that are less costly to replace than to decontaminate.

Staging area: Under the ICS, the staging area is where incident personnel and equipment are staged awaiting tactical assignment. The Operations Section Chief manages the staging area, which is located in the support zone (see definition below).

Subject matter expert (SME): An SME is a technical expert in a specific area of study or in performing a specialized job, task, or skill.

Support zone: The support zone (staging area; see definition below) is free from contamination and may be safely used as a planning and staging area (EPA 2004).

Targeted sampling: This type of sampling occurs during clearance at specific locations found to be contaminated during the site characterization. Targeted sampling is a special case of judgmental sampling. The term is used differently in different reports.

Technical Specialist: A technical specialist has special skills or expertise useful to the incident response. Specialists may serve anywhere within the organization, including the Command Staff. No specific incident qualifications are prescribed or required because technical specialists normally perform the same duties during an incident that they perform in their everyday jobs and because they typically are certified in their fields or professions (FEMA 2008). Example technical specialties include environmental sampling, air modeling, cleanup and decontamination technologies, risk assessment and toxicology, QA, analytical laboratory services, transportation, and disposal.

Technical Working Group (TWG): For some incidents, a group of technical experts is established to review technical documents developed by the Planning Section's EU. The TWG often consists of SMEs from EPA, other federal agencies, and the private sector who review remediation plans and help ensure conformance with current standard operating procedures (SOP) and guidance.

Toxic industrial chemical (TIC): The International Task Force 25, Hazards from Toxic Industrial Chemicals, April 1998 (ITF-25), defines a TIC as a material produced in quantities of greater than 30 tons in a single factory and having a toxicity (lethal concentration and time 50 percent [LCt50] inhalation) of less than 100,000 milligrams per minute per cubic meter and an appreciable (undefined) vapor pressure at 20 °C. More information about TICs is available at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA406889

Time-weighted average (TWA): The TWA is an exposure concentration averaged over a designated time. For example, a PEL is an exposure concentration standard for an averaged exposure over a normal 8-hour workday or a 40-hour workweek (EPA 2002). More information about TWAs is available at www.OSHA.gov.

Unified Command (UC): The UC is application of the ICS used when more than one agency has incident jurisdiction or when incidents cross political jurisdictions. Designated agency officials with jurisdictional authority (who make up the UC) work together to establish a common set of objectives, strategies, and guidance. The UC, for example, approves the IAPs (FEMA 2008; DHS 2008).

Verification sampling: The purpose of verification sampling is to ensure that decontamination is being conducted properly. Verification sampling takes place during decontamination and may use chemical indicators to determine that a particular decontamination reagent has been in contact with specified surfaces. Verification sampling should not be confused with clearance sampling (see definition above), which occurs after decision-makers are satisfied that decontamination was conducted properly.

Volumetric space: This space is the volume of a room or other indoor area.

Warm zone: The warm zone is a transition area between the exclusion and support zones where responders enter and exit the exclusion zone and where decontamination of personnel takes place (EPA 2004). the warm zone also is called the contamination reduction zone (see definition above) during HAZWOPER training.

Weapon of mass destruction (WMD): As defined in Title 18, USC Section 2332a, a WMD includes (1) any explosive, incendiary, or poison gas, bomb, grenade, or rocket having a propellant charge of more than 4 ounces, or missile having an explosive or incendiary charge of more the 0.25 ounce, or mine or similar device; (2) any weapon designed or intended to cause death or serious bodily injury through the release, dissemination, or impact of toxic or poisonous chemicals or the precursors; (3) any weapon involving a disease organism; or (4) any weapon designed to release radiation or radioactivity at a level dangerous to human life.

Wipe sampling: Wipe sampling is a procedure for collecting environmental samples by rubbing a small area of a surface with a thin, flat piece of dry or wet absorptive material. Wipe sampling also is sometimes referred to a swipe sampling.

Worker population limit (WPL): The WPL is the concentration at which an unprotected worker can operate safely 8 hours per day, 5 days per week, for a working lifetime without adverse health effects.

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FOREWORD

This Comprehensive Chemical Agent Tactical Guidebook for Consequence Management (Guidebook) provides a tactical guide for United States Environmental Protection Agency (EPA) regions, program offices, and special teams to use in expediting decisions for characterizing and cleaning up after a deliberate or unintentional chemical warfare agent (CWA) release. Incidents generally are managed at the local level when appropriate. However, as the incident increases in size, scope, and complexity, and definitely for a large-scale incident, the EPA may require other federal government assistance to support the response. It is likely that any incident involving CWAs will require federal assistance to the affected local or state agencies. The National Response Framework (NRF) and National Incident Management System (NIMS) provide the general structure for incident management and decision-making, with the recommendation that incidents be managed at the lowest jurisdictional level possible.

To facilitate response decision-making, this Guidebook embraces the concept of a flexible, multi-attribute, site-specific decision process that seeks to consider and balance many factors. A flexible process that incorporates site-specific decision-making may apply to a variety of large-scale incidents. Flexible, site-specific cleanup decisions will vary depending on the extent of outdoor versus indoor CWA contamination, the potential magnitude and severity of risk posed by the CWA, the demographics and size of affected populations, the location and geography of the city, meteorological conditions, cost, and other socio-economic factors. This Guidebook identifies a process for making timely and effective decisions (despite uncertainties) that can be applied to a variety of circumstances.

Critical decisions made early in the response and recovery process will determine the speed and effectiveness of cleanup operations. Ideally, every effort should be made to avoid delays because timely decisions early in a response may have a profound impact on options available later in the process.

Although any deliberate, large-scale release of a CWA does not necessarily fall within the context of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA has approximately 40 years of experience in cleaning up CERCLA sites. An integral part of this experience is the development of environmental, health-based exposure levels that guide different facets of response and cleanup activities. This Guidebook reflects EPA's experience applied to consideration of incidents involving the release of a CWA.

In many respects, CWAs are similar to chemicals with which EPA has experience, but it is important to note that CWAs differ in several important respects that require careful application of existing knowledge. First, a chief concern about CWAs is their acute toxicity, whereas many "standard" environmental cleanup operations are based on chronic, long-term health effects. CWAs can be much more acutely toxic and have equally acutely toxic environmental degradation and decontamination by-products. Second, a CWA attack is very unpredictable with regard to its location, contaminated area, types of material contaminated, and many other factors that have not necessarily been considered for chemicals that are not CWAs. *This unpredictability causes non-routine activities performed by cleanup professionals to become critical* (for example, establishing zones for prioritizing cleanup, ensuring worker safety, developing sampling plans, and ensuring analytical capacity). Although many of the activities described in this Guidebook resemble guidance activities for non-CWA chemicals, important nuances should be considered to avoid extending the effects of a CWA release beyond the initial attack.

CWAs receive significantly less attention than nuclear and biological threats. However, history shows that chemical weapons are by far the most widely used and widely proliferated weapons of mass

destruction (WMD). CWAs use the toxic properties of chemicals to cause physical harm, with effects ranging from discomfort to death. Relatively small amounts of CWAs can inflict devastating psychological and physical effects. The military value of CWAs is such that the United States and the Soviet Union stockpiled tens of thousands of tons of chemical weapons during the Cold War. Countries traditionally have acquired chemical weapons before attempting to produce biological or nuclear weapons because chemical weapons are the least technologically demanding. Although 188 countries have joined the Chemical Weapons Convention (CWC) and have agreed not to develop, produce, stockpile, or use chemical weapons, a handful of key countries, particularly in the Middle East, remain outside the treaty. Additionally, interest in chemical weapons continues to grow as terrorist groups and non-state-sponsored entities seek ways to further their causes.

CWAs can be released accidentally or deliberately. Releases may be in combination (for example, an explosion that releases a CWA) or in sequence. Threats from CWAs also may arise from natural or unintentional incidents, such as a train derailment or the discovery of old munitions. As noted in Section 1.2 of this Guidebook, emergency response to an incident involving a CWA is similar in many ways to a conventional hazardous materials (HAZMAT) incident response.

During a significant CWA incident, federal agencies, including EPA, have designated response roles as defined in the NRF. The NRF presents the guiding principles that enable all response partners to prepare for and provide a unified national response to disasters. More detailed information about the NRF is available at http://www.fema.gov/emergency/nrf/mainindex.htm.

1. INTRODUCTION

This Comprehensive Chemical Agent Tactical Guidebook for Consequence Management (Guidebook) provides a tactical guide for United States Environmental Protection Agency (EPA) regions, program offices, and special teams to use in expediting decisions for characterizing and cleaning up after a deliberate or unintentional chemical warfare agent (CWA) release.

This section provides an overview of this Guidebook and discusses its background, purpose, scope, and organization.

1.1 OVERVIEW

This EPA Guidebook describes a general risk management framework for EPA decision-makers at all levels in planning and executing activities required for response and recovery from a CWA or large-scale chemical release incident. Although the EPA has many years of experience responding to and recovering from incidents involving accidental chemical releases and legacy sites with deliberate historical contamination, this Guidebook is provided to facilitate decision-making in response to releases related to deliberate terrorist acts. The Guidebook is intended for use by EPA On-scene Coordinators (OSC), response personnel, and contractors who conduct or oversee response, recovery, and restoration activities made in response to a CWA contamination incident resulting from a deliberate or unintentional act.

In general, CWAs are toxic chemicals developed for use as chemical weapons. They can be categorized as choking, blister, blood, and nerve agents. The most well-known agents are as follows: choking agents such as chlorine, chloropicrin, diphosgene, and phosgene; blister agents or vesicants such as sulfur mustard, Lewisite, and nitrogen mustard; blood agents such as hydrogen cyanide and cyanogen chloride; and nerve agents such as tabun, sarin, soman, and VX. Blister agents irritate the skin, eyes, and lungs. Victims eventually develop painful blisters but usually do not die. Choking agents cause severe and painful breathing problems, leading to suffocation. Blood agents stop blood from distributing needed oxygen throughout the body. Nerve agents debilitate the nervous system, causing muscle contraction, loss of control over bodily functions, and death within minutes. World War II-era nerve agents tabun, sarin, soman, and VX remain the most widely proliferated.

This Guidebook focuses on the nerve agents tabun (GA), sarin (GB), soman (GD), cyclosarin (GF) and O-ethyl S-(diisopropylaminoethyl) methylphosphonthiolate (VX), and blister agents sulfur mustard (HD), Lewisite, and mustard mixtures. EPA currently considers nerve agents and blister agents the highest-priority chemical agents. Table 1-1 lists the priority chemical agents and summarizes some of their properties. Both nerve and blister agents were mass produced during the Cold War. Similar to many pesticides, nerve agents belong to the organophosphate group and are easily manufactured. Blister agents, or vesicants, are one of the most common CWA agents. The raw materials to make these CWAs are inexpensive and generally readily available. As science and threat assessments continue to evolve, EPA prioritization of CWAs may change and focus may shift to other CWAs.

1.2 BACKGROUND

EPA's cleanup and recovery activities after a large-scale deliberate or unintentional CWA release should follow some of the same basic procedures taken in response to hazardous material (HAZMAT) incidents. A large-scale incident would require the involvement and collaboration of the EPA and other federal,

Table 1-1. Chemical Agents Considered Priority by the EPA

NAME (SYMBOL)	PHYSICAL CHARACTERISTICS	PERSISTENCE	MEANS OF EXPOSURE	EFFECTS
Tabun (GA)	Evaporates quickly; Tasteless/colorless; Fruity odor; Spread in aerosol or liquid form; Heavier than air	1–2 days if heavy concentration	Skin contact or inhalation	Contraction of pupils, eye pain, and dim or blurred vision; runny nose; chest tightness; nausea and vomiting possible; twitching or convulsions when skeletal muscle reached
Sarin (GB)	Evaporates quickly; Odorless/tasteless/colorless; Absorbed slowly through skin; Evaporates quickly;	1–2 days will evaporate with water	Skin contact or inhalation	
Soman (GD)	Evaporates quickly; Clear, colorless, liquid. Discolors with aging to dark brown. Odor like camphor or rotting fruit; Evaporates quickly;	Moderate, 1–2 days	Skin contact or inhalation	Fluctuations in heart rate; loss of consciousness and seizure activity possible within 1 minute of exposure when agent concentration is high; eventual paralysis and death
Cyclosarin (GF)	A colorless room temperature liquid; Odor is described as sweet and musty; resembling peaches or shellac; Persistent liquid, flammable, with a flash point of 201 °F	Moderate, 1–2 days	Skin contact or inhalation	Similar to sarin. Effects seen in eyes (contraction of pupils, pain, dim or blurred vision), runny nose), and air ways (chest tightness); nausea and vomiting also possible; Twitching/convulsions result when skeletal muscle reached
VX	Odorless / tasteless; Oily consistency; Amber color; Spread in aerosol or liquid form; Heavier than air	High, 1 week if heavy concentration; As volatile as motor oil	Skin contact or inhalation	Fluctuations in heart rate; loss of consciousness and seizure activity possible within 1 minute of exposure when agent concentration is high; eventual paralysis and death
Sulfur Mustard (HD)	Pale yellow or amber color; Usually odorless but can smell like mustard, onions, or garlic; Can remain in environment for up to a week (but much longer if buried beneath soil surface); Heavier than air	Very high, days to weeks	Skin contact or inhalation	Pain not immediate; topical effects on the skin (blisters), in airways (coughing, lesions, and, in rare cases, respiratory failure), and in eyes (itchiness, burning, and possible cornea damage); nausea and vomiting possible
Nitrogen Mustard (HN-3)		Very high, days to weeks	Skin contact or inhalation	Skin blistering; respiratory tract damage
Mustard Lewisite (HL)	Properties are dependant on exact composition; munitions grade has a composition of 63/37 weight percentage L & H. Garlic-like odor, if there is sufficient H present.	Semi-persistent; Very high, days to weeks	Skin contact or inhalation	Skin blistering; respiratory tract damage
Lewisite (L)	Evaporates quickly; Pure- oily, colorless and odorless. Impure - yellow brown to violet black liquid with strong penetrating geranium odor; Heavier than air	Moderate	Skin contact or inhalation	Effects similar to those of mustard; skin blistering, burning, watery, or swollen eyes; upper airway irritation; systemic blood poisoning

state, tribal and local agencies, especially for decisions about when to deem a site ready for resumed use and re-occupancy, either with or without limitations on site use.

No single cleanup level or approach is appropriate for every scenario. In addition, inconsistencies can occur among agencies addressing separate aspects of a response. Different CWA environmental- or health-based exposure levels may be applicable to different phases of the response (for example, higher action levels may be applicable to the crisis management phase, while more stringent cleanup levels may be appropriate for the consequence management phase). Advance planning between EPA and all other agencies is necessary to ensure transparent and clear communication throughout all phases of the response and is strongly encouraged by national guidance documents such as the National Response Framework (NRF) (Department of Homeland Security [DHS] 2008). Therefore, the most effective response includes coordinated decision-making among federal, state, tribal, and local decision-makers.

1.3 PURPOSE

Homeland Security Presidential Directive-5 (HSPD-5), Management of Domestic Incidents, states that "to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies, the United States Government shall establish a single, comprehensive approach to domestic incident management" (DHS 2003) Accordingly, this document provides guidance for cleanup as a part of restoration and recovery activities in response to a deliberate CWA release. It is consistent with HSPD-5 and other presidential directives that task federal agencies to strengthen the ability of the United States to prevent, protect, respond to and recover from terrorist attacks employing toxic chemicals and other chemical incidents" (DHS 2007).

PURPOSE OF THIS GUIDEBOOK

- Facilitate decision-making in response to a nationally significant or CWA incident
- Establish clear and consistent general guidelines that can be used to appropriately tailor the cleanup strategy to the specific CWA cleanup situation
- Provide criteria for determining or selecting appropriate environmental- and health-based exposure levels for various conditions and scenarios
- Promote cost-effective, fiscally responsible cleanup

The purpose of this Guidebook is to facilitate decision-making after a deliberate release of a CWA that require coordinated federal response to assist state, tribal, or local agencies. This Guidebook is intended to help EPA decision-makers formulate timely, effective cleanup and clearance decisions, often in situations involving incomplete data and high levels of uncertainty during the early phases of a CWA incident.

This document is intended to provide a starting framework for EPA planners and response technical advisors in determining cleanup strategies. Cleanup strategies should consider how to best determine and select protective environmental- and health-based exposure levels for various exposure conditions and scenarios while promoting a cost-effective, fiscally responsible cleanup.

1.4 SCOPE

This Guidebook describes a general risk management framework for decision-makers to use in planning and executing the many activities required for response and restoration for a deliberate release of a CWA, primarily in a domestic, civilian setting. Decision-makers should use this Guidebook in the context of NRF policies and procedures (DHS 2008).

Although the overall risk management framework covers all phases of a response to a CWA incident, this Guidebook primarily focuses on the consequence management component of the response (characterization, remediation [cleanup], and clearance). For each activity during the management phases, this Guidebook discusses decision-making processes and scientifically based methods, practices, and procedures. References for the information in this Guidebook are provided as applicable. Each incident will have unique site- and chemical-specific characteristics associated with cleanup. Therefore, even though a general framework can be used, final decision-making must be done on a case-by-case basis.

This Guidebook applies to deliberate or unintentional releases of CWAs in public areas through dispersal as a vapor or gas plume, liquid, or solid, under the following scenarios:

- Release in indoor areas such as buildings and subways, and their contents
- Release in semi-outdoor areas such as airports, railways, and public transit facilities
- Release in outdoor urban areas such as building exteriors, sporting arenas, streets, parks, and other open public areas

Deliberate release directly into a drinking water supply or system (at a point in the distribution system)

These scenarios may include many types of contaminated media (such as air, surface water, drinking water, groundwater, soil, and porous and non-porous surfaces in buildings or open areas) or involve a single environmental medium (for example, water resulting from an attack on a water treatment facility). Decontamination of human victims, food, plants, and animals is specifically excluded from this Guidebook.

1.5 ORGANIZATION OF DOCUMENT

This Guidebook is organized into the following eight sections:

- Section 1, Introduction - Provides an overview of this Guidebook and discusses its background, purpose, scope, and organization
- Section 2, Framework for Decision-Making - Describes the risk management framework for decision-making, including roles, responsibilities, and planning documents
- Section 3, Response and Recovery Activities - Describes the phases of a response and the key activities under each phase
- Section 4, Sampling - Describes sampling objectives, plans, resources, strategies, data management, sampling checklist, and sampling methods for each response phase
- Section 5, Decontamination - Describes the decontamination approach, including actions to take for cleanup
- Section 6, Waste Disposal - Describes waste-related regulations, management issues, and processes
- Section 7, Clearance - Describes the site- and task-specific clearance process, decisions, Sampling and Analysis Plan (SAP), sampling strategy and methods, and monitoring

- Section 8, Worker Health and Safety - Describes the health and safety regulatory basis, requirements and training, and the elements of health and safety

References used to prepare each section are listed at the end of each section. In addition, this Guidebook includes appendices presented after Section 8. The appendices are support documents that provide additional information.

1.6 REFERENCES – INTRODUCTION

Department of Homeland Security (DHS). 2003. Homeland Security Presidential Directive-5, Management of Domestic Incidents. On-line Address: http://www.dhs.gov/publication/homeland-security-presidential-directive-5

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Federal Emergency Management Agency (FEMA). 2013. *National Incident Management System (NIMS).* On-line Address: https://www.fema.gov/national-incident-management-system

2. FRAMEWORK FOR DECISION-MAKING

Federal agencies have been responding to hazardous chemical releases for approximately 40 years, but incidents involving deliberate release of CWAs present unique challenges. These intentional incidents have a malicious intent and likely will occur without warning. In addition, the nature of the incident may not be immediately understood, and its scope may overwhelm local resources. Confusion can arise during a CWA incident regarding jurisdiction, appropriate statutes, and which agency has the leadership role. The various roles and responsibilities should be determined under the NRF (DHS 2008). Also, decisions often require agreement by multiple agencies. Further, despite numerous standards and regulatory guidelines, no cleanup approach or level is universally applicable to every CWA incident. Therefore, coordination between federal, state, tribal, and local governments is critical to ensure that the CWA cleanup process is acceptable and effective but flexibly applied to ensure consideration of site- and incident-specific characteristics. These challenges can be addressed by planning ahead, understanding organizational roles and responsibilities, and developing a defined, well-organized and agreed-upon approach to CWA cleanup and decision-making.

The following sections discuss the decision-making process, management infrastructure to support decision-making, and planning documents.

2.1 DECISION-MAKING PROCESS

Cleanup decision-making should involve a flexible process that includes situation-specific considerations and the most current science and engineering techniques and approaches. A flexible process is required that considers numerous factors to achieve a result that balances local needs and desires, health risk considerations, costs considerations, technical feasibility, and other factors.

The goals of a decision-making process are summarized below.

1. **Transparency** – Information about the basis for cleanup and other decisions should be available to stakeholder representatives and ultimately the general public.
2. **Inclusiveness** – Representative stakeholders should be involved in decision-making activities.
3. **Effectiveness** – Technical subject matter experts (SME) should analyze remediation options, assess various technologies to assist in decisions optimal for the incident, and consider clearance decisions and cleanup goals.
4. **Shared Accountability** – The final decision to proceed should be jointly made by federal, state, tribal, and local officials in Unified Command (UC).

2.2 MANAGEMENT INFRASTRUCTURE TO SUPPORT DECISION-MAKING

The NRF (DHS 2008) and the National Incident Management System (NIMS) (FEMA 2013) have established a comprehensive, all-hazards approach to enhance planning and preparedness for the management of domestic incidents. The NIMS Incident Command System (ICS) is a tool that can be used to manage tactical operations of an incident regardless of the size or complexity. The ICS is a modular system that expands as the incident expands. An Incident Commander (IC) has the jurisdictional authority to direct response activities. However, for large-scale incidents, the IC normally functions within the UC with other agencies and state, local, and tribal responders. The ICS provides for Command and General Staff positions with well-defined functions. Figure 2-1 provides an example ICS organizational chart.

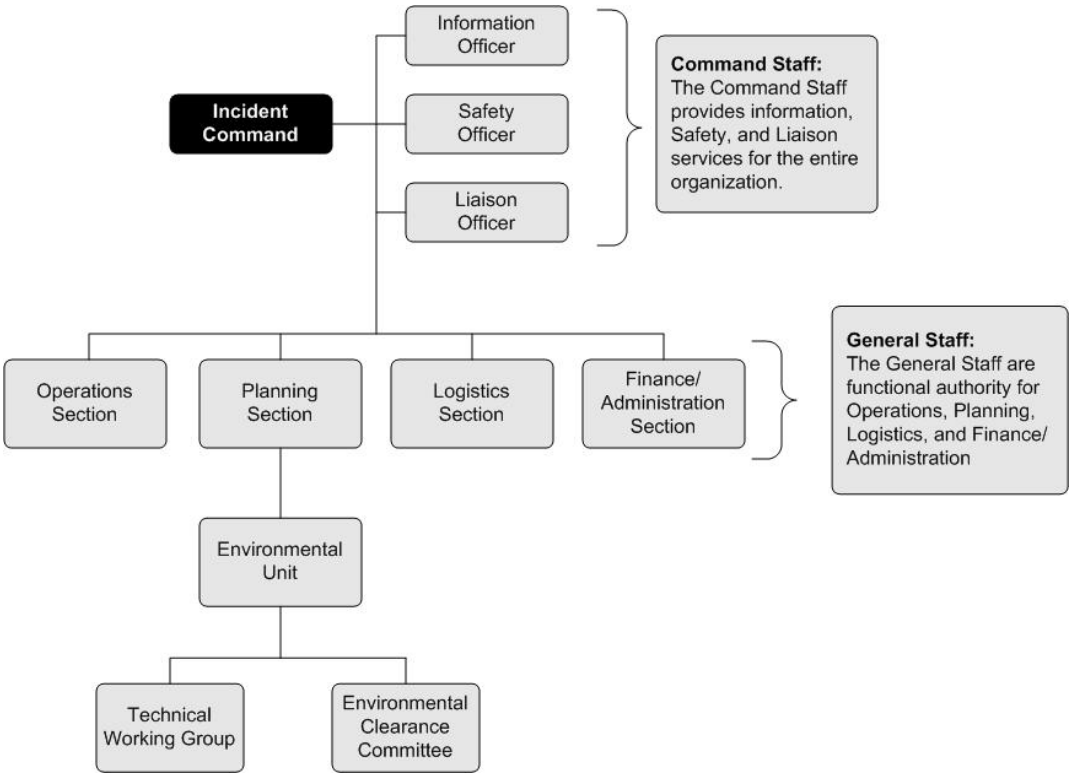


Figure 2-1. Incident Command System (ICS) Organizational Chart

Source: FEMA Emergency Management Institute (http://training.fema.gov/emi.aspx)

Command Staff consist of a Public Information Officer (PIO), Safety Officer (SO), and Liaison Officer (LNO). A Scientific Support Coordinator (SSC) position also can be established under Command Staff. The SSC is the scientific advisor to Incident Command/Unified Command (IC/UC).

General Staff consist of four sections: Operations, Planning, Logistics, and Finance/Administration. The Planning Section of the ICS, in coordination with the Operations Section Chief and the IC, is responsible for developing the Incident Action Plan (IAP). The IAP is a planning document that directs the deployment of personnel and materials during all stages of the response and recovery activities. The IAP is updated during each operational period of the response. The Planning Section also consists of the Environmental Unit (EU), which develops sampling, debris removal, disposal, and other plans as needed during the response. The EU coordinates and manages large amounts of environmental sampling and analytical data from multiple sources. The EU also facilitates interagency environmental data management, monitoring, sampling, analysis, assessment, and interpretation. The EU may include experts to plan site cleanup and waste disposal activities.

The IC/UC can assign responsibility for managing the cleanup optimization process to the EU, the SSC or a separate unit under the Planning Section (such as a Long-Term Cleanup Planning Unit). The unit with this responsibility coordinates work group processes and interactions and reports the optimization analysis results and working efforts to the IC/UC through the Planning Section Chief.

A Technical Working Group (TWG) of SMEs from various agencies should be convened as soon as possible and scaled to the needs of the specific incident. The TWG provides multi-agency, multi-

disciplinary expert input on the optimization analysis, including advice on technical issues, analysis of relevant regulatory requirements and guidelines, risk analysis, and development of cleanup options and clearance decisions. The purpose of the TWG is to provide expert technical input to the IC/UC and not to make decisions. The TWG should include federal, state, tribal, local, and private-sector SMEs in such fields as environmental fate and transport modeling; technical remediation options analysis; time, cost, risk, and benefit analysis; and relevant regulatory requirements. The group may not be physically located at the Incident Command Post (ICP), and may conducted operations remotely. Experts in the TWG may review data and documents; provide technical input to the IC/UC; and meet with incident management officials. Also, the TWG may be asked to participate in meetings with the Joint Field Office (JFO) United Coordination Group.

The Environmental Clearance Committee (ECC) is an independent peer-review body that can be established to provide additional credibility and confidence that clearance goals have or have not been achieved in the remediation effort. The ECC functions as an advisory group to the IC/UC and determines if clearance goals have been met. In an incident where multiple jurisdictions are affected and more than one ECC is established, affected federal, state, and local authorities will make every effort to coordinate and communicate with the ECC(s) and various jurisdictions to ensure consistency across jurisdictions as well as to most effectively and efficiently utilize the resources of the ECC(s). ing a determination.

A Stakeholder Working Group with a vested interest in the recovery of the facilities, properties, or environment impacted by the incident should be convened as soon as possible. This group also should be scaled to the needs of the specific incident. The selection and balance of stakeholders is incident-specific, but the Stakeholder Working Group should include federal, state, tribal, and local representatives; local non-government representatives; and local and regional business stakeholders. The function of the Stakeholder Working Group is to provide input to the IC/UC concerning local needs and desires for site recovery, proposed cleanup options, and other recommendations. The group should present local goals for site use by prioritizing current and future potential land uses and functions, such as utilities and infrastructure, light industrial, downtown business, and residential land uses. The Stakeholder Working Group is not a decision-making body.

The IC/UC should work with the PIO and Joint Information Center (JIC) to publish a summary of the cleanup and recovery process, the options analyzed, and the recommendations for public comment. Public meetings should be convened at appropriate times. At this time, it may be useful to reconvene the Stakeholder Working Group or TWG to resolve issues.

Additional information about the NIMS, ICS, and ICS functions is available at https://www.fema.gov/national-incident-management-system.

2.3 PLANNING DOCUMENTS

Planning documents are essential during the decision-making process, from the initial response to final recovery. Example planning documents are listed below.

- **Quality Assurance Project Plan (QAPP)** – The QAPP establishes site-specific data quality objectives (DQO) for the project. The QAPP sometimes includes a Field Sampling Plan (FSP). Appendix 1 provides example QAPP/FSP templates.

- **Health and Safety Plan (HASP)** – The HASP establishes overall site-specific safety requirements, work areas, and levels of personal protection equipment (PPE). Appendix 2 provides an example HASP template.
- **Ambient Air Monitoring Plan (AAMP)** – The AAMP establishes air monitoring protocols, sampling frequency, and spatial distribution to ensure the safety of response workers and the nearby public. The AAMP is used to determine plume migration, provide evacuation guidance, and provide shelter-in-place actions, if needed. Real-time air monitoring can be combined with discrete or composite air samples submitted for laboratory analysis. The AAMP may be used throughout the crisis and consequence management phases. Appendix 3 discusses air monitoring instrumentation need for the AAMP and provides the EPA air monitoring tables for CWAs.
- **Sampling and Analysis Plan (SAP)** – The SAP establishes the number and spatial distribution of samples for all matrices during the consequence management phase of site recovery. The AAMP may be incorporated into the SAP.
- **Remedial Action Plan (RAP)** – The RAP establishes decontamination technologies and methods for site remediation and cleanup.
- **Remediation Guidance** – Remediation guidance identifies key activities and issues that must be considered after an incident involving a CWA release.
- **Data Management Plan (DMP)** – The DMP identifies the data management process and procedures for work activities associated with data collection.
- **Uniform Federal Policy (UFP) QAPP** – The UFP for QAPPs is a consensus quality systems document prepared by the Intergovernmental Data Quality Task Force (IDQTF), a working group of representatives from EPA, the Department of Defense (DOD), and the Department of Energy (DOE).

EPA and non-EPA planning documents are discussed below.

2.3.1 EPA Planning Documents

EPA has 10 regional offices, each responsible for the execution of EPA programs in multiple states and territories. Although this Guidebook is meant to serve as a national planning document for all EPA regions, several EPA regions have developed their own basic plans to assist with CWA response in their states. Table 2-1 lists some of these regional response plans.

Table 2-1. Regional Response Plans

REGION-SPECIFIC PLAN	ELECTRONIC VERSION
Water Laboratory Alliance National Response Plan	Draft_WLA_National Response_Plan_02_11_09.doc
EPA Regions 1 and 2 Planning Team Planning Assessment for Response to Homeland Security Blister Agent Scenario Yale Bowl – New Haven, Connecticut	R1&2_Blister_Agent_Regional_Response_Plan.rev07-01-08.pdf
Draft Analytical Protocol for Extractable CWAs using GC/MS	CWA Protocol_03182011.doc
EPA Region 5 Homeland Defense, Chapter 4 - Chemical Agents	CWA Chapter.pdf
EPA Regions 7 and 8 Laboratory Emergency Response Full-Scale Exercise After-Action Report: Chemical Environmental and Food Scenario	Regions 7&8 Chem_Evn AAR_final_07132012.pdf
EPA Regions 9 and 10 Laboratory Full-Scale Exercise After-Action Report – CWA and Toxic Industrial Chemicals Environmental	Chemical_AAR_R9_R10_revised_11022011.pdf

Scenario	
EPA Region III Response to CWA Analytical Support through the ERLN	EPA Region III CWA analytical support.pdf
Chemical Weapons Response Outline -- Region 7	Chemical Weapons Response Outline R 7.doc

Notes:

ERLN Environmental Response Laboratory Network
GC Gas chromatography
MS Mass spectrometry

2.3.2 Non-EPA Planning Documents

Some agencies have developed planning documents that can be very useful during the decision-making process for a CWA incident. Table 2-2 lists some example planning documents from non-EPA sources.

Table 2-2. Non-EPA CWA Planning Documents

AIRPORT REMEDIATION DOCUMENTS	ELECTRONIC VERSION OR HYPERLINK
Draft Remediation Guidance for Major Airports After a Chemical Attack (LLNL 2012)	Available upon request
Draft Remediation Guidance for Major Airports After a Chemical Attack, Annexes (LLNL 2012)	Available upon request
Key Planning Factors for Recovery from a CWA Incident (FEMA 2012)	https://www.fema.gov/media-library/assets/documents/31719

Notes:

LLNL Lawrence Livermore National Laboratory
GC Gas chromatography

In addition, other non-EPA agencies also have developed potentially useful planning documents, including Regional Response Teams (RRT), the U.S. Department of Transportation (DOT), and the National Response Team (NRT) as discussed below.

- **RRTs** – There are 13 RRTs, 1 for each of 10 federal regions, plus 1 for Alaska, 1 for the Caribbean, and 1 for the Pacific Basin (Oceania). Each RRT maintains a Regional Contingency Plan and has state as well as federal government representation. EPA and the U.S. Coast Guard (USCG) co-chair the RRTs. Like the NRT, the RRTs are planning, policy, and coordinating bodies and do not respond directly to the incident scene. RRTs provide assistance as requested by the EPA OSC during an incident. Specific RRT planning documents are available at the following links:
  - Region 1 - http://www.rrt1.nrt.org/
  - Region 2 - http://www.rrt2.nrt.org/
  - Region 3 - http://www.rrt3.nrt.org/
  - Region 4 - http://www.rrt4.nrt.org/
  - Region 5 - http://www.rrt5.org/
  - Region 6 – http://www.epaosc.org/site/doc_list.aspx?site_id=5083
  - Region 7 - http://www.rrt7.nrt.org/

- Region 8 – http://www.rrt8.nrt.org/
- Region 9 - http://www.rrt9.org/go/site/2763/
- Region 10 - http://www.rrt10nwac.com/
- Alaska - http://www.akrrt.org/index.shtml
- Caribbean - http://www.crrt.nrt.org/
- Pacific Basin - http://www.oceaniarrt.org/go/doc/3911/1039647/Oceania-RRT-Homepage

- DOT – The DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) has published the "U.S. DOT Emergency Response Guidebook" (DOT 2012) that provides first responders with a go-to manual for responding to HAZMAT incidents during the critical first 30 minutes.
- **NRT** – The NRT is an organization of 15 federal departments and agencies that have developed Chemical Quick Reference Guides (QRG) to help responders identify hazards associated with CWAs (NRT 2011 through 2015). These QRGs provide critical information for the emergency response community in the unlikely event of a simple spill or terrorist event. The QRGs also cover critical response topics, including health effects, chemical properties, general health and safety information, and sampling and waste disposal information. Appendix 4 provides the latest versions of CWA QRGs.

2.4 REFERENCES – FRAMEWORK FOR DECISION-MAKING

Department of Homeland Security (DHS). 2008. *National Response Framework*. On-line Address: http://www.fema.gov/emergency/nrf/

Federal Emergency Management Agency (FEMA). 2012. Key Planning Factors for Recovery from a Chemical Warfare Agent Incident. On-line Address: https://www.fema.gov/media-library/assets/documents/31719

FEMA. 2013. *National Incident Management System (NIMS).* On-line Address: https://www.fema.gov/national-incident-management-system

Lawrence Livermore National Laboratory (LLNL). 2012. "Draft Remediation Guidance for Major Airports After a Chemical Attack – Annexes." Available upon Request.

National Response Team (NRT). 2011 through 2015. Chemical Quick Reference Guides. On-line Address: http://www.nrt.org/production/NRT/NRTWeb.nsf/PagesByLevelCat/Level3ChemicalHazards?Opendocument

U.S. Department of Transportation (DOT). 2012. "U.S. DOT Emergency Response Guidebook." Pipeline and Hazardous Materials Safety Administration (PHMSA). On-line Address: http://phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/Hazmat/ERG2012.pdf

3. RESPONSE AND RECOVERY ACTIVITIES

Response activities can be grouped into two broad categories: crisis management and consequence management. Under these categories, six phases are designated as shown in Table 3-1 (LLNL 2012). The overall goal of a response to a CWA incident is to protect human health and the environment, achieve an acceptable level of cleanup, and return a site to normal operations to the extent feasible. However, many activities are required to make final decisions regarding acceptable cleanup goals and clearance. Multiple agencies use many terms to describe the phases listed in Table 3-1 to represent the general timeline of required response and recovery activities. However, in most cases, multiple activities occur concurrently, so the concept of an absolute, strict, step-by-step process for individual activities is not realistic.

Table 3-1. CWA Incident Response and Recovery Activities Timeline and Phases

RESPONSE AND RECOVERY ACTIVITIES					
CRISIS MANAGEMENT		CONSEQUENCE MANAGEMENT			
		Restoration			
Notification	First Response	Characterization	Remediation (Cleanup)	Clearance	Recovery
Receive and assess information Identify suspected release sites Relay key information and potential risks to appropriate agencies	HAZMAT and emergency Actions Forensic investigation Public health actions Screening and sampling Determination of agent type, concentration, and viability Risk communication (for example, public warnings and recommended protective actions) Evacuations	SAP and QAPP Detailed characterization of CWA Characterization of affected area(s) or site(s) Site containment Continued risk communication Initial risk assessment Clearance goals Environmental sampling and analysis	Remediation and decontamination strategy RAP Worker health and safety Site preparation Source reduction Decontamination of sites, items, or both Treatment Verification of decontamination parameters Waste disposal Continued risk communications	Clearance sampling and analysis Clearance decisions Continued risk communication	Renovation Resumed use or reoccupation decision Potential environmental and public health monitoring Continued risk communication

Note:

Adapted from LLNL 2012

Both the information gathered and the decisions made during the crisis management phase will inform subsequent actions taken during the consequence management phase. Decision-makers should consider

long-range consequences from decisions made during earlier phases of the response on later phases. For example, action levels selected to protect first responders during the crisis management phase may not be adequately protective for longer-term exposures that may occur during resumed site use or re-occupancy.

The Guidebook provides a continuum for consistent criteria and decision-making for crisis management and consequence management as discussed in the following sections.

3.1 CRISIS MANAGEMENT

Crisis management during a response typically is characterized by a lack of knowledge and uncertainties during the immediate aftermath of the release. The source of the release may still be present. In general, priority is given to life-saving and First Aid actions, such as evacuation, sheltering in place, and protection of emergency workers. Figure 3-1 presents a flowchart outlining the main actions performed and decisions made during crisis management.

Crisis management can be divided into the notification and first response phases as discussed below. It should be noted that although attributes of each phase are discussed below, successful cleanup must be governed by a dynamic and flexible process. Thus, the phases should not be construed to be discrete. For example, risk communication is essential during each phase.

3.1.1 Notification Phase

During the notification phase, appropriate federal agencies and the Emergency Operations Center (EOC) are notified about the incident. Also, information is collected and disseminated to site responders during this phase.

3.1.2 First Response Phase

During the first response phase, local emergency response assets are activated to respond to the site. Fire, police and HAZMAT teams will conduct rescue activities and the Site will likely be declared a crime scene. Access will be restricted for an unknown period of time while the forensic collection activities take place. It's likely that FBI or another agency will control access to the site. EPA's access will be limited and/or completely restricted while forensic investigations take place over at least the first several days. While this time period, limits EPA response activities with the exception of monitoring activities at the perimeter of the crime scene. Time behind yellow tape can be spent planning disposal, multi-agency interaction and addressing difficult issues like laboratory capability, designing sampling plans and mobilizing resources. The IC or UC may be set up

During the first response phase, actions may be based on rough estimates (such as the visibility of a plume or based on emergency response guidelines), plume models, and information reported by first responders, including visual and olfactory observations and gross level field instrumentation readings. If the CWA has been identified, other field instrumentation or more precise chemical dispersion models can be used to estimate the extent of the spread of the CWA. However, field instruments may only indicate if the CWA is present above a certain concentration rather than providing actual concentration information. Likewise, the detection limit of the field instrument (the concentration at which the instrument can detect the CWA) may be quite high and in some cases exceed the concentration at which responders are likely to show symptoms of exposure. Therefore, it is advisable to verify "non-detect" readings using an alternative methodology, especially if highly toxic substances may be present.

Within the established perimeter of the incident site (the area impacted by the CWA release), decisions need to be made regarding areas for evacuation, sheltering-in-place actions, and restricted-use actions. During both the crisis and consequence management phases, a variety of containment actions may be taken to prevent the spread or movement of a CWA, including the following:

- Cordoning off all areas known or suspected of being contaminated
- Turning off a facility's heating, ventilation, and air conditioning (HVAC) system

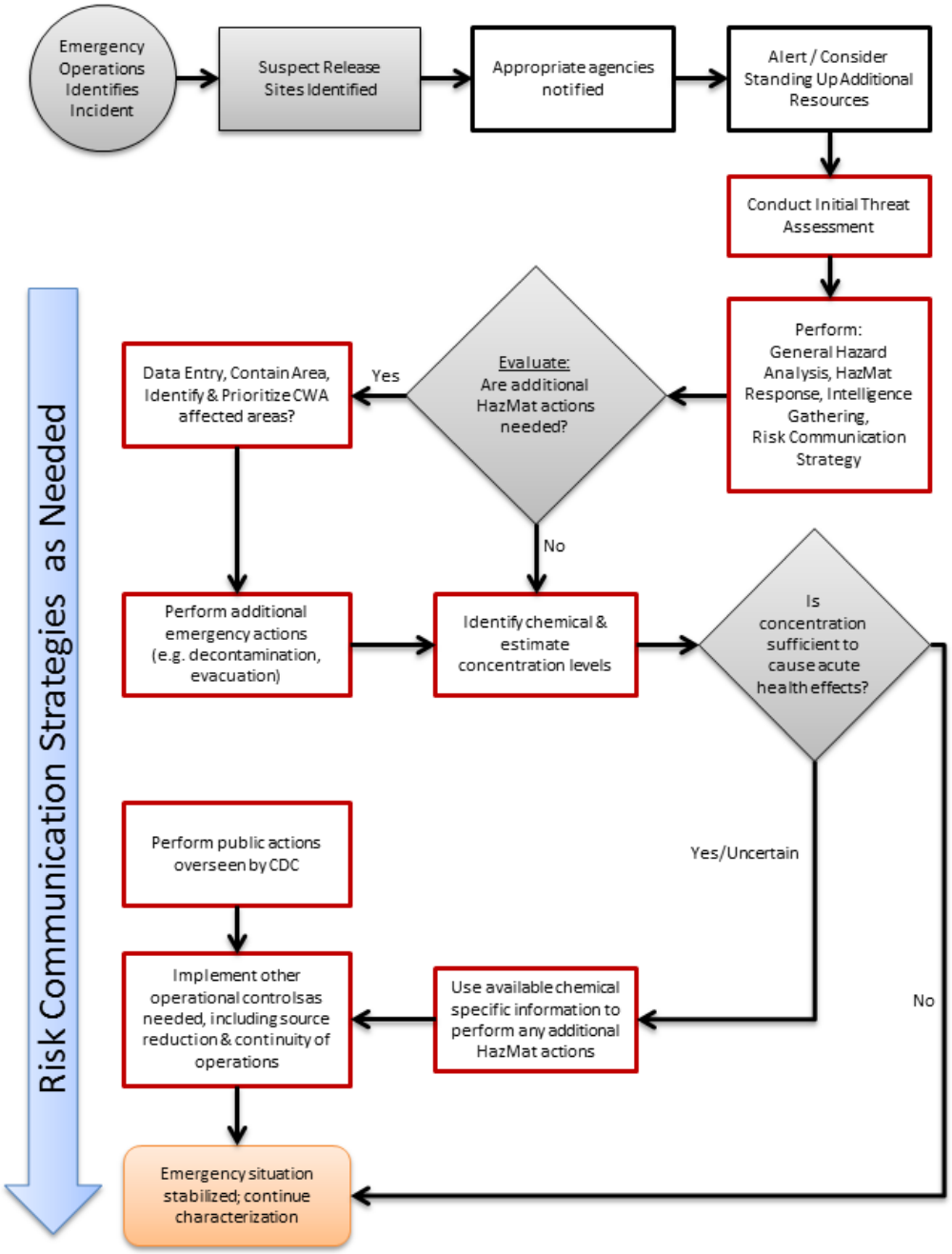


Figure 3-1. Actions Performed and Decisions Made During the Notification and First Response Phases of Crisis Management

- For a CWA deliberately released indoor, sealing off all air ducts, windows, doors, and vents with 6-millimeter polyethylene sheeting
- Ensuring site security by establishing procedures to restrict entry of unauthorized personnel (for example, posting signs, installing physical barriers, or using guards)
- Establishing standard work areas to control site access and the spread of CWA contamination

3.2 CONSEQUENCE MANAGEMENT

This component of a response constitutes the longest part of site recovery activities and includes site characterization, which requires determining the extent of CWA contamination, cleanup and decontamination activities, and the final restoration and recovery of the site for proper resumed use or re-occupancy. Data acquired during the consequence management phase must be adequate for evaluating options (cleanup approaches) as well as for making final clearance decisions. Most key steps and elements in the cleanup decision-making process take place during consequence management.

Figure 3-2 provides a flowchart outlining the main activities performed and decisions made during consequence management. Consequence management can be divided into two main phases as discussed below, the restoration and recovery phases.

3.2.1 Restoration Phase

This consequence management phase typically involves identifying infrastructure and population(s) affected and fully characterizing potentially contaminated areas. By confirming that areas have not been affected, the IC can allow a rapid return to normal operations for these areas, including roads, airports, businesses, hospitals, residences, and other areas. The restoration phase can further be divided into the following phases:

- **Characterization Phase** – Detailed characterization of the CWA and site or area(s); preparation of the SAP; risk communication and risk assessment clearance goals set
- **Remediation (Cleanup) Phase** – Remediation technologies and procedures selected and implemented; preparation of RAP; cleanup activities; waste transportation and disposal
- **Clearance Phase** – Remediation efforts evaluated to determine if the site is cleaned up sufficiently to allow release for resumed use or re-occupancy

During the characterization phase, additional site and scenario data are gathered. Example site characterization activities include the following:

- Developing a detailed description and determining the dimensions of the area(s) affected (both natural and man-made)Estimating the extent of contamination, including potentially contaminated surface areas and volumes of materials, using maps, building blueprints, and water distribution system maps (including connections and components of water distribution system)
- Identifying material types, such as non-porous (such as glass and metals), semi-porous (such as walls and concrete), or porous (such as ceiling tile and carpet)

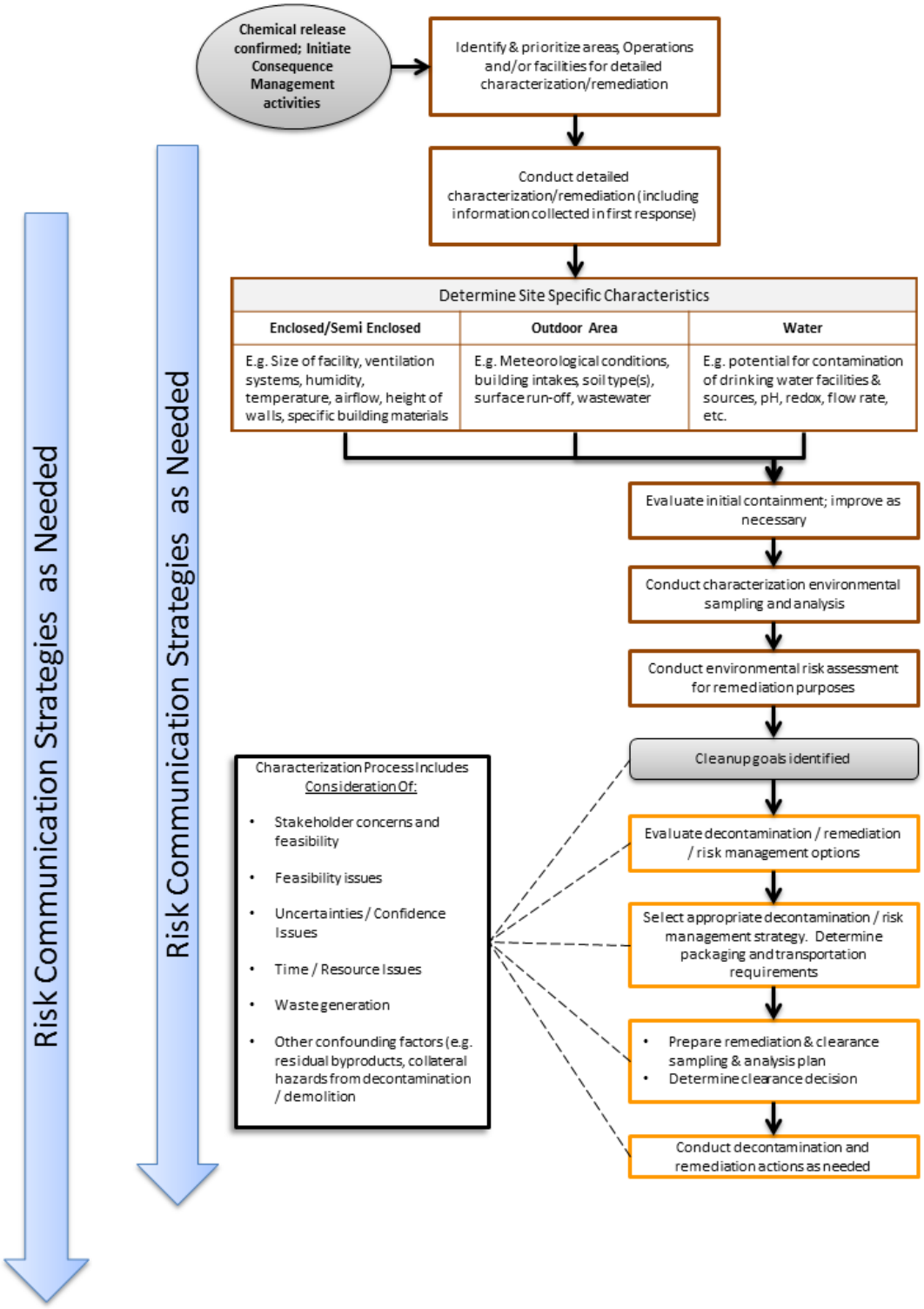


Figure 3-2. Actions Performed and Decisions Made During the Recovery and Restoration Phases of Consequence Management

- Documenting environmental conditions during and after the CWA incident (such as ambient temperature, humidity, exposure to sunlight, cloud cover, wind speed and direction, rate and directional flow of water, and rainfall)
- Predicting where runoff from precipitation and early decontamination activities may have spread CWA contamination
- Applying mathematical models to characterize the fate and transport of a CWA (such as air, groundwater, and surface water models)

Decontamination technologies and procedures are used to clean up affected sites and areas. The decontamination process is iterative, with continual decontamination activities and re-characterization of the decontaminated areas to determine if additional decontamination is required, until clearance levels are reached. Decontamination technologies use mechanical, physical, chemical, biological, or natural degradation and natural attenuation methods to physically remove, chemically treat, biologically degrade, or naturally dissipate CWAs (Environment Canada 2005). Section 5 of this Guidebook, Decontamination, discusses some decontamination technologies for specific CWAs for surface "hot spots," large volumetric spaces, and sensitive equipment.

3.2.2 Recovery Phase

During this phase of the response, final decisions are made regarding resumed use and re-occupancy of contaminated sites and facilities. Plans for determining if long-term environmental monitoring is required also should be considered to ensure achievement of clearance levels and determine if site controls or restrictions are necessary. Continued risk communication is important during the recovery phase to inform the public and help them make decisions regarding themselves and their families and to maintain trust between the public and government decision-makers.

Risk communication and public education are discussed in more detail below.

Risk communication is a vital component of risk analysis and critical to effective risk, crisis, and consequence management during and after a CWA incident. The goal of effective risk communication is to share information and inform the public about actions taken to reduce risk. The risk should not be over- or understated. Practical information should be communicated, including response guidance about government and public responsibilities during and after the incident. Trusted community leaders should deliver these messages in a simple and straightforward manner (DHHS 2002). Risk communication is a continuous process because knowledge about risks may be fragmentary at first but increase over time. Effective risk communication builds public knowledge and trust over time.

RISK COMMUNICATION

According to the Department of Health and Human Services (DHHS), risk communication is "an interactive process of exchange of information and opinion among individuals, groups, and institutions. It often involves multiple messages about the nature of risk or expressing concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management" (DHHS 2002).

In response to a large-scale, deliberate incident, a JIC should be established immediately to coordinate all public affairs activities and environmental media releases. The JIC serves as a single point of contact that provides quick, accurate public information throughout the response and cleanup process. In addition, the JIC works closely with elected officials, community leaders, local hospitals, health officials, social and support groups, advocacy groups, news media, and other involved stakeholders all the way through the decision for site return to use. Under the NRF, an information officer (such as the PIO)

develops and releases information about the incident to news media and all agencies and organizations involved.

Public education regarding the complex technical, scientific, and risk issues arising from CWA incidents is challenging, especially in the face of uncertainties related to these incidents. However, by carefully placing the hazards of an incident into perspective for the public, risk effective communication can make complex scientific information accessible and understandable to a layperson. One effective technique is to ensure that risk communication occurs in phases, with the content synchronized with the incident timeline. For example, there may be a preparation stage during which a risk communication plan and strategy are developed, including public messages that anticipate areas of concern during each phase of an incident.

Effective risk communication serves as a platform for the discussion of risks and goals with the public. This platform can evolve into a two-way dialogue that becomes an important component of the decision-making process. In this way, risk communication is an approach for "scientists and public health professionals to provide information that allows an individual, stakeholders or an entire community, to make the best possible decisions about their well-being, under nearly impossible time constraints, while accepting the imperfect nature of their choices" (Centers for Disease Control and Prevention [CDC] 2008).

On the other hand, release of incorrect, undocumented, or misleading information to the public can cause confusion and lead to mistrust. Decision-makers must be especially careful when communicating uncertain information and information about the evolving situation to avoid undermining the trust of stakeholders. By maximizing communication about the goals of the response and cleanup processes, the decision-maker gains public trust, minimizes confusion, and fosters cooperation from the stakeholders and citizens. These benefits will reduce the human, economic, and social costs of the incident.

3.3 REFERENCES – RESPONSE AND RECOVERY ACTIVITIES

Centers for Disease Control and Prevention (CDC). 2008. "Crisis and Emergency Risk Communication. August 7. On-line Address: http://emergency.cdc.gov/cerc/

Department of Health and Human Services (DHHS). 2002. "Communicating in a Crisis: Risk Communication Guidelines for Public Officials." Washington, DC. On-line Address: http://www.orau.gov/cdcynergy/erc/Content/activeinformation/resources/HHSRiskCommPrimer.pdf

Environment Canada. 2005. "Review of Decontamination and Restoration Technologies for Chemical, Biological, and Radiological/Nuclear Counter-terrorism." Report EE-176, CRTI-IRTC.

Lawrence Livermore National Laboratory (LLNL). 2012. "Draft Remediation Guidance for Major Airports After a Chemical Attack – Annexes." Available upon Request.

4. SAMPLING

As discussed in Section 2, despite numerous standards and regulatory guidelines, no cleanup approach or sampling strategy is universally applicable to every CWA incident. Therefore, coordination between federal, state, tribal, and local governments is critical to ensure that the CWA sampling process is acceptable and effective but flexibly applied to ensure consideration of site- and incident-specific characteristics.

The UFP QAPP should be used as a guide for developing the QAPP for data collection (see Appendix 1). The UFP QAPP is available at http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf .

This section provides an overview of environmental sampling and discusses sampling objectives for a CWA event, sampling plans, sampling resources, sampling strategies, data management, the sampling checklist, and sampling methods.

4.1 OVERVIEW

Environmental sampling during a CWA event has three distinct phases: field screening during initial stages, characterization sampling, verification sampling, clearance sampling, and long-term environmental monitoring during restoration. Each sampling phase and its purpose are discussed in the following sections.

4.1.1 Field Screening

Field screening usually occurs during first response in order to determine if CWA contamination is present. Field screening may be conducted during initial assessment to rapidly identify potential pathways for further sampling. Field screening conducted by EPA and public health officials has the primary objectives of confirming the presence of a CWA and quickly identifying the populations at risk. Investigators are likely to use judgmental sampling as a primary strategy to determine locations with the greatest likelihood of contamination that need to be evaluated first (Emanuel et al. 2008).

4.1.2 Characterization Sampling

Characterization sampling typically is used to obtain information concerning the extent and magnitude of contamination to guide remediation. For example, characterization sampling may be used to determine which areas, items, and materials require decontamination. The information from characterization sampling also is used to help modify and refine public health actions developed based on the initial assessment. Uses of characterization sampling data include estimating potential exposure to the CWA and deciding decontamination locations, items, materials, and methods (DHS 2006).

Characterization systematically expands on initial assessment findings to identify other contaminated locations and determine the contamination footprint to better define the contamination boundaries. The strategy of the characterization phase is to supplement the information already collected during initial assessment. The sampling information, specific information about the scenario, and data collected during the initial assessment may have many forms and come from different groups involved in the initial response. Initial assessment data are reviewed, evaluated, and used to assist in formulating the objectives, strategy, and approach for the characterization phase. Information from the characterization phase affects and guides the planning and implementation of the remediation phase.

4.1.3 Verification Sampling

Verification samples are collected from previously contaminated areas and surfaces to determine if contamination remains. Verification sampling is performed during the remediation process to determine if decontamination or a related process was effective or sufficient in removing contamination. In other words, verification sampling is conducted to determine if remediation activities can cease. Verification sampling may have less stringent criteria than clearance sampling, which is conducted to determine if re-occupancy can occur.

4.1.4 Clearance Sampling

Clearance sampling allows objective determination of whether clearance goals have been met and a site or facility is ready for final preparation for re-occupancy. The purpose of clearance sampling is to determine if remediation was effective. Clearance sampling is conducted after decontamination activities are complete and before critical barriers are removed and is used to confirm that the contaminated site or facility no longer poses an unacceptable health risk.

After all clearance samples are collected and the sample results reported, the clearance sampling team presents the findings and methods to the Environmental Clearance Committee (ECC). The ECC then prepares a written clearance statement or document for presentation to the IC/UC. The IC/UC can then advise local health department entities that the site or facility is "safe" for re-occupancy. Local health departments have the final decision on the next steps and whether or not to reoccupy a facility or site.

When appropriate, clearance sampling may use results from earlier characterization and verification sampling efforts to augment decisions that support the ECC's recommendation for clearance. The use of data from characterization or verification sampling efforts is appropriate only if the samples have the same level of rigor and the same quality assurance (QA) criteria as the clearance samples.

4.1.5 Long-Term Environmental Monitoring

After successful clearance, it may be necessary to conduct long-term environmental monitoring. Environmental monitoring ensures that no areas of CWA contamination remain and that possible sinks of CWA contamination do not go undetected (such as through seepage from porous materials). Monitoring also helps maintain the safety of workers, the environment, and the community. It also provides psychological support to stakeholders that the decontamination process is continuing.

4.2 SAMPLING OBJECTIVES FOR A CWA EVENT

Clear and tangible sampling objectives are critical to effective contamination characterization during a CWA event. The sampling objectives are to determine the types, numbers, and locations of samples required to provide the information needed to draw conclusions regarding the contamination. The sampling objectives also should include determining the appropriate data quality requirements for supporting those conclusions. The general sampling objectives listed below may be applicable to a CWA contamination event (Occupational Safety and Health Administration [OSHA] 2008).

- **Immediately Assess Potential Contamination:** Determine, in real-time, if a release is occurring or has occurred at a site or facility. Real-time detection instruments may be used to detect CWA agents as they are released.
- **Identify Bulk Material:** Determine if a bulk material, such as a liquid or powder (dusty agent) is a source or is contaminated with a CWA. On-site analysis may be used for preliminary assessment,

but laboratory analysis provides confirmation. Identification of bulk material primarily is not an EPA responsibility, but EPA may assist in this effort if requested.

- **Perform Initial Agent Identification:** Determine the identity of the CWA, presence of the agent, formulation, toxicological properties, persistence, break-down products, and other physical properties. Initial agent identification primarily is not an EPA responsibility, but EPA may assist in this effort if requested.
- **Characterize Actual or Potential Exposure Pathways:** Characterizing exposure pathways at a contaminated site is challenging. Consideration must be given to degradation properties and how the chemical behaves in various media (soil, air, water, sediment, and biota). Some contaminants disperse quickly, but others are more tenacious. Knowing which chemicals are present, their degradation properties, and how they behave in different media are critical to understanding potential and real risks.
- **Determine Contamination of Articles:** Determine if the surfaces of articles are contaminated. Typically, composite surface samples are collected to determine if large articles are contaminated, and individual samples are used for small articles.
- **Determine Extent and Location of Contamination (Characterization Sampling):** After a CWA is positively identified, further sampling is necessary to determine how far the contamination has spread. Characterization sampling is performed to determine qualitatively, and if possible, semi-quantitatively, the extent and magnitude of contamination. Characterization sampling is used by cleanup personnel to determine CWA fate and transport. Characterization sampling also is used to determine decontamination plans and for comparison of results with future clearance samples.
- **Determine the Effectiveness of Decontamination (Verification Sampling):** Determine if decontamination has eliminated the CWA or reduced CWA contamination to established cleanup goals.

Conduct Post-Decontamination Sampling (Clearance Sampling): Final post-decontamination sampling is conducted inside and outside of an area designated as contaminated above an established cleanup goal. The ECC typically establishes cleanup goals to verify that the originally contaminated area has been sufficiently decontaminated to allow re-occupancy of the area without the use of PPE and to prevent secondary, off-site contamination.

4.3 SAMPLING PLANS

An incident-specific SAP should be prepared to ensure that the data match the needs of the investigation. A systematic planning process is used to design and safeguard the data collection process. A well-designed SAP ensures that resulting data are representative of the target population and defensible for their intended use. A good SAP should require no more resources than necessary to meet associated objectives. EPA develops SAPs using current regional templates. The unique features of a CWA response (for example, limited laboratory capacity) require help from sampling tools such as geographic information systems (GIS), global positioning systems (GPS), and other tools. Also, SMEs can help develop a SAP that supports the overall DQOs of the IC/UC.

One group of SMEs, the Visual Sample Plan (VSP) Work Group, defines a sampling plan as a documented approach for field execution that captures the specific combination of operating precepts and diagnostic tools used for a given scenario to answer a specific hypothesis. A sampling plan is an executable plan of

action that addresses the sampling and analytical requirements of a specific situation and is formulated in accordance with the sampling strategy. A sampling plan must specify the sampling approaches, methods, and analyses as well as the number, types, and locations of samples to be collected in a given physical space. The plan also must address quality control (QC) considerations (DHS 2007).

A comprehensive sampling plan cannot be developed before an incident. Only after sampling objectives have been determined and associated sampling approaches have been selected can an incident-specific SAP be written. A SAP may develop into several individual plans for multiple locations, each with a different objective. A SAP also may be developed for each task or phase of the response (first response, characterization, remediation, and clearance) (DHS 2007).

SAP development is governed by the amount of information known about the agent; whether the release location is known; and whether the agent has been modified, degraded, or enhanced. For example, for an overt release with a known or apparent release location and delivery mechanism, the sampling strategy must account for information known about the release. For a covert release, the areas of contamination may be less well defined and the SAP may require more initial judgmental sampling to support an optimal overall SAP (Emanuel et al. 2008).

The Planning Section is responsible for developing SAPs for all sampling efforts, including characterization, remediation, decontamination verification, and clearance. Under Planning Section, the EU develops SAPs in cooperation with the Sampling Group in the Operations Section, other elements of the Operations Section, SMEs, and other technical specialists as needed.

The following sections discuss the DQOs, initial assessment, initial preparations and plans, laboratory methods, and planning for sampling lag.

4.3.1 Data Quality Objectives

The SAP should employ a DQO process (EPA 2006 and 2000) and be written in the context of a QAPP that meets the requirements in the UFP QAPP guidance (EPA 2005). DQOs should be derived for each sampling objective. Each objective should have a clear hypothesis and a decision statement for each study area. DQOs are scalable but should be as specific as the objective and decision statement require.

Appendix 1 of this Guidebook provides templates for an example emergency response QAPP/FSP for air sampling and other media. The templates provide an overview of the requirements for QA documentation for sampling plans. The template for the QAPP is based on templates from multiple sources, including EPA Region 9 air sampling guides. The Region 9 templates were designed to combine, "in a short form, the basic elements of a QAPP and a Field Sampling Plan (FSP) to meet the requirements for any EPA Region 9 funded project in which environmental measurements are to be taken" (EPA 2005).

After completion, the draft SAP undergoes an internal review. Upon approval of the SAP by the IC/UC, sampling can begin. There is no requirement that a single written SAP be generated for an entire complex. For example, the central building and each adjacent wing or building may have separate written SAPs. Incident-specific information should be used to determine the best approach for SAP preparation.

4.3.2 Initial Assessment

According to EPA, "The planning team will typically begin by developing a conceptual model of the problem, which summarizes the key environmental release, transport, dispersion, transformation, deposition, uptake, and behavioral aspects of the exposure scenario which underlies the problem. The conceptual model is an important tool for organizing information about the current state of knowledge and understanding of the problem, as well as for documenting key theoretical assumptions underlying an exposure assessment" (EPA 2006). Initial assessment includes identifying the following (EPA 1989):

- Potential sources, including CWA(s), concentrations, time of release, and known or expected locations of contamination
- Pathways for CWA contamination, including media, methods, rates of migration, time, and loss or gain of functions
- Receptors, including types, sensitivities, time, concentrations, and numbers

The initial assessment guides many subsequent actions, so it is important that initial assessment is as thorough and accurate as possible. Information about potential sources of CWA contamination should be available from the first response phase, which includes forensic investigation. The information may include details about if the release was overt or covert, the location of the release, and the mechanism of release (such as aerosol, explosive, etc.). Figure 4-1 summarizes actions to evaluate first response data and the steps leading to characterization.

4.3.3 Initial Preparations and Plans

A detailed site- and incident-specific environmental characterization SAP is developed incorporating the initial assessment results. The SAP is used to systematically expand upon initial findings, identify other locations of contamination, and continue sampling until the extent and magnitude of the contamination is fully known. The characterization sampling plan should address data gaps for areas not assessed during initial assessment and incorporate recommendations from the TWG and expert resources (DHS 2006).

4.3.4 Laboratory Methods

Positive confirmation of a CWA begins with proper sampling, followed by proper extraction and analysis and full QA in a laboratory experienced in analyzing samples for CWAs and their break-down products. The EPA's Environmental Response Laboratory Network (ERLN) laboratories have CWA laboratory certification. EPA's "Selected Analytical Methods for Environmental Remediation and Recovery" (SAM) identifies testing methods for environmental contaminants (EPA 2012).

Most of the methods listed in SAM have undergone validation using authentic standards of CWAs. The searchable SAM document is available at http://www.epa.gov/sam/ or http://www.epa.gov/sam/SAM_2012_07162012.pdf (for the PDF file). Appendix 5 contains the SAM 2012 Appendix A of selected analytical methods for CWAs.

Consultation and coordination with a qualified laboratory or qualified chemical-analysis professional is essential when selecting sampling and analysis methods. To the extent possible, sample collection and analysis should be conducted by trained teams using approved and validated standard operating procedures (SOP). Many sampling methods are available depending on the CWA(s) and media to be

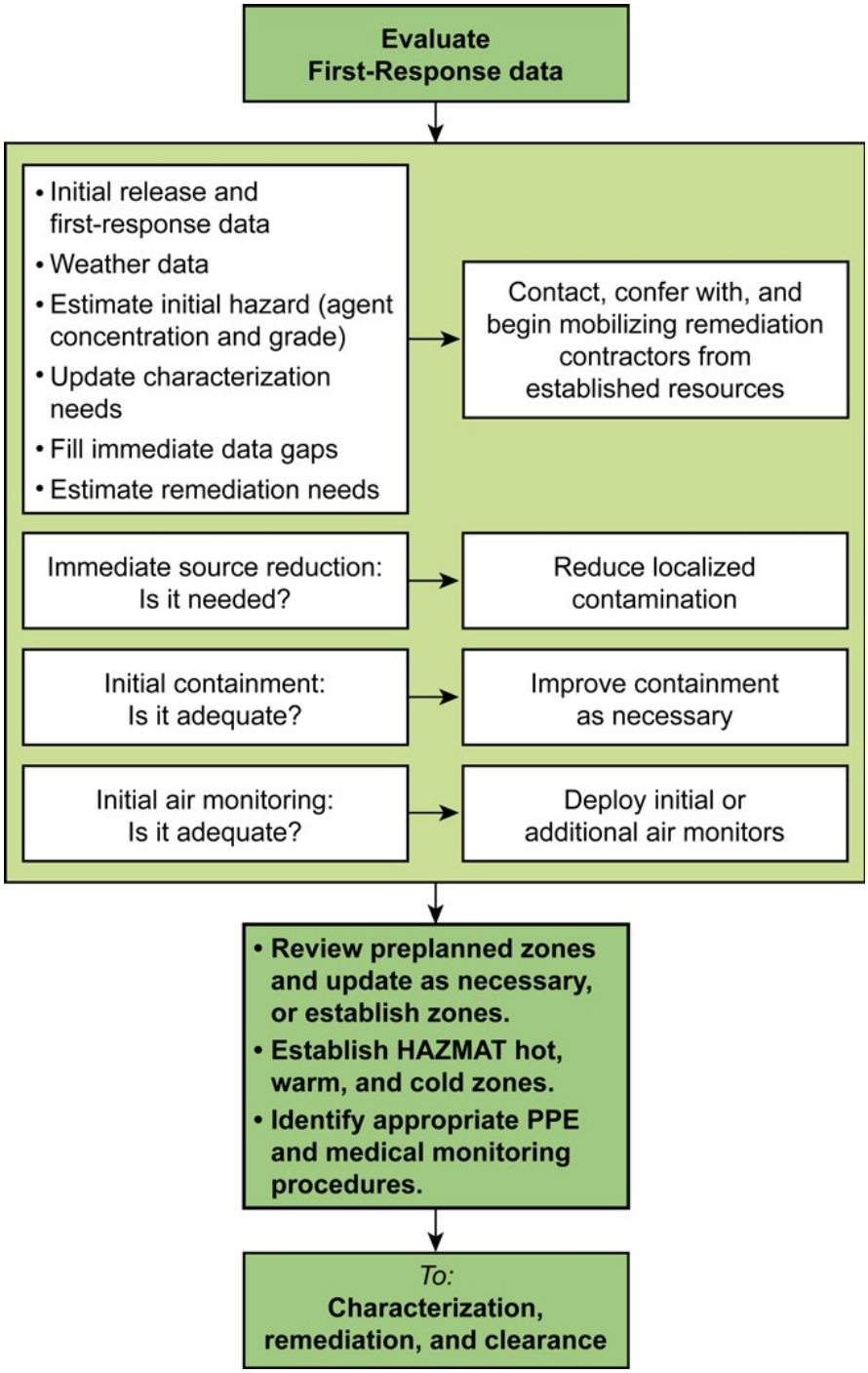


Figure 4-1. Evaluation of First Response Data and Steps Leading to Characterization

sampled. OSCs are directed to use the ERLN's recommended sample collection and analytical methods contained in SAM.

Many analytical methods can be used to detect and measure CWAs. The selection of an appropriate detection technique depends on the analyte, required detection levels, how quickly analytical results are needed, and the degree of analytical accuracy desired. In particular, the laboratory must be able to assess samples using methods with detection limits lower than the selected clearance goals. This requirement minimizes uncertainty about potential health impacts associated with negative results (non-detections). Because clearance goals are incident-specific and probably will not be available at first, for initial characterization samples, detection limits should be as low as possible, at least for samples outside the immediate release location (where environmental levels might be relatively low). Detection limits below clearance goals is an absolute requirement for clearance sampling.

Real-time (field) instruments include flame photometric detectors, ion-mobility spectrometers, mass spectrometers, infrared spectroscopes, and Raman spectroscopes. The main advantage of these instruments is that they can be used by operators with minimal training to provide data in the field. Laboratory methods include gas chromatography (GC) coupled with flame photometric detection, mass spectrometry (MS), tandem mass spectrometry, and others. Laboratory-based methods typically provide a higher level of confidence about chemical identification and quantification and can detect very low concentrations of chemicals. However, laboratory-based methods must be performed by highly trained operators in a laboratory. Because samples must be transported to the laboratory and some sample preparation is required before analysis, test results will be not be immediately available. Results are likely to be reported several days (or several hours in special cases) after samples are submitted for analysis.

The sampling and analysis methods partially depend on the specific CWA. If the CWA is a regulated toxic industrial chemical (TIC), it is likely that formally validated methods (such as the EPA Test Methods) are available for chemical analysis. Many qualified commercial laboratories use such methods. However, if the CWA is not a regulated TIC, at present, no formally validated methods are available for sample analysis. Experiments currently are being conducted to verify that some CWAs on selected surfaces can be detected at concentrations lower than potential health-based guidelines that could be adopted as clearance goals. EPA also currently is verifying, through multi- laboratory efforts, analytical methods for selected CWAs. If this work is successful, the methods will be published and commercial laboratories will be able to use validated methods for some CWAs. When validated methods are not available, then best practices or newly developed and documented (but unvalidated) methods adapted from chemical literature may be used by a qualified laboratory. Appendix 5 contains more information about available analytical methods.

In general, to resolve sampling and analysis issues, the analytical laboratory should provide the following:

- Appropriate guidance on sample collection, including types of samples to be collected, quantity of sample needed, and any required sample preservation
- Well-documented sample preparation methods
- Well documented analytical procedures
- Proof that desired detection limits can be achieved

- A documented QA/QC program
- The levels of QA/QC data packages that the laboratory can provide

Relatively few laboratories are qualified to perform CWA analyses. If large numbers of samples are collected, a bottleneck may result. One way to avoid bottlenecks is to allow additional laboratories to perform analyses. Such an approach may result in the use of multiple analytical methods, possibly with different detection limits. This situation would in turn result in difficulties in comparing results, performing statistical analyses, and interpreting the results for planning decontamination or clearance efforts. Therefore, the selection of laboratories and methods must be carefully planned and controlled. Enhanced communication and advanced notification with the laboratories is the key to solving this problem.

4.3.5 Planning for Sampling Lag

Sampling analysis lag commonly occurs when repetitive sampling efforts produce samples faster than the laboratory can analyze them. Processing and analysis generally take longer than sampling, and it is more difficult to conduct several iterations of sample collection than to collect multiple samples during a single event. Therefore, multiple samples collected simultaneously may be processed and analyzed in a staged manner to achieve the result of sequential sampling.

During a CWA event, it is important to plan for sampling lag. Good planning can reduce the lag time between sample submission and receipt of results. If a decision must be made as soon as results are available from the laboratory, then investigators can plan to collect potentially desired samples at once. If time is less of a constraint or time and costs can be balanced, then some questions can be answered using an iterative procedure where samples are collected, results obtained, and then different areas are sampled based on the first sampling results. An iterative sampling procedure can be more generally referred to as adaptive sampling (see Section 4.5.3.2 for more details).

4.4 SAMPLING RESOURCES

Characterization activities can begin as soon as contamination by a CWA is suspected or immediately upon confirmation of such contamination even if first response activities are not complete. The IC/UC or organization in charge establishes an ICS structure that may include technical specialists and mobilizes other resources needed for characterization, such as personnel and equipment. Sampling resource personnel and equipment may include the following:

- Contractors ready to respond on short notice
- Sampling teams with up-to-date training on health and safety and sampling
- Analytical laboratories with experience, certification, and security; if many characterization environmental samples require analysis, primary laboratory may have insufficient capacity and additional laboratories would be recruited; use the ERLN to access capabilities of the entire network
- Personnel who maintain current physical information on a site or facility, such as architectural drawings depicting HVAC and mechanical systems; if available, copies stored off site may be most accessible
- Facility operators and maintenance contractors knowledgeable about HVAC system operation

- Numerical modeling and sampling design experts
- Data management and documentation specialists to organize a database for environmental sampling results; existing tools used by people familiar with them preferred
- Remediation experts with experience in planning and performing environmental remediation projects, including preparation of a QA/QC plan using DQOs
- Construction workers to place containment barriers for CWA contamination and isolation barriers for sensitive equipment and to conduct prompt source reduction under hazardous conditions
- Waste management authorities, waste disposal facility owners, and wastewater management authorities
- Experts from the EPA's special teams, including the EPA Chemical, Biological, Radiological, Nuclear and High-Yield Explosives (CBRNE) Consequence Management Advisory Division (CMAD) and Environmental Response Team (ERT), to provide technical support; each special team has specialized equipment that can assist with a CWA response as summarized below.
    - Trace atmospheric gas analyzer (TAGA) bus – In response to a disaster, EPA uses a self-contained mobile laboratory bus to monitor air quality. The mobile TAGA bus is capable of real-time sampling and analysis. TAGA is used to provide real-time concentrations of toxic substances in ambient air. The TAGA bus has been used also to provide very rapid analyses of gas samples from specific sources. The bus is equipped with satellite communications and internet access for completely independent operation. Instrumentation aboard the TAGA bus includes (1) a TAGA tandem mass spectrometry (MS/MS) detector that provides real-time monitoring for many organic and inorganic compounds at the part-per-billion-by-volume (ppbv) level or lower; (2) an Agilent GC/MS detector equipped with auxiliary electron capture and photoionization detectors that analyzes for volatile organic compounds at the ppbv level from direct injections, Tedlar® bags, or thermal desorption tubes; (3) an Agilent Micro GC detector that assays permanent gases at the part-per-million-by-volume (ppmv) level; (4) a GPS unit that supplies accurate, real-time positional data during mobile monitoring or stationary events; and (5) a GIS that maps and presents in real time the TAGA bus position. The ERT, working with the Homeland Security Research Center, contracted Battelle to develop a method for monitoring for CWAs using the TAGA bus's MS/MS. The TAGA bus's MS/MS can detect CWAs at and below the part-per-trillion-by-volume (pptv) level. Additionally, other work at the Oak Ridge National Laboratory (ORNL) has shown the TAGA bus MS/MS technology can monitor for explosive compounds (EPA 2013a).
    - Portable High Throughput Integrated Laboratory Identification Systems (PHILIS) units – EPA's PHILIS units are mobile laboratories designed to analyze for CWAs and TICs. The PHILIS units provide on-site laboratory capabilities to support EPA's ERLN in responding to CWA attacks. The PHILIS mobile laboratories are certified by the National Environmental Laboratory Accreditation Conference (NELAC) and can provide on-site confirmatory environmental analysis for decision-making needs (EPA 2013b). Available PHILIS resources are summarized below.

Edison, NJ	Castle Rock, CO
Analytical Trailer: 9 GC/MS instruments, 1 GC unit with electron capture detector (ECD), 1 liquid chromatography (LC) MS/MS unit, 2 purge-and-trap (P&T) units, 1 thermal desorption unit (TDU) system	**Analytical Trailer:** 6 GC/MS instruments, 1 LC MS/MS unit, 2 P&T units, 2 TDU systems, 3 time-of-flight (TOF) GC/MS units
Sample Preparation Trailer: For preparation of soil, water, air, and wipe samples	**Sample Preparation Trailer:** For preparation of soil, water, air, and wipe samples
Sample Log-In and Standards: Ultra-dilute CWAs storage trailer	**Sample Log-In and Standards:** Ultra-dilute CWAs storage trailer
Wireless laboratory information system (LIMS)	**Wireless LIMS:** Compatible with Staged Electronic Data Deliverable (SEDD) Tiers 1 through 3, Scribe, Building Restoration Operations Optimization Model (BROOM), and WebEDR
Anticipated Capacity of 100 to 200 TIC or CWA samples per 24-hour period	

- Airborne Spectral Photometric Environmental Collection Technology (ASPECT) Aircraft – EPA uses the small ASPECT aircraft to detect and gather chemical and radiological data to assist response agencies in the United States. ASPECT uses a variety of sensors and cameras to quickly collect data and information and provide it to emergency response teams (EPA 2013a).

- The startup time for characterization will be reduced if sampling resources are identified in advance. EPA will use its dedicated contracts already in place, Superfund Technical Assistance and Response Team (START) and Emergency Rapid Response Services (ERRS). EPA will use START for sampling and assessment activities and ERRS for cleanup and disposal activities. Planners should refer to the "USCG Hazardous Materials Response Special Teams Capabilities and Contact Handbook" (USCG 2006), which briefly describes each special team and asset that can provide technical support to the federal OSC during a major disaster or HAZMAT emergency.

- The National Response System (NRS) mechanism by which the OSC mobilizes technical resources is described in the NCP. An overview of the NRS is available at http://www.epa.gov/oem/content/nrs/snapshot.htm. Planners should be familiar with local resources, including those available through local EPA offices, and should establish a working relationship with personnel at those offices before an incident. If feasible, contracts should be put in place with environmental consultants and cleanup contractors for characterization and decontamination work. Another option is to modify existing environmental cleanup contracts to include CWAs.

4.5 SAMPLING STRATEGIES

Rapid remediation is a high priority for a CWA event. *Each* sampling strategy should be specific to *each* selected sampling objective so that it can provide actionable information to decision-makers in a short timeframe. Because resources may be limited, sampling must be centered on well-defined, site-specific

objectives, perhaps drawn from the general objectives described in Section 4.2. Sampling strategies should remain focused on gathering *essential* information to ensure that resources are used efficiently. A sampling strategy should consider the following *essential* information inputs:

- Chemical toxicity and relative exposure risk for the CWA of concern
- Chemical properties that influence the CWA's fate and transport
- Actual and potential exposure pathways that may require environmental sampling
- Professional (qualitative) judgment as to possibility of contamination in a given area using a "zone" determination system
- Other information relevant to designing the decontamination approach

The SAP will cover these information inputs (and possibly others) and will allow sampling planners to define decision statements. A specific sampling approach combined with a specific sampling zone would represent a sampling decision statement ultimately needed to support the conclusion for that zone. Sampling approaches, such as judgmental and probability-based sampling, may be used to gather contamination concentration results and used to test hypotheses, and hypothesis conclusions may be used to resolve each SAP decision statement. If the decision statement cannot be resolved, then more sampling may be necessary. If the statement can be resolved, then the next phase of remediation may be considered.

Sample collection is simple. The sampling team will work systematically and thoroughly, zone by zone. Zones should be assessed simultaneously to the extent possible and if resources are sufficient. Within a suspected area or zone, sampling teams should work from the outside inward toward the suspected source.

The following sections discuss the characterization sampling strategy, numerical modeling approach, and VSP sampling.

4.5.1 Characterization Sampling Strategy

All characterization sampling should be designed to answer specific questions identified before sampling begins. Initial environmental sampling, conducted during first response activities, provides preliminary data for use in developing hypotheses about the extent of CWA contamination. During characterization, these hypotheses are tested, further hypotheses are developed and tested, uncertainty is reduced, and a more complete assessment of the condition of the site is developed. Sampling for this purpose is documented in the characterization SAP. Technical specialists in the Planning Section and the EU coordinate with sampling team members in the Operations Section to develop and write the SAP. It is important that these groups closely collaborate on strategies documented in the SAP. Upon completion, the SAP becomes part of the next operational period's IAP, which is reviewed and approved by the IC/UC. The SAP describes the selected sampling strategies, provides specific information on sampling locations, and includes a variety of supporting information. Potential sampling locations should be assessed for the likelihood that they will support necessary decisions or answer characterization questions.

Suggested characterization sampling approaches include the zone approach and detailed characterization based on dispersal pattern and decontamination method. Each approach is discussed below.

4.5.1.1 Zone Approach

The condition of a facility or CWA-contaminated area likely can be qualitatively assessed starting with an area or areas of confirmed (or assumed) CWA contamination around the release location. These areas are known as "zones." Upon initiation of site characterization sampling, each zone is assigned a class ranging from 1 through 4. During this initial assignment, the selection of a classification should be conservative and based on careful examination of all available data and best judgment. Areas near the release location are referred to as Class 1 zones. Outside the Class 1 zone are areas in which the degree and patterns of CWA contamination are uncertain. Such areas can be subdivided into two classes: Class 2 zones in which CWA contamination is believed to be highly likely and Class 3 zones in which CWA contamination is considered possible but relatively unlikely. In both Class 2 and Class 3 zones, there is some reason to suspect CWA contamination but insufficient evidence to confirm or refute such contamination. Class 4 zones are areas plausibly believed to be uncontaminated. Class 5 zones are areas released from restricted use.

In essence, the zone approach implements a DQO process. The conceptual model is that around a release location, concentrations are high and gradually decrease with distance from the release point. Decisions made by response personnel may be based on expected concentration as described in DHS's "Key Planning Factors for Recovery from a Chemical Warfare Agent Incident" (DHS 2012). Therefore, different sampling strategies are suggested for the different classes of zones.

Table 4-1 summarizes the five zone classes and assigns each zone class a unique color to simplify its representation.

Table 4-1. Summary of Zone Classifications

ZONE CLASS	COLOR	DEFINITION	SUPPORTING DATA
Class 1 Extremely High Likelihood of Being Contaminated	Red	Confirmed presence or very high confidence that contamination is present and area fails clearance criteria	Reliable prior knowledge, visual inspection, or screening or analytical data
Class 2 High Likelihood of Being Contaminated	Orange	Unconfirmed presence but high likelihood that contamination is present and area fails clearance criteria	Reliable screening or analytical data from other site or facility zones, and area is near threat agent release location with viable transport and dispersion mechanisms
Class 3 Low Likelihood of Being Contaminated	Blue	Unconfirmed presence but low likelihood that contamination is present or that area fails clearance criteria	Reliable screening or analytical data from other site or facility zones, and area is a significant distance from threat agent release location with no viable transport and dispersion mechanisms
Class 4 Extremely Low Likelihood of Being Contaminated	Yellow	High confidence that contamination is not present or that area passes clearance criteria	Characterization data, successful decontamination data and clearance sampling results, or other data and factors indicating no reasonable potential for incident-related contamination that fails clearance criteria
Class 5 Released	Green	Released for unrestricted use by ECC and local health department	ECC review and approval protocols

The use of five classes instead of four or fewer is not meant to be prescriptive. Remediation planners can *adjust* the number and definition of zones to suit the incident. Factors to consider for initial zone identification include the following:

- Release location
- Screening sampling results from crisis management efforts (if known)
- Distance from release location (if known)
- Areas suspected to be contaminated by threat agent
- Physical barriers (if any) between zone and release location (if known) or any potentially contaminated zone
- Agent type, especially taking into consideration volatility, persistence, and material interactions
- Threat agent characteristics (such as viability and if weaponized)
- Building or site layout
- Migration and dispersion mechanisms of threat agent based on ventilation, traffic patterns, and other potential CWA contamination pathways
- Indoor features, such as furniture, counter, tabletop, and shelf configurations'
- Surface materials
- Emergency response actions to contain, control, or neutralize threat agent, if any
- Time since release of the threat agent (if known or estimated with confidence)
- Initial response activities that may have redistributed the agent
- Decontamination technology options and their areas of application

Class assignments will change as response and recovery efforts progress and information is developed from characterization, decontamination, and clearance evaluation activities as described in the site SAP.Templates can be developed to support and document the zone classification process and provide a structure designed to help the Planning Section and technical specialists work through an area zone by zone. The Planning Section can used templates to perform the following:

- Assess the likelihood of CWA contamination in each zone
- Decide information needed to support decisions in each zone
- Decide sampling methods for gathering information needed to support decisions
- Define decision points to cease characterization sampling if data warrant gas- or vapor-phase decontamination or the complete removal of items.

Templates may provide the following benefits:

- Provide a mechanism for tracking objects and structures
- Ensure that all types of items, materials, and structures are considered, even if not all are sampled
- Save time by ensuring that sampling tasks are systematic and thorough

As discussed below, in Class 1 zones, an *ad hoc* approach can be used to support source reduction. In Class 2, 3, and 4 zones, detailed characterization is required.

Ad Hoc Approach to Support Source Reduction in Class 1 Zones

In the immediate vicinity of a release, materials and surfaces suitable for source reduction may be identified by physical evidence, such as visible liquid and spatters and security video recordings. An *ad hoc* approach to sampling consists of collecting samples as needed to find items and materials for removal and to guide the decontamination or removal of surfaces and materials.

Detailed Characterization in Class 2, 3, and 4 Zones

Detailed characterization in Class 2, 3, 4, and 5 zones is discussed below, followed by a discussion of reclassification. Figure 4-2 illustrates major activities during the characterization phase.

Class 2 Zones: CWA contamination is considered likely in Class 2 zones, so characterization should continue with sampling designed to confirm this expectation as quickly as possible. The process begins with judgmental sampling of materials and surfaces where a CWA is expected to be present and to have persisted. Samples should include permeable materials that, if contaminated, are likely to be outgassing. Air samples also may be collected. Detection of a CWA in an air sample implies the presence of contaminated materials near the air sampling device.

If judgmental samples fail to find CWA contamination at levels exceeding specified clearance goals, random sampling (probably grid-based) should be implemented to initiate a more thorough search for CWA contamination. If CWA contamination still is not found, the area should be protected from cross contamination, if possible, and set aside for later clearance sampling as deemed necessary. If CWA contamination is found, the area should be reclassified as a Class 1 zone and dealt with as such. Further sampling can be conducted to support additional source reduction, followed by planned decontamination.

Class 3 Zones: CWA contamination is considered possible but unlikely in Class 3 zones, so characterization should continue with sampling designed to develop confidence that the area is not contaminated. A combined judgmental and random (CJR) sampling approach (Sego et al. 2010) may reduce the total sample load provided that reliable information is used to place the judgmental sampling locations. The process begins with judgmental sampling of materials and surfaces where a CWA is expected to be present and to have persisted. Samples should include permeable materials that, if contaminated, are likely to be outgassing. Air samples also may be collected. Detection of a CWA in an air sample implies the presence of contaminated materials near the air sampling device.

If CWA contamination is not found, the area should be protected from cross contamination, if possible, and set aside for later review of the confidence achieved during characterization and possibly for clearance sampling. If CWA contamination is found, the area should be reclassified as a Class 1 zone and dealt with as such. Further sampling can be conducted to support additional source reduction, followed by planned decontamination.

Class 4 Zones: CWA contamination is considered *highly unlikely* in Class 4 zones, so the EU may decide that no further sampling is necessary. Otherwise, a purely judgmental approach (sampling at locations where the CWA is expected to persist or air sampling) or a combined judgmental with random sampling approach is appropriate.

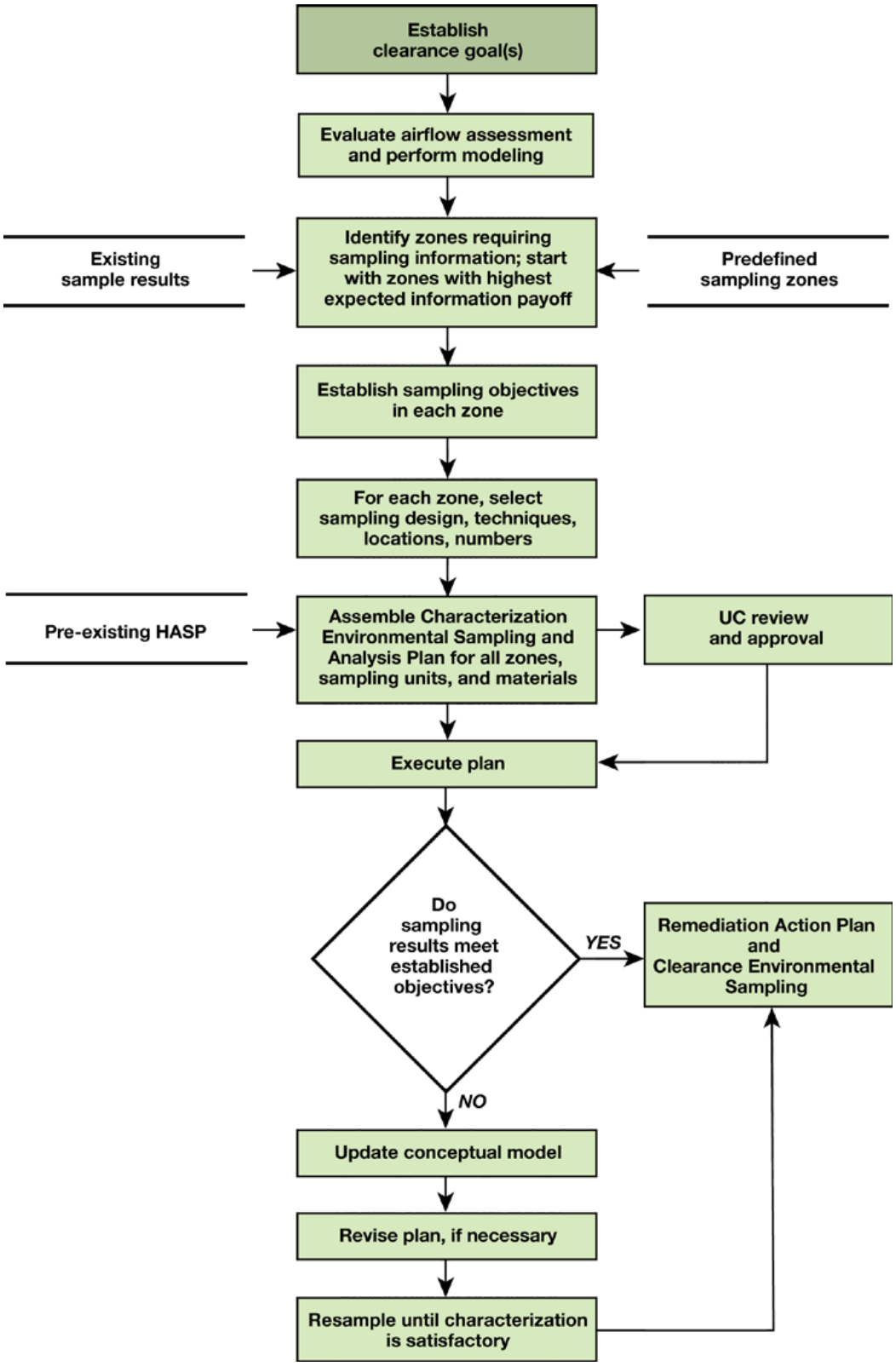


Figure 4-2. Major Activities During the Characterization Phase

Class 5 Zones: CWA contamination is considered not present in Class 5 zones. Class 5 zones have been released for unrestricted use by the ECC and local health department.

Reclassification: If CWA contamination is found through either judgmental or probability-based sampling, the area may be reclassified as a Class 1 zone. Further sampling may be conducted to support additional expedient decontamination, followed by planned decontamination. If CWA contamination is found in a Class 2, 3, or 4 zone, then adjacent zones may by implication be more likely to be contaminated than previously thought, and a reassessment of their classifications is appropriate.

For Class 2, 3, and 4 zones, if CWA contamination is not found at this time, decision-makers may consider concluding that a given zone does not need decontamination. However, deciding that a zone needs decontamination is easier in many respects than deciding that it does not. Concluding that a zone does not need decontamination involves a risk assessment best handled using technical data and reviews. It is essentially equivalent to making a positive clearance decision during the characterization phase. Before such a decision is made, the EU should determine the strength of evidence and amount of sampling support necessary.

4.5.1.2 Detailed Characterization Based on Dispersal Pattern and Decontamination Method

The purpose of characterization environmental sampling often is described as assessment of the nature and extent of CWA contamination. The "nature of contamination" is described by determining the identity of a CWA and types of contaminated materials. The "extent of contamination" suggests a sampling strategy whose purpose is to locate approximate boundaries of the CWA contamination. It is necessary to decide how precisely the extent of CWA contamination needs to be determined. For example, is it necessary to determine such a boundary to within 5, 25, or 100 feet? In contrast, the search for extent may be just sufficient to decide in each zone if decontamination is needed. More comprehensively, the search for extent may involve comparing characterization sample results with future clearance sample results or learning about how the CWA was dispersed.

The most efficient characterization strategy depends on the dispersal pattern and decontamination method. For example, CWA residuals may be identified at locations other than those where release devices were found. In such cases, there is reason to suspect the presence of one or more unknown, relatively small areas with high levels of CWA contamination. The areas may be decontaminated using a localized method, which would require that characterization sampling be designed to yield a high likelihood of discovery of all such hot spots. In contrast, a scenario may have the following characteristics: (1) the release locations are known, (2) the CWA is present only in an area surrounding the release locations, (3) concentrations gradually decrease from the release point, and (4) only the areas with concentrations exceeding a clearance goal require decontamination. In this case, characterization sampling designed to conservatively estimate the boundaries of the area is preferred over sampling primarily designed to locate a hot spot. If the decontamination design depends on the highest range of concentrations in given materials within any small area, then sampling must be designed to find the corresponding subarea(s) with the highest range of concentrations in those materials.

If a gas- or vapor-phase decontamination method is under consideration, then precise determination of the extent of CWA contamination is not needed within a zone that will be treated as a unit. If there is much uncertainty about the spread of CWA after its initial release, then sampling must have a much

broader scope unless the entire suspected area is to be treated. Therefore, an early characterization priority is to determine the likely decontamination method(s). This determination, in turn, depends on CWA properties and distribution. The entire remediation effort should be viewed as an integrated process rather than as strictly sequential steps.

The following determinations are key during characterization and in shaping the decontamination strategy:

- Deciding which areas require decontamination and which do not
- Deciding decontamination methods to be used based on the type of CWA, levels and locations of CWA contamination, and types of materials contaminated
- Deciding which materials, equipment, items, and surface types require decontamination in place versus removal and disposal or removal and treatment
- Identifying area(s) with the greatest predicted or confirmed CWA concentrations
- Identifying area(s) with the greatest potential for exposure to the public or from site workers
- Identifying area(s) with CWA contamination at levels above and below risk-based exposure guidelines adopted as clearance goals

The area(s) of greatest concentration and greatest potential for exposure may not be the same, and the potential for exposure may differ for different CWAs. For example, public spaces are likely to pose the greatest exposure potential, whereas the greatest agent concentration may be on exposed surfaces near the release point or within HVAC ducts. Both types of areas must be considered when developing characterization SAPs. All sources of information should be considered, including the following:

- Known and suspected locations of the release(s)
- Estimates of the extent of CWA contamination based on the operating parameters of HVAC systems at the time of release, either known or suspected
- Estimates of areas to which CWA contamination may have been carried by methods other than HVAC systems, such as tracking by foot traffic and other means
- Expected CWA contamination patterns from airflow modeling results, if available

4.5.2 Numerical Modeling Approach

A complex computer model (such as a multidimensional numerical model) may not be needed if there is sufficient weight of evidence distinguishing the best remedial option based on an adequate understanding of site conditions. However, this is not often the case. At some sites, significant uncertainties exist about site characterization data and the processes that contribute to the relative effectiveness of available remedial alternatives. Models can help fill in knowledge gaps and allow investigation of relationships and processes at a site that are not fully understood. For this reason, simple or complex modeling may be needed.

Computer-assisted mathematical and physical modeling of dispersion can be used to assess the extent of CWA contamination. Such models can help identify areas of greatest expected concentration and help prioritize characterization actions. However, considerable sampling always is required. Therefore, an

investment in highly sophisticated modeling may not provide a substantial return on investment over simple or conceptual models when the latter are coupled with the necessary on-the-ground sampling.

A numerical modeling approach (using multi-zone airflow and transport analysis software, for example) is complex, and extensive time may be required to develop such models. Unless a model has been developed as part of pre-incident planning, completion of a viable model may not be possible within the time required for characterization. However, it may be possible to develop a model in time to assist with clearance sampling design.

Expertise in mathematical modeling is available from many sources, including national laboratories, the National Institute of Standards and Technology (NIST), universities, EPA, and private organizations. Qualitative and numerical models can help guide the selection of locations, types, and numbers of samples to be collected. Regardless of the approach used, an understanding is essential of the mechanical ventilation design of a facility, its operating condition at the time of the incident, and ambient conditions.

4.5.3 Visual Sample Plan (VSP) Sampling

The VSP Work Group adopted the International Organization for Standardization (ISO) 17025 definition of sampling strategy as "a set of operating precepts and diagnostic tools (including sample collection methods; packaging and shipping protocols; recovery, extraction and analytical methods; and statistical analysis packages) that are combined to confidently answer specific hypotheses." The sampling strategy includes the approach or combination of approaches used to select sampling locations and describes general guidance for sampling determined using a decision support process. Effectively, a sampling strategy is a compendium of information on relevant methods and the phenomenology that prescribes their use across multiple potential scenarios (DHS 2007).

The sampling approach specifies the number, type or method, and location (spatial or temporal) of sampling units selected for measurement. The sampling approach also includes an explanation and justification for the numbers and types of samples collected.

A well-planned sampling approach is designed to ensure that resulting data are representative of the target population and defensible for their intended use. To ensure that the collected data matches the needs of a decision, a systematic planning process is needed to design data collection. EPA's recommended systematic planning tool is the DQO process. Throughout the implementation of the sampling strategy process, efficient use of time, money, and human resources is critical. A good design should meet the needs of the study with a minimum expenditure of resources.

The following sections discuss two categories of sampling strategies: a judgmental sampling approach and a probability-based sampling approach, In addition, determination of the number of probability-based samples is discussed. Table 4-2 compares the judgmental and probability-based sampling approaches. A combined judgmental and random (CJR) sampling approach also may be appropriate for inclusion in a sampling strategy.

4.5.3.1 Judgmental Sampling Approach

In a judgmental environmental sampling approach, sampling locations are determined based on professional judgment. Judgmental sampling is effective when the source of contamination is known and supporting epidemiological or forensic data are available. It generally is based on event-specific

information, such as a known release location, obvious presence of contamination (such as observable powder), or facility-specific information such as air-flow patterns. Judgmental sampling can be used to sample items or areas most likely to be contaminated to quickly determine if a zone is contaminated. If contamination is found, then the area of contamination may be further delineated, if necessary, for the anticipated decontamination method. However, with judgment sampling, probability and confidence statements cannot be made (EPA 2002).

Table 4-2. Judgmental versus Probability-based Sampling Approaches

	JUDGMENTAL	PROBABILITY-BASED
Advantages	• Can be less expensive than probability-based designs • Can be very efficient with knowledge of the site or facility • Easy to implement	• Provides ability to calculate uncertainty associated with estimates • Provides unreproducible results within uncertainty limits • Provides ability to make statistical inferences • Can handle decision error criteria
Disadvantages	• Depends on expert knowledge • Cannot reliably evaluate precision of estimates • Depends on personal judgment to interpret data relative to study objectives	• Random locations may be difficult to locate • Optimal design depends on an accurate model

Source: EPA 2002

There are two types of judgmental sampling: targeted and biased. Targeted sampling is used in areas where samples previously tested positive. Targeted sampling can be used during clearance at specific locations found to be contaminated during the characterization phase. Biased sampling involves collecting samples from near areas of known contamination, high-traffic areas, and surfaces likely to be encountered by occupants after re-occupancy (DHS 2006).

4.5.3.2 Probability-based Sampling Approach

If no contamination is found, additional probability-based sampling may be required to achieve an acceptable level of confidence that no contamination exists. Probability-based sampling applies sampling theory and involves random selection of sampling locations. An essential feature of a probability-based sample is that each member of the population from which the sample was selected has a known probability of selection. When a probability-based approach is used, statistical inferences can be made about the sampled population from the data obtained from the sampling units. In other words, under a probability-based design, inferences can be drawn about the sampled population, such as the concentration of fine particulate matter in ambient air at a specific location even though not every single location is sampled. As stated earlier, a probability-based random approach can be used when little or nothing is known about where a release occurred (such as a covert release) or if sampling is conducted in zones where information about probable locations is weak or uncertain. Probability-based sampling is appropriate for quantitative comparisons with risk-based exposure levels (EPA 2002).

Whenever sampling is used to characterize a population, uncertainty is involved. Uncertainty can result from a variety of sources. Even if 100 percent of a population can be sampled, sampling and measurement error can distort the true representation of the population to some degree. Statistical sampling theory accounts for the fact that sampling provides imperfect representation of the population of interest and helps quantify uncertainties and confidences that can be achieved. Of course, as more

samples and more precise measurements are obtained, a more accurate representation of the population is achieved, thereby increasing confidence levels and decreasing uncertainties. Sample recoveries and inefficiencies can also bias results and lead to imperfect representation of the population (Emanuel et al. 2008).

Types of probability-based sampling include random, stratified, systematic, ranked set, adaptive cluster, and composite sampling as discussed below.

Random Sampling

Simple random sampling is the most fundamental probability-based sampling design. Most commonly used statistical analysis methods assume either implicitly or explicitly that the data were obtained using a simple random sampling design. Simple random sampling is appropriate when the population sampled is relatively uniform or homogeneous. In practice, simple random sampling usually is used in conjunction with other sampling designs. The primary benefit of simple random sampling is that it protects against selection bias by guaranteeing selection of a sample representative of the sampling frame provided that the sample size is not extremely small (for example, 20 observations or more). Simple random sampling has the two primary limitations summarized below.

- Because all possible samples are equally likely to be selected, by definition, the sampling points could, by random chance, not be uniformly dispersed in space or time. This limitation is overcome somewhat as the sample size increases, but it remains a consideration, even with a large number of samples.
- Simple random sampling designs ignore all prior information or professional knowledge regarding the site or incident except for the expected variability of the site or process measurements (EPA 2002).

Stratified Sampling

When some information is known about the CWA, how it was dispersed, or environmental factors, stratified random sampling may be conducted. For example, if a CWA was thought to be released in an area of a building with ventilation that serves other areas, then stratified random sampling can be conducted in areas covered by that ventilation system. In general, a sampling area is subdivided into separate areas (such as within or outside the ventilation zone), and a sampling strategy is implemented separately within each stratum. If the sampling strategy within each stratum is random, then the term "stratified random sampling" is used. If separate decisions are to be made for each stratum, a separate sampling design is developed for each stratum. If a single decision is to be made for all strata combined, a stratified sampling approach is developed (EPA 2002).

Systematic Sampling

Systematic sampling, also called "grid sampling" or "regular sampling," consists of collecting samples at locations or over time in a specified pattern. Systematic sampling ensures that the target population is fully and uniformly represented in the set of *n* samples collected. To make systematic sampling a probability-based design, the initial sampling location is chosen at random. Systematic sampling often is used in environmental applications because it is practical and convenient to implement in the field. It often provides better precision (smaller confidence intervals and smaller standard errors of population estimates) and more complete coverage of the target population than random sampling. Some examples of systematic sampling are summarized below (EPA 2002).

- **Grid Sampling - Locating patches of a given size:** During grid sampling, samples are collected at regularly spaced intervals over space or time. An initial location or time is chosen at random, and then the remaining sampling locations are chosen so that all locations are at regular intervals over an area (grid) or time (systematic). A sampling grid can be designed to yield a high probability of discovering a hot spot of a given size or to increase confidence that a large proportion of the surface area within a zone is uncontaminated. The EU should specify the grid size and the probability of discovery or desired degree of confidence. Probability-based sampling for comparison with clearance goals requires that the EU specify an acceptable degree of uncertainty in the comparison. This kind of probability-based sampling can help decide how much characterization sampling is necessary.
- **Transect Sampling - Locating an unknown event:** When the location of the contaminant is unknown, sampling may be conducted using transects. This type of sampling requires the sampling team to move along a fixed path or series of fixed paths. Sampling is performed along these fixed paths, and the number of times that the contaminant is detected is noted. Based on the number and location of positive results, the extent of the contaminant can be estimated.
- **Margin Sampling – Sampling hot spots:** Hot spots can have different sizes and shapes. Information to consider includes if the level of contamination needs to be above background levels to be classified as a hot spot and if the level of contamination within a hot spot is relatively consistent or varies widely. It is expected that surfaces primarily are sampled using wipe and vacuum samples. If hot spots must be searched for, then the area wiped or vacuumed may be relatively large compared to the hot spot (DHS 2006).
- **Population Estimation - Sampling to extinction**: Population estimation sampling is used to sample a representative portion of a larger population. Conclusions about the characteristics of the larger body can be made. In this manner, sampling can be a valuable tool for determining the presence, type, and extent of contamination by hazardous or harmful substances in the environment. Sampling in a contaminated environment may continue as decontamination activities are conducted until sampling results indicate that the contaminant has been removed or rendered inert (EPA 2006).

Ranked Set Sampling

Ranked set sampling increases the chance that the collected samples will yield representative measurements (measurements that span the range of low, medium, and high values in the population). This type of sampling results in better estimates of the mean as well as improved performance of many statistical procedures, such as testing for compliance with a risk-based or background-based (reference-based) standard. Moreover, ranked set sampling can be more cost-efficient than simple random sampling because fewer samples require collection and analysis (EPA 2002).

Adaptive Cluster Sampling

Adaptive cluster sampling involves the selection of an initial probability-based sample. Typically, additional samples are selected for collection when a characteristic of interest is present in an initial unit or when the initial unit has an observed value meeting some pre-specified condition (for example, when a critical threshold is exceeded). Choosing an adaptive cluster sampling design requires two key elements: (1) choosing initial sample units and (2) choosing a rule or condition for determining adjacent units to be added to the sample. Adaptive cluster sampling is useful when the characteristic of interest is sparsely distributed but highly aggregated (EPA 2002). Based on observations from a previous sampling iteration (Thompson and Seber 1996), adaptive sampling can allow increased sampling intensity. An

adaptive sampling approach typically is used to optimize the number and location of samples collected to define the statistical or spatial distribution of a quantity, such as contaminant distribution.

Several variations of adaptive sampling have been published in literature. Cox 1999 promotes an approach with the following steps. First, a random set of samples is collected and analyzed. The results are analyzed using gradient methods, regression techniques, or geostatistics. Next, sampling locations are selected where concentrations are likely to exceed a concentration threshold of interest. Finally, continuing locations are selected until the area above the concentration threshold is adequately defined. This approach is essentially an "inside-out" approach to characterization.

Composite Sampling

Composite sampling includes sampling of multiple surfaces with one medium and CJR sampling as discussed below.

Multiple Surfaces Sampled with One Medium: This type of composite sampling involves physically sampling several judgmental locations with one medium to form a new environmental sample (a composite sample). The chemical or biological analyses of interest then are performed on aliquots of the composite sample. Because the compositing physically averages individual samples, averaging the analytical results of a few composite samples can produce an estimated mean as precise as one based on many more individual sample results. Because fewer analyses are needed, composite sampling can substantially reduce study costs when analytical costs are high relative to costs associated with the collection, handling, and compositing of samples (EPA 2002) or when the laboratory is reaching capacity. Optimizing the way in which samples are collected can save money and resources and help prioritize samples to reduce the impact on laboratory throughput.

Combined Judgmental and Random (CJR) Sampling: The CDC and DHS sponsored the development of a CJR sampling approach (Sego et al. 2007 and 2010) that includes both judgmental and probability-based samples. The CJR sampling approach uses a Bayesian methodology that allows investigators to determine the number and location of probability-based samples required in combination with a given number of judgmental samples to obtain a specified level of confidence (X percent) that a high percentage of a building or area (Y percent) has no detectable contamination. The Bayesian approach incorporates prior knowledge about the chances that judgmental samples are contaminated so that the combination of judgmental and probability-based samples allows for statistical inferences about the likelihood of no detectable contamination. Increased confidence in the conclusion that there is no detectable contamination is important in deciding on the need for further public health or decontamination measures after initial assessment.

Figure 4-3 illustrates the value of a sampling approach that combines judgmental and probability-based sampling to provide greater confidence in results. The CJR sampling approach ensures that samples are obtained from the locations perceived to be most likely contaminated (through judgmental samples) while protecting against the possibility that contamination may exist in less likely areas (through probability-based samples).

Probability-based sampling applies sampling theory and involves a randomization aspect in selecting sampling locations. During the CJR approach, probability-based sampling augments judgmental sampling to achieve an acceptable level of confidence that no detectable contamination exists. An essential feature of the probability-based sampling portion of CJR is that each member of the population from which the sample was selected has a known probability of selection. When the CJR sampling approach is

used, statistical inferences may be made about the sampled population from the sampling data. Therefore, through the use of CJR sampling, inferences can be drawn about the sampled population even though not every single location is sampled.

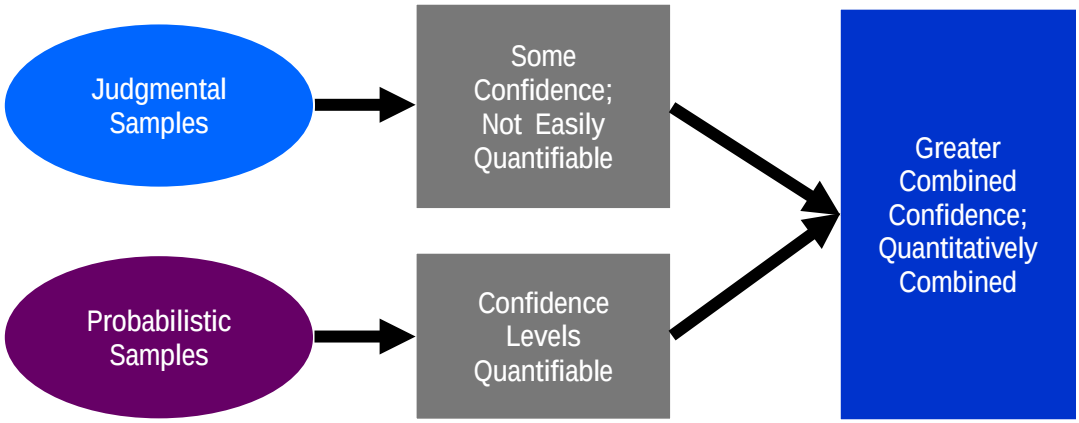


Figure 4-3. Combined Judgmental and Probability-based Samples

The CJR sampling approach should be used when little or nothing is known about where a release occurred (such as a covert release). The CJR approach also is appropriate for certain designated zones.

The CJR sampling approach is appropriate for the two situations summarized below.

- In a characterization situation (or a clearance situation when decontamination is not performed), judgmental sample results that are all negative may be augmented with probability-based results for samples selected using the CJR approach.
- In a clearance situation after decontamination, a CJR approach may be used to select judgmental samples from locations more likely to still be contaminated (such as locations identified as contaminated before decontamination and targeted locations along contamination pathways), and the judgmental sample results may be augmented with additional probability-based samples.

4.5.3.3 Determination of the Number of Probabilistic Samples

For both situations described above, the number of probability-based samples is based on the number of judgmental samples so that if all judgmental and probability-based sample results are negative, a statement can be made that there is X percent confidence that at least Y percent of the area does not have detectable contamination. The desired X and Y percentage values should also be risk-based and strike a balance between very costly and unreasonable nearly 100 percent sampling and a more reasonable number of samples.

For the CJR approach, the following input parameters affect the required number of probability-based samples: (1) the percent confidence (X percent) desired, (2) the minimum percentage (Y percent) of the area that can be stated to not contain detectable contamination, (3) the number of judgmental samples collected, (4) how much more likely it is that a judgmental sampling location contains detectable contamination than a probability-based sampling location, and (5) the expected *a priori* probability that a judgmental sample will detect contamination.

Another parameter that affects the required number of probability-based samples is the false-negative rate (FNR) for an individual sample result. However, the CJR methods have not yet been extended to account for situations when the sampling method has an FNR greater than 0. The FNR may vary with the sampling method, surface material sampled, and surface concentration of the CWA. Because the CJR methodology does not yet account for FNRs, the X and Y percent clearance statement that can be made is "X percent confidence that at least Y percent of the area does not contain detectable contamination."

An important assumption of the mathematical model used in the CJR approach is that the decision area can be divided into areas of high and low probabilities of being contaminated (high- and low-probability areas need not be contiguous). The CJR model assumes that all high-probability areas are sampled judgmentally. In essence, the judgmental sampling locations define the high-probability areas in the SAP. Consequently, fewer probability-based samples are necessary when more judgmental samples are collected and when locations for judgmental sampling are more likely to contain detectable contamination.

4.6 DATA MANAGEMENT

It is recommended that a DMP be used so that field personnel and data managers can provide consistent, quality-assured data that can be used for decision-making purposes, efficient project archiving, and sharing with stakeholders. A DMP establishes protocols for data control, consistency, reliability, and reproducibility throughout the life of the project. The DMP also establishes a framework for consistent documentation of the quality and validity of field and laboratory data compiled during consequence management.

DMPs must be in place before characterization samples are collected. It is imperative to have a data collection, processing, storage, and reporting system in place that efficiently manages data to ensure and document its integrity. A good DMP helps determine if analytical data meet measurement quality objectives, tracks samples through the entire process (from collection through the return of results from the laboratory), and provides flexible and convenient access to results for the purpose of interpretation.

Data management is especially important if sampling teams from more than one outside organization (contractor) collect the samples. The value of sampling is undermined if sampling itself is not well documented. Digital photographs of every sampling location can help document sampling activities. The UFP QAPP contains additional details on sample control and documentation.

EPA SCRIBE is the current EPA data management system developed for use by OSCs (see Section 4.6.2).

The following sections discuss sampling and data management support tools; VSP, BROOM, SCRIBE, and VIPER; GISs; and Spatial Analysis and Decision Assistance (SADA).

4.6.1 Sampling and Data Management Support Tools

If possible, comprehensive sampling and data management decision support tools should be used to facilitate data management and help design the sampling approach. Decision support tools may be used to codify the processes for developing a sampling design plan and to document the data and assumptions associated with the plan. Electronic documentation should facilitate better defensibility of the assumptions, goals, and data associated with the project.

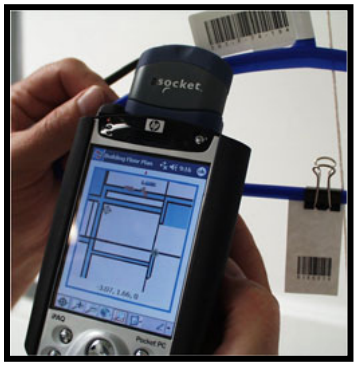
Existing sampling and data management support tools provide users with the following capabilities:

- Development of DQOs
- Development of defensible sampling design plans (for example, for locating hot spots, testing hypotheses of the confidence in meeting a cleanup goal, etc.)
- Spatial representation of the sampling locations
- Building or site layout display (such as engineering drawings)
- Documentation of information associated with sample collection (such as collection method, sampling locations, surface type, sample identification number, etc.), including electronic data capture with handheld devices
- Management of the data in a secure database (such as SCRIBE or SQL)
- Spatial mapping of sample analytical results
- Analysis of the data to determine statistical relationships and information suitable for decision-making
- Optimization of the sampling design if an adaptive sampling strategy is desired

The following sections discuss some existing decision support tools that facilitate many of the capabilities discussed above.

4.6.2 VSP, BROOM, SCRIBE, and VIPER

The Pacific Northwest National Laboratory (PNNL) has developed the VSP to facilitate the development of DQOs, sampling design plans, and mapping of sampling locations (Matzke et al. 2007). VSP is freeware and can be downloaded from http://vsp.pnl.gov/.



Sandia National Laboratory (SNL) has developed a product called BROOM that facilitates electronic data capture of information and data management in a secure database, mapping of sampling locations and spatial distribution of contamination (including probability mapping), analytical capabilities, and optimization of sampling locations with adaptive sampling strategies. Currently, EPA does not support the development of BROOM data collected using handheld devices. Although the BROOM tool still is available and SNL still provides support to BROOM users, the BROOM tool can be considered a proxy for all GIS-based data management tools that may be used in a CWA response for discussion purposes in this Guidebook.

The VSP and BROOM tools have been integrated to facilitate the sharing of data between the two tools as well as to facilitate integration with EPA's SCRIBE database. EPA promotes the use of a SCRIBE database. SCRIBE is a software tool developed by EPA's ERT to assist in environmental data management. SCRIBE captures sampling, observational, and monitoring field data. Examples of SCRIBE-assisted field tasks include soil, water, air and biota sampling. SCRIBE can import electronic data, including electronic analytical laboratory results (electronic data deliverables [EDD]) and sampling location data (such as GPS). SCRIBE supports handheld extensions through Scriblets to capture and import sampling and monitoring data collected on handheld personal data assistants (PDA). SCRIBE outputs include labels for collected samples, chain of custody (COC) generation, and analytical laboratory result data reports. SCRIBE provides a flexible user interface to manage, query, and view all

this information. SCRIBE supports the export of electronic data for user services such as GIS tools and spreadsheets so that sampling data can be further analyzed and incorporated into report writing and deliverables. The BROOM tool can share data with the SCRIBE database.

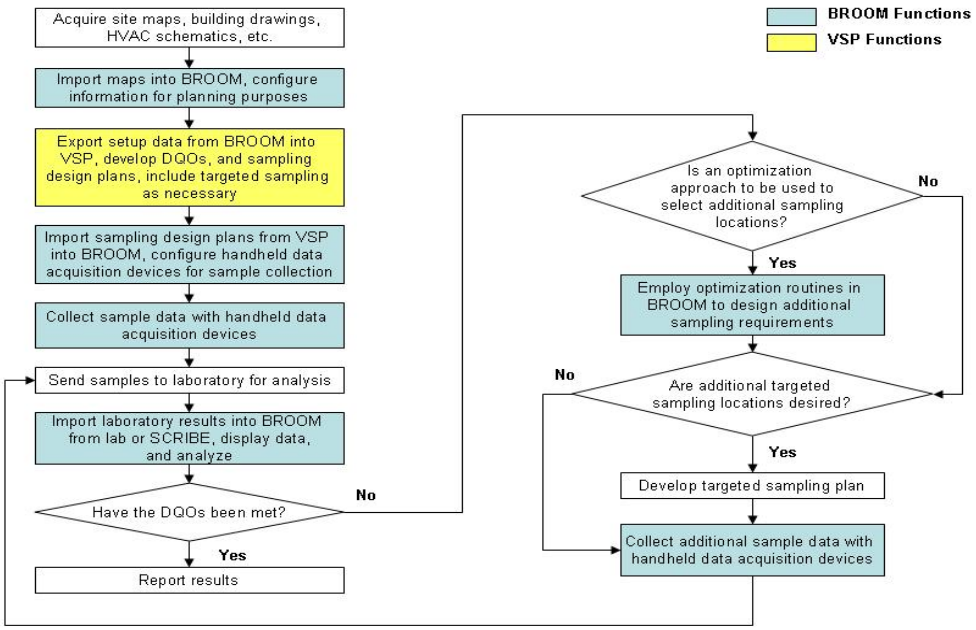
In a typical application with these tools, a pre-planning setup would be prepared in BROOM to assemble all available maps and spatial information about the site or facility. This data would be passed to VSP to facilitate the development of DQOs and sampling design plans. These plans then would be ported back to BROOM for integration with handheld electronic data capture devices. While sampling is being performed, the BROOM software has an option for tracking the progress of the sampling teams and the samples they have collected. Once sampling data have been collected using the electronic data capture devices, the information is uploaded to the BROOM server for immediate input to the database. The sampling technician must sign a COC record on the handheld device, which uses an electronic capture algorithm to securely store the information and display it on a COC form. The user of the BROOM software can then view location and sample information as well as completed COC forms.

Once laboratory data are available, they may be imported into the BROOM database for immediate display within the map display window. Alternatively, laboratory data may be input to a SCRIBE database and then imported to BROOM. Optimization routines are also available in BROOM to further define the SAP for improving confidence and reducing uncertainty about the distribution of contamination. If the DQOs have not been met, decision-makers may desire to use optimization routines to select additional sampling locations in order to meet the DQOs. Targeted sampling may also be used alone or in addition to the optimized sampling design to meet the DQOs. This multi-step approach to sampling design is referred to as “adaptive sampling. “ At any time, the data within the BROOM system can be exported to SCRIBE and vice versa. Figure 4-4 shows the general decision logic for using VSP and BROOM in a sampling process.

The use of handheld electronic data capture devices such as PDAs can greatly reduce the time required to collect samples and can reduce the number of errors associated with documentation of the sample collection process. When paper documentation is used, a significant time element is associated with capturing the necessary information, typically on forms on a clip board. With electronic handheld devices associated with the BROOM system, once the data have been collected, they can be wirelessly transmitted to the secure database and be immediately available for viewing results.

The EPA ERT has developed a wireless-network-based communications system called VIPER. VIPER uses commercially available technology enhanced by custom software called the VIPER Survey Controller. The system is designed to enable real-time transmission of data from field sensors to a local computer, remote computer, or enterprise server. Because of its great flexibility, the VIPER Survey Controller assists the user in composing and controlling a field survey. The user can use local or enterprise communication strategies and support mobile and fixed monitoring modes with independent or clustered sensor arrays. Drawing upon the SCRIBE.NET enterprise data model, the software allows the capture, aggregation, persistence, communication, and visualization of sensor data in a manner applicable to a wide range of environmental field monitoring equipment scenarios. VIPER also allows data management, analysis, and visualization of sensor data. The VIPER Survey Controller manages all hardware and software applications. The system launches the commercially available sensor controller applications with appropriate configuration files based on user-defined survey components, communications strategies, and survey modes. In addition, the VIPER Survey Controller manipulates the Common Alerting Protocol (CAP) XML data streams; locally persists the data in SQL Server Express;

produces KML data forms viewable in Google Earth; and publishes data to the VIPER.NET enterprise servers for access via the internet. Enterprise services include a subscription service for maintaining a



Source: Pulsipher et al. 2009

Figure 4-4. Decision Logic for Using VSP and BROOM in a Sampling Process

SQL Server database and a service that provides for monitoring system status and reporting. More information on the ERT's VIPER system is available on the EPA OSC website under the ERT's VIPER Profile page at http://www.epaosc.org/site/site_profile.aspx?site_id=5033.

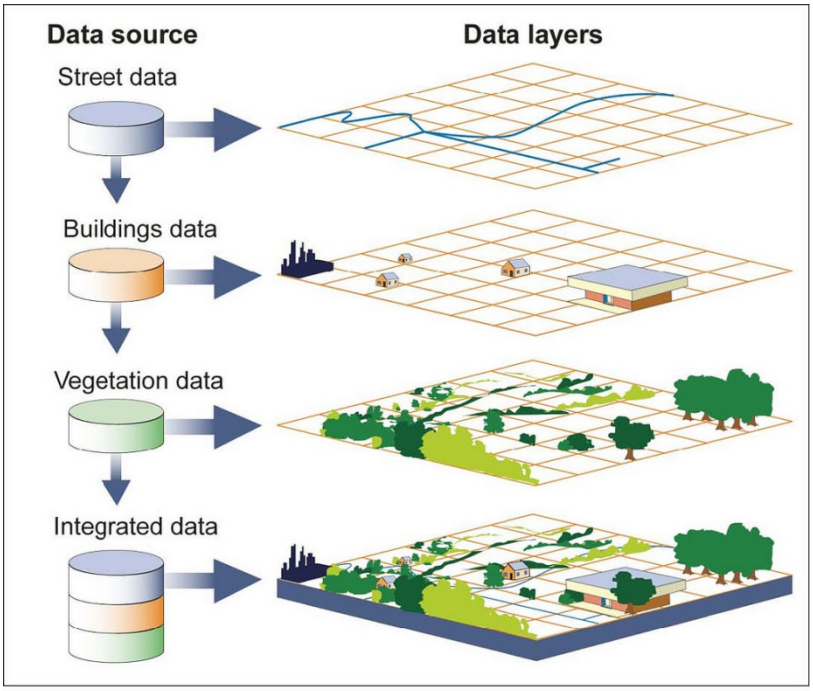
4.6.3 Geographic Information Systems (GIS)

Another tool generally recommended for the display of site information is a GIS. A GIS allows the spatial display of maps, sampling data points, and other spatial information. Users can manage various layers of information and data within a GIS and pan and zoom to different portions of a map. With engineered drawings (such as computer-aided design [CAD] drawings) of a site or facility, GIS preserves the spatial scales, and vectorized information is embedded in the files. Analytical results may be overlain in the GIS to provide a spatial map of sampling results. The BROOM software has a built-in GIS for management and display of spatial information. Figure 4-5 shows an example GIS data presentation.

4.6.4 Spatial Analysis and Decision Assistance (SADA)

The SADA decision support tool (EPA 2000) provides several variations of adaptive sampling protocols. One variant in the tool uses a rank estimation technique that concentrates additional samples around locations with elevated concentrations similar to the method described by Cox 1999. Another variant focuses sampling in areas where the variance is greatest, equating to areas where uncertainty is highest. Another variant, the percentile rank method, combines the rank estimation and variance techniques to account for magnitude and variability. The most robust method in the SADA tool is the uncertainty rank

method, which is similar to the percentile rank method except that it brings the cleanup goal concentration into the performance metric to focus on delineating the boundary between clean and contaminated areas. With this last method, sampling is performed where it is most needed to focus on



Source: GAO.

Figure 4-5. Example GIS Data Presentation

the estimated cleanup area. Sampling is avoided where the confidence is high that the area is either above or below the cleanup goal.

4.7 SAMPLING CHECKLIST

Table 4-3 presents an example sampling checklist. The checklist presents questions that authorities should consider during the planning and preparedness process. The questions are not exhaustive. Therefore, planners are not constrained from including other questions, sections, or provisions, nor must all the items listed in the table be included. The intent of the example is to prompt discussions and aid the planner in designing and organizing a SAP for a CWA response.

4.8 SAMPLING METHODS

For the CWAs that are the focus of this Guidebook, sampling methods are similar regardless of the specific agent of interest. As stated in Section 1.1, this Guidebook focuses on the nerve agents tabun (GA), sarin (GB), soman (GD), cyclosarin (GF), and VX, and blister agents sulfur mustard (HD), Lewisite, and mustard mixtures. Samples that may be collected during a CWA incident include wipe, air, water, soil, sediment, and waste samples. Sampling for a CWA is similar to sampling of a typical waste, soil, or water. Appendix 3 provides information on air monitoring. Appendix 4 provides QRGs. Appendix 5 presents some typical analytical methods. These appendices contain information useful when sampling and monitoring for CWAs. SOPs for sampling specific to CWAs have not been developed. However, generic sampling SOPs for various matrices developed by EPA ERT are applicable to sampling for CWAs. EPA ERT SOPs are

Table 4-3. Example Sampling Checklist

BASIC SAMPLING PREPAREDNESS CHECKLIST	YES	NO
Have you outlined the objectives and purpose of the sampling plan?		
• Have you cited appropriate federal, state, and local public health authorizing legislation, ordinances, and regulations?		
• Have you outlined any assumptions on which the sampling plan is based?		
• Have you assigned roles and responsibilities?		
• Have you identified specific sampling methods and alternate methods?		
• Have you referenced existing interagency or inter-jurisdictional agreements?		
• Have you explained all abbreviations and defined key and unfamiliar terms?		
Does the plan identify data quality objectives?		
Does the plan identify laboratory methods?		
Does the plan allow for sampling lag?		
Does the plan address sampling strategies?		
• Field screening		
• Characterization sampling o Characterization sampling strategy o Numerical modeling approach o VSP sampling		
• Verification sampling		
• Clearance sampling		
• Long-term environmental monitoring		
Does the plan address data management?		
• Use of decision support tools		
• Use of VSP and BROOM		
• Use of GISs		
• Use of Spatial Analysis and Decision Assistance (SADA)		
Have you provided guidance for updating the plan as conditions change?		
Have you included procedures for maintaining chain of custody and a record-of-receipt form?		

available at http://www.ert.org/mainContent.asp?section=Products&subsection=List#

. Table 4-4 summarizes sampling and analytical methods for CWAs (nerve and blister agents).

Table 4-4. Sampling and Analytical Methods

SAMPLE MATRIX	ANALYTICAL METHOD	SAMPLING CONTAINERS, MEDIA, AND WETTING SOLUTIONS (AS APPLICABLE)	EPA ERT SOP NO.
Wipe	8270D modified	Cotton gauze pad wetted with one of the following solvents: methylene chloride, methanol, isopropyl alcohol, or acetone; clean 40-milliliter vial or glass jar	2011
Air (tabun, VX, mustard agents)	TO-10A	Polyurethane foam (PUF) or PUF/XAD-2 cartridge	2008
Air (sarin, soman)	TO-15	SUMMA canisters	1704
Water	8270D modified	Three 40-milliliter vials (micro-extraction) or one 1-liter amber glass jar	2007 and 2013
Soil, sediment, and waste	8270D modified	One 4- to 8-ounce glass jar	2012, 2016, and 2017

Sources: CSS-Dynamac 2014; EPA 2007 and 2012

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5. DECONTAMINATION

The goal of decontamination is to remove, reduce, or render inactive any CWA contamination from an area so that all criteria for site clearance are met and any necessary reconstruction and refurbishment can be performed so that normal operations can resume. A decontamination strategy prioritizes critical operations of a targeted area or facility and minimizes the potential for adverse health effects. Decontamination starts with source reduction, which includes (1) removing or decontaminating visible CWA on surfaces to reduce the CWA contamination load and secondary dispersion of CWAs and (2) separating salvageable from non-salvageable items. Incident-specific decontaminating reagents and delivery systems are selected, depending on the nature and extent of CWA contamination and other site parameters identified during characterization. After specified performance and design criteria for decontamination actions are met, the effectiveness of decontamination must be confirmed using the clearance process described in Section 7, Clearance.

Decontamination activities are documented in the RAP (EPA 1995), and steps must be taken when implementing the RAP to prevent further environmental impacts. Some decontamination technologies, such as the use of liquid bleach, require little site preparation. Others, such as gas- or vapor-phase decontamination, may require extensive preparation. Performance criteria for various decontamination approaches are assessed by monitoring key process variables specific to the decontamination strategy selected, such as temperature, pH, contact time, and concentration of a gaseous reagent. Although clearance activities take place after decontamination actions are completed, clearance sampling should be planned concurrently with decontamination. It is important to anticipate issues and educate all relevant parties on the various technologies and clearance process to be used.

If multiple types of CWAs are present, each CWA requires careful consideration when planning the decontamination strategy. Cleanup procedures that can address multiple CWAs simultaneously are expected to increase remediation efficiency. Additional operational considerations require evaluation to prevent adverse outcomes from competing CWA decontamination techniques, such as the spread of one CWA while cleanup of another CWA proceeds.

This section discusses actions to be taken and decisions to be made in devising an optimal decontamination approach. Appendix 6 provides information on specific decontamination reagents, techniques, and applications.

5.1 EVALUATE DECONTAMINATION CAPABILITIES

Several decisions must be made before implementation of an incident-specific RAP in response to a terrorist attack. Decisions regarding decontamination capabilities include the following:

- Equipment to have on hand, either for general use (such as ventilation fans and blowers) or dedicated to decontamination (such as carbon air filters and absorbent spill kits with vapor suppression)
- Extent and types of decontamination supplies to store
- Location and number of staging areas or warehouses for equipment and supplies
- Selection of potential contractors to use as members of the decontamination team
- Identification of potential waste-disposal facilities

- Consideration of waste-related transportation requirements and costs, which may be substantial

Decontamination-related decisions can have a major impact on waste-disposal costs and may present substantial non-technical (such as legal and regulatory) challenges when disposal occurs.

OSCs also need to make decisions on recruiting SMEs to aid in the remediation of areas and facilities contaminated with CWAs. These SMEs are part of the TWG that will review remediation plans and help ensure conformance with current SOPs. Depending on the size of the response, IC/UC may set up a separate Decontamination Branch under the Operations Section to perform site decontamination activities in accordance with the RAP prepared by the Planning Section under the ICS. Figure 5-1 summarizes major activities during the decontamination phase of the response.

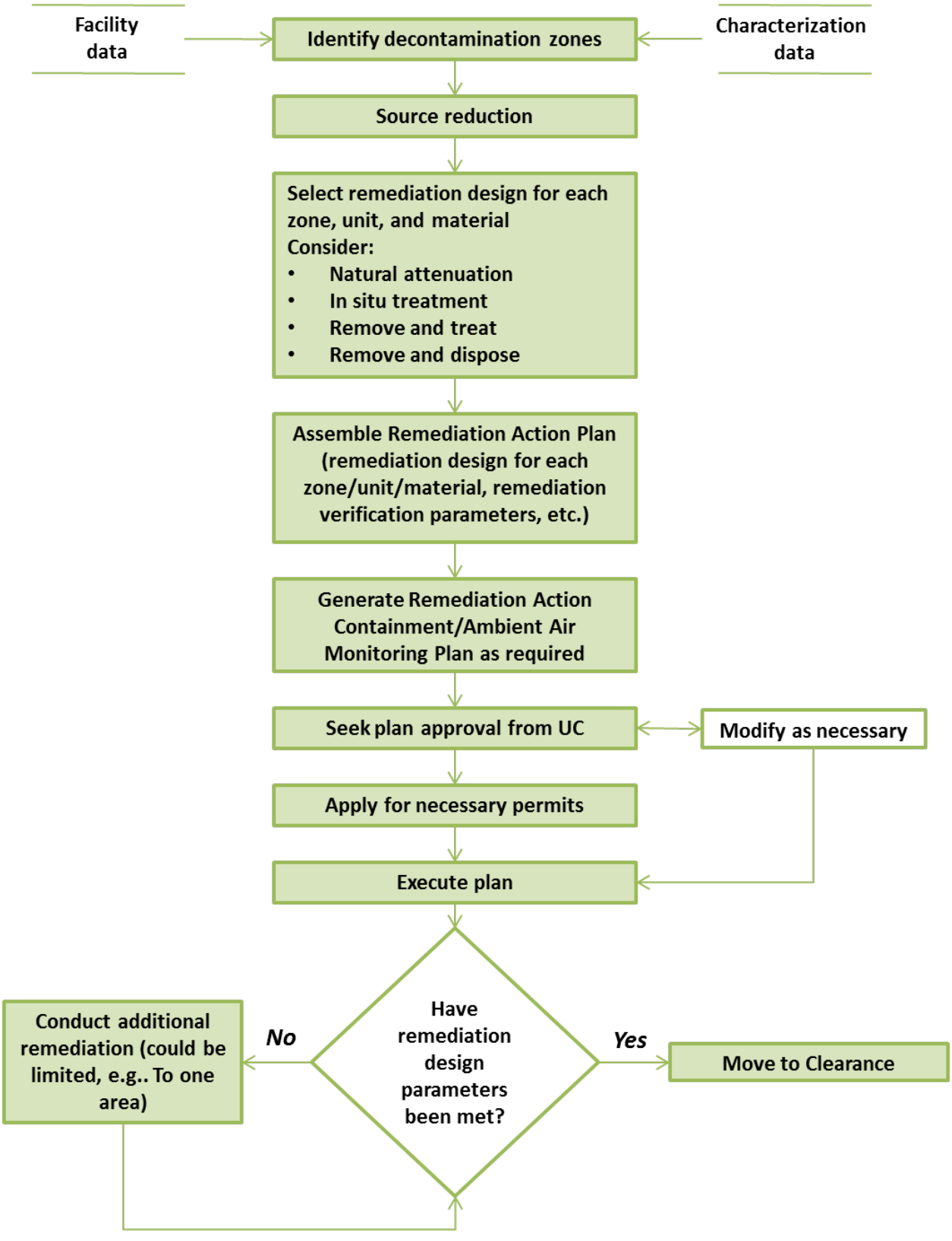

Figure 5-1. Major Activities during the Decontamination Phase

5.2 CONTAIN AND ISOLATE DECONTAMINATION ZONES

Containment to prevent the spread of a CWA to uncontaminated areas should begin during the first phases of the response and continue into the characterization and consequence management phases of the response. Any containment barriers used at an incident during earlier phases must be reviewed for adequacy during all subsequent phases to contain CWA contamination for the duration of a possibly lengthy decontamination phase. If containment barriers also are used to isolate contaminated areas and equipment during decontamination, they must be reviewed for adequacy as isolation barriers for the decontamination approach selected.

Containment areas set up during characterization may correspond to designed isolation zones used during decontamination. In some cases, smaller decontamination isolation zones may be desirable, especially when volumetric decontamination technologies or fumigants are used. Minimizing treatment volumes is especially critical for gases or vapors that rapidly cool and condense (such as steam) or decompose (such as hydrogen peroxide). Containment barriers constructed for an initial and non-corrosive chemical release at room temperature may be inadequate as isolation barriers for high-temperature or corrosive gases or vapors used for decontamination. In such cases, specially constructed isolation barriers are required, and their seals must be tested for leaks. This process is similar to dividing a site into "operable units" for operational process. The decontamination zones can be ranked, prioritized, and treated separately during the response.

5.3 EVALUATE MONITORED NATURAL ATTENUATION

Natural attenuation in the context of this Guidebook refers to a decrease in the concentration of a CWA into less hazardous concentrations through natural environmental degradation catalysts, such as heat, light, and volatilization (Ho et al. 2006; Talmage et al. 2007a and b). Natural attenuation may be assisted by increased outdoor air exchange and increased temperature. If natural attenuation is used, its progress and effectiveness must be continually assessed through appropriate sampling and monitoring. Monitored natural attenuation should be considered as an option along with other decontamination approaches within a risk-based framework (Watson et al. 2011).

For incidents involving volatile or short-lived CWAs, monitored natural attenuation may eliminate acute and chronic impacts. Examples of volatile CWAs are sarin (GB), phosgene (CG), arsine (SA), cyanogen chloride (CK), hydrogen cyanide (AC), and other volatile toxic industrial chemicals and gases. For threats involving such CWAs, many of the more aggressive decontamination activities described in this section may not be required and re-entry and resumption of operations may be allowed after sufficient time for monitored natural attenuation and upon confirmation through clearance sampling. For low-volatility or long-lived CWAs such as VX, monitored natural attenuation alone may not be appropriate. The purity of a CWA also can alter the effectiveness of natural attenuation by enhancing reactivity or inhibiting volatilization, and all CWAs should be evaluated for potential deviations from expected persistence characteristics. For a major incident requiring an aggressive decontamination technology, at least some natural attenuation likely will occur during the days or even weeks of characterization and remediation planning before engineered decontamination technologies begin. Natural attenuation should be assessed through monitoring.

After an indoor CWA release, natural attenuation may be more rapid if clean air from the outside is exchanged with contaminated air inside. If contaminated indoor air is allowed to escape outdoors, the concentration of CWA in escaping air must be monitored to determine the hazard level. If escaping air may be hazardous, remediation teams should capture or treat the air before it is released outside.

Even volatile CWAs may adsorb onto or absorb into some materials and then gradually be released. In some cases, such processes can slow natural attenuation resulting from volatilization. Surfaces with material properties that make adsorption or absorption of CWA contamination more likely should receive particular attention when monitored natural attenuation is used to ensure that residual CWA contamination levels actually achieve clearance criteria.

Monitored natural attenuation also should include monitoring for toxic degradation products. Depending on the reactions occurring and the parent CWA involved, CWA degradation products can vary in toxicity. However, because they are typically less volatile, the degradation products also can be more persistent. Therefore, clearance guideline levels should be selected to also be protective against exposure to degradation products resulting from initial CWA contamination.

5.4 DEVELOP THE DECONTAMINATION STRATEGY

Decontamination planning activities can begin when data are obtained from site characterization actions identifying the areas and types of materials requiring decontamination. This effort culminates in the preparation of an incident-specific RAP. RAP preparation is a coordinated effort by the Planning and Operations Sections. The RAP describes a decontamination strategy that discusses the following:

- Area and facility-specific information, a summary of the CWA incident, members of the project team, and a summary of characterization sampling and air monitoring results
- Alternatives to engineered decontamination actions, if any, such as monitored natural attenuation
- Facilities and areas requiring decontamination
- Materials and structural components decontaminated *in situ*, removed, or both
- Surface decontamination technologies to be used
- Gas- or vapor-phase decontamination technologies to be used
- Chemical compatibility of structural components and materials to be treated with the selected decontamination reagent(s)
- Any pre-decontamination work required, such as sealing off or partitioning areas
- Monitoring of the effectiveness of decontamination
- Decontamination process parameters and their acceptable ranges
- Specific clearance goals to be met
- Decisions regarding operation of the HVAC system or other means by which the CWA could spread
- Selection of staging areas
- Selection of waste-storage areas
- Waste management and safety
- Reference to the clearance SAP, a HASP, and an AAMP, if required, to monitor for any uncontrolled release of decontaminant outside a treatment area

- A thorough description of actions to be taken, the order in which they are to occur (project schedules), and who will perform such actions
- A QA/QC plan that specifies DQOs or an equivalent process

Areas requiring decontamination likely will have been determined after sampling and analysis during characterization. If decontamination technologies have been determined in advance, then the RAP can be prepared more rapidly. The assumptions, decisions, and timing of decisions that shape the components of a decontamination strategy are summarized below.

ASSUMPTIONS, DECISIONS, AND THE TIMING OF DECISIONS THAT SHAPE THE COMPONENTS OF A DECONTAMINATION STRATEGY
For a major incident, the referral of a site by law enforcement officials may occur days or even weeks after the initial CWA release. For volatile CWAs such as sarin and semivolatile CWAs such as soman and sulfur mustard, experimental data suggest that natural attenuation (both volatilization and degradation) will have reduced air and non-permeable surface concentrations to very low levels. Vapors from CWAs with very low volatility, such as VX, will have a very slow evaporation rate and therefore will remain a contact hazard on surfaces for weeks or months if the contamination does not degrade or is not decontaminated. The IC/UC may decide to operate or not operate the HVAC system of a facility depending on indoor air concentrations and whether the air in the HVAC system is treated before return or release. If vapor concentrations of a CWA or decontamination reagent within an isolation area are expected to persist above toxic levels for an extended time, or if the area is to be filled with a decontaminating vapor or gas, then negative air units (NAU) should be used in that area to control air emissions. The use of NAUs may require changes in the operation of the HVAC system, such as installing filters to reduce emissions of toxic chemicals to the atmosphere.

The following sections discuss performance of source reduction and selection of decontamination technologies.

5.4.1 Perform Source Reduction

Source reduction during the decontamination phase is performed by the Operation Section's Decontamination Group working with the Disposal Group. Initial source reduction may begin during the first response or characterization phases of an incident. Understanding a site or facility and its contents as well as making general decisions about decontamination and disposal before an incident expedites source reduction.

Before decontamination, decisions need to be made concerning which materials and structural components requiring decontamination will be (1) reused either on site or off site or (2) not reused but packaged (either with or without prior decontamination) and removed for disposal either as waste or through recycling. Non-essential items removed for disposal are treated differently from essential items removed for off-site treatment and returned for reuse. A site's or facility's structural components and essential items likely will be decontaminated for reuse. Removable materials can be decontaminated, packaged, and transported for disposal in accordance with the requirements identified in Section 6, Waste Disposal. A qualitative cost–benefit analysis should be part of the decision process to determine retention versus disposal of items. Otherwise, unnecessary costs can result. For many substrates, the best approach may be to physically remove and properly dispose of the items and then replace them with new ones after clearance.

For sites and facilities where gas- or vapor-phase decontamination is conducted, source reduction of materials that will remain on site (such as equipment) and structural elements may include prior surface treatment. Appendix 6 provides details on various decontamination methods.

Once contaminated material (such as soil, sediment, and water) has been removed or collected, it requires transportation to an approved treatment and disposal facility. The DOT and individual states have many requirements for (1) pre-treating and packaging materials before they leave a contaminated site, (2) labeling packages for transport, and (3) transporting materials to approved facilities. The separate category of personal or valuable items that can be removed for off-site decontamination is discussed below. Appendix 7 provides additional information about waste management and disposal.

5.4.2 Select Decontamination Technologies

Many items selected for removal, decontamination, and disposal are inexpensive items made of plastics, polymers, and porous materials, and sampling such items after decontamination to prove that no residual CWA is present can be prohibitively expensive or burdensome. It may be necessary to categorize certain removed decontaminated materials as having residual CWA levels for the purposes of packaging, transportation, treatment, storage, and disposal. Such an approach can result in extended timeframes to achieve final waste disposal. Therefore, it is critical to communicate with state solid waste management officials and waste disposal facilities during remediation planning. It also is important to select appropriate staging and waste storage areas so that the timeline for waste disposal does not adversely affect the timelines for clearance and restoration.

The selection of decontamination technologies depends on the specific CWA used in an attack, items requiring decontamination, and the materials involved. Sensitive equipment, such as computers, electronic and electrical circuit boards, high-voltage power lines, and electronic control panels, are not amenable to aqueous decontamination systems. The problem of decontaminating sensitive equipment is discussed below. Also, many different types of areas may require decontamination.

In a complex situation, the following three types of decontamination technology may be required:

- Exposed-surface decontamination reagents for large-area surface cleaning, which must address both non-porous and porous surfaces
- Gas- or vapor-phase decontamination reagents to ensure that air handling systems and hidden and hard-to-reach spaces are sufficiently decontaminated, and a method to contain and control the gases
- Technologies to decontaminate sensitive electronic equipment and small, personal, or valuable items, such as artwork

Figure 5-2 shows a high-level a series of questions to help identify classes of decontamination methods needed for a specific incident. This figure does not imply a particular order in which to use the methods. Decontamination methods can be deployed in different orders depending on incident-specific conditions. For example, monitored natural attenuation may be used first while CWA contamination is being characterized, then, if semivolatile CWAs are present, ventilation may be applied using the HVAC system while gas- or vapor-phase decontamination equipment is set up to treat more persistent CWA contamination. Alternatively, certain items may be treated first using surface reagents (such as liquids, foams, and gels) if the CWA contamination is known to be located on accessible surfaces.

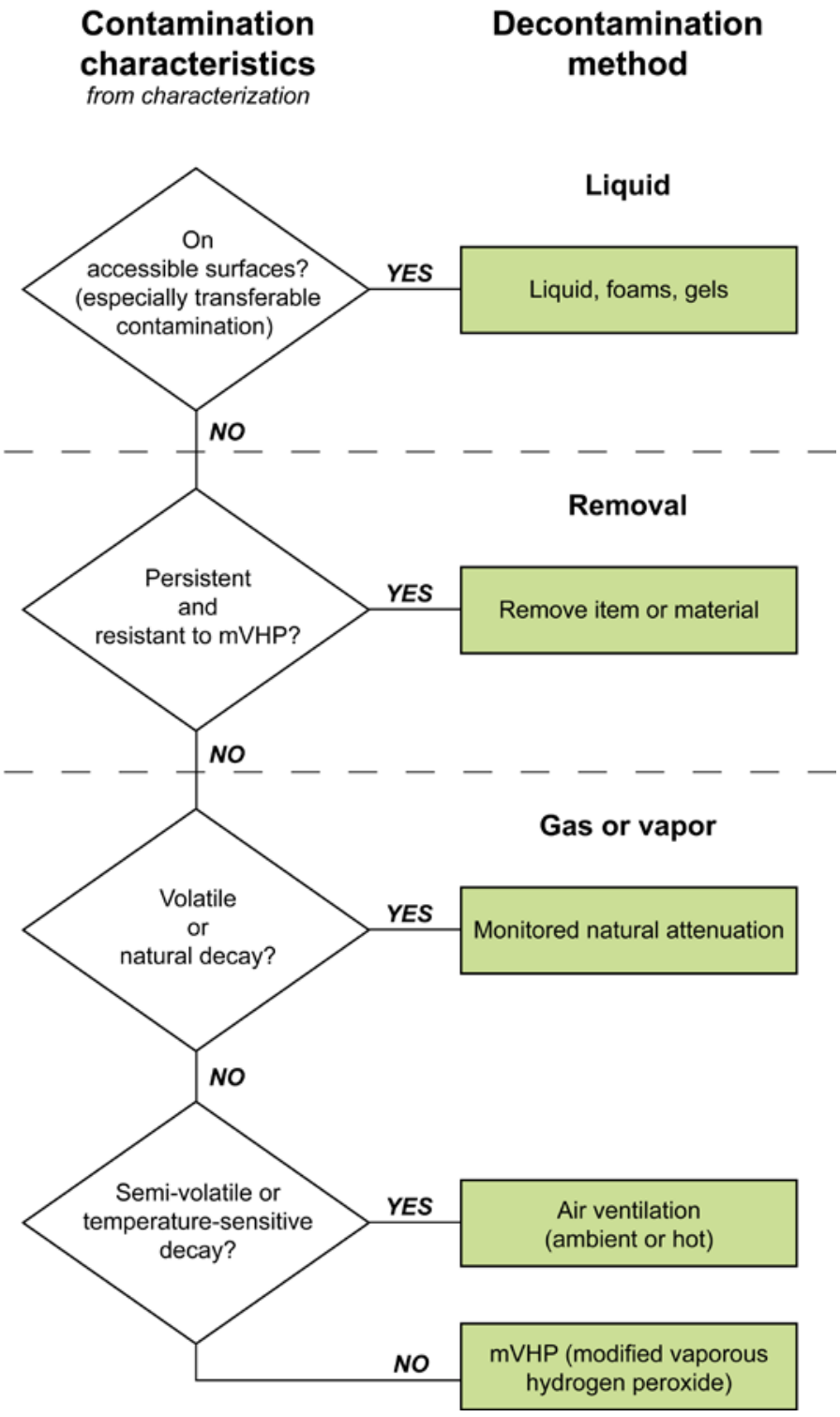

Figure 5-2. Outline of a Process for Selecting Decontamination Methods for an Incident

Tables 5-1 through 5-3 summarize different decontamination technologies for different types of CWAs. Different incident scenarios involve different distributions of the types of decontamination needed. In some incidents, only surface CWA contamination may exist in a small area, but other incidents may involve a more extensive and complex distribution of CWA contamination. The most appropriate decontamination strategy also depends on the CWA used. A release involving a persistent CWA, such as VX, requires a different response from one involving a less-persistent CWA, such as sarin. Finally, the strategy depends on where the attack occurs. An attack with sarin at one site may require different treatment from an attack at another site because of the different ability of sarin to persist in the different materials present.

5.5 PREPARE REMEDIAL ACTION PLAN AND RELATED DOCUMENTS

Developing the RAP is a coordinated effort by the Planning and Operations Sections, including the EU and Decontamination Group. The incident-specific RAP specifies the decontamination method(s) to be used and many other details. The Operations Section Chief reviews and the IC/UC approves the RAP. The RAP is implemented in a series of daily (or other specified interval) IAPs as defined in the NIMS. During a complex response, all three types of decontamination technologies discussed in Section 5.4.2 may be required. If the RAP specifies gas- or vapor-phase decontamination, then the RAP should contain an AAMP to ensure that air releases of the treatment gas are managed. If required by a jurisdiction, the RAP (containing an AAMP) may be submitted to local regulatory boards, especially those that regulate air quality. The site SO develops a Contingency Plan to address actions taken during potential, uncontrolled releases of treatment gas and for other contingencies, such as explosion, fire, or severe storm.

Sampling performed to directly support the decontamination process can be documented in the RAP or in a separate related document. For example, if monitored natural attenuation is used, a monitoring plan is required. Similarly, SAPs must be prepared for any monitoring of key process variables specific to the selected decontamination strategy, such as temperature and concentration of a gaseous reagent.

5.6 PERFORM SITE PREPARATION

The Operations Section's Decontamination and Sampling Groups perform all site preparations specified in the RAP. Site preparation requirements are incident- and site-specific. If gas- or vapor-phase decontamination technologies are used, site preparation before decontamination may include the following actions:

- Subdividing spaces with temporary walls
- Sealing all leaks and openings and testing for leaks, or arranging for tenting
- Installing and testing oxidant-generation systems
- Installing and testing systems for monitoring oxidant concentrations, temperature, and humidity
- Installing and testing NAUs and air filter systems
- Commissioning new equipment
- Testing low-level gas or vapor
- Modeling (to ensure low costs) and airflow measurements to determine the approximate amount and direction of air movement

Table 5-1. Decontamination of Surfaces

DECON TECHNOLOGY	HD		VX		G AGENTS		CORROSIVENESS	TOXICITY	DEPLOYMENT	COST	RESIDUE	SOURCE
	Contact Time	Efficacy	Contact Time	Efficacy	Contact Time	Efficacy						
DF-200[1]	30 min	>99.8%	30 min	>99.8%	30 min	>99.9%	L	L	M	M	Yes	Proprietary; Modec, Inc., EnviroFoam Technologies Inc.
L-Gel[2]	24 hr	100%	24 hr	69% on asphalt 99% on concrete	24 hr	98% on asphalt 99% on concrete	M	L	M	M	Yes	Proprietary; LLNL
HTH[3]	5 min	✓	5 min	✓	5 min	✓	H	H	H	L	No	Non-proprietary; easily formulated
STB[3]	30 min	✓	30 min	✓	30 min	✓	H	H	M	L	No	Non-proprietary; easily formulated
Bleach[3,4]	5 min	✓	5 min	✓	5 min	✓	H	H	M	L	No	Non-proprietary; widely available
CASCAD[5]	5 min	>99.95%	5 min	✓	5 min	>99%	L	L	M	M	Yes	Proprietary; Allen-Vanguard
GDS 2000[6]	1 min 3 hrs	>99.8% 99.87%	1 min 3 hrs	>99.8% 99.97%	1 min 3 hr	>99.8% 99.95%	—	—	M	—	Yes	Proprietary; Kärcher Futuretech
Decon Green[7]	20 min 15 min	99.9% 99%	20 min 15 min	>99.9% 96%	20 min 15 min	>99.9% 90%	H	H	M	M	Yes	Proprietary; Strategic Technologies Enterprises
Liquid ClO_2[8]	Minutes	Good	Hours	Poor	—	None	M-H	M-H	M	L	No	Non-proprietary; widely available
All-Clear[9]	—	—	—	—	30 min	95%	L	L	M	—	—	Proprietary; Kidde
BIT[10]	sec-min	98%	sec-min	99% >99.999%	sec-min	99%	L	L	M	M	No	Proprietary; L3 Titan

Notes:

✓ Technology stated to be effective, but numerical value not given
— Data not available
For corrosiveness, toxicity, and cost, L indicates low, M indicates medium, and H indicates high.
For deployment, L indicates easy, M indicates moderately difficult, and H indicates highly difficult.
For residue, YES indicates the presence of visually noticeable residue that must be cleaned off before reuse.

1. DF-200 efficacy measured in surface testing on chemical agent-resistant coating (CARC) coupons in DOD testing
2. Surface testing on concrete and asphalt surfaces, respectively (Raber et al. 2002), alkyd paint, polyurethane paint, and indoor-outdoor carpet
3. Hoenig 2002; CDC 2004
4. Household bleach (5% sodium hypochlorite in water) diluted by adding 1 part bleach to 9 parts water (McGuire et al. 2001)
5. Laboratory stirred-reactor data from Allen-Vanguard 2005
6. First numbers: laboratory stirred-reactor data (Franke and Toepfer 2002). Second numbers: field tests on painted metal at 12.5°C, includes cold water wash after treatment (Toepfer 2002).
7. Agent removal on CARC coupons (Wagner 2004)
8. Extrapolation from performance of vaporous chlorine dioxide; performance of liquid may differ
9. USGN 2005
10. Binary Ionization Technology (BIT) from L-3 Communications/Applied Technologies/Titan Corporation; numbers primarily for painted surfaces (CARC); additional numbers for VX for bare metal surface

Table 5-2. Decontamination of Volumetric Surfaces

DECON TECHNOLOGY	HD		VX		G AGENTS		CORROSIVENESS	TOXICITY	DEPLOYMENT	COST	RESIDUE	SOURCE
	Contact Time	Efficacy	Contact Time	Efficacy	Contact Time	Efficacy						
Natural attenuation	Days to weeks[1]	Material-dependent	Days to weeks[2]	Material-dependent	GB: hours Others: days to weeks	GB: best All: material-dependent	L	L	L	L	No	Non-proprietary; widely available
Forced ventilation	Days to weeks[1]	Material dependent	Days to weeks[2]	Material dependent	GB: hours Others: days to weeks	GB: best All: material dependent	L	L	L	L	No	Non-proprietary; widely available
Hot-air ventilation	Days[1]	Good	Hours	Good	Hours	GB: good Others: material-dependent	L	L	M	L	No	Nonproprietary; A&E firm
Steam	Hours	Good	Hours	Good	Hours	Poor	L	L	M	L	No	Nonproprietary; A&E firm
mVHP	Hours	Good	Hours	Good	Hours	Good	L	M	M	M	No	Proprietary; STERIS
Ammonia (gas)	—	Good	—	Poor	—	Poor	M	M	M	M	Yes	Nonproprietary; A&E firm
Ammonia (gas) and steam	Minutes	Good	Days	Good	Minutes	Good	L	M	M	M	Yes	Nonproprietary; A&E firm
ClO_2	Minutes	Good	Hours	Poor	Hours	Poor	H	H	M	H	Yes; must be neutralized to minimize corrosion	Proprietary; Sabre
Ozone[3]	—	Good	Hours	Fair	—	—	M	H	M	M	No	Nonproprietary; A&E firm
Perchloryl fluoride	—	Fair (thin films only)	Hours	Poor	—	—	H	M	H	H	Yes	Nonproprietary; Limited Distribution; A&E firm
Nitrogen tetroxide	Hours	Good	—	—	—	—	H	H	H	M	No	Nonproprietary; A&E firm

Notes:

— Data not available
A&E - Architecture and Engineering
Numerical values for efficacy not available, so qualitative indicators used
For corrosiveness, toxicity, and cost, L indicates low, M indicates medium, and H indicates high.
For deployment, L indicates easy, M indicates moderately difficult, and H indicates highly difficult.
For residue, YES indicates the presence of visually noticeable residue that must be cleaned off before reuse.

1. Although fresh mustard is volatile, several hours exposure to air causes exposed surfaces of mustard to polymerize, forming an impermeable shell that prevents further evaporation.
2. For VX, efficiency depends on droplet size.
3. See Wagner et al. 2000 for efficacy with VX and GD

Table 5-3. Decontamination of Sensitive Items

DECON TECHNOLOGY	HD		VX		G AGENTS		CORROSIVENESS	TOXICITY	DEPLOYMENT	COST	RESIDUE	SOURCE
	Contact Time	Efficacy	Contact Time	Efficacy	Contact Time	Efficacy						
Forced ventilation	Days to weeks	Material-dependent	Days to weeks	Material dependent	GB: hours Others: days to weeks	GB: best All: material dependent	L	L	L	L	No	Nonproprietary; widely available
mVHP[1]	24 hr	✓	24 hr	✓	24 hr	✓	L	L	M	H	No	Proprietary STERIS
ClO_2[2]	30	Good	Hours	Poor	Hours	None	M-H	M-H	M	L	Yes; must be neutralized to minimize corrosion	Proprietary; Sabre
Solvent Bath[3]	15 min	>99.0%	15 min	>99.99%	15 min	>99.93%	L	L	H	—	No	Proprietary; Battelle and Guild Associates

Notes:

✓ Technology stated to be effective, but numerical value not given
— Data not available
For corrosiveness, toxicity, and cost, L indicates low, M indicates medium, and H indicates high.
For deployment, L indicates easy, M indicates moderately difficult, and H indicates highly difficult.
For residue, YES indicates the presence of visually noticeable residue that must be cleaned off before reuse.

1. Vaporous hydrogen peroxide with ammonia; large chamber tests (Wagner et al. 2004a)
2. Brickhouse 2005
3. Coupon test data from Rossin 2005

5.7 PREPARE CLEARANCE ENVIRONMENTAL SAMPLING AND ANALYSIS

The EU, with input from the TWG (if such a group is in place) develops the clearance SAP and justification for the sampling and evaluation scheme used to confirm the effectiveness of decontamination. Section 7, Clearance, describes the clearance SAP and actions implemented during the clearance phase in more detail.

5.8 PERFORM DECONTAMINATION

After the SAP, RAP, and AAMP are completed, the Operations Section's Decontamination Group performs an internal review of the three documents. After the internal review is complete, the IC/UC (1) approves and submits the three documents, (2) applies for any regulatory permits needed for off-site actions (such as National Pollutant Discharge Elimination Program [NPDES] permits and off-site storage permits for hazardous waste), and (3) determines substantive requirements for on-site actions (such as hazardous waste treatment and demolition). EPA OSCs are exempt from having to obtain permits for on-site actions conducted in emergency situations under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Upon receipt of any required permits, the designated decontamination contractor(s) and trained decontamination personnel carry out the decontamination, with oversight by the Operations Section's Decontamination Group.

Decontamination strategies and tactics for a particular incident are determined by Planning and Operations Section staff members. During tactics meetings, resource needs are identified for each work assignment. Specific decontamination actions cannot be suggested in advance of an attack because the details are specific to the CWA, site and incident. After decontamination, the EU and the Decontamination Group, with input from the TWG, evaluate the results for completeness and to ensure that process criteria have been met. The EU, Decontamination Group, or both, may recommend more decontamination activities, if warranted.

5.9 REFERENCES – DECONTAMINATION

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6. WASTE DISPOSAL

The role of an OSC is important one in waste disposal and management. Sections 300.120(a) and 300.135(a) of the NCP (EPA 2014) state that the OSC directs response efforts and coordinates all other efforts at the scene of a discharge or release. The OSC is pre-designated by the regional or district head of the lead agency within the affected jurisdiction (for example EPA, USCG, DOD, or DOE). Section 300.130(a) of the NCP (EPA 2014) states that the EPA is authorized to take response measures deemed necessary to protect the public health, welfare, or environment from discharges of oil or releases of hazardous substances. Section 300.135(d) of the NCP (EPA 2014) states that the OSC coordinates response efforts with other appropriate federal, state, and private response organizations.

The OSC promotes the use of an IC/UC that brings together federal, state, and local governments with the owner and operator of the affected site or facility to achieve an efficient and effective response. An EPA OSC can access various federal authorities and resources to support the local IC on issues related to waste disposal and management, including the mobilization of Special Teams under the NCP. Special Teams trained in counter-terrorism response include the EPA's ERT, the USCG's National Strike Force, and the National Oceanographic and Atmospheric Administration's (NOAA) Scientific Support Coordinator.

This section provides information regarding waste management decisions during remediation after a CWA attack. Specifically, the following sections discuss the structure of environmental waste regulation, waste-related implications of the NRF, assumptions for regulatory determinations regarding CWA waste, regulation of CWA waste streams under the Resource Conservation and Recovery Act (RCRA), disposal under the Clean Water Act, issues under the Clean Air Act, and state-specific regulatory schemes.

6.1 STRUCTURE OF ENVIRONMENTAL WASTE REGULATIONS

Environmental laws and regulations reflect the various statutes enacted to address targeted environmental problems. Although the Clean Air Act and Clean Water Act are good examples of comprehensive statutes passed to address an entire medium (air and water), other statutes, such as the following, deal with particular problems:

- CERCLA, enacted to address cleanup of accidental spills or sites with chronic environmental damage
- RCRA, enacted to address the handling, management, and final disposal of solid and hazardous wastes
- Safe Drinking Water Act, enacted to address the purity of drinking water supplied to the public by public drinking water suppliers
- Hazardous Materials Transportation Act and DOT's Hazardous Materials Regulation provisions (Title 49 of the *Code of Federal Regulations* [CFR] 100–185), enacted to govern the placarding, packaging, and safe transportation of HAZMATs (including most hazardous wastes) destined for disposal at hazardous waste treatment, storage, or disposal facilities

The federal government's cleanup contractors, especially the EPA's ERRS contractors, have specialized Transportation and Disposal Coordinators trained in applying complex federal regulations to shipments of hazardous waste materials from CERCLA sites.

Even today, some areas such as cleanup levels for soil and groundwater are not addressed by federal environmental laws. Table 6-1 lists applicable federal environmental statutes. For the purposes of remediation after a CWA attack, it is important to have a basic understanding of CERCLA, RCRA, and the Clean Water Act.

Table 6-1. Key Environmental Statutes

STATUTE	CITATION	SUMMARY
CERCLA	USCA §9601 et seq.	Provides for the cleanup of contaminated sites, including releases of hazardous substances
RCRA	42 USCA §6901 et seq.	Directs the management and disposal of solid and hazardous wastes
Clean Water Act	33 USCA §1251 et seq.	Addresses pollution to U.S. waters, including discharges to surface water bodies and wastewater treatment facilities
Clean Air Act	42 USCA §7401 et seq.	Addresses and controls pollution to ambient air through national air standards and control of air pollution sources
Safe Drinking Water Act	42 USCA §300f et seq.	Protects public health by establishing standards for the nation's public drinking water supply
National Environmental Policy Act	42 USCA §4331 et seq.	Requires federal agencies to evaluate and consider effects on the environment in decision-making
Toxic Substances Control Act	15 USCA §2601 et seq.	Addresses the use and disposal of PCBs as well as tracking of industrial chemicals currently produced by or imported into the U.S.
Endangered Species Act	16 USCA §1531 et seq.	Provides for the conservation of threatened and endangered plants and animals and the habitats in which they are found
Oil Pollution Act	33 USCA §2702 et seq.	Provides for the prevention and response to catastrophic oil spills
Federal Insecticide, Fungicide and Rodenticide Act	7 USCA §136 et seq.	Provides for the federal control of pesticide distribution, sale, and use
Federal Emergency Planning and Community Right To Know Act	42 USCA §11001 et seq.	Provides tracking and notification of chemical hazards to local communities to protect public health, safety, and the environment

Notes:

PCB Polychlorinated biphenyl
USCA *United States Code Annotated*

Appendix 7 provides a general list of waste disposal regulations, and Appendix 8 provides waste disposal information, including environmental screening and exposure guidelines for selected CWAs. The sections below discuss listed and characteristic waste, the Hazardous Debris Rule, and hazardous waste identification and management.

6.1.1 Listed and Characteristic Waste

EPA uses two approaches for defining RCRA hazardous waste. For the first approach, EPA has identified specific chemicals or process residuals known to pose a threat to human health and the environment if improperly disposed of. Hundreds of the process residuals and toxic chemicals are identified on four separate waste lists for F wastes, K wastes, P wastes, and U wastes. F wastes are wastes from common

manufacturing and industrial processes, including spent solvents, heavy metal and cyanide wastes, dioxin wastes, wood-preserving wastes, petroleum refining sludge, and leachate from multiple sources. Because any of these wastes can be produced by a wide variety of industrial operations, the F-listed wastes are known as wastes from non-specific sources. K-listed wastes are produced from a specific industrial process and are identified in the lists by the industry that generates them. P- and U-listed wastes are for commercial chemical products being discarded or that have been spilled in an essentially pure form. The P-listed wastes are acutely toxic and regulated when they are generated at a rate of at least 1 kilogram per month. TICs are P-listed hazardous wastes. The U-listed wastes are mainly toxic wastes but also include ignitable, reactive, and corrosive wastes and are regulated when they are generated at a rate of at least 100 kilograms per month. Wastes that appear on any of the lists are called "listed wastes." The only way to exempt a listed waste from hazardous waste management requirements is to petition EPA or a state authorized to implement RCRA in lieu of the EPA to delist the waste (40 CFR 260.22).

The second approach that EPA uses to define hazardous wastes is based on the particular characteristics of the waste. EPA evaluates four characteristics of hazardous waste: ignitability, reactivity, corrosivity, and toxicity. Characteristics applicable to CWAs are further discussed below.

Reactivity

For solid wastes generated from remediation efforts after a CWA attack, only the following reactivity criteria potentially apply:

- Reacts violently with water
- Generates toxic gas, vapors, or fumes when mixed with water in a quantity sufficient to present a danger to human health and the environment
- A cyanide- or sulfur-bearing waste that, when exposed to a pH less than or equal to 2 or greater than or equal to 12.5, generates toxic gas, vapors, or fumes in a quantity sufficient to present a danger to human health and the environment

Toxicity

None of the CWAs considered in this Guidebook appears in the toxicity listing at 40 CFR 261.24. Therefore, although decontamination wastes resulting from a CWA restoration effort prior to waste treatment may be toxic from a scientific and technical perspective, such wastes would not be classified from a regulatory perspective as hazardous waste on the basis of the characteristic of toxicity under federal RCRA regulations. Such decontamination wastes may still be considered hazardous waste based on another characteristic of hazardous waste, such as corrosivity, or because the waste itself (aside from the CWA or involved in an attack) is listed as a hazardous waste. If a waste is not classified as hazardous waste, it is by default a solid waste.

With minor exceptions, treatment residuals are classified as summarized below for hazardous waste treatment.

- When the waste treated is "characteristic," the treatment residuals are hazardous waste only if they also exhibit a "characteristic."
- When the waste treated is a "listed" waste, the treatment residuals also retain the "listed" waste classification (40 CFR 261.3[c][2][i] and 40 CFR 261.3[d]).

6.1.2 Hazardous Debris Rule

For characterizing and treating wastes, EPA has determined that when certain solid materials (referred to as debris) are contaminated with a hazardous waste, the treatment methodology applicable to the underlying hazardous waste may not be appropriate to the contaminated solid material. Therefore, EPA has promulgated the Hazardous Debris Rule. The rule establishes separate treatment standards for debris the EPA defines as solid material greater than 2.5 inches in size (the size of a tennis ball) intended for disposal and a manufactured object, plant, or animal material, or a natural geologic material (40 CFR 268.2[g]).

As part of the Hazardous Debris Rule, EPA has codified the "contained-in" policy with respect to debris that alters the classification of hazardous debris after treatment with specified treatment technologies. Debris is considered to be hazardous (and regulated as RCRA hazardous waste) when it contains a listed hazardous waste or exhibits a characteristic of hazardous waste identified in 40 CFR 261.21 through 261.24 (40 CFR 268.2[h]). Under the Hazardous Debris Rule, when listed hazardous waste is treated by alternative hazardous debris treatment standards (specified extraction or destruction technologies), the resulting treated waste is no longer considered a hazardous waste. In addition, the corollary to the "contained-in" policy also allows EPA to make a case-by-case determination that debris treated by other methods no longer contains a listed hazardous waste and thus is exempt from RCRA regulation (40 CFR 261.3[f][2]). Therefore, debris contaminated with a listed hazardous waste that has been treated using one of the specified technologies in the debris rule or so that the debris no longer contains the listed waste (the listed waste has been neutralized) no longer is considered hazardous. For characteristic waste, if the treated waste no longer exhibits the hazardous waste characteristic, it is exempt from hazardous waste regulation.

6.1.3 Hazardous Waste Identification and Management

During CWA decontamination, the most likely method of storage for any hazardous waste generated is in a container, such as a 55-gallon drum, roll-off container, shipping container, or railroad car. If large volumes of liquid are generated, tanks may be the best way to store the waste stream. The RCRA container storage requirements at 40 CFR 265.171 through 174 and additional requirements at 40 CFR 262.34 apply to all waste storage resulting from remediation activities.

After removal from the accumulation area, waste may be treated on site and transported off site for disposal or may be transported to an off-site treatment and disposal facility. Regulations governing the transportation of hazardous waste are presented at 40 CFR 263. To developing regulations, EPA has adopted by reference most of the DOT's HAZMAT transportation regulations implementing the Hazardous Materials Transportation Act (HMTA) for the safe transportation of hazardous wastes (49 CFR 171 through 179). Before off-site waste shipment, the hazardous waste generator must comply with the generator pre-transport requirements.

The primary responsibility for implementing the RCRA hazardous waste program largely has been delegated to the states in lieu of EPA. EPA delegates this responsibility through a rulemaking process called authorization. Therefore, states with such responsibility are termed "authorized states." As of May 2009, all states except Iowa and Alaska have been authorized for the base RCRA program. An authorized state promulgates its own hazardous waste regulations that apply in lieu of federal regulations. Under RCRA, state RCRA programs and regulations must be at least as stringent as the federal requirements, but states can adopt more stringent requirements (RCRA Section 3009, Title 42 of the *United States Code* [USC], Section 6929).

6.2 WASTE-RELATED IMPLICATIONS OF THE NATIONAL RESPONSE FRAMEWORK

The overall response to a CWA attack, including the regulatory structure, is affected by the NRF (DHS 2008). Site personnel have access to direct input and support from federal, state, and local officials through a temporary field office located at or near the incident site. Federal, state, and local officials can access vast amounts of resources, personnel, and equipment needed to assist site personnel in the response effort.

The NRF is the federal government's comprehensive plan for managing domestic incidents such as terrorist attacks. In part, it establishes a framework for federal agencies to coordinate response efforts and explains how federal agencies coordinate with state and local governments and the private sector. The NRF distinguishes between incidents that can be responded to by state and local officials, with the federal government serving in a support role, from incidents involving a Governor's request for federal assistance, with the Secretary of Homeland Security managing the federal response as the principal federal official.

Response to a release of oil or HAZMATs under the NRF is addressed by the NRF's Emergency Support Function (ESF) #10, Oil and Hazardous Materials Response. In general, for releases at a site, EPA is the primary federal agency for ESF #10 actions. HAZMATs addressed under ESF #10 include chemical weapons of mass destruction (WMD), whether accidentally or intentionally released. ESF #10 directs that responses to the release of HAZMATs be conducted under the NCP process. Emergency repair of damaged infrastructure and critical facilities, including removal of contaminated and uncontaminated debris from roads, demolished buildings, and damaged structures, is addressed by the NRF's ESF #3, Public Works and Engineering. The DOD or U.S. Army Corps of Engineers (USACE) is the primary agency assigned to response activities under ESF #3. The management of contaminated debris is coordinated with ESF #10. In general, the NCP contemplates wastes generated as a result of hazardous waste response actions to be handled under ESF #10. However, depending on site-specific circumstances and coordination between EPA and the DOD or USACE, either agency may take the lead on removing contaminated debris.

The NCP process has been promulgated pursuant to CERCLA and the Clean Water Act and establishes a process to address HAZMAT releases. Under the NCP, coordination is carried out through the NRS provided in the NCP, including the NRT (national planning and response coordination), the Regional Response Team (deployment of regional resources and provision of assistance and advice), and the OSC. The NRF under ESF #10 indicates that these NCP teams should coordinate and operate in the NRF structure.

The NCP process provides for two types of responses to HAZMAT releases: removal and remedial actions. Under the NCP, the most response to a CWA attack is removal actions used for early response. Removal actions respond to an immediate release or threat of a release of hazardous substances. They are distinct from remedial actions in that removal actions mitigate or stabilize an immediate threat. Removal actions are categorized as emergency (immediate), time-critical (action to be taken in less than 6 months), and non-time-critical (action to be taken in greater than 6 months) on the basis of the urgency and threat of the release. Most removal actions related to a CWA release likely are classified as emergency removal actions. Emergency removal actions are streamlined to quickly address the immediate nature of the threat. Documentation of emergency removal actions under the NCP occurs after the action has taken place. In accordance with Section 300.415(I) of the NCP, on-site removal

actions conducted under CERCLA must meet applicable or relevant and appropriate requirements (ARAR) under federal and state environmental statutes and regulations to the extent practicable and considering the exigencies of the situation. The NCP identifies two factors to consider in determining if identifying and complying with ARARs is practicable: urgency of the situation and scope of the removal action. The NCP provides waivers from ARARs under certain circumstances.

The NCP provides that on-site actions do not require permits. The term "on site" is defined as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (40 CFR 300.400[e]). The NCP requires on-site actions to comply with substantive state and federal requirements. These provisions reflect CERCLA provisions that exempt on-site response action from state and federal permits (42 USCA Section 9621[e]). CERCLA and the NCP offer such exemptions to allow rapid emergency response. Releases responded to through the NCP process do not require federal, state, or local permits (such as a RCRA permit for treatment and decontamination procedures).

6.3 ASSUMPTIONS FOR REGULATORY DETERMINATIONS REGARDING CWA WASTE

Regulatory determinations regarding waste characterization, further waste management, and disposal requirements are case-by case-determinations. For an actual incident, such determinations are made by response personnel along with federal and state regulatory agencies. To provide a context in which to make regulatory determinations regarding waste and for the purposes of illustration in this Guidebook, the assumptions summarized below apply with regard to the nature of remediation activities.

1. Decontamination wastes include materials such as spent decontamination fluids, PPE, cleaning materials used in the decontamination process (such as rags and mops), and items at an incident location that will be disposed of and not reused. Potential waste items include decontaminated furniture, computers, upholstery, carpet, drywall, and other materials. This Guidebook does not analyze the disposal of site components considered HAZMATs in and of themselves, such as items that contain polychlorinated biphenyls (PCB) or asbestos, or building components that, when disposed of, would be considered hazardous waste without contamination by a CWA.
2. Wastes do not include any pure CWAs. Any pure agent or undispersed CWA from a failed device is addressed and removed as part of the initial emergency response.
3. All CWA items to be disposed of are decontaminated before off-site disposal to (1) eliminate potential cross-contamination of the CWA at previously unexposed areas, (2) eliminate the potential for secondary source production, (3) reduce the exposure of decontamination workers to the CWA, and (4) facilitate waste handling and transportation.
4. Potentially toxic CWA degradation products are neutralized or reacted to non-toxic degradation products by decontamination procedures.
5. Decontamination is performed until all CWAs have been neutralized. However, for an actual incident, it may not be practical, necessary, or cost-effective to sample some waste items to a level that ensures that no residual CWA remains.
6. All decontamination waste streams are contained until treatment, and monitoring can ascertain that the waste streams are not toxic to personnel or the environment from the presence of unreacted CWA, excess bleach, or other incident-related wastes.

7. Likely decontamination methods include, but are not limited to, chlorine bleach solutions, chemical decontamination foam, modified vaporous hydrogen peroxide (mVHP), and natural attenuation or the use of hot air or steam.
8. A CWA terrorist attack at a large site invokes the provisions of the NRF and all appropriate provisions of the NCP. All disposal activities occur under existing environmental regulatory frameworks at state and federal levels.

The regulatory analysis in this section corresponds only to a remediation effort based on the assumptions summarized above. The assumptions are based on the expected, most-likely scenario to be addressed by a remediation effort and were evaluated in light of federal regulations. Actual remediation activities should be analyzed on a case-by-case basis and consider the possibility of more stringent state regulations with coordination of federal, state, and local officials through the local JFO.

6.4 REGULATION OF CWA WASTE STREAMS UNDER RCRA

This section addresses the federal regulation of waste streams from decontamination activities. Almost all states have adopted their own RCRA programs and have obtained authorization from EPA to operate the RCRA program in lieu of EPA. Although the regulations of most states follow federal regulations closely, some states have promulgated and implemented regulations that are more stringent than those of the federal program. As part of pre-incident planning for a decontamination effort, the owner or operator of a site or facility must consult state-specific regulations and appropriate state agencies regarding pertinent waste-related requirements.

The following sections discuss the origin of the waste stream (disposal versus reuse) and disposal as non-hazardous waste.

6.4.1 Origin of the Waste Stream (Disposal vs. Reuse)

During remediation, some materials and structural components are likely to be decontaminated for reuse, whereas other materials may be removed from the site for decontamination and subsequent disposal. In general, materials that will be decontaminated and reused at the site do not qualify as solid or hazardous wastes.

Spent decontamination fluids or materials, carpet, furniture, computers, telephone sets, and other components that are discarded and not reused require management and disposal as waste.

Regulation of decontamination wastes begins when the decision has been made to discard items or when spent decontamination fluids or materials are recovered. For items that qualify as solid waste, the generator requirements under RCRA are triggered, requiring a determination about if the solid waste also qualifies as hazardous waste (40 CFR 264.11).

The sections below discuss characterizing waste streams from decontamination technologies, listed waste, and characteristic waste.

6.4.1.1 Characterizing Waste Streams from Decontamination Technologies

One of the primary waste streams from decontamination is spent decontamination solution or material used to implement the decontamination activity. If the spent solution is a liquid and treated and

disposed of through discharge to a publicly owned treatment works (POTW) or waterway, the discharges is regulated by the Clean Water Act (see Section 6.6).

The following four decontamination methods are recommended for decontaminating a site:

- Bleach solutions in water
- Sandia Decontamination Foam Technology (DF-200)
- mVHP
- Natural attenuation or the use of hot air or steam

Spent decontamination solution, PPE, carpet, furniture, computers, telephones, and other site components disposed of through transport to a landfill or other non-Clean Water Act treatment facility are regulated depending on classification as a hazardous or non-hazardous waste based on characterization determined by monitoring. The first step is to determine if a waste is a solid waste, then if it is an excluded solid waste or RCRA hazardous waste (either listed or characteristic waste as discussed below).

6.4.1.2 Listed Waste

The first determination in characterizing a waste stream is whether the waste is a listed waste. None of the decontamination materials or CWAs considered in this Guidebook are listed wastes at the federal level. However, some of the CWAs considered in this Guidebook are P-listed wastes. Cyanogen chloride (CK), hydrogen cyanide (AC), and phosgene (CG) all are listed as RCRA hazardous wastes and carry the wastes codes P063, P033, and P095, respectively. Regardless of whether the decontamination technologies have neutralized the CWA, spent decontamination waste streams from remediation of these three CWAs may be listed hazardous wastes.

P-listed wastes apply to commercial chemical products discarded or spilled in essentially pure form. However, in the event of a CWA release as a result of a terrorist attack, it is unlikely that a CWA would be released in pure form or that specific information regarding the manufactured chemical composition would be known. In such situations, EPA policy is to assume that a source, CWA, or waste is not a listed hazardous waste. When information is inconclusive or unavailable to make a listed waste determination, EPA allows the site owner or operator to assume that the source, CWA, or waste is not a listed waste. This approach first was articulated in the proposed and final NCP rulemaking and most recently in EPA guidance (see 53 *Federal Register* 51444, December 21, 1988, for proposed NCP preamble discussion; 55 *Federal Register* 8758, March 13, 1990, for final NCP preamble discussion; and EPA 1998). Therefore, when information needed to make a listed waste determination is unavailable, waste streams from remediation of cyanogen chloride (CK), hydrogen cyanide (AC), and phosgene (CG) are not be classified as listed hazardous wastes.

6.4.1.3 Characteristic Waste

Characteristic wastes may include spent decontamination solution or material and PPE, carpet, furniture, computers, telephones, and other site components.

Spent Decontamination Solution or Material

Bleach solution in water may be considered a RCRA hazardous waste if it exhibits a hazardous waste

characteristic. As discussed above, all CWAs involved in an attack are assumed to be completely reacted by the decontamination process, and the level of reaction is monitored. However, bleach solution itself is considered to exhibit the characteristic of corrosivity if the spent bleach solution pH is less than 2 or greater than 12.5. However, once the solution is treated to adjust the pH (to greater than 2 but lower than 12.5), the characteristic has been removed and the waste no longer is considered hazardous because of the corrosivity characteristic.

The manufacturer of Sandia Decontamination Foam indicates that the foam is naturally biodegradable with a low environmental hazard. It is assumed that Sandia Decontamination Foam residues do not exhibit any hazardous waste characteristics after completely neutralization of the CWA.

The hydrogen peroxide part of the mVHP technology decomposes to water and oxygen. Therefore, any recovered residues do not exhibit a hazardous waste characteristic. However, the modified process that is recommended also uses ammonia. It assumed that the ammonia component of the modified process does not result in decontamination residuals exhibiting a hazardous waste characteristic. However, standard waste stream monitoring should be conducted to verify that ammonia concentrations meet all applicable requirements.

For natural attenuation or the use of hot air or steam, the only decontamination solution or material recovered is condensate or runoff from steam. Assuming that the CWA has been fully reacted, the recovered steam does not exhibit any hazardous waste characteristic. Natural attenuation or hot air itself do not produce any waste streams from the decontamination technology. However, the exhausted air likely will be filtered during decontamination. Spent filters are not expected to exhibit a hazardous waste characteristic, but as a precaution, used filters should be either monitored or decontaminated before disposal. For all residual liquid waste streams, monitoring is recommended to ensure any recovered decontamination waste stream does not exhibit any characteristics of RCRA hazardous waste.

PPE, Carpet, Furniture, Computers, Telephones, and Other Site Components

After decontamination, site components are considered hazardous waste only if, at the time of generation (when the decision is made to dispose of an item), an item exhibits a characteristic of hazardous waste or if the item has been contaminated with a listed waste. As discussed above, none of the CWAs are considered hazardous listed wastes at the federal level, and any TIC-related waste is likely to be assumed as not meeting hazardous waste listing requirements. After appropriate decontamination, site components previously contaminated with CWAs also are assumed to not exhibit any hazardous waste characteristic. Of the decontamination technologies considered in this Guidebook, only bleach solution has a hazardous characteristic (corrosivity). However, after decontamination, any bleach solution remaining on an item is not likely to retain a pH sufficient to be considered corrosive. Section 6.4.2 below summarizes preliminary decontamination waste regulations.

6.4.2 Disposal as Non-hazardous Waste

Regulation of non-hazardous solid wastes primarily is the responsibility of the individual states. Federal regulation has been limited to establishing minimum criteria for solid waste disposal facilities. Criteria for classifying solid waste disposal facilities and practices are established at 40 CFR 257, Subtitle D. Direct implementation of the minimum nationwide standards outlined in Subtitle D remains a state and local function.

With respect to wastes from decontamination, the decision to accept solid waste declared non-hazardous by the proper decision-making authorities is ultimately up to the individual Subtitle D landfill.

Landfills have a considerable invested interest in the wastes they accept. Because of the unique nature of wastes potentially resulting from a CWA attack, discussions with likely disposal facilities during the pre-planning stages are crucial to efficiently remediate a site after a CWA attack. TICs generally do not cause the same types of concerns because public and private sectors have considerable experience in dealing with TIC-contaminated materials.

Solid wastes disposed of as a result of a decontamination incident require transport to an approved solid waste landfill or other solid waste disposal facility. The type of facility appropriate for decontamination wastes and waste-handling procedures are controlled by state regulations governing solid wastes. A few states have promulgated regulations that differentiate solid wastes on the basis of the level of threat a solid waste poses after disposal in a municipal waste landfill.

6.5 DISPOSAL UNDER THE CLEAN WATER ACT

Recovered decontamination solutions and materials (such as bleach solution or Sandia Decontamination Foam) or rinse waters may be disposed of either to a sewer (a POTW) or surface water body if prerequisites for such discharges can be met. Table 6-2 summarizes pretreatment requirements before discharge to a POTW. Discharges to a POTW or surface water body under the Clean Water Act under an NPDES permit are exempted as hazardous wastes under RCRA (40 CFR 261.4[a][1] and 40 CFR 261.4[a][2]). The local POTW pretreatment program must include the federal pretreatment requirements of 40 CFR 403 and may include additional, more stringent local standards. Based on such prohibitions, bleach in water solution potentially requires pH adjustment before discharge to a sewer (Haffenden and Kimmell 2002).

Table 6-2. Pretreatment Requirements before Discharge to a POTW

PRETREATMENT REQUIREMENTS	DESCRIPTION	CFR CITATION
Materials Destined for POTW	Any decontamination solution or material destined for a POTW must be pretreated if necessary before discharge to a local POTW.	40 CFR Part 403
Materials and parameters prohibited from discharge to a POTW	Pollutants that pass through the POTW at concentrations that violate the POTW's NPDES permit and pollutants that inhibit or interfere with POTW operation, sludge processes, use, or disposal	40 CFR 403.5(b)
	Discharge of pollutants to POTWs that create a fire or explosion hazard in the POTW	40 CFR 403.5(b)
	Discharge of corrosive (pH less than 5.0) pollutants	40 CFR 403.5(b)
	Discharges that obstruct flow and discharges at a flow rate or concentration that result in interference	40 CFR 403.5(b)
	Increase of temperature of wastewater entering the treatment plant that results in interference but in no case raises the POTW temperature above 104 °F (40 °C)	40 CFR 403.5(b)
	Any trucked or hauled pollutants except at discharge points designated by the POTW	40 CFR 403.5(b)
	Discharges that would result in the presence of toxic gases, vapors, or fumes within the POTW at a quantity that may cause acute worker safety problems	40 CFR 403.5(b)

Decontamination solution discharged to a surface water body is regulated by the NPDES discharge program. As for RCRA, most states have adopted regulations and have been authorized by EPA to operate the NPDES program in lieu of EPA. The NPDES program requires all dischargers to obtain a

permit and meet effluent limitations prior to discharge, with the objective of maintaining surface water criteria. Requirements for such discharges are based on the specific classification and criteria of the particular receiving body and on the characteristic of the discharge determined on a case-by-case basis. A permit is required for a discharge to a surface water body under the NPDES discharge program because the discharge from a remediation effort is considered an off-site action (Haffenden and Kimmell 2002).

6.6 ISSUES UNDER THE CLEAN AIR ACT

As necessary, an OSC or site owners or operators take measures during response and remediation to contain any released CWA and reduce its spread. After remediation is complete, the CWA is neutralized so that any releases after remediation are minimal. Ambient air monitoring must be implemented during all phases of remediation to that ensure no fugitive emissions are released. The level and frequency of air monitoring must be part of a site-specific AAMP (Haffenden and Kimmell 2002). Fugitive emissions in this case are not regulated under the Clean Air Act. Appendix 3 provides air monitoring information.

6.7 STATE-SPECIFIC REGULATORY SCHEMES

An evaluation of state-specific CWA regulations (Appendix 7) provides good insight into of the development of state regulations on chemical remediation efforts. States with domestic CWA munitions stockpiles tend to have well developed laws and regulations. Utah, the state with the largest stockpile, has regulatory precedents for all CWAs. All CWAs are represented in the Utah repository and have been addressed by state regulators through carefully crafted disposal policies and statutes. For future CWA incidents, Utah provides a good example of how wastes related to CWAs are regulated for disposal. Utah's regulatory schemes highlight considerations that must be accounted for in monitoring to ensure that waste acceptance criteria are met.

6.8 REFERENCES – WASTE DISPOSAL

Department of Homeland Security (DHS). 2008. *National Response Framework*. On-line Address: http://www.fema.gov/emergency/nrf/

Haffenden, R., and T. Kimmell. 2002. "Applicability of Federal and State Hazardous Waste Regulatory Programs to Waste Chemical Weapons and Chemical Warfare Agents." Argonne National Laboratory, Environmental Assessment Division. ANL/EAD/TM/02-2. On-line Address: https://www.hsdl.org/?view&did=694650

United States Environmental Protection Agency (EPA). 1998. "Management of Remediation Wastes under RCRA." Office of Solid Waste and Emergency Response. EPA530-F-98-026. October.

EPA. 2014. "National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Overview." On-line Address: http://www2.epa.gov/emergency-response/national-oil-and-hazardous-substances-pollution-contingency-plan-ncp-overview.

7. CLEARANCE

Clearance is a determination that further cleanup is not required or that cleanup has met the criteria necessary for site or facility reuse or re-occupancy. The overall approach to achieving clearance is a risk analysis process that includes Risk Assessment and Risk Management (National Academy of Sciences [NAS] 2012). EPA and other federal government agencies have developed risk assessment tools and guidelines to evaluate threats to exposed populations (EPA 2009b and 1989; National Research Council [NRC] 1983). Risk assessment is a method that provides evaluation of options to be used in risk management to reduce risks (NRC 2009). These options should be developed by integrating public health, political, social, economic, engineering, and other considerations into response decisions and actions. Throughout this clearance phase, a mechanism should be established to communicate with stakeholders, such as property owners; federal, state, tribal, and local government officials; and representatives of labor and community groups (EPA 2009a). Figure 7-1 summarizes critical components involved with achieving clearance.

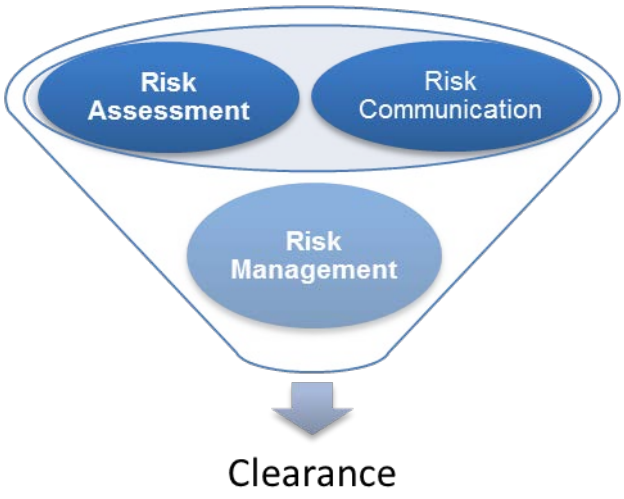

Figure 7-1 Components of Clearance Process

The following sections discuss the clearance process, clearance decisions, the clearance SAP, sampling strategy and methods, post-clearance environmental monitoring, long-term monitoring, and a summary of the clearance process.

7.1 CLEARANCE PROCESS

A variety of government and professional organizations use similar risk-based exposure guidelines in the clearance process. Each organization uses site-specific information to develop **risk-based clearance goals**. A clearance goal sets the amount of residual contamination for a specific contaminant that provides acceptable protection of human health and the environment. A Clearance Committee in the Planning Section develops clearance goals (DHS 2008). The Clearance Committee should include public health officials, scientists, SMEs, site or facility managers, and various stakeholders. The Clearance Committee must understand the regulatory authority (EPA policies and Presidential Executive Orders) for and the basis of the risk assessment. The ultimate clearance purpose should be defined for the risk assessment as well as management objectives.

Clearance goals ultimately should be site-and situation-specific to ensure that clearance decisions are protective of human health and the environment. Clearance will permit the general public to re-enter and re-occupy a site or facility. Clearance decisions must take into account factors including previous actions and decisions made during crisis management, type of CWA contamination, feasibility, PPE and safety requirements for cleanup workers, and waste management. Consideration of these factors helps to achieve an end result that balances local needs and desires.

The clearance process involves risk assessment, qualitative assessments, quantitative assessments, and uncertainty and confidence issues as discussed below.

7.1.1 Risk Assessment

A risk is the likelihood or probability of a given hazard at a given concentration causing a particular level of loss or damage. Risk assessments include the four steps outlined below.

1. A hazard assessment is conducted to determine the type(s) of health effects associated with exposure to a CWA.
2. Dose response is assessed to determine the relationship between exposure and health effects.
3. The level of exposure is determined for various uses and individuals.
4. Risk characterization is conducted, which combines exposure and dose response information to provide a numerical estimate of risk. Figure 7-2 provides a mathematical equation for determining chemical risk. Risk assessment provides "Information" on potential health risks, while risk management is the "Action" taken based on consideration of all information. A numerical unit of risk called a “target risk” (representing a 1 in 1 million or other value of risk judged to be acceptable) is defined by the Clearance Committee, with stakeholder input. The Clearance Committee then develops a risk-based clearance goal for the CWA based on the target risk, chemical toxicity data, and information on the magnitude and duration of exposure. The Clearance Committee is located under the IC/UC structure under the Planning Section and includes public health officials, scientists, SMEs, site managers, and various stakeholders.

Figure 7-2. Mathematical Equation for Chemical Risk

Clearance goals should be set appropriately at health protective levels for the appropriate populations using site-specific information on CWA identity, exposure, and health effects. Clearance goals can be determined using methods developed and used by federal and state health agencies using appropriate exposure durations. Many agencies have developed a variety of environmental, health-based exposure guidelines. These guidelines estimate potential health risks from exposure through inhalation, ingestion, or dermal contact to various contaminated matrices for specified periods of exposure. Although numerous standards and regulatory guidelines exist, there are no pre-determined cleanup approaches or levels universally applicable to every CWA release incident. Health-based exposure guidelines can be used for both qualitative and quantitative risk assessments.

7.1.2 Qualitative Assessments

Risk assessments can be initiated at different phases of the response and should be flexible enough to allow the quantification and evaluation of risk for different groups and for different purposes (for example, clearance versus temporary re-entry). Selection of temporary re-entry monitoring levels may include qualitative assessments applied at different stages of the site restoration decision-making process, such as characterization, evaluation of cleanup options, implementation of the chosen cleanup alternative, and clearance sampling. Many exposure guidelines exist for TICs and CWAs. Table 7-1 lists some of these guidelines.

Table 7-1. Exposure Guidelines for Specified Durations

GUIDELINE	AGENCY AND YEAR	DURATION	LEVEL	MEDIUM	RECEPTOR
AEGLs[1]	EPA NRC 2001 (EPA 2013a)	10-, 30-, or 60-min and 4- or 8-hr	AEGL-1, AEGL-2, and AEGL-3[1]	Air	General public
IDLH Levels[2]	NIOSH 2005 (NIOSH 1995)	30 min	Single	Air	Workers
RELs[3]	NIOSH 2005 (NIOSH 2005)	• TWA – 10-hr workday • STEL – 15-min TWA • Ceiling – never exceeded	Single	Air	Workers
PELs[4]	OSHA 2000	• TWA – 8-hr workday • STEL – 15-min • Ceiling – never exceeded	Single	Air	Workers
ERPGs[5]	AIHA 1999	1 hr	ERPG1, ERPG2, and ERPG3[5]	Air	General public
TLVs[6]	ACGIH 2006	• TWA 8-hr workday, 40-hr work week[6] • STEL – 15-min TWA[6] • Ceiling – never exceeded	Single	Air	Workers
TEELs[7]	DOE 2012	15 min	TEEL1, TEEL2, and TEEL3[7]	Air	General public
MCLs[8]	EPA Office of Water	Single	Single	Drinking water	General public (adults)
HA Levels[9]	EPA Office of Water	1-day, 10-day, and lifetime	Single	Drinking water	General public (children)
PALs[10]	EPA Office of Research and Development	24-hr, 30-day, 90-day, and 2-yr	PAL1, PAL2, and PAL3[10]	Drinking water and air	General public
SWSL[11]	USACHPPM	8-hr workday, 40-hr work week, 10 yrs	Single	Surfaces	Office workers

Notes:

ACGIH American Conference of Government Industrial Hygienists
AIHA American Industrial Hygienists Association
USACHPPM U.S. Army Center for Health Promotion and Preventive Medicine

1 **Airborne Exposure Guideline Levels (AEGL)** represent threshold exposure limits for the general public, including susceptible individuals, and apply to emergency exposures ranging from 10 minutes to 8 hours. AEGLs are intended to describe the risk to humans resulting from once-in-a-lifetime or rare exposure to airborne chemicals (EPA 2013a). Three levels are developed for each exposure period (10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours) and are distinguished by varying degrees of severity of toxic effects. Concentrations exceeding the values provided result in the following:

- AEGL-1 - threshold, mild effects
- AEGL-2 - potentially irreversible effects or impaired ability to escape
- AEGL-3 - severe effects and increasing potential for lethality

2 **Immediately Dangerous to Life and Health (IDLH)** levels were developed as respirator selection criteria. The definition of an IDLH level is an atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life, that would cause irreversible or delayed adverse health effects, or that would interfere with an individual's ability to escape from a dangerous atmosphere (NIOSH 1995).

3 **NIOSH Recommended Exposure Limits (REL)** represent not only no-effect exposure but also exposure levels at which there *may be* residual risks (NIOSH 1995).

- Time-weighted average (TWA) concentration for up to a 10-hour workday during a 40-hour work week
- Short-term exposure limit (STEL) 15-minute TWA exposure should not be exceeded at any time during a workday
- Ceiling value should not be exceeded at any time

4 **OSHA Permissible Exposure Limits (PEL)** are enforceable PELs to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. PELs also may contain a skin designation. If a NIOSH PEL also is available, then the more protective limit always is used.

- TWA concentration for 8-hour exposure (OSHA 2013)
- STEL 15-minute TWA exposure should not be exceeded at any time during a workday (OSHA 2013)
- Ceiling value should not be exceeded at any time (OSHA 2013)

5 **Emergency Response Planning Guidelines (ERPG)** are developed by the AIHA. ERPGs are similar to the AEGLs in that there are three different ranges for levels of effects. The difference is that the effects are maximum concentrations that all individuals can be exposed to for up to 1 hour before the effects summarized below are caused.

- ERPG1 - mild, transient adverse health effects
- ERPG2 - irreversible or serious effects that may cause impairment
- ERPG3 - life-threatening health effects

6 **Threshold Limit Values (TLV)** for worker protection were developed by the ACGIH and are defined as a concentration in air at parts per million (ppm) for gases and milligrams per cubic meter (mg/m^3) for particulates.

- TWA for an average exposure of 8 hours per day, 40 hours per week
- STEL is peak concentration for a duration of 15-minutes that cannot be repeated more than four times per day, with 60 minutes between exposure periods
- Ceiling value should not be exceeded at any time (OSHA 2013)

7 **Temporary Emergency Exposure Limits (TEEL)** are not peer-reviewed and are developed by the DOE Office of Emergency Management (DOE 2012). A TEEL is the airborne concentration (expressed as ppm or mg/m^3 of a substance above which it is predicted that the general population, including susceptible individuals, when exposed for more than 1 hour, could experience the following:

- TEEL1 - notable discomfort, irritation, or certain asymptomatic, non-sensory effects that are transient and reversible upon cessation of exposure
- TEEL2 - irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape
- TEEL3 - life-threatening adverse health effects or death

8 **Maximum Contaminant Levels (MCL)** are the highest levels of contaminants allowed in drinking water in public water systems (EPA 2012). These values are promulgated regulatory standards. However, states have established their own standards, which must be at least as stringent as the federal standards.

9 **Health Advisory (HA)** levels are chemical-specific concentrations in drinking water not expected to cause any adverse non-carcinogenic effects for either 1 day, 10 days, or a lifetime (EPA 2012). HAs specify guidance values health effects, analytical methodologies, and treatment technologies associated with drinking water contamination.

10 **Provisional Advisory Levels (PAL)** are developed and internally peer-reviewed by EPA's National Homeland Security Research Center (NHSRC) to assist in emergency planning and response (EPA 2009c). PALs represent exposure limits for acute (24 hours), short-term (more than 1 to 30 days), and long-term (more than 30 days to 2 years) exposure for the general public, with three tiers of health effects:

- PAL1- levels above result in measureable changes
- PAL2 – levels above which serious, irreversible, or escape-impairing effects could result
- PAL3 – levels above which result in lethality in the general population

11 **Surface Wipe Screening Levels (SWSL)** are developed by USACHPPM (USACHPPM 2009) using EPA methods for evaluating potential health risks to office workers from exposure to chemical substances on indoor work surfaces.

Qualitative assessments evaluate the potential for human exposure to chemicals and are based on a risk assessors professional judgment and knowledge of chemical exposures. Risk assessors must consider both acute health risks associated with short-term exposure and potential chronic health effects associated with low-level residual chemical concentrations remaining after cleanup. Qualitative risk assessments can be developed by comparing measured environmental chemical concentrations to benchmarks of toxicity and exposure (such as pre-calculated, health-based exposure guidelines). For example, Acute Exposure Guideline Levels (AEGL) that evaluate acute effects after short-term exposure can help in the evaluation of emergency response-phase decisions such as evacuation or sheltering in place.

Qualitative risk assessments may vary with the different phases of a response and can be used to assess different locations within a response site, depending on the complexity of the response. Initial characterization assessments may identify areas not likely contaminated, potentially resulting in an accelerated decision process and early reopening of these areas. For example, when a CWA incident response occurs at a large, complex site, the purpose of clearance may be to help decide whether to open back to the public previously contaminated areas. Alternatively, such areas may be set aside for later clearance evaluation. Both options require that such areas be effectively isolated from contaminated areas to protect them from cross-contamination. Whether or not formal clearance sampling is required in such areas depends on the degree of confidence developed during characterization.

7.1.3 Quantitative Assessments

- When developing clearance goals, always coordinate with stakeholders to identify risk perceptions and concerns that may require public education.
- Effective and frequent communications can help avoid subjective perceptions of risk made by individuals.

Scientific factors provide the basis for risk assessment, including information drawn from multiple disciplines such as toxicology, chemistry, and statistics. Throughout the different stages of an incident, it is recommended that all exposures, even low-level exposures, be assumed to have some level of risk (unless sufficient data indicate otherwise) after accounting for background chemical exposures, biological make-up, and population variability. In risk assessments, information about the types of health effects and dose responses associated with exposure to a chemical may have numerous gaps and uncertainties.

In a quantitative risk assessment, measurements of all media that may be contaminated are examined. Quantitative assessment requires a clearance SAP. The exposure assessment not only provides direct measurements of chemical concentrations, it also identifies and defines site-specific receptors based on site characterization data. The human health risk assessment should take into account background chemical exposures, genetic make-up, and population variability (Office of Science and Technology Policy [OSTP] 2013).

The detection of chemicals at a site or facility does not imply an unacceptable risk to human health. Risk from chemical exposure less than a target risk range of 1×10^{-4} to 1×10^{-6} for chemicals that cause cancer or a hazard index equal to or exceeding 1 for chemicals that have a threshold may be deemed “acceptable” and provide an “ample margin of safety. The target risk range, hazard indices, and toxicity values are used in risk-based calculations to derive concentrations in each medium of concern that require some action such as cleanup or institutional control. The cleanup effort’s effectiveness is measured relative to a clearance goal.

7.1.4 Uncertainties and Confidence Issues

Uncertainty is inherently associated with environmental data and its interpretation. These uncertainties may be minor and result in undisputed data and decisions. However, it is more likely that many uncertainties will arise associated with sampling, analytical results, exposure estimates, toxicity data, and other factors. These uncertainties make decision-making difficult. It is of paramount importance that these uncertainties are communicated not only to IC/UC but also to the public. IC/UC and the public must be informed of decisions made. Transparency is critical to ensure trust in the IC/UC and its decisions.

The range of human exposures varies considerably across uses and individuals. Risk characterization identifies all uncertainties and confidence and technical feasibility issues for stakeholders to provide input and risk managers to make decisions. This approach ensures that the cleanup process is acceptable, effective, and flexible enough to incorporate all considerations of site-specific characteristics for a particular incident. Coordination and communication among federal, state, territorial, tribal, and local government entities is critical to developing a defined, well-organized, and agreed-upon approach to CWA cleanup decision-making.

Uncertainties and confidence issues associated with exposure guidelines, toxicity and exposure data, and feasibility are discussed below.

Exposure Guidelines: Despite the availability of many quantitatively derived human toxicity and health-based exposure guidelines for certain chemicals and certain types of environmental media, there may not be an existing exposure guideline appropriate for a CWA release incident. Two examples of methods that may be used in such situations are summarized below.

- Review available toxicity data (from animal studies, human studies, anecdotal information, etc.) to determine if a human exposure value can be estimated using the same procedures and principles used to develop the exposure guidelines.
- Use structural modeling to estimate toxicity. Examples of structural modeling include quantitative structure-activity relationship (QSAR) modeling and the modeling of surrogate or relative potency chemical toxicity information.

Toxicity and Exposure Data: Many of the acute and short-term exposure guidelines described in Table 7-1 are prescribed for use only during emergency response decisions, such as decisions about evacuation or sheltering in place and decisions based on emergency drinking water guidance. These acute and short-term values likely are inappropriate as final clearance goals. Ideally, the full range of exposure guidelines and the underlying bases and assumptions should be evaluated for appropriateness to the phase of cleanup under consideration.

Feasibility: Feasibility concerns include technical, operational, and economic issues that affect the development of clearance goals. These concerns are summarized below, along with concerns that should be considered during the development of clearance goals and decision criteria.

Technical Issues:

- Ability of analytical capability and laboratory capacity to support clearance goals
- Ability of the decontamination options to be applied to incidents of varying scale

- Ability of field screening instruments to detect CWAs at operationally useful levels
- Surfaces, media, and material resistant to currently available decontamination technologies
- Long-term effectiveness

Operational Issues:

- Organizational conflicts and policies
- Social acceptability
- Government regulations
- Whether or not management supports the task or site project

Economic Issues:

- Cost-effectiveness of the system
- If benefits outweigh costs
- Project feasibility based on time and resource constraints

7.2 CLEARANCE DECISIONS

- Clearance goals that have considered detection limits often are required in order to develop clearance SAP objectives.
- A range of clearance goals and decontamination methods should be compared.
- The overall estimated direct cleanup cost, length of time to final clearance, and indirect economic impacts should be considered.

Clearing any site or facility for re-occupancy requires determining if environmental sampling data indicate that the clearance goal and any other criteria have been met. The selected clearance goal(s) must be ***feasible to achieve and acceptable to those affected***. For example, for an incident with a significant extent of CWA contamination and complex cleanup options, an extremely stringent cleanup goal may be technically infeasible or may contribute to other adverse economic problems that significantly decrease the quality of life of affected populations. Feasibility and acceptability decisions should be made with as much input as possible by those affected and should consider all available information. However, it is of paramount importance that all potential health effects are evaluated when determining preliminary clearance goals and clearance criteria used to make the final decision for ultimate resumed reuse or re-occupancy.

Final decisions ultimately are made at the local level with accountability shared amongst all stakeholders. The EU, in coordination with Planning and Operation Section special units or branches, will prepare a report on remediation actions, including details on decontamination and data from clearance sampling. The report should include a data quality assessment and statistical evaluation of results. The IC/UC will review the report and confirms that site, regulatory, and stakeholder needs are met. Therefore, the clearance criteria for evaluating clearance goals should be clearly discussed with stakeholder representatives.

Clearance decisions may include quantitative and qualitative assessments applied at each stage of site restoration activities (see Sections 7.1.2 and 7.1.3). Such assessments may involve issues unique to the

site-specific circumstances and development of risk-based clearance goals. Site-specific circumstances affect the time to achieve recovery and the resources required, including the extent of CWA contamination, the numbers and types of critical infrastructure, specific on-site items, and economic impacts of cleanup options. Other confounding factors may include crisis management or first response activities, the nature and toxicity of breakdown products, collateral hazards, and waste generation.

7.3 CLEARANCE SAMPLING AND ANALYSIS PLAN

The goal and objectives of a clearance SAP are developed in coordination with individuals directly involved with the sampling effort or who have a direct interest in the information or data collected. The ultimate goal of the clearance SAP is to support the clearance criteria for re-occupancy. Clearance SAP objectives must be site-specific. Typical objectives of a sampling design for environmental data collection for clearance include the following:

- To support a decision about if CWA contamination levels exceed a threshold of unacceptable risk
- To determine if certain characteristics of affected human populations differ
- To identify the location of "hot spots" (areas having high levels of CWA contamination) or plume delineation
- To characterize the nature and extent of CWA contamination at a site

A well-planned sampling design ensures that data are defensible for their intended use and acquired with appropriate use of time, money, and resources. It is recommended that a DMP be prepared so that field personnel and data managers can provide consistent, quality-assured data that can be used for decision-making purposes, efficient project archiving, and sharing with stakeholders (see Section 4.6). In addition, a DMP allows OSCs to establish protocols for data control, consistency, reliability, and reproducibility throughout the life of the project. Finally, the DMP establishes a framework for consistent documentation of the quality and validity of field and laboratory data compiled during consequence management.

Clearance goals and criteria are developed by a Clearance Committee that includes public health officials, scientists, SMEs, facility and site managers, and various stakeholders. The Clearance Committee operates under the Planning Section of the EU in NIMS (DHS 2008). The Clearance Committee must understand the regulatory authority (EPA policies and Presidential Executive Orders) for and the basis of the risk assessment. The ultimate purpose of clearance sampling as well as the management objectives should be defined for the assessment.

Clearance criteria provides for measures and decisions made during a response to implement the clearance goals. The development, selection, and use of clearance goals affect all phases of the response, with the ultimate purpose of allowing the general public to re-enter and re-occupy a site or facility. Clearance decisions must consider factors such as previous actions and decisions made during crisis management, the type of chemical contamination, feasibility, PPE, safety requirements for cleanup workers, and waste management. Sound and defensible clearance decisions result in shared acceptance and accountability by the IC/UC as well as an end result that balances local needs and national requirements.

The clearance SAP must include specific information on the numbers and labels of samples collected, exact sampling locations, and the rationales for the sampling and selection of the sampling locations.

The SAP must specify the sampling methods, sample packaging and transport procedures, and sample documentation procedures. In addition, the SAP should identify the individuals who will instruct the necessary sampling personnel, collect the necessary supplies, and perform all sampling-related activities. Such tasks largely are the responsibility of the contractor performing the sampling.

After the clearance SAP is completed, the Planning Section Chief approves it. IC/UC attaches the clearance SAP to the IAP for the next operational period, and clearance sampling begins. Both the Planning and Operations Sections must review data continuously and work closely with the contractor to ensure that all sampling guidance is followed. Guidance should include, for example, reviewing the method for generating random sampling locations and working with the contractor's staff to ensure that they understand and follow the guidance for statistical sampling. It is important that the data are managed locally and constantly to ensure consistent production of high-quality data.

7.4 SAMPLING STRATEGY AND METHODS

Clearance sampling scheme(s) for the different media affected by a CWA incident should be identified and discussed by the ECC. If CWA contamination occurs indoors, then samples most likely will be collected from solids, air, and surfaces. However, if an indoor facility has an indoor terrace, soil samples also may be required. Similarly, ornamental indoor water features may require water sampling. Also, decontamination methods can produce liquid wastes, so water sampling should be considered early in the clearance process.

The clearance sampling strategy should determine sampling locations and methods. Samples can be collected using a grid system and may be collected randomly (unbiased), judgmentally (biased), or both. Sample collection procedures depend on the media to be sampled. For example, soil and surface samples can be collected as discrete or composite samples. Although air monitoring data are collected in real-time, not all analytes can be detected in real-time and some samples will be sent to a laboratory for further analysis. SOPs should be used for both sampling and monitoring. A searchable SAM document is available at http://www.epa.gov/sam/ or http://www.epa.gov/sam/SAM_2012_07162012.pdf (for the PDF file). Appendix 5 contains the SAM 2012 Appendix A of selected analytical methods for CWAs.

In addition, the sampling strategy and methods must consider that a CWA may sorb into some materials. If the CWA may outgas from materials after decontamination, then bulk samples of these materials should be collected. Bulk sampling should be considered only if the CWA may penetrate into a material or material pore spaces. If bulk sampling results are positive for CWA contamination, it should be assumed that the material poses a low level of exposure associated with some level of risk. Consequently, the materials may require removal or sealing, or long-term monitoring may be required.

Laboratory-based methods often have the required sensitivity for clearance decision-making and are rigorous. Laboratory data often need to be defensible so they can instill public confidence. Therefore, the analytical laboratory's work should follow good laboratory practices, and standard operating proceedures for CWA.

7.5 LONG-TERM MONITORING

After clearance goals are met, long-term monitoring requirements will be determined with guidance from local public health officials and other stakeholders. The clearance goals should be suitable as action levels for long-term monitoring. The duration of long-term environmental monitoring depends on CWA- and site-specific conditions.

Site conditions should initially guide the duration of sampling. Repeated sampling for the presence or dissipation of released CWAs can be conducted weekly for at least 1 month to confirm that concentrations remain at or below acceptable levels. Source strength and degree of dispersion throughout the site can be evaluated to determine the duration of air monitoring. Release of more persistent CWAs may require longer monitoring durations.

7.6 SUMMARY OF CLEARANCE ACTIONS

Clearance is an iterative process that may be continuously refined throughout the consequence management phase. Clearance requires coordination with many internal and external groups or teams. Effective risk communication should be a priority throughout the process to facilitate re-occupancy of an affected area or facility. Decisions on clearance should be based, in part, on recommendations from the Clearance Committee evaluating decontamination efficacy data and clearance sampling results. The process for re-entry should be closely coordinated with the IC/UC and stakeholder groups. Decision-makers must carefully review and analyze the recommendation(s) of the Clearance Committee. Generally, local public health authorities are responsible for re-occupancy and resumed use determinations made based on sampling data, data interpretation, and site-specific clearance goals and criteria. Table 7-2 summarizes the clearance actions.

Table 7-2. Summary of Clearance Actions

PERSONNEL	ACTION
Planning Section: EU, with input from the TWG	Review and revise incident-specific clearance SAP as necessary
PIO	Communicate with the public
IC/UC	Approve incident-specific clearance SAP if it was revised.
Operations Section: Sampling Group	Perform clearance sampling
Planning Section: EU, with input from Decontamination Group, TWGs, and Clearance Committee	Evaluate clearance SAP results Determine if clearance goals are met Recommend additional decontamination, if necessary
Planning Section: EU, with input from Clearance Committee	Write final report on remediation actions for submittal to IC/UC
IC/UC	Review final report to ensure site, regulatory, and stakeholder needs are met Make recommendations about whether site and items have been effectively remediated
Public Health Officials	Determine whether to initiate restoration activities in all or parts of the site; if not, additional decontamination may be warranted

7.7 REFERENCES – CLEARANCE

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8. WORKER HEALTH AND SAFETY

Numerous agencies and organizations have developed lists of potential CWAs, and there is a growing body of research on the subject. Emergency responders should familiarize themselves with the sources cited as references in this section and elsewhere in this Guidebook to develop a basic understanding of the major classes and types of CWAs and their properties.

This section discusses worker health and safety, including the background and regulatory basis, requirements and training, and elements of health and safety.

8.1 BACKGROUND AND REGULATORY BASIS

The purpose of this section of the Guidebook is to help emergency and recovery responders respond safely and effectively to incidents involving CWAs. As always, saving lives and preserving public health takes precedence over all other considerations. This section does not discuss health and safety issues associated with individual agents in detail instead but provides an overview. Comprehensive information about the various CWAs is presented in the Appendices of this document. Emergency responders should maintain a working knowledge of the agent categories and their general properties (EPA 2011).

Emergency response and recovery related to a CWA release are somewhat similar to conventional HAZMAT incident response and recovery. However, there are important differences that may have profound implications for responders. CWAs may be designed to be lethal in very small amounts. Further complicating the response and recovery, emergency responders may need to follow special procedures to treat the incident site as a crime scene. A CWA release also may be recognized through symptoms developed by victims. These factors pose unique challenges to those charged with responding to an incident (EPA 2011).

EPA is responsible for supporting state and local responders addressing the environmental consequences of a CWA incident to minimize or mitigate human health threats. In this capacity, EPA serves as a "safety net" for state and local first responders by providing a range of capabilities, including site characterization, source containment, preliminary decontamination, ambient air monitoring (for health and safety purposes), and preliminary waste staging. During a CWA incident, EPA emergency responders likely will integrate into or establish an IC/UC. As in the case of conventional HAZMAT response and recovery, each incident is unique, and cleanup procedures as well as site-specific HASPs must be developed based on the site-specific hazards (EPA 2011). Appendix 2 provides a generic CWA HASP, and Appendix 3 provides relevant air monitoring information. Exposure guidelines are provided in Appedix 8.

8.2 REQUIREMENTS AND TRAINING

This Guidebook is intended for use by emergency responders who have received, at a minimum, the 40-hour OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training and annual refresher training as prescribed in 29 CFR 1910.120 (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9765).

The information in this section of the Guidebook supplements but does not replace this comprehensive training and is based on the premise that the user has a thorough working knowledge of HAZMAT incident response and recovery. By itself, this section is not intended to prepare responders to work in areas contaminated with CWAs. This information must be integrated into existing emergency responder

training and HASPs. This section also refers users to the procedures described in other sections of this Guidebook.

The following sections discuss 40-hour HAZWOPER training, medical monitoring, and CWA awareness.

8.2.1 40-Hour HAZWOPER

Emergency responders must receive initial 40-hour HAZWOPER training, followed by annual 8-hour HAZWOPER refresher courses that comply with the OSHA regulations at 29 CFR 1910.120.

8.2.2 Medical Monitoring

Emergency responders must receive initial and annual medical monitoring and clearance. Medical examinations are performed to establish an employee's baseline health status and to determine if an employee's health status changes over time because of occupational exposures. In addition, medical examinations are used to determine if employees are capable of performing their duties while wearing PPE under conditions (such as extreme temperatures) that may be expected at a work site. Examinations must be performed by or under the supervision of a physician, who, at a minimum, is licensed in medicine, possesses specific training or expertise in occupational medicine, and has experience performing medical surveillance examinations (EPA 2008).

8.2.3 CWA Awareness

As part of training required before entry onto the site is allowed, site workers should complete CWA awareness training covering potential hazards at the job site, required PPE, signs and symptoms of exposure, and work practices and engineering controls to limit exposure. The training should also cover decontamination as outlined in the requirements at 29 CFR 1910.120(e)(2).

8.3 ELEMENTS OF HEALTH AND SAFETY

This section discusses program elements that specifically address the health and safety of emergency responders who will participate in CWA incident response and recovery. Specifically, medical monitoring and surveillance, the HASP, training, and exposure limits and PPE are discussed.

8.3.1 Medical Monitoring and Surveillance

In addition to medical monitoring of employees before site entry is allowed (see Section 8.2.2), medical monitoring and surveillance will be performed during employee entry and exit from the site. Employees will be monitored for symptoms such as heat stress, cold stress, and exposure. During a suspected CWA release incident, EPA will have access to medical professionals from the EPA, CDC, and state and local health departments.

During on-site emergency response and recovery activities, the Health and Safety Supervisor will direct health and safety efforts as directed by OSHA at 29 CFR 1920.120(b)(2)(i)(B). The Health and Safety Supervisor position may be filled through the ICS by the SO who is part of the Command Staff to the IC/UC. The SO may have assistants who may also represent assisting agencies or jurisdictions. The SO or assistants may provide medical monitors to perform close observation and monitoring of emergency responders for signs of acute exposure and other safety or health problems (such as heat stress). Working with the SO, these medical monitors may determine if any special monitoring or special tests are required. In addition, the SO will work to develop and implement agent- and site-specific protective measures, such as the administration of DuoDote® kits. In the case of CWA exposure, health care

providers must provide emergency responders with follow-up treatment and medical evaluations to monitor for possibly chronic or latent health effects.

8.3.2 Health and Safety Plan

In accordance with 29 CFR 1920.120(b)(1)(i), one components of the safety and health program is a site-specific HASP. The HASP, which must be kept on site, must address the health and safety hazards for each phase of site operations and must specify the requirements and procedures for employee protection. At a minimum, the HASP should include the following:

- A safety and health risk or hazard analysis for each site task and operation
- Employee training assignments
- PPE to be used by employees for each site task and operation
- Medical surveillance requirements
- Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration for the monitoring and sampling equipment
- Action levels for air monitoring and personnel monitoring (see Appendix 4)
- Site control measures in accordance with the site control program
- Decontamination procedures
- An emergency response and recovery plan meeting the requirements for safe and effective responses to emergencies, including necessary PPE and other equipment
- Hospital location, hospital route map, and emergency telephone numbers
- Confined space entry procedures
- A spill containment program
- Sign-off sheet for signatures of personnel that have read the HASP

The site specific HASP provides for pre-entry briefings held before the initiation of any site activity and at other times as necessary to ensure that employees are apprised of the site-specific HASP and that the HASP is being followed. Information and data obtained from site characterization and analysis work should be used to prepare and update the HASP. The HASP is an ever-changing document as information changes and updates are required. One of the responsibilities of the SO is to ensure that a relevant site-specific HASP is developed and updated.

8.3.3 Training

A site-specific awareness or training program should be implemented as required under the health and safety program. Before any work is performed at a hazardous waste or CWA incident site, the employer must provide its employees with initial training based on the tasks and operations that employees will perform and the associated anticipated exposures. Not only should this training cover the CWA involved, it should also discuss risks associated with the work to be conducted at the site, including auxiliary risks such as hazards related to heavy machinery, heat stress, and the decontamination process and chemicals (OSHA 1998).

8.3.4 Exposure Limits and Personal Protective Equipment

The SO (or company SO or other designated person) must work closely with public health officials to select the PPE used during an incident. The following sections summarize recommended airborne exposure limits (AEL) and PPE for selected blister and nerve CWAs. Appendix 8 also contains inhalation exposure guidelines for selected CWAs

8.3.4.1 Blister Agent Airborne Exposure Limits and Personal Protective Equipment

The recommendations for PPE should be based on a site-specific hazard analysis of possible hazards, including skin contact with a blister agent, air concentrations, heat stress, and other anticipated hazards. All PPE should be used with appropriate additional administrative controls, including medical surveillance, employee training, respirator fit-testing, and decontamination procedures, to limit the potential for unforeseen adverse effects.

There are no current OSHA Permissible Exposure Limits (PEL) for exposure to blister agents. The NRC and EPA have published AEGLs of airborne limits for various agents to characterize risk to the general population during a one-time accident and emergency scenario with time limits not to exceed 8 hours of exposure. For emergency responders and support personnel responding to a blister agent incident, it may be appropriate to establish a target exposure limit at time-weighted averages (TWA) less than the lowest recommended AEGL-1 level for a given exposure duration. The AEGL-1 level represents the mildest effect category above which the general population, including susceptible individuals, may experience noticeable eye discomfort, irritation, or non-sensory effects. However, the effects are not disabling and are reversible upon cessation of exposure. The AEGL-1 and AEGL-2 values are based on direct vapor exposure of the human eye and tissues surrounding the eye (conjunctiva), which the NRC and NAS consider the most sensitive organ or tissue for blister agent vapor exposure effects. The CDC has made recommendations for worker exposure limits during with routine work processes such as demilitarization and transportation. (**Note:** The CDC/National Center for Environmental Health (NCEH) worker exposure limits do not specifically include storage. These exposure standards may be substituted for work extending beyond the 8-hour AEGL limit if deemed appropriate after an incident.)

The PPE ensemble selected depends on the level of knowledge available regarding the CWA. Each responder initially entering a known release area should wear a positive-pressure self-contained breathing apparatus (SCBA) with a Level A protective suit until monitoring results allow for other decisions. OSHA generally requires these respirators to be NIOSH-certified chemical, biological, radiological, and nuclear (CBRN) SCBA respirators. Some CWAs have been shown to seriously degrade and damage some respirators. Respiratory protection specifically approved by NIOSH for CBRN exposures is highly desirable, but when such protection is not available, the IC may allow the use of alternative suitable respirators during emergency operations. Depending on exposure levels, other NIOSH-approved SCBAs or full-face air-purifying respirators (APR) may be used if the respirators have been specifically tested by the manufacturer as effective against CWAs. Respirators other than SCBAs may be selected based on accurate monitoring results with appropriate limits of detection for the agent of concern. When conditions have been determined to be appropriate for the use of APRs, a NIOSH-approved, CBRN, full-facepiece APR with a CBRN canister or a CWA-tested, full-facepiece APR with a combination organic vapor/acid gas/particulate canister may be used. A list of CBRN-approved SCBAs and APRs is available at the NIOSH website. (http://www2a.cdc.gov/drds/cel/cel_form_code.asp)

The requirements for skin protection above AEGL-1 but below the AEGL-2 should initially focus on reducing the potential for contact with liquid agent residue. As airborne exposure rises above the AEGL-

2 level, the potential for significant vapor absorption through the skin is possible, and exposed skin should be minimized with the use of chemically protective clothing, preferably vapor-tight encapsulating suits. Above AEGL-3, the incidence and severity of skin burns increases and the use of encapsulating suits should be mandatory.

Tables 8-1 and 8-2 consolidate some information relating to AELs for blister agents and the relative protection provided by certain types of PPE, including respirators and clothing, for blister agents. The information in these tables are for planning purposes only and do not constitute recommendations for particular work schedules. All work schedules should be reviewed by a competent occupational health professional skilled in use of exposure limits and PPE.

Respiratory protection and other PPE recommendations are presented in Tables 8-1 and 8-2 as time-dependent exposure limits by multiplying the NIOSH current assigned protection factor (APF) of the type of respirator and the AEGL-1 target level. Exposures above the AEGL-1 level require a more protective respirator. It should be noted that OSHA's proposed rule on APFs indicates that some hooded or helmeted powered APRs have much higher protection factors than the current APF of 25. However, this rule is pending and subject to change. The U.S. Army's immediately dangerous to life or health (IDLH) level is set as the ceiling limit for respirators other than SCBAs. Any exposures approaching the IDLH level should be regarded with extreme caution and the use of SCBAs should be considered. All APRs require a change schedule for cartridges or canisters not to exceed the maximum 8-hour exposure covered by the AEGLs.

8.3.4.2 Nerve Agent Airborne Exposure Limits and Personal Protective Equipment

The recommendations for PPE should be based on a site-specific hazard analysis of possible hazards, including skin contact with a nerve agent, air concentrations, heat stress, and other anticipated hazards. All PPE should be used with appropriate additional administrative controls, including medical surveillance, employee training, respirator fit-testing, and decontamination procedures, to limit the potential for unforeseen adverse effects.

There are no current OSHA PELs for exposure to nerve agents. The NRC and EPA have published AEGLs of airborne limits for various agents to characterize risk to the general population during a one-time accident and emergency scenario with time limits not to exceed 8 hours of exposure. For emergency responders and support personnel responding to a nerve agent incident, it may be appropriate to establish a target exposure limit at TWAs less than the lowest recommended AEGL-1 level for a given exposure duration. The AEGL-1 level represents the mildest effect category above which the general population, including susceptible individuals, may experience noticeable eye discomfort, irritation, or non-sensory effects. However, the effects are not disabling and are reversible upon cessation of exposure. The AEGL-1 and AEGL-2 values are based on direct vapor exposure of the human eye and tissues surrounding the eye (conjunctiva), which the NRC and NAS consider the most sensitive organ or tissue for nerve agent vapor exposure effects. The CDC has made recommendations for worker

Table 8-1. Summary of CDC and U.S. Army Airborne Exposure Limits for Blister Agents

AIRBORNE EXPOSURE LIMIT	MAXIMUM TIME OF EXPOSURE	SULFUR MUSTARD (HD) CONCENTRATION (mg/m^3)	LEWISITE (L) CONCENTRATION (mg/m^3)
IDLH	One-time exposure	0.7 (7E-1)	Not available
STEL	15-Minute exposure limited to one occurrence per day	0.003 (3E-3)	Not available
WPL	TWA for 8-hour day, 5 days per week	0.0004 (4E-4)	0.003
GPL	TWA for 24-hour day, 7 days per week over a lifetime	0.00002 (2E-5)	0.003

Notes:

IDLH Immediately dangerous to life or health
GPL General population limit
mg/m^3 Milligram per cubic meter
STEL Short-term exposure limit
WPL Worker population limit

Table 8-2. PPE Selection Guide for Emergency and Accident Responses Based on EPA's AEGLs for Blister Agents

ONE-TIME EMERGENCY EXPOSURE NOT TO EXCEED 8 HOURS TOTAL			
Effects for Exposures Above AEGLs and PPE Guidance	Maximum Time of Exposure	Sulfur Mustard (HD) Concentration (mg/m^3)	Lewisite (L) Concentration (mg/m^3)
Greater than AEGL-1: Threshold for conjunctival injection and minor discomfort, with no functional decrement in human volunteers Respiratory: Any NIOSH CBRN-approved or CWA-tested SCBA, NIOSH-approved CBRN full-facepiece APR with CBRN canister, or CWA-tested full-facepiece APR with combination organic vapor/acid gas/particulate canister Skin protection: Protect against contact with liquid residues; minimize exposed skin and protect high-contact-potential skin areas using gloves and boots; butyl rubber or impervious construction are desirable	10 min	0.40	Not available
	30 min	0.13	Not available
	1 hr	0.067	Not available
	4 hr	0.017	Not available
	8 hr	0.0083	Not available
Greater than AEGL- 2: Threshold for well-marked generalized conjunctivitis, edema, photophobia, and eye irritation; potentially impacting functional abilities or ability to escape; delayed recovery; some studies indicate increased potential for delayed skin burns from vapor exposure Respiratory: Any NIOSH CBRN-approved or CWA-tested SCBA, NIOSH-approved CBRN full-facepiece APR with CBRN canister, or CWA-tested full-facepiece APR with combination organic vapor/acid gas/particulate canister Skin Protection: An encapsulating Level A-type suit that provides skin vapor protection constructed of butyl rubber or layered impervious clothing that has received material and construction testing against specific CBRN agents by the manufacturer, the government, or a third-party testing agency using an accepted protocol; the NFPA 1991 Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and the NFPA 1994 Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents require mandatory testing against CWAs	10 min	0.60	Not available
	1 hr	0.10	Not available
	4 hr	0.025	Not available
	8 hr	0.013	Not available
	30 min	0.20	Not available
Greater than AEGL- 3 (life-threatening): Threshold for sulfur mustard inhalation lethality in mice; some studies indicate that severe skin vesication from vapor exposure likely above this level Respiratory: Any NIOSH CBRN-approved or CWA-tested SCBA Skin Protection: An encapsulating Level A-type suit that provides skin vapor protection constructed of butyl rubber or layered impervious clothing that has received material and construction testing against specific CBRN agents by the manufacturer, the government, or a third-party testing agency using an accepted protocol; the NFPA 1991 Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies and the NFPA 1994 Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents require mandatory testing against CWAs	10 min	3.9	Not available
	30 min	2.7	Not available
	1 hr	2.1	Not available
	4 hr	0.53	Not available
	8 hr	0.27	Not available

Note:

NFPA National Fire Protection Association

exposure limits during with routine work processes such as demilitarization and transportation. (**Note:** The CDC/NCEH worker exposure limits do not specifically include storage. These exposure standards may be substituted for work extending beyond the 8-hour AEGL limit if deemed appropriate after an incident.)

The PPE ensemble selected depends on the level of knowledge available regarding the CWA. Each responder initially entering a known release area should wear a positive-pressure SCBA with a Level A protective suit until monitoring results allow for other decisions. OSHA generally requires these respirators to be NIOSH-certified CBRN SCBA respirators. Some CWAs have been shown to seriously degrade and damage some respirators. Respiratory protection specifically approved by NIOSH for CBRN exposures is highly desirable, but when such protection is not available, the IC may allow the use of alternative suitable respirators during emergency operations. Depending on exposure levels, other NIOSH-approved SCBAs or full-face APRs may be used if the respirators have been specifically tested by the manufacturer as effective against CWAs. Respirators other than SCBAs may be selected based on accurate monitoring results with appropriate limits of detection for the agent of concern. When conditions have been determined to be appropriate for the use of APRs, a NIOSH-approved, CBRN, full-facepiece APR with a CBRN canister or a CWA-tested, full-facepiece APR with a combination organic vapor/acid gas/particulate canister may be used. A list of CBRN-approved SCBAs and APRs is available at the NIOSH website. (http://www2a.cdc.gov/drds/cel/cel_form_code.asp)

Tables 8-3 and 8-4 consolidate some information relating to AELs for nerve agents and the relative protection provided by certain types of PPE, including respirators and clothing, for nerve agents. The information in these tables are for planning purposes only and do not constitute recommendations for particular work schedules. All work schedules should be reviewed by a competent occupational health professional skilled in use of exposure limits and PPE.

Respiratory protection and other PPE recommendations are presented in Tables 8-3 and 8-4 as time-dependent exposure limits by multiplying the NIOSH current APF of the type of respirator and the AEGL-1 target level. Exposures above the AEGL-1 level require a more protective respirator. It should be noted that OSHA's proposed rule on APFs indicates that some hooded or helmeted powered APRs have much higher protection factors than the current APF of 25. However, this rule is pending and subject to change. The U.S. Army's IDLH level is set as the ceiling limit for respirators other than SCBAs. Any exposures approaching the IDLH level should be regarded with extreme caution and the use of SCBAs should be considered. All APRs require a change schedule for cartridges or canisters not to exceed the maximum 8-hour exposure covered by the AEGLs.

A recent estimation of percutaneous absorption of nerve agent vapor suggests that a hazardous dose from skin absorption through airborne exposures is unlikely unless levels are significantly greater than the IDLH levels listed below. Skin protection at lower levels should be designed to prevent skin contact with liquid or contaminated surfaces. Nerve agents are toxic in small amounts on the skin, and some can persist in the environment for days.

Table 8-3. Summary of CDC and U.S. Army Airborne Exposure Limits for Nerve Agents

AIRBORNE EXPOSURE LIMIT	MAXIMUM TIME OF EXPOSURE	TABUN (GA) CONCENTRATION (mg/m^3)	SARIN (GB) CONCENTRATION (mg/m^3)	SOMAN (GD) or CYCLOSARIN (GF) CONCENTRATION (mg/m^3)	VX CONCENTRATION (mg/m^3)
IDLH	One-time exposure	0.1 (1E-1)	0.1 (1E-1)	0.05 (5E-2)	0.003 (3E-3)
STEL	15-Minute exposure limited to one occurrence per day	0.0001 (1E-4)	0.0001 (1E-4)	0.00005 (5E-5)	0.00001 (1E-5)
WPL	TWA for 8-hour day, 5 days per week	0.00003 (3E-5)	0.00003 (3E-5)	0.00003 (3E-5)	0.000001 (1E-6)
GPL	TWA for 24-hour day, 7 days per week over a lifetime	0.000001 (1E-6)	0.000001 (1E-6)	0.000001 (1E-6)	0.0000006 (6E-7)
Percutaneous Vapor Toxicity: Calculated minimal effect values for 2-hour exposure period	2 hours	2.7 (2. 7E-0)	1.5 (1. 5E-0)	0.375 (3.75E-1)	0.03 (3E-2)

Notes:

IDLH Immediately dangerous to life or health
GPL General population limit
mg/m^3 Milligram per cubic meter
STEL Short-term exposure limit
WPL Worker population limit

Table 8-4. PPE Selection Guide for Emergency and Accident Responses Based on EPA's AEGLs for Nerve Agents

EFFECTS FOR EXPOSURES ABOVE AEGLs AND PPE GUIDANCE	MAXIMUM TIME OF EXPOSURE (ONE-TIME EXPOSURE)	TABUN (GA) CONCENTRATION (mg/m^3)	SARIN (GB) CONCENTRATION (mg/m^3)	SOMAN (GD) OR CYCLOSARIN (GF) CONCENTRATION (mg/m^3)	VX CONCENTRATION (mg/m^3)
AIR: Less than AEGL-1 for stated duration times: No respirator required SKIN: Level D clothing if no splash or contact hazard; general washable work clothing or disposable coverall; washable or disposable boots and gloves recommended for general protection; if skin contact with liquid possible, butyl rubber or layered impervious clothing that has received material and construction performance testing against specific chemical agents by the manufacturer, the government, or a third-party testing agency using an accepted protocol	10 min	0.0069	0.0069	0.0035	0.00057
	30 min	0.0040	0.0040	0.0020	0.00033
	1 hr	0.0028	0.0028	0.0014	0.00017
	4 hr	0.0014	0.0014	0.00070	0.00010
	8 hr	0.0010	0.0010	0.00050	0.000071
AIR: Less than 25 times the 8-hour AEGL-1: (a) Any CBRN-approved or CWA-tested powered air-purifying loose-fitting facepiece, hood, or helmet, and NIOSH-approved CBRN filter or a combination organic/vapor/acid gas/particulate cartridge or filter, or (b) Any CBRN-approved or CWA-tested continuous-flow respirator with a loose-fitting facepiece, hood, or helmet SKIN: Same as above for less than AEGL-1 except that if skin contact with liquid possible, boots and gloves mandatory; other chemical clothing based on hazard assessment; butyl rubber or layered impervious clothing that has received material and construction performance testing against specific chemical agents by the manufacturer, the government, or a third-party testing agency using an accepted protocol	30 min	<0.1(IDLH)	<0.1(IDLH)	<0.05(IDLH)	<0.003(IDLH)
	1 hr	<0.07	<0.07	<0.035	<0.003(IDLH)
	4 hr	<0.035	<0.035	<0.0175	<0.0025
	8 hr	<0.025	<0.025	<0.0125	<0.00178
AIR: 50 times the 8-hour AEGL-1: Any CBRN-approved or CWA-tested tight-fitting air-purifying or powered air-purifying full-facepiece SKIN: Same as above for less than 25 times the 8-hour AEGL-1	30 min	<0.1(IDLH)	<0.1(IDLH)	<0.05(IDLH)	<0.003(IDLH)
	1 hr	<0.1(IDLH)	<0.1(IDLH)	<0.05(IDLH)	<0.003(IDLH)
	4 hr	<0.07	<0.07	<0.035	<0.003(IDLH)
	8 hr	<0.050	<0.05	<0.025	<0.003(IDLH)
AIR: Greater than 50 times the 8-hour AEGL-1: (a) Any CBRN-approved or CWA-tested SCBA or full-facepiece APR operated in pressure-demand mode or (b) any CBRN-approved or CWA-tested APR with full facepiece operated in pressure-demand mode with auxiliary escape bottle SKIN: Level A if vapor concentration exceeds levels listed in Table 8-3 for percutaneous effects; Level A or B otherwise; skin contact more likely at higher air concentrations; butyl rubber or layered impervious clothing that has received material and construction performance testing against specific chemical agents by the manufacturer, the government, or a third-party testing agency using an accepted protocol	8 hr	>0.050	>0.050	>0.025	>0.003(IDLH)

8.4 REFERENCES – WORKER HEALTH AND SAFETY

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APPENDICES

APPENDIX 1

QAPP/FSP TEMPLATES

(FOR FULL TEMPLATE, PLEASE SEE HTTP://WWW.EPA.GOV/REGION3/ESC/QA/QAPP.HTM)

UNIFORM FEDERAL POLICY

GENERIC QUALITY ASSURANCE PROJECT PLAN

FOR CHEMICAL WARFARE AGENTS

Submitted by
Weston Solutions, Inc., RST 2

January

2014

INTRODUCTION:

According to U.S. Environmental Protection Agency (EPA) policy, systematic planning must be used to develop acceptance or performance criteria for collection, evaluation, or use of environmental data. Systematic planning identifies the expected outcome of the project, technical goals, cost and schedule, and the acceptance criteria for the final result, which must be documented in a Quality Assurance Project Plan (QAPP). As defined in the Code of Federal Regulations (CFR) at 40 CFR 300, the QAPP describes policy, organization, and functional activities, as well as the Data Quality Objectives (DQOs) and measurements necessary to achieve data of adequate quality to meet its intended use. The QAPP is a plan that integrates the technical and quality control aspects of a project throughout its life cycle, including planning, implementation, evaluation, and corrective actions.

The purpose of this Generic QAPP is to provide the information and tools needed to prepare a Site-Specific QAPP for Chemical Warfare Agents. Information contained herein is from the most current Chemical Warfare Agents planning, collection, and analytical method guidance documents available and are referenced throughout this Generic QAPP. The Uniform Federal Policy (UFP) for QAPPs [a consensus policy effort by EPA/U.S. Department of Defense (DOD)/U.S. Department of Energy (DOE)] has been adopted as policy in EPA, Region II for all Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)/Resource Conservation and Recovery Act (RCRA) projects for management of environmental data collection and use. As such, this Generic QAPP also has been prepared in accordance with the UFP-QAPP Manual requirements.

A graded approach should be used to prepare a QAPP that is specific to the incident and appropriate for the type of environmental data collection activities performed that will support the decisions being made. Within EPA, Region II, QAPPs for environmental data collection activities associated with emergency response have been divided into the following three categories: initial incident monitoring, transitional or follow-up monitoring, and long-term monitoring, based upon the time-critical nature of the incident and immediacy of threat to human health and the environment. The information provided in this Generic QAPP for Chemical Warfare Agents is to be used as the basis for developing/preparing the Site-Specific QAPP appropriate to each emergency response category, when Chemical Warfare Agents data is needed.

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LIST OF ACRONYMS

ANSI	American National Standards Institute
APHL	Association of Public Laboratories
ASM	American Society for Microbiology
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BSC	Chemical Warfare Agents Safety Cabinet
CAIS	Chemical Agent Identification Set
CDC	Centers for Disease Control and Prevention
CDTF	Chemical Defense Training Facility
CLIA	Clinical Laboratory Improvement Amendment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("Superfund")
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMAT	Consequence Management Advisory Team
COC	Chain of Custody
CWA	Clean Water Act
CWM	Chemical Warfare Material
DF	Dilution Factor
DoD	Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	Data Quality Objective
DCN	Document Control Number
DESA	Division of Environmental Science and Assessment
DI	Deionized Water
DQI	Data Quality Indicator
EPA	Environmental Protection Agency
ERT	Environmental Response Team
FAR	Federal Acquisition Regulations, CFR Title 48
FBI	Federal Bureau of Investigation
IMT	Incident Management Team
IDL	Instrument Detection Limit
ISO	International Organization for Standardization
LAN	Local Area Network
LCS	Laboratory Control Sample
LRN	Laboratory Response Network
MDL	Method Detection Limit
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NELAP	National Environmental Laboratory Accreditation Program
NIOSH	National Institute of Safety and Health
NIST	National Institute of Standards and Technology
OSC	On-Scene Coordinator
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
QC	Quality Control

LIST OF ACRONYMS (Concluded)

QSAS	Quality Systems for Analytical Services
QMP	Quality Management Plan
RPD	Relative percent difference
SOP	Standard Operating Procedure
SOW	Statement of Work
SPM	Site Project Manager
START	Superfund Technical Assessment and Response Team
TDD	Technical Direction Document
UFP	Uniform Federal Policy
USDA	United States Department of Agriculture

CROSSWALK

The following table provides a "cross-walk" between the QAPP elements outlined in the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP Manual), the necessary information, and the location of the information within the text document and corresponding QAPP Worksheet. Any QAPP elements and required information that are not applicable to the project are circled.

QAPP Element(s) and Corresponding Section(s) of UFP-QAPP Manual	Required Information	Crosswalk to QAPP Section	Crosswalk to QAPP Worksheet No.
Project Management and Objectives			
2.1Title and Approval Page	-Title and Approval Page	Approval Page	1
2.2Document Format and Table of Contents 2.2.1Document Control Format 2.2.2Document Control Numbering System 2.2.3Table of Contents 2.2.4QAPP Identifying Information	-Table of Contents -QAPP Identifying Information	TOC Approval Page	2
2.3Distribution List and Project Personnel Sign-Off Sheet 2.3.1Distribution List 2.3.2Project Personnel Sign-Off Sheet	-Distribution List -Project Personnel Sign-Off Sheet	Approval Page	3 4
2.4Project Organization 2.4.1Project Organizational Chart 2.4.2Communication Pathways 2.4.3Personnel Responsibilities and Qualifications 2.4.4Special Training Requirements and Certification	-Project Organizational Chart -Communication Pathways -Personnel Responsibilities and Qualifications -Special Personnel Training Requirements	2	5 6 7 8
2.5Project Planning/Problem Definition 2.5.1Project Planning (Scoping) 2.5.2Problem Definition, Site History, and Background	-Project Planning Session Documentation (including Data Needs tables) -Project Scoping Session Participants Sheet -Problem Definition, Site History, and Background -Site Maps (historical and present)	1	9 10

CROSSWALK (Continued)

2.6Project Quality Objectives and Measurement Performance Criteria 2.6.1Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2Measurement Performance Criteria	-Site-Specific PQOs -Measurement Performance Criteria	3	11 12
2.7Secondary Data Evaluation	-Sources of Secondary Data and Information -Secondary Data Criteria and Limitations	1 2	13
2.8Project Overview and Schedule 2.8.1Project Overview 2.8.2Project Schedule	-Summary of Project Tasks -Reference Limits and Evaluation -Project Schedule/Timeline	4	14 15 16
Measurement/Data Acquisition			
3.1Sampling Tasks 3.1.1Sampling Process Design and Rationale 3.1.2Sampling Procedures and Requirements 3.1.2.1Sampling Collection Procedures 3.1.2.2Sample Containers, Volume, and Preservation 3.1.2.3Equipment/Sample Containers Cleaning and Decontamination Procedures 3.1.2.4Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures 3.1.2.5Supply Inspection and Acceptance Procedures 3.1.2.6Field Documentation Procedures	-Sampling Design and Rationale -Sample Location Map -Sampling Locations and Methods/SOP Requirements -Analytical Methods/SOP Requirements -Field Quality Control Sample Summary -Sampling SOPs -Project Sampling SOP References -Field Equipment Calibration, Maintenance, Testing, and Inspection	5	17 18 19 20 21 22

CROSSWALK (Continued)

3.2Analytical Tasks 3.2.1Analytical SOPs 3.2.2Analytical Instrument Calibration Procedures 3.2.3Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4Analytical Supply Inspection and Acceptance Procedures	-Analytical SOPs -Analytical SOP References -Analytical Instrument Calibration -Analytical Instrument and Equipment Maintenance, Testing, and Inspection	6	23 24 25
3.3Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1Sample Collection Documentation 3.3.2Sample Handling and Tracking System 3.3.3Sample Custody	-Sample Collection Documentation Handling, Tracking, and Custody SOPs -Sample Container Identification -Sample Handling Flow Diagram -Example Chain-of-Custody Form and Seal	7	27 26
3.4Quality Control Samples 3.4.1Sampling Quality Control Samples 3.4.2Analytical Quality Control Samples	-QC Samples -Screening/Confirmatory Analysis Decision Tree	5	28
3.5Data Management Tasks 3.5.1Project Documentation and Records 3.5.2Data Package Deliverables 3.5.3Data Reporting Formats 3.5.4Data Handling and Management 3.5.5Data Tracking and Control	-Project Documents and Records -Analytical Services -Data Management SOPs	6	29 30

CROSSWALK (Concluded)

Assessment/Oversight			
4.1Assessments and Response Actions 4.1.1Planned Assessments 4.1.2Assessment Findings and Corrective Action Responses	-Assessments and Response Actions -Planned Project Assessments -Audit Checklists -Assessment Findings and Corrective -Action Responses	8	31 32
4.2QA Management Reports	-QA Management Reports		33
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Data Review			
5.1Overview			
5.2Data Review Steps 5.2.1Step I: Verification 5.2.2Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities 5.2.3Step III: Usability Assessment 5.2.3.1Data Limitations and Actions from Usability Assessment 5.2.3.2Activities	-Verification (Step I) Process -Validation (Steps IIa and IIb) Process -Validation (Steps IIa and IIb) Summary -Usability Assessment	9	34 35 36 37

QAPP Worksheet #1: Title and Approval Page

Title: Weapon of Mass Destructions (WMD) - Generic Quality Assurance Project Plan
Site Name/Project Name: [ ]
Site Location: [ ]
Revision Number: [ ]
Revision Date: DD/MM/Year

[Name of Organization]
Lead Organization
e.g., [Contractor Project Manager's Name; or EPA, Region II DESA Sampler Lead Name]
[Contractor Project Manager's phone #; or EPA, Region II DESA Sampler Lead phone #]
[Contractor Project Manager's e-mail; or EPA, Region II DESA Sampler Lead e-mail]

Preparer's Name and Organizational Affiliation

Preparer's Address, Telephone Number, and E-mail Address
[Date]
Preparation Date (Day/Month/Year)

Environmental Unit Leader: _____
Signature

Printed Name/Organization/Date

Planning Section Chief: _____
Signature

Printed Name/Organization/Date

Operations Section Chief: _____
Signature

Printed Name/Organization/Date

Document Control Number: [ ]

QAPP Worksheet #2: QAPP Identifying Information

Site Name/Project Name: [ ]
Site Location: [ ]
Operable Unit: [ ]
Title: Weapon of Mass Destructions (WMD) - Generic Quality Assurance Project Plan
Revision Number: [ ]
Revision Date: [ ]

1. Identify guidance used to prepare QAPP: Uniform Federal Policy for Quality Assurance Project Plans. Refer to attached reference list for other Chemical Warfare Agents guidance documents

2. Identify regulatory program: [Insert EPA, Region II, appropriate target agency, and emergency response authority]

3. Identify approval entity: EPA, Region II or Incident Management Team (IMT)

4. Indicate whether the QAPP is a generic or a project-specific QAPP: Generic QAPP

5. List dates of scoping sessions that were held: DD/MM/YY

6. List dates and titles of QAPP documents written for previous site work, if applicable:

7. List organizational partners (stakeholders) and connection with lead organization:
[*e.g.*, NYSDEC, NYSDOH, NJDEP, DOE, NRC, FBI, CDC]

8. List data users:
EPA, Region II, appropriate target agency, and emergency response authority (see Worksheet #4 for individuals)

9. If any required QAPP elements and required information are not applicable to the project, then provide an explanation for their exclusion below:

Note: This worksheet will be completed in a Site-Specific QAPP for each project. Project team members will complete all the required information and identify which Worksheets are not required for the current project.

10. Document Control Number: [ ]

QAPP Worksheet #3: Distribution List

[List those entities to which copies of the approved QAPP, subsequent QAPP revisions, addenda, and amendments are sent]

QAPP Recipient	Title	Organization	Telephone Number	Fax Number	E-mail Address	Document Control Number
[Project Manager Name]	Contractor Project Manager; and EPA, Region II Remedial Project Manager, Brownfield Project Manager or On-Scene Coordinator	Name of Organization	[ ]	[ ]	[Name]@e-mail address	[Repeat DCN throughout]
[QAO Name]	Contractor QA Officer; and EPA, Region II QAO	Name of Organization	[ ]	[ ]	[Name]@e-mail address	
[Lead Sampler's Name]	Contractor Project Manager	Name of Organization	[ ]	[ ]	[Name]@e-mail address	
[ENVL Name]	Environmental Unit Leader	Name of Organization	[ ]	[ ]	[Name]@e-mail address	
	Operation Section Chief	Name of Organization	[ ]	[ ]	[Name]@e-mail address	

QAPP Worksheet #4: Project Personnel Sign-Off Sheet

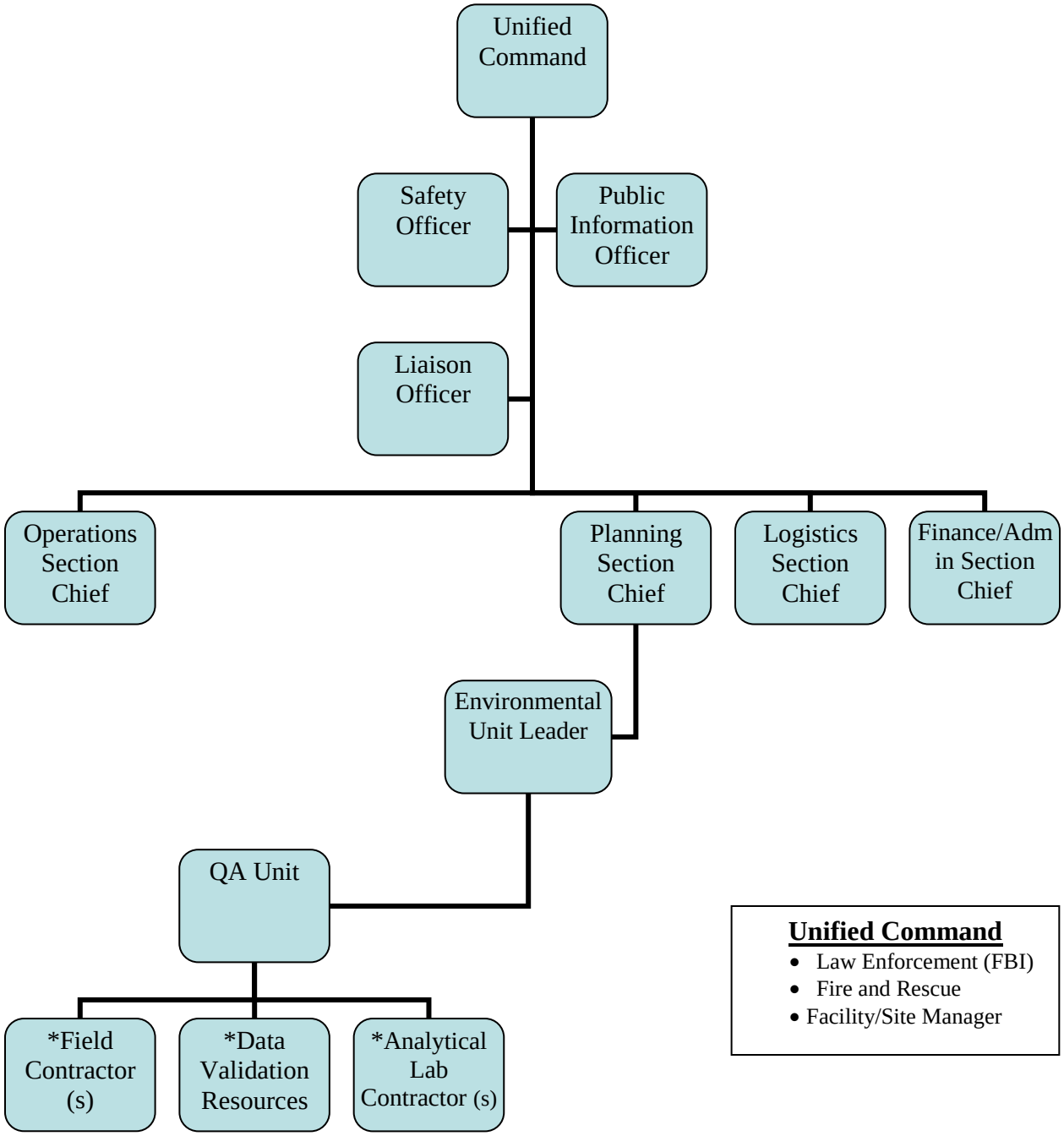
[Copies of this form signed by key project personnel from each organization to indicate that they have read the applicable sections of the QAPP and will perform the tasks as described; add additional sheets as required. Ask each organization to forward signed sheets to the central project file.]

Organization: Name of Organization

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
[Project Manager Name]	Contractor Project Manager; or EPA, Region II Remedial Project Manager, Brownfield Project Manager or On-Scene Coordinator	[ ]		
[QAO Name]	Contractor QAO EPA, Región II QAO	[ ]		
[Lead Sampler's Name]	Contractor Project Manager	[ ]		
[Assistant Sampler]	Field Support	[ ]		
[Assistant Sampler]	Field Support	[ ]		
[If applicable]	Hydro geologist	[ ]		
[If applicable]	Risk Assessor	[ ]		
[If applicable]	Environmental Unit Leader	[ ]		
[If applicable]	Operation Section Chief	[ ]		

QAPP Worksheet #5: Project Organizational Chart

Identify reporting relationship between all organizations involved in the project, including the lead organization and all contractor and subcontractor organizations. Identify the organizations providing field sampling, on-site and off-site analysis, and data review services, including the names and telephone numbers of all project managers, project team members, and/or project contacts for each organization.



* Not part of the ICS - only provides ancillary support

QAPP Worksheet #6: Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, pathways, etc.)
Operations	Environmental Branch Director (EBD)			Under the direction of Operation Section Chief (OPS), EBD is responsible for environmental sampling, air monitoring, waste management, building decontamination and construction and engineering activities inside and outside the hot zone. Collaborate with law enforcement's and offer EPA's environmental sampling expertise to assist them in assessing and collecting forensic evidence; secure potential contaminated areas, prior to characterization activities, to prevent cross-contamination and dispersal of chemical agents into the air; and ensure initial characterization sampling activities focus on critical areas.
Preparation of QAPP	Sampling Group Supervisor (SGS)			Under the direction of EBD, the SGS assisting in the development of sampling strategies and approaches, specific sampling objectives, and methods. Review sampling group supervisor responsibilities; Implement quality assurance and quality control (QA/QC); and maintain unit/activity log.
Approval of QAPP	Environmental unit Leader			Approval of the QAPP and all technical/ QA/QC changes to QAPP. Provide guidance as necessary. * Determine acceptable levels following: Decontamination, providing information needed to make final clearance decisions on "how clean is clean"; *. Coordinate with Headquarters' * Coordinate with operations;

QAPP Worksheet #6: Communication Pathways (Concluded)

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, pathways, etc.)
Modification to Site QAPP due to field Changes.	Technical Working Group Supervisor (TWGS)/Environmental Clearance Committee Leader (ECCL)			Modification to QAPP and all technical, QA/QC, changes to field work, and other issues related to site. Develop an incident-specific Environmental Clearance Sampling and Analysis plan, although the ECC may provide input to the development of this plan; and Recommend a chemical agent decontamination goal to the Incident Commander (IC) using a risk-based decision making framework.
Data Review and Recommendation to stop work (due to H & S)				Notifies all environmental unit teams of any corrections to analytical data.
Procurement of Field Services	Sampling Group Supervisor (SGS)			Conduct air, water, and soil sampling as directed by the regulatory agencies and other interested parties through the sampling protocol team.
Procurement of Analytical Services	Sampling Group Supervisor (SGS) and ENVL			SGS is responsible for assisting in the development of sampling strategies, approaches, specific sampling objectives, and methods. Ensure that all samples are obtained following appropriate sample protocol, properly documented and follow the chain-of-custody procedures.
Reporting issues related to analytical data qualifications	Sampling Group Supervisor (SGS)/ Environmental Clearance Committee Leader (ECCL)			SGS communicate sampling data such as results of routine air monitoring to the on-site operational and safety personnel. ECCL's primary responsibility is to evaluate the totality of environmental data to determine whether the facility is safe for re-occupancy.
Distribution of lab results to Sampling Group Supervisor	Environmental Response Laboratory Network (ERLN) Manager			Receive all analytical data, check for completeness and appropriate level of validation before submittal to ENVL.
Data Assessment: ECCL distribution of results to ENVL, ENVL distribution of results to IC and general staff.	Environmental Unit Leader			Provide summary reports in coordination with the PIO, EPA office of research and development (ORD) and other inquiries as approved by the IC.

QAPP Worksheet #7A: Personnel Responsibilities and Qualifications Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
	Environmental Unit Leader (ENVL)		Develop QA/QC procedures and obtain any necessary permits. * Establish an interagency, interdisciplinary Environmental Clearance Committee to assist in determining whether site-specific cleanup goals have been met. Develop multi-disciplinary teams for characterization and remediation planning activity. Utilize the EPA's Special Teams, including ERT and CMAT, and the National Homeland Security Research Center (NHSRC) as a clearinghouse for Chemical Warfare Agents characterization and decontamination. planning activities that include environmental; medical; public health; industrial hygiene professionalism; representatives from Federal, state, and local agencies; analytical laboratories; and facility managers familiar with the building or site layout and Heating, Ventilation, and Air Conditioning (HVAC) equipment; * Identify laboratories; * Develop QA/QC procedures; *Coordinate and submit requests for Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) crises exemptions that may be required for use of selected decontamination chemicals; and * Obtain any necessary permits	
	Environmental Branch Director (EBD)		The EBD is responsible for environmental sampling, air monitoring, building decontamination, waste management, and construction and engineering activities inside and outside the hot zone. Collaborate with law enforcement's effort to collect forensic evidence samples to enhance response sampling efficiency and effectiveness and offer EPA's environmental sampling expertise to assist them in assessing and collecting forensic evidence. Secure potentially contaminated areas, prior to characterization activities to prevent the cross contamination and dispersal of chemical agents into the air. Ensure initial characterization sampling activities focus on critical areas.	

QAPP Worksheet #7A: Personnel Responsibilities and Qualifications Table (Concluded)

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
	Sampling Group Supervisor (SGS)		SGS responsible for assisting in the development of sampling strategies and approaches, specific sampling objectives, and methods, review sampling group supervisors	
	Technical Working Group Supervisor (TWGS)		Develop an incident specific Environmental Clearance Sampling and Analysis Plan. Recommend chemical-agent decontamination goals to the Incident Commander (IC) using a risk-based decision making framework.	
	Environmental Clearance Committee Leader (ECCL)		ECCL's primary responsibility is to evaluate the totality of environmental data to determine whether the facility is safe for re-occupancy. Assists in the development of an incident-specific Environmental Clearance Sampling and Analysis Plan, recommend an acceptable chemical-agent decontamination goal using a risk-based decision-making framework.	

QAPP Worksheet #7B: Special Team and Assets

Organizational Affiliation	Responsibilities
Hazardous Substance/Materials Group Supervisor	Tasks specific to terrorist incidents, in support of responders, are: a. Review Division/Group Supervisor Responsibilities b. Review the Hazardous Substance/Materials Group tasks; c. Ensure the implementation of defensive mitigation practices (e.g., evacuation) when applicable; d. Ensure that information regarding the agent(s) and patient symptoms are passed to the Medical Group; e. Determine hazards presented by the event; f. Ensure availability of emergency decontamination; g. Coordinate with Safety Officer for a Health and Safety Plan (HASP); h. Recommend best protective actions (e.g., evacuation, shelter-in-place); i. Assist in the development of re-entry procedures if applicable; and Maintain Unit/Activity Log
Environmental Response Laboratory Network (ERLN)	For homeland Security related response activities, the Office of Emergency Management (OEM)/ CMAT the ERLN serves as the central Agency focal point and clearinghouse on laboratory preparedness. Its primary responsibility is to establish and maintain national environmental sampling and laboratory analytical capabilities and capacities necessary for effective and timely response to environmental contamination resulting from a terrorist incident, national threat event associated with Weapons of Mass Destruction (WMDs), or other incidents of national significance (INS). To carry out this responsibility, the Environmental Response Laboratory Network (ERLN) is building upon existing networks and infrastructure to develop laboratory assets which will have testing capability and capacity to meet EPA's responsibilities for surveillance, response, and recovery from incidents involving the release of Chemical, Chemical Warfare Agents, or Radiological (CBR) agents. The ERLN is responsible for coordinating with EPA programs and laboratories as well as working with other Federal and state agencies to leverage resources and build necessary laboratory capacity to meet the nation's needs for environmental analyses associated with an INS. It should be contacted for environmental analytical needs associated with an INS or a WMD event prior to contacting or obtaining laboratory services from other providers such as the Department of Defense or the LRN. The ERLN has established relationships with these providers or networks via memoranda of understanding, which are in final developmental stages. For additional information contact EPA Office of Emergency Management, CMAT Team Leader.
Chemical Warfare Agents Incident Response Force (CBIRF)	CBIRF is a U.S. Marine Corps response unit located at Camp Lejeune, NC. It provides a highly trained rapid response force capable of providing consequence management (threat identification, casualty extraction, personnel decontamination and medical triage/treatment/stabilization) for terrorist initiated attacks in order to mitigate the effects of multiple/mass casualty incidents. It also maintains an information "reach-back" capability that allows quick access to a cadre of WMD matter and response experts for consulting purposes.

QAPP Worksheet #7B: Special Team and Assets (Continued)

Organizational Affiliation	Responsibilities
US Army Technical Escort Unit (TEU)	TEU provides a worldwide, quick response capability to conduct field sampling, identification and verification, monitoring, recovery, decontamination, escort, and mitigation of hazards associated with WMD materials. The operational component of TEU is the Chemical-Chemical Warfare Agents Response Team (CBRT). CBRTs are available from Aberdeen Proving Ground, MD, Dugway Proving Ground, UT, and Pine Bluff Arsenal, AR.
Army Material Command Treaty Laboratory, Soldier Chemical Warfare Agents Chemical Command (SBCCOM)	The Army Material Command Treaty Laboratory provides an on-site analytical laboratory capability. The laboratory is capable of analyzing chemical surety materials, and foreign chemical warfare agents. The laboratory also maintains an analytical spectra database that provides the capability for analyzing other hazardous industrial chemicals. The laboratory is comprised of a series of transportable modules which contain analytical instruments such as flame photometric/mass selective detectors, fume hood, and all supporting equipment such as electrical generators for short term power requirements. The laboratory is located at Aberdeen Proving Ground, MD.
Weapons of Mass Destruction Civil Support Team (WMD CSTs)	WMD CST is an Army National Guard WMD response unit. The mission of the WMD CST is to rapidly deploy to an incident to assess a suspected nuclear, Chemical Warfare Agents, chemical, or radiological incident in support of a local incident commander. When responding to a domestic support request, the WMD CST will remain under state control unless federalized.
U.S. Marine Corps, Chemical l Warfare Agents Incident Response Force (CBIRF)	The Marine Corps created CBIRF to provide a rapid response force to counter a chemical/Chemical Warfare Agents terrorist threat. Although CBIRF is primarily dedicated to the National Capitol Region, they are a national response asset that can be tasked by NORTHCOM for domestic consequence management operations to deal with a CBRNE threat. CBIRF can provide a number of significant capabilities to include coordinating initial relief efforts, security, detection, identification, expert medical advice, and limited decontamination of personnel and equipment. The CBIRF team can make initial entry into the exclusion zone in Level "A" personnel protective equipment (PPE) to identify and sample unknown chemical/Chemical Warfare Agents agent(s), locate casualties and perform initial medical assessments, and stabilize and evacuate casualties to the decontamination area.

QAPP Worksheet #7B: Special Team and Assets (Concluded)

Organizational Affiliation	Responsibilities
U.S. Army Soldier Chemical Warfare Agents Chemical Command (SBCCOM)	SBCCOM maintains the Edgewood Chemical Warfare Agents Center and Chemical and Chemical Warfare Agents Defense information Analysis Center (CBIAC) to assist military and civilian organizations in planning for and responding to a CBRNE event. SBCCOM conducts research, concept exploration, demonstration, validation, engineering, manufacturing, and development for production of chemical and Chemical Warfare Agents defense systems. SBCCOM has subject matter experts in nuclear, Chemical Warfare Agents, and chemical agent recognition; decontamination methods, sample collection, and detection methods; PPE selection and use and practical exercises; near real-time monitoring; onsite analysis; perimeter monitoring using Open-Path Fourier Transform Infrared Spectroscopy to detect 250 compounds including chemical warfare agents; field operations including maintaining the Army's chemical stockpiles; and demolition of former chemical/Chemical Warfare Agents process facilities; site remediation; and environmental investigation.
U.S. Army's Technical Escort Unit (TEU)	The TEU can assist in transporting and escorting unconventional munitions and material—nuclear, Chemical Warfare Agents, and chemical. Its core capabilities involve chemical, Chemical Warfare Agents, and explosive ordinance disposal, reconnaissance, recovery, sampling, detection, monitoring, limited decontamination, Department of Transportation (DOT) packaging, transportation, disposal, and performing or recommending final disposition of weaponized and non-weaponized chemical and Chemical Warfare Agents materials and hazards encountered.
Department of Health & Human Services (HHS), Centers for Disease Control and Prevention (CDC), National Center for Environmental Health (NCEH)	The NCEH identifies potential health hazards, recommends and evaluates methods of preventing injuries, and studies the aftermath of disasters and other major emergencies to learn new ways of mitigating the effects of future disasters. The Emergency and Environmental Health Services (EEHS) is a division of CDC's NCEH. The EEHS can respond to national and international emergencies, and provide technical support for public health activities during environmental disasters, disease outbreak investigations, food safety, water quality, and sanitation issues. The EEHS maintains a Laboratory Response Team that can respond 24/7 to a chemical terrorism or other emergency event anywhere in the country, within two hours. The Environmental Public Health Readiness Branch (EPHRB) serves as CDC's primary all-hazards response unit.
Department of Health & Human Services (HHS), Laboratory Response Network (LRN)	The LRN mission is to maintain an integrated national and international network of laboratories that are fully equipped, employ advanced technologies, and increase capacity to respond to Chemical Warfare Agents or chemical terrorism, emerging infectious diseases, and other public health threats and emergencies. The CDC's LRN main focus is on clinical and human health samples and not environmental samples needed for characterization and remediation.
US Coast Guard Strike Team and National Guard Civilian Support	Refer to: http://www.uscg.mil/hq/nsfweb/AST/ASTServices.asp and http://www.army.mil/article/48838/

QAPP Worksheet #8: Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates[1]
[Specify location of training records and certificates for samplers]						
QAPP Training	This training is presented to new OSCs to introduce the provisions, requirements, and responsibilities detailed in the UFP. The training presents the relationship between the site-specific QA Project Plans (QAPPs), SOPs, work plans, and the QAPP. QAPP refresher training will be presented to all employees following a major QAPP revision.	EPA, Region II DESA OSCs	As needed	ALL OSCs upon initial employment and as refresher training	EPA, Region II	Within Division
Health and Safety Training	Health and safety training will be provided to ensure compliance with Occupational Safety and Health Administration (OSHA) as established in 29 CFR 1910.120.	Health and Safety Officer	Yearly at a minimum	ALL Employee upon initial employment and as refresher training every year	EPA, Region II	Within Division
Others	Scribe, ICS 100 and 200, and Air Monitoring Equipment Trainings provided to all employees	EPA ERT – all other trainings	Upon initial employment and as needed			
	Dangerous Goods Shipping	JJ Keller Corporation	Every 3 years			
Chemical Agents	**CDC Training for Chemical Emergencies:** http://emergency.cdc.gov/chemical/training.asp					

All team members are trained in the concepts and procedures in recognizing opportunities for continual improvement, and the approaches required to improve procedures while maintaining conformance with legal, technical, and contractual obligations. [1]If training records and/or certificates are on file elsewhere; document their location in this column. If training records and/or certificates do not exist or are not available, then this should be noted.

Additional information Training for Chemical Emergencies

NOTE: the following is a list of training resources related specifically to chemical emergencies. For other training resources, please see the Emergency Preparedness and Response Training page.

- Video Webcast: "Recognition of Chemical Associated Gastrointestinal Foodborne Illness" Will provide training to clinicians & health officials on accurately recognizing, reporting, & managing victims of a covert chemical-associated event such as the intentional contamination & subsequent distribution of food.
- Video Webcast: "Grand Round Series: Assessing Chemical Exposure: A Different Approach" Provides instruction on identification of chemical agents & mechanisms of potential chemical weapons. (NOTE: Videotapes of this webcast can be ordered from the Public Health Foundation.)
- Video Webcast: "Recognition of Illness Associated with Chemical Exposure" This webcast aims to increase the likelihood that health-care providers will recognize a chemical-release–related illness & that public health authorities will implement the appropriate emergency response & public health actions. (NOTE: Videotapes & CD-ROMs of this webcast can be ordered from the Public Health Foundation.)
- Video Webcast: "Recognition, Management & Surveillance of Ricin-Associated Illness" Information for clinicians & public health officials on recognition, management, & disposition of patients; & identification of epidemiologic clues possibly associated with a covert ricin release. (NOTE: CD-ROMs of this webcast can be ordered from the Public Health Foundation.)

http://emergency.cdc.gov/chemical/training.asp

QAPP Worksheet #9: Project Scoping Session Participants Sheet

Site Name/Project Name: [ ]
Site Location: [ ]
Operable Unit: [ ]
Date of Session: [ ]
Scoping Session Purpose: To discuss questions, comments and assumptions regarding technical issues involved with the project

Name	Title	Affiliation	Phone #	E-mail Address	*Project Role
[Name]	ENVL		( ) -	[Name]@e-mail address	
	QA Coordinator		( ) -	[Name]@e-mail address	
	Analytical Coordinator		( ) -	[Name]@e-mail address	
	OSC	EPA, Region II	( ) -	[Name]@e-mail address	

Comments/Decisions:	e.g. The chemical warfare agents sampling event to be conducted as part of the Emergency Response of XYZ Chemical Plant Site (the Site) is scheduled for December 24, 20XX. As per discussion with the EPA OSC, up to 63 samples will be collected from properties located adjacent to the Site and submitted for analysis. A screening data deliverable has been requested for Chemical agents; therefore field duplicate samples will not be collected.
Action Items:	RST 2 submitted the Analytical Services Request Form for analytical services on December XX, XXXX.
Consensus Decisions:	Sampling will begin on December XX, XXXX and will be completed in two days. See the comments/decisions section of this report for a detailed summery of matrices and analysis.

Note: This worksheet will be completed in the site-specific QAPP for each project session held. Project team members will be identified who are responsible for planning the project.

* Refer to Worksheet #6 and #7

QAPP Worksheet #10: Problem Definition

PROBLEM DEFINITION

State the purpose for this sampling event, QA objectives and goals. Also include the organizational structure to implement the QA objectives, mechanisms to establish standards for performance, audit mechanisms to evaluate performance and corrective action mechanisms to address identified problems, documentation protocols to demonstrate a level of performance.

The Problem to be addressed by the Project: A generic QAPP will be used as a basis for all site-specific sampling plans: For example, "Environmental sampling to determine the presence or absence of Nitrogen Mustard, Phosgene or other chemical agents in environment".

The Environmental question being asked: For example, "What is the source of the Nitrogen Mustard and Phosgene contamination in the indoor air, "type and form of agent (liquid, powder, and aerosol), method of delivery, and location in structure?

Observation from any site reconnaissance report: Observe present site condition, physical evidence, wet/dry agent from a point of source, threat of agent placed in HVAC system or package, confirmed agent placed into HVAC system (visible fogger, sprayer or aerosolizing device), dirty bomb, the potential for the contaminant to migrate, initiate search of building

- This is an urgent health message from the U.S. Department of Health and Human Services (HHS). Please pay careful attention to this message to protect your health and that of others.
- Public officials suspect that a chemical agent has been released in the *xyz area* or *xyz building.*
- *xyz number* of cases have been reported, with symptoms of [*chemical agent*]. These symptoms include: [*list of symptoms]*.
- *HHS Users: Give description of agent (e.g., colorless gas, odorless, or mild smell of garlic or almond), depending upon the agent.*

http://emergency.cdc.gov/firsthours/pdf/messages_chemicalagent.pdf

PROJECT DECISION STATEMENTS: for example,

- If the chemical was released, than determine and/or confirm which agent(s) are present utilizing available real-time air monitoring equipment and field screening kits, then medical personnel should be notified of results as soon as possible so victims can be treated.

- If you are near the *xyz area*, protect yourself and your family by staying home or where you are and wait for further instructions.

For more information on chemical agents, go to the HHS Web site at www.hhs.gov, the Centers for Disease Control and Prevention's Chemical Emergencies Web site at http://emergency.cdc.gov/firsthours/pdf/messages_chemicalagent.pdf, or call the CDC Hotline at 1-800-CDC-INFO for the latest updates.

Note: This worksheet will be completed to define the problem and the environmental questions that should be answered for the current investigation and develop the current project decision "If …,then…"statement included in the site-specific QAPP.

QAPP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

The objective of this document is to present a framework and analytical approaches for sampling the various matrices that may be involved in a chemical warfare agent incident. Sufficient data will be obtained from a representative number of air, solid, liquid and wipe samples to support defensible decisions by EPA. Overall project objectives after the initial 72-hours of this response will include the following:

1.)To continue to assess and evaluate the magnitude, extent, and impact of the release, including:

Determine/verify the magnitude of the release and extents of contamination
Identify the areas of highest contamination
Determine/verify if contamination is migrating or has migrated
Identify areas that require decontamination and to verify the effectiveness of that decontamination

2.)To determine the overall scope of the incident

3.)To determine contaminated and non-contaminated zones and areas

4.)To supply public health agencies (such as Agency for Toxic Substances and Disease Registry [ATSDR] or others) with information about the nature and magnitude of any health threat and to support subsequent public health advisories.

5.) To categorize waste material to support timely transportation and disposal decisions.

Who will use the data?
The data will be used by the EPA, Region II, ICS Commander, Environmental Unit Leader, Technical Leader, FBI, Field Investigators, Medical Professionals, Local, State and Federal agencies, Politicians and other agencies.

What will the data be used for?
The purpose of this work is to confirm that no Chemical Agent Identification Set (CAIS) materials or Chemical Warfare Material (CWM) residues are present within the *xyz* Site. The CAIS materials could include mustard, lewisite, phosgene, chloropicrin or any other chemical agents.

Explain the ultimate use of data: *e.g.*, to determine potential risk to human health hazards associated with chemical agents; Contact local law enforcement immediately if you think that you may have been exposed to Lewisite. This includes being exposed to a liquid spray released in an indoor building.

QAPP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements (Concluded)

What type of data are needed / how much data are needed
Sampling type and matrix: Liquid (aerosol) or vapor, air.
Qualitative, Quantitative or semi-quantitative data
Field screening: On-site/Off site analyses
Parameters: e.g., Phosgene and Nitrogen Mustard (HN-1, HN-2, HN-3).
Type of sampling: Air sampling, wipe, water etc.
Sampling locations: To be determined

How "good" do the data need to be in order to support the environmental decision?
[RPD required accuracy and precision of analytical methods, Positive control strain, negative control strain, method controls, resolving out-of-control results, follow analytical and sampling methods. Refer to worksheet#12, establish criteria for performance measurement: qualitative vs. quantitative].

Where, when, and how should the data be collected/generated? [Sample locations and time frame]: The number of samples needed for each analytical group, matrix, and concentration level. Site map, present existing locations, time frame, refer to sampling SOPs, and how samples will be collected.

Who will collect and generate the data?
e.g., Lead organization, IMT, Contractor organizations, and others.

How will the data be reported?
The data will be reported by the assigned laboratory (Preliminary, Electronic, and Hardcopy) and provided to environmental unit leader, IMT.

How will the data be archived?
Analytical Coordinator will archive Electronic data deliverables in database, ensure security and archival of all data.

Note: This worksheet will be completed to develop PQOs in term of type, quantity, and quality of data determined using a systematic planning process in the site-specific QAPP.

QAPP Worksheet #12: Measurement Performance Criteria Table

Chemical QC Guidelines

Having analytical data of appropriate quality requires that laboratories: (1) conduct the necessary QC to ensure that measurement systems are in control and operating correctly; (2) properly document results of the analyses; and (3) properly document measurement system evaluation of the analysis-specific QC, including corrective actions. Information regarding EPA's DQO process, considerations and planning is available at http://www.epa.gov/QUALITY/dqos.html. In addition to the laboratories being capable of generating accurate and precise data during site remediation, they must be able to deliver results in a timely and efficient manner. Therefore, laboratories must be prepared with calibrated instruments, the proper standards, standard analytical procedures, and qualified and trained staff. Laboratories also must be capable of providing rapid turnaround of sample analyses and data reporting.

The level or amount of QC needed during sample analysis and reporting depends on the intended purpose of the data that are generated (e.g., the decision(s) to be made). The specific needs for data generation should be identified. QC requirements and DQOs should be derived based on those needs, and should be applied consistently across laboratories when multiple laboratories are used. The EPA's ERLN program has set up a cadre of state and EPA fixed and mobile laboratories that can analyze a select group of chemical warfare agents as part of the ERLN's CWA Ultra-dilute Agent (UDA) program. For information regarding laboratory analysis of samples containing chemical warfare agents (CWAs) or laboratory requirements to possess and use ultra-dilute agent standards, please use the contact information provided on the ERLN website at: http://www.epa.gov/oemerln1/contact.html.

A minimum set of analytical QC procedures should be planned, documented and conducted for all chemical testing. Some method-specific QC requirements are described in many of the individual methods that are cited within SAM and will be referenced in any analytical protocols developed to address specific analytes and sample types of concern. Individual methods, sampling and analysis protocols or contractual statements of work should also be consulted to determine if any additional QC might be needed. Analytical QC requirements generally consist of analysis of laboratory control samples to document whether the analytical system is in control; matrix spikes to identify and quantify measurement system accuracy for the media of concern, and at the levels of concern, various blanks as a measure of freedom from contamination; as well as matrix spike duplicates or sample replicates to assess data precision.

In general, for measurement of chemical analytes, appropriate QC includes an initial demonstration of measurement system capability as well as ongoing analysis of standards and other samples to ensure the continued reliability of the analytical results. Examples of appropriate QC include:

- Demonstration that the measurement system is operating properly
  - Initial calibration
  - Method blanks

QAPP Worksheet #12: Measurement Performance Criteria Table (Continued)

- Demonstration of analytical method suitability for intended use
  - Detection and quantitation limits
  - Precision and recovery (verify measurement system has adequate accuracy)
  - Analyte/matrix/level of concern-specific QC samples (verify that measurement system has adequate sensitivity at levels of concern)
- Demonstration of continued analytical method reliability
  - Matrix spike/matrix spike duplicates (MS/MSDs) recovery and precision
  - QC samples (system accuracy and sensitivity at levels of concern)
  - Surrogate spikes (where appropriate)
  - Continuing calibration verification
  - Method blanks

QC tests should be consistent with EPA's Good Laboratory Practice Standards (http://www.epa.gov/oecaerth/monitoring/programs/fifra/glp.html) and be run as frequently as necessary to ensure the reliability of analytical results. Additional guidance can be found at http://www.epa.gov/quality/qatools.html; in Chapter 1 of EPA SW-846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (33 pp, 274 KB, About PDF); and in EPA's 2005 "Manual for the Certification of Laboratories Analyzing Drinking Water" (EPA 815-R-05-004) (209 pp, 3.78 MB, About PDF). As with the identification of needed QC samples, the frequency of QC sampling should be established based on an evaluation of DQOs. The type and frequency of QC tests can be refined over time.
http://www.epa.gov/sam/SAM_2012_07162012.pdf

Ensuring data quality also requires that laboratory results are properly assessed and documented. The results of the data quality assessment are included within the data report when transmitted to decision makers. This evaluation is as important as the data for ensuring informed and effective decisions. While some degree of data evaluation is necessary in order to be able to confirm data quality, 100% verification and/or validation is neither necessary nor conducive to efficient decision making in emergency situations. The level of such reviews should be determined based on the specific situation being assessed and on the corresponding DQOs. In every case, the levels of QC and data review necessary to support decision making should be determined as much in advance of data collection as possible.

Please note: The appropriate point of contact identified on the Technical Contacts page of this website should be consulted regarding appropriate quality assurance (QA) and QC procedures prior to sample analysis. These contacts will consult with the EPA Environmental Response Laboratory Network (ERLN) or WLA coordinator responsible for laboratory activities during the specific event to ensure QA/QC procedures are performed consistently across laboratories. Under EPA policy, analysis should be performed by laboratories that have demonstrated competency via a National recognized accreditation program. For CWA, there is no specific program that accredits the CWA analytes themselves. However, because CWA can be consider being SVOCs, an accreditation program that accredits other more common SVOCs is appropriate.

QAPP Worksheet #12A: Measurement Performance Criteria Table (Definitive Data - Example only)

Matrix	Soil and Aqueous
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure	Analytical Method[1]/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
CWA in Soil - Sample placed in 4-oz. Teflon-lined amber glass jar. **CWA in Aqueous** – Samples placed in a 250 –ml Teflon lined amber glass jar.	SW-846 Method no. 8270d Modified and laboratory SOPs.	Field Precision	1 per 20 samples RPD < 50% (Soil) RPD <30% (Aqueous)	Field Duplicate	S and A
		Field Representativeness/ Accuracy/Bias	1 per 20 samples/matrix <½ PQL	Equipment Rinsate	S and A
		Accuracy/Precision/ Bias	Per Field Team submission	Matrix Spike/ Matrix Spike Duplicate	A
		Accuracy/Precision	Five-point calibration for all analytes prior to sample analysis SPCCs avg. RF ≥0.050 and %RSD for RFs for CCCs ≤30% and mean RSD for all analytes ±15% with no individual analyte RSD >30%	Initial Calibration	A
		Accuracy/Bias	Once per five-point initial calibration All analytes within ±25% of expected value	Second Source Calibration Verification	A

[1]QAPP will be revised if the analytical methods change
Note: Measurement Performance criteria are matrix specific. Laboratories may use their own in-house QC criteria.

QAPP Worksheet #12A: Measurement Performance Criteria Table (Continued)
(Definitive Data - Example only)

Matrix	Soil and Aqueous
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure	Analytical Method[1]/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
CWA in Soil - Sample placed in 4-oz. Teflon-lined amber glass jar. **CWA in Aqueous** – Samples placed in a 250 –ml Teflon lined amber glass jar.	SW-846 Method no. 8270d Modified and laboratory SOPs.	Accuracy/Bias	Each sample for each analyte RRT of the analyte within ± 0.06 RRT units of the RRT	Retention Time Window	S and A
		Precision	Daily, before sample analysis and every 12 hours of analysis time SPCCs average RF ≥0.050 and CCCs ≤20% difference, all calibration analytes within ±20% of expected value	Calibration Verification	A
		Accuracy/Sensitivity	Immediately after or during data acquisition for each sample RT ±30 seconds from RT of the midpoint standard in the initial calibration EICP area within -50% to +100% of initial calibration midpoint standard	Internal Standards	A
		Accuracy/Bias	Prior to initial and calibration verification decafluorotriphenyl/phosphine (DFTPP) Refer to SW-846	Instrument Performance Check	A
		Accuracy/Bias	Every sample	Surrogate	A
		Laboratory Representativeness/ Accuracy/Bias	1 per batch per matrix or 1 per 20 samples, whichever is more frequent <½ PQL	Method Blank	A

[1]QAPP will be revised if the analytical methods change

QAPP Worksheet #12A: Measurement Performance Criteria Table (Concluded)
(Definitive Data - Example only)

Matrix	Soil and Aqueous
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure	**Analytical Method[1]/SOP**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
CWA in Soil - Sample placed in 4-oz. Teflon-lined amber glass jar.	SW-846 Method no. 8270d Modified and laboratory SOPs.	Laboratory Representativeness/ Accuracy/Bias	1 per batch <½ PQL	TCLP Extraction Blank (as applicable)	A
CWA in Aqueous – Samples placed in a 250 –ml Teflon lined amber glass jar.		Laboratory Accuracy/Sensitivity	1 per batch per matrix or 1 per 20 samples, whichever is more frequent	Laboratory Control Sample	A

[1]QAPP will be revised if the analytical methods change

Note: Prior to any sampling, the sampling team should closely coordinate with the contracted laboratory because standard analytical Methods may not been developed for many chemical warfare agents and the sampling requirement may be different.

QAPP Worksheet #12B: Measurement Performance Criteria Table (Definitive Data - Example only)

Matrix	Wipe
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
CWA in Wipes Laboratory-provided, Methylene chloride pre-cleaned sample gauze pad placed in a 40-ml VOA vial.	SW-846 8270d Modified (Fort Meade Laboratory SOPs)	Field Precision	1 per 20 samples RPD< 50% (soil)	Field Co-Located Sample	S and A
		Field Representativeness/ Accuracy/Bias	1 per 20 samples/matrix <½ PQL	Equipment Blank	S and A
		Accuracy/Precision/ Bias	Per Field Team submission	Matrix Spike/ Matrix Spike Duplicate	A
		Accuracy/Precision	Five-point calibration for all analytes prior to sample analysis SPCCs avg. RF ≥0.050 and %RSD for RFs for CCCs ≤30% and mean RSD for all analytes ±15% with no individual analyte RSD >30%	Initial Calibration	A

[1]QAPP will be revised if the analytical methods change

QAPP Worksheet #12B: Measurement Performance Criteria Table (Continued)

(Definitive Data - Example only)

Matrix	Wipe
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure[1]	**Analytical Method/SOP[2]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
CWA in Wipes Laboratory-provided, Methylene chloride pre-cleaned sample gauze pad placed in a 40-ml VOA vial.	SW-846 8270d Modified and Laboratory SOPs	Accuracy/Bias	Once per five-point initial calibration All analytes within ±25% of expected value	Second Source Calibration Verification	A
		Accuracy/Bias	Each sample for each analyte RRT of the analyte within ±0.06 RRT units of the RRT	Retention Time Window	A
		Precision	Daily, before sample analysis and every 12 hours of analysis time SPCCs average RF ≥0.050 and CCCs ≤20% difference, all calibration analytes within ±20% of expected value	Calibration Verification	A
		Accuracy/Sensitivity	Immediately after or during data acquisition for each sample RT ±30 seconds from RT of the midpoint standard in the initial calibration EICP area within -50% to +100% of initial calibration midpoint standard	Internal Standards	A
		Accuracy/Bias	Prior to initial and calibration verification decafluorotriphenyl/phosphine (DFTPP) Refer to SW-846	Instrument Performance Check	A

[1]QAPP will be revised if the analytical methods change

QAPP Worksheet #12B: Measurement Performance Criteria Table (Concluded)
(Definitive Data - Example only)

Matrix	Wipe
Analytical Group	Chemical Warfare Agents
Concentration Level	LOW (SCAN or SIM)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
CWA in Wipes Laboratory-provided, Methylene chloride pre-cleaned sample gauze pad placed in a 40-ml VOA vial.	SW-846 8270d Modified and Laboratory SOPs.	Accuracy/Bias	Every sample	Surrogate	A
		Laboratory Representativeness/ Accuracy/Bias	1 per batch per matrix or 1 per 20 samples, whichever is more frequent <½ PQL	Method Blank	A
		Laboratory Representativeness/ Accuracy/Bias	1 per batch <½ PQL	TCLP Extraction Blank (as applicable)	A
		Laboratory Accuracy/Sensitivity	1 per batch per matrix or 1 per 20 samples, whichever is more frequent	Laboratory Control Sample	A

[1]QAPP will be revised if the analytical methods change

QAPP Worksheet #13: Secondary Data Criteria and Limitations Table

Any data needed for project implementation or decision making that are obtained from non-direct measurement sources such as computer databases, background information, technologies and methods, environmental indicator data, publications, photographs, topographical maps, literature files and historical data bases will be compared to the DQO for the project to determine the acceptability of the data. Thus, for example, analytical data from historical surveys will be evaluated to determine whether they satisfy the validation criteria for the project. If the data have not been validated to Region II criteria, the package will be examined to determine whether sufficient data was provided to allow a proper validation to be done. If not, then a decision to conduct additional sampling for the site may be necessary.

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation / collection dates)	How Data Will Be Used	Limitations on Data Use
Previous Investigation Sampling Results	[Document with results, e.g., ER Removal Action Report, dated 'x']	[Who collected data and when]	[What was purpose of previous sampling]	[Reason for additional sampling, i.e. data gaps, and discussions on comparability issues, incomplete data sets as well as qualified data]

QAPP Worksheet #14: Summary of Project Tasks

Sampling Tasks: The objective of this sampling event is to present a framework and analytical approaches for sampling the various matrices that may be involved in a chemical warfare agent incident. Since, the various agencies, official, and medical personnel on-site may have different analytical needs, priorities must be established to streamline the sampling event. Information obtained through laboratory analysis of samples collected by the entry team may be used to verify the extent of contamination and confirm decontamination effectiveness. In addition, any information that could assist medical personnel with the treatment and care of any victims should be considered a priority. Results obtained by first responders during the initial response to the incident may need to be confirmed by a fixed laboratory as quickly as possible. A number of different matrices may need to be collected to describe the incident, including air, soil, water, and wipe samples.

Standard Operating Procedures (SOPs) and other guidelines will be utilized during a chemical agent incident. These SOPs and guidelines will be followed as closely as possible, but may require adjustments based upon site conditions or equipment limitations. In all instances, the procedures utilized will be thoroughly documented in the logbook and final site deliverables.

Analysis Tasks: [Analysis requested by media]

Air samples-Arsine (SA) – NIOSH Method 6001
Air samples - Phosgene – OSHA Method 61

Quality Control Tasks: All matrices will have the QC samples to be collected. Based on the objectives of the sampling event, one or more of the following samples should be collected: duplicates, background samples, split samples, rinsate/equipment blanks, trip blanks, temperature blanks, and field blanks. Determination of which QA/QC samples to collect will be based on the time available, the quantity of samples available, analytical method specifications, and the data objectives.

Data Management Tasks: The data collected for the sampling activities will be organized, analyzed, and summarized in a final project report that will be submitted to the RPM or OSC according to the project Schedule. The report will be prepared by the project officer and include appropriate data quality assessment. Standard methods and references will be used as guidelines for data reduction and reporting.

Documentation and Records: Should include: Field notebook, sample labels, custody seals, chain of custody, sample logs, etc.

Field Logbook: The field logbook is a descriptive notebook detailing site activities and observations so that an accurate, factual account of procedures may be reconstructed. The logbook must be bound and contain consecutively numbered pages. Each day should start a new page and each page should contain the following: date, project numbers, and signature(s) of personnel making the entry in the logbook. Entries should be made in chronological order and include the following:

QAPP Worksheet #14: Summary of Project Tasks (Continued)

1. Site name and project number
2. Name(s) of personnel on-site
3. Dates and times of all entries (military time preferred)
4. Descriptions of all site activities, site entry and exit times
5. Noteworthy events and discussions
6. Weather conditions
7. Site observations
8. Sample and sample location identification and description*
9. Subcontractor information and names of on-site personnel
10. Date and time of sample collections, along with chain of custody information
11. Record of photographs
12. Site sketches

The description of the sample location will be noted in such a manner as to allow the reader to reproduce the location in the field at a later date.

Sample Labels

Labels will be securely affixed to each sample container to clearly identify each particular sample. Each sample label should include the following information:

1. Site/project number
2. Sample identification number
3. Sample collection date and time
4. Designation of sample (grab or composite)
5. Sample preservation
6. Analytical parameters
7. Name of sampler

Chain-of-Custody Record

A COC record will be maintained from the time of sample collection until final disposition-analysis. Every sample custody transfer must be noted and the signature of the receiving part obtained. Custody should be maintained throughout decontamination of the sample(s). This may require the entry team member maintaining custody to maintain eye contact with the sample during his/her own decontamination. A copy of the record will be kept with the samples until they are analyzed and will be returned with the analytical results. The COC record must include at least the following information:

1.) Any available information regarding the potential hazards associated with the agent.
2.) Handling procedures associated with the samples.
3.) Sample identification number.
4.) Sample concentration, if known.
5.) Sample location.
6.) Collection date.
7.) Sample matrix.

QAPP Worksheet #14: Summary of Project Tasks (Concluded)

8.) Names and signatures of sampling personnel.
9.) Signatures of all individuals who had custody of the samples.
10.) Analytical method(s).

When samples are not under the direct control of the individual currently responsible for them, they should be stored in a locked container or room, which has been sealed with a custody seal.

Photographic and Video Documentation

In addition to the written documentation, photographic and video documentation should be conducted during all site activities, as appropriate. In conjunction with all photographs and videotape segments, a written entry should be made in the logbook or on a photograph/video log and maintained in the site files. During the sampling event, photographic and video documentation will be critical in determining sample location, and documenting sample collection methodology. The sampling personnel should take pictures of the sample location, the collection process, and the sample in the location where it was collected. In addition, any other pictures that depict the critical scene in which those samples were collected should also be taken. In the case of high profile situation that may involve casualties, procedures for handling the film should be addressed. A secure criminal laboratory should be considered for film developing rather than commercial businesses. A COC form should be maintained for all film development to ensure proper handling and tracking of all photographs.

Crime Scene Preservation Approach

Following a counterterrorism incident, the area should be secured, as soon as reasonably possible. Securing the area consist s of cordoning off the site and ensuring that all unauthorized personnel are restricted from entering the site. Evidence should be collected in an expedient and controlled manner to decrease the risk of evidence being altered (e.g., cross-contamination). Evidence collection will be coordinated with the appropriate law enforcement official in charge of the scene, in consultation with appropriate members of the scene's Unified Command System (UCS). In order to maintain the integrity of the evidence, sampling personnel must ensure that strict COC protocol is followed during sampling and transport to the laboratory.

Assessment / Audit Tasks: No performance audit of field operations is anticipated at his time. If conducted, performance and systems audits will be in accordance with project work plan. Review sampling SOPs

Data Review Tasks: Each laboratory performing analysis of samples will verify that all data are complete for samples received. The assessment of data acceptability or usability will be provided separately, or as part of the analytical report. Quality Assurance Coordinator will resolve QA issues and limitations on the use of their data with outside laboratories and sampling team, and review data package as appropriate measurement performance criteria set in QAPP.

Data Assessment and Interpretation Coordinator will assemble assessment team with technical expertise appropriate to the project; provide preliminary assessments of environmental data regarding implications to human health and the environment, compare data with benchmarks, standards, or appropriate background level and prepare data for internal use and for public consumption.

Note: This worksheet will be completed in Site-Specific QAPP for each project activities.

QAPP Worksheet #15A: Reference/Exposure Limits Guidelines

Matrix: Air/Solid/Water

Analytical Group: Chemical Warfare Agents

Compound	CAS RN	*Project Action Level	** Minimum Detectable Activity	**Lab Achievable detection limit
NERVE AGENTS				
Tabun (GA)	77-81-6	NA	NA	TBD
Soman (GD)	96-64-0	NA	NA	TBD
Sarin (GB)	107-44-8	NA	NA	TBD
VX	50782-69-9	NA	NA	TBD
BLISTER AGENTS				
Sulfur Mustard (H, HD, HT)	505-60-2	NA	NA	TBD
Nitrogen Mustard (HN-1)	538-07-8	NA	NA	TBD
Nitrogen Mustard (HN-2)	51-75-2	NA	NA	TBD
Nitrogen Mustard (HN-3)	555-77-1	NA	NA	TBD
Lewisite (L)	541-25-3	NA	NA	TBD
Mustard-Lewisite (HL)	541-25-3	NA	NA	TBD
BLOOD AGENTS				
Hydrogen Cyanide (AC)	74-90-8	NA	NA	TBD
Arsine (SA)	7784-42-1	NA	NA	TBD
Cyanogen Chloride (CK)	506-77-4	NA	NA	TBD
CHOKING AGENTS				
Phosgene (CG)	75-44-5	NA	NA	TBD
TEAR AGENTS				
Chloropicrin (PS)	76-06-2	NA	NA	TBD

TBD – To be determine MDA: minimum detectable activity
* - Project Action Level to be agreed upon
** - Sample and Laboratory dependent; must be below project action level.
MDL/Reporting Limits depend on a number of variables including sample size, counting times, matrix, instrument background, interferences, dilution, etc.

QAPP Worksheet #15B: Exposure Guideline Concentrations of Chemical Agents in Various Media

Exposure	Air				Water	Soil
	Worker 8-Hour µg/m^3	**Worker 14-Day µg/m^3**	**Worker 1-Year µg/m^3**	**General Population µg/m^3**	**Worker 5-Day µg/L**	**Worker 1-Year µg/kg**
Mustard (H, HD)	3	NA	NA	0.1	140	0.51
Lewisite (L, including L-1, L-2, and L-3)	3	3	NA	3	80	11
Arsine (SA)	170	4	0.034	NA	300 (As)	NA
Cyanogen Chloride (CX)	600	NA	NA	NA	NA	NA
Hydrogen Cyanide (AC)	1,100	110	2.1	NA	200	NA
Chlorine (CL)	1,500	290	NA	NA	NA	NA
Phosgene (CG)	400	NA	NA	NA	NA	NA
Tabun (GA)	0.1	NA	NA	0.003	140	4.6
Sarin (GB)	0.1	NA	NA	0.003	28	2.7
Soman (GD)	0.03	NA	NA	0.003	12	0.27
Agent VX (VX)	0.01	NA	NA	0.003	15	0.079

Notes: The water concentration for arsine is for total arsenic.
NA = None available
µg/m^3 = micrograms per cubic meter
µg/L = micrograms per liter
mg/kg = milligrams per kilogram

Sources: The listed values are the lowest in each category from these publications:

National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards, June 1997.

Army Chemical Agent Safety Program (Army Regulation 385-61), February 1997.

Chemical Exposure Guidelines for Deployed Military Personnel (USACHPPM Technical Guide 230). April 2002.

Refer to below website for the Provisional Advisory Levels (PALs) for CWA:

http://informahealthcare.com/doi/abs/10.3109/08958370903202747

QAPP Worksheet #15C: General Chemical and Physical Properties of Chemical Agents

Agent	Chemical Class	Physical Properties			Persistence	Typical Analyses
		mp	bp	vp		
Mustard, distilled mustard (H, HD)	Organic	14.5	227.8	0.672	Days to weeks	Extract, chromatograph
Lewisite (L, L-1) (L-2 and L-3 are similar)	Organometallic	0.1 to 18	190	0.394	Somewhat less than HD	(1) Digest and measure total arsenic (2) Extract, chromatograph
Nitrogen mustard (HN-2) (HN-1 and HN-3 are similar)	Organic	65 to 60	75	0.29	Somewhat less than HD	Extract, chromatograph
Phosgene oxime (CX)	Organic	35 to 40	129	11.2	Somewhat less than HD	Extract, chromatograph
Arsine (SA)	Inorganic	116	62.5	11,100	Minutes to hours	Digest, measure total arsenic
Hydrogen cyanide (AC)	Inorganic	13.3	25.7	612	Minutes to hours	Dissolve in water, then colorimetry or titrimetry
Cyanogen chloride (CK)	Inorganic	6.9	12.8	1,000	Minutes to hours	Dissolve in water, hydrolyze, measure as cyanide
Chlorine (CL)	Inorganic	101	34	5,000	Minutes to hours	Dissolve in water, then colorimetry or titrimetry
Phosgene (CG)	Inorganic	128	7.6	1,200	Minutes to hours	Dissolve in water, then colorimetry
Tabun (GA)	Organophosphate	50	220	0.038	Hours to days	(1) Extract, chromatograph (2) React with AChE, then colorimetry
Sarin (GB)	Organophosphate	56	158	2.1	Hours to days	(1) React with AChE, then colorimetry (2) Extract, chromatograph
Soman (GD)	Organophosphate	42	198	0.40	Hours to days	(1) React with AChE, then colorimetry (2) Extract, chromatograph
Agent VX (VX)	Organophosphate	39	298	0.0007	Days to weeks	(1) Extract, chromatograph (2) React with AChE, then colorimetry

Notes: Physical properties are: mp = melting point, in degrees centigrade (^{0}C)
bp = boiling point, in ^{0}C
vp = vapor pressure, in millimeters of mercury, at 20 ^{0}C

"Persistence" is how long incapacitating to lethal concentrations will remain in an area before dissipating or degrading. Persistence depends on temperature, humidity, air speed, and other environmental parameters.

QAPP Worksheet #16: Project Schedule / Timeline Table

Activities	Organization	Dates (MM/DD/YY)		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Preparation of QAPP	TBD	Prior to sampling date	TBD	QAPP	TBD
Review of QAPP	TBD	Prior to sampling date	TBD	Approved QAPP	TBD
Preparation of Health and Safety Plan	TBD	Prior to sampling date	TBD	HASP	TBD
Procurement of Field Equipment	TBD	Prior to sampling date	TBD	N/A	TBD
Laboratory Request	TBD	Prior to sampling date	TBD	Analytical/CLP Request Form	TBD
Field Reconnaissance/Access	TBD	TBD	TBD	N/A	N/A
Collection of Field Samples	TBD	TBD	TBD	N/A	N/A
Preliminary Laboratory Results	TBD	TBD	TBD	Email/Fax Draft results	TBD
Laboratory Package Received		TBD	TBD	Unvalidated data package	TBD
Validation of Laboratory Results	TBD	TBD	TBD	Validated data Packages	TBD
Data Evaluation/ Preparation of Final Report	TBD	TBD	TBD	Final Report	TBD

Note: Anticipated date of initiation and completion will be added in the Site-Specific QAPP.
Refer to Worksheet# 33

QAPP Worksheet #17: Sampling Design and Rationale

Collect approximately number and type of samples from locations. The [type] samples will be analyzed by [laboratory]. Include map, QA/QC samples, sampling method and SOPs, Refer to Worksheet#21-Field Quality Control Sample Summary Table.

The site-specific QAPP will provide sufficient detail to allow the rationale for and provide a historical perspective for the sampling event. It will state the problem to be solved or decision to be made. In addition, the site-specific QAPP will describe the measurements that will be made during the course of the project; maps, tables, or geographic locations; applicable technical regulations; program-specific quality standards criteria and objectives; any special personnel and equipment requirements; assessment tools needed; a schedule of the work to be performed; and project and quality control records required, including the type of reports required.

Include project team's rationale for choosing the sampling design.

*Specific locations for sampling and number of samples to be collected
*Procedures for collecting various types of samples
*Estimated laboratory capacity for processing specimens
* Special considerations for determining agent viability
* Contingencies for weather
* Information of decontamination and packaging
* Use of appropriate PPE and medical countermeasures following possible occupational exposure
* Chain-of-custody requirements
* Quality assurance and quality control requirements
* Geographic information System (GIS) mapping of all locations

Air Sample Collection

Air sampling of the general environment and of potentially degassing surfaces provides the most direct evidence of the presence of chemical warfare agents. In addition, the air is the pathway of highest concern with respect to human exposure and provides the best quantitative basis to determine risk to humans. However, air sample results do not provide contact or ingestion hazard information. In addition, air sampling is less useful for determining the precise location of chemical warfare agent contamination to guide decontamination activities.

Air sampling can be conducted on-site and air samples are commonly used for laboratory methods which have much greater sensitivity. High-volume air samplers and chemical agent monitors (CAMs) are the most common on-site sampling tools. High-volume air samplers can sample over a large area to determine the presence of chemical warfare agents but cannot determine the specific location of contamination. Small, hand-held CAMs, can rapidly monitor smaller areas.

Surface Sample Collection

Surface samples are used to determine the presence of chemical warfare agents and to evaluate contact hazard. This method can be used to rapidly determine the contamination extent and decontamination efficacy. Surface sampling may not detect low concentration of sorbed chemical warfare agents that may still present an inhalation hazard. In addition, sample results do not determine the potential inhalation hazard from the results of surface samples.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

Swipe samples are the most common surface contamination sample collection method. Clean cotton swabs or pads are moistened with a solvent (*e.g.,* methylene chloride or acetonitrile) and then wiped over the area of interest. Forceps or a hemostat can be used to hold the swipe to prevent direct contact by the worker and to reduce contamination of the workers protective clothing (e.g., glove). The swipe is then placed in a clean glass vial and sealed for transport to the analytical laboratory. One unusual swipe sample collection method is for workers to use their booties (shoe coverings) as swipes along the floor to assist in determining the general presence of chemical warfare agents on floors.

Solid Sample Collection (Chip or Bulk Sampling)

Collection and analysis of pieces of solid materials (e.g., pieces of walls, floors, carpeting, and personal protective equipment) allow for the detection of sorbed chemical warfare agents. These samples can more definitively determine the presence of CWA. Chip/bulk sampling may also provide evidence of decontamination verification. The heterogeneity among samples and the characteristics of the material can interfere with the chemical analysis and reduce the reliability of the analysis results. As an example, concrete is an alkaline matrix that promotes rapid degradation of most chemical warfare agents. Because the chemical warfare agent is sorbed into the material, analytical results do not provide either a direct measure of contact or inhalation hazard. Pieces of the contaminated surface are chipped or cut, removed, and placed and sealed in clean glass containers and transported to the laboratory for analysis. The sample is further ground and extracted with an appropriate solvent, and the resulting extract is analyzed for the presence of chemical warfare agents. The destructive sampling collection process and lengthy laboratory extraction time limits the number of samples that can be collected.

Soil, Vegetation, and Liquid Sample Collection

Soils, vegetation, and liquids are special types of solid samples that are relatively easy to collect. Similar to other types of bulk samples, the potential for signal interference is large and laboratory sample handling (extraction and analysis) is slow. In addition, it is not possible to translate the results of the analysis into a inhalation hazard. Soil samples can be collected using scoops (spatulas, shovels, and pans), coring devices, or sweeping devices. The soil sample should be placed in a clean glass bottle. At the laboratory, the sample should be thoroughly mixed (homogenized) so that the sample has not fractionated based on soil particle size or texture. Vegetation can be clipped using shears or vegetation cutters. Both woody material and leaf material should be collected separately because sorption by chemical warfare agents will likely be different because of orientation of surfaces and differences in permeability. Water samples can be collected using vials, syringes, teflon tubing, bailers, dippers, etc. (EPA 2002). The choice of sampling equipment will depend of the environment in which the sample is being collected. Syringes may be most appropriate for small puddles, whereas bailers or pumps with Teflon tubing best used for deeper water sources. Refer the link for SAM method.
http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

SAMPLING PROTOCOLS AND ANALYTICAL METHODS FOR CHEMICAL AGENTS

The sampling protocol listed in this section is acceptable for all chemical warfare agents. The selection of sampling will be dependent upon the nature of the incident and the suspected agent. Included in this section are equipment lists and sampling procedures.

AIR SAMPLING – SORBENT TUBE SAMPLING FOR CHEMICAL WARFARE AGENTS

Method Summary: Sorbent tube sampling is a National Institute of Occupational Safety and Health and Occupational Safety and Health Administration (NIOSH/OSHA)-approved method of collecting gases and vapors from the air to determine occupation exposure. A personal sampling pump, used in conjunction with a sorbent tube, draws a controlled volume of air containing the vapor or gas through the sorbent tube at a fixed flow rat. After a predetermined period of time, the tube is removed from the sample pump apparatus and transported to a laboratory for analysis.

Analytical methods and tubes vary for different agents (Consult specific sorbent tubes and NIOSH/OSHA methods for specific agents). Note that standard methods are not available for all chemical agents. Individual laboratories have developed their own analytical methods; therefore, it may be necessary to contact the laboratory to determine any specific sampling requirements prior to the initiation of sampling activities. One field blank should be obtained for every 10 samples and a minimum of one blank sample should be collected per sampling episode. Check with your laboratory, prior to sampling, for any additional requirements.

Sample Equipment:

*Personal sampling pump.
* Flow meter.
* Air flow calibrator.
* Sorbent tube.
* Flexible Tygon tubing.
* Universal tube holder.
* Tube scoring device.
* Sterile gloves.
* Sealable plastic bags (clear).
* Chain of custody form.
* Custody seal.
* Transportation documents.

Procedure:

* Don a fresh pair of gloves.
* Calibrate pump to specified flow rate.
* Break the ends of the glass tube using the tube scorer.
* Insert calibration tube into holder.
* Check flow rate with flow meter three times and record the average flow rate.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

* Remove calibration blank, insert sample tube into holder, and attach a protective sleeve over the tube.
* Place the pump in the breathing zone or sampling zone.
* Adjust and record pump sampling time.
* Check the pump flow rate at the midpoint of sampling period, if longer than 4 hours.
* Remove the tube from the sleeve using a latex glove, and cap both ends.
* Using calibration blank, record flow rate at end of sampling period.
* Place sample tube in re-sealable plastic bag and properly label.
* Complete chain of custody form.
* Attach custody seal to each sample and package for transportation.
* Arrange for transportation.

Sample Preservation, Handling, and Storage
All samples should be placed in a locked container and affixed with custody seals. Extreme care should be taken to avoid heat and rough handling. Samples shall be stored out of direct sunlight to reduce photo degradation, and shipped on ice at 4°C. Samples must be analyzed within 14 days.

Potential Problems/Interferences
In order to reduce cross-contamination, the use of dedicated sampling equipment, containers, and personal protective equipment (PPE) is required.

See Checklist and Forms for Sorbent Tube Sampling for Chemical Warfare Agents in Appendix: C

WIPE SAMPLES FOR CHEMICAL WARFARE AGENTS

Method Summary: Wipe samples are collected from relatively smooth surface contamination. Within the suspected area, designate an area measuring approximately 10 centimeters (cm) by 10 cm. Wet a sterile gauze pad with Methylene Chloride, or if unavailable, hexane or chloroform will work, and wipe over the designated sample location. A blank wipe sample should be collected for each sampling event.

Equipment/Apparatus
* Pre-cleaned, 4-ounce (oz.) glass container with Teflon-lined lid.
* Sterile wrapped gauze pad (3 inches x 3 inches) or sterile filter paper.
* Appropriate solvent(s) i.e.: Hexane, Methylene Chloride, Chloroform (HPLC grad) or isopropyl alcohol, etc.
* Disposable, sterile sampling template (10 cm by 10 cm).
* Sterile gloves.
* Sealable plastic bag (clear).
* Chain of custody seals
* Chain of custody forms.
* Transportation documents.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

Procedure

* Choose appropriate 10 cm by 10 cm sampling area.
* Don a fresh pair of gloves.
* Saturate a sterile gauze or sterile filter paper with solvent.
* Wipe the designated surface once horizontally and once vertically using firm strokes.
* Fold the gauze with exposed side inward.
* Place gauze in sample container with Teflon- lined lid.
* Place sample container in a sealable plastic bag.
* Complete chain of custody form.
* Attach custody seal to each sample and package for transportation.
* Arrange for transportation.

Sample Preservation, Handling, and Storage

All samples should be placed in a locked container and affixed with custody seals. Extreme care should be taken to avoid heat and rough handling. Samples shall be stored out of direct sunlight to reduce photo degradation, and shipped on ice at 4°C. Aqueous samples should be analyzed as soon as is feasibly possible in the lab to prevent hydrolysis of CWA.

Potential Problems/Interferences

Collection of wipe samples on rough, porous, or uneven surfaces may be difficult. If the surface is not flat, ensure crevices or depressions are sampled. In order to reduce cross-contamination, the use of dedicated sampling equipment, containers, and PPE is required.

See Checklist and Forms for Wipe Sampling for Chemical Warfare Agents in Appendix: C

SOIL SAMPLES FOR CHEMICAL WARFARE AGENTS

Method Summary: Soil Samples can be collected using a variety of methods and equipment depending on Site conditions. A surface sample of soil will be collected, placed in a sample container, and transported to an appropriate laboratory for analysis.

Equipment/Apparatus

* Pre-cleaned 8-oz. Sample container with Teflon lid.
* Sealable plastic bag (clear).
* Plastic or stainless steel spoon.
* Stainless steel trowel.
* Sterile gloves.
* Chain of custody seals.
* Chain of custody forms.
* Transportation documents.

Procedure

* In order to reduce cross-contamination, use separate sampling equipment and containers for each sample point.
* Don a fresh pair of gloves.
* Carefully collect a sample of soil to a depth of approximately 1 inch and place in the sample container. Collect enough soil to fill the 8-oz. container.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

* Place sample container in a sealable plastic bag and label properly.
* Complete chain of custody form.
* Attach custody seal to each sample and package for transportation.
* Arrange for transportation.

Sample Preservation, Handling, and Storage
All samples should be placed in a locked container and affixed with custody seals. Extreme care should be taken to avoid heat and rough handling. Samples shall be stored out of direct sunlight to reduce photo degradation, and shipped on ice at 4°C. Samples must be analyzed within 14 days.

Potential Problems/Interferences
Cross-contamination is the primary interference commonly associated with soil samples. In order to reduce cross-contamination, the use of dedicated sampling equipment, container, and PPE is required.

See Checklist and Forms for Soil Sampling for Chemical Warfare Agents in Appendix: C

WATER SAMPLES FOR CHEMICAL WARFARE AGENTS

Method Summary: Representative liquid samples can be collected from bodies of water (streams, rivers, lakes, ponds, lagoons, and surface impoundments); run-off water; or puddles. Sampling techniques will vary widely depending on the situation.

Equipment/Apparatus
* Dip sampler (used for collection of surface water).
* Bailer (used for specific depth or for column of water).
* Syringe.
* Disposable pipettes.
* Two, 30- milliliter (ml) volatile organics analysis (VOA) bottles with Teflon-lined septa lids.
* 1-liter amber sample bottle with Teflon- lined lid.
* Sealable plastic bag (clear).
* Sterile gloves.
* Chain of custody seals.
* Chain of custody forms.
* Transportation documents.

Procedure
* Don a fresh pair of gloves.
* Select sampling apparatus based on sample requirements.
* Label sample bottles appropriately.
* Collect a sample of liquid for each sample bottle, minimizing agitation of liquid.
* Ensure that no air is trapped under the septa lid of the VOA bottles.
* Place sample bottle in a sealable plastic bag.
* Complete chain of custody form.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

* Attach custody seal to each sample and package for transportation.
* Arrange for transportation.

Sample Preservation, Handling, and Storage
All samples should be placed in a locked container and affixed with custody seals. Extreme care should be taken to avoid heat and rough handling. Samples shall be stored out of direct sunlight to reduce photo degradation, and shipped on ice at 4°C. Aqueous samples should be analyzed as soon as is feasibly possible in the lab to prevent hydrolysis of CWA.

Potential Problems/Interferences
There are two primary interferences commonly associated with surface water samples: cross contamination and improper sample collection. In order to reduce cross-contamination, the use of dedicated sampling equipment, containers, and PPE is required. Improper sample collection results from the disturbance of the stream or impoundment substrate. The following factors should be considered when collecting VOA samples:

* Fill the sample vial until a convex meniscus forms on the top of the container.
* Carefully cap the vial, invert vial, and tap gently. If and air bubble appears, discard the sample and begin again. It is imperative that no entrapped air be present in the sample vial.

See Checklist and Forms for Liquid Sampling for Chemical Agents in Appendix: C

MISCELLANEOUS SAMPLES FOR CHEMICAL WARFARE AGENTS

Method Summary: Collection of samples from media other than those discussed in previous sections may be necessary. Additional media could include clothing, vegetation, household items, or other miscellaneous material. Sampling procedures will vary depending on the type of sample required and will be determined in the field.

Equipment/Apparatus
* Scissors.
* Shovel.
* Spoon.
* Sealable plastic bags (clear).
* Sample containers of various sizes.
* Sterile gloves.
* Chain of custody seals.
* Chain of custody forms.
* Transportation documents.

QAPP Worksheet #17: Sampling Design and Rationale (Continued)

Procedure

* Don a fresh pair of gloves.
* Place miscellaneous material, cut up or broken up into small pieces, into an appropriately sized sample container.
* Place sample container in a sealable plastic bag.
* Complete chain of custody form.
* Attach custody seal to each sample and package for transportation.
* Arrange for transportation.
* Note any deviation or change in procedures in the logbook.

Sample Preservation, Handling, and Storage

All samples should be placed in a locked container and affixed with custody seals. Extreme care should be taken to avoid heat and rough handling. Samples shall be stored out of direct sunlight to reduce photo degradation, and shipped on ice at 4°C. Samples must be analyzed within 14 days.

Potential Problems/Interferences

In order to reduce cross-contamination, the use of dedicated sampling equipment, containers, and PPE is required.

See Checklist and Forms for Miscellaneous Solid Samples for Chemical Warfare Agents in Appendix: C

QAPP Worksheet #18: Sampling Locations and Methods/SOP Requirements Table

Sampling Location / ID Number	Matrix	Depth (units)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference[1]	Rationale for Sampling Location
	Air		Chemical Agent			
	Soil		Chemical Agent			
e.g. ABC-S-		NA		e.g. 12	SOP#	Background
	Wipe		Chemical Agent			
	Aqueous		Chemical Agent			

[1] Reference number from QAPP Worksheet #21
Note: Sampling locations, Methods and SOP requirements will be added in site specific QAPP

Example:

Sampling Locations: Sampling locations should be mapped and documented ahead of time to identify the most suitable collection sites and to reduce the time needed for obtaining test results. Determination of agent viability; and Estimation of agent concentration.

QAPP Worksheet #19: Analytical SOP Requirements Table

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label	Source/ SAM Method (1)
Air	Arsine	0.1 L (at 0.05 ppm) -10 L	Solid Sorbent tube (coconut shell charcoal [100 mg/50 mg])	6 days	25° C	Wipe outside of each sorbent tube clean using a damp, then dry cloth. Cap tubes with plastic (not rubber) caps. Place tubes in double plastic bags and wrap with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Arsine, 2.3 (2.1), Poisonous gas, UN2190	6001 (NIOSH)
	Hydrogen Cyanide	2 – 90 L (at 5 ppm)	Solid Sorbent Tube (soda lime [600 mg/200 mg])	At least 21 days at 25° C.	Store at 25° C.		Standard carrier shipping label AND Hydrogen Cyanide , 2.3, Poisonous gas, UN1956	6010 (NIOSH)
	Cyanogen chloride(5)	One to four 1-L or 6-L samples (depending on suspected concentration), each in a separate canister(6)	Specially prepared 1-L or 6-L stainless steel canister For subatmospheric pressure sampling, the canister is evacuated to 0.05 mm Hg; for pressurized sampling, the sample is collected using a pump and flow control arrangement to achieve a typical 101 – 202 kPa (15 – 30 psig)	Minimize transport and storage time. If feasible, analyze or extract immediately upon receipt at the laboratory.	None	Ship canister in container provided by laboratory.	Standard carrier shipping label AND Cyanogen chloride, 2.3, Poisonous gas, UN1589	TO-15 (EPA ORD)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label	Source/ SAM Method (1)
Air	Chloropicrin (5)	5 L (at 0.2 L/min)	Solid Sorbent Tube (XAD-4[100 mg/50 mg])	Minimize transport and storage time. If feasible, analyze or extract immediately upon receipt at the laboratory.	Room temperature in the dark.	Wipe outside of each sorbent tube clean using a damp, then dry cloth. Cap tubes with plastic (not rubber) caps. Place tubes in double plastic bags and wrap with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Chloropicrin, 6.1, Poison, UN1580	PV2103 (OSHA)
	Phosgene	240 L (at 1 L/min)	4-mm i.d. × 6-mm o.d. × 11-cm long silane-treated glass tubes packed with 150 mg/75 mg of pretreated XAD-2 adsorbent coated with 2-HMP (2-[hydroxymethyl] piperidine)	Can be stored at ambient temperature for up to 19 days. Desorbed samples remain stable for at least 16 hours.	Store at ambient temperature.	Wipe outside of each sorbent tube clean using a damp, then dry cloth. Cap tubes with plastic (not rubber) caps. Place tubes in double plastic bags and wrap with bubble wrap. Pack samples as described in Footnote (4). Air-tight container containing activated carbon.	Standard carrier shipping label AND Phosgene, 2.3, Poisonous gas, UN1076	OSHA 61/ Footnote (8)
Air	Nitrogen Mustard (HN-1, HN-2, and HN-3), Tabun (GA), Sarin (GB)[2], Soman (GD)[2], and VX	1 – 5 L/min)	Sorbent cartridge containing PUF or PUF in combination with other solid sorbent	Extract samples within 7 days of collection; analyze within 40 days of extraction.	Store at ≤ 4C.	Remove PUF cartridge from sampler, wrap with aluminum foil used to store cartridge, and place in a sealed container. Place container in double plastic bags and wrap with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Organophosphorus pesticides, solid, 6.1, Poison, UN2783	TO-10A (EPA ORD

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label	Source/ SAM Method (1)
Air	Lewisite (L)	Up to 1700m3	Filter (quartz, silica, or cellulose fiber)	6 months	None	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Lewisite compounds, solid, n.o.s, 6.1, Poison, UN2810	IO-3.1 / IO-3.4 / IO-3.5 (EPA ORD) / Footnote (8)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label)	Source/ SAM Method (1)
Aqueous/ Liquid	Arsine(5)	120 – 480 mL	Plastic or glass (special cleaning needed)(11)	Minimize transport and storage time; if feasible, analyze or extract immediately upon receipt at the laboratory.	Acidify to pH < 2 with nitric acid and store at 4°C. If arsenic species are to be determined, remove unpreserved aliquot prior to sample preservation.(12)	Wipe outside of each bottle clean using a damp, then dry cloth. Seal the bottle with non-reactive tape or film. Wrap glass bottles with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Arsine, 2.3 (2.1), Poisonous gas, UN2189	200.7 / 200.8 (EPA OW
	Hydrogen Cyanide	Not of concern in this sample type						
	Cyanogen chloride(5)	40 – 160 mL (one to four VOA vials)	40-mL VOA glass screw-cap vials with PTFE septa	Minimize transport and storage time; if feasible, analyze or extract immediately upon receipt at the laboratory.	Cool to 4°C and adjust to pH < 2 with H2SO4, HCl, or solid NaHSO4. Store samples in capped vials, with no headspace in an area free of solvent fumes. Add sodium thiosulfate to remove residual chlorine from treated wastewater samples.(9)	Wipe outside of each bottle clean using a damp, then dry cloth. Seal the bottle with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4). (Air-tight container containing activated carbon)	Standard carrier shipping label AND Cyanogen chloride, 2.3, Poisonous gas, UN1589. See Footnote (10) when bisulfate is used.	Ch. 4 / 5030B / 8260B (EPA SW-846) / Footnote

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label[1]	Source/ SAM Method (1)
Aqueous/ Liquid	Chloropicrin (5)	120 – 240 mL	60-mL screw cap glass vials with PTFE-lined septum or lid.	Extract all samples within 14 days of collection and analyze within 14 days following extraction.	Cool to 4°C and store extracts at < negative (-) 10°C until analysis.	Wipe outside of each bottle clean using a damp, then dry cloth. Seal the bottle with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4). (Air-tight container containing activated carbon)	Standard carrier shipping label AND Chloropicrin, 6.1, Poison, UN1580	551.1 (EPA OW)
	Phosgene	Not of concern in this sample type						
	Nitrogen Mustard (HN-1, HN-2, and HN-3)	1 – 4 L	Amber glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent-rinsed aluminum foil may be used as a liner.	Extract samples within 7 days of collection; analyze within 40 days of extraction.	Cool to ≤ 6°C. Add sodium thiosulfate to remove residual chlorine from wastewater samples.(9)	Wipe outside of each bottle clean using a damp, then dry cloth. Seal the bottle with non-reactive tape or film. Wrap glass bottles with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Coumarin derivative pesticides, liquid, toxic, 6.1, Poison, UN2810	Ch.4 / 3520C / 3535A / 8321B (EPA SW-846); and 8270D

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume[0]	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label[)]	Source/ SAM Method [(1)]
Aqueous/ Liquid	Mustard Sulfur, Sarin (GB)[2], and VX	1 – 4 L	Amber glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent-rinsed aluminum foil may be used as a liner.	Extract samples within 3 days of collection; analyze within 14 days of extraction.	GB. Add 1 mL of glacial acetic acid for each 1 mL of aqueous sample. HD: Add 1 mL of glacial acetic acid/NaCl for each 1 mL of aqueous sample. VX: Adjust pH between 7 and 8 using glacial acetic acid or sodium thiosulfate as preservative[EPA 1996]	Wipe outside of each bottle clean using a damp, then dry cloth. Seal the bottle with non-reactive tape or film. Wrap glass bottles with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND chemical agent, liquid, toxic, 6.1, Poison, UN2810	3535A/ 3571 and (EPA SW-846); and 8270D
	Lewisite (L)	120 – 480 mL	Plastic or glass (special cleaning needed)(11)	Preserve with acid within 2 weeks of collection. Samples can be held 6 months with acidification; if not acid preserved, analyze immediately.	Acidify to pH < 2 with nitric acid and store at 4°C. If arsenic species are to be determined, remove unpreserved aliquot prior to sample preservation.(12)	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Lewisite, Refer to UN2810	200.7 / 200.8 (EPA OW)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label[0]	Source/ SAM Method [(1)]
Solid	Arsine[(5)]	1 – 8 g (wet weight) or 1 – 4 g (dry weight)	Plastic or glass (special cleaning needed)(11)	Minimize transport and storage time; if feasible, analyze or extract immediately upon receipt at the laboratory.	None	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Arsine, 2.3 (2.1), Poisonous gas, UN2188	Ch. 3 / 3050B / 7010 (EPA SW-846)
	Hydrogen Cyanide	Not of concern in this sample type						
	Cyanogen chloride[(5)]	5 – 20 g When collected without preservative, fill the container, leaving no headspace.	40-mL VOA vial (with septum) and magnetic stirring bar	Minimize transport and storage time; if feasible, analyze or extract immediately upon receipt at the laboratory.	Preserve to pH ≤ 2 with NaHSO4 (low analyte concentrations) or methanol (high analyte concentrations) and cool to 4°C. Freeze unpreserved samples at negative (-) 7°C. (Frozen vials should be placed on their side.)	Wipe outside of each vial clean using a damp, then dry cloth. Seal the vial with non-reactive tape or film. Wrap glass vials with bubble wrap. Pack samples as described in Footnote (4). (Air-tight container containing activated carbon)	Standard carrier shipping label AND Cyanogen chloride, 2.3, Poisonous gas, UN1589. See Footnote (11) when methanol or bisulfate is used.	Ch. 4 / 5035A / 8260B (EPA SW-846) / Footnote (8)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Solid	Chloropicrin (5)	30 – 120 g	Wide mouth glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent rinsed aluminum foil may be used as a liner.	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool to ≤ 6°C.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4). (Air-tight container containing activated carbon)	Standard carrier shipping label AND Chloropicrin, 6.1, Poison, UN1580 (Guide 154)	Ch. 4 / 3545A / 8270D (EPA SW-846) / Footnote (8)
	Phosgene	Not of concern in this sample type						
	Nitrogen Mustard (HN-1, HN-2, and HN-3)	30 – 120 g	Wide mouth glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent rinsed aluminum foil may be used as a liner.	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool samples to ≤ 6°C and store extracts at negative (-) 10°C in the dark.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Nitrogen Mustard, solid, n.o.s, 6.1, Poison, UN2810 (Guide 153)	Ch. 4 / 3541 / 3545A / 8270D (EPA SW-846)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Solid	Mustard Sulfur, Sarin (GB)[2], and VX	30 – 120 g	Wide mouth glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent rinsed aluminum foil may be used as a liner.	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool samples to ≤ 6°C and store extracts at negative (-) 10°C in the dark.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Mustard Sulfur, Sarin, VX, 6.1, Poison, UN2810 (Guide 153)	3541 / 3571 / 8270D (EPA SW-846)
	Lewisite (L)	200 g	PTFE, plastic or glass. If using 6020A, only PTFE or fluorocarbon containers are recommended. (special cleaning needed).(11)	Digest samples as soon as possible after arrival; analyze within 180 days of digestion.	None	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Arsenic, 6.1, Poison, UN2810 (Guide 153)	Ch. 3 / 3050B / 6010C / 6020A (EPA SW-846)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Matrix	Analyte	Sample Volume	Sample Container	Holding Time	Sample Preservation or Preparation	Packaging Requirements	Shipping Label	Source/ SAM Method (1)
Wipe	Arsine(5)	TBD	Plastic or glass (special cleaning needed)(11)	Minimize transport and storage time; if feasible, analyze or extract immediately upon receipt at the laboratory.	None	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Arsine, 2.3 (2.1), Poisonous gas, UN2188	9102 (NIOSH) / 7010 (EPA SW-846)
	Hydrogen Cyanide	Not of concern in this sample type						
	Cyanogen Chloride	Not of concern in this sample type						
Wipe	Chloropicrin(5)	wiper per 24in2	Wide mouth glass or PTFE container with PTFE-lined septum or lid. When PTFE-lined septa or lids are not available, solvent rinsed aluminum foil may be used as a liner.	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool samples to ≤ 6°C and store extracts at negative (-) 10°C in the dark.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4). (Air-tight container containing activated carbon)	Standard carrier shipping label AND Chloropicrin, 6.1, Poison, UN1580	Ch. 4 / 3570 / 8290A Appendix A / 8270D (EPA SW-846)
	Phosgene	Not of concern in this sample type						

http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #19: Analytical SOP Requirements Table (Continued)

Wipe	Nitrogen Mustard (HN-1, HN-2, and HN-3)	wiper per 24in2	250-mL wide-mouth glass container with PTFE-lined septa or lid	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool to ≤ 6°C.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Nitrogen Mustard, 3.0, Flammable Liquid, 6.1, Poison, UN2810 (Guide 153)	Ch. 4 / 3570 / 8290 Appendix A
	Mustard Sulfur, Sarin (GB)[2], and VX	wiper per 24in2	250-mL wide-mouth glass container with PTFE-lined septa or lid	Extract samples within 14 days of collection; analyze within 40 days of extraction.	Cool to ≤ 6°C.	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Mustard Sulfur, Sarin, and Vx, 3.0, Flammable Liquid, 6.1, Poison, UN2810 (Guide 153)	Ch. 4 / 3570 / 8290 Appendix A
	Lewisite (L)	TBD	PTFE, plastic or glass. If using 6020A, only PTFE or fluorocarbon containers are recommended. (special cleaning needed).(11)	Digest samples as soon as possible after arrival; analyze within 180 days of digestion.	None	Wipe outside of each container clean using a damp, then dry cloth. Seal the container with non-reactive tape or film. Wrap glass containers with bubble wrap. Pack samples as described in Footnote (4).	Standard carrier shipping label AND Lewisite, solid, 6.1, Poison, UN2810 (Guide 153)	9102 (NIOSH) / Ch. 3 / 6010C / 6020A (EPA SW-846)

[1] http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	**Analytical and Preparation SOP Reference[1]	No. of Sampling Locations	No. of Field Duplicate Pairs[1]	No. of MS/MSD[1]	No. of Field Blanks[2]	No. of PT Samples	Total No. of Samples to Lab
Air (Air)	Chemical Agents	Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events Revision 5.	TBD	1/20 Samples per matrix	1/20 Samples per matrix	As per equipment type	As Required	TBD
Aqueous/Liquid	Chemical Agents	Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events Revision 5.	TBD	1/20 Samples per matrix	1/20 Samples per matrix	As per equipment type	As Required	TBD
Solid	Chemical Agents	Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events Revision 5.	TBD	1/20 Samples per matrix	1/20 Samples per matrix	As per equipment type	As Required	TBD
Wipe	Chemical Agents	Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events Revision 5.	TBD	1/20 Samples per matrix	1/20 Samples per matrix	As per equipment type	As Required	TBD

[1] MS/MSD and field duplicate samples will be collected for each matrix at a ratio of 1 per 20 samples.
[2] Field/Media Blank samples will be collected based on non-dedicated or dedicated equipment is used.
*Refer to Worksheet #28
** Also Refer to Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events, Section 6:

QAPP Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and / or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
75-00902.00 EPA Counter Terrorism **SOP**	Technical Standard Operating Procedures For Counter Terrorism Emergency Response	U.S. EPA	Refer to SOP		
ERT Technical Bulletin 2002-1 - June 2002	Supplemental ERT CB HASP Information Chemical Warfare Agents Hazards – Anthrax http://www.ert.org/products/Anthrax.pdf	EPA/OSWER/ERT	Refer to SOP		
ERT Technical Bulletin 2002-2 - June 2002	Supplemental ERT CB HASP Information Chemical Warfare Agents Hazards – Smallpox	EPA/OSWER/ERT	Refer to SOP		
ERT Technical Bulletin 2001-2 - October 2001	Recommended Occupational Immunizations	EPA/OSWER/ERT	Refer to SOP		
ERT Technical Bulletin 2001-3 - October 2001	Exercise Program for Transient Personnel	EPA/OSWER/ERT	Refer to SOP		
ERT Technical Bulletin 2001-1 - July 2001	Personal Air Sampling 29CFR 1910.120	EPA/OSWER/ERT	Refer to SOP		
DRAFT SOP	STANDARD OPERATING PROCEDURE DRAFT CHEMICAL WARFARE AGENTS AND CHEMICAL AGENT SAMPLING PROCEDURES AND ANALYTICAL APPROACH	**ROY F. WESTON, INC.** 14160 Dallas Parkway Suite 850, Dallas, Texas 75254 (469) 374-7700			
Publication 9285.1-03 June 1992	Standard Operating Safety Guides	Office of Emergency and Remedial Response U.S. Environmental Protection Agency Washington, DC 20460			
SOP#2001	General Field Sampling Guidelines (all media); Rev. 0.0 August 1994	EPA/OSWER/ERT	Site Specific		

QAPP Worksheet #21: Project Sampling SOP References Table (Concluded)

Reference Number	Title, Revision Date and / or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP#2008	General Air Sampling Guidelines, Rev. 0.0 November 1994	EPA/OSWER/ERT	FID, PID, RAM, CGI, Colorimetric Tubes, Meteorological Station		
Bio Watch Outdoor Program Guidance Document for BioWatch Jurisdictions. March 18, 2013	Bio Watch Outdoor Program - Guidance Document for BioWatch Jurisdictions. March 18, 2013 Department of Homeland Security (For official use only)	Department of Homeland Security	Refer to: Bio Watch Outdoor March 18, 2013		

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
APD 2000	Annual Manufacturer Calibration, Check calibration date on a tag or sticker	Check/ replace battery Six C size alkaline batteries power the APD 2000®.	APD 2000®. Monitors environment and detects chemical agents (GA, GB, GD, VX, HD, HN, L) and irritants (pepper spray and mace). Identifies threat and provides an audible and visual warning. As an option, the APD 2000® can be used as a radiation detector.	Not applicable. Manufacturer Calibration,	Agents Detected: GA, GB, GD, VX, HD, HN, Lewisite (L), Pepper Spray, Mace Sensitivity Response Time V – 4 ppb 30 seconds; G – 15 ppb 30 seconds; H – 300 ppb 15 seconds L – 200 ppb 15 seconds For high concentrations of these agents, detection time is 10 seconds	Replace alkaline battery, or Replace Unit Under normal conditions (70 □F), the batteries will last for up to 7 hours. Battery life will decrease as the temperature drops. At 43□F, average battery life will be less than 3 hours, and at 32□F it can be 1 hour or less.	Equipment Vendor	
Dräger Civil Defense Simultest (CDS) Kit	No Calibration is necessary	-	Rapid identification of a chemical agent using a set of five detector tubes in a manifold. A total of eight different chemical agents can be detected.	Not Applicable	Each tubes range from a sensitivity of 0.025 ppm for nerve agents to 1 mg/m3 for S-Mustard.	Highly recommended that the Quantimeter 1000 pump be used instead of the hand pump.	Drager Safety, Inc. E-mail: prodinfo@draeger.net www.draeger.com (800)-615-5503	
M8 Chemical Agent Detector Paper	No Calibration is necessary	-	M* paper used to detect the presence of liquid V, G, and H chemical agents.	Not Applicable	M8 paper responds (changes color) within 30 seconds of exposure to liquid. G Nerve Agent – Yellow Color V Nerve Agent – Green Color H and L Blister Agent – Red Color	-	US Army Soldier and Chemical Warfare Agents Chemical Command Ecbc-communications@apgea.army.mil www.ecbc.army.mil	

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table (Concluded)

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
M9 Chemical Agent Detector (CAD) Paper	No Calibration is necessary	-	M9 paper used by ground forces and is placed on personnel and equipment to identify the presence of liquid chemical agent aerosol.	Not Applicable	M9 paper when expose to liquid, it can detect and turn PINK, Red, Reddish brown and Red-purple, but does not identify the specific agent.	-	US Army Soldier and Chemical Warfare Agents Chemical Command Ecbc-communications@apgea.army.mil www.ecbc.army.mil	
M256 Chemical Agent Detector Kit Model: M256A-1-36842	No Calibration is necessary	-	*Provides real-time measurement of chemical warfare agent vapor, with detection limit near immediately dangerous to life and death (IDLH) concentration *Discriminates between nerve, blood, and blister agents *Identified contaminated area and sources.		The detection kit relies on a reaction between the chemicals/enzymes used in the vapor sampler, or those impregnated within M8 paper, and a chemical warfare agent to produce a uniquely colored response.	Read the "Instruction to Use of Paper" inside the back cover of small tan booklet labeled "Paper Chemical Agent Detector , VGH, ABC-M8".	US Army Soldier and Chemical Warfare Agents Chemical Command Ecbc-communications@apgea.army.mil www.ecbc.army.mil	
S4PE	No field calibration is possible for this instrument	Use 3.5 V lithium battery supplied with unit. It can provide sufficient charge 1,000 samples and can be stored up to 3 years.	S4PE is used for sampling liquids or solids to allow the AP2Ce/AP4C to analyze for the presence of hazardous concentrations of nerve and mustard agents in liquid and vapor forms.		(Based on Ap2Ce) Vapors, Aerosols and Droplets: All G Agents (nerve)-1.5 ppb (3 seconds) HD (blister) -60 ppb (5 seconds) VX (nerve) – (5 seconds)		Prongin, Inc. E-mail:eric.damiens@Proengin.com www.proengin.com (954)-760-9990	
Guidelines for Mass Casualty Decontamination During a HAZMAT/Weapon of Mass Destruction Incident								

Equipment's will be maintained and calibrated in accordance with manufacturer's procedures. Refer To: https://www.ncjrs.gov/pdffiles1/nij/184450.pdf

QAPP Worksheet #23: Analytical SOP References Table

Reference Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis*	Modified for Project Work? (Y/N)*
NIOSH Method No.6001	NIOSH Manual for Analytical Methods – ARSINE-Air Matrix	Screening Data with Definitive Confirmation or Definitive Data	Arsine	Atomic Absorption, Graphite Furnace (GFAA)	Chemical Laboratory	
NIOSH Method No.6010	NIOSH Manual for Analytical Methods – Hydrogen Cyanide	Screening Data with Definitive Confirmation or Definitive Data	Hydrogen Cyanide	Spectrophotometry	Chemical Laboratory	
NIOSH Method No.9102	NIOSH Manual for Analytical Methods – ELEMENTS ON WIPES-Hydrogen Cyanide-Wipe Matrix	Screening Data with Definitive Confirmation or Definitive Data	Hydrogen Cyanide	ICP-AES	Chemical Laboratory	
TO-10A (EPA ORD)	Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition: EPA/625/R-96/010b	Screening Data with Definitive Confirmation or Definitive Data	Sarin (GB), Soman (GD), Tabun (GA), VX, Nitrogen Mustard (HN-1, HN-2, HN-3) - Chemical Agents	GC-MS	Chemical Laboratory	
TO-15 (EPA ORD	Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition: EPA/625/R-96/010b	Screening Data with Definitive Confirmation or Definitive Data	Chemical Agents	GC-MS	Chemical Laboratory	
PV 2103 (OSHA)	OSHA Method PV2103: Chloropicrin	Screening Data with Definitive Confirmation or Definitive Data	Chloropicrin - Chemical Agents	GC-ECD	Chemical Laboratory	
IO-3.1/ IO-3.4/ IO-3.5 (EPA – ORD)	Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air: EPA/625/R-96/010a	Screening Data with Definitive Confirmation or Definitive Data	Lewisite, Chemical Agents	ICP-AES/ICP-MS	Chemical Laboratory	

http://www.epa.gov/sam/SAM_2012_07162012.pdf.

QAPP Worksheet #23: Analytical SOP References Table (Continued)

Reference Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis*	Modified for Project Work? (Y/N)*
EPA Method 200.7/200.8	Determination Of Metals And Trace Elements In Water And Wastes By Inductively Coupled Plasma-Atomic Emission Spectrometry/Mass Spectrometry	Screening Data with Definitive Confirmation or Definitive Data	Arsine and Lewisite	ICP-AES/ICP-MS	Chemical Laboratory	
EPA Method 551.1	Determination Of Chlorination Disinfection Byproducts, Chlorinated Solvents, And Halogenated Pesticides/ Herbicides In Drinking Water By Liquid-Liquid Extraction And Gas Chromatography With Electron-Capture Detection	Screening Data with Definitive Confirmation or Definitive Data	Chloropicrin - Chemical Agents	GC-ECD	Chemical Laboratory	
SW 846 Methods: 3541, 3545A, 5035A, 3520, 3535, 3570, and 3571	SW-846 On-line Test Methods for Evaluating Solid Waste Physical/Chemical Methods.	Screening Data with Definitive Confirmation or Definitive Data	Chemical Agents (Chloropicrin, Chloride Cyanogen, Sarin (GB), Soman (GD), Tabun (GA), VX and Nitrogen Mustard (HN-1, HN-2, HN-3)	GC-MS/GC-ECD	Chemical Laboratory	
SW 846 Method: 3050B	SW-846 On-line Test Methods for Evaluating Solid Waste Physical/Chemical Methods.	Screening Data with Definitive Confirmation or Definitive Data	Chemical Agents (Arsine and Lewisite)	GFAA/ICP-AES/ICP-MS	Chemical Laboratory	

http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #23: Analytical SOP References Table (Concluded)

Reference Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis*	Modified for Project Work? (Y/N)*
SW 846 Methods: 8321B, 8270D, 8260b, and 8290A	SW-846 On-line Test Methods for Evaluating Solid Waste Physical/Chemical Methods.	Screening Data with Definitive Confirmation or Definitive Data	Chemical Agents (Chloropicrin, Chloride Cyanogen, Sarin (GB), Soman (GD), Tabun (GA), VX and Nitrogen Mustard (HN-1, HN-2, HN-3)	GC-MS/GC-ECD	Chemical Laboratory	
SW 846 Method: 6010C, 6020A and 7010	SW-846 On-line Test Methods for Evaluating Solid Waste Physical/Chemical Methods.	Screening Data with Definitive Confirmation or Definitive Data	Chemical Agents (Arsine and Lewisite)	GFAA/ICP-AES/ICP-MS	Chemical Laboratory	

http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/MS	See SW 846 Methods: http://www.epa.gov/osw/hazard/testmethods/sw846/online/	Initial calibration: upon award of the contract, whenever the laboratory takes corrective action which may change or affect the initial calibration criteria (e.g., ion source cleaning or repair, column replacement, etc.), or if the continuing calibration acceptance criteria have not been met. Continuing calibration: Once every 12 hours	Initial calibration/ Continuing calibration: relative response factor (RRF) greater than or equal to minimum acceptable response factor listed in Table 5 of procedure; %RSD must be less than or equal to value listed in Table 5 of procedure.	Initial calibration: inspect system for problems (e.g., clean ion source, change the column, service the purge and trap device), correct problem, re-calibrate. Continuing calibration: inspect system, recalibrate the instrument, and reanalyze samples.	Chemical Laboratory GC/MS Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/
GC/ECD	See SW 846 Methods: http://www.epa.gov/osw/hazard/testmethods/sw846/online/	Initial calibration: upon award of the contract, whenever major instrument maintenance or modification is performed or if the calibration verification technical acceptance criteria have not been met. Calibration verification: Once every 12 hours	Initial calibration/ Calibration verification: resolution between two adjacent peaks must be greater than or equal to 60.0 percent, single components must be greater than or equal to 90.0 percent resolved, RTs within the RT window, %D must be greater than or equal to -25 percent and less than or equal to 25 percent, %RSD must be less than or equal to 20.0 percent.	Initial calibration: inspect the system (e.g., change the column, bake out the detector, clean the injection port) , correct problem, re-calibrate. Calibration verification: inspect system, recalibrate the instrument, and reanalyze samples.	Chemical Laboratory GC/ECD Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/

http://www.epa.gov/sam/SAM_2012_07162012.pdf.

QAPP Worksheet #24: Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP-AES / ICP-MS	See SW-846 Methods; as per instrument manufacturer's recommended procedures	ICP-AES or ICP-MS Initial calibration: daily or once every 24 hours and each time the instrument is set up. ICP-AES or ICP-MS Continuing calibration: beginning and end of run and frequency of 10% or every 2 hours during an analysis run.	ICP-AES: As per instrument manufacturer's recommended procedures, with at least 2 standards. ICP-MS: As per instrument manufacturer's recommended procedures, with at least 2 standards. A minimum of three replicate integrations are required for data acquisition.	ICP-AES or ICP-MS: inspect the system, correct problem, re-calibrate, and re-analyze samples.	Chemical Laboratory ICP-AES / ICP-MS Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/
Spectrophoto-metry	See NIOSH Methods; as per instrument manufacturer's recommended procedures	Spectrophotometer: Initial calibration: daily or once every 24 hours and each time the instrument is set up. Spectrophotometer:: Continuing calibration: beginning and end of run and frequency of 10% or every 2 hours during an analysis run.	Spectrophotometer:: As per instrument manufacturer's recommended procedures, with at least 2 standards.	Spectrophotometer:: inspect the system, correct problem, re-calibrate, and re-analyze samples.	Chemical Laboratory ICP Technician	NIOSH Method 6010

http://www.epa.gov/sam/SAM_2012_07162012.pdf.

QAPP Worksheet #24: Analytical Instrument Calibration Table (Concluded)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP-AES/ICP-MS	See Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air	ICP-AES/ICP-MS: Initial calibration: daily or once every 24 hours and each time the instrument is set up. ICP-AES: Continuing calibration: beginning and end of run and frequency of 10% or every 2 hours during an analysis run.	ICP-AES: As per instrument manufacturer's recommended procedures, with at least 2 standards. ICP-MS: As per instrument manufacturer's recommended procedures, with at least 2 standards. A minimum of three replicate integrations are required for data acquisition.	ICP-AES: inspect the system, correct problem, re-calibrate, and re-analyze samples.	Chemical Laboratory ICP Technician	Compendium Methods: IS-3.1. IS-3.4, and IS-3.5

Calibration and Quality operation should be performed in accordance with manufacturer's published instructions or procedures or as per instrument Manufacturer's recommendations.

QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing/Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
GC/MS	See TO-15/TO-10a; as per instrument manufacturer's recommendations	See TO-15/TO-10a; as per instrument manufacturer's recommendations	See TO-15/TO-10a; as per instrument manufacturer's recommendations	Acceptable re-calibration; see TO-15/TO-10a	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory GC/MS Technician	TO-15 and TO-10a
GC/MS	See SW-846; as per instrument manufacturer's recommendations	See SW-846; as per instrument manufacturer's recommendations	See SW-846; as per instrument manufacturer's recommendations	Acceptable re-calibration; see SW-846	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory GC/MS Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/
GC/ECD	See SW-846; as per instrument manufacturer's recommendations	See SW-846; as per instrument manufacturer's recommendations	See SW-846; as per instrument manufacturer's recommendations	Acceptable re-calibration; see SW-846	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory GC/ECD Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/
ICP-AES / ICP-MS	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	Acceptable re-calibration; see Sw-846	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory ICP-AES / ICP-MS Technician	SW-846 http://www.epa.gov/osw/hazard/testmethods/sw846/online/
Spectrophotometry	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	Acceptable re-calibration; see NIOSH Method	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory ICP-AES Technician	NIOSH Method: http://www.cdc.gov/niosh/docs/2003-154/
ICP-AES / ICP-MS	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	Acceptable re-calibration; see ILM05.4	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Chemical Laboratory ICP-AES / ICP-MS Technician	Compendium Methods: IS-3.1. IS-3.4, and IS-3.5

Refer to: http://www.epa.gov/sam/SAM_2012_07162012.pdf

QAPP Worksheet #26: Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): [ ]
Sample Packaging (Personnel/Organization): [ ]
Coordination of Shipment (Personnel/Organization): [ ]
Type of Shipment/Carrier: Federal Express, UPS, DHL, …..etc.
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodian, ERLN Laboratory
Sample Custody and Storage (Personnel/Organization): Sample Custodian, ERLN Laboratory
Sample Preparation (Personnel/Organization): Sample Technician, ERLN Laboratory
Sample Determinative Analysis (Personnel/Organization): Sample Technician, ERLN Laboratory
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): Samples to be shipped within [ ], and arrive at laboratory within 24 hours (1 day) of sample shipment.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): As per analytical methodology; see Worksheet #19
SAMPLE DISPOSAL
Personnel/Organization: Sample Technicians, CWA Laboratory. Sample disposal will occur per the requirement of the particular governing contract with the RAD laboratory.
Number of Days from Analysis: Until analysis and QA/QC checks are completed; as per analytical methodology; see Worksheet #19.

Note: This worksheet will be completed in Site-Specific QAPP.
Foe waste disposal refer to:
http://www.nrt.org/production/NRT/NRTWeb.nsf/PagesByLevelCat/Level3ChemicalHazards?Opendocument

QAPP Worksheet #27: Sample Custody Requirements Table

Sample custody is maintained when a sample is in a secure area, or in view of, or under the control of a particular individual. Personnel responsible for maintaining sample custody will be identified in the site-specific QAPP. For large sampling events, dedicated personnel will be responsible for sample management and custody.

Sample Identification Procedures: Each sample will be labeled with the site identification code [ ] and a sample type letter code and number that depicts a specific location. Depending on the type of sample, additional information such as depth, sampling round, date, etc., will be added.
Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Each sample will be individually identified and labeled after collection, then sealed with custody seals and enclosed in a plastic cooler. The sample information will be recorded on chain-of custody (COC) forms, and the samples shipped to the appropriate laboratory via overnight delivery service or courier. Chain-of-custody records must be prepared in Scribe to accompany samples from the time of collection and throughout the shipping process. Each individual in possession of the samples must sign and date the sample COC Record. The chain-of-custody record will be considered completed upon receipt at the laboratory. A traffic report and chain-of-custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples are not under direct control of the individual responsible for them, they must be stored in a locked container sealed with a custody seal. Specific information regarding custody of the samples projected to be collected on the weekend will be noted in the field logbook. The chain-of-custody record should include (at minimum) the following: **1) the document number assigned and the date that the evidence was received, (2) the specimen identification number, (3) a brief description of the evidence (e.g., specimen type and Chemical Warfare Agents agent), (4) the date of final disposition, (5) signatures of all personnel who handled and examined the evidence, and (6) remarks.** **Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal):** Within the laboratory, the person responsible for sample receipt must sign and date the chain-of-custody form; verify that custody seals are intact on shipping containers; compare samples received against those listed on the chain-of-custody form; examine all samples for possible shipping damage and improper sample preservation; note on the chain-of-custody record that specific samples were damaged; notify sampling personnel as soon as possible so that appropriate samples may be regenerated; verify that sample holding times have not been exceeded; maintain laboratory chain-of-custody documentation; and place the samples in the appropriate laboratory storage. At this time, no samples will be archived at the laboratory. Disposal of the samples will occur only after analyses and QA/QC checks are completed.

Refer to Department of Defense Instruction for Minimum Security Standards for Safeguarding Chemical Agents:
http://www.dtic.mil/whs/directives/corres/pdf/521065p.pdf

QAPP Worksheet #27: Sample Custody Requirements Table (Continued)

Transport of Samples

In this section, precautions necessary for health protection of individuals potentially exposed to the samples during transport and preservation of samples during transport are described.

Samples collected at the site of a chemical agent attack may themselves present a health hazard and their transport should be treated as transport of a hazardous material. Samples will either be transported to an onsite location for analysis or be taken to an offsite laboratory specializing in the detection of trace concentrations of chemical agents. Transport of samples within the response site boundaries should follow all site requirements for contamination control. For example, contamination control may require additional external packaging at the boundaries of specific contamination zones. Procedures and facilities for this additional packaging should be in-place prior to the transport of samples. Composition of packing materials should be selected so that it forms a barrier to permeation of contaminant materials and their vapors. The outside of packages containing samples should be screened for contamination by the use of portable field monitors. For example, photoionization monitors can be used to detect the presence of organophosphate chemical agents.

Samples destined to offsite laboratories for analysis may fall under hazardous material transportation regulations. Note that there are only a few laboratories in the United States that are capable of conducting analyses of chemical warfare agents (CWAs) and, thus, to which samples containing CWAs could be sent. Within the United States, samples might be transported by highway, air, rail, and/or water. The transport of hazardous materials/environmental samples is governed by regulations that are based on the mode of sample transport. For example, highway transportation of hazardous materials is governed by Department of Transportation 49 Code of Federal Regulations (CFR), civilian air transport is governed by International Air Transport Association (IATA) and military air transport is governed by Air Force Joint Manual 24-404 (AFJM 24-404), and water transportation is governed by International Maritime Dangerous Goods (IMDG) Code. Sample packaging and labeling will need to conform to the regulations under which the shipping company operates. However, in a federally declared State of Emergency, there is precedent for the U.S. Secretary of Transportation to waive some regulatory requirements. In addition, both the military and the U.S. Federal Bureau of Investigation have special authority and provisions for shipping hazardous materials. Shipping samples that are considered to be neat agents will be difficult, if not impossible. If samples can be designated as environmental samples, which typically have low or negligible concentrations of hazardous constituents (as would be the case after decontamination procedures have been applied), sampling shipping is considerably easier. The previously described regulations will specify appropriate sample shipping and packaging protocols. There are also recommended procedures for packaging samples collected by the Organization for Prohibition of Chemical Weapons (OPCW) to verify the Chemical Weapons Convention treaty.

QAPP Worksheet #27: Sample Custody Requirements Table (Continued)

Neat agent and potentially-highly contaminated materials are packaged in a sampling container, placed in a stainless steel secondary container with absorbent material, and placed in a tertiary stainless steel, pressure-tight container (lid sealed with nuts and bolts) before being placed in a shipping crate. All containers are also sealed with tamper-indicating tape or seals. Environmental samples are packaged in a comparable manner, with the exception that, because the concentration of agent residues are expected to be below those associated with extremely adverse health effects, tertiary containment is not necessary. Once packaged, the outside of the sample container could be checked for contamination, as previously described. During transport, samples must be accompanied by a shipping document (*i.e.* a Bill of Lading, Declaration for Dangerous Goods, Air-bill, or Manifest) completed and signed by a properly trained (per Defense Transportation Regulations, DOD 4500.9) individual.

Actions should be taken to assure that collected samples accurately reflect conditions at the location and time they were obtained in the contamination zone. Preservation of the integrity of samples requires actions to prevent loss of material from the sample and to prevent contamination of the sample. Loss of material from the sample can occur through direct contact packing materials or through outgassing of vapors from the sample. Often, environmental samples are shipped in coolers packed with ice to keep the temperature of the sample sufficiently low (4-7ºC) to minimize volatilization of analytes. Shipping Secure specimens in cardboard vial storage boxes or Styrofoam-molded tube holders and enclose in large, zipper locking, plastic bags. Place in a Styrofoam-insulated shipper, and surround with absorbent material for cushioning. Ship refrigerated using cool-packs, and not dry ice. Enclose a shipping list with pertinent information about specimens and the name and telephone number of the appropriate contact person. Each sample container top must be wrapped with waterproof, tamper-proof security tape (available from FBI/Police supply stores).

QAPP Worksheet #28: QC Samples Table (Example)

(UFP-QAPP Manual Section 3.4)
Complete a separate worksheet for each sampling technique, analytical method/SOP, matrix, analytical group, and concentration level. If method/SOP QC acceptance limit exceed the measurement performance criteria, the data obtained may be unusable for making project decisions.

NOTE: Worksheet Not Applicable: Information provided in Worksheet #12 was prepared using the method specific performance criteria. However, if the project specific criteria are different from the method specific criteria, then Worksheet #28 should be completed with the method specific criteria and Worksheet #12 should be completed with the project specific criteria. Additionally, the corrective action procedures related to not meeting the method/laboratory performance criteria should also be completed for this worksheet once the laboratory have been procured.

Matrix	Filter (Air/Wipe), Soil, Aqueous
Analytical Group	Chemical Agents
Concentration Level	Low
Sampling SOP(s)	
Analytical Method/SOP Reference	
Sampler's Name	
Field Sampling Organization	
Analytical Organization	
No. of Sample Locations	

Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Laboratory Method Blank	1/ Preparation Batch					
Laboratory Duplicate Sample	1/ Preparation Batch					
Field Duplicate	1 per ≤ 20 samples					

QAPP Worksheet #29: Project Documents and Records Table

Sample Collection Documents and Records	On-Site Analysis Documents and Records	Data Assessment Documents and Records	Other
• Site and field logbooks • COC forms • Field Data Sheets • Airbills • GIS map for sampling locations * Packing and Shipping Instructions * Handling of possible BT agents * Policy Sign-off List * Training Sign-off List • Incident Action Plan • Photographs • Video	• Samples receipt logs • Sample preparation worksheets/logs • Telephone/email logs • Corrective action documentation	• Data validation reports • Review forms for electronic entry of data into database • Laboratory Preliminary Data • Laboratory Final Data	• Chemical Agents- CDC Information Checklist

QAPP Worksheet #30A: Analytical Services Table (Example)

Matrix	Analytical Group	Analytical SOP	Data Package Turnaround Time	Laboratory / Organization[1] (name and address, contact person and telephone number)	Backup Laboratory / Organization (name and address, contact person and telephone number)
Air/Filter	Chemical Agents			ERLN Laboratory	NA
Wipe	Chemical Agents			ERLN Laboratory	NA
Aqueous	Chemical Agents			ERLN Laboratory	NA
Soil	Chemical Agents			ERLN Laboratory	NA

Note: Specific information will be added in site-specific QAPP.

[1]Laboratory criteria for processing potential Chemical Warfare agents

ERLN Overview: EPA established the Environmental Response Laboratory Network (ERLN) to assist in addressing chemical, biological, and radiological threats during nationally significant incidents. The ERLN is managed by EPA's Office of Emergency Management and serves as a national network of laboratories that can be accessed as needed to support large scale environmental responses by providing consistent analytical capabilities, capacities, and quality data in a systematic, coordinated response. The ERLN integrates capabilities of existing public sector laboratories with accredited private sector labs to support environmental responses.

QAPP Worksheet #30B: Source of Chemical Agents Methods

Name	Publisher	Reference
Standardized Analytical Methods for Environmental Restoration Following Homeland Security Events, EPA/600/R-12/555 July 16, 2012	Office of Research and Development National Homeland Security Research Center	http://www.epa.gov/sam/SAM_2012_07162012.pdf. and http://www.epa.gov/nhsrc/
Centers for Disease Control and Prevention. Chemical Agent Information	Center for Disease Control and Prevention	* http://www.cdc.gov/nceh/demil/chemical_agent.htm
SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods	National Technical Information Service (NTIS) U.S. Department of Commerce	http://www.epa.gov/osw/hazard/testmethods/sw846/index.htm
Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition: EPA/625/R-96/010b	Center for Environmental Research Information Office of Research and Development U.S. Environmental Protection Agency, Cincinnati, OH 45268, January 1999	http://www.epa.gov/ttnamti1/files/ambient/airtox/to-15r.pdf
Occupational Safety and Health Administration (OSHA) – Index of Sampling and Analytical Methods	United State Department of Labor	http://www.osha.gov/dts/sltc/methods/toc.html
Compendium of Methods for the Determination of Inorganic Compounds	U.S. EPA	http://www.epa.gov/ttnamti1/files/ambient/inorganic/iocompen.pdf

QAPP Worksheet #30B: Source of Chemical Agents Methods (Concluded)

Name	Publisher	Reference
Guide for the Selection of Chemical Agent and Toxic Industrial Material Detection Equipment for Emergency First Responders NIJ Guide 100-00, Volume II, June 2000	**U.S. Department of Justice** Office of Justice Programs *National Institute of Justice*	https://www.ncjrs.gov/pdffiles1/nij/184450.pdf
NIOSH AND CDC INTERIM GUIDANCE FOR BLISTER AGENTS (FEBRUARY 2006)	NIOSH and CDC	http://www.osha.gov/SLTC/emergencypreparedness/cbrnmatrix/nerve.html
Guidance on Emergency Responder Personal Protective Equipment (PPE) for Response to CBRN Terrorism Incidents	DEPARTMENT OF HEALTH AND HUMAN SERVICES CentersforDiseaseControlandPreventionNationalInstituteforOccupationalSafety and Health	http://www.cdc.gov/niosh/docs/2008-132/pdfs/2008-132.pdf
Chemical, Chemical Warfare Agents, Radiological And Nuclear consequence Management Advisory Team	U.S. EPA, CBRN, Consequence Management Advisory Team	
The Medical BATTLEBOOK, CBRN, October 2008	U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM)	
NIOSH MANUAL OF ANALYTICAL METHODS (NMAM), 4th ed., DHHS (NIOSH) Publication No. 94-113 (August, 1994),	Center for Disease Control and Prevention	http://www.cdc.gov/niosh/docs/2003-154/
Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents:	National Response team (NRT)	http://notebook.lausd.net/pls/ptl/docs/PAGE/CA_LAUSD/LAUSDNET/OFFICES/SCHOOL_OPS/SCHOOL_OPERATIONS_DIVISION/EMERGENCY_SERVICES/CRITICAL_EMPLOYEE_EMERGENCY%20_PLANNING/DISASTER_PREPAREDNESS_GENERAL_INFORMATION/NATIONAL%20RESPONSE%20TEAM%20%E2%80%93%20CHEMICALS.PDF

***** Subscription and/or purchase is required from the ASTM and the Standard Methods was not provided.

QAPP Worksheet #31: Planned Project Assessments Table

Assessment Type	**Frequency**	**Internal or External**	**Organization Performing Assessment**	**Person(s) Responsible for Performing Assessment** (title and organizational affiliation)	**Person(s) Responsible for Responding to Assessment Findings** (title and organizational affiliation)	**Person(s) Responsible for Identifying and Implementing Corrective Actions (CA)** (title and organizational affiliation)	**Person(s) Responsible for Monitoring Effectiveness of CA** (title and organizational affiliation)
Laboratory Technical Systems	[ ]	External					Association of Public Health Laboratories (APHL)
Performance Evaluation Samples	Every year	External/Internal					CLIP/ Clinical Laboratory Improvement Amendment (CLIA)
NELAP	Every year	External					Department of Health; Bureau of Laboratory Improvement; Epidemiology and Laboratory Services
Data Assessment	Project Specific	External	Lead Organization	Environmental Unit leader			EPA or other Regulatory Agency
Drinking Water	Status Change	External					State Agency or EPA
Chemical Warfare Agents	Status Change	External					CDC/State government

The Clinical Laboratory Improvement Amendments, or "CLIA," sets quality standards for laboratory testing of clinical specimens for patient diagnosis and treatment. Most APHL member laboratories perform testing regulated under CLIA.

The LRN is also a partnership between government and private organizations that have a stake in bioterrorism and chemical preparedness. CDC runs the program with direction and recommendations provided by the following agencies and organizations: **1.)** The Association of Public Health Laboratories; **2.)** The Federal Bureau of Investigation (Department of Justice); **3.)** The American Association of Veterinary Laboratory Diagnosticians; **4.)** The American Society for Microbiology; **5.)** The Environmental Protection Agency; **6.)** The US Department of Agriculture; **7.)** The Department of Defense; **8.)** The US Food and Drug Administration; and **9.)** The Department of Homeland Security.

QAPP Worksheet #32: Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (name, title, organization)	Timeframe for Response
Project Readiness Review	Checklist or logbook entry		Immediately to within 24 hours of review	Checklist or logbook entry		
Field Observations/Deviation from Sampling Plan	Logbook		Immediately to within 24 hours of review	Logbook and revision to the QAPP and/or Corrective Action Plan		
Laboratory Technical Systems/Performance Audit	Written Report		30 days	Letter		
On-Site Field Inspection	Written Report		7 calendar days after completion of the audit	Letter/internal Memorandum and QAPP revision		
Performance Evaluation Samples	Electronic Report		30 days	Letter or Written Report		

QAPP Worksheet #33: QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Site Specific QAPP	As performed	Prior to sampling date		
Health And Safety plan	As performed	Prior to sampling date		
On-Site Field Inspection		7 days after completion of the inspection		
Field Change Request	As required per field change	3 days after identification of need for field change		
Chemical Agents laboratory data (Preliminary)	As performed	ASAP after receipt of preliminary data		
Final Report	As specified in the site TDD	2 to 4 weeks after receipt of EPA approval of data package		

* The 60 day time frame will be changed in the Site-Specific QAPP based on the site specific needs.

QAPP Worksheet #34: Verification (Step I) Process Table

Verification Input	Description	Internal / External	[1]Responsible for Verification (name, organization)
Site/field logbooks	Field notes will be prepared daily by the Operational Staff and will be complete, appropriate, legible and pertinent. Upon completion of field work, logbooks will be placed in the project files.	I	
Chain of Custody(COC)	COC forms will be reviewed against the samples packed in the specific cooler prior to shipment. The reviewer will be initial the form. An original COC will be sent with the samples to the laboratory, while copies are retained for (I) Sampling Trip Report and in the project files.	I	
Sampling Trip Reports(STRs)	STRs will be prepared for each week of field sampling [for which samples are sent to an RAD laboratory]. STR will be reviewed against the COC forms, and potential discrepancies will be discussed with field personnel to verify locations, dates, etc.	I	
Laboratory Analytical Data Package	Data packages will be reviewed/verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. Then review/verify by contractor or lab coordinator.	I/E	
Laboratory Preliminary data	Preliminary data may be limited review for either contract compliance or technical compliance.	E	
Laboratory Analytical Data Package	Data packages will be reviewed as to content and sample information upon receipt by EPA.	E	
Final Sample Report	The project data results will be compiled in a sample report for the project. Entries will be reviewed/verified against hardcopy information.	I	

[1] Responsible for verifications, them their name and organization will be added.

QAPP Worksheet #35: Validation (Steps IIa and IIb) Process Table

Step IIa / IIb	Validation Input	Description	[1]Responsible for Validation (name, organization)
IIa	SOPs	Ensure that the sampling methods/procedures outlined in QAPP were followed, and that any deviations were noted/approved.	Sampling and Monitoring Plan Coordinator and Quality Assurance Coordinator
IIb	SOPs	Determine potential impacts from noted/approved deviation, in regard to PQOs.	Environmental Unit Leader
IIa	Chain of Custody	Examine COC forms against QAPP and laboratory contract requirements (e.g., analytical methods, data qualifiers, QC samples, etc.).	Analytical Coordinator
IIa	Laboratory Data Package	Examine packages against QAPP and laboratory contract requirements, and against COC forms (e.g., holding times, sample handling, analytical methods, sample identification, data qualifiers, QC samples, etc.).	Quality Assurance Coordinator
IIb	Laboratory Data Package	Determine potential impacts from noted/approved deviation, in regard to PQOs. Examples include PQLs and QC sample limits (precision/accuracy).	Quality Assurance Coordinator and Assistant Environmental Unit Leader
IIb	Field Duplicates	Compare results of field duplicate (or replicate) analyses with RPD criteria.	Quality Assurance Coordinator

Note: Site-Specific QAPP may contain additional data validation inputs as required by the project objectives.

QAPP Worksheet #36: Validation (Steps IIa and IIb) Summary Table

Step IIa / IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa / IIb	Air	Chemical Agents	Sampling Method, Calculations, QC Criteria	
IIa / IIb	Wipe	Chemical Agents	Sampling Method, Calculations, QC Criteria	
IIa / IIb	Soil	Chemical Agents	Sampling Method, Calculations, QC Criteria	
IIa / IIb	water	Chemical Agents	Sampling Method, Calculations, QC Criteria	

Note: Site specific QAPP will reference the most current and appropriate data validation SOP available. In addition, the criteria presented on QAPP Worksheet 11, 12, and 28 will be used.

Laboratory testing methods are constantly evolving: new methods are adopted rapidly, reflecting escalating advances in scientific and medical knowledge, and laboratory technology. Many methods emerging into use today use molecular techniques and reagents that did not exist just a few years ago. Implementation and management of Wadsworth Center's mandate under the statutory laboratory reference system require that the Center possess and maintain expert knowledge of new methods and advances in technology, as well as expertise in generally accepted, established methods currently in use. The laboratory reference system has three components:

1.validation and approval of standard laboratory methods and materials;
2.cooperative research relevant to advancement, development and assessment of laboratory methods and materials;
3.Inspection of laboratory facilities and distribution of proficiency test specimens for laboratory examination, or other measures of laboratory performance.

QAPP Worksheet #37: Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: Data, whether generated in the field or by the laboratory, are tabulated and reviewed for Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCCS) by the SPM for field data or the data validator for laboratory data. The review of the PARCC Data Quality Indicators (DQI) will compare with the DQO detailed in the site-specific QAPP, the analytical methods used and impact of any qualitative and quantitative trends will be examined to determine if bias exists. A hard copy of field data is maintained in a designated field or site logbook. Laboratory data packages are validated, and final data reports are generated. Questions about Non-CLP data, as observed during the data review process, are resolved by contacting the respective site personnel and laboratories as appropriate for resolution. All communications are documented in the data validation record with comments as to the resolution to the observed deficiencies.

The data will be evaluated to determine whether they satisfy the PQO for the project. The validation process determines if the data satisfy the QA criteria.

Identify the personnel responsible for performing the usability assessment: Site project management Team, Environmental unit Leader and Chemical Warfare Agents Agent's Technical Specialist

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

A copy of the most current approved QAPP, including any graphs, maps and text reports developed will be provided to all personnel identified on the distribution list.

Appendix A: Communication Contact List

Public Health Contacts for Laboratory Testing To Confirm Exposure During a Potential or Known Chemical Terrorism Event

Emergencies

To obtain emergency information from CDC, contact

CDC
Director's Emergency Operations Center
Atlanta, Georgia
770-488-7100
http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5401a2.htm

Non-emergencies

To obtain non-emergency information, contact

CDC
National Center for Environmental Health
Division of Laboratory Sciences
Atlanta, Georgia
770-488-7950
http://www.cdc.gov/nceh/dls

CDC
National Center for Infectious Diseases
Bioterrorism Rapid Response and Advanced Technology Laboratory
Atlanta, Georgia
404-639-4910

CDC
National Institute of Occupational Safety and Health
Cincinnati, Ohio
800-356-4674
http://www.cdc.gov/niosh/homepage.html

Environmental Protection Agency
National Response Center
Washington, DC
800-424-8802
http://www.epa.gov

Appendix B: References

The Emergency Response Safety and Health Database

NERVE AGENTS

TABUN (GA): Nerve Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750004.html

SARIN (GB): Nerve Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750001.html

SOMAN (GD): Nerve Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750003.html

VX: Nerve Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750005.html

BLISTER AGENTS

LEWISITE (L): Blister Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750006.html

SULFUR MUSTARD: Blister Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750008.html

NITROGEN MUSTARD HN-1: Blister Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750010.html

NITROGEN MUSTARD HN-2: Blister Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750011.html

NITROGEN MUSTARD HN-3: Blister Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750012.html

BLOOD AGENTS

ARSINE (SA): Systemic Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750014.html

HYDROGEN CYANIDE (AC): Systemic Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750038.html

CYANOGEN CHLORIDE (CK): Systemic Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750039.html

Appendix B: References
The Emergency Response Safety and Health Database (Concluded)

CHOKING AGENTS

PHOSGENE (CG): Lung Damaging Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750023.html

TEAR AGENT

CHLOROPICRIN (PS): Lung Damaging Agent
http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750034.html

Appendix C: Checklist and Forms

Checklist#1: Checklist for Sorbent Tube Sampling for Chemical Agents

Checklist#2: Checklist for Absorption Air Sampling for Chemical Agents

Checklist#3: Checklist for Wipe Sampling for Chemical Agents

Checklist#4: Checklist for Soil Sampling for Chemical Agents

Checklist#5: Checklist for Vegetation Sampling for Chemical Agents

Checklist#6: Checklist for Liquid Sampling for Chemical Agent

Checklist#7: Checklist for Miscellaneous Solid Samples for Chemical Agents

Checklist#1

Checklist for Sorbent Tube Sampling for Chemical Agents

Laboratory contacted: Address: _____

Phone number: Laboratory contact: _____ Fax number: _____

_____ Contacted by: _____

Information to be obtained from the laboratory: _____

- Sorbent tube _____
- Flow rate _____
- Required volume _____
- Sample time _____
- Special handling requirement _____
- QA samples required

Equipment/Materials Checklist:

- Personal sampling pump
- Flow rate meter
- Sorbent tube and tube caps
- Type: (specify)
- Flexible Tygon tubing
- Universal tube holder and protective sleeve
- Tube scoring device
- Sterile gloves
- Sealable plastic bags
- Chain-of-custody form
- Custody seals
- Transportation documents

Procedure Checklist:

- Don fresh pair of gloves
- Calibrate pump to specified flow rate.
- Break the ends of the glass tube using the tube scorer.
- Insert calibration tube into holder.
- Check flow rate with flow meter three times and record average flow rate..
- Remove calibration blank, insert sample tube into holder and place protective sleeve over the tube.
- Place pump in the breathing or sampling zone.
- Adjust and record pump sampling time.
- Check the pump flow rate at the midpoint of the sampling period, if longer than four hours.
- Collect QA/QC samples, method specific.
- At end of collection period, remove tube from sleeve using sterile glove and cap ends.
- Using calibration blank, record flow rate at end of sampling period.
- Place sample tube in a re-sealable plastic bag and label properly.
- Double bag the bagged sample in another re-sealable plastic bag.
- Complete standard EPA COC form.
- Attach custody seal to each sample and package for transportation.
- Arrange for transportation.

Sampler(s): _____

Date: _____ **Project:** _____

Sorbent Tube Sample Form for Chemical Agents

Date:				Site Name:						TDD:		
Sample Number	Sampling Location	Tube Type and Lot No.	No. Analysis	Initial Flow Rate			Final Flow Rate			Start Time	Final Time	Sampler
				1	2	3	1	2	3			

Checklist#2

Checklist for Absorption Air Sampling for Chemical Agents

Laboratory contacted:_____

Address: _____
Phone number: _____ Fax number:_____
Laboratory contact: _____Contacted by:_____
Information to be obtained from the laboratory:

- Solution for impinger or filter_____
- Solution volume for impinger_____
- Required sample volume for impinger or filter_____
- Flow rate for filter or impinger_____
- Sampling time for filter or impinger_____
- Special handling instructions_____

Equipment/Materials Checklist:

- ˂ Calibrated personal sample pump
- ˂ Flow meter
- ˂ Sterile gloves
- ˂ Impinger or filter holder
- ˂ Flexible Tygon tubing
- ˂ Labeled pre-cleaned sample jars
- ˂ Method-specific solution or filter
- ˂ Chain-of-custody form
- ˂ Custody seals
- ˂ Transportation documents

Procedure Checklist:

- ˂ Set the pump to the flow rate specified by the laboratory or the method.
- ˂ Don sterile gloves.
- ˂ Fill the impinger with the appropriate volume of method-specific medium (or put the filter in the holder), as specified by the analytical method or laboratory.
- ˂ Set up the sampling train by attaching one end of the Tygon tubing to the impinger or the filter holder and the other to the inlet plug of the pump.
- ˂ Calibrate the pump with the flow meter.
- ˂ Check the flow rate with the flow meter 3 times and record the average flow rate.
- ˂. Place the pump and impinger in the breathing zone or sampling zone.
- ˂ Collect QA/QC samples, method specific.
- ˂ Adjust and record pump sampling time.
- ˂ Check the flow rate at the midpoint of sampling period, if longer than 4 hours.
- ˂ Record run time and flow rate at end of sampling period.
- ˂ With sterile gloves, remove the impinger or filter holder from the manifold and transfer the solution into a labeled pre-cleaned container.
- ˂ Complete COC form.
- ˂ Attach custody seal to each sample and package for transportation.
- ˂ Arrange for transportation.

Sampler(s):_____

Impinger Sample Form

Date:				Site Name:					TDD:			
Sample Number	Sampling Location	Solution and Volume (mL)	Analysis	Initial flow Rate			Final flow Rate			Start Time	Final Time	Sampler
				1	2	3	1	2	3			

Checklist#3
Checklist for Wipe Sampling for Chemical Agents

Laboratory contacted:_____

_____

Address: _____ _____

Phone number: _____ Fax number: _____

Laboratory contact: Contacted by:

Information to be obtained from the laboratory:

- Solvent _____
- Special handling requirements _____

Equipment/Apparatus Checklist

- Pre-cleaned 4oz. glass container with Teflon lid.
- Sterile wrapped gauze pad (3 inches x 3 inches) or sterile filter paper.
- Chloroform (HPLC grad) or isopropyl alcohol.
- Disposable, sterile template (10 cm x 10 cm).
- Chain-of-custody form.
- Sterile gloves.
- Clear sealable plastic bags.
- Custody seals.
- COC forms..
- Transportation documents.

Procedure Checklist:

- Choose the appropriate 10 cm by 10 cm sampling area.
- Don a fresh pair of gloves..
- Saturate a sterile gauze or sterile filter paper with solvent.
- Wipe the designated surface once horizontally and once vertically using firm strokes.
- Collect QA/QC samples, method specific.
- Fold the gauze with exposed side inward.
- Place gauze in sample container with Teflon lid.
- Place sample container in a sealable plastic bag.
- Complete COC form.
- Attach custody seal to each sample and package for transportation.
- Arrange for transportation.

Sampler(s):_____

Date:_____ **Project:**_____

Wipe Sample Form

Date:		Site Name:			TDD:
Sample Number	Sample Location	Sample Description	Method-Specified Solvent and Volume (mL)	Analysis	Sampler

Checklist#4
Checklist for Soil Sampling for Chemical Agents

Laboratory contacted:_____

Address:_____
Phone number:_____ Fax number: Contacted by:_____
Laboratory contact:_____ _____

Information to be obtained from the laboratory:

- Sample volume required_____
- Special handling requirements_____
- Required QC samples_____

Equipment/Materials Checklist:

- Pre-cleaned 8oz. sample container with Teflon lid.
- Sealable plastic bags (clear).
- Plastic or stainless steel spoon.
- Stainless steel trowel.
- Sterile gloves.
- Chain-of-custody forms.
- Custody seals.
- Transportation documents.

Procedure (surface sampling) Checklist:

- Use separate sampling equipment and containers for each sample point to ensure cross-contamination does not occur.
- Don a fresh pair of gloves.
- Collect a sample of soil to a depth of approximately 1 inch and place in the sample container. Collect enough soil to fill the 8-oz container.
- Collect QA/QC sample Method Specific
- Collect a sample of soil to a depth of approximately 1inch and place in the sample container. Collect enough soil.
- Place sample container in a sealable plastic bag and label properly.
- Complete COC form.
- Attach COC seal to each sample and package for transportation.
- Arrange for transportation.

Sampler(s):_____

Date: _____ **Project:** _____

Soil Sample Form

Date:		Site Name:			TDD:
Sample Number	**Sample Location**	**Sample Description**	**Volume (mL) and Number of Bottles**	**Analysis**	**Sampler**

Checklist#5
Checklist for Vegetation Sampling for Chemical Agents

Laboratory contacted: _____

Address: _____

Phone number: _____ Fax number: _____

Laboratory contact: _____ Contacted by: _____

Information to be obtained from the laboratory: _____

- Sample mass required _____
- Special handling requirements
- Required QC samples

Equipment/Materials Checklist:

- Pre-cleaned 8oz. sample container with Teflon lid.
- Sealable plastic bags (clear).
- Scissors, sheers, or other suitable tool to obtain sample.
- Sterile gloves.
- Chain-of-custody forms.
- Custody seals.
- Transportation documents.

Procedure (surface sampling) Checklist:

- Use separate sampling equipment and containers for each sample point to avoid cross-contamination.
- Don a fresh pair of gloves.
- Collect a sample 4 cm above the soil surface and place in sample container. Vegetation sample should be no longer than 14 cm in overall length.
- Place sample container in a sealable plastic bag and label properly.
- Collect QA/QC samples, method specific.
- Complete COC form.
- Attach COC seal to each sample and package for transportation.
- Arrange for transportation.

Sampler(s): _____

Date: _____ **Project:** _____

Vegetation Sample Form

Date:		Site Name:			TDD:
Sample Number	**Sample Location**	**Sample Description**	**Weight (g) and Number of Bottles**	**Analysis**	**Sampler**

Checklist#6

Checklist for Liquid Sampling for Chemical Agent

Laboratory contacted: _____
Address: _____
Phone number: _____ Fax number: _____
Laboratory contact: _____ Contacted by: _____

Information to be obtained from the laboratory:

- Sample Volume Required _____
- Special Handling Requirements _____

Equipment/Materials Checklist:

- Kemmerer sampler.
- Bacon bomb sampler.
- Dip sampler.
- Bailer.
- Miscellaneous sampling equipment (syringe, pipettes, etc).
- 30-mL volatile organics analysis (VOA) bottles with Teflon-lined septa lids.
- Sealable bags (clear).
- Sample preservatives, if required.
- 1-Liter amber sample bottle with Teflon-lined lid.
- Sterile gloves.
- Chain-of-custody form.
- Custody seals.
- Transportation documents.

Procedure Checklist:

- Don a fresh pair of gloves.
- Select the sampling apparatus based on the sampling requirements.
- Collect the sample using the appropriate technique.
- Label sample bottles appropriately.
- Collect a sample of liquid for each sample bottle, minimizing agitation of liquid.
- Ensure that no air is trapped under the septa lid, of the VOA bottles.
- Add sample preservative to the sample, if required.
- Place sample bottle in a sealable plastic bag.
- Collect QA/QC samples, method specific.
- Complete chain of custody.
- Attach COC seal to each sample and package for transportation.
- Arrange for transportation.

Sampler(s): _____

Date: _____ **Project:** _____

Liquid Sample Form

Date:		Site Name:			TDD:
Sample Number	**Sampling Location**	**Sample Description**	**Volume (mL) and Number of Bottles**	**Analysis**	**Sampler**

Checklist#7

Checklist for Miscellaneous Solid Samples for Chemical Agents

Laboratory contacted: _____

Address: _____

Phone number: _____ Fax number: _____

Laboratory contact: _____ Contacted by: _____

Information to be obtained from the laboratory:

- ☐ Items to be sampled_____
- ☐ Required sample volume_____
- ☐ Special handling requirements_____

Equipment/Materials Checklist:

- ☐ Scissors.
- ☐ Shovel.
- ☐ Spoon, disposable.
- ☐ Sealable plastic bags (clear).
- ☐ Pre-cleaned sample containers of various sizes.
- ☐ Chain-of-custody forms.
- ☐ Custody seals.
- ☐ Transportation documents.
- ☐ Sterile gloves.

Procedure Checklist:

- ☐ Don a fresh pair of gloves.
- ☐ Cut up or break the material into small pieces, if possible.
- ☐ Place miscellaneous material into a large sealable bag or 1-liter wide-mouth sample bottle (laboratory-cleaned).
- ☐ Place sample in another sealable plastic bag.
- ☐ Collect QA/QC samples, method specific.
- ☐ Complete COC form.
- ☐ Attach COC seal to each sample and package for transportation.
- ☐ Arrange for transportation.

Sampler(s): _____

Date: _____ **Project:** _____

Miscellaneous Solids Sample Form

Date:	Site Name:		TDD:		
Sample Number	**Sampling Location**	**Sample Description**	**Volume (mL) and Number of Bottles**	**Analysis**	**Sampler**

APPENDIX D: CHEMICAL AGENT HAZARD

Agent Name Symbol CAS No.	Type	Hazard	ICT50 mg-min/m3 ICT50 ppm	LCT50 mg-min/m3 LCT50 ppm	Volatility/ Persistence	IDLH ppm PEL	Symptoms of Exposure	Treatment	Physical Characteristics
Phosgene Oxime (CX) 35274-08-9	Blister	Respiratory, Skin, Eyes	>3 0.6	3200 687	P	Unknown Not Listed	Immediate burning; Weal-like skin lesions;	Airway Maintenance, Ventilation; Treat individual symptoms of contact;	A solid below 95EF, but a vapor can result
Thionyl Chloride Mustard T (HT) 505-60-2/ 693-07-2	Blister	Respiratory, Skin, Eyes	Approx. Same as H Approx. Same as H	Approx. Same as H Approx. Same as H	P	0.0005 Not Listed			
Distilled Mustard (H/HD) 505-60-2	Blister	Respiratory, Skin, Eyes	150 - 200 21.5 - 30	1500 231	P	0.0005 Not Listed	Reddening of skin; Blisters; Eye pain, redness & damage;		Oily light yellow to brown liquids with a strong odor of garlic
Nitrogen Mustard (NH-1) 538-07-08	Blister	Respiratory, Skin, Eyes	200 (29)	1500 (216)	**P**	0.0004 Not Listed	Coughing; Airway	Flush eyes with copious amount of water and	Fishy odor for HN series;
Nitrogen Mustard (NH-2) 51-75-2	Blister	Respiratory, Skin, Eyes	100 (16)	3000 (470)	**P**	0.0005 Not Listed	Respiratory (effects & blisters in 4-24 hrs)	Lung injuries are treated with bronchodilatory	H and HD freeze at 57F;
Nitrogen Mustard (NH-3) 555-77-1	Blister	Respiratory. Skin, Eyes	200 (24)	1500 (179)	P	0.0005 Not Listed	Can be lethal in large doses	Infection Control by	All are volatile at room temperature
Lewisite (L) 541-25-3	Blister	Respiratory, Skin, Eyes	<300 <35	1200 - 1500 141 - 177	P	>0.0004 Not Listed	Immediate pain or irritation of	Pain can be eased by local anesthetics	Oily colorless liquid with the odor of geraniums; More volatile than H
Tabun (GA) 77-81-6	Nerve	Respiratory, Skin, Eyes	300 45	135 - 400 20 - 60	SP	0.03 Not Listed	Pinpointed pupils;	Auto-injector (Atropine, Oxime),	Colorless or lightly colored liquid at normal temperature;

APPENDIX D: CHEMICAL AGENT HAZARD (Concluded)

Agent Name Symbol CAS No.	Type	Hazard	ICT_{50} mg-min/m3 ICT_{50} ppm	LCT_{50} mg-min/m3 LCT_{50} ppm	Volatility/ Persistence	IDLH ppm PEL	Symptoms of Exposure	Treatment	Physical Characteristics
Sarin (GB) 107-44-8	Nerve	Respiratory, Skin, Eyes	35 - 75 8	70 - 100 12	NP	0.03 Not Listed	Tightness of chest; Difficulty breathing;	Anti-convulsant drugs (diazepam),	G-agents slightly less volatile than water;
Soman (GD) 94-64-0	Nerve	Respiratory, Skin, Eyes	35 - 300 4	70 9	SP	0.008 Not Listed	Twitching or paralysis; Tachycardia; vomiting;	Pyridostigmine - preventative antidote,	V-agents about as volatile as motor oil.
EA 1701 (VX) 50782-69-9	Nerve	Respiratory, Skin, Eyes	24 - 50 2	30 - 100 3	P	0.0018 Not Listed	Loss of consciousness; Convulsions	Airway Maintenance, Ventilation.	
Chlorine (CL) 7782-50-5	Choke	Respiratory	1800 620	19,000 6551	**NP**	30 Ceiling - 1.0 ppm	Coughing, choking	Airway Maintenance, Ventilation	Gas odor - swimming pool
Phosgene (CG) 75-44-5	Choke	Respiratory	1600 395	3200 791	**NP**	2 0.1 ppm	Coughing, choking	Airway Maintenance, Ventilation	Gas odor - new mown hay
			Varies	< 2000		45			
Cyanogen Chloride (CK) 506-77-4			7000	11000		Unknown	Dizziness, Nausea, Vomiting, Headache, Convulsions, Death	Bind ions to heavy metals - such as: Sodium nitrate (NaNO2), Dimethylaminophenol (DMAP), or Vitamin B12.	

Sources:

1. Chemical Agent Data Sheets V.1 Dec. 1974, EO-512-74001
2. Field Manual 3-9, 12 Dec 90
3. Merck Index, 12th Ed., 1996
4. CRC Handbook, 69th Ed., 1988
5. MSDS from CBDCOM Safety
6. CHPPM Detailed Facts Sheets

APPENDIX E: Basic Decontamination Procedures

(Example)

Decontamination Solutions for Responders					
Agent	**Symbol**	**Decontamination Solution**	**Methods**	**Preparation**	**Cautions**
Chemical		**Bleach or Soap and Water**		Wash with soap and water. Wash with a 1:10 dilution of household bleach (1 part bleach, 9 parts water) (0.5% hypochlorite). Rinse with water.	Use: For skin. Undiluted bleach: harmful to skin and clothing. Remove from skin and clothing by flushing with water. Keep out of victim-s eyes and mouth, do not use if victims have any abdominal wounds.
					Corrosive to metals. Use: 5% hypochlorite. Use undiluted household bleach.
Tabun	GA		Removes		
Sarin	GB		Removes		
Soman	GD		Removes		
V Agent	VX	Soap and Water	Neutralizes	Wash with soap and water. Flush with copious amounts of water.	Some research states that bleach solutions used on V-agents may cause toxic off-gassing and formation of a more toxic solution.
Vesicants		Bleach or Soap and Water	Physical Removal	Wash with soap and water. Wash with a 1:10 dilution of household bleach (1 part bleach, 9 parts water) (0.5% hypochlorite). Rinse with water.	Use: For skin. Undiluted bleach: harmful to skin and clothing. Remove from skin and clothing by flushing with water. Keep out of victim-s eyes and mouth, do not use if victims have any abdominal wounds. Corrosive to metals. Use: 5% hypochlorite. Use undiluted household bleach, PPE. Soap and detergents may decrease the hydrolyzation rate of these agents.

APPENDIX E: Basic Decontamination Procedures (Concluded)

(Example)

Decontamination Solutions for Responders					
Agent	**Symbol**	**Decontamination Solution**	**Methods**	**Preparation**	**Cautions**
Mustard	H				
Distilled Mustard	HD				
Lewisite	L				
Phosgene Oxime	CX				
Blood		Water	Removes	Flush with copious amounts of water.	Effective in physically removing the agent, but may not neutralize the agent.
Hydrogen Cyanide	AC				
Cyanogen Chloride	CK				
Choking		Water	Removes	Flush with copious amounts of water.	Effective in physically removing the agent, but may not neutralize the agent.
Phosgene	CG				
Chlorine	CL				
Riot Control	CS/CN	Water	Removes	Flush with copious amounts of water.	Effective in physically removing the agent, but may not neutralize the agent.
Unknown		Water	Removes	Flush with copious amounts of water.	
Other					

Sources: F.R. Sidell, M.D., W.C. Patrick III, and T.R. Dashiell, 1998, Jane-s Chem-Bio Handbook, Jane-s Information Group; CBDCOM Domestic Preparedness Program, Domestic Preparedness Training Program - Hazmat Technician, 1999; Textbook of Military Medicine, Medical Aspects of Chemical and Chemical Warfare Agents Warfare, 1997; Hazardous Materials Exposure, 1994, Second Edition; Fort McClellan Army Chemical School, Student Handbook.

APPENDIX F: Equipment Lists

(Example)

EQUIPMENT CHECKLIST			
PROTECTIVE GEAR			
Level A	**No.**	**Level B**	**No.**
SCBA		**SCBA**	
SPARE AIR TANKS		**SPARE AIR TANKS**	
ENCAPSULATING SUIT (Type _____)		**PROTECTIVE COVERALL (Type)**	
SURGICAL GLOVES		**BUTYL APRON**	
SAFETY BOOTS (NEOPRENE, LEATHER)		**SURGICAL GLOVES (Type)**	
BOOTIES (Type)		**OUTER GLOVES (Type)**	
GLOVES (Type ____)		**OUTER WORK GLOVES (Type)**	
OUTER GLOVES: (Type:)		**SAFETY BOOTS (NEOPRENE; LEATHER)**	
HARD HAT		**BOOTIES (Type)**	
CASCADE SYSTEM; MANIFOLD SYSTEM		**HARD HAT (FACE SHIELD; LINER)**	
5-MINUTE ESCAPE MASK		**CASCADE SYSTEM; MANIFOLD SYSTEM**	
COOLING VEST		**SCBA/AIR-LINE SYSTEM**	
		HIP AIR SYSTEM	
Level C		**COTTON CLOTHING**	
ULTRA-TWIN RESPIRATOR		**COOLING VEST**	
POWER AIR PURIFYING RESPIRATOR		**HEARING PROTECTION**	
CARTRIDGES (Type)			
5-MINUTE ESCAPE MASK		**Level D**	
PROTECTIVE COVERALL (Type)		**ULTRA-TWIN RESPIRATOR (Available)**	
RAIN SUIT		**CARTRIDGES (Type)**	
BUTYL APRON		**5-MINUTE ESCAPE MASK (Available)**	
SURGICAL GLOVES (Type _____)		**PROTECTIVE COVERALL (Type)**	
OUTER GLOVES (Type)		**RAIN SUIT**	
OUTER WORK GLOVES (Type)		**SAFETY BOOTS (NEOPRENE; LEATHER)**	
SAFETY BOOTS (NEOPRENE; LEATHER)		**BOOTIES (Type)**	
HARD HAT (FACE SHIELD; LINER)		**WORK GLOVES (Type)**	
BOOTIES (Type)		**SURGICAL GLOVES (Type)**	
COTTON CLOTHING		**HARD HAT (FACE SHIELD; LINER)**	
COOLING VEST		**SAFETY GLASSES**	
LIFE JACKET/VEST		**COTTON CLOTHING**	

APPENDIX F: Equipment Lists (Continued)

(Example)

EQUIPMENT CHECKLIST		
INSULATED: (COVERALLS; BOOTS)	**JACKET (LIGHT; HEAVY)**	**No.**
HEARING PROTECTION	**LIFE JACKET/VEST**	
	INSULATED; (___COVERALLS; ___BOOTS)	
	HEARING PROTECTION (available)	
INSTRUMENTATION	**No. INSTRUMENTATION (Continued)**	
ORGANIC VAPOR MONITOR	**CHARGERS FOR EQUIPMENT**	
Type: __	**EQUIPMENT LOG BOOKS**	
	TOTAL STATION	
CALIBRATION GAS	**MERCURY METER**	
O_2/EXPLOSIMETER WITH CAL. KIT	**NOISE DOSIMETER**	
SINGLE GAS MONITOR	**SOUND LEVEL METER**	
Types: _		
DRAEGER PUMP, TUBES	**RADIATION EQUIPMENT**	
ACCURO PUMP, TUBES	**TLD BADGE**	
REAL TIME AEROSOL MONITOR	**RADIATION ALERT MONITOR 4 (RAM-4)**	
PERSONAL REAL TIME AEROSOL MONITOR	**POCKET DOSIMETERS WITH CHARGER**	
~~XRF, PORTABLE~~	**DOCUMENTATION FORMS**	
HAZARD CATEGORIZATION KIT, WITH GAS	**PORTABLE RATEMETER:**	
INFRARED MONITOR		
INFRARED PYROMETER	**Type: __**	
GROUND PENETRATING RADAR		
MAGNETOMETER	**MICRO R METER:**	
MAGNETIC CABLE LOCATOR	**Type:**	
GROUND CONDUCTIVITY METER	**SCALER/RATEMETER:**	
TERRAIN RESISTIVITY METER WITH ACC's	**NaI PROBE**	
EM-31 _EM-34	**ZnS PROBE**	
SEISMOGRAPH	**GM PANCAKE PROBE**	
WEATHER STATION; DATALOGGER	**GM SIDE WINDOW PROBE**	
HEAT STRESS MONITOR	**ION CHAMBER**	
WIND GAUGE, HAND HELD	**Type:**	
pH: PAPER; PEN; METER		
CONDUCTIVITY PROBE /PEN		
WATER QUALITY TESTER		
DISSOLVED OXYGEN METER	**FIRST AID EQUIPMENT**	
RELATIVE HUMIDITY: PROBE; PEN	**FIRST AID KIT**	
H_2S TEST STRIPS	**PORTABLE EYE WASH**	

APPENDIX F: Equipment Lists (Continued)

(Example)

EQUIPMENT CHECKLIST			
SPILFYTER TEST STRIPS	**No.**	**BLOOD PRESSURE MONITOR**	**No.**
ANEMOMETER		**PORTABLE SHOWER**	
SLING PSYCHROMETER		**FIRE EXTINGUISHER**	
INTERSCAN SO_2 H_2S		**FIRE BLANKET**	
LIGHT METER		**STRETCHER/LITTER**	
CHLOR-N-OIL KIT			
CHLOR-N-SOIL KIT			
BATTERIES FOR EQUIPMENT			
SAMPLING EQUIPMENT		**SAMPLING EQUIPMENT (Continued)**	
GLASS BOTTLES (Sizes)		**PERSONAL AIR SAMPLING PUMPS**	
GLASS BOTTLES, WIDE MOUTH ( )		**WITH CALIBRATOR, CHARGERS, SUPPLIES**	
VOA BOTTLES (40 ml)		**AIR-FLOW CALIBRATOR**	
POLYETHYLENE BOTTLES (Size)		**GENERATOR(S), PORTABLE**	
SAMPLE PRESERVATIVES: HNO_3,		**HIGH-VOLUME AIR SAMPLERS WITH**	
NaOH, H_2S0_4 HCL		**CALIBRATORS: PM-10; PS-1; PM-2.5**	
HAND BAILERS		**HIGH-FLOW AIR SAMPLER**	
STRING AND/OR ROPE		**ANALYTICAL BALANCE**	
WATER LEVEL INDICATOR		**pH PAPER**	
WELL PUMP			
CAT HEAD/MOTOR/PULLEY			
SAMPLING PLATFORM (BOAT)			
KEMMERER WATER SAMPLER			
ECKMAN DREDGE			
TROWELS AND/OR SPOONS		**DECON EQUIPMENT**	
SHOVEL AND/OR POST HOLE DIGGER		**WASH TUBS**	
MIXING PLATES AND/OR BOWLS		**BUCKETS**	
SIEVES		**SCRUB BRUSHES**	
HAND AUGER (Size)		**PRESSURIZED SPRAYER**	
SLEEVES/CAPS/EXTENSIONS		**DETERGENT (Type)**	
SPLIT SPOON SAMPLER		**SOLVENT (Type)**	
GEOPROBE		**HOUSEHOLD BLEACH SOLUTION**	
SOIL GAS TILE PROBE WITH ACCESSORIES		**DISTILLED WATER**	
SLAM BAR (Size)		**DEIONIZED WATER**	
EXTENSIONS/SLEEVES/CAPS		**DISPOSA BLE FACEPIECE SANITIZER WIPES**	
SOIL PROBE		**FACE MASK SANITIZER POWDER**	

APPENDIX F: Equipment Lists (Continued)

(Example)

EQUIPMENT CHECKLIST			
KNIVES AND/OR SCISSORS	**No.**	**WIRE BRUSH**	**No.**
BANNER TAPE		**SPRAY BOTTLE**	
PLASTIC SHEETING		**BANNER/BARRIER TAPE**	
SURVEYING: FLAGS; TAPE		**PLASTIC SHEETING**	
AUTO LEVEL; TRIPOD		**TARPS AND POLES**	
FIELD TRANSIT; TRIPOD		**TRASH BAGS**	
BRUNTON COMPASS; ROD, 25 FT.		**TRASH CANS**	
CHAIN OR TAPE (200 FT.) AND/OR ROLATAPE		**MASKING TAPE**	
HAND HELD GPS ( )		**DUCT TAPE**	
NON-SPARKING TOOLS		**PAPER TOWELS**	
THIEVING RODS WITH BULBS		**FOLDING CHAIRS**	
COLIWASA SAMPLERS WITH TUBES		**STEP LADDERS**	
SLUDGE JUDGE		**5-GALLON WATER JUGS**	
SPRAY PAINT/MARKER		**TABLES**	
		STEAM CLEANER WITH GENERATOR	
VAN EQUIPMENT		**MISCELLANEOUS**	
TOOL KIT		**35-mm CAMERA, FILM, BATTERIES**	
HYDRAULIC JACK		**VIDEO CAMERA, TAPE, BATTERIES**	
LUG WRENCH		**CAMERA, DIGITAL**	
TOW CHAIN		**LOG BOOK (_ LARGE, SMALL)**	
VAN CHECK OUT		**LOG BOOK STAMPS**	
Gas		**CHEMICAL REFERENCES**	
Oil		**MSDS'S REQUIRED**	
Antifreeze		**QASP IF REQUIRED**	
Battery		**SITE SAFETY PLAN**	
Windshield Wash		**BINOCULARS**	
Tire Pressure		**MEGAPHONE; AIR HORN; BULL HORN**	
Lights		**INTRINSICALLY SAFE FLASHLIGHTS**	
Level A Trailer		**WITH BATTERIES**	
		WEATHER RADIO	
		2-WAY RADIOS WITH CHARGERS	
SHIPPING EQUIPMENT		**CELLULAR TELEPHONE WITH CHARGER**	
COOLERS		**SATELLITE TELEPHONE**	
PAINT CANS WITH LIDS, 7 CLIPS EACH SIZE		**COMPUTER WITH PRINTER, BATTERIES**	
		COMPUTER DISKS, PAPER, CORDS	
VERMICULITE		**MODEM; TELECOUPLER**	
BUBBLE WRAP		**EXTENSION CORDS; OUTLET STRIP**	

APPENDIX F: Equipment Lists (Continued)

(Example)

EQUIPMENT CHECKLIST		
FEDERAL EXPRESS AIRBILLS	REGULAR HAND TOOLS	
ADDRESS LABELS	BOLT CUTTERS; KEYS, PADLOCKS	
DOT LABELS: "DANGER"	MAPS	
"THIS SIDE UP"	COMPASS	
"INSIDE CONTAINER COMPLIES..."	TAPE MEASURE	
OTHER HAZARD GROUP(S)	PERMANENT MARKERS; PENS, PENCILS	
BAGGIES; GARBAGE BAGS	SCISSORS; KNIVES	
CUSTODY SEALS	WATER COOLER; STRESS DRINKS	
COC FORMS	APR FOG PRUF, NOSECUP (Cold Weather)	
SAMPLE TAGS	SNAKE LEGGINGS	
SAMPLE LABELS	WADERS (HIP, CHEST)	
CLP FORMS/STICKERS	INSECT REPELLENT	
CLEAR PACKING TAPE	SUNSCREEN	
STRAPPING TAPE	HEARING PROTECTION	
DUCT TAPE	FALL PROTECTION SAFETY BELT W/LAN-YARD	
PERMANENT MARKERS		
SHARPIE PENS		
BALLPOINT PENS		

APPENDIX F: Equipment Lists (Continued)

(Example)

EMERGENCY RESPONDER DETECTION AND MONITORING EQUIPMENT				
Equipment	**Hazard Agent**	**Readings**	**Physical State**	**Time**
Colorimetric Tube Detector Tubes	Nerve-G series	Phosphoric	Vapor	5-25 mins
	Nerve-VX	Acid Esters	Vapor	
	Mustard-H, HD	Thioether Tube	Vapor	
	Lewisite	Organic Arsenic	Vapor	
	Blood-AC	Hydrocyanic Acid	Gas/Vapor	
	Blood-CK	Cyanogen Chloride	Gas/Vapor	
	Choking-CG	Phosgene Tube	Gas/Vapor	
	Choking-CL	Chlorine Tube	Gas/Vapor	
	Chloropicrin-PS	Carbon Tetrachloride	Vapor	
	Hydrogen Arsenide	Organic Arsenic	Gas/Vapor	
Combination Meters Single Gas Meters	Oxygen	0-25% by vol	Vapor/Gas	Seconds
	Carbon Monoxide	0-900 ppm/ 35 ppm	Vapor/Gas	
	Hydrogen Sulfide	0-90 ppm/ 10 ppm	Vapor/Gas	
3/4/5-Sensor Gas Meters	LEL	0-100%/ 10%	Gas	Seconds
	Oxygen	0-25% / 19.5-23%	Gas	
	Carbon Monoxide	0-2,000 ppm / 35p	Gas	
	Hydrogen Sulfur	0-250 ppm/ 10pp	Gas	
CGI- **Combustible Gas Indicator** Explosimeter	Flammability	Meas. in % LEL	Gas/Vapor	Seconds
Draeger Chip System	Ammonia	2-50 ppm	Vapor/Gas	1-2 mins
	Benzene	.2-10 ppm	Vapor/Gas	
	Carbon Dioxide	1,000-25,000 ppm	Vapor/Gas	
	Carbon Monoxide	5-150 ppm	Vapor/Gas	
	Chlorine	.2-10 ppm	Vapor/Gas	
	Hydrochloric Acid	1-25 ppm	Vapor/Gas	
	Hydrogen Cyanide	2.0-50 ppm	Vapor/Gas	
	Hydrogen Sulfide	2-50 ppm	Vapor/Gas	
	Nitrogen Dioxide	.5-25 ppm	Vapor/Gas	
	Nitrous Fumes	.5-15 ppm	Vapor/Gas	
	Perchloroethylene	5-150 ppm	Vapor/Gas	
	Sulfur Dioxide	.4-10 ppm	Vapor/Gas	
Flame Ionization Detector (FID)	Organic vapors	Organic vapors present in ppm	Gas/Vapor	

APPENDIX F: Equipment Lists (Continued)

(Example)

EMERGENCY RESPONDER DETECTION AND MONITORING EQUIPMENT				
Survey Instrument Ludlum GM Detector Probe	Beta	14 - C needle	Radiation	<=30 secs
	Gamma	2240 digital	Radiation	
	43-5 Alpha	2241 newer	Radiation	
	44-6 Side Window		Radiation	
Dosimeter Pocket/Self-Reading	Gamma	CDV-138 0-200 mR	Radiation	Immediate
	X-rays	CDB-742 0-200R	Radiation	

MILITARY DETECTION, MONITORING, AND TREATMENT EQUIPMENT				
Equipment	**Agent**	**Readings**	**Analyte**	**Time**
M-9 Paper	Nerve-G	Develops a single color indicating agent present	Liquid	<=20 sec
	Nerve-VX		Liquid	
	Mustard		Liquid	
M-8 Paper	Nerve-G	Turns yellow	Liquid	<=30 sec
	Nerve-VX	Turns green	Liquid	
	Vesicant-H	Turns red	Liquid	
M-256A1 Detector Kit	Nerve-G & V	As indicated in kit's instructions	Vapor	15 min-series take longer
	Mustard-H	As indicated in kit's instructions	Vapor	
	Lewisite CX	As indicated in kit's instructions	Vapor	
	Blood-AC, CK	As indicated in kit's instructions	Vapor	AC-25 min

APPENDIX G: DOT AND IATA SHIPPING GUIDANCE FOR CHEMICAL AGENTS

DOT REGULATIONS FOR SHIPPING OF CHEMICAL AGENTS

Agent	Tabun (GA)	Sarin (GB)	Soman (GD)	V-agent (VX)
Shipping Name	Toxic liquid, organic, n.o.s. (#)	Toxic liquid, organic, n.o.s. (#)	Toxic liquid, organic, n.o.s. (#)	Toxic liquid, organic, n.o.s. (#)
DOT Hazardous Classification	6.1, Packing Group I Hazardous Zone B	6.1, Packing Group I Hazardous Zone A	6.1, Packing Group I Hazardous Zone B	6.1, Packing Group I Hazardous Zone A
DOT Label	Toxic	Toxic	Toxic	Toxic
DOT Marking	Toxic liquid, organic, n.o.s. (Ethyl diethel-phophoramidocyanidate) UN 2810, Inhalation Hazard	Toxic liquid, organic, n.o.s. (Isopropyl methyl-phosphonofluoridate) UN 2810, Inhalation Hazard	Toxic liquid, organic, n.o.s. (Pinacolyl methyl phosphonofluoridate) UN 2810, Inhalation Hazard	Toxic liquid, organic, n.o.s. (O-ethyl S-(2-diisopropyl-aminoethyl)methyl phosphonothiolate) UN 2810, Inhalation Hazard
DOT Placard	Toxic	Toxic	Toxic	Toxic
Source	1	1	1	1
Precautions	Motor vehicles will be placarded regardless of quantity. Drivers will carry full information regarding shipment and procedures in case of emergency.			

Agent	Lewisite (L)*	Distilled Mustard (HD)	Phosgene	Diphosgene
Shipping Name	Poisonous liquid, n.o.s.	Toxic liquid, corrosive, inorganic, n.o.s.(#)_	Phosgene	Toxic liquid, corrosive, organic, n.o.s. (#)
DOT Hazardous Classification	6.1, Packing Group I	6.1 and 8, Packing Group I Hazardous Zone B	2.3, Hazardous Zone B	6.1, and 8 Packing Group I
DOT Label	Poison	Toxic and Corrosive	Poison Gas, Corrosive	Toxic and Corrosive
DOT Marking	Poisonous liquids, n.o.s. (Dichloro-(2-chlorovinyl) arsine) UN 2810, Inhalation Hazard	Toxic liquid, corrosive, inorganic, n.o.s. (Bis-(2-chlorethyl) sulfide) UN 3289, Inhalation Hazard	Phosgene UN 1076, Inhalation Hazard	Toxic liquid, Corrosive, organic, n.o.s. (Trichloromethyl chloroformate) UN 2927
DOT Placard	Poison	Toxic	Poison	Toxic
Source	1	4	2	4
Precautions	Motor vehicles will be placarded regardless of quantity. Drivers will carry full information regarding shipment and procedures in case of an emergency.			

APPENDIX G: DOT AND IATA SHIPPING GUIDANCE FOR CHEMICAL AGENTS (Concluded)

Agent	Hydrogen Cyanide, solution in alcohol	Hydrogen Cyanide, stabilized < 3% water	Hydrogen Cyanide, stabilized < 3% water and absorbed in a porous inert	Cyanogen Chloride
Shipping Name	Hydrogen Cyanide, solution in alcohol	Hydrogen Cyanide, stabilized	Hydrogen Cyanide, stabilized	Cyanogen Chloride, inhibited
DOT Hazardous Classification	6.1, Packing Group I	6.1, Packing Group I	6.1, Packing Group I	2.3
DOT Label	Poison Flammable liquid	Poison Flammable liquid	Poison	Poison Gas Corrosive
DOT Marking	Hydrogen Cyanide, solution in alcohol UN 3294, Inhalation Hazard	Hydrogen Cyanide, stabilized UN 1051, Inhalation Hazard	Hydrogen Cyanide, stabilized UN 1614, Inhalation Hazard	Cyanogen Chloride, inhibited UN 1589 Inhalation Hazard
DOT Placard	Poison	Poison	Poison	Poison
Source	2	2	2	2
Precautions	Motor vehicles will be placarded regardless of quantity. Drivers will carry full information regarding shipment and procedures in case of emergency.			

Agent	Arsine	Chemical Warfare Agents Agents
Proper Shipping Name	Arsine	Infectious substance, affecting humans (#)
DOT Hazardous Classification	2.3	6.2
DOT Label	Poison Gas	Infectious Substance
DOT Marking	Arsine UN 2188, Inhalation Hazard	Infectious substance, (#) UN 2814
DOT Placard	Poison	Infectious Substance
Source	2	4
Precautions	Motor vehicles will be placarded regardless of quantity. Drivers will carry full information regarding shipment and procedures in case of emergency.	

Source:

1 Keegan, R. IV and R Keegan, 1997/1998 Hazardous Materials, Substances & Wastes Compliance Guide, Transportation Skills Programs, Inc., Kutztown, PA, 1997.

2. www.fisher1.com

3 International Air Transport Association, Dangerous Goods Regulations 42nd Edition, Montreal, OT, 2001.

* Forbidden from transport other than via military (Technical Escort Unit) transport in accordance with 49 CFR 172 # Add the technical name of the chemical within the parenthesis.

APPENDIX H:

Refer to: Key References Cited/Used* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents

APPENDIX I

CHEMICAL AGENT SYMPTOMOLOGY

AGENT	PHYSICAL STATE	SIGNS AND SYMPTOMS	ODOR	DECONTAMINATION	PERSISTENCE	DOT ERG
NERVE						
GA/GB/GD	Liquid	Pinpoint Pupils, SLUDGE -Salivation, Lacrimination (tearing), Urination, Defecation, Gastrointestinal distress, Emesis (vomiting), twitching, convulsions	Fruity	Remove contaminated clothing. Flush with soap and large volumes of water.	Minutes; days in heavy concentration	153
VX	Like Oil		Sulfur		Days to weeks	
BLISTER						
Mustard	Liquid	Eye pain, gritty eyes, reddened skin, large fluid-filled blisters	Garlic	Remove contaminated clothing. Flush with soap and large volumes of water.	Days to years	153
Lewisite	Liquid	Immediate eye pain and burning lungs, bee sting blisters, grayish skin	Geraniums		Hours to days	153
BLOOD						
Hydrogen Cyanide	Gas	Bright red lips and skin, headache, gasping, nausea	Bitter Almonds	Remove contaminated clothing. Flush with soap and large volumes of water.	Minutes	117
Cyanogen Chloride						125
CHOKING						
Phosgene	Gas	Coughing, choking, pneumonia	New-mown hay	Remove contaminated clothing. Flush with soap and large volumes of water.	Minutes	125
Chlorine	Gas	Coughing, choking	Bleach			124

APPENDIX J

Chemical Warfare Agent Laboratory Contacts

Fixed EPA CWA Labs

Unit	Point of Contact
USEPA Region 1 - New England Regional Laboratory 11 Technology Drive ***Mail Code:*** EIA North Chelmsford, MA 01863-2431	Ernest Waterman 617-918-8632 Waterman.Ernest@epa.gov
USEPA Region 3 Environmental Science Center 701 Mapes Road ***Mail Code:*** 3EA21 Fort Meade, MD 20755-5350	Caporale, Cynthia 410-305-2732 Caporale.cynthia@Epa.gov
USEPA Region 6 Laboratory Houston Branch 10625 Fallstone Road ***Mail Code:*** 6MD Houston, TX 77099	Neleigh, David W 281-983-2209 Neleigh.david@Epa.gov
USEPA Region 9 Laboratory 1337 South 46th Street Building # 201 ***Mail Code:*** MTS-2 Richmond, CA 94804-4698	Bettencourt, Brenda 510-412-2311 Bettencourt.brenda@Epa.gov
USEPA Region 10 - Manchester Laboratory 7411 Beach Drive East ***Mail Code:*** LAB Port Orchard, WA 98366	Pepich, Barry V. 360-871-8701 Pepich.barry@Epamail.epa.gov
EPA PHILIS Mobile Labs	
Castle Rock, Colorado Edison, New Jersey	Lawrence Kaelin 732-321-6625 (work) 513-675-4751 (cell) Kaelin.Lawrence@epa.gov Terry Smith 202-564-2908 (work) 202-503-8981 (cell)
State CWA Labs (via EPA contract)	Please note these labs are under contract to EPA, and the EPA POC should be contracted, and not the lab unless absolutely necessary.
Florida Department of Environmental Protection 2600 Blair Stone Road, Tallahassee, FL 32399. Timothy W. Fitzpatrick (850) 245-8083	Terry Smith 202-564-2908 (work) 202-503-8981 (cell)
Virginia Division of Consolidated Laboratory Services 500 N. 5th Street, Richmond, VA. 23219 Christopher Retarides Phone - (804) 648-4480 Ext.332 Cell - (804) 382-3480	Terry Smith 202-564-2908 (work) 202-503-8981 (cell)

APPENDIX 2

HASP TEMPLATE

(FOR FULL TEMPLATE, PLEASE SEE HTTP://WWW.EPAOSC.ORG/MAIN/HEALTHSAFETY.ASPX)

Version 1.0
(April 2014)

Emergency Responder Health and Safety Manual

Chapter 1

Site-Specific Health and Safety Plan Development

Final

Customized for Organization Name on Date

U.S. Environmental Protection Agency

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LIST OF ACRONYMS

ANSI	American National Standards Institute
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRZ	contamination reduction zone
EPA	U.S. Environmental Protection Agency
ERP	emergency response plan
EZ	exclusion zone
HASP	site-specific health and safety plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSPC	Health and Safety Program Contact
IAP	Incident Action Plan
ICS	Incident Command System
JHA	job hazard analysis
NAR	National Approach to Response
NCP	National Contingency Plan
NIMS	National Incident Management System
NPL	National Priorities List
NRF	National Response Framework
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
OSWER	Office of Solid Waste and Emergency Response
PPE	personal protective equipment
PRP	potentially responsible party
RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Plan
SARA	Superfund Amendments and Reauthorization Act
SCBA	self-contained breathing apparatus
SDS	safety data sheet
SHEMP	Safety, Health, and Environmental Management Program
SOP	standard operating procedure
SOSG	Standard Operating Safety Guides
TSD	treatment, storage, and disposal

1.0 INTRODUCTION

1.1 Background Information and Regulatory Basis

The Occupational Safety and Health Administration (OSHA) requires employers to prepare site-specific health and safety plans (HASPs) for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. HAZWOPER requires each employer on a site to protect its employees under a HASP. As an employer, EPA must also cite all other relevant OSHA standards (e.g., lead standard, fall protection, asbestos) in the HASP that may be applicable to a particular response.

EPA Standard Operating Safety Guides (SOSG) are intended for federal, state, and local managers and for personnel at sites where hazardous materials are present. In accordance with EPA's Standard Operating Safety Guides, the rule is One Site, One HASP. There are several options for generating one HASP for sites with multiple employers (see Section 5).

HAZWOPER generally covers three different types of work:

(1) clean-up operations at hazardous waste sites (paragraphs [b] through [o]);
(2) operations at EPA-licensed treatment, storage, and disposal (TSD) facilities (paragraph [p]); and
(3) emergency response operations involving the release of hazardous substances (paragraph [q]).

HAZWOPER only requires a HASP for the operations covered in paragraphs (b) – (o) and for post emergency response operations (see Text Box 1 for a description of the scope of HAZWOPER).

Text Box 1
Scope of HAZWOPER

Paragraph (a)(1) of HAZWOPER provides the scope of the standard and covers three different categories of work, listed below.

(1) Paragraphs (b)–(o):

- Clean-up operations required by a governmental body — whether federal, state, local, or other — involving hazardous substances that are conducted at uncontrolled hazardous waste sites (including, but not limited to, EPA's National Priorities List [NPL], state priority site lists, sites recommended for the NPL, and initial investigations of government-identified sites that are conducted before the presence or absence of hazardous substances has been ascertained).
- Corrective actions involving clean-up operations at sites covered by the Resource Conservation and Recovery Act of 1976 (RCRA) as amended (42 U.S.C. 6901 et seq.).
- Voluntary clean-up operations at sites recognized by federal, state, local, or other governmental bodies as uncontrolled hazardous waste sites.

(2) Paragraph (p):

- Operations involving hazardous waste that are conducted at TSD facilities regulated by 40 CFR Parts 264 and 265 pursuant to RCRA, or by agencies under agreement with EPA to implement RCRA regulations.

(3) Paragraph (q):

- Emergency response operations for releases of, or substantial threats of releases of, hazardous substances without regard to the location of the hazard.

This chapter does not cover emergency response operations under 1910.120(q) nor operations at TSD facilities covered by paragraph (p) of HAZWOPER. Instead, this chapter focuses on the generation of one HASP to address clean-up operations at hazardous waste sites in accordance with HAZWOPER paragraphs [b] through [o].

Emergency responders who perform response operations covered by HAZWOPER must comply with the standard. In addition, Executive Order 12196 requires federal agencies to maintain an effective health and safety program that meets the same standards that apply to private employers, and 29 CFR Part 1960 (Basic Program Elements for Federal Employees) requires agencies to comply with standards promulgated under the OSHA Act (Part 1960.16). The Act also allows federal agencies to adopt agency-specific alternative standards provided they afford equivalent or greater protection for their employees. The OSHA fact sheet "Occupational Safety and Health for Federal Employees" provides a summary of the health and safety requirements federal employees must follow.

1.2 Instructions for Users

The chapter provides guidance on generating one HASP for multiple employers and the elements that must be addressed in a HASP. The chapter also provides guidance on the approval process for a HASP and on using the Incident Action Plan (IAP) to fulfill HASP requirements. Templates are attached that emergency responders may use to generate a HASP or an employer addendum to a HASP. When developing a HASP, it is important to keep the document to a manageable size to ensure that all staff working at a site will read it.

This chapter must be implemented across all EPA regions, OSWER special teams, and headquarters. This means that each EPA organization must adopt the minimum Agency requirements and management practices listed in this chapter and produce a customized version of the chapter that is reviewed/updated on an annual basis.

To customize the chapter, users must (1) complete Appendix A and (2) verify that the task assignments presented throughout the chapter (highlighted in yellow) are correct or modify them accordingly to reflect organization-specific practices. If organizations advocate additional policies and procedures, they must document them in Appendix B. Tools have been developed to support this chapter, including a glossary (Appendix C); an implementation checklist (Appendix D) that organizations can use to ensure that they have met the requirements of this chapter; and a detailed list of HASP-related resources (Appendix E).

See the Introduction to this manual for details on customizing and posting an organization's HASP Development chapter to the manual's website. The website also includes useful tools and resources, including downloadable forms, reference documents, training materials, and a Field Guide. The latter presents a brief summary of each of the manual's chapters, highlighting main points and identifying key management practices and activities that must be followed in the field.

2.0 ROLES AND RESPONSIBILITIES

OSHA requires that all employers, including EPA, generate a HASP that conforms with HAZWOPER where employees may become involved in hazardous waste operations. Response actions conducted under the National Contingency Plan (NCP) must comply with HAZWOPER. In addition, the NCP gives the On-Scene Coordinator (OSC) responsibility for coordinating response efforts and for addressing worker health and safety concerns. Therefore, at a response action, OSCs must ensure that a HASP is generated for the site that covers all employers subject to OSHA.

Health and Safety Program Contacts (HSPCs); Removal Managers; Safety, Health, and Environmental Management Program (SHEMP) Managers; OSCs; and individual emergency responders have roles and responsibilities in preparing and implementing HASPs. During a response, an OSC often serves as the Safety Officer. Appendix A summarizes the tasks that these key personnel must perform. Organizations may delegate a task to someone other than the default assignment presented in the appendix if they wish to do so.

3.0 HAZWOPER REQUIREMENTS FOR A HASP

This section describes HAZWOPER regulations that require and/or impact HASP development for a site. A brief synopsis of the following HAZWOPER paragraphs follow:

- Paragraph (b): development of a safety and health program, comprehensive work plan and a HASP;
- Paragraph (c): site characterization and analysis; and
- Paragraph (q): emergency response.

3.1 Work Plans, Site Characterization, and an Overview of the HASP Development Process

Paragraph (b) of HAZWOPER requires that a health and safety program be developed for hazardous waste operations and says that this program must identify, evaluate, and control safety and health hazards. As part of this program, a comprehensive work plan must be prepared to identify the tasks and objectives of site operations and the logistics and resources required to accomplish those tasks and objectives (see Text Box 2). The health and safety program also requires a HASP under paragraph (b)(4) of HAZWOPER. The HASP must be kept on site, must address the health and safety hazards of each phase of site operations, and must include the requirements and procedures for employee protection.

Text Box 2
Comprehensive Work Plan

As required by HAZWOPER, the written health and safety program should specify that a comprehensive work plan will be developed for each site to evaluate the logistics and resources needed to reach work objectives for site operations. The work plan should identify anticipated cleanup activities as well as normal operating procedures. It should also establish implementation strategies for carrying out the training, informational, and medical surveillance programs of the general health and safety program. The following steps should be undertaken in developing the work plan:

- Review available information, including the site's health and safety training program. HAZrecords, waste inventories, manifests, sampling data, site photos, and other program records;
- Define work objectives;
- Determine methods for accomplishing the objectives (e.g., sampling plan, defining alternate technologies);
- Determine personnel requirements;
- Determine need for additional training; and
- Determine equipment requirements.

Paragraph (c) of HAZWOPER requires the employer to continuously identify and evaluate health and safety risks, beginning at the time of initial site characterization (Text Box 3) and continuing throughout site operations.

Text Box 3
Site Characterization

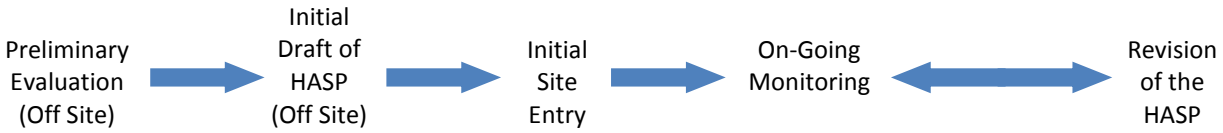
The site characterization provides information needed to identify site hazards, select proper personal protective equipment (PPE), and implement safe work practices. Site characterization generally proceeds in three phases:

- Prior to site entry, an offsite characterization, including data gathering and perimeter reconnaissance;
- An onsite survey; and,
- Ongoing monitoring to provide a continuous source of information about site conditions and potential changes in exposure.

The OSC (or another designated person) must ensure that a HASP is written before site activities are initiated. As job tasks and health and safety hazards change, the HASP must be updated to reflect these changing site conditions. The OSC (or another designated person) must ensure that the HASP is kept on site.

Figure 1 illustrates the HASP development process.

Figure 1
HASP Development Process



Section 4.0 of this chapter describes the HASP elements and Section 5.0 describes different options for creating one HASP on a multi-employer site.

3.2 The Early Stages of an Emergency Response

Employers are not required to develop a HASP when employees are engaged in emergency response operations, such as responding to an overturned tanker truck (see Paragraph [q] of HAZWOPER). *Note: OSHA and EPA may define an emergency response differently. Therefore, EPA emergency responders must use their professional judgment and experience in determining whether a site falls under OSHA's* 1910.120*(q) definition of an emergency response.*

Employees responding to an incident under 1910.120(q) must be operating under an existing emergency response plan (ERP). Therefore, EPA emergency responders can comply with 1910.120(q) and deploy to an emergency response site without a HASP as long as they perform minimal planning (e.g. identify existing ERPs) beforehand.

The ERP required by 1910.120(q) is intended to address anticipated emergencies prior to the commencement of emergency response operations. For the purposes of 1910.120(q), EPA emergency responders address ERP requirements in accordance with the NCP, the National Response Framework (NRF), and Area Contingency Plans. In addition, many ERP requirements are satisfied by EPA responders participating in drills and exercises. Also, 1910.120(q)(2)(xii) allows local and state ERPs and Superfund Amendments and Reauthorization Act (SARA) Title III plans to substitute for the 1910.120(q) ERP. Finally, elements of an emergency that are site-specific will generally be addressed by facility, local, and/or state plans (e.g., places of refuge). Table 1 lists existing references that can be used by EPA to address the 1910.120(q) requirements of an ERP. This table should be customized by regions to identify other available resources.

Table 1
ERP Elements and Example Reference Materials

HAZWOPER (q)(2) Requirements	ERP Elements	Reference
(i)	Pre-emergency planning and coordination with outside parties	Area Contingency Plans, Facility Response Plans (FRPs), RCRA Part B Permits, Risk Management Plan (RMP), National Approach to Response (NAR)
(ii)	Personnel roles, lines of authority, training, and communication	NCP, NAR, NRF, EPA Orders (1440.1, 1440.2, 14601.1, 4800.1)
(iii)	Emergency recognition and prevention	1910.120 Training, Emergency Responder H&S Manual
(iv)	Safe distances and places of refuge	SARA Title III plans per 1910.120(q)(xii). FRP, RCRA Part B Permits, RMP
(v)	Site security and control	SARA Title III plans per 1910.120(q)(xii), FRP, RCRA Part B Permits, RMP
(vi)	Evacuation routes and procedures	SARA Title III plans per 1910.120(q)(xii), FRP, RCRA Part B Permits, RMP
(vii)	Decontamination.	Standard Operating Procedures (SOPs) for OSWER
(viii)	Emergency medical treatment and first aid.	SARA Title III plans per 1910.120(q)(xii), FRP, RCRA Part B Permits, RMP, SHEMP Occupant Emergency Plans
(ix)	Emergency alerting and response procedures	SOPs for OSWER, FRP, RCRA Part B Permits, RMP
(x)	Critique of response and follow-up.	SOPs for OSWER, EPA Near Miss Procedures
(xi)	PPE and emergency equipment	PPE Program chapter, Core NAR equipment, SOPs for OSWER

3.3 Transition From Emergency Response to Clean-up Operations

Upon completion of the emergency response phase, the employer must prepare a HASP prior to post-emergency response operations. Paragraph (q)(11) (post-emergency response operations) regulates what response operation requirements must be complied with following an emergency response. If it is determined that it is necessary to remove or collect hazardous substances (e.g., remove contaminated soil or drums, or conduct air monitoring) following an emergency response, all of the requirements of HAZWOPER paragraphs (b) through (o) must be met, including the development of a HASP.

Post-emergency clean-up begins when the person in charge of the initial emergency response declares the site to be under control and ready for clean-up. Once the person in charge has declared the emergency response activity over or finished, and the immediate threat has been stabilized, any remaining clean-up is considered a post-emergency operation. Emergency responders must use their knowledge, authority, and experience to make a determination that an emergency is over and ready for clean-up. For further details on the transition from emergency response activities to clean-up operations, see OSHA Directive CPL 02-02-073 (Inspection Procedures for 29 CFR 1910.120 and 1926.65, paragraph [q]: Emergency Response to Hazardous Substance Releases), Section XI.L.

4.0 HASP ELEMENTS

This section describes each of the OSHA-required elements of a HASP (see Text Box 4). Although HAZWOPER mandates what must be in a HASP, it does not specify the format or design. See OSHA Directive CPL-02-02-071, Technical Enforcement and Assistance Guidelines for Hazardous Waste Site and RCRA Corrective Action Clean-up Operations HAZWOPER 1910.120 (b)–(o) Directive, for additional guidance on what OSHA requires in a HASP.

Text Box 4
Minimum Elements of a HASP

In accordance with paragraph (b)(4)(ii), a HASP must include at least the following elements:

- Job hazard analyses for tasks identified in the site work plan (Section 4.1).*
- Employee training (Section 4.2).*
- PPE (Section 4.3).
- Medical surveillance requirements (Section 4.4).*
- Environmental and personnel monitoring (Section 4.5).
- Site control measures in accordance with the site control program (Section 4.6).
- Decontamination procedures (Section 4.7).
- ERP for safe and effective responses to emergencies (Section 4.8).*
- Confined space entry procedures (if applicable) (Section 4.9).
- Spill containment program (Section 4.10).

*All or a portion of these elements may be employer-specific.

Appendix F provides a HASP template. It is provided as guidance and is not intended to replace existing templates or formats used across EPA. Appendix G provides a template for an addendum to a HASP and Appendix H provides an example cover for a consolidated HASP. These templates and their uses are described further in Section 5.

4.1 Job Hazard Analyses (JHAs)

The completion of JHAs is a required element of the HASP under paragraph (b)(4)(ii)(A) of HAZWOPER. A JHA is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. After hazards are identified, controls are implemented to eliminate them or reduce them to an acceptable risk level. A hazardous waste site response operation may involve tasks that include a variety of chemical, biological, and physical hazards. JHAs must be conducted for each of these tasks and adequate controls (e.g., traffic control plans, PPE, hazard-specific onsite training) must be identified to address the hazards. An example JHA template is provided in Appendices F and G. Other useful tools include: 1) an appendix in the manual's Respiratory Protection Program chapter titled *Tools to Assist with Hazard Evaluations and HASPs* and 2) Safety, Health and Environmental Management (SHEM) Guideline No. 56: Job Hazard Analysis. In addition, completed JHAs for typical hazardous waste site response activities (e.g., container sampling) are maintained in repositories located on SHEMD's Intranet and under the "Resources" section of the manual's website. JHAs must be prepared for each task identified in the site work plan.

Since JHAs are task specific, they may also be employer-specific where employers on a site perform separate and distinct tasks.

4.2 Employee Training

Required training for employees on a site must be identified in the HASP in accordance with paragraph (b)(4)(ii)(B) of HAZWOPER. The HASP must confirm that personnel are adequately trained to perform their job responsibilities and can handle the specific hazards they may encounter. Emergency responders must receive training in accordance with paragraph (e) of HAZWOPER. This includes initial training of at least 40 hours of off-site instruction, a minimum of 3 days of actual field experience, and 8 hours of annual refresher training. Employees with "equivalent" experience and skills from previous work experience and/or training do not have to receive the initial training, provided that it can be verified through documentation or certification. Responders who will fulfill supervisory roles on a site must receive 8 hours of training in addition to the initial 40 hours of offsite instruction. In addition, as a requirement of this chapter, emergency responders must receive HASP Development Training. This training can be delivered as a standalone course or during HAZWOPER training.

While there are common training requirements for work on a hazardous waste site (i.e. HAZWOPER-required training), employers may also have employee-specific training requirements based on job assignment and/or company policy. For instance, EPA has identified core training EPA OSCs must take, in addition to HAZWOPER-required training. A list of EPA OSC training that may be required for a specific site is provided in Appendices F and G. OSC training requirements are further outlined in the manual's Health and Safety Training Program chapter. In addition, a portion of the training program must include hands-on experience and exercises (e.g., donning and doffing of PPE) to provide employees with an opportunity to become familiar with equipment and safe practices in a non-hazardous setting.

Pre-entry briefings (or tailgate meetings) are required by OSHA under 1910.120(b)(4)(iii). Routine (i.e., daily or shift) pre-entry briefings must be conducted before any site activities begin. The purpose of these briefings is to describe assigned tasks and the level and degree of likely exposure; coordinate activities; identify controls to prevent injuries; describe site emergency response procedures and any potential fire, explosion, health, safety, or other hazards; and if necessary describe any changes to the HASP.

4.3 Personal Protective Equipment (PPE)

PPE is a required element of the HASP under paragraph (b)(4)(ii)(C) of HAZWOPER. Using completed JHAs, designated levels of PPE (i.e., levels A, B, C, and D) must be selected and used to protect employees from hazards and potential hazards likely to be encountered during site activities for specific tasks and work areas. For example, the level of PPE used in the exclusion zone (EZ) would be more protective than for the level of PPE used in the contamination reduction zone (CRZ). Further discussion on PPE can be found in the manual's PPE Program chapter, the Guidelines for PPE Ensemble Selection, and Appendix B of HAZWOPER.

The criteria for downgrading or upgrading from one level of protection to another level of protection must be determined by the OSC (or another designated person). The initial criteria should be developed before site activities begin. The level of protection may be decreased when additional information (e.g., air monitoring results) or other site conditions show that decreased protection will not result in employee exposures to hazardous materials or situations above action levels established for the site. Any decisions to downgrade or upgrade PPE must be documented in the HASP. A few examples of reasons to downgrade or upgrade PPE are presented below.

Reasons to downgrade:

- New information indicates that the situation is less hazardous than originally assumed.
- Changes in site conditions that decrease the potential hazard.
- Changes in work tasks that reduce exposure to hazardous materials.

Reasons to upgrade:

- Known or suspected presence of dermal hazards.
- Occurrence or likely occurrence of gas, vapor, or dust emission.
- Changes in work tasks that increase the exposure or potential exposure to hazardous materials.
- New information indicates that the situation is more hazardous than originally assumed.
- Changes in site conditions increase potential hazards.

4.4 Medical Surveillance

Medical surveillance is a required element of the HASP under paragraph (b)(4)(ii)(D) of HAZWOPER. Medical surveillance policies may be employer specific. For instance, HASPs should reference the Medical Surveillance Program chapter for medical surveillance requirements for EPA emergency responders. Baseline and annual medical examinations are required for EPA emergency responders and all exams must be completed and documented prior to assignment to a site. A medical examination must have been completed within a 12-month period prior to onsite activity. All exams must be conducted following the elements specified in EPA's Medical Surveillance Program. If there are any site-specific medical surveillance requirements, they must be described in the HASP.

4.5 Environmental and Personal Monitoring

Environmental and personal monitoring is a required element of the HASP under paragraph (b)(4)(ii)(E) of HAZWOPER. The HASP must address the frequency and types of air monitoring and personnel monitoring as well as the environmental sampling techniques and instrumentation to be used. The methods for the maintenance and calibration of instruments and sampling equipment should also be included.

The purpose of air monitoring is to identify and quantify airborne contaminants in order to determine the appropriate levels of worker protection needed. There are two principal approaches for identifying and/or quantifying airborne contaminants: the use of direct-reading instruments and laboratory analysis of air samples collected by sampling equipment. Table 2 provides a few basic types of direct-reading instruments. Pre-determined action levels are often assigned to site contaminants. When monitoring shows that an action level is exceeded, exposures are reduced through engineering controls, changing the work tasks or tools, making administrative changes, or upgrading to a higher level of PPE. Table 3 lists some action levels for common contaminants. Chapter 7 of the Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities provides additional information on the types of monitoring instruments, sampling equipment, monitoring procedures, and laboratory analysis.

Table 2
Types of Direct-Reading Instruments

Examples
• Combustible gas indicator • Flame ionization detector • Photo ionization detector • Colorimetric indicator tubes • Radiation survey meter (alpha, beta, gamma) • Mercury meter • Oxygen meter • Carbon monoxide meter

Table 3
General Action Levels

Contaminant	Level	Action
Oxygen	19.5%–22%	Continue work in Level D or C
	<19.5% or >22%	Upgrade to Level B or A
Lower explosive limit (LEL)	10%–25% of LEL	Continuous monitoring
	>25% of LEL	Evacuate immediately
Particulates	>5 milligrams per cubic meter (assume that all dust is respirable dust)	Upgrade to Level C
Radiation	Above background but <1 milliroentgen (mR) per hour	Continuous monitoring
	≥1 mR/hr	Withdraw, contact radiation safety officer, and reassess work plan
Unknown organic vapors/gases	Background to 1 part per million (ppm)	Level D with continuous monitoring
	1 ppm to ≤5 ppm	Level C with continuous monitoring
	>5 ppm to ≤500 ppm	Level B
	>500 ppm	Level A

4.6 Site Control Program

The site control program is a required element of the HASP under paragraph (b)(4)(ii)(F) of HAZWOPER. A site control program must be implemented to control employee exposure to hazardous materials before response work begins and then modified as site conditions change. Text Box 5 lists site control program requirements.

The site map should show site work zones; topographic features; prevailing wind directions; drainage; and the locations of buildings, containers, impoundments, pits, ponds, and tanks. Overlays can be helpful to provide necessary information without cluttering a map.

To reduce the accidental spread of hazardous materials by workers from a contaminated area to a clean area, work zones must be clearly delineated on the site where different types of operations will occur, and the flow of personnel among the zones must be controlled. These zones help ensure that personnel are properly protected against hazards, that work activities and contamination are confined to the appropriate areas, and that personnel can be located and evacuated in an emergency. Work zones include the EZ, CRZ, and support zone.

The buddy system must be used in contaminated or otherwise hazardous areas. The buddy must be able to:

- Provide the partner with any necessary assistance.
- Observe the partner for signs of chemical or heat exposure.
- Periodically check the integrity of the partner's protective clothing.
- Notify the command post or others if emergency help is needed.

Text Box 5
Site Control Program Requirements

Site control program requirements under HAZWOPER include:

- A site map.
- Site work zones.
- Use of a buddy system.
- Site communications, including alerting means for emergencies.
- SOPs or safe work practices.
- Identification of nearest medical assistance.

(Note: If these requirements are covered elsewhere in the HASP, they do not need to be repeated.)

Although not specifically listed in Text Box 5, site security is a part of site control and should be maintained during both working and non-working hours.

4.7 Decontamination Procedures

Decontamination is a required element of the HASP under paragraph (b)(4)(ii)(G) of HAZWOPER (Text Box 6). All employees leaving a contaminated area must be appropriately decontaminated. Procedures should include the following:

- Number and layout of decontamination stations.
- Decontamination equipment needed.
- Appropriate decontamination methods.
- Procedures to prevent contamination of clean areas.
- Methods to minimize worker contact with contaminants during removal of PPE and equipment.
- Methods for disposal of clothing and equipment that are not completely decontaminated.
- Specified level of PPE for decontamination personnel. (*Note: The level of protection required for personnel assisting with decontamination is generally one level below that of the person being decontaminated*).

Procedures for decontaminating heavy equipment (e.g., trackhoes) must be developed to prevent contamination from migrating out of the EZ. Vehicles that enter and exit the site (e.g., dump trucks) must be decontaminated to prevent contamination from leaving the site.

Text Box 6
Decontamination Requirements

Major decontamination requirements under HAZWOPER include:

- Procedures must be developed and communicated to employees.
- All contaminated clothing and equipment leaving a contaminated area must be appropriately decontaminated.
- Decontamination procedures must be monitored to determine their effectiveness.
- Decontamination must be performed in areas that will minimize the exposure of uncontaminated employees or equipment to contaminated employees or equipment.
- Permeable clothing that becomes wet with hazardous materials must be removed.

Table 4 lists some examples of equipment used to decontaminate personnel, PPE, and equipment.

Table 4
Decontamination Equipment

Examples	
• Plastic sheeting • Collection containers • Plastic wading pools • Wash and rinse solutions	• Long-handled brushes • Paper or cloth towels • Sealed pads with drains • Shower facilities

Chapter 9 of the Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities provides additional information on decontamination methods. Appendix D of the above mentioned manual provides three example decontamination layouts for Levels A, B, and C.

4.8 Emergency Response Plan

The ERP is a required element of the HASP under paragraph (b)(4)(ii)(H) of HAZWOPER (Text Box 7).[1] The plan must define the responsibilities, lines of authority, resources, and actions necessary to respond to any emergencies that could occur on a site. These procedures do not have to repeat existing emergency response elements included in other sections of the HASP (e.g., site layout, monitoring equipment).

Emergency response procedures must be rehearsed regularly, as applicable, during project activities. The ERP must also be reviewed and revised on a regular basis (if necessary) by the OSC (or another designated person). This will ensure that the plan is adequate and consistent with prevailing project conditions.

Procedures should be developed for the following types of emergencies, as applicable:

- Fire and explosions
- Chemical spills
- Personnel injuries in the EZ or CRZ
- Releases of toxic vapors
- Reactions of incompatible materials
- Collapse of structures
- Radiation discovery

Maps must be developed to show evacuation routes, safe distances, places of refuge, and a travel route to the nearest hospital.

Text Box 7
ERP Requirements

ERP requirements under HAZWOPER include:

- Pre-emergency planning.
- Personnel roles, lines of authority, training, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination procedures that are not covered by other sections of the HASP.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- PPE and emergency equipment.

It may be appropriate to identify employer-specific emergency notification procedures. For instance, the HASP should identify regional representatives (e.g. supervisor, SHEMP manager) who should be contacted in the event of an injury. Following any accidental or suspected uncontrolled exposure to site contaminants, employees should be scheduled for a special medical examination. In the event of such suspected exposure, an injury report must be completed and sent to the SHEMP Manager (or another designated person) within 24 hours.

[1] HAZWOPER paragraphs (b) and (q) both use the term "emergency response plan" or "ERP."

Table 5 presents examples of common safety equipment, emergency organizations, and methods for onsite emergency alerting. The HASP must provide contact information for the emergency organization.

Table 5
Emergency Equipment and Contact Information

Equipment	Emergency Organizations	Methods for Emergency Alerting
• Industrial first aid kit • Fire extinguisher (ABC) • Eyewash station • Emergency shower	• Hospital • Ambulance/rescue • Fire department • Police department • Chemtrec (24 hours) • U.S. Coast Guard National Response Center • Poison control	• Air horns (e.g., "three blasts means evacuate site") • Megaphones • Sirens

4.9 Confined Spaces

Confined space entry procedures are a required element of the HASP under paragraph (b)(4)(ii)(I) of HAZWOPER, if applicable. A confined space is defined as a space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, and pits), and is not designed for continuous occupancy. All confined spaces on a site must be evaluated to determine if any of them meet the definition of a permit-required confined space (PRCS). A PRCS is a confined space that may contain a hazardous atmosphere or material that could engulf an entrant; have an internal configuration (such as inwardly converging walls or a sloping floor that tapers to a small area) that could trap or asphyxiate an entrant; or contain any other recognized serious safety or health hazard. The manual's Confined Space Safety Program chapter provides more information on confined spaces.

If a PRCS entry is conducted, it must be done in accordance with OSHA's PRCS standard (29 CFR 1910.146) and the entry procedures must be part of the HASP. For a PRCS entry, an Onsite Safety Officer (or another designated person) must perform a hazard evaluation and identify means of entry, work to be completed, exit procedures, emergency exit procedures, needed equipment, and assigned personnel. A PRCS permit must be completed to reflect this evaluation. Prior to any entry, a PRCS must be tested or monitored as necessary to determine if acceptable entry conditions exist. Testing must be conducted in the following order: oxygen first, then combustible gases and vapors, and then toxic gases and vapors.

4.10 Spill Prevention and Response

A spill containment program is a required element of the HASP under paragraph (b)(4)(ii)(J) of HAZWOPER. Spill containment procedures are necessary as accidents can occur during the handling of hazardous waste drums and containers. The spill containment program should address all hazardous material spill scenarios that are likely to occur. The spill containment program should also provide procedures to contain and isolate the entire volume of any hazardous material spilled in the course of a transfer, accident, or onsite release. The following procedures must be used to prevent or contain spills:

- All hazardous material must be stored in appropriate containers.
- Tops/lids must be placed back on containers after use.
- Containers of hazardous materials must be stored away from moving equipment and in safe areas.

The containment measure should be appropriate to the hazardous materials identified and should be installed in the area or located nearby. The following items are frequently used:

- Absorbent materials (e.g., pads, booms, powders);
- Salvage containers (e.g., over-pack drums);
- Bermed, lined pads;
- Concrete pad and dike;
- Inflatable containment (e.g., "kiddie" pools, bladders); and
- Associated equipment (e.g., pumps, hoses, shovels, hoists).

Procedures should be developed to properly maintain and replace, as necessary, all spill containment equipment and fixtures.

5.0 ONE HASP FOR MULTIPLE EMPLOYERS

When multiple employers are present at a site, EPA recommends developing one HASP for the Agency, EPA contractors, and other federal and state agencies to follow. This "One Site, One HASP" model reduces the possibility of inconsistent application and awareness of site safety requirements and concerns. Sections 5.1 through 5.3 provide options for developing one HASP without interfering with individual employer HASP obligations. EPA does not, however, advise having EPA employees operate under a HASP developed by a potentially responsible party (PRP). Therefore, at sites led by a PRP, EPA should operate under a separate HASP. If EPA is the lead Agency, the OSC must ensure that all employers' health and safety practices at a site are consistent and protective of employees**. If a dispute arises over the HASP that the OSC cannot resolve, contact the National Safety, Health and Environmental Management Official through the Environmental Response Team for resolution at 732-321-6740.**

5.1 General Site HASP

At a multi-employer site, employers can work together to generate one HASP that covers all the required HASP elements discussed in Section 4 of this chapter. With this option, EPA should coordinate with the other employers to ensure that the HASP covers all of the required elements and identifies and incorporates appropriate protective measures to address all the tasks that are to be performed on site. This option is not recommended for sites where there are more than three employers. Appendix F contains a HASP template.

5.2 Employer-Specific Addendum

Provided that at least one employer on the site develops a HASP that addresses common HASP elements required by HAZWOPER, all other employers, including EPA, may meet their employer-specific HASP requirements by completing and attaching an addendum to the HASP. Appendix G contains an addendum template that includes elements that may vary among employers, such as JHAs, training, respirator fit testing, medical surveillance, emergency notification procedures, and any additional SOPs. Standard and regional EPA training, medical surveillance requirements, and emergency notifications can be completed in advance by the HSPC/SHEMP Manager to reduce administrative burden on the responding OSC.

This option is recommended when common HASP elements (Table 6) can be addressed by one document, but employers still need to address employer-specific elements (Table 7). This option should result in a simplified and consistent approach among employers to common HASP elements without interfering with employer-specific elements.

Table 6
Common HASP Elements

1) A JHA for each site task and operation (including estimated duration of tasks) for tasks to be performed (Section 4.1).
2) Minimum PPE for each of the site tasks and operations (including respiratory protection) per work zone (Section 4.3).
3) Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment to be used (Section 4.5).
4) A site control program for protecting employees shall be developed during the planning stages of a hazardous waste clean-up operation and modified as necessary as new information becomes available (Section 4.6).
   a. Site map (location, topography and size of site)
   b. Site work zones
   c. Use of a "buddy system"
   d. Site communications including alerting means for emergencies
   e. SOPs or safe work practices
   f. Identification of the nearest hospital
5) Decontamination procedures (Section 4.7).
6) An ERP (Section 4.8).
   a. Pre-emergency planning
   b. On-site roles, lines of authority, training, and communication
   c. Emergency recognition and prevention
   d. Safe distances and places of refuge
   e. Site security and control
   f. Evacuation routes and procedures
   g. Decontamination procedures which are not covered by the HASP
   h. Emergency medical treatment and first aid
   i. Emergency alerting and response procedures
   j. Critique of response and follow-up
   k. PPE and emergency equipment
7) Confined space entry procedures if applicable (Section 4.9).
8) A spill containment program (Section 4.10).

Table 7
Employer-Specific HASP Elements

1) A JHA for each site task and operation (including estimated duration of tasks) to be performed by EPA where a JHA does not already exist in the HASP (Section 4.1).
2) Employee training requirements (Section 4.2).
3) Medical surveillance requirements (Section 4.4).
4) Emergency notification procedures that are required by the ERP (Section 4.8).

5.3 Consolidated HASP

When multiple employers generate separate HASPs that include all of the required elements discussed in Section 4 of this chapter, the individual HASPs can be consolidated to form one HASP. Individual employers, including EPA, can generate their HASP using the template in Appendix F. If the consolidated HASP option is chosen, the OSC must ensure that all the common HASP elements (see Table 6) are consistent between the different HASPs before creating one consolidated HASP.

Alternatively, information from employer-specific HASPs can be extracted to generate one HASP that explicitly states that it is the HASP for the site. It must identify the common HASP elements for all employers at the site and refer employees to their respective HASPs for employer-specific elements. Table 6 lists common HAZWOPER elements and Table 7 lists HAZWOPER elements that may be employer-specific. This approach consolidates the HASP elements that should be the same among all employers in one document without interfering with employer-specific elements. Note that in this HASP, at least one employer will address employer-specific elements. It is recommended that EPA generate the consolidated HASP to guide other employers on common HASP elements, while also addressing EPA-specific elements. Appendix H provides an example of a cover for the consolidated HASP.

The consolidated HASP option allows employers to maintain their own HASP as long as common elements across multiple employers are explained in the consolidated HASP.

6.0 APPROVAL PROCESS

The HASP template presented in Appendix F includes a space at the beginning of the document for the author to sign indicating who prepared the HASP (e.g., OSC, contractor, or other organization). The template also includes a signature page at the end of the document that must be signed by all EPA employees and any other site personnel who will be covered by the HASP. Whether the template provided in Appendix F is used or not, the site HASP must be signed to document that personnel understand and acknowledge the content of the HASP. Additionally, as a good practice, visitors to a site should review and sign the HASP.

All employers must be covered by a HASP regardless of lead or support role. If EPA is the lead agency at a site, any support agencies (federal or state) and contractors that are also working at the site must sign the HASP to document that they understand and acknowledge the content of the HASP. An OSC (or another EPA official) does not need to sign a support agency or contractor HASP. If EPA is not the lead, an OSC (or another EPA official) should sign the lead agency's HASP. **When OSCs (or other EPA officials in charge) sign a multi-employer HASP, they are acknowledging – not approving – the content of the HASP. If upon review, EPA does not concur with the HASP, they should not sign it.**

EPA must also ensure that individual employees are apprised of the HASP, as well as any updates that are made to the HASP as site conditions change. In accordance with 1910.120(b)(4)(iii), daily pre-entry briefings (tailgate meetings) must be held prior to initiating any site activity and at such other times as necessary to ensure that employees are apprised of the HASP and/or changes to the HASP. EPA can use pre-entry attendance or sign-in sheets (see Section 8.2) to document that employees acknowledge the HASP and any changes made to it.

7.0 INCIDENT ACTION PLAN (IAP) AND HASP

Issued in June 2003, the National Approach to Response (NAR) provided a framework for a consistent, EPA-wide approach for quickly and comprehensively responding to an incident of national significance. Under NAR, EPA adopted the National Incident Management System (NIMS) and Incident Command System (ICS) as the management structure for a major incident. This approach brings together existing emergency response assets to ensure the effective use of EPA resources. It provides consistency in addressing key aspects of a response and is intended to prepare EPA to respond to an incident of national significance by integrating existing response plans, authorities, and mechanisms.

The IAP includes the overall incident objectives and strategies established by the Incident Commander or Unified Commander. The IAP also addresses the mission, operational assignments, and policy needs of each jurisdictional agency. An IAP is developed when the ICS is used on sites, including sites that are not an incident of national significance.

The IAP developed in accordance with an ICS can also serve as a HASP in compliance with HAZWOPER. Using the IAP instead of generating a separate stand-alone HASP avoids developing redundant information. This is especially valuable when a response is still in the crisis phase, as it may reduce administrative burden. The ICS has developed a number of forms to be used in preparing an IAP.

The ICS forms in Table 8 address elements identified in paragraph (b)(4)(ii) of HAZWOPER. Appendix I provides information about the forms. Some or all of these forms should be referenced to generate a HASP. Table 9 provides a crosswalk between required HASP elements and relevant ICS forms. Since the IAP is updated each operational period, these forms have current information that can be used to guide decisions that affect the safety of emergency responders against site hazards. Appendix J presents an IAP HASP checklist that can be used to determine which items are needed to assemble a HASP. Initially, this checklist along with some JHAs may fulfill requirement to generate a HASP. As the response progresses, however, EPA must develop a comprehensive work plan and HASP.

To generate a HASP using an IAP, complete the checklist in Appendix J along with the required forms, JHAs, Safety Data Sheets (SDS), and confined space permits (if applicable). The forms can be referred to or attached. It may be preferable to refer to forms that are expected to change frequently. Alternatively, forms that will not change frequently may more easily be attached to the actual HASP document. Use the checklist as a cover sheet for the HASP to show which forms are attached. In addition, use blank rows to add or reference other items to the HASP (e.g., SOPs).

Table 8
ICS Forms That Cover Elements of a HASP Specified in HAZWOPER

Form	Title
201	Incident Briefing
202	Incident Objectives
203	Incident Organization
204	Assignment Lists
205	Incident Radio Communication Plan
205a	Communication List
206	Medical Plan
208	Site Safety and Control Plan (see Appendix K)
215A	Incident Action Plan Safety Analysis
223	General Safety Message
	Executive Summary

Table 9
HASP Elements and Relevant ICS Forms

HAZWOPER (b)(4)(ii) Requirements	HASP Elements	ICS Forms
(A)	Job hazard analysis	215A, 208, 204(#8)
(B)	Employee training assignments (including fit testing)	202
(C)	PPE for each of the site tasks and operations	202, 204(#8), 208
(D)	Medical surveillance requirements	208
(E)	Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used	215A, 208
(F)	Site control plan	
	Site map (location, topography, and size of site)	201, 208
	Site work zones	201, 208
	Use of a "buddy system"	223
	Site communications including alerting means for emergencies	205(a), 203, 205(a), 204(#9), 208
	SOPs or safe work practices	202, 223
	Identification of the nearest hospital	206
(G)	Decontamination procedures	208
(H)	Emergency response plan	208
	Critique of response and follow-up	Executive Summary
(I)	Confined space entry procedures	208, 204(#8), Confined Space Permits
(J)	Spill containment program	208

8.0 RECORDKEEPING

EPA's recordkeeping goal is to ensure that nationally consistent, readily accessible records are maintained at each EPA organization. Table 10 and Sections 8.1 and 8.2 provide details about the specific recordkeeping procedures that must be followed, who is expected to complete specific forms, and who must retain copies of the records.

8.1 The HASP

Per 1910.120(4)(i), HASPs must be available on site. Per EPA recordkeeping requirements, HASPs must also be retained with the site files after work at the site has been completed.

8.2 Attendance Sheets

OSCs or other emergency responders must document which topics are covered during pre-entry briefings and indicate who is present. An attendance sheet or sign-in sheet may be used for this purpose (see the "Forms" section of the manual's website for a sample roster). The attendance or sign-in sheets must be retained with the site files.

Table 10
Recordkeeping Requirements Associated With the HASP Chapter

Required Record	Details/Specified Forms	Completed/Compiled By[a]	Retained By[a]
HASPs	All documents in the HASP	Emergency Responder (OSC)	Site file
Attendance sheets from safety briefings	Attendance or sign-in sheets	Emergency Responder (OSC)	Site file

[a] The delegation of recordkeeping responsibilities presented in this table reflects the chapter authors' opinions. The assignments have been made with regional audiences in mind, so the positions listed might not be applicable for OSWER special teams and headquarters. Users can adjust the assignments when they customize Appendix A and fill information into the yellow-highlighted spaces that appear throughout this chapter.

APPENDIX A

HASP Development:
Designation of Roles and Responsibilities

Instructions for Users

Appendix A provides a place for users to insert organization-specific information into the HASP chapter. The appendix presents a list of tasks that must be performed to ensure that EPA meets HAZWOPER's requirements for a HASP. The tasks are listed in rows. EPA position titles (e.g., the Removal Manager or the HSPC) are listed in columns. Each task has been assigned to a default position. For some of the tasks, check marks have been placed in two or more columns to indicate that more than one person is responsible for that task. **Please note that users can re-delegate tasks.**

Users must take the following steps to customize Appendix A:

- Fill in the background information requested at the top of page A-3. For example, indicate when the table is being updated and who is doing the updating.

- Fill in actual names under the position titles.

- Add additional key players to the table (if necessary). *Note: The chapter authors have already provided a placeholder to add a new position, as the last column is labeled "Other." Users should customize this column to identify the position title (and name) of any additional key player assigned responsibility to implement this chapter. Users can insert more columns to include additional key players (if necessary).*

- Add rows to the table (if necessary) to provide information about activities that exceed the minimum requirements already included in Appendix A. (See Appendix B for a list of your organization's additional policies and procedures related to this chapter.)

- Determine whether any of the recommended task assignments must be delegated to another person. (If so, move the check marks to re-assign the task.)

- Ensure that each task has been assigned.

Attention OSWER Special Teams and headquarters users: The tasks and position titles that appear in Appendix A have been written with regional audiences in mind. OSWER special teams and headquarters users should modify the language that appears in the rows and column headers to reflect the needs of their organization.

APPENDIX A
Task Chart for Implementing the HASP Chapter

This table has been customized for: EPA Organization.
Last Updated on: Month Day, Year.
Updated by: Name .

TASKS ▼ / ROLES ►	Who Is Responsible for Each Task or Action?							
	Removal Manager	**SHEMP Manager**	**HSPC**	**Immediate Supervisors**	**Onsite Safety Officers**	**Emergency Responders (e.g., OSC)**	**Medical Monitors**	**Other**
Name of Person in Role ►	**(Name)**	**(Name)**	**(Name)**	**(Name)**	**(Name)**	**(See note below*)**	**(Name)**	**(Name)**
General Tasks								
1. Implement the HASP chapter by: (1) customizing the chapter with organization-specific information, (2) reviewing/updating the customized version annually, and (3) adopting the requirements and practices in the chapter. Post the customized chapter to the manual's Web site and inform stakeholders of its availability.	✓	✓	✓	✓	✓	✓		
2. Develop site work plans that include site-specific project tasks and anticipated response operations.						✓		
3. Ensure that HASPs are written and that they include all of the required elements under paragraph (b)(4)(ii) of HAZWOPER.					✓	✓		
Tasks Required for a HASP (Section 3.0)								
4. Ensure that HASPs are kept on site, address the health and safety hazards of each phase of site operations, and include requirements and procedures for employee protection.					✓	✓		
Tasks Associated With HASP Elements (Section 4.0)								
5. Ensure that HASPs are implemented on site and revised as site conditions and tasks change.	✓	✓	✓		✓	✓		
6. Ensure that JHAs are completed for new tasks and existing JHAs are updated if site tasks change.				✓	✓	✓		
7. Upon request, perform task-specific evaluations to assess chemical, biological, and physical hazards and ensure that the HASP adequately addresses these hazards.	✓	✓	✓		✓			
Tasks Associated With Developing One HASP for Multiple Employers (Section 5.0)								
8. Ensure a single HASP is coordinated and prepared among all of the employers at a site by using one of the three options described in Section 5.0.					✓	✓		
Tasks Associated With HASP Approval (Section 6.0)								
9. Ensure that the signature page of the HASP is signed by all EPA employees and any other site personnel who are covered by the HASP.					✓	✓		
10. Ensure that the concurrence page is signed if attaching an addendum to a HASP developed by another employer and that emergency responders concur with the HASP.					✓	✓		

*Note: A list of the organization's emergency responders is provided in Appendix A-2 of the Introduction chapter.

TASKS ▼ / ROLES ► / Name of Person in Role ►	Who Is Responsible for Each Task or Action?							
	Removal Manager	**SHEMP Manager**	**HSPC**	**Immediate Supervisors**	**Onsite Safety Officers**	**Emergency Responders (e.g., OSC)**	**Medical Monitors**	**Other**
	(Name)	**(Name)**	**(Name)**	**(Name)**	**(Name)**	**(See note below*)**	**(Name)**	**(Name)**
Tasks Associated With the IAP (Section 7.0)								
11. If an IAP is used, ensure that the ICS forms used are equivalent to all of the HASP elements required by HAZWOPER. Also, ensure that applicable JHAs are included with the IAP HASP.					✓	✓		
Tasks Associated With Recordkeeping (Section 8.0)								
12. Ensure HASPs are maintained with the site file.				✓	✓	✓		
13. Retain pre-entry briefing attendance sheets with the site file.					✓	✓		
Additional Tasks That Reflect Organization-Specific Procedures (Appendix B)								

*Note: A list of the organization's emergency responders is provided in Appendix A-2 of the Introduction chapter.

APPENDIX B

HASP Development:
Additional Policies and Procedures

The procedures and tasks outlined in the HASP chapter represent the **minimum requirements** that each EPA organization must meet. If organizations advocate the use of additional policies and procedures, they must document them in the table below. After doing so, they must also:

- Ensure that the additional policies and procedures that are added to the table below are also addressed in the main text of the HASP chapter. This can be accomplished by either (1) inserting the additional policies and procedures directly into the relevant portions of the main body of the chapter or (2) adding a sentence within the main text that directs readers to Appendix B for more information.

- Update Appendix A to capture any additional tasks that are listed in the table below and ensure that each task is assigned to a specific individual.

Topic	**Please document the additional elected policies and procedures required for Organization Name here.**
Section 3.0 HAZWOPER Requirements for a HASP	
Section 4.0 HASP Elements	
Section 5.0 Developing One HASP for Multiple Employers	
Section 6.0 Approval Process	
Section 7.0 Incident Action Plan (IAP) and HASP	
Section 8.0 Recordkeeping	
Other topics _____ _____ _____ _____	

APPENDIX C

Glossary

GLOSSARY

Buddy system
The buddy system is a way of organizing employees into work groups in such a manner that each employee is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

Clean-up operation
A clean-up operation is where hazardous substances are removed, contained, incinerated, neutralized, stabilized, or in any other manner processed or handled with the ultimate goal of making the site safer for people or the environment.

Decontamination
Decontamination is the removal of hazardous substances from employees and their equipment to the extent necessary to preclude the dissemination of hazardous substances outside of the exclusion zone and to reduce the chance that individuals may be exposed.

Hazardous substance
A hazardous substance is any substance belonging to one of the following categories, exposure to which results or may result in adverse effects on the health of employees:

- Any elements, compounds, mixtures, solutions, and substances which when released into the environment may present a substantial danger to the public health or welfare or the environment, that are designated as such by the Administrator of EPA under Section 102(a) of CERCLA, in addition to those referred to in Section 101(14) of CERCLA.

- Any biologic agent and other disease-causing agent which, after release into the environment and upon exposure will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformations in such persons or their offspring.

- Any substance listed by the U.S. Department of Transportation as hazardous materials under 49 CFR 172.101 and appendices.

- Hazardous waste (see definition below).

Hazardous waste
A hazardous waste is one of the following:

- A waste or combination of wastes as defined in 40 CFR 261.3, RCRA.

- A substance defined as hazardous waste in 49 CFR 171.8, DOT.

Hazardous waste operation
A hazardous waste operation is any operation conducted within the scope of HAZWOPER.

Hazardous waste site
A hazardous waste site is any facility or location within the scope of HAZWOPER at which hazardous waste operations take place.

Health hazard
A health hazard results from exposure to a chemical, mixture of chemicals, or pathogen for which acute or chronic health effects may occur. It also includes stress due to temperature extremes. Further definition of the terms used above can be found in Appendix A to OSHA's Hazard Communication standard, 29 CFR 1910.1200.

Job hazard analysis (JHA)
A JHA is a technique to identify hazards for specific job tasks before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. After hazards are identified, controls are implemented to eliminate or reduce them to an acceptable risk level.

Oxygen deficiency
An oxygen-deficient atmosphere is one in which the percentage of oxygen by volume is below 19.5 percent. Atmosphere supplying respiratory protection must be provided in such an atmosphere.

Permissible exposure limit (PEL)
A PEL is an OSHA inhalation or dermal exposure limit specified in 29 CFR Part 1910, Subparts G and Z.

Threshold limit value (TLV®)
A TLV is an exposure limit guideline set by the American Conference of Governmental Industrial Hygienists.

Post-emergency response
A post-emergency response is that portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated and clean-up of the site has begun.

Uncontrolled hazardous waste site
An uncontrolled hazardous waste site is an area identified by a governmental body, whether federal, state, local, or other, where an accumulation of hazardous substances creates a threat to the health and safety of individuals or the environment or both.

APPENDIX D

HASP Development: Implementation Checklist

HASP Development: Implementation Checklist

This evaluation form has been filled out for: Organization Name
Date: _____
Name and title: _____

	Yes	No	N/A
Transition From Emergency Response to Clean-up Operations (Section 3.3)			
1. Are emergency responders trained to know when to transition from emergency response to clean-up operations in accordance with this chapter and HAZWOPER?			
HASP Elements (Section 4.0)			
2. Are emergency responders required to ensure that HASPs are written and that they include all of the elements required by HAZWOPER?			
3. Are emergency responders required to ensure that JHAs are developed for all EPA-specific tasks that involve chemical, biological, or physical hazards?			
Employee Training (Section 4.2)			
4. Do emergency responders receive all HASP-required training?			
5. Are daily pre-entry briefings held and are all in attendance required to sign an attendance log?			
One HASP for Multiple Employers (Section 5.0)			
6. Are EPA personnel always covered by their own HASP, an addendum attached to another organization's HASP, or a HASP that has been coordinated with other employers?			
Approval Process (Section 6.0)			
7. Are emergency responders signing HASPs?			
IAP and HASP (Section 7.0)			
8. Are emergency responders required to be familiar with the IAP and ICS forms as they relate to meeting HASP requirements?			
Recordkeeping (Section 8.0)			
9. Are copies of HASPs retained with the site records?			
10. Are attendance sheets for daily pre-entry briefings retained with the site records?			

Notice of Findings:

APPENDIX E

HASP Development:
Additional EPA Resources

HASP Resources

EPA's Emergency Responder Health and Safety Manual Chapters
http://www.epaosc.org/_HealthSafetyManual/manual-index.htm

Chapter 1: Site-Specific Health and Safety Plan Development
Chapter 2: Health and Safety Training Program
Chapter 3: Medical Surveillance Program
Chapter 4: Respiratory Protection Program
Chapter 5: Personal Protective Equipment Program
Chapter 6: Injury, Illness, and Exposure Reporting
Chapter 7: Physical Stress Management Program
Chapter 8: Transportation Safety Program
Chapter 9: Radiation Safety Program
Chapter 10: Chemical and Biological Agents
Chapter 11: Confined Space Safety Program
Chapter 12: Bloodborne Pathogens Exposure Control Plan

Other EPA Resources

EPA Order 1440.1. Safety, Health, and Environmental Management Program. November 20, 2012.
http://intranet.epa.gov/ohr/rmpolicy/ads/orders/1440_1.pdf

EPA Order 1440.2. Safety and Health Training Requirements for Agency Employees. January 10, 2011.
http://intranet.epa.gov/ohr/rmpolicy/ads/orders/1440_2.pdf

EPA Order 1460.1. Occupational Medical Surveillance Program. April 20, 2010.
http://intranet.epa.gov/shemd/content/epa_1460_1_508.pdf

EPA Order 4800.1. EPA Policy for Providing Wearing Apparel to Employees. March 17, 2002.
http://intranet.epa.gov/shemd/content/epa_4800_1.pdf

EPA Diving Safety Manual. Revision 1.1.
http://intranet.epa.gov/oaintran/shemd/divmanuals/index.htm

OSWER Directive — Mandatory Implementation of the Emergency Responder Health and Safety Manual. July 28, 2005.
http://www.epaosc.org/_HealthSafetyManual/emergency-responder-manual-directive-final.pdf

Memorandum of Understanding between OARM/SHEMD and OSWER Concerning the Management of USEPA Internal Safety, Health, and Environmental Management Initiatives.
http://www.ert.org/HealthAndSafety/CenterofEx.pdf

EPA Integrated Health and Safety Program (Standard Operating Practices for Office of Solid Waste and Emergency Response Field Activities). November 2002.
http://intranet.epa.gov/oswer/workforce/health_and_security/hsSopDoc.pdf

SHEM Guideline 56: Job Hazard Analysis.
http://intranet.epa.gov/oaintran/shemd/national/content/guides/56_jha_guide.pdf

SHEM Guideline 29: Permit-Required Confined Space.
http://intranet.epa.gov/oaintran/shemd/national/content/guides/29_guide508.pdf

SHEM Guideline 33: Heat Stress and Cold Stress.
http://intranet.epa.gov/shemd/content/guides/33_hac_guide508.pdf

SHEM Guideline 42: Hazard Communication.
http://intranet.epa.gov/oaintran/shemd/national/content/guides/42_hac_guide.pdf

SHEM Guideline 51: Mandatory Health and Safety Training.
http://intranet.epa.gov/shem/content/guides/51_guideline_508.pdf

Standard Operating Safety Guides. Office of Emergency and Remedial Response. Publication 9285.1-03. PB92-96314. June 1992.
http://www.epaosc.org/_HealthSafetyManual/operating-safety-guide.pdf

Other Resources

OSHA. 2008 Hazardous Waste Operations and Emergency Response. OSHA 3114-07R 2008.
http://www.osha.gov/Publications/OSHA3114/OSHA-3114-hazwoper.pdf

OSHA Fact Sheet: "Occupational Safety and Health for Federal Employees."
http://www.osha.gov/OshDoc/data_General_Facts/federal-employee-factsheet.pdf

NIOSH/OSHA/USCG/EPA. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. October 1985.
http://www.osha.gov/Publications/complinks/OSHG-HazWaste/4agency.html

APPENDIX F

HASP Template

Instructions

This appendix provides a template for a HASP, including the required minimum elements and example formatting/structure. The template will assist OSCs and other EPA emergency responders (e.g., Removal Managers) in developing a HASP for their own site activities where there is not another HASP and/or reviewing HASPs prepared by others.

HASP Template

HASP Prepared by:	Signature:	Date:

A. SITE INFORMATION: ROLES AND RESPONSIBILITIES

Site Name:
Site Address:
Date of Activities:
Site Description Including History:
Scope of Work:

Site Roles/Responsibilities			
Site Role/Responsibility:	**Employer:**	**Name:**	**Title:**

B. SITE TASKS AND DESCRIPTIONS

Identify the individual tasks or activities that are required to complete the scope of work. A JHA (Section C) must be completed for each task listed below.

Site Tasks and Descriptions		
Task Number:	**Task Titles:**	**Task Descriptions:**
1		
2		
3		
4		
5		

C. EVALUATION AND HAZARD CONTROL

Site hazards and controls are documented in JHAs for each task identified in the site work plan. These JHAs are attached to the HASP (see Attachment #1).

JHA			
JHA Number:	**Name of Task:**	**Location Where Task Is Performed:**	
Task Description:			
Step 1:		**Step 3:**	
Step 2:		**Step 4:**	
Estimated Duration of Task:		**Date JHA Conducted/Updated:**	
Biological Hazards			
Biological Hazard:	**Characteristics:**	**Concentration:**	**Exposure Potential During Task:**
	Infectious/pathogenic/ toxic	N/A	High Medium Low
Chemical Hazards			
Chemical Hazard:	**Characteristics:**	**State/Concentration:**	**Exposure Potential During Task:**
	Flammable/ignitable Corrosive Poison/acutely toxic Air-/water-reactive Carcinogenic Explosive/shock Sensitive Volatile	Gas/vapor Solid Liquid	High Medium Low
Chemical Evaluation Sheets or SDSs are located in Attachment 2 for known chemical hazards.			
Physical Hazards			
Physical Hazard (Check Applicable Hazards):			**Exposure Potential During Task**
Overhead Below grade Slip/trip/fall Burn Puncture Cut Splash Noise Heat stress Cold stress Excavation/trench Electrocution Traffic** Other			High Medium Low
Ionizing radiation Alpha particles Beta particles Gamma rays Neutrons			High Medium Low
Confined space (hazards associated with PRCS entries will be addressed in a separate document)			High Medium Low N/A
Control Measures			
Engineering Controls: (list engineering controls necessary for this task)			
Work Practices: (describe those work practices specific to this task [e.g., medical monitoring])			
PPE: (list PPE necessary for this task)			
Workers/Site Role:	**PPE Level:**	**Modifications Allowed:**	

*** If traffic is identified as a hazard, provide a Traffic Control Plan (place holder provided on next page).*

[Insert Traffic Control Plan if applicable.]

D. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Designated levels of personal protection for the applicable tasks and work areas are based on JHAs.

Designated Levels of Personal Protection			
Task Number:	**Work Area (e.g., EZ, CRZ, other):**	**Job Function:**	**Level of Protection:**
			A B C D
			A B C D
			A B C D
			A B C D
			A B C D

Levels of PPE	
Level of Protection:	**Specific Equipment (e.g., Clothing Materials, Respirator Type, Cartridges):**

Criteria for Upgrading or Downgrading Levels of Personal Protection:
All decisions to downgrade PPE must be accompanied by air monitoring results. The Safety Officer must be advised of onsite decisions to downgrade. See Section H, Environmental and Personal Monitoring.

E. SITE CONTROL

Work Practices and Control Measures
Procedures for Restricting Access to the exclusion zone (EZ) and contamination reduction zone (CRZ):
Work Shift Schedules:
Other Safe Work Practices:
The buddy system must be maintained on a line-of-sight basis

Communications Equipment		
Communications Equipment:	**Location/Person:**	**Channels and Phone Numbers:**

Standard Hand Signals	
Hand Signal:	**Meaning:**
Thumbs up	I'm OK/I agree
Thumbs down	I don't agree
Hands across throat	Out of air/trouble breathing
Grab hand/arm	Come with me
Hands on head	I need assistance

[Insert site map(s)/sketch(es) showing the site location and site layout including work zones, topography, and site size.]

F. EMERGENCY RESPONSE PLAN

Emergency Response Procedures
Accident Reporting/Investigation:
Accidents involving injuries requiring professional medical attention must be reported within one hour of occurrence to the Safety Officer. -First aid cases not involving professional medical attention must be reported within 24 hours after occurrence. -Incidents involving property damage must be reported within 24 hours of occurrence. -After hours illnesses must be reported within 24 hours (i.e. flu, rashes) (See the Injury, Illness, and Exposure Reporting chapter)
Additional Emergency Response Procedures:
Procedures for Response Critique and Follow-up:
Conduct hot wash with all responding agencies.

Emergency Equipment/Facilities and Emergency Contact Information

List emergency equipment to be maintained at the site along with emergency contact and alerting information.

Safety Equipment		
Equipment:	**Number of Items:**	**Location On Site:**

Emergency Contact Information	
Emergency Assistance Organization:	**Telephone Number:**

Emergency Alerting and Response Procedures		
Emergency Equipment:	**Alerting Noise:**	**Meaning:**

At least two emergency exit routes must be identified and communicated (verbal and/or written) to workers on site. See site map or sketch.

Audio alarms must be perceptible above ambient noise. If visible (light) alarms are used, they must be distinguishable from ambient light levels and sources.

Upon discovering an emergency situation, personnel notify the Safety Officer, who will evaluate available information and initiate an appropriate response. Site workers are alerted to emergencies through the use of the onsite evacuation signal/alarm.

Emergency Recognition and Prevention
Daily safety meetings must be held at the start of each shift to ensure that all personnel understand site conditions and operating procedures, to ensure that PPE is being used correctly, and to address worker health and safety concerns.

[Insert map showing evacuation routes, safe distances, and places of refuge.]

[Insert map to hospital]

G. DECONTAMINATION

Decontamination Procedures

Personnel (Level A, B, C) Decontamination Procedures:

These are the minimum acceptable requirements for a wet decon:

Station 1: Equipment Drop

Deposit equipment used on site (tools, sampling devices and monitoring instruments, radios, etc.) on plastic drop cloths. These items must be decontaminated or discarded as waste prior to removal from the exclusion zone.

Station 2: Outer Boot and Outer Glove Wash and Rinse

Scrub outer boots, outer gloves and/or splash suit with decontamination solution or detergent water. Rinse off using water.

Station 3: Outer Boot and Glove Removal

Remove outer boots (if disposable) and gloves. If outer boots are disposable, deposit in container with plastic liner. If non-disposable, store in a clean dry place.

Station 4: Tank Change (Level B)

If person leaves exclusion zone to change air tank, this is the last step in the decontamination procedure. Air tank is exchanged, new outer gloves and boot covers donned, joints taped, and person returns to hot zone.

Station 5: Outer Garment Removal

If applicable, remove SCBA backpack and remain on air as long as possible. Remove chemical resistant outer garments and deposit in container lined with plastic. Decontaminate or dispose of splash suits as necessary.

Station 6: Respiratory Protection Removal

Remove hardhat, face piece, and if applicable, deposit SCBA on a clean surface. Air-purifying respirator cartridges will be discarded as appropriate. Wash and rinse respirator at least daily. Wipe off and store respiratory gear in a clean, dry location.

Station 7: Inner Glove Removal

Remove inner gloves. Deposit in container for disposal.

Station 8: Field Wash

Thoroughly wash hands and face with soap and water. Shower as soon as possible.
If it is determined that emergency response personnel or persons involved with the incident need further medical attention, transportation must be arranged by the OSC.

Emergency Decontamination Procedures:

Heavy Equipment Decontamination Procedures:

Sampling Equipment Decontamination Procedures:

Decontamination of equipment must be performed by using portable wash tubs, sprayers, and disposable scrub brushes. Any equipment that cannot be thoroughly decontaminated along with the contents from the wash tub must be considered hazardous and must be stored and disposed of appropriately.

Monitoring Equipment
If monitoring equipment becomes contaminated, it may require special cleaning techniques. Methods for decontamination must be obtained from the equipment's manufacturer.

Hand Tools
Hand tools must be cleaned as appropriate by chemical or physical means. At the end of the incident, if the hand tools cannot be decontaminated, they must be disposed of as hazardous waste.

Decontamination Waste Disposal Procedures:	
Decontamination waste must be segregated, characterized, and disposed of with similar appropriate waste streams generated by the response.	
Decontamination Equipment:	**Location Stored On Site:**
Plastic sheeting	Table, chairs, and tent (if possible)
Kiddie swimming pools	5-gallon pails and scrub brushes
Pump (hand or electric)	Water sprayer
Decontamination solution (determined in SDS)	Sorbent materials (towels, boom, kitty litter)

H. ENVIRONMENTAL AND PERSONAL MONITORING

AIR MONITORING SUMMARY (common site air requirements)			
Instrument Type:	**Contaminant:**	**Frequency:**	**Action Level/Comments:**
Combustible Gas Indicator	Explosive/ flammable atmospheres	As needed	<10% proceed with caution; ≥10% evacuate area and re-evaluate
Oxygen Meter	Oxygen	Confined space work	≤ 19.5% or ≥ 23.5% oxygen, evacuate area and re-evaluate
Photo ionization detector/flame ionization detector	Organic vapors and gases, CO	Periodic during container handling	Unidentified contaminants Background units - Level D > Background – TBD - Level C > TBD - Level B
Detector Tubes	Benzene, cyanide, total hydrocarbons, etc. (Tubes are chemical-specific and used for verification of photo ionization detector readings.)	As necessary to further evaluate photo ionization detector/flame ionization detector readings	TBD on site according to PEL
Other: MiniRam	Dust particulates Respirable dust	During dusty conditions resulting from site operations	> 7.5 mg/m^3, Level C > 2.5 mg/m^3 respirable dust, Level C
AIR MONITORING SUMMARY (site-specific air requirements)			

Personal Monitoring Procedures
Personal Monitoring Instruments and Procedures:
Heat/Cold Stress Monitoring:
BP cuff and thermometer to monitor vital signs. Follow Physical Stress Management Program chapter guidelines.
Monitoring Instrument Maintenance and Calibration Methods:
Per manufacturer's recommendations
Storage of Monitoring Records:
Keep records in a secure location

I. PERMIT-REQUIRED CONFINED SPACE (PRCS) ENTRY PROCEDURES (IF APPLICABLE) (See Attachment #3)

Permit-Required Confined Spaces		
Type of PRCS:	**Location On Site:**	**Comments:**

J. SPILL PREVENTION AND RESPONSE

Spill Prevention Controls and Response Procedures	
Potential for Spills and Prevention Controls:	
Procedures for Handling Drums and Other Containers:	
Post-Spill Response Procedures:	
Spill Response Materials:	**Location Stored On Site:**
Disposal Procedures:	

K. TRAINING

Emergency Responder Core Training	
Health and Safety	
Medical surveillance	First aid (29 CFR 1910.120)
Fit test	Radiation safety (EPA Order 1440)
40-hour HAZWOPER training (165.5 or equivalent) or 24-hour HAZWOPER if appropriate	Radiation safety refresher (EPA Order 1440)
8-hour HAZWOPER refresher	Radiation safety/badge training (4 hours)
8-hour HAZWOPER supervisor	Defensive driving (EPA Order 1440.2)
Bloodborne pathogens (1910.1030)	Asbestos awareness (EPA Order 1440)
CPR	
Site-Specific Training	

Pre-Entry Briefings (Attendees at each site safety briefing must sign an attendance sheet)		
Date and Time:	**Topic Addressed:**	**Led By:**
Daily	Daily Safety Message (see sign in sheets)	Safety Officer

L. MEDICAL SURVEILLANCE

Medical Requirements: OSCs must be in a Medical Surveillance Program in accordance with 29 CFR 1910 and 29 CFR 1926. A medical examination must have been completed within a 12-month period prior to on-site activity and repeated annually.

Episodic Examinations
Following any accidental or suspected uncontrolled exposure to site contaminants, employees should be scheduled for a special medical examination. In the event of such suspected exposure, an injury report must be completed and sent to the SHEMP Manager (or another designated person) within 24 hours.

Fit Test Requirements: OSCs entering any area requiring the use or potential use of any respirator must have had a quantitative fit test with a fit factor of 1,000, administered in accordance with OSHA 29 CFR 1910.134 or ANSI within the last 12 months.

Thermoluminescent Dosimeter (TLD) Requirements: OSCs must be in a TLD program. TLDs must be worn at all oil and hazardous waste sites and all sites where there is a potential for exposure to ionizing radiation

For additional information see the Medical Surveillance Program chapter for medical surveillance requirements.

M. EMPLOYEE EMERGENCY NOTIFICATION PROCEDURES

Emergency notification procedures that do not already exist in the emergency response plan in the HASP are provided below.

Emergency Notification Procedures		
Employer:	**Contacts:**	**Telephone Numbers:**

N. EPA SOPs

EPA has developed SOPs for specific work tasks and emergency responder's health and safety. SOPs containing specific information regarding tasks anticipated at removal sites are linked below.

http://www.epaosc.org/_HealthSafetyManual/manual-index.htm
http://intranet.epa.gov/oeca/oc/campd/inspector/health/1440_1.pdf
http://intranet.epa.gov/ohr/rmpolicy/ads/orders/1440_2.pdf
http://intranet.epa.gov/shemd/content/epa_1460_1_508.pdf
http://intranet.epa.gov/shemd/content/epa_4800_1.pdf
http://intranet.epa.gov/oswer/workforce/health_and_security/hsSopDoc.pdf

ATTACHMENT #1
Site JHAs

ATTACHMENT #2
SDS

ATTACHMENT #3
Confined Space Entry Permit

Date and time issued: _____ Date and time expires: _____
Job site/Space I.D.: _____ Job supervisor:_____
Equipment to be worked on: _____ Work to be performed: _____

Stand-by personnel: _____ _____ _____

1. Atmospheric checks: Time _____
Oxygen _____%
Explosive _____% L.F.L.
Toxic _____PPM

2. Tester's signature: _____

3. Source isolation (No Entry):

	N/A	Yes	No
Pumps or lines blinded,	( )	( )	( )
disconnected, or blocked	( )	( )	( )

4. Ventilation modification:

	N/A	Yes	No
Mechanical	( )	( )	( )
Natural ventilation only	( )	( )	( )

5. Atmospheric check after isolation and ventilation:

Oxygen _____%	>	19.5	%
Explosive _____% L.F.L	<	10	%
Toxic _____PPM	<	10	PPM H(2)S

Time: _____ Testers signature: _____

6. Communication procedures: _____
_____

7. Rescue procedures: _____
_____
_____
_____

8. Entry, standby, and back up persons:

	Yes	No
Successfully completed required training?	( )	( )
Is it current?	( )	( )

9. Equipment:

	N/A	Yes	No
Direct reading gas monitor tested:	( )	( )	( )
Safety harnesses and lifelines for entry and standby persons:	( )	( )	( )
Hoisting equipment:	( )	( )	( )
Powered communications:	( )	( )	( )
SCBA's for entry and standby persons:	( )	( )	( )
Protective clothing:	( )	( )	( )
All electric equipment listed Class I, Division I, Group D and non-sparking tools:	( )	( )	( )

10. Periodic atmospheric tests:

Oxygen	____%	Time ____	Oxygen	____%	Time ____
Oxygen	____%	Time ____	Oxygen	____%	Time ____
Explosive	____%	Time ____	Explosive	____%	Time ____

Explosive	_____%	Time _____	Explosive	_____%	Time _____
Toxic	_____%	Time _____	Toxic	_____%	Time _____
Toxic	_____%	Time _____	Toxic	_____%	Time _____

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit prepared by: (Supervisor)_____
Approved by: (Unit Supervisor)_____
Reviewed by (Confined Space Operations Personnel):

_____/_____
(printed name) (signature)

This permit must be kept at the job site. Return the job site copy to the Safety Office following job completion.

HASP Sign-off

By signing below, I am indicating that I have read and acknowledge the contents of the HASP prepared for the XXX Site.

Name:	Signature:	Date:

APPENDIX G

HASP Employer Addendum Template

Instructions

This appendix is a template for an addendum that includes elements that are specific to EPA emergency responders, such as training, medical surveillance, and emergency notification. This addendum must be attached to a HASP prepared by another organization. Contractors or other organizations may also add their own addendums to the HASP.

HASP Employer Addendum Template

HASP Concurrence

By signing below, I am indicating that I concur with the contents of the HASP prepared for the XXX site.

_____

A. GENERAL SITE INFORMATION

Site Name:
Site Address:
Date of Activities:
Site Description Including History:
Scope of Work:

B. SITE TASKS AND DESCRIPTIONS

The EPA individual tasks or activities that are required to complete the scope are listed below.

Site Tasks and Descriptions		
Task Number:	**Task Titles:**	**Task Descriptions:**
1		
2		
3		
4		
5		

C. TRAINING

Emergency Responder Core Training	
Health and Safety:	
Medical surveillance	First aid (29 CFR 1910.120)
Fit test	Radiation safety (EPA Order 1440)
40-hour HAZWOPER training (165.5 or equivalent) or 24-hour HAZWOPER if appropriate	Radiation safety refresher (EPA Order 1440)
8-hour HAZWOPER refresher	Radiation safety/badge training (4 hours)
8-hour HAZWOPER supervisor	Defensive driving (EPA Order 1440.2)
Bloodborne pathogens (1910.1030)	Asbestos awareness (EPA Order 1440)
CPR	

Site-Specific Training

Pre-entry Briefings (Attendees at each site safety briefing must sign an attendance sheet)		
Date and Time:	**Topic Addressed:**	**Led By:**
Daily	Safety Message (see sign in sheets)	Safety Officer

D. MEDICAL SURVEILLANCE

Medical Requirements: OSCs must be in a Medical Surveillance Program in accordance with 29 CFR 1910 and 29 CFR 1926. A medical examination must have been completed within a 12-month period prior to on-site activity and repeated annually.

Episodic Examinations
Following any accidental or suspected uncontrolled exposure to site contaminants, employees should be scheduled for a special medical examination. In the event of such suspected exposure, an injury report must be completed and sent to the SHEMP Manager (or another designated person) within 24 hours.

Fit Test Requirements: OSCs entering any area requiring the use or potential use of any respirator must have had a quantitative fit test with a fit factor of 1,000, administered in accordance with OSHA 29 CFR 1910.134 or ANSI within the last 12 months.

Thermoluminescent Dosimeter (TLD) Requirements: OSCs must be in a TLD program. TLDs must be worn at all oil and hazardous waste sites and all sites where there is a potential for exposure to ionizing radiation.

For additional information see the Medical Surveillance Program chapter for medical surveillance requirements.

E. EMPLOYEE EMERGENCY NOTIFICATION PROCEDURES

Emergency notification procedures that do not already exist in the emergency response plan in the HASP are provided below.

Emergency Notification Procedures		
Employer:	**Contacts:**	**Telephone Numbers:**

F. EVALUATION AND HAZARD CONTROL

Site hazards and controls are documented in JHAs for each task identified in the site work plan. These JHAs are attached to the HASP Employer Addendum (see Attachment #1).

EXAMPLE JHA			
JHA Number:	**Name of Task:**	**Location Where Task Is Performed:**	
Task Description:			
Step 1:		**Step 4:**	
Step 2:		**Step 5:**	
Step 3:		**Step 6:**	
Estimated Duration of Task:		**Date(s) JHA Conducted/Updated:**	
Biological Hazards			
Biological Hazard:	**Characteristics:**	**Concentration:**	**Exposure Potential During Task:**
	Infectious/pathogenic/ toxic	N/A	High Medium Low

Chemical Hazards			
Chemical Hazard:	**Characteristics:**	**State/Concentration:**	**Exposure Potential During Task:**
	Flammable/ignitable Corrosive Poison/acutely toxic Air-/water-reactive Carcinogenic Explosive/shock Sensitive Volatile	Gas/vapor Solid Liquid	High Medium Low
Chemical Evaluation Sheets or SDSs are located in Attachment 2 for known chemical hazards.			
Physical Hazards			
Type of Physical Hazard:			**Exposure Potential During Task:**
Overhead Below grade Slip/trip/fall Burn Puncture Cut Splash Noise Heat stress Cold stress Excavation/trench Electrocution Traffic Other			High Medium Low
Ionizing radiation Alpha particles Beta particles Gamma rays Neutrons			High Medium Low
Confined space (hazards associated with PRCS entries will be addressed in a separate document)			High Medium Low N/A
Control Measures			
Engineering Controls: (list engineering controls necessary for this task)			
Work Practices: (describe those work practices specific to this task [e.g., medical monitoring])			
PPE: (list PPE necessary for this task)			
Workers Role:	**PPE Level:**	**Modifications Allowed:**	

G. EPA SOPs

EPA has developed SOPs for specific work tasks and emergency responder's health and safety. SOPs containing specific information regarding tasks anticipated at removal sites are linked below.

http://www.epaosc.org/_HealthSafetyManual/manual-index.htm
http://intranet.epa.gov/oeca/oc/campd/inspector/health/1440_1.pdf
http://intranet.epa.gov/ohr/rmpolicy/ads/orders/1440_2.pdf
http://intranet.epa.gov/shemd/content/epa_1460_1_508.pdf
http://intranet.epa.gov/shemd/content/epa_4800_1.pdf
http://intranet.epa.gov/oswer/workforce/health_and_security/hsSopDoc.pdf

ATTACHMENT #1
Site JHAs

ATTACHMENT #2
SDS

APPENDIX H

Consolidated HASP

The information in this appendix supplements Section 5.0 of this chapter and provides an example of the first two pages of a consolidated HASP. The remainder of the HASP can follow the template provided in Appendix F or another template preferred by the organization.

Site Name:_____ CERCLA ID#:_____
Type of Response:_____ USEPA Site ID#:_____
Address of Site:_____ Start Date:_____

This HASP is for use by EPA OSCs for responses or operations conducted under the NCP. The NCP states in 40 CFR 300.150(a) that "Response actions under the NCP will comply with the provisions for response action worker safety and health in 29 CFR 1910.120…" The NCP also states in 40 CFR 300.135(l) that "The OSC/RPM is responsible for addressing worker health and safety concerns at a response scene, in accordance with section 300.150." Accordingly, the OSC has determined that a HASP is required for this site in accordance with the NCP and 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER).

This HASP sets minimum standards for common elements required by HAZWOPER and consolidates all employer HASPs for employer-specific elements. This HASP ensures consistent application and awareness of site safety requirements and concerns. This HASP does not supersede any employer's safety and health program. It is intended to consolidate common HASP element requirements and prevent conflicting HASP elements among multiple employers.

EPA's health and safety responsibilities under the NCP do not relieve other employers working at this site from meeting their responsibilities under HAZWOPER for their employees' health and safety. In accordance with the NCP 40 CFR 300.150(e)], "All government agencies and private employers are directly responsible for health and safety of their own employees."

All employers that participate in this HASP acknowledge that they comply with any applicable requirements under 29 CFR 1910.120 (HAZWOPER), 29 CFR 1910 Subpart I (Personal Protective Equipment and 29 CFR 1910 Subpart Z (Toxic and Hazardous Substances).

As required by paragraph (b) of HAZWOPER, EPA has a written safety and health program which by incorporation includes this HASP, other safety and health programs (PPE, respiratory protection, medical surveillance, site control, spill containment), the organizational structure, and a comprehensive work plan. Any aspects of the various programs, the organizational structure, or the comprehensive work plan that are refined at the site level are captured in this HASP.

This HASP will be kept on site per paragraph (b)(4)(i) of HAZWOPER and addresses all of the elements required in paragraph (b)(4)(ii)(A – J) of HAZWOPER:

(A) Safety and health risk or hazard analysis
(B) Employee training assignments
(C) PPE
(D) Medical surveillance requirements
(E) Air monitoring, personnel monitoring, and environmental sampling
(F) Site control measures
(G) Decontamination procedures
(H) Emergency response
(I) Confined space entry procedures
(J) Spill containment program

Employer-specific elements in the HASP should refer the employee back to their respective employer HASPs that are attached to the lead HASP.

HEALTH & SAFETY PLAN

Date:
Amendment Date:

U.S. Environmental Protection Agency, Region #
On-Scene Coordinator: _____

START Contractor:
_____
Project Director/Safety Officer:
_____

ERRS Contractor:
_____
Response Manager/Safety Officer:
_____

Other Employers: _____
Representatives: _____

Plan Concurrence:

_____ USEPA On-Scene Coordinator	_____ Date
_____ ERRS Response Manager/Safety Officer	_____ Date
_____ START Project Manager/Safety Officer	_____ Date
_____ [Other]	_____ Date
_____ [Other]	_____ Date

APPENDIX I

Descriptions of ICS Forms

The information in this appendix supplements Section 7.0 of this chapter and describes each of the ICS forms.

1. Site Safety and Control Plan (ICS Form 208) – see Appendix K

The Site Safety and Control Plan (Form 208) provides the Safety Officer and ICS personnel with a plan for safeguarding personnel during the initial emergency phase of the response. It is intended to meet the requirements of HAZWOPER. This form will address the hazards common to all operations involved in the response (initial site characterization). For smaller incidents, Form 201 supplements ICS Form 208. For large incidents, Form 208 supplements the IAP, as a number of ICS forms may be required to address HAZWOPER HASP requirements.

ICS Form 208		
Item #	**Item Title**	**Instructions**
1	Incident Name	Enter incident name.
2	Date/Time Prepared	Enter date/time prepared.
3	Operational Period	Enter time interval for which the assignment applies.
4	Attachments	Enter attachments: ICS forms and checklist, safety data sheets, and safe work practices.
5	Organization	Identify the responsible personnel for these positions. (Incident Commander and Safety Officer are mandatory.)
6	Physical Hazards and Protection	Check off the physical hazards at the site. Identify the major tasks involved in the response (e.g., skimming, lightering, over packing). Check off the controls that would be used to safeguard workers from the physical hazards for each major task.
7	Chemical/Agent	List the chemicals involved in the response. Chemicals may be listed numerically. Check off the hazards, potential health effects, pathway of dispersion, and exposure route of the chemical. Numbers corresponding to the chemical may be entered into the check blocks to differentiate. Check off the PPE to be used and identify the type of PPE selected (e.g., gloves: butyl rubber).
8	Instruments	Indicate the instruments being used for monitoring. List the action levels adjacent to the instruments being used. Identify the chemicals being monitored. List the physical parameters of the chemicals. Use a separate form for additional chemicals monitored.
9	Decontamination	Check off the decontamination steps to be used. Numbers may be entered to indicate the preferred sequence. Identify any intervening steps necessary on the form or in a separate attachment.
10	Site Map	Draw a rough site map. Ensure that it identifies all the information listed.
11	Potential Emergencies	Identify any potential emergencies that may occur. If none, so state. Check off the appropriate alarms that may be used. Identify emergency prevention and evacuation procedures in the space provided or on a separate attachment.
12	Communications	Indicate the type of site communications (phone, radio) to be used. Indicate phone numbers or frequencies for the command, tactical, and entry functions.
13	Site Security	Identify the personnel assigned to site security. Identify security procedures in the space provided or on a separate attached sheet. Identify the equipment needed to support security operations.
14	Medical Emergency	Identify the personnel assigned to respond to medical emergencies. Identify medical emergency procedures in the space provided or on a separate attachment. Identify the equipment needed to support medical emergency operations.
15	Prepared By	Enter the name and position of the person completing the form.
16	Date/Time Briefed	Enter the date/time the document was briefed to the appropriate workers and by whom.

2. Incident Briefing (ICS Form 201)

The Incident Briefing form provides the Unified Command (and the command and general staffs assuming command of the incident) with basic information regarding the response situation and the resources allocated to the incident. It is also a permanent record of the initial incident response and includes a site map/sketch.

3. Incident Action Plan Safety Analysis (ICS Form 215A)

This form communicates safety and health issues identified by the Safety Officer to the Operations and Planning Section Chiefs. The Resources Unit uses this worksheet to complete ICS Form 204 and operations briefings.

4. Incident Objectives (ICS Form 202)

The Incident Objectives form describes the basic incident strategy and control objectives. It also provides weather, tide, and current information and safety considerations for use during the next operational period.

5. Assignment Lists (ICS Form 204)

The Assignment List(s) informs division and group supervisors of incident assignments. Once the Unified Command and general staff agree on the assignments, the assignment information is given to the appropriate divisions and groups.

> *See #8 (ICS Form 204: Special Instructions for Division/Group).* Provide a statement noting any safety problems, specific precautions to be exercised, or other important information.
>
> *See #9 (ICS Form 204: Communications).* Provide specific communications information (including emergency numbers) for the division/group. If radios are being used, enter function (command, tactical, support, etc.), frequency, system, and channel from the Incident Radio Communications Plan (ICS Form 205-OS).

6. Incident Organization (ICS Form 203)

This form provides ICS personnel with information on the units that are currently activated and the names of personnel staffing each position/unit.

7. Medical Plan (ICS Form 206)

The Medical Plan provides information on incident medical aid stations, transportation services, hospitals, and medical emergency procedures.

8. Incident Radio Communication Plan (ICS Form 205)

The Incident Radio Communications Plan is a summary of information obtained from the Radio Requirements Worksheet (ICS Form 216) and the Radio Frequency Assignment Worksheet (ICS Form 217).

9. Communication List (ICS Form 205a)

The Communications List records methods of contact to be used by on-scene personnel.

10. General Safety Message (ICS Form 223)

This form is used to provide a daily message that highlights safety issues.

11. Executive Summary

The Executive Summary communicates significant response issues during the current operational period, summarizing the daily activities for all sections in a brief format to senior managers, administrators, senior agency staff, and civic leaders.

Additional Supporting Documentation

See Appendices B and J for additional procedures and resources that can be used for IAP HASPs. Also, sample JHAs (which can be attached to IAP HASPs) can be found in repositories located on SHEMD's Intranet and under the "Resources" section of the manual's website.

APPENDIX J

IAP HASP Checklist

The information in this appendix supplements Section 7.0 of this chapter and provides an IAP checklist that can be used as an aid to determine what ICS forms should be attached to a HASP.

FORM NAME	FORM #	USE	REQUIRED	See Current IAP	ATTACH
Site Safety And Control Plan	208	Emergency response phase (uncontrolled) HASP	X		X
JHAs			X		X
SDS			X		X
Incident Briefing	201	Site map/sketch			X
Incident Action Plan Safety Analysis	215A	JHA, air monitoring		X	
Incident Objectives	202	Training, PPE		X	
Assignments Lists	204	Communications, JHA, PPE		X	
Incident Organization	203	Notifications		X	
Medical Plan	206	Emergency Procedures and identify Hospitals			X
Incident Radio Communication Plan	205	Communication			X
Communication List	205a			X	
General Safety Message	223			X	
Executive Summary		Critique of response and follow-up		X	
Confined Space Permits			X		X

APPENDIX K

Site Safety and Control Plan (ICS 208)

1. Incident Name:	2. Operational Period: (Date/Time) From: To:	**HAZARDOUS MATERIALS SITE SAFETY AND CONTROL PLAN ICS 208 HM - EPA**
3a. Incident Location:		3b. Incident Area Size:

ORGANIZATION

4. Incident/Unified Command:	5. Safety:	6. Operations :
7. Division/Group Supervisor :	8. Team Leader:	9. Other (Specify):

10. Team Members / Tasks (Box 24):

	Names	Task # (Box 24)		Names	Task # (Box 24)		Names	Task # (Box 24)
1			4			7		
2			5			8		
3			6			9		

11. SITE MAP	Attached: Yes: ☐ No: ☐	Includes:	☐ Command Post	☐ Work Zones	☐ Evacuation Route(s)
			☐ Assembly Point(s)	☐ Topography	☐ Accessibility by Air, Ground and/or Water
			☐ Location of Hazards	☐ North Arrow	☐ Decontamination Line

EMERGENCY PROCEDURES

12a. Notified	☐ Hospital:	☐ Air Ambulance	☐ Law Enforcement	
	☐ Ambulance:	☐ Fire	☐ Other: _____	
12b. On-Site	Medical Monitoring: Yes ☐ No ☐	Medical Treatment and Transport: Yes ☐ No ☐		
12c. Evacuation Plan	Assembly Area(s) Identified: ☐	Safe Distance: _____	Assembly Point(s): ☐ _____	
	ALARM System(s):	Horn ☐ # Blasts	Bells ☐ # Rings	Radio Code ☐
		Other (specify): _____		
12d. In Case of Emergency, Notification Procedures	☐ Phone ☐ Radio ☐ Other: _____			
	Safety Officer #:		Medical #:	
	Command #:		Site Security / Entry #:	
	Operations #:		Other (specify): _____	
12e. Directions to Nearest Medical Assistance	Attached: Yes: ☐ No: ☐ If NO, then Describe:			
12 f. Additional Emergency Procedures / Comments	_____			

13. DECONTAMINATION PROCEDURES	BELOW: ☐ ATTACHED: ☐		
☐ DROP: Segregated Equipment	☐ WASH: Suit/Safety Boot	☐ WASH: Inner Glove	☐ WASH: Field
☐ WASH: Boot Cover/Glove	☐ RINSE: Suit/Safety Boot/SCBA	☐ RINSE: Inner Glove	☐ Redress
☐ RINSE: Boot Cover/Glove	☐ RE-ENTER: Tank Change/Redress	☐ REMOVE: Face Piece	
☐ REMOVE: Tape	☐ REMOVE: Safety Boot	☐ REMOVE: Inner Glove	
☐ REMOVE: Boot Cover	☐ REMOVE: Suit/Hard Hat	☐ REMOVE: Inner Clothing	
☐ REMOVE: Outer Gloves	☐ REMOVE: SCBA (A/B)		

14. RECORDS MAINTAINED	☐ Medical Surveillance	☐ Fit Testing	☐ Mandatory Training	☐ Other: _____

15. ATTACHMENTS	**Procedures, SOPs, Safe Work Practices, IAP Components, Other**	
☐ MSDS/SDS Chemical 1	☐ Decontamination Plan	IAP COMPONENTS
☐ MSDS/SDS Chemical 2	☐ Confined Space Procedures: _____	☐ 201 Incident Briefing; or
☐ MSDS/SDS Chemical 3	☐ JHA: _____	☐ 202 Incident Objectives
☐ Spill Containment Plan	☐ JHA: _____	☐ 203 Organization List
☐ Handling Drums/Other Containers	☐ JHA: _____	☐ 204 Assignment List (#8, #9)
☐ Disposal Procedures	☐ Other (specify): _____	☐ 205 A Incident Comms Plan
☐ Release Map Pathway	☐ Other (specify): _____	☐ 206 Medical Plan
☐ Modifications to Documented SOPs Work Practices: _____		☐ 215 A IAP Safety Analysis

HAZARD ANALYSIS / ENVIRONMENTAL & PERSONNEL MONITORING

16. Chemical Name(s)	Action Levels	LEL/UEL %	Physical State (S / L / G)	Ceiling IDLH	STEL / TLV	Flash Pt / Ignition Pt (F or C)	Vapor Pressure (mm HG)	Vapor Density	*Sp. Gravity*	Boiling Pt (F or C)	Odor Thresh (ppm)
1)											
2)											
3)											
4)											

17. Instruments: ☐ $\%O_2$ ☐ H_2S ☐ PID ☐ Thermal ☐ CGI
☐ %LEL ☐ CO ☐ FID ☐ Colorimetric ☐ Personnel:_____
☐ Radiation / Specify: _____ ☐ Other: _____

18. Monitoring Frequency: ☐ 24 hr ☐ 8 hr ☐ Hourly ☐ Continuous Other: _____

19. Containers: Types / Quantities / Comments: _____

20. Physical Hazards:
☐ Confined Space ☐ Heat Stress ☐ Noise ☐ Water ☐ Biomedical waste / needles
☐ Slips/Trips/Falls ☐ Cold Stress ☐ Electrical ☐ Ionizing Rad ☐ Other: _____
☐ Excavation ☐ Fatigue ☐ Ergonomic ☐ Animal/Plant/Insect ☐ Other: _____

21a. Hazards	Chemical 1	2	3	4	21b. Target Organs	Chemical 1	2	3	4	21b. Con't	Chemical 1	2	3	4	21c. Exposure Routes	Chemical 1	2	3	4
Explosive	☐	☐	☐	☐	Eyes	☐	☐	☐	☐	Lungs	☐	☐	☐	☐	Inhalation	☐	☐	☐	☐
Flammable	☐	☐	☐	☐	Nose	☐	☐	☐	☐	Bone	☐	☐	☐	☐	Absorption	☐	☐	☐	☐
Reactive	☐	☐	☐	☐	Ears	☐	☐	☐	☐	Throat	☐	☐	☐	☐	Ingestion	☐	☐	☐	☐
Radioactive	☐	☐	☐	☐	Liver	☐	☐	☐	☐	Kidney	☐	☐	☐	☐	Injection	☐	☐	☐	☐
Carcinogen	☐	☐	☐	☐	Skin	☐	☐	☐	☐	Heart	☐	☐	☐	☐	Membrane	☐	☐	☐	☐
Oxidizer	☐	☐	☐	☐	CNS	☐	☐	☐	☐	Blood	☐	☐	☐	☐	NOTES: _____				
Corrosive	☐	☐	☐	☐	Gastrointestinal	☐	☐	☐	☐	Respiratory	☐	☐	☐	☐					
Biomedical	☐	☐	☐	☐	Circulatory	☐	☐	☐	☐	Other: _____	☐	☐	☐	☐					
Toxic	☐	☐	☐	☐	Other:_____	☐	☐	☐	☐										

TASK / PPE / CONTROLS

22a. TASK 1: PPE Level D ☐ C ☐ B ☐ A ☐ Description:

22b. TASK 2: PPE Level D ☐ C ☐ B ☐ A ☐ Description:

22c. TASK 3: PPE Level D ☐ C ☐ B ☐ A ☐ Description:

23a. PPE	TASK 1	2	3	Comment/Modifications	23b. CONTROLS	TASK 1	2	3	Comment/Modifications
Boots (Steel-toe)	☐	☐	☐		Work/Rest (hrs)	☐	☐	☐	
Hard Hats	☐	☐	☐		Fluids (amt/time)	☐	☐	☐	
Hearing Protection	☐	☐	☐		Clothing (cold)	☐	☐	☐	
Eye Protection	☐	☐	☐		Ventilate	☐	☐	☐	
Gloves (Inner/Outer)	☐	☐	☐		Signs & Barricade	☐	☐	☐	
Face Shield/ Splash Suit	☐	☐	☐		Fall Protection	☐	☐	☐	
Suit (Inner/Outer)	☐	☐	☐		Post Guards	☐	☐	☐	
APR/PAPR (cartridges)	☐	☐	☐		Life Jacket	☐	☐	☐	
SAR	☐	☐	☐		Fire Resistance PPE	☐	☐	☐	
SCBA	☐	☐	☐		Flash Protection	☐	☐	☐	
EPD:	☐	☐	☐		Sanitation Facilities	☐	☐	☐	
OTHER:	☐	☐	☐		OTHER:	☐	☐	☐	

PREPARED/APPROVED BY

24. Prepared by:	Signature:	Date / Time:
57. Approved by:	Signature:	Date / Time:

APPENDIX 3

AIR MONITORING

EPA AIR MONITORING TABLES: CHEMICAL WARFARE AGENTS

Table 16 -- Chemical Warfare Agents

Target Compound[1]	Instrument	Detection Level	Intrinsically Safe (Y/N)	IP[2]	PID CF (ISO)[2]	Conversion	Occupational Action Levels		AEGL-1			TEEL-0	ERPG-1	Air Sampling		
							TWA/AEL	IDLH	1-hr	4-hr	8-hr	15-min TWA	1-hr	Media	Method	Flow Rate/ Total Volume
Nerve																
Tabun (GA)	APD 2000	15 ppb	N	NA	NA	1 ppm = 6.63 mg/m^3	WPL = 0.00003 mg/m^3 STEL = 0.0001 mg/m^3 GPL = 0.000001 mg/m^3	0.1 mg/m^3	0.00042 ppm (0.0028 mg/m^3)	0.00021 ppm (0.0014 mg/m^3)	0.00015 ppm (0.001 mg/m^3)	0.000125 ppm	0.00042 ppm*	Tenax Tube, DAAMS	NA	NA
	ChemPro 100i	0.1 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	10 µg/m^3	N													
	SAW Mini-CAD	0.17 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.001 ppm	Y													
	Dräger CDS Tube	0.025 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y		0.8 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Sarin (GB)	APD 2000	15 ppb	N	NA	NA	1 ppm = 5.73 mg/m^3	WPL = 0.00003 mg/m^3 STEL = 0.0001 mg/m^3 GPL = 0.000001 mg/m^3	0.1 mg/m^3	0.00048 ppm (0.0028 mg/m^3)	0.00024 ppm (0.0014 mg/m^3)	0.00017 ppm (0.001 mg/m^3)	0.00015 ppm	0.00048 ppm*	XAD-2 OVS Tube, 226-30-16	OSHA CSI	1 L/min; 480 L
	ChemPro 100i	0.1 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	10 µg/m^3	N													
	SAW Mini-CAD	0.17 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.0008 ppm	Y													
	Dräger CDS Tube	0.025 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	<16 eV	3-6 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Soman (GD)	APD 2000	15 ppb	N	NA	NA	1 ppm = 7.45 mg/m^3	WPL = 0.00003 mg/m^3 STEL = 0.0001 mg/m^3 GPL = 0.000001 mg/m^3	NA	0.00018 ppm (0.0014 mg/m^3)	0.000091 ppm (0.0007 mg/m^3)	0.000065 ppm (0.0005 mg/m^3)	0.00003 ppm	0.00018 ppm*	Sorbent Tube, DAAMS***	NA	NA
	ChemPro 100i	0.1 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	10 µg/m^3	N													
	SAW Mini-CAD	0.02 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.001 ppm	Y													
	Dräger CDS Tube	0.025 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	<10.6 eV	~3 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											

Table 16 -- Chemical Warfare Agents

Target Compound[1]	Instrument	Detection Level	Intrinsically Safe (Y/N)	IP[2]	PID CF (ISO)[2]	Conversion	Occupational Action Levels		AEGL-1			TEEL-0	ERPG-1	Air Sampling		
							TWA/AEL	IDLH	1-hr	4-hr	8-hr	15-min TWA	1-hr	Media	Method	Flow Rate/ Total Volume
Nerve (continued)																
Cyclo-Sarin (GF)	APD 2000	15 ppb	N	NA	NA	1 ppm = 7.36 mg/m^3	PEL = 0.003 mg/m^3 U-STEL = 0.001 mg/m^3 WPL = 0.00003 mg/m^3 GPL = 0.000001 mg/m^3 A-TWA = 0.00003 mg/m^3	NA	0.00020 ppm (0.0014 mg/m^3)	0.0001 ppm (0.0007 mg/m^3)	0.00007 ppm (0.0005 mg/m^3)	0.00006 ppm	0.0002 ppm*	NA	NA	NA
	ChemPro 100i	0.1 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	10 µg/m^3	N													
	SAW Mini-CAD	0.01 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.002 ppm	Y													
	Dräger CDS Tube	0.025 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	10.6 eV	~3 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
VX	APD 2000	15 ppb	N	NA	NA	1 ppm = 10.93 mg/m^3	STEL = 0.00001 mg/m^3 WPL = 0.000001 mg/m^3 GPL = 0.0000006 mg/m^3	0.003 mg/m^3	0.000016 ppm (0.00017 mg/m^3)	0.0000091 ppm (0.0001 mg/m^3)	0.0000065 ppm (0.000071 mg/m^3)	0.000005 ppm	0.000016 ppm*	Sorbent Tube, Tenax	NA	NA
	ChemPro 100i	0.1 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	10 µg/m^3	N													
	SAW Mini-CAD	0.01 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.002 ppm	Y													
	Dräger CDS Tube	0.025 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y		~0.5 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Blister																
Mustard (H) & Distilled Mustard (HD)	APD 2000	300 ppb	N	NA	NA	1 ppm = 6.5 mg/m^3	STEL = 0.003 mg/m^3 WPL = 0.0004 mg/m^3 GPL = 0.00002 mg/m^3	0.7 mg/m^3	0.01 ppm (0.067 mg/m^3)	0.003 ppm (0.017 mg/m^3)	0.001 ppm (0.0083 mg/m^3)	0.0035 ppm	0.01 ppm*	Sorbent Tube, Tenax	NA	NA
	ChemPro 100i	2 mg/m^3	N													
	AP2C	1.5 ppb	N													
	AP4C	0.5 mg/m^3	N													
	SAW Mini-CAD	0.09 ppm	N													
	HAPSITE	0.1-10 ppb	N													
	M256 A-1	0.31 ppm	Y													
	Dräger CDS Tube	1 mg/m^3	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	<11.1 eV	~0.5 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											

Table 16 -- Chemical Warfare Agents

	Instrument Guidance						Regulatory Guidance							Reference		
							Occupational Action Levels		AEGL-1			TEEL-0	ERPG-1	Air Sampling		
Target Compound[1]	Instrument	Detection Level	Intrinsically Safe (Y/N)	IP[2]	PID CF (ISO)[2]	Conversion	TWA/AEL	IDLH	1-hr	4-hr	8-hr	15-min TWA	1-hr	Media	Method	Flow Rate/ Total Volume
Blister (continued)																
Nitrogen Mustard (HN1, HN2, HN3)	APD 2000	300 ppb	N	NA	NA	1 ppm = HN1 -- 6.95 mg/m^3 HN2 -- 6.38 mg/m^3 HN3 -- 8.36 mg/m^3	NA	HN1 = 1 ppm HN2 =NI HN3 = NI	0.0022 mg/m^3*	0.0056 mg/m^3*	0.0028 mg/m^3*	HN1: 0.004 mg/m^3 HN2: 001 mg/m^3 HN3: 0.001 mg/m^3	HN1: 0.0125 mg/m^3* HN2: 0.003 mg/m^3* HN3: 0.003 mg/m^3*	NA	NA	NA
	ChemPro 100i	5 mg/m^3 (HN3)	N													
	AP4C	10 mg/m^3	N													
	SAW Mini-CAD	does not	N													
	M256 A-1	0.6 ppm	Y													
	Dräger CDS Tube	1 mg/m^3	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	<11.1 eV	~0.5 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Lewisite (L)	APD 2000	200 ppb	N	NA	NA	1 ppm = 8.47 mg/m^3	NA	NA	0.12 mg/m^3*	0.035 mg/m^3*	0.018 mg/m^3*	0.12 mg/m^3	0.12 mg/m^3*	Sorbent Tube, Tenax	NA	NA
	ChemPro 100i	2 mg/m^3	N													
	AP4C	1.5 mg/m^3	N													
	M256 A-1	1 ppm	Y													
	Dräger CDS Tube	3 mg/m^3	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	~10.6 eV	1 (10.6 lamp)											
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Phosgene Oxime (CX)	MultiRAE/AreaRAE PID**	0-2000 ppm	Y	~10.6 eV	1 (10.6 lamp)	1 ppm = 4.66 mg/m^3	NA	NA	0.028 mg/m^3	0.0069 mg/m^3	0.0035 mg/m^3	0.0075 mg/m^3	0.028 mg/m^3*	NA	NA	NA
	TVA 1000B**	0.5-2000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Systemic/Blood																
Hydrogen Cyanide (AC), HCN	AP4C	10 mg/m^3 or 1.5 ppm	N	NA	NA	1 ppm = 1.1 mg/m^3	REL = ST 4.7 mg/m^3 S PEL = 10 ppm S TLV = C 4.7 ppm S	50 ppm	2 ppm	1.3 ppm	1 ppm	1.9 ppm	2 ppm*	Soda Lime Tube, 226-28	NIOSH 6010	0.05-0.2 L/min; 2-90 L
	ChemPro 100i	50 mg/m^3	N													
	M256 A-1	7.13 ppm	Y													
	Dräger CDS Tube	1 ppm	Y													
	Dräger CDS Chips	2 ppm	Y													
Cyanogen Chloride (CK)	M256 A-1	0.25 ppm	Y	12.34 eV	NA	1 ppm = 2.51 mg/m^3	REL = C 0.3 mg/m^3 TLV = C 0.3 ppm	NA	NA	NA	NA	0.02 ppm	0.06 ppm*	XAD-2 Tube, 226-117	OSHA CSI	0.2 L/min; 1 L
	ChemPro 100i	50 mg/m^3	N													
	Dräger CDS Tube	3.13 ppm	Y													

Table 16 -- Chemical Warfare Agents

Target Compound[1]	Instrument	Detection Level	Intrinsically Safe (Y/N)	IP[2]	PID CF (ISO)[2]	Conversion	Occupational Action Levels		AEGL-1			TEEL-0	ERPG-1	Air Sampling		
							TWA/AEL	IDLH	1-hr	4-hr	8-hr	15-min TWA	1-hr	Media	Method	Flow Rate/ Total Volume
Systemic/Blood (continued)																
Arsine (SA)	ChemPro 100i	3 ppm	N	9.89 eV	NA	1 ppm = 3.19 mg/m^3	REL = C 0.002 mg/m^3 PEL = 0.05 ppm TLV = 0.05 ppm	3 ppm	0.17 ppm*	0.04 ppm*	0.02 ppm*	0.005 ppm	0.025 ppm*	Anasorb CSC Tube, 226-01	NIOSH 6001	0.02-0.2 L/min; 10 L
	Dräger CDS Tube	0.1 ppm	Y													
	MultiRAE/AreaRAE PID**	0-2000 ppm	Y													
	TVA 1000B**	0.5-2,000 ppm (PID) 1-50,000 ppm (FID)	Y		NA											
Radiation[3]																
Radiation	Ludlum Model 192	0-5,000 µR/hr	N	NA	NA	NA	60-100 µR/hr*	NA	NA	NA	NA	NA	NA	RADeCO Filter Paper (2")	RSSOP 209/501	α = 2500 ft^3 β/γ = 1250 ft^3
	Ludlum Model 2241-2 w/Pancake Probe	0-100,000 cpm or 0-200 mR/hr	N				300 cpm*									
	Ludlum Model 2241-3 w/Pancake Probe	0-100,000 cpm or 0-200 mR/hr	N				300 cpm*									
	*These are not TWA(s). Normal gamma radiation background is from 5-20 µR/hr; however, higher backgrounds may exist. If readings are 3 times background or greater than 60-100 µR/hr or greater than 300 cpm, then stop work and consult with a Health Physicist. Refer to Hazardous Evaluation Flow Chart for Unknowns in Attachment A.															

Table 16 -- Chemical Warfare Agents

Notes:

For guidance only. These tables do not supersede a SSHASP at any time or on any response.

[1] Does not include all pollutants associated with this type of event, only the most common pollutants with the lowest action levels.

[2] Estimated response of warfare agent detection products by PID. Source: RAE TN-159.

[4] Standard EPA Emergency Response Protocol is to screen for radiation with a Micro-R at all emergency responses. If readings are three times background, responders consult with a Health Physicist. Additional radiation equipment is available to monitor for Alpha, Beta and Gamma, but is not included in this table.

AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects; however, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

TEEL-0 is the temporary level of concern derived according to a tiered, formula-like methodology; representing concentrations associated with no effects.

ERPG-1 is the acute exposure concentration of the general population for up to 1 hour associated with effects expected to be mild or transient.

PAC-1 is based on the applicable AEGL-1, ERPG-1, or TEEL-1 value

Data on tables are from the following sources:

http://www.epa.gov/oppt/aegl/pubs/chemlist.htm	EPA's website used to research AEGLs using the chemical's name or chemical abstracts service registry numbers.
http://www.cdc.gov/niosh/npg/npgsyn-a.html	CDC NIOSH Pocket Guide to Chemical Hazards website
http://wiser.nlm.nih.gov/	WISER website
http://www.skcinc.com/	SKC, Inc. website (Air Sampling Media Part No. is specific to SKC)

*AEGL-2--There are no AEGL-1 for this compound

*PAC-1--There are no ERPG-1 for this compound

**PIDs/FIDs are non-specific detectors and cannot differentiate between VOCs, even with CFs applied. See RAE PID CF Guidance Document TN-106 for information and TVA Response Factor document P/N 50039 THERMO.

***The method can capture GD, but laboratory analysis capability maybe limited.

Acronyms:

~ -- approximately
≥ -- greater than or equal to
< -- less than
A-TWA -- ATSDR time-weighted average
ACGIH -- American Conference of Governmental Industrial Hygienists
AEGL -- acute exposure guideline levels
AEL -- airborne exposure limits (CDC)
ATSDR -- Agency for Toxic Substances and Disease Registry
C -- ceiling (concentrations that should not be exceeded during any part of work exposure)
C-STEL -- CDC short-term exposure limit
CDC -- Centers for Disease Control and Prevention
CF -- conversion factor
cpm -- counts per minute
DAAMS - Depot Area Air Monitoring System
DOE -- U.S. Department of Energy
EPA -- U.S. Environmental Protection Agency
ERPG -- emergency response planning guideline
eV -- electron volt
FID -- flame ionization detector
GPL -- general population limit
IDLH -- immediately dangerous to life and health
IP -- ionization potential
ISO -- isobutylene
L/min -- liter per minute
mg/m^3 -- milligrams per cubic meter
$\mu g/m^3$ -- micrograms per cubic meter
µR/hr -- micro Roentgens per hour
NA -- not available/applicable
NIOSH -- National Institute for Occupational Safety and Health
OSHA -- Occupational Safety and Health Administration
PEL -- permissible exposure limit (OSHA)
PID -- photoionization detector
ppb -- parts per billion
ppm -- parts per million
R/hr -- Roentgens per hour
REL -- recommended exposure limit (NIOSH)
SPM -- single-point monitor
SSHASP -- site-specific health and safety plan
STEL -- short-term exposure limit
TEEL -- temporary emergency exposure limit (DOE)
TLV -- time-limited value (ACGIH)
TWA -- time-weighted average
WISER -- Wireless Information System for Emergency Responders
WPL -- worker population limit
Y w/option - yes with option; see manufacturer's instrument manual for information

APPENDIX 4

CWA QUICK REFERENCE GUIDES (QRG)
NRT QUICK REFERENCE GUIDE

NRT Quick Reference Guide:
Sulfur Mustard (HD)
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Blister (Vesicant) Agent; **CAS:** 505-60-2; **Formula:** $C_4H_8Cl_2S$; **Molecular Weight:** 159.08 g/mol.
Description: Sulfur mustard is sometimes called "mustard gas" but is actually a yellow to brown oily liquid with a garlic, onion, horseradish or mustard-like odor. It is a blister (vesicant) agent that will have delayed health effects on the order of hours, and is reported to be a known human carcinogen. It can be manufactured at different concentrations; with impurities, additives, or thickening materials that will all affect physical properties, appearance, persistence and analytical detection limits. Distilled mustard (HD) is considered the most potent form and is the basis of this QRG. Environmental breakdown products of HD, including thiodiglycol (TDG) and hydrochloric acid, are relatively non-toxic, but some decontamination by-products can be toxic (e.g., sulfones).
Persistence: HD is considered a "semi-persistent" chemical warfare agent with liquid deposition on surfaces lasting for hours to days. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Under certain environmental conditions, HD liquid may go through a partial hydrolysis that results in an outer protective coating around "globules" that are resistant to further hydrolysis and can persist for decades if not physically disturbed. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can act as "sinks" for absorbing HD vapors and liquids, prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.1538; mg/m³ = ppm x 6.503

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
5.4 (air = 1)	0.072 mm Hg (68°F/20°C)	610 mg/m³ (68°F/20°C)	~422°F/217°C	58.1°F/14.5°C	223°F/106°C	1.27 g/mL (77°F/25°C)	0.92 g/L (72°F/22°C)	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
Open Areas: HD is difficult to disperse in air due to low volatility; however, it may be possible to disperse HD as a vapor/aerosol plume if an appropriate heat/explosive device is employed. The low volatility of HD would limit the size and extent of plume dissipation, posing localized hazards. **HD has a freezing point at 15°C (58°F), so the re-aerosolization of liquids and solids, as ambient temperatures rise, may present a real hazard.** HD vapors are heavier than air, so vapors can accumulate in lower terrains.
Water/Water Systems: HD released into water may dissolve and hydrolyze with a half-life of about 8.5 minutes at 25°C, but in sufficient amounts (relative to water volume) HD may also form globules surrounded by a protective outer layer resistant to hydrolysis. These globules may settle out or be entrapped, persisting for years and posing a contact hazard to anyone disturbing them. Areas in which the globules may persist include stagnant volumes of water as small as puddles formed by precipitation events. Water systems, plumbing, surfaces and equipment that have contacted HD globules, must be evaluated for decontamination.
Indoor Facility: HD is a semi-persistent agent with low to moderate volatility, and would be difficult to distribute effectively throughout a building or facility from a point source. Liquid HD will result in localized areas of surface contamination. HVAC system intakes near to liquid HD should be investigated for contamination from HD vapors and aerosols. HD vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset and severity of effects depend on dose, duration and route of exposure (not all signs/symptoms may develop). The effects caused by HD are not typically fatal immediately, but can require substantial supportive medical care as there is no antidote, and secondary infections from blisters/tissue damage may also be fatal. HD produces effects by 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, so those exposed may not be aware.
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. **Mild:** Effects delayed 1-48 hours (severity depends on dose): Eye irritation (tearing, grittiness), runny nose, sneezing, nosebleed, hoarseness, hacking cough. **Moderate:** Effects delayed 1-24 hours: Mild effects plus reddening and swelling of eyelids, severe cough, shortness of breath, reddening of skin. **Severe:** Effects delayed 1-24 hours: Upper respiratory/lung damage may occur at high concentrations and longer exposure durations.
Exposure Routes	**Inhalation:** Injury develops slowly, intensifies over several days. Vapor exposure is absorbed in mucous membranes (mouth, throat and lungs). **Skin:** Direct contact with HD liquid can cause redness or blisters in 2-24 hours. Warm and sweaty skin areas (underarms, groin) are most susceptible to exposure. **Eyes:** Eyes are the most sensitive to HD injury; effects noted after 1-12 hours include irritation, burning, gritty feeling, itching, weeping, reddening, lid swelling, light sensitivity, pain and corneal injury. High concentration effects are extremely painful and generally require extended medical treatment. **Ingestion:** Consumption of contaminated food or drink could cause burning, nausea and vomiting.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for HD (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m³, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.40	0.13	0.067	0.017	0.0083
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

Exposure Guidelines: IDLH = 0.7 mg/m³; STEL = 3.0 x 10^{-3} mg/m³; **Worker Population Limit (WPL)** [an 8-hr time-weighted average occupational value] = 4.0 x 10^{-4} mg/m³; **General Population Limit (GPL)** [a 24-hr time-weighted average] = 2.0 x 10^{-5} mg/m³. **Soil: Industrial Exposure Scenario** = 0.3 mg/kg (10^{-4} cancer risk); **Residential Exposure Scenario** = 0.01 mg/kg (10^{-5} cancer risk). **Drinking Water:** Provisional Advisory Levels (PAL-1) for HD are not available due to the rapid hydrolysis of dissolved HD to TDG. In the absence of PALs, the U.S. Army's Military Exposure Guidelines (MEGs) may be used; the MEG at 5 L/day, for 7 days = 140 µg/L.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs) if they have them.
Medical	**Pre-incident:** Annual physical and respiratory function exams. **During Incident:** Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: NO ANTIDOTE AVAILABLE. Send person for follow-up medical attention and evaluation; **be aware effects are delayed 1-48 hours.** If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, & protective clothing should be used. Pre-incident training & exercises on the proper use of PPE are recommended. Per NIOSH guidance - **LEVEL A:** Recommended for the initial response to an HD incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), & eye protection when the contaminant identity or concentration is unknown. Select Level A when the HD concentration is unknown or above the IDLH or AEGL-2, & when there is a potential of ocular or dermal exposure. **LEVEL B:** Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the HD concentration is unknown or above the IDLH or AEGL-2 & dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. **LEVEL C:** Select Level C when the contaminant identity & concentration are known & the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. **LEVEL D:** Select Level D when the contaminant is known & the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. **Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.**

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams & other agencies & responders, some with similar capabilities & limitations.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of HD at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.3	0.03-0.142	0.3	0.15	0.31-0.46	2.0 mg/L
mg/m³	0.1-2	0.2-1	0.22-2	1	2-3	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine HD, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because HD is a semi-persistent liquid, sample priorities should include surfaces that are potentially contaminated with aerosol/liquid (e.g., release site, low lying areas) and that humans are likely to contact or where vegetation is used as food.
	Note: HD breaks down in most environmental conditions to numerous breakdown products, especially TDG, which may be used as a marker to determine the extent of contamination of the parent HD. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. 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 the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of HD on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid HD deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of HD into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for HD analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: HD degrades via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Fix-in-Place Option: The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decontamination processes in a tiered approach to the overall site-specific decontamination strategy. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. In contrast to the rapid hydrolysis when HD is dissolved in water, the hydrolysis of HD on surfaces is slow. 1) Hypochlorite solutions are effective but can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) are very effective for HD with efficacy achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® have been reported to be effective against HD on the order of minutes to hours, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of HD in large volumetric spaces or open areas; efficacy typically can be achieved in hours to days with less waste and adverse impacts to materials. 3) Fumigation with modified vaporous hydrogen peroxide (VHP®) has been reported to be effective against HD. HVAC systems in large indoor spaces may require a separate decontamination strategy that could include the use of Hot Air ventilation or fumigation. Sensitive Equipment and Items: 1) Forced or Hot Air ventilation may be used for HD and can be used either in-situ or ex-situ to decontaminate these items. 2) modified VHP® fumigation can be used on these items with less corrosion to electronics than dilute hypochlorite solutions. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Strong oxidizers, such as hypochlorite, may react violently with organics. Under oxidizing conditions (i.e., bleach), HD can break down into several toxic by-products, such as mustard and vinyl sulfones. Hydrolysis of HD releases Cl ions that can affect the pH of solutions. Formulations should be chosen that do not allow the formation of these toxic breakdown products. Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org. Current resources on packaging, labeling and shipping are available at: www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. HD is not a hazardous waste under the Federal regulations, but state codes may apply for HD-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

NRT Quick Reference Guide:
Tabun (GA)
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Nerve Agent; CAS: 77-81-6; Formula: $C_5H_{11}N_2O_2P$; Molecular Weight: 162.13 g/mol.
Description: Colorless to brown liquid; generally odorless, though possibly fruity or almond-like. GA is a lethal cholinesterase inhibitor with a mechanism of toxicity similar to organophosphate insecticides, though it is much more potent. GA is less volatile than GB (Sarin), has similar volatility to HD (Sulfur Mustard), and it is more volatile than the persistent agent VX. Environmental breakdown products of GA, including cyanide compounds, may be present. Other breakdown products include cyanide ion, which may convert to hydrogen cyanide gas depending on the pH. GA can react violently with strong oxidizers and may decompose when in contact with metals, evolving flammable hydrogen gas. GA is combustible but not easily ignited when heated; GA vapors can form explosive mixtures with air.
Persistence: GA is considered a "moderately low persistent" chemical warfare agent. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon the amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can accumulate agent by sorbing GA vapors and liquids, acting as "sinks," thereby prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.1508; mg/m³ = ppm x 6.631

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
5.63 (air = 1)	0.07 mm Hg (77°F/25°C)	610 mg/m³ (77°F/25°C)	446-473°F/230-245°C	-58°F/-50°C	172°F/78°C	1.08 g/mL (77°F/25°C)	73 g/L (68°F/20°C)	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
Open Areas: GA has low volatility but may still be present as a vapor or aerosol, and the primary release/attack scenario is an airborne release. GA is expected to degrade in the environment fairly rapidly; however, liquid GA on surfaces generally persists for hours to days. Environmental conditions will affect the degradation and evaporation rates of GA with cooler and drier conditions enhancing persistence. GA vapors are heavier than air, so vapors can accumulate in lower terrains.
Water/Water Systems: GA is not typically considered a water release hazard. If released into natural waters or water systems, GA will likely hydrolyze with a half-life of about 8.5 hours at pH 7, with persistence depending on released amount and environmental conditions.
Indoor Facility: GA could potentially be dispersed as a vapor or aerosol inside a building or facility; HVAC systems could be impacted. GA vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. After exposure, symptoms may occur within seconds if GA is present in vapor form or within minutes to hours if in liquid form. Even a relatively low dose exposure to GA can be fatal and immediate administration of an antidote is critical (see First Aid below).
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficulty in 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, death.
Exposure Routes	Inhalation: A primary exposure route; inhalation of very small concentrations can produce health effects. Skin: Direct contact with liquid agent is especially toxic. Moderate to severe *signs/symptoms occur at, but are not limited to, the site of contact*. Exposure can also result from absorption of vapors via 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: Contaminated drinking water and foods are the most likely route for ingestion of agent. Target organ from ingestion is the GI tract. Other: Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for GA (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m³, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.0069	0.0040	0.0028	0.0014	0.0010
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.087	0.050	0.035	0.017	0.013
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	0.76	0.38	0.26	0.14	0.10

Exposure Guidelines: IDLH = 0.1 mg/m³; STEL = 1.0 x 10^{-4} mg/m³; Worker Population Limit (WPL) [an 8-hr time-weighted average occupational value] = 3.0 x 10^{-5} mg/m³; General Population Limit (GPL) [a 24-hr time-weighted average] = 1.0 x 10^{-6} mg/m³. Soil: Industrial Exposure Scenario = 68 mg/kg; Residential Exposure Scenario = 2.8 mg/kg.
Drinking Water: Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 74, 16, and 4 µg/L, respectively.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs), if they have them.
Medical	Pre-incident: A baseline cholinesterase activity determination and an annual physical and respiratory function exam. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). Antidote kit should only be administered as per pre-incident training. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to a GA incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the GA concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the GA concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.015-0.02	0.0015-0.004	0.015	0.025	0.0008-0.001	0.02 mg/L
mg/m³	0.03-0.1	0.01-0.1	0.027-0.27	0.17	0.005	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine GA, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because GA is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.
	Note: GA breaks down in most environmental conditions to numerous breakdown products, especially cyanide compounds, which may be used as a marker to determine the extent of contamination of the parent GA. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives; G-agents are unlikely to persist in water. Soil: For localized hot spot areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples may not be necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of GA on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid GA deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of GA into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for GA analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: GA degrades via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Fix-in-Place Option: The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decontamination processes in a tiered approach to the overall site-specific decontamination strategy. All statements about decontamination efficacy are based upon GB and have not been verified for GA. Because hydrolysis has been identified as a major degradation pathway for both GA and GB and because the hydrolysis rate of GA is around 5 times that of GB, the limited data available for GA suggest at least equal or perhaps greater efficacy. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. Decontamination of GA occurs mainly through hydrolysis, which may be catalyzed (sped up), by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) may be very effective for GA with efficacy expected to be achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Hydroxide (e.g., sodium, potassium – 10% solution) is expected to react rapidly with GA, but solutions are very damaging to many surfaces and should be rinsed thoroughly after use. 3) Other high pH solutions, such as sodium carbonate (10% solution), are expected to decontaminate but slower than decontamination with sodium or potassium hydroxide. Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® may be effective against GA, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of GA in large volumetric spaces or open areas; efficacy may be typically achieved in hours to days with less waste and adverse impacts to materials. Sensitive Equipment and Items: Forced or Hot Air ventilation may be used for GA and can be used either in-situ or ex-situ to decontaminate these items. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org/. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. GA is not a hazardous waste under the Federal regulations, but state codes may apply for GA-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

NRT Quick Reference Guide:
Sarin (GB)
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Nerve Agent; **CAS:** 107-44-8; **Formula:** $C_4H_{10}FO_2P$; **Molecular Weight:** 140.10 g/mol.

Description: Colorless and odorless liquid when pure; brown liquid with a fruity odor in impure form. GB is a lethal cholinesterase inhibitor with a mechanism of toxicity similar to organophosphate insecticides, though it is much more potent. GB is more easily generated and more volatile than chemical warfare agents GA, GD, GF, HD, Lewisite, and VX. Environmental breakdown products of GB, including methylphosphonic acid (MPA) and isopropyl methylphosphonic acid (IMPA), are relatively non-toxic. Other breakdown products include fluoride ion, which may exist as hydrofluoric acid (HF) depending on the pH. GB can react violently with strong oxidizers and may decompose when in contact with metals, evolving flammable hydrogen gas. GB vapors can form explosive mixtures with air.

Persistence: GB is considered a "very low persistent" chemical warfare agent. Vapor: minutes to hours; liquid: 2-24 hours. Persistence will depend upon the amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can accumulate agent by sorbing GB vapors and liquids, acting as "sinks," thereby prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.1745; mg/m³ = ppm x 5.730

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
4.86 (air = 1)	2.94 mm Hg (77°F/25°C)	22,000 mg/m³ (77°F/25°C)	316°F/158°C	-69°F/-56°C	>280°F/138°C	1.09 g/mL (77°F/25°C)	miscible	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.

Open Areas: GB has high volatility relative to other nerve agents but may still be present as a liquid or aerosol, and the primary release/attack scenario is an airborne release. GB is expected to degrade in the environment fairly rapidly; however, liquid GB on surfaces could persist for up to 24 hours. Environmental conditions will affect the degradation and evaporation rates of GB with cooler and drier conditions enhancing persistence. GB vapors are heavier than air, so vapors can accumulate in lower terrains. GB vapors can form explosive mixtures with air.

Water/Water Systems: GB is not typically considered a water release hazard. If released into natural waters or water systems, GB will likely hydrolyze with a half-life of about 39 hours at pH 7, with persistence depending on released amount and environmental conditions.

Indoor Facility: Due to its volatility, GB could potentially be dispersed as a vapor or an aerosol inside a building or facility; HVAC systems could be impacted. GB vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. After exposure, symptoms may occur within seconds if GB is present in vapor form or within minutes to hours if in liquid form. Even a relatively low dose exposure to GB can be fatal and immediate administration of an antidote is critical (see First Aid below).
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. **Mild:** Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficulty in 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, death.
Exposure Routes	**Inhalation:** A primary exposure route; inhalation of very small concentrations can produce health effects. **Skin:** Direct contact with liquid agent is especially toxic. Moderate to severe *signs/symptoms occur at, but are not limited to, the site of contact*. Exposure can also result from absorption of vapors via 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:** Contaminated drinking water and foods are the most likely route for ingestion of agent. Target organ from ingestion is the GI tract. **Other:** Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for GB (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m³, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.0069	0.0040	0.0028	0.0014	0.0010
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.087	0.050	0.035	0.017	0.013
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	0.38	0.19	0.13	0.070	0.051

Exposure Guidelines: IDLH = 0.1 mg/m³; STEL = 1.0 x 10^{-4} mg/m³; **Worker Population Limit (WPL)** [an 8-hr time-weighted average occupational value] = 3.0 x 10^{-5} mg/m³; **General Population Limit (GPL)** [a 24-hr time-weighted average] = 1.0 x 10^{-6} mg/m³. **Soil: Industrial Exposure Scenario** = 32 mg/kg; **Residential Exposure Scenario** = 1.3 mg/kg. **Drinking Water:** Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 37, 8.1, and 2 µg/L, respectively.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs) if they have them.
Medical	**Pre-incident:** A baseline cholinesterase activity determination and an annual physical and respiratory function exam. **During Incident:** Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). **Antidote kit should only be administered as per pre-incident training.** Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - **LEVEL A:** Recommended for the initial response to a GB incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the GB concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. **LEVEL B:** Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the GB concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. **LEVEL C:** Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. **LEVEL D:** Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. **Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.**

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.005-0.02	0.0015-0.003	0.005-0.015	0.025	0.0008-0.0009	0.02 mg/L
mg/m³	0.03-0.1	0.01-0.03	0.025-0.27	0.14	0.005	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine GB, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because GB is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.
	Note: GB breaks down in most environmental conditions to numerous breakdown products, especially fluoride ion, MPA and IMPA, which may be used as markers to determine the extent of contamination of the parent GB. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. G-agents are unlikely to persist in water. Soil: For localized hot spot areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples may not be necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of GB on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid GB deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of GB into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for GB analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: GB degrades via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Fix-in-Place Option: The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decontamination processes in a tiered approach to the overall site-specific decontamination strategy. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. Decontamination of GB occurs mainly through hydrolysis, which may be catalyzed (sped up), by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) are very effective for GB with efficacy achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Hydroxide (e.g., sodium, potassium – 10% solution) reacts rapidly with GB but solutions are very damaging to many surfaces and should be rinsed thoroughly after use. 3) Other high pH solutions, such as sodium carbonate (10% solution) have been shown to decontaminate but slower than decontamination with sodium or potassium hydroxide. Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® have been shown to be effective against GB on the order of minutes to hours, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination, especially given GB's relative high volatility. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of GB in large volumetric spaces or open areas; efficacy typically can be achieved in hours to days with less waste and adverse impacts to materials. Sensitive Equipment and Items: Forced or Hot Air ventilation may be used for GB and can be used either in-situ or ex-situ to decontaminate these items. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. GB is not a hazardous waste under the Federal regulations, but state codes may apply for GB-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

NRT Quick Reference Guide:
Soman (GD)
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Nerve Agent; CAS: 96-64-0; Formula: $C_7H_{16}FO_2P$; Molecular Weight: 182.18 g/mol.
Description: Colorless liquid that with aging may discolor to dark brown; generally odorless, but sometimes has odor of camphor or rotting fruit. GD is a lethal cholinesterase inhibitor with a mechanism of toxicity similar to organophosphate insecticides, though it is much more potent. GD is less volatile than Sarin (GB); it is much more volatile than persistent agents VX or Sulfur Mustard (HD). Environmental breakdown products of GD, including methylphosphonic acid (MPA), are relatively non-toxic. Other breakdown products include fluoride ion, which may exist as hydrofluoric acid (HF) depending on the pH. GD can react violently with bases, weak acids and strong oxidizers, and may decompose when in contact with metals, evolving flammable hydrogen gas. GD is combustible but not easily ignited when heated; GD vapors can form explosive mixtures with air.
Persistence: GD is considered a "low persistent" chemical warfare agent. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon the amount and purity of the agent, method of release, environmental conditions, and types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can accumulate agent by sorbing GD vapors and liquids, acting as "sinks," thereby prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m^3 x 0.1342; mg/m^3 = ppm x 7.451

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
6.33 (air = 1)	0.40 mm Hg (77°F/25°C)	3,900 mg/m^3 (77°F/25°C)	388°F/198°C	-44°F/-42°C	250°F/121°C	1.02 g/mL (77°F/25°C)	21 g/L (68°F/20°C)	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
Open Areas: GD has low volatility but may still be present as a vapor or aerosol, and the primary release/attack scenario is an airborne release. GD is expected to degrade in the environment fairly rapidly; however, liquid GD on surfaces generally persists for hours to days. Environmental conditions will affect the degradation and evaporation rates of GD with cooler and drier conditions enhancing persistence. GD vapors are heavier than air, so vapors can accumulate in lower terrains.
Water/Water Systems: GD is not typically considered a water release hazard. If released into natural waters or water systems, GD will likely hydrolyze with a half-life of about 45 hours at pH 6.6, with persistence depending on released amount and environmental conditions.
Indoor Facility: GD could potentially be dispersed as a vapor or aerosol inside a building or facility; HVAC systems could be impacted. GD vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. After exposure, symptoms may occur within seconds if GD is present in vapor form or within minutes to hours if in liquid form. Even a relatively low dose exposure to GD can be fatal and immediate administration of an antidote is critical (see First Aid below).
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficulty in 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, death.
Exposure Routes	Inhalation: A primary exposure route; inhalation of very small concentrations can produce health effects. Skin: Direct contact with liquid agent is especially toxic. Moderate to severe *signs/symptoms occur at, but are not limited to, the site of contact*. Exposure can also result from absorption of vapors via 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: Contaminated drinking water and foods are the most likely route for ingestion of agent. Target organ from ingestion is the GI tract. Other: Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for GD (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m^3, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.0035	0.0020	0.0014	0.00070	0.00050
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.044	0.025	0.018	0.0085	0.0065
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	0.38	0.19	0.013	0.070	0.051

Exposure Guidelines: IDLH = 0.05 mg/m^3; STEL = 5.0 x 10^{-5} mg/m^3; Worker Population Limit (WPL) [an 8-hr time-weighted average occupational value] = 3.0 x 10^{-5} mg/m^3; General Population Limit (GPL) [a 24-hr time-weighted average] = 1.0 x 10^{-6} mg/m^3. Soil: Industrial Exposure Scenario = 5.2 mg/kg; Residential Exposure Scenario = 0.22 mg/kg.
Drinking Water: Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 7.4, 1.6, and 0.44 µg/L, respectively.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs), if they have them.
Medical	Pre-incident: A baseline cholinesterase activity determination and an annual physical and respiratory function exam. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). Antidote kit should only be administered as per pre-incident training. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to a GD incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the GD concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the GD concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.013-0.02	0.001-0.0015	0.013-0.015	0.025	0.0007-0.001	0.02 mg/L
mg/m^3	0.03-0.1	0.01-0.1	0.025-0.1	0.19	0.005	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine GD, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because GD is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.
	Note: GD breaks down in most environmental conditions to numerous breakdown products, especially fluoride ion and MPA, which may be used as markers to determine the extent of contamination of the parent GD. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives; G-agents are unlikely to persist in water. Soil: For localized hot spot areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples may not be necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of GD on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid GD deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of GD into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for GD analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). 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Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decontamination processes in a tiered approach to the overall site-specific decontamination strategy. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. Decontamination of GD occurs mainly through hydrolysis, which may be catalyzed (sped up), by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) are very effective for GD with efficacy achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Hydroxide (e.g., sodium, potassium – 10% solution) reacts rapidly with GD but solutions are very damaging to many surfaces and should be rinsed thoroughly after use. 3) Other high pH solutions, such as sodium carbonate (10% solution), have been shown to decontaminate but slower than decontamination with sodium or potassium hydroxide. Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® have been shown to be effective against GD on the order of minutes to hours, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of GD in large volumetric spaces or open areas; efficacy typically can be achieved in hours to days with less waste and adverse impacts to materials. 3) Fumigation with modified vaporous hydrogen peroxide (VHP®) has been reported to be effective against GD. HVAC systems in large indoor spaces may require a separate decontamination strategy that could include the use of Hot Air ventilation or fumigation. Sensitive Equipment and Items: 1) Forced or Hot Air ventilation may be used for GD and can be used either in-situ or ex-situ to decontaminate these items, 2) modified VHP® fumigation can be used on these items with less corrosion to electronics than dilute hypochlorite solutions. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org/. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. GD is not a hazardous waste under the Federal regulations, but state codes may apply for GD-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

NRT Quick Reference Guide:
Cyclosarin (GF)
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Nerve Agent; CAS: 329-99-7; Formula: $C_7H_{14}FO_2P$; Molecular Weight: 180.2 g/mol.
Description: Colorless liquid, generally odorless. GF is a lethal cholinesterase inhibitor with a mechanism of toxicity similar to organophosphate insecticides, though it is much more potent. Environmental breakdown products of GF, including methylphosphonic acid (MPA), are relatively non-toxic. Other breakdown products include fluoride ion, which may exist as hydrofluoric acid (HF) depending on the pH. GF can react violently with strong oxidizers and may decompose when in contact with metals, evolving flammable hydrogen gas. GF is combustible but not easily ignited when heated; GF vapors can form explosive mixtures with air.
Persistence: GF is considered a "moderately low persistent" chemical warfare agent. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can accumulate agent by sorbing GF vapors and liquids, acting as "sinks," thereby prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.1357; mg/m³ = ppm x 7.370

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
6.2 (air = 1)	0.044 mm Hg (77°F/25°C)	580 mg/m³ (77°F/25°C)	462°F/239°C	-22°F/-30°C	201°F/94°C	1.13 g/mL (68°F/20°C)	Insoluble in H_2O	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
Open Areas: GF has low volatility but may still be present as a vapor or aerosol, and the primary release/attack scenario is an airborne release. GF is expected to degrade in the environment fairly rapidly; however, liquid GF on surfaces generally persists for hours to days. Environmental conditions will affect the degradation and evaporation rates of GF with cooler and drier conditions enhancing persistence. GF vapors are heavier than air, so vapors can accumulate in lower terrains.
Water/Water Systems: GF is not typically considered a water release hazard. If released into natural waters or water systems, GF will likely hydrolyze with a half-life estimated at 19 hours at pH 7, with persistence depending on released amount and environmental conditions.
Indoor Facility: GF could potentially be dispersed as a vapor or aerosol inside a building or facility; HVAC systems could be impacted. GF vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. After exposure, symptoms may occur within seconds if GF is present in vapor form or within minutes to hours if in liquid form. Even a relatively low dose exposure to GF can be fatal and immediate administration of an antidote is critical (see First Aid below).
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficulty in 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, death.
Exposure Routes	Inhalation: A primary exposure route; inhalation of very small concentrations can produce health effects. Skin: Direct contact with liquid agent is especially toxic. Moderate to severe *signs/symptoms occur at, but are not limited to, the site of contact.* Exposure can also result from absorption of vapors via 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: Contaminated drinking water and foods are the most likely route for ingestion of agent. Target organ from ingestion is the GI tract. Other: Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for GF (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m³, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.0035	0.0020	0.0014	0.00070	0.00050
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.044	0.025	0.018	0.0085	0.0065
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	0.38	0.19	0.013	0.070	0.051

Exposure Guidelines: IDLH = 0.05 mg/m³; STEL = 5.0 x 10^{-5} mg/m³; Worker Population Limit (WPL) [an 8-hr time-weighted average occupational value] = 3.0 x 10^{-5} mg/m³; General Population Limit (GPL) [a 24-hr time-weighted average] = 1.0 x 10^{-6} mg/m³. Soil: Industrial Exposure Scenario = 5.2 mg/kg; Residential Exposure Scenario = 0.22 mg/kg.
Drinking Water: Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 7.4, 1.6, and 0.44 µg/L, respectively.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs), if they have them.
Medical	Pre-incident: A baseline cholinesterase activity determination and an annual physical and respiratory function exam. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). Antidote kit should only be administered as per pre-incident training. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to a GF incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the GF concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the GF concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.014-0.02	0.0015-0.0017	0.015	0.025	0.002-0.009	0.02 mg/L
mg/m³	0.03-0.1	0.01-0.03	0.1-0.11	0.18	0.005-0.007	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine GF, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because GF is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.
	Note: GF breaks down in most environmental conditions to numerous breakdown products, especially fluoride ion and MPA, which may be used as markers to determine the extent of contamination of the parent GF. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives; G-agents are unlikely to persist in water. Soil: For localized hot spot areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples may not be necessary unless a large amount of liquid was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of GF on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid GF deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of GF into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for GF analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: GF degrades via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Fix-in-Place Option: The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decontamination processes in a tiered approach to the overall site-specific decontamination strategy. All statements about decontamination efficacy are based upon GB and have not been verified for GF. However, because hydrolysis has been identified as a major degradation pathway for both GF and GB and because reports of hydrolysis rates for GF are similar to GB, the limited data available suggest similar efficacy for GF as GB. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. Decontamination of GF occurs mainly through hydrolysis, which may be catalyzed (sped up), by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) may be very effective for GF with efficacy expected to be achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Hydroxide (e.g., sodium, potassium – 10% solution) is expected to react rapidly with GF, but solutions are very damaging to many surfaces and should be rinsed thoroughly after use. 3) Other high pH solutions, such as sodium carbonate (10% solution), are expected to decontaminate but slower than decontamination with sodium or potassium hydroxide. Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® may be effective against GF, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of GF in large volumetric spaces or open areas; efficacy may be typically achieved in hours to days with less waste and adverse impacts to materials. Sensitive Equipment and Items: Forced or Hot Air ventilation may be used for GF and can be used either in-situ or ex-situ to decontaminate these items. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org/. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. GF is not a hazardous waste under the Federal regulations, but state codes may apply for GF-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

NRT Quick Reference Guide:
VX
[January 2015 Update]

For references, please see Key References Cited/Used in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs.

Agent Characteristics

Agent Classification: Schedule 1 Chemical Warfare Nerve Agent; CAS: 50782-69-9; Formula: $C_{11}H_{26}NO_2PS$; Molecular Weight: 267.38 g/mol.
Description: Odorless, oily, yellow/amber colored liquid when pure. VX is a lethal cholinesterase inhibitor having a similar mechanism of toxicity as organophosphate insecticides, though it is much more potent. VX is more potent than the G-agents. However, VX has a very low vapor pressure and is difficult to maintain or disperse as vapor in air. Environmental breakdown products of VX, including methylphosphonic acid (MPA) and ethyl methylphosphonic acid (EMPA), may be present. VX breakdown can result in the formation of compound EA-2192, which is considered almost as toxic as VX by ingestion exposure route. EA-2192 formation is maximized between pH 7-10, but can be formed in potentially significant amounts outside this range.
Persistence: VX is considered a "persistent" chemical warfare agent. Vapor: hours to days; liquid: hours to months. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets and vinyl tiles can act as "sinks" for absorbing VX vapors and liquids, prolonging persistence.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m^3 x 0.09144; mg/m^3 = ppm x 10.936

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
9.2 (air = 1)	0.0007 mm Hg (68°F/20°C)	10.5 mg/m^3 (77°F/25°C)	568°F/298°C	<-38°F/-39°C	318°F/159°C	1.008 g/mL (77°F/25°C)	30 g/L (temp not reported)	Common solvents, alcohols, gasoline, oils, fats

Release Scenarios

AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.
Open Areas: VX is difficult to disperse in air as a gas due to low volatility, but even small quantities can be lethal. It may be possible to disperse VX as a vapor/aerosol plume if an appropriate heat/explosive device is employed; however, the low volatility of VX would limit the size and extent of plume dissipation, posing localized hazards. VX vapors when present are heavier than air, so vapors can accumulate in lower terrains.
Water/Water Systems: VX released into water will likely hydrolyze with a half-life of about 1,000 hours at pH 7, with persistence depending on released amount and environmental conditions; however, it could potentially persist for weeks depending on overall dilution and breakdown processes. The hydrolysis breakdown product of VX, EA-2192, may be a greater ingestion concern. If released into water systems such as reservoirs, treatment plants, distribution systems, public fountains or pools, treatment processes can further break down agent. For water systems, plumbing, surfaces and equipment that have contacted contaminated water must be evaluated for decontamination along with the bulk water.
Indoor Facility: Due to its low volatility, VX would be difficult to distribute effectively throughout a building or facility from a point source. Liquid VX will result in localized areas of surface contamination. VX vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. After exposure, symptoms may occur within seconds if VX is present in vapor form or within minutes to hours if in liquid form. Even extremely low dose exposure to VX can be fatal and immediate administration of an *antidote is critical* (see First Aid below).
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild: Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficulty in 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, death.
Exposure Routes	Inhalation: Inhalation of very small concentrations can produce health effects. Skin: Direct contact with liquid agent is especially toxic. Moderate to severe *signs/symptoms occur at, but are not limited to, the site of contact*. Exposure can also result from absorption of vapors via 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: Contaminated drinking water and foods are the most likely route for ingestion of agent. Target organ from ingestion is the GI tract. Other: Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for VX (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

AEGL Level in mg/m^3, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	0.00057	0.00033	0.00017	0.00010	0.000071
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.0072	0.0042	0.0029	0.0015	0.0010
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	0.029	0.015	0.010	0.0052	0.0038

Exposure Guidelines: IDLH = 0.003 mg/m^3; STEL = 1.0 x 10^{-5} mg/m^3; Worker Population Limit (WPL) [an 8-hr time-weighted average occupational value] = 1.0 x 10^{-6} mg/m^3; General Population Limit (GPL) [a 24-hr time-weighted average lifetime chronic value] = 6.0 x 10^{-7} mg/m^3. Soil: Industrial Exposure Scenario = 1.1 mg/kg; Residential Exposure Scenario = 0.043 mg/kg. Drinking Water: Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 2.7, 0.21, and 0.21 µg/L, respectively.

Personnel Safety

Note	Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs) if they have them.
Medical	Pre-incident: Annual physical, respiratory function exams and a baseline cholinesterase activity determination. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.
First Aid	Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). Antidote kit should only be administered as per pre-incident training. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to a VX incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the VX concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the VX concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative) AND may not specify type of nerve agent. Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.

NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

Minimum Screening Ranges	CAM/ICAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
ppm	0.0037-0.02	0.0009-0.0015	0.0037-0.004	0.025	0.002-0.009	0.02 mg/L
mg/m^3	0.03-0.1	0.01-0.03	0.25-0.04	0.27	0.005-0.1	NA

Sampling	*Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)* Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine VX (or its breakdown product EA-2192), in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or 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 that humans are likely to contact or where vegetation is used as food.
	Note: VX breaks down in most environmental conditions to numerous breakdown products, especially EA-2192, MPA and EMPA, which may be used as markers to determine the extent of contamination of the parent VX. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. In large volumes of water, VX is expected to dissipate via breakdown, hydrolysis and dilution. To rule out contamination concerns, particularly in small bodies of water, analyses should include EA-2192. 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 the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of VX on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid VX deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of VX into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.
Analysis	CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for VX analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information. General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: VX degrades via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Potential formation of EA-2192 must be considered and addressed. Fix-in-Place Option: The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Decontamination Strategy: A decon strategy can be developed by designating contaminated areas into three broad categories: 1) surfaces or hot spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decon processes in a tiered approach to overall site-specific decon strategy. CAUTION: VX hydrolyzes and forms the toxic breakdown product EA-2192, with greatest yields between pH levels 7 and 10. For decontamination and EA-2192 information, contact the EPA/HQ-EOC at 202-564-3850. It is advisable to choose a decontamination solution containing a strong oxidant, such as chlorine or peroxide, which will help limit EA-2192 formation regardless of pH. Presence of EA-2192 may present significant challenges in waste disposal. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) are very effective for VX with efficacy achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. 2) Aqueous peroxide solutions may be effective in breaking down VX without the formation of the EA-2192 species. Proprietary decontamination foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® have been shown to be effective against VX on the order of minutes to hours, but not all have been thoroughly tested. Availability, cost and the need for specialized equipment may limit their use early in the response. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. 1) Monitored Natural Attenuation is more passive than other decontamination options and is non-destructive to materials. This option may be preferable given the scope and severity of contamination. 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of VX in large volumetric spaces or open areas; efficacy typically can be achieved in days to weeks with less waste and adverse impacts to materials. 3) Fumigation with modified vaporous hydrogen peroxide (VHP®) has been reported to be effective against VX. HVAC systems in large indoor spaces may require a separate decontamination strategy that could include the use of Hot Air ventilation or fumigation. Sensitive Equipment and Items: 1) Forced or Hot Air ventilation may be used for VX and can be used either in-situ or ex-situ to decontaminate these items. The low volatility of VX may necessitate high operating temperatures. 2) modified VHP® fumigation can be used on these items with less corrosion to electronics than dilute hypochlorite solutions. CAUTION: Decontamination products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Strong oxidizers, such as hypochlorite, may react violently with organics. Formulations should be chosen that do not allow the formation of toxic breakdown products such as EA-2192. Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent and toxic breakdown products. **Verification of Decon**tamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. These regulations differ from state-to-state. Detailed state regulations can be found at: www.envcap.org. Current resources on packaging, labeling and shipping are available at: www.phmsa.dot.gov/hazmat.
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial, present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR§261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is a spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. VX is not a hazardous waste under the Federal regulations, but state codes may apply for VX-contaminated residues, soils and debris. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).

APPENDIX 5

ANALYTICAL METHODS
AIR METHOD
SOIL METHOD
WATER METHOD
SAM 2012 APPENDIX A; SELECTED CHEMICAL METHODS FOR CWA

ANALYSIS FOR CHEMICAL AGENTS IN AIR SAMPLES BY GC/MS

ANALYSIS OF CHEMICAL AGENTS (GB, GD and VX) IN AIR

CONTENTS

ANALYSIS FOR CHEMICAL AGENTS IN AIR SAMPLES BY GC/MS

1.0 SCOPE AND APPLICATION

The objective of this standard operating procedure is to provide guidance on the requirements for the analysis of chemical agents in air samples using XAD-2 absorbent tube and analyzed by gas chromatography/mass spectrometry (GC/MS) selective ion monitoring mode (SIM).

These are standard (i.e., typically applicable) operating procedures with may be varied or changed as required, dependent upon matrix conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

The air samples are collected on two-stage XAD-2 resin tubes, extracted with acetone: methylene chloride 20:80 and the extracts analyzed by GC/MS. Prior to GC/MS analysis, a 1-mL aliquot of the extract is spiked with the internal standards and analyzed for the chemical agents. Identification and quantitation is made by comparing the retention times and mass spectral data of sample target compounds with those of known target compounds from calibration standards.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

The XAD-2 resin used for sampling is housed in a glass tube that has been flame sealed. These tubes most often contain 150 mg or 600 mg of XAD resin.

To preserve and store air samples collected on XAD-2 tubes:

1. Place plastic caps on the XAD-2 tube ends.
2. Place the sample in a whirl bag. If duplicate samples are collected, place both tubes in one whirl bag.
3. Protect the samples from light and refrigerate at 4°C (±2°C) from the time of receipt until extraction and analysis.
4. Recommended maximum holding time is two weeks.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

1. High humidity and temperature, and high sampling flow rates may decrease the absorption capacity of the resin. Contaminants may migrate from the front portion to the back portion of the tube.

2. Impurities in the purge gas and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by analyzing laboratory reagent blanks.

3. Samples can be contaminated during storage and handling. A holding blank or field blank carried through the holding period and the analysis protocol serves as a check on such contamination. One holding (field) blank per batch of samples should be analyzed.

5.0 EQUIPMENT/APPARATUS

1. Micro syringes - Hamilton gas tight syringes: 10, 25, 50, 100, 500, and 1000 µL, 0.006 inch ID needle.

2. XAD-2 resin tubes - 150 mg and 600 mg two stage XAD-2 tubes (SKC, Inc. Catalog No. 226-30-06 or equivalent).

3. Balance - Analytical, capable of accurately weighing ±0.0001 g.

4. Water bath sonicator

5. Serum vial - 10 mL, crimp top with Teflon cap liner.

6. Volumetric flasks - class A with ground-glass stoppers: 5, 10, 25, and 50 mL volumes.

7. Vials - 2 mL for GC autosampler.

8. Desorption vials - Supelco 7.4 mL vials (Cat #2-3178 or equivalent), screw cap with Teflon cap liner.

9. Gas Chromatography/Mass Spectrometer (GC/MS)

A GC/MS system which meets the following specifications will be used:

Gas Chromatograph - An analytical system complete with a temperature programmable gas chromatograph suitable for on-column injection and all required accessories including syringes, analytical columns, and gases is required.

Capillary Gas Chromatography Columns - Any gas chromatography column that meets the performance criteria of separating the calibration mixture of this method is acceptable. Several useful columns have been identified. GC conditions and columns are listed in Section 7.3.

Mass spectrometer - The mass spectrometer must be capable of electron ionization at a nominal electron energy of 70 eV, and must be capable of scanning in the selective ion monitoring (SIM) mode. The ions to be monitored are shown as follows:

Compound	Primary Ion	Secondary Ions
d_{10}-acenaphthene (Internal Standard))	162	164, 160
d_{10}-Phenanthrene (Surrogate)	188	189, 184
Sarin (GB)	99	125, 81
Soman (GD)	99	126, 82
VX	114	72, 127

The mass spectrometer must produce a spectrum that meets all criteria in Section 7.4 when 50 ng of decafluorotriphenylphosphine (DFTPP) is introduced into the GC.

GC/MS interface - Any gas chromatograph to mass spectrometer interface that allows 20 ng or less per injection for each of the parameters of interest and achieves all acceptable performance criteria may be used. The capillary column is directly coupled with the analyzer, providing maximum sensitivity.

Data system - A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specified mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP).

The computer software should be capable of processing stored GC/MS data by recognizing a GC peak within any given retention time window, comparing the mass spectra from the GC peak with spectral data in a user-created database. The software must allow integration of the ion abundance of any specific ion between specified time or scan number limits. The software should also allow the calculation of response factors (or construction of a second or third order regression calibration curve), response factor statistics (mean and standard deviation), and concentrations of analytes using either the calibration curve or the equation in Section 8.

6.0 REAGENTS

1. Sarin (GB; isopropyl methylphosphonofluoridate CAS# 107-44-8), Soman (GD; pinacolyl methyl phosphonofluoridate CAS# 96-64-0) and V-Agents (VX; o-ethyl s-(2-diisopropylaminoethyl) methyl phosphonofluoridate CAS# 050782-69-9) 1000 µg/mL stock solutions as provided by TEU, a division of U. S. Army Corp. Prepare a 200 µg/mL stock mix solution for routine analysis.

2. Acetone and Methylene chloride (glass distilled, suitable for GC).

3. Decafluorotriphenylphosphine (DFTPP).

   Prepare a 50 µg/mL daily working standard solution of DFTPP by diluting 50 µL of a commercially available 25,000 µg/mL (Supelco catalog number 4-8724 or equivalent) in 25.0 mL of methylene chloride. Protect the DFTPP from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

4. d_{10}-Acenaphthene (Aldrich catalog # 45181-9) , internal standard for GC analysis.

   Prepare a working stock of 20 µg/mL in methylene chloride. Protect the solution from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

5. d_9-Dibutylbutylphosphonate (DBBP) or diisopropylmethylphosphonate (DIMP), alternate internal standard.

6. d_{10}-Phenanthrene (Supelco catalog # 4-8710), surrogate compound.

   Prepare a working stock of 20 µg/mL in methylene chloride. Protect the solution from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

7. Matrix Spike/Matrix Spike Duplicate Solution:

   Prepare a 20 µg/mL spike solution of chemical agents by dilution of the stock solution in methylene chloride. Store the spiking solution at 4°C (± 2°C) in Teflon-sealed containers, protected from light. The solution should be checked frequently for stability. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

8. Calibration Standards

Prepare calibration standards at five concentration levels (0.05, 0.1, 0.5, 1.0, and 2.0 µg/mL). Prepare serial dilutions in methylene chloride of the 20 µg/mL solution to obtain the five calibration standards. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

7.0 PROCEDURES

7.1 Sample Preparation and Extraction

This method is designed for using both 150 mg or 600 mg two stage XAD resin tubes in the air sampling. However, the larger 600 mg XAD resin tubes are recommended because they allow for higher sample volumes (about 1000 liters), higher capacity, and lower detection limits. An unopened lot blank of each lot of tubes used is included with each twenty samples or less per project. A blank tube from the same lot may be included as a trip blank. To qualify as a trip blank, the blank is broken open and carried to the site in the same type of container as the samples. It is brought to the laboratory with the samples and treated exactly as the samples.

1. Remove the glass wool plug from the back portion of the tube and discard.

2. Remove the XAD-2 resin packing from the back of the tube and place it in a 7.4 mL screw top vial. Label this vial "back" along with the sample name.

3. Remove the glass wool from supporting XAD resin in the front portion of the tube and discard it.

4. Place the front XAD packing in a second sample vial. Label this vial "front" along with the sample name.

5. Spike 200 µL of 20 µg/mL surrogate solution and then pipette 5.0 mL of acetone : methylene chloride 20:80 in each of the vials with the carbon packing. Screw the tops on tightly.

6. Place the sample vials in a sonic bath for 10 to 15 minutes.

7. Let settle 30 minutes. Transfer 1.0 mL of the extract from the vial containing the XAD resin to a 1 mL auto sample vial.

7.2 Matrix Spike/Matrix Spike Duplicate Extraction

Break the glass in the front portion of the tube. Spike the XAD resin with 200µL of the matrix spiking solution; take care that the syringe is in the middle of the XAD resin in the front portion of the tube. Place only the front portion of the resin into a vial and extract the spike as in Section 7.1.

7.3 GC/MS Operating Conditions

A Hewlett Packard (HP) 6890 series GC system equipped with a HP 5972 mass selective detector (MSD) and a 7673A HP autosampler can be used. The GC/MSD and the autosampler are controlled by an HP-ChemStation computer system under DOS 6.22 and Windows 3.11 software. The instrument is operated under the following conditions:

Column	Restek Rtx-5MS or equivalent, 30 meters in length, 0.25-mm ID and 0.50 µm film thickness
Injection Temperature	250°C
Transfer Line Temperature	280°C
Oven Temperature Programming	
Initial Temperature	55°C
Initial Time	2 minutes

Temperature Ramp#	Rate (°C/min.)	Final Temp. (°C)	Final Time (min.)
1	15	130	0.5
2	50	305	1.0

Splitless Injection	Split time 0.25 min.
Injection Volume	1 µL
Column Flow	1.0 mL/min. with electron pressure control (EPC) system enabled
Nominal Initial Pressure	8.0 psi
Average Velocity	36 cm/sec.

7.4 Tune (DFTPP)

Before analysis, the instrument should be tuned by injecting 50 nanograms of decafluorotriphenylphosphine (DFTPP) into the system. A short program adapted from U.S. Environmental Protection Agency's Contract Laboratory Program (U.S. EPA/CLP SOW OLM01.03/90) should be utilized. This criteria must be demonstrated every 24 hours during analysis.

Ion Abundance Criteria for Tune (DFTPP)

Mass	Ion Abundance Criteria
51	30.0 - 80.0 percent of mass 198
68	Less than 2.0 percent of mass 69
69	Present
70	Less than 2.0 percent of mass 69
127	25.0 - 75.0 percent of mass 198
197	Less than 1.0 percent of mass 198
198	Base peak, 100 percent relative abundance (see note)
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	Greater than 0.75 percent of mass 198
441	Present but less than mass 443
442	40.0 - 110.0 percent of mass 198
443	15.0 - 24.0 percent of mass 442

NOTE: All ion abundances MUST be normalized to m/z 198, the nominal base peak, even though the ion abundances of m/z 442 may be up to 110 percent that of m/z 198.

7.5 Initial Calibration

1. Add 20 µL of the internal standard d_{10}-acenaphthene at 20 µg/mL to each 1-mL aliquot of calibration standards.

2. Inject each of the calibration standards after a successful DFTPP analysis.

3. Calculate and tabulate the relative response factor (RRF) against the concentration for each compound by using the equation listed below. The primary ion from the specific internal standard must be used for quantitation.

   The average RRF and percent relative standard deviation (%RSD) must also be calculated and tabulated.

$$RRF = \frac{(A_x)(C_{is})}{(A_{is})(C_x)}$$

Where:

A_x	=	Area of the characteristic ion for the compound to be measured
C_{is}	=	Concentration of the internal standard (µg/mL)
A_{is}	=	Area of the characteristic ion for the internal standard.
C_x	=	Concentration of the compound to be measured (µg/mL)

The % RSD of the RRF for each chemical agents has been tentatively adopted to be less than or equal to 30%. The average RRF of chemical agents should not be less than 0.05.

7.6 Continuing Calibration

A check of the initial calibration curve must be performed every 24 hours during analysis.

1. Inject 1 µL of a 0.5 µg/mL chemical agents standard containing the internal standard.

2. Calculate and tabulate the daily RRF for each compound. All daily RRF should be equal to or greater than 0.05.

3. Calculate the percent difference (% D) of each daily RRF compared to the average RRF from the initial calibration curve. The % D for all compounds can be calculated using the equation listed below and must be less than or equal to 25%.

$$\%\ D = \frac{|RRF_{Daily} - RRF_{Average}|}{RRF_{Average}} \times 100$$

4. All sample and standards are quantitated using the response factors from the daily calibration check or from the average RRF of initial calibration for samples analyzed right after the initial calibration is passed.

7.7 Sample Analysis

Sample extracts may be analyzed only after the GC/MS system has met the DFTPP, initial calibration,

and continuing calibration requirements mentioned above. The same instrument conditions must be employed for the analysis of samples as were used for calibration.

1. Add 20 µL of the internal standard into the blank(s), the matrix spikes, and all the sample extracts.

2. Inject 1 µL each of the matrix spikes, method blank(s), and all the sample extracts.

3. If the analyst has reason to believe that diluting the final extracts will be necessary, an undiluted run may not be required.

4. If any chemical agents is detected at a level greater than the highest calibration standard, sample extracts must be diluted so that the chemical agents response is within the linear range established during calibration.

5. If dilutions of sample extracts are made, additional internal standards must be added to maintain the required concentration (0.4 µg/mL) of the internal standard in the extract.

7.8 Identification of Chemical Agents

Chemical agents identification will be conducted by comparison of the sample mass spectrum to the mass spectrum of a standard of chemical agent. Two criteria must be satisfied to verify the identifications:

- Elution of the chemical agents in the sample at the same GC relative retention time as chemical agents.

- Correspondence of chemical agents in the sample and the reference chemical agents mass spectra. Note that in SIM mode not all characteristic ions will be obtained.

1. For establishing correspondence of the GC relative retention time (RRT), the sample component RRT must compare within ±0.06 RRT units of the RRT of the standard component. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

2. For comparison of standard and sample component mass spectra, reference mass spectra must be obtained from the 1.0 µg/mL standard. These standard spectra may be obtained from the run used to obtain reference RRTs.

3. The requirements for qualitative verification by comparison of mass spectra are as follows:

   a. All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum. In SIM mode, those ions within the scan ranges used, must be present.

   b. The relative intensities of ions specified in (a) must agree within ±20% between the standard and sample spectra. (For example: for an ion with an abundance of 50% in the standard spectra, the corresponding sample ion abundance must be between 30-70%.)

   c. Ions greater than 10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst making the comparison. All compounds meeting the identification criteria must be reported with their spectra. For all compounds below the quantitation limit, report the actual

value followed by "J", e.g., "3J".

4. If a compound cannot be verified by all of the criteria in step 3, but in the technical judgment of the mass spectral interpretation specialist, the identification is correct, then the analyst shall report that identification and proceed with the calculation in Section 8.0. The analyst should note in the case narrative that technical judgment was utilized.

7.9 Desorption Efficiencies

The desorption efficiency (DE) or relative recoveries were determined for each compound at 200, 1000, and 4000 ng levels, (for 600-mg charcoal tubes). Three replicate XAD tubes were spiked with a standard solution mixture at each level, extracted with acetone : methylene chloride 20:80 and analyzed by GC/MS. The desorption efficiencies will be determined for each lot of tubes, or once per year whichever is more frequent. The DE were calculated as follows:

$$C_r\ (ng) = \frac{A_s \times C_{is}}{A_{is} \times RRF}; \quad DE = \frac{C_s}{C_r}$$

where:

A_S	=	Area of the characteristic ion for the compound to be measured
A_{IS}	=	Area of the characteristic ion for the specific internal standard (IS)
C_{IS}	=	Amount of internal standard added in nanograms
C_s	=	Amount of target standard spiked in nanograms
C_r	=	Amount of target standard recovered in nanograms
RRF	=	Relative response factor from the analysis of calibration standard

7.10 Method Detection Limits

The Method Detection Limits (MDL) for 600 mg tubes listed in Appendix D were determined by analyzing seven XAD-2 resin tubes spiked with analytes at 10 µg/mL. The 10µg/mL standard solution represents the lowest concentration on the linear range of the five-point calibration curve. The spiked tubes were subsequently extracted with acetone : methylene chloride 20:80 as in Section 7.1 and analyzed by GC/MS. Method detection limits are analyzed every one year or for each lot of carbon tubes, which ever is more frequent.

$$MDL = (S)\, t_{(n-1,1-\alpha = 0.99)}$$

where:

$t_{(n-1,1-\alpha = 0.99)}$	=	Student's t value for the 99% confidence level with n-1 degrees of freedom
n	=	number of replicates
S	=	the standard deviation of the replicate analyses

$$S = \sqrt{\frac{\sum (X_i - X)^2}{(n - 1)}}$$

For seven injections $t_{(n-1,1-\alpha = 0.99)} = 3.143$. Therefore, substituting into equation above yields:

$$MDL = 3.143 \times s$$

8.0 CALCULATIONS

8.1 Chemical Agents

Chemical agents must be quantitated by the internal standard method.

Calculate the concentration in the sample using the average relative response factor (RRF) obtained from the initial calibration standard as determined in Section 7.5 and the equation listed below. If samples are analyzed under the initial calibration curve, the average RRF must be used. If daily continuing calibration (CC) is performed , use the updated CC RRF to quantitate the concentration of chemical agents in the samples.

Total amount of compound in sample (µg/sample)

$$\mu g/sample = \frac{A_s \times C_{is}}{A_{is} \times RRF} \times V \times DE$$

where:

V	=	Extraction volume (mL)
DE	=	Desorption efficiency

Calculate the concentration of analyte in mg/m^3 and parts per billion by volume (ppbv):

$$Concentration\ (mg/m^3) = \frac{(Total\ \mu g\ front + total\ \mu g\ back)}{Liters\ sampled} \times \frac{1\ mg}{1000} \times \frac{1000L}{1\ m^3}$$

$$Concentration\ (ppbv) = (mb/m^3)\ time\ \frac{24.45}{MW} \times 1000\ (at\ conditions\ 25°C,\ 1\ atmosphere)$$

where:

MW is the molecular weight of the analyte.

When chemical agent concentrations are below the quantitation limits but the spectrum meets the identification criteria, report the concentration as estimated by flagging the results with a "J".

The relative response factor (RRF) is calculated from the calibration standard solution using the formula from Section 7.5.3.

8.2 Matrix Spike Recoveries

The percent recoveries and the relative percent difference (RPD) between the recoveries in the matrix spike/matrix spike duplicate will be calculated and reported by using the following equations:

$$Matrix\ Spike\ Recovery\ (\%) = \frac{SSR - SR}{SA} \times 100\%$$

where:

SSR = Spike sample result
SR = Sample result
SA = Spike added

$$RPD = \frac{|MSR - MSDR|}{(MSR + MSDR)/2} \times 100\%$$

where:

RPD = Relative percent difference
MSR = Matrix spike recovery
MSDR = Matrix spike duplicate recovery

The vertical bars in the formula above indicate the absolute value of the difference; hence RPD is always expressed as a positive value.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 Tune (DFTPP)

Prior to initiating any data collection activities involving samples, blanks, or standards, it is necessary to establish that a given GC/MS system meets the instrument tune criteria specified in Section 7.4. The purpose of this instrument check is to assure correct mass calibration, mass resolution, and mass transmission. This is accomplished through the analysis of DFTPP.

1. The analysis of DFTPP must be performed every 24 hours during the analysis.

2. The key ions produced during the analysis of DFTPP and their respective ion abundance criteria are given in Appendix A.

9.2 Initial Calibration for Chemical Agents

Prior to the analysis of samples and required blanks, and after instrument performance criteria have been met, the GC/MS system must be initially calibrated at a minimum of five concentrations to determine the linearity of response utilizing chemical agents standards.

1. The levels of the initial calibration standards for chemical agents are 0.05, 0.1, 0.5, 1.0 and 2.0 μg/mL.

2. The calibration of the GC/MS is evaluated on the basis of the magnitude and stability of the relative response factors of chemical agents. Criteria have not been established for the minimum RRF and %RSD. However, tentative criteria have been adopted at this time. The minimum RRF of each compound at each concentration level in the initial calibration across all five points is tentatively adapted to be equal to or greater than 0.05; the %RSD is tentatively adopted to not exceed 30%.

9.3 Continuing Calibration for Chemical Agents

Once the GC/MS system has been calibrated, the calibration must be verified each 24-hour time period for each GC/MS system during the analysis.

1. The level of the continuing calibration standard for chemical agents is 0.50 µg/mL.

2. The standard is to be analyzed every 24 hours after an acceptable DFTPP analysis.

3. The continuing calibration of the GC/MS system is evaluated on the basis of the magnitude of the relative response factors and the percent difference between the average RRF of chemical agents from the initial calibration and the RRF of chemical agents in the continuing calibration standard. Criteria have not been established for the minimum RRF and %D. However, tentative criteria have been adopted at this time. The minimum RRF of chemical agents in the continuing calibration is tentatively adopted to be greater than or equal to 0.05. The %D is tentatively adopted to not exceed 25%.

4. If any of the requirements listed in Item 3 are not met, another initial calibration will be analyzed.

9.4 Lot Blank Analysis

A lot blank is an unopened XAD-2 resin tube from the same lot as the sample tubes. The purpose of the lot blank is to determine the levels of contamination associated with the manufacture, extraction, and analysis of the samples

1. One lot blank must be extracted and analyzed for every lot represented in the sampling event for each project.

2. The lot blank must contain less than or equal to the MDL of any single target compound.

3. If a lot blank exceeds the limits for contamination above, the analyst must consider the analytical system out of control. The source of the contamination must be investigated and appropriate corrective action taken and documented before further sample analysis proceeds.

9.5 Dilution Analysis

If the concentration of any sample extract exceeds the initial calibration range, that sample extract must be diluted and reanalyzed as described in Section 7.7.

1. Use the results of the original analysis to determine the approximate dilution factor required to get chemical agents within the initial calibration range.

2. The dilution factor chosen should keep the response of chemical agents in the upper half of the initial calibration range of the instrument.

3. Do not submit data for more than two analyses, i.e., the original sample and one dilution, or, from the most concentrated dilution analyzed and one further dilution.

9.6 Matrix Spike/Matrix Spike Duplicate Recoveries

The purpose of spiking chemical agents into two aliquots of a sample to evaluate the effects of the sample matrix on the methods used in this SOP.

1. The MS/MSD must be prepared for every 20 samples for each project.

2. The recoveries of chemical agents are calculated according to the procedures in Section 8.2. The relative percent difference between the results of the matrix spike and the matrix spike duplicate are calculated according to the procedures in Section 8.2.

3. No quality control limits for recovery and relative percent difference are available.

10.0 DATA VALIDATION

Data validation will be performed by the Data Validation and Report Writing Group and therefore it is not applicable to this SOP. However, data is considered satisfactory for submission purposes when the requirements mentioned below are met.

1. All samples must be analyzed under an acceptable tune, initial calibration, and continuing calibration check at the required frequency.
2. An acceptable method blank must be submitted for each batch.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, refer to U.S. EPA, OSHA and corporate health and safety practices. More specifically, refer to ERTC/REAC SOP #3013, REAC Laboratory Safety Program.

12.0 REFERENCES

1. M. Rautio, Recommended Operating Procedures For Sampling and Analysis In The Verification of Chemical Disarmament, The Ministry of Foreign Affairs of Finland, Helsinki 1994.

2. SciTech Services, Inc., "Screening Procedures for The Trace Level Analysis of Potentially Contaminated Soil Samples Using DAAMS Technology and Gas Chromatography", Final Report, Abington MD, December 3, 1992.

3. Midwest Research Institute, Attachment 5-3, "Internal Operating Procedures For Analysis of Chemical Warfare Agents", APG Environmental Remediation Contract No. DACA87-90-0031, Kansas City, Missouri, 1991.

4. Southern Research Institute, "3X/5X Delisting Plan -- Analytical Methods Report", Draft Final Report, Birmingham AL, January 15, 1992, SRI-APC-92-29-6840.45,

5. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste, Third Edition, SW-846, September 1986.

6. U.S. EPA Contract Laboratory Program (CLP), Statement of Work for Organic Analysis, Revision 2/88.

7. U.S. EPA Contract Laboratory Program (CLP), Statement of Work for Organic Analysis, Document Number OLM01.0 (including revisions through OLM01.8).

ANALYSIS FOR CHEMICAL AGENTS IN SOIL SAMPLES BY GC/MS

ANALYSIS OF CHEMICAL AGENTS (GB, GD and VX) IN SOIL

CONTENTS

1.0 SCOPE AND APPLICATION

ANALYSIS FOR CHEMICAL AGENTS IN SOIL SAMPLES BY GC/MS

The objective of this standard operating procedure is to provide guidance on the requirements for the analysis of chemical agents in soil samples using gas chromatography/mass spectrometry (GC/MS) selective ion monitoring mode (SIM).

These are standard (i.e., typically applicable) operating procedures with may be varied or changed as required, dependent upon matrix conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Approximately 10 grams (g) of a soil/sediment sample are agitated with 10 mL methylene chloride. The extract is centrifuged and decanted, an internal standard is added, and the extract analyzed by GC/MS. Compounds are identified by comparing their measured mass spectra and retention times to reference spectra and retention times obtained by the measurement of calibration standards under the same conditions used for samples. Quantitation of each identified analyte is calculated by internal standard method.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

3.1 Sample Storage

From the time of receipt and after analysis, extracts and unused samples must be protected from light and refrigerated at 4°C (±2°C) for the periods specified by the Task Leader and/or Work Assignment Manager.

Samples, sample extracts, and standards must be stored separately in an atmosphere demonstrated to be free of all potential contaminants.

3.2 Holding Times

Extraction of soil/sediment samples shall be completed within seven days of sampling, and analysis completed within 40 days of sample extraction.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be shown to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in an all glass system may be required.

5.0 EQUIPMENT/APPARATUS

1. Micro syringes

2. Balance - Analytical, capable of accurately weighing ±0.01 g.

3. Gas Chromatography/Mass Spectrometer (GC/MS)

A GC/MS system which meets the following specifications will be used:

Gas Chromatograph - An analytical system completed with a temperature programmable gas chromatograph suitable for on-column injection and all the required accessories including syringes, analytical columns, and gases is required.

Capillary Gas Chromatography Columns - Any gas chromatography column that meets the performance criteria of separating the calibration mixture of this method is acceptable. Several useful columns have been identified. GC conditions and columns are listed in Section 7.3.

Mass spectrometer - The mass spectrometer must be capable of electron ionization at a nominal electron energy of 70 eV, and must be capable of scanning in the selective ion monitoring (SIM) mode. The ions to be monitored are shown as follows:

Compound	Primary Ion	Secondary Ions
d_{10}-acenaphthene (Internal Standard))	162	164, 160
d_{10}-Phenanthrene (Surrogate)	188	189, 184
Sarin (GB)	99	125, 81
Soman (GD)	99	126, 82
VX	114	72, 127

The mass spectrometer must produce a spectrum that meets all criteria in Section 7.4 when 50 ng of decafluorotriphenylphosphine (DFTPP) is introduced into the GC.

GC/MS interface - Any gas chromatograph to mass spectrometer interface that allows 20 ng or less per injection for each of the parameters of interest and achieves all acceptable performance criteria may be used. The capillary column is directly coupled with the analyzer, providing maximum sensitivity.

Data system - A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specified mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP).

The computer software should be capable of processing stored GC/MS data by recognizing a GC peak within any given retention time window, comparing the mass spectra from the GC peak with spectral data in a user-created database. The software must allow integration of the ion abundance of any specific ion between specified time or scan number limits. The software should also allow the calculation of response factors (or construction of a second or third order regression calibration curve), response factor statistics (mean and standard deviation), and concentrations of analytes using either the calibration curve or the equation in Section 8.

6.0 REAGENTS

1. Sarin (GB; isopropyl methylphosphonofluoridate CAS# 107-44-8), Soman (GD; pinacolyl methyl phosphonofluoridate CAS# 96-64-0) and V-Agents (VX; o-ethyl s-(2-diisopropylaminoethyl) methyl phosphonofluoridate CAS# 050782-69-9) 1000 µg/mL stock solutions as provided by TEU, a division of U. S. Army Corp. Prepare a 200 µg/mL stock mix solution for routine analysis.

2. Methylene chloride (glass distilled, suitable for GC).

3. Sodium sulfate-anhydrous powdered reagent grade, heated at 400°C for four hours, cooled in a desiccator, and stored in a glass bottle.

4. Decafluorotriphenylphosphine (DFTPP).

   Prepare a 50 µg/mL daily working standard solution of DFTPP by diluting 50 µL of a commercially available 25,000 µg/mL (Supelco catalog number 4-8724 or equivalent) in 25.0 mL of methylene chloride. Protect the DFTPP from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

5. d_{10}-Acenaphthene (Aldrich catalog # 45181-9) , internal standard for GC analysis.

   d_9-Dibutylbutylphosphonate (DBBP) or diisopropylmethylphosphonate (DIMP), alternate internal standard. Prepare a working stock of 20 µg/mL in methylene chloride. Protect the solution from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

6. d_{10}-Phenanthrene (Supelco catalog # 4-8710), surrogate compound.

   Prepare a working stock of 20 µg/mL in methylene chloride. Protect the solution from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

7. Matrix Spike/Matrix Spike Duplicate Solution:

   Prepare a 20 µg/mL spike solution of chemical agents by dilution of the stock solution in methylene chloride. Store the spiking solution at 4°C (± 2°C) in Teflon-sealed containers, protected from light. The solution should be checked frequently for stability. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

8. Calibration Standards

   Prepare calibration standards at five concentration levels (0.05, 0.1, 0.5, 1.0, and 2.0 µg/mL). Prepare serial dilutions in methylene chloride of the 20 µg/mL solution to obtain the five calibration standards. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

7.0 PROCEDURES

7.1 Sample Preparation and Extraction

1. Transfer the sample container into a fume hood. Open the sample bottle and discard any foreign objects such as sticks, leaves, and rocks. Mix the sample thoroughly.

2. Weigh approximately 10 g of sample to the nearest 0.1 g into a 250-mL beaker and add 10 g of anhydrous granular sodium sulfate. Mix well. The sample should have a sandy texture at this point. A method blank must be prepared by using a 20 g of baked sodium sulfate according to the same procedure at a frequency of one per 20 samples.

3. Weigh two additional 10 g portions of samples to the nearest 0.1 g for use as matrix and matrix spike duplicates (MS/MSD) at a rate of one per 20 samples or ten percent.

   NOTE: The sample may be specified on the Chain of Custody record for this purpose.

4. Add 0.5 mL of the matrix spiking solution (20 µg/mL) to each of the samples chosen for MS/MSD.

5. Spike 500 µL of 20 µg/mL surrogate solution and then pipette 10 mL of methylene chloride to each sample and shake for ten minutes on a shaker. (Note: Sonication may make new active sites in the soil, thereby affecting the recovery of chemical agents from the soil.)

6. Centrifuge at 3000 G for three minutes, decant and filter the decantate.

7. Optional - for low level samples to enhance the detection limits: Evaporate the extract to a final volume of 1-mL with a gentle stream of clean, dry nitrogen. DO NOT ALLOW THE EXTRACT TO GO DRY. Spike only 50 µL of matrix spike solution to the MS/MSD pair for low level samples.

8. Pipette one ml of the extract to a GC vial, and add 20 µL internal standard, 20 µg/mL d_{10}-acenaphthene (see Section 7.7). The extract is ready for analysis. If the analysis is not performed immediately, the extract should be protected from light and refrigerated at 4°C (±2°C).

7.2 Total Percent Solids

The samples for total percent solids determination are weighed in conjunction with the samples for the extraction. The total percent solid for the MS/MSD is based on the corresponding sample. The blank is expected to have 100% total percent solids.

Weigh and record the aluminum sample dish to the nearest .01-g. Weigh at least 10 g of the soil/sediment into the aluminum dish. Determine the total percent solid by drying in an oven placed inside a fume hood overnight at 105°C (±2°C). Before weighing, cool in a desiccator. Concentrations of individual analytes will be reported relative to the dry weight of the sediment. Calculate the total percent solids using the following equation:

$$\textit{Total Percent Solids} = \frac{\textit{weight of dried sample with dish(g)} - \textit{dish weight(g)}}{\textit{weight of wet sample with dish(g)} - \textit{dish weight(g)}} \times 100$$

7.3 MS Operating Conditions

A Hewlett Packard (HP) 6890 series GC system equipped with a HP 5972 mass selective detector (MSD) and a 7673A HP autosampler can be used. The GC/MSD and the autosampler are controlled by an HP-ChemStation computer system under DOS 6.22 and Windows 3.11 software. The instrument is operated under the following conditions:

Column	Restek Rtx-5MS or equivalent, 30 meters in length, 0.25-mm ID and 0.50 µm film thickness
Injection Temperature	250°C
Transfer Line Temperature	280°C
Oven Temperature Programming	
Initial Temperature	55°C
Initial Time	2 minutes

Temperature Ramp#	Rate (°C/min.)	Final Temp. (°C)	Final Time (min.)
1	15	130	0.5
2	50	305	1.0

Splitless Injection	Split time 0.25 min.
Injection Volume	1 µL
Column Flow	1.0 mL/min. with electron pressure control (EPC) system enabled
Nominal Initial Pressure	8.0 psi
Average Velocity	36 cm/sec.

7.4 Tune (DFTPP)

Before analysis, the instrument should be tuned by injecting 50 nanograms of decafluorotriphenylphosphine (DFTPP) into the system. A short program adapted from U.S. Environmental Protection Agency's Contract Laboratory Program (U.S. EPA/CLP SOW OLM01.03/90) should be utilized. This criteria must be demonstrated every 24 hours during analysis.

Ion Abundance Criteria for Tune (DFTPP)

Mass	Ion Abundance Criteria
51	30.0 - 80.0 percent of mass 198
68	Less than 2.0 percent of mass 69
69	Present
70	Less than 2.0 percent of mass 69

127	25.0 - 75.0 percent of mass 198
197	Less than 1.0 percent of mass 198
198	Base peak, 100 percent relative abundance (see note)
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	Greater than 0.75 percent of mass 198
441	Present but less than mass 443
442	40.0 - 110.0 percent of mass 198
443	15.0 - 24.0 percent of mass 442

NOTE: All ion abundances MUST be normalized to m/z 198, the nominal base peak, even though the ion abundances of m/z 442 may be up to 110 percent that of m/z 198.

7.5 Initial Calibration

1. Add 20 µL of the internal standard d_{10}-acenaphthene at 20 µg/mL to each 1-mL aliquot of calibration standards.

2. Inject each of the calibration standards after a successful DFTPP analysis.

3. Calculate and tabulate the relative response factor (RRF) against the concentration for each compound by using the equation listed below. The primary ion from the specific internal standard must be used for quantitation.

   The average RRF and percent relative standard deviation (%RSD) must also be calculated and tabulated.

$$RRF = \frac{(A_X)(C_{IS})}{(A_{IS})(C_X)}$$

   Where:

A_X	=	Area of the characteristic ion for the compound to be measured
C_{IS}	=	Concentration of the internal standard (ng/µL)
A_{IS}	=	Area of the characteristic ion for the internal standard.
C_X	=	Concentration of the compound to be measured (ng/µL)

   The % RSD of the RRF for each chemical agents has been tentatively adopted to be less than or equal to 30%. The average RRF of chemical agents should not be less than 0.05.

7.6 Continuing Calibration

A check of the initial calibration curve must be performed every 24 hours during analysis.

1. Inject 1 µL of a 0.5 µg/mL chemical agents standard containing the internal standard.

2. Calculate and tabulate the daily RRF for each compound. All daily RRF should be equal to or greater than 0.05.

3. Calculate the percent difference (% D) of each daily RRF compared to the average RRF from the initial calibration curve. The % D for all compounds can be calculated using the equation listed below and must be less than or equal to 25%.

$$\%\ D = \frac{|RRF_{Daily} - RRF_{Average}|}{RRF_{Average}} \times 100$$

4. All sample and standards are quantitated using the response factors from the daily calibration check or from the average RRF of initial calibration for samples analyzed right after the initial calibration is passed.

7.7 Sample Analysis

Sample extracts may be analyzed only after the GC/MS system has met the DFTPP, initial calibration, and continuing calibration requirements mentioned above. The same instrument conditions must be employed for the analysis of samples as were used for calibration.

1. Add 20 µL of the internal standard into the method blank(s), the matrix spikes, and all the sample extracts.

2. Inject 1 µL each of the matrix spikes, method blank(s), and all the sample extracts.

3. If the analyst has reason to believe that diluting the final extracts will be necessary, an undiluted run may not be required.

4. If any chemical agents is detected at a level greater than the highest calibration standard, sample extracts must be diluted so that the chemical agents response is within the linear range established during calibration.

5. If dilutions of sample extracts are made, additional internal standards must be added to maintain the required concentration (0.4 µg/mL) of the internal standard in the extract.

7.8 Identification of Chemical Agents

Chemical agents identification will be conducted by comparison of the sample mass spectrum to the mass spectrum of a standard of chemical agent. Two criteria must be satisfied to verify the identifications:

- Elution of the chemical agents in the sample at the same GC relative retention time as chemical agents.
- Correspondence of chemical agents in the sample and the reference chemical agents mass spectra. Note that in SIM mode not all characteristic ions will be obtained.

1. For establishing correspondence of the GC relative retention time (RRT), the sample component RRT must compare within ±0.06 RRT units of the RRT of the standard component. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

2. For comparison of standard and sample component mass spectra, reference mass spectra must be obtained from the 1.0 µg/mL standard. These standard spectra may be obtained from the run used to obtain reference RRTs.

3. The requirements for qualitative verification by comparison of mass spectra are as follows:

   a. All ions present in the standard mass spectra at a relative intensity greater than 10%

(most abundant ion in the spectrum equals 100%) must be present in the sample spectrum. In SIM mode, those ions within the scan ranges used, must be present.

b. The relative intensities of ions specified in (a) must agree within ±20% between the standard and sample spectra. (For example: for an ion with an abundance of 50% in the standard spectra, the corresponding sample ion abundance must be between 30-70%.)

c. Ions greater than 10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst making the comparison. All compounds meeting the identification criteria must be reported with their spectra. For all compounds below the quantitation limit, report the actual value followed by "J", e.g., "3J".

4. If a compound cannot be verified by all of the criteria in step 3, but in the technical judgment of the mass spectral interpretation specialist, the identification is correct, then the analyst shall report that identification and proceed with the calculation in Section 8.0. The analyst should note in the case narrative that technical judgment was utilized.

8.0 CALCULATIONS

8.1 Chemical Agents

Chemical agents must be quantitated by the internal standard method.

Calculate the concentration in the sample using the average relative response factor (RRF) obtained from the initial calibration standard as determined in Section 7.5 and the equation listed below. If samples are analyzed under the initial calibration curve, the average RRF must be used. If daily continuing calibration (CC) is performed , use the updated CC RRF to quantitate the concentration of chemical agents in the samples.

$$\textit{Concentration } (\mu g/kg) = \frac{(A_X)(I_S)(V_T)(DF)}{(A_{IS})(RRF)(W)(V_I)(S)}$$

where:

A_X	=	Area of the characteristic ion for the compound to be measured
I_S	=	Amount of internal standard injected (ng)
V_T	=	Volume of the concentrated extract (mL)
DF	=	Dilution factor
A_{IS}	=	Area of the characteristic ion for the internal standard
RRF	=	Relative response factor
W	=	Weight of soil/sediment extracted (kg)
V_I	=	Volume of extract injected (µL)
S	=	Decimal percent solid

When chemical agent concentrations are below the quantitation limits but the spectrum meets the identification criteria, report the concentration as estimated by flagging the results with a "J".

The relative response factor (RRF) is calculated from the calibration standard solution using the formula from Section 7.5.3.

8.2 Matrix Spike Recoveries

The percent recoveries and the relative percent difference (RPD) between the recoveries in the matrix spike/matrix spike duplicate will be calculated and reported by using the following equations:

$$\textit{Matrix Spike Recovery (\%)} = \frac{SSR - SR}{SA} \times 100\%$$

where:

SSR	=	Spike sample result
SR	=	Sample result
SA	=	Spike added

$$RPD = \frac{|MSR - MSDR|}{(MSR + MSDR)/2} \times 100\%$$

where:

RPD	=	Relative percent difference
MSR	=	Matrix spike recovery
MSDR	=	Matrix spike duplicate recovery

The vertical bars in the formula above indicate the absolute value of the difference; hence RPD is always expressed as a positive value.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 Tune (DFTPP)

Prior to initiating any data collection activities involving samples, blanks, or standards, it is necessary to establish that a given GC/MS system meets the instrument tune criteria specified in Section 7.4. The purpose of this instrument check is to assure correct mass calibration, mass resolution, and mass transmission. This is accomplished through the analysis of DFTPP.

1. The analysis of DFTPP must be performed every 24 hours during the analysis.

2. The key ions produced during the analysis of DFTPP and their respective ion abundance criteria are given in Appendix A.

9.2 Initial Calibration for Chemical Agents

Prior to the analysis of samples and required blanks, and after instrument performance criteria have been met, the GC/MS system must be initially calibrated at a minimum of five concentrations to determine the linearity of response utilizing chemical agents standards.

1. The levels of the initial calibration standards for chemical agents are 0.05, 0.1, 0.5, 1.0 and 2.0 µg/mL.

2. The calibration of the GC/MS is evaluated on the basis of the magnitude and stability of the relative response factors of chemical agents. Criteria have not been established for the minimum RRF and %RSD. However, tentative criteria have been adopted at this time. The minimum RRF of each compound at each concentration level in the initial calibration across

all five points is tentatively adapted to be equal to or greater than 0.05; the %RSD is tentatively adopted to not exceed 30%.

9.3 Continuing Calibration for Chemical Agents

Once the GC/MS system has been calibrated, the calibration must be verified each 24-hour time period for each GC/MS system during the analysis.

1. The level of the continuing calibration standard for chemical agents is 0.50 µg/mL.

2. The standard is to be analyzed every 24 hours after an acceptable DFTPP analysis.

3. The continuing calibration of the GC/MS system is evaluated on the basis of the magnitude of the relative response factors and the percent difference between the average RRF of chemical agents from the initial calibration and the RRF of chemical agents in the continuing calibration standard. Criteria have not been established for the minimum RRF and %D. However, tentative criteria have been adopted at this time. The minimum RRF of chemical agents in the continuing calibration is tentatively adopted to be greater than or equal to 0.05. The %D is tentatively adopted to not exceed 25%.

4. If any of the requirements listed in Item 3 are not met, another initial calibration will be analyzed.

9.4 Method Blank Analysis

A method blank is a weight of a clean reference matrix (sodium sulfate for soil/sediment samples) that is carried through the entire analytical procedure. The weight of the reference matrix must be approximately equal to the weight of samples associated with the blank. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

1. One method blank must be extracted and analyzed for every sampling event for each project.

2. The method blank must contain less than or equal to the MDL of chemical agents.

3. If a method blank exceeds the limits for contamination above, the analyst must consider the analytical system out of control. The source of the contamination must be investigated and appropriate corrective action taken and documented before further sample analysis proceeds.

9.5 Dilution Analysis

If the concentration of any sample extract exceeds the initial calibration range, that sample extract must be diluted and reanalyzed as described in Section 7.7.

1. Use the results of the original analysis to determine the approximate dilution factor required to get chemical agents within the initial calibration range.

2. The dilution factor chosen should keep the response of chemical agents in the upper half of the initial calibration range of the instrument.

3. Do not submit data for more than two analyses, i.e., the original sample and one dilution, or, from the most concentrated dilution analyzed and one further dilution.

9.6 Matrix Spike/Matrix Spike Duplicate Recoveries

The purpose of spiking chemical agents into two aliquots of a sample to evaluate the effects of the sample matrix on the methods used in this SOP.

1. The MS/MSD must be prepared for every 20 samples for each project.

2. The recoveries of chemical agents are calculated according to the procedures in Section 8.2. The relative percent difference between the results of the matrix spike and the matrix spike duplicate are calculated according to the procedures in Section 8.2.

3. No quality control limits for recovery and relative percent difference are available.

10.0 DATA VALIDATION

Data validation will be performed by the Data Validation and Report Writing Group and therefore it is not applicable to this SOP. However, data is considered satisfactory for submission purposes when the requirements mentioned below are met.

1. All samples must be analyzed under an acceptable tune, initial calibration, and continuing calibration check at the required frequency.
2. An acceptable method blank must be submitted for each batch.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, refer to U.S. EPA, OSHA and corporate health and safety practices. More specifically, refer to ERTC/REAC SOP #3013, REAC Laboratory Safety Program.

12.0 REFERENCES

1. M. Rautio, Recommended Operating Procedures For Sampling and Analysis In The Verification of Chemical Disarmament, The Ministry of Foreign Affairs of Finland, Helsinki 1994.

2. SciTech Services, Inc., "Screening Procedures for The Trace Level Analysis of Potentially Contaminated Soil Samples Using DAAMS Technology and Gas Chromatography", Final Report, Abington MD, December 3, 1992.

3. Midwest Research Institute, Attachment 5-3, "Internal Operating Procedures For Analysis of Chemical Warfare Agents", APG Environmental Remediation Contract No. DACA87-90-0031, Kansas City, Missouri, 1991.

4. Southern Research Institute, "3X/5X Delisting Plan -- Analytical Methods Report", Draft Final Report, Birmingham AL, January 15, 1992, SRI-APC-92-29-6840.45,

ANALYSIS FOR CHEMICAL AGENTS IN WIPE SAMPLES BY GC/MS

ANALYSIS OF CHEMICAL AGENTS (GB, GD and VX) IN WIPE SAMPLES

CONTENTS

ANALYSIS FOR CHEMICAL AGENTS IN WIPE SAMPLES BY GC/MS

1.0 SCOPE AND APPLICATION

The objective of this standard operating procedure is to provide guidance on the requirements for the analysis of chemical agents in wipe samples using gas chromatography/mass spectrometry (GC/MS) selective ion monitoring mode (SIM). Sample size should be determined based upon the detection limit desired and the amount of sample requested by the analytical laboratory. Typical sample area collected is one square foot (929 square centimeters). However, based upon sampling location, the sample size may need modification due to area configuration.

These are standard (i.e., typically applicable) operating procedures with may be varied or changed as required, dependent upon matrix conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

The wipe samples are extracted with methylene chloride and the extracts analyzed by GC/MS. Prior to GC/MS analysis, a 1-mL aliquot of the extract is spiked with the internal standard. The extract is then analyzed for chemical agents. Compounds are identified by comparing their measured mass spectra and retention times to reference spectra and retention times obtained by the measurement of calibration standards under the same conditions used for samples. Quantitation of each identified analyte is calculated by internal standard method.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

3.1 Sample Storage

From the time of receipt and after analysis, extracts and unused samples must be stored in 40 mL VOA bottles and protected from light and refrigerated at 4°C (±2°C) for the periods specified by the Task Leader and/or Work Assignment Manager.

Samples, sample extracts, and standards must be stored separately in an atmosphere demonstrated to be free of all potential contaminants.

3.2 Holding Times

Extraction of wipe samples shall be completed within seven days of sampling, and analysis completed within 40 days of sample extraction.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

This method has few significant interferences or problems. Typical problems result from rough porous surfaces which may be difficult to wipe. Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be shown to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in an all glass system may be required.

5.0 EQUIPMENT/APPARATUS

Equipment required for performing wipe analysis for chemical agents is as follows:

1. Micro syringes
2. RELEASE™, non-adhering dressing, 2 in x 3 in, Johnson and Johnson Products, Inc., or equivalent
3. Balance - Analytical, capable of accurately weighing ±0.01 g.
4. Water bath sonicator
5. Gas Chromatography/Mass Spectrometer (GC/MS)
   A GC/MS system which meets the following specifications will be used:

   Gas Chromatograph - An analytical system completed with a temperature programmable gas chromatograph suitable for on-column injection and all the required accessories including syringes, analytical columns, and gases is required.

   Capillary Gas Chromatography Columns - Any gas chromatography column that meets the performance criteria of separating the calibration mixture of this method is acceptable. Several useful columns have been identified. GC conditions and columns are listed in Section 7.4.

   Mass spectrometer - The mass spectrometer must be capable of electron ionization at a nominal electron energy of 70 eV, and must be capable of scanning in the selective ion monitoring (SIM) mode. The ions to be monitored are as follows:

Compound	Primary Ion	Secondary Ions
d_{10}-acenaphthene (Internal Standard))	162	164, 160
Sarin (GB)	99	125, 81
Soman (GD)	99	126, 82
VX	114	72, 127

   The mass spectrometer must produce a spectrum that meets all criteria in Section 7.4 when 50 ng of decafluorotriphenylphosphine (DFTPP) is introduced into the GC.

   GC/MS interface - Any gas chromatograph to mass spectrometer interface that allows 20 ng or less per injection for each of the parameters of interest and achieves all acceptable performance criteria may be used. The capillary column is directly coupled with the analyzer, providing maximum sensitivity.

   Data system - A computer system must be interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that allows searching any GC/MS data file for ions of a specified mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP).

   The computer software should be capable of processing stored GC/MS data by recognizing a GC peak within any given retention time window, comparing the mass spectra from the GC peak with spectral data in a user-created database. The software must allow integration of the ion abundance of any specific ion between specified time or scan number limits. The software should also allow

the calculation of response factors (or construction of a second or third order regression calibration curve), response factor statistics (mean and standard deviation), and concentrations of analytes using either the calibration curve or the equation in Section 8.

6.0 REAGENTS

1. Sarin (GB; isopropyl methylphosphonofluoridate CAS# 107-44-8), Soman (GD; pinacolyl methyl phosphonofluoridate CAS# 96-64-0) and V-Agents (VX; o-ethyl s-(2-diisopropylaminoethyl) methyl phosphonofluoridate CAS# 050782-69-9) 1000 µg/mL stock solutions as provided by TEU, a division of U. S. Army Corp. Prepare a 200 µg/mL stock mix solution for routine analysis.

2. Methylene chloride (glass distilled, suitable for GC).

3. Decafluorotriphenylphosphine (DFTPP).

   Prepare a 50 µg/mL daily working standard solution of DFTPP by diluting 50 µL of a commercially available 25,000 µg/mL (Supelco catalog number 4-8724 or equivalent) in 25.0 mL of methylene chloride. Protect the DFTPP from light and refrigerate at 4°C (±2°C). This solution must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

4. d_{10}-Acenaphthene (Aldrich catalog # 45181-9) , internal standard for GC analysis.

   d_9-Dibutylbutylphosphonate (DBBP) or diisopropylmethylphosphonate (DIMP), alternate internal standard.

5. Matrix Spike/Matrix Spike Duplicate Solution:

   Prepare a 20 µg/mL spike solution of chemical agents by dilution of the stock solution in methylene chloride. Store the spiking solution at 4°C (± 2°C) in Teflon-sealed containers, protected from light. The solution should be checked frequently for stability. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

6. Calibration Standards

   Prepare calibration standards at five concentration levels (0.05, 0.1, 0.5, 1.0, and 2.0 µg/mL). Prepare serial dilutions in methylene chloride of the 20 µg/mL solution to obtain the five calibration standards. These solutions must be replaced every 12 months, or sooner if comparison with quality control check samples indicates a problem.

7.0 PROCEDURES

7.1 Sample Preparation and Extraction

The wipe consists of non-adhering dressing, 2 in x 3 in. (RELEASE™, Johnson and Johnson Products, Inc. or equivalent). The dressing is wet with a few mL of an appropriate solvent such as isopropyl alcohol. The suggested maximum sample area is one square foot . The wipe is stored in a 40mL VOA vial prior to shipping. Extract the sample as follows:

1. Add 30 mL of methylene chloride to the sample vial.
2. Cap the vial tightly with a PETE lined cap.
3. Immerse the vial in an ultrasonic bath for approximately 30 minutes.
4. Transfer 1.0 mL from the vial to a clean 1-mL auto sample vial. Cap and label the vial.
5. Add 20 µL internal standard, 20 µg/mL d_{10}-acenaphthene (see Section 6.0). The extract is ready for analysis. If the analysis is not performed immediately, the extract should be protected from light and refrigerated at 4°C (±2°C).

7.2 Method Blank

Wet the face of a dressing with few drops of isopropyl alcohol. Insert the wipe dressing into a 40mL VOA vial. Allow to stand for a minimum of 1 hour. Extract exactly as a sample as stated in Section 7.1.

7.3 Blank Spike/Blank Spike Duplicate

Wet the face of a dressing with few drops of isopropyl alcohol. Insert the wipe dressing into a 40mL VOA vial and spike 30 µL of spiking solution. Allow to stand for a minimum of 1 hour. Extract exactly as a sample as stated in Section 7.1 Perform in duplicate.

7.4 MS Operating Conditions

A Hewlett Packard (HP) 6890 series GC system equipped with a HP 5972 mass selective detector (MSD) and a 7673A HP autosampler can be used. The GC/MSD and the autosampler are controlled by an HP-ChemStation computer system under DOS 6.22 and Windows 3.11 software. The instrument is operated under the following conditions:

Column	Restek Rtx-5MS or equivalent, 30 meters in length, 0.25-mm ID and 0.50 µm film thickness
Injection Temperature	250°C
Transfer Line Temperature	280°C
Oven Temperature Programming	
Initial Temperature	55°C
Initial Time	2 minutes

Temperature Ramp#	Rate (°C/min.)	Final Temp. (°C)	Final Time (min.)
1	15	130	0.5
2	50	305	1.0

Splitless Injection	Split time 0.25 min.
Injection Volume	1 µL
Column Flow	1.0 mL/min. with electron pressure control (EPC) system enabled
Nominal Initial Pressure	8.0 psi
Average Velocity	36 cm/sec.

7.5 Tune (DFTPP)

Before analysis, the instrument should be tuned by injecting 50 nanograms of decafluorotriphenylphosphine (DFTPP) into the system. A short program adapted from U.S. Environmental Protection Agency's Contract Laboratory Program (U.S. EPA/CLP SOW OLM01.03/90) should be utilized. This criteria must be demonstrated every 24 hours during analysis.

Ion Abundance Criteria for Tune (DFTPP)

Mass	Ion Abundance Criteria
51	30.0 - 80.0 percent of mass 198
68	Less than 2.0 percent of mass 69
69	Present
70	Less than 2.0 percent of mass 69
127	25.0 - 75.0 percent of mass 198
197	Less than 1.0 percent of mass 198
198	Base peak, 100 percent relative abundance (see note)
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	Greater than 0.75 percent of mass 198
441	Present but less than mass 443
442	40.0 - 110.0 percent of mass 198
443	15.0 - 24.0 percent of mass 442

NOTE: All ion abundances MUST be normalized to m/z 198, the nominal base peak, even though the ion abundances of m/z 442 may be up to 110 percent that of m/z 198.

7.6 Initial Calibration

1. Add 20 µL of the internal standard d_{10}-acenaphthene at 20 µg/mL to each 1-mL aliquot of calibration standards.

2. Inject each of the calibration standards after a successful DFTPP analysis.

3. Calculate and tabulate the relative response factor (RRF) against the concentration for each compound by using the equation listed below. The primary ion from the specific internal standard must be used for quantitation.

   The average RRF and percent relative standard deviation (%RSD) must also be calculated and tabulated.

$$RRF = \frac{(A_X)(C_{IS})}{(A_{IS})(C_X)}$$

Where:

A_X = Area of the characteristic ion for the compound to be measured

C_{IS} = Concentration of the internal standard (ng/μL)
A_{IS} = Area of the characteristic ion for the internal standard.
C_X = Concentration of the compound to be measured (ng/μL)

The % RSD of the RRF for each chemical agents has been tentatively adopted to be less than or equal to 30%. The average RRF of chemical agents should not be less than 0.05.

7.7 Continuing Calibration

A check of the initial calibration curve must be performed every 24 hours during analysis.

1. Inject 1 μL of a 0.5 μg/mL chemical agents standard containing the internal standard.

2. Calculate and tabulate the daily RRF for each compound. All daily RRF should be equal to or greater than 0.05.

3. Calculate the percent difference (% D) of each daily RRF compared to the average RRF from the initial calibration curve. The % D for all compounds can be calculated using the equation listed below and must be less than or equal to 25%.

$$\%\ D = \frac{|RRF_{Daily} - RRF_{Average}|}{RRF_{Average}} \times 100$$

4. All sample and standards are quantitated using the response factors from the daily calibration check or from the average RRF of initial calibration for samples analyzed right after the initial calibration is passed.

7.8 Sample Analysis

Sample extracts may be analyzed only after the GC/MS system has met the DFTPP, initial calibration, and continuing calibration requirements mentioned above. The same instrument conditions must be employed for the analysis of samples as were used for calibration.

1. Add 20 μL of the internal standard into the method blank(s), the matrix spikes, and all the sample extracts.

2. Inject 1 μL each of the matrix spikes, method blank(s), and all the sample extracts.

3. If the analyst has reason to believe that diluting the final extracts will be necessary, an undiluted run may not be required.

4. If any chemical agents is detected at a level greater than the highest calibration standard, sample extracts must be diluted so that the chemical agents response is within the linear range established during calibration.

5. If dilutions of sample extracts are made, additional internal standards must be added to maintain the required concentration (0.4 μg/mL) of the internal standard in the extract.

7.9 Identification of Chemical Agents

Chemical agents identification will be conducted by comparison of the sample mass spectrum to the mass spectrum of a standard of chemical agent. Two criteria must be satisfied to verify the identifications:

- Elution of the chemical agents in the sample at the same GC relative retention time as chemical agents.
- Correspondence of chemical agents in the sample and the reference chemical agents mass spectra. Note that in SIM mode not all characteristic ions will be obtained.

1. For establishing correspondence of the GC relative retention time (RRT), the sample component RRT must compare within ±0.06 RRT units of the RRT of the standard component. If coelution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT should be assigned by using extracted ion current profiles for ions unique to the component of interest.

2. For comparison of standard and sample component mass spectra, reference mass spectra must be obtained from the 1.0 µg/mL standard. These standard spectra may be obtained from the run used to obtain reference RRTs.

3. The requirements for qualitative verification by comparison of mass spectra are as follows:

   a. All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum. In SIM mode, those ions within the scan ranges used, must be present.

   b. The relative intensities of ions specified in (a) must agree within ±20% between the standard and sample spectra. (For example: for an ion with an abundance of 50% in the standard spectra, the corresponding sample ion abundance must be between 30-70%.)

   c. Ions greater than 10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst making the comparison. All compounds meeting the identification criteria must be reported with their spectra. For all compounds below the quantitation limit, report the actual value followed by "J", e.g., "3J".

4. If a compound cannot be verified by all of the criteria in step 3, but in the technical judgment of the mass spectral interpretation specialist, the identification is correct, then the analyst shall report that identification and proceed with the calculation in Section 8.0. The analyst should note in the case narrative that technical judgment was utilized.

8.0 CALCULATIONS

8.1 Chemical Agents

Chemical agents must be quantitated by the internal standard method.

Calculate the concentration in the sample using the average relative response factor (RRF) obtained from the initial calibration standard as determined in Section 7.6 and the equation listed below. If samples are analyzed under the initial calibration curve, the average RRF must be used. If daily

continuing calibration (CC) is performed , use the updated CC RRF to quantitate the concentration of chemical agents in the samples.

$$Concentration\ (\mu g/ft^2) = \frac{(A_X)(I_S)(V_T)(DF)}{(A_{IS})(RRF)(A_w)(V_I)}$$

where:

A_X	=	Area of the characteristic ion for the compound to be measured
I_S	=	Amount of internal standard injected (ng)
V_T	=	Volume of the concentrated extract (mL)
DF	=	Dilution factor
A_{IS}	=	Area of the characteristic ion for the internal standard
RRF	=	Relative response factor
A_w	=	Area wiped in square foot
V_I	=	Volume of extract injected (μL)
S	=	Decimal percent solid

When chemical agent concentrations are below the quantitation limits but the spectrum meets the identification criteria, report the concentration as estimated by flagging the results with a "J".

8.2 Matrix Spike Recoveries

The percent recoveries and the relative percent difference (RPD) between the recoveries in the matrix spike/matrix spike duplicate will be calculated and reported by using the following equations:

$$Matrix\ Spike\ Recovery\ (\%) = \frac{SSR - SR}{SA} \times 100\%$$

where:

SSR	=	Spike sample result
SR	=	Sample result
SA	=	Spike added

$$RPD = \frac{|MSR - MSDR|}{(MSR + MSDR)/2} \times 100\%$$

where:

RPD	=	Relative percent difference
MSR	=	Matrix spike recovery
MSDR	=	Matrix spike duplicate recovery

The vertical bars in the formula above indicate the absolute value of the difference; hence RPD is always expressed as a positive value.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 Tune (DFTPP)

Prior to initiating any data collection activities involving samples, blanks, or standards, it is necessary to establish that a given GC/MS system meets the instrument tune criteria specified in Section 7.5. The purpose of this instrument check is to assure correct mass calibration, mass resolution, and mass transmission. This is accomplished through the analysis of DFTPP.

1. The analysis of DFTPP must be performed every 24 hours during the analysis.

2. The key ions produced during the analysis of DFTPP and their respective ion abundance criteria are given in Section 7.5.

9.2 Initial Calibration for Chemical Agents

Prior to the analysis of samples and required blanks, and after instrument performance criteria have been met, the GC/MS system must be initially calibrated at a minimum of five concentrations to determine the linearity of response utilizing chemical agents standards.

1. The levels of the initial calibration standards for chemical agents are 0.05, 0.1, 0.5, 1.0 and 2.0 μg/mL.

2. The calibration of the GC/MS is evaluated on the basis of the magnitude and stability of the relative response factors of chemical agents. Criteria have not been established for the minimum RRF and %RSD. However, tentative criteria have been adopted at this time. The minimum RRF of each compound at each concentration level in the initial calibration across all five points is tentatively adapted to be equal to or greater than 0.05; the %RSD is tentatively adopted to not exceed 30%.

9.3 Continuing Calibration for Chemical Agents

Once the GC/MS system has been calibrated, the calibration must be verified each 24-hour time period for each GC/MS system during the analysis.

1. The level of the continuing calibration standard for chemical agents is 0.50 μg/mL.

2. The standard is to be analyzed every 24 hours after an acceptable DFTPP analysis.

3. The continuing calibration of the GC/MS system is evaluated on the basis of the magnitude of the relative response factors and the percent difference between the average RRF of chemical agents from the initial calibration and the RRF of chemical agents in the continuing calibration standard. Criteria have not been established for the minimum RRF and %D. However, tentative criteria have been adopted at this time. The minimum RRF of chemical agents in the continuing calibration is tentatively adopted to be greater than or equal to 0.05. The %D is tentatively adopted to not exceed 25%.

4. If any of the requirements listed in Item 3 are not met, another initial calibration will be analyzed.

9.4 Method Blank Analysis

A method blank is a clean non-adhering dressing, 2 in x 3 in. (RELEASE™, Johnson and Johnson Products, Inc. or equivalent) that is carried through the entire analytical procedure. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

1. One method blank must be extracted and analyzed for every sampling event for each project.

2. The method blank must contain less than or equal to the MDL of chemical agents.

3. If a method blank exceeds the limits for contamination above, the analyst must consider the analytical system out of control. The source of the contamination must be investigated and appropriate corrective action taken and documented before further sample analysis proceeds.

9.5 Dilution Analysis

If the concentration of any sample extract exceeds the initial calibration range, that sample extract must be diluted and reanalyzed as described in Section 7.8.

1. Use the results of the original analysis to determine the approximate dilution factor required to get chemical agents within the initial calibration range.

2. The dilution factor chosen should keep the response of chemical agents in the upper half of the initial calibration range of the instrument.

3. Do not submit data for more than two analyses, i.e., the original sample and one dilution, or, from the most concentrated dilution analyzed and one further dilution.

9.6 Matrix Spike/Matrix Spike Duplicate Recoveries

The purpose of spiking chemical agents into two aliquots of a sample to evaluate the effects of the sample matrix on the methods used in this SOP.

1. The MS/MSD must be prepared for every 20 samples for each project.

2. The recoveries of chemical agents are calculated according to the procedures in Section 8.2. The relative percent difference between the results of the matrix spike and the matrix spike duplicate are calculated according to the procedures in Section 8.2.

3. No quality control limits for recovery and relative percent difference are available.

10.0 DATA VALIDATION

Data validation will be performed by the Data Validation and Report Writing Group and therefore it is not applicable to this SOP. However, data is considered satisfactory for submission purposes when the requirements mentioned below are met.

1. All samples must be analyzed under an acceptable tune, initial calibration, and continuing calibration check at the required frequency.
2. An acceptable method blank must be submitted for each batch.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, refer to U.S. EPA, OSHA and corporate health and safety practices. More specifically, refer to ERTC/REAC SOP #3013, REAC Laboratory Safety Program.

12.0 REFERENCES

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2. SciTech Services, Inc., "Screening Procedures for The Trace Level Analysis of Potentially Contaminated Soil Samples Using DAAMS Technology and Gas Chromatography", Final Report, Abington MD, December 3, 1992.

3. Midwest Research Institute, Attachment 5-3, "Internal Operating Procedures For Analysis of Chemical Warfare Agents", APG Environmental Remediation Contract No. DACA87-90-0031, Kansas City, Missouri, 1991.

4. Southern Research Institute, "3X/5X Delisting Plan -- Analytical Methods Report", Draft Final Report, Birmingham AL, January 15, 1992, SRI-APC-92-29-6840.45,

SAM 2012 Appendix A: Selected Chemical Methods for CWA													
Analyte(s)	**CAS RN**	**Determinative Technique**	**Method Type**	**Solid Samples**		**Aqueous Liquid Samples**		**Drinking Water Samples**		**Air Samples**		**Wipes**	
Chlorosarin	1445-76-7	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A[2] (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Chlorosoman	7040-57-5	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A[2] (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
2-Chlorovinylarsonous acid (2-CVAA) (degradation product of Lewisite) (analyze as total arsenic)	85090-33-1	ICP-AES / ICP-MS	Sample Prep	3050B (EPA SW-846)	I	200.7/200.8 (EPA OW)	I	200.7/200.8 (EPA OW)	I	IO-3.1 (EPA ORD)	I	9102 (NIOSH)	I
			Determinative	6010C/6020A (EPA SW-846)						IO-3.4/IO-3.5 (EPA ORD)		6010C/6020A (EPA SW-846)	
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)						8270D (EPA SW-846)	
Cyclohexyl sarin (GF)	329-99-7	GC-MS	Sample Prep	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*
			Determinative										
1,2-Dichloroethane (degradation product of HD)	107-06-2	GC-MS	Sample Prep	5035A (EPA SW-846)	I	5030C (EPA SW-846)	I	524.2 (EPA OW)	I	TO-15 (EPA ORD)	I	Not of concern	NA
			Determinative	8260C (EPA SW-846)		8260C (EPA SW-846)							
			Determinative	8015C (EPA SW-846)		8015C (EPA SW-846)		8015C (EPA SW-846)				8015C (EPA SW-846)	
Diisopropyl methylphosphonate (DIMP) (degradation product of GB)	1445-75-6	HPLC / LC-MS-MS	Sample Prep	E2866-12 (ASTM)	II	D7597-09 (ASTM)	II	538 (EPA OW)	I	TO-10A[2] (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	II
			Determinative									8321B (EPA SW-846)	
			Determinative	8270D (EPA SW-846)								8270D (EPA SW-846)	
Dimethylphosphoramidic acid (degradation product of GA)	33876-51-6	HPLC	Sample Prep	3541/3545A (EPA SW-846)	III	3535A (EPA SW-846)	III	3535A (EPA SW-846)	III	TO-10A (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	III
			Determinative	8321B (EPA SW-846)		8321B (EPA SW-846)		8321B (EPA SW-846)				8321B (EPA SW-846)	
1,4-Dithiane (degradation product of HD)	505-29-3	GC-MS	Sample Prep	3570 (EPA SW-846)	II	3511 (EPA SW-846)	II	3511 (EPA SW-846)	II	Not of concern	NA	3570/8290A Appendix A (EPA SW-846)	II
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
EA2192 [S-2-(diisopropylamino)ethyl methylphosphonothioic acid] (hydrolysis product of VX)	73207-98-4	HPLC	Sample Prep	3541/3545A (EPA SW-846)	III	3535A (EPA SW-846)	III	3535A (EPA SW-846)	III	TO-10A (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	III
			Determinative	8321B (EPA SW-846)		8321B (EPA SW-846)		8321B (EPA SW-846)				8321B (EPA SW-846)	

SAM 2012 Appendix A: Selected Chemical Methods for CWA													
Analyte(s)	**CAS RN**	**Determinative Technique**	**Method Type**	**Solid Samples**		**Aqueous Liquid Samples**		**Drinking Water Samples**		**Air Samples**		**Wipes**	
Ethyl methylphosphonic acid (EMPA) (degradation product of VX)	1832-53-7	HPLC / LC-MS-MS	Sample Prep	E2866-12 (ASTM)	II	D7597-09 (ASTM)	II	D7597-09 (ASTM)	III	TO-10A (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	II
			Determinative									8321B (EPA SW-846)	
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Isopropyl methylphosphonic acid (IMPA) (degradation product of GB)	1832-54-8	HPLC / LC-MS-MS	Sample Prep	E2866-12 (ASTM)	II	D7597-09 (ASTM)	II	D7597-09 (ASTM)	III	TO-10A (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	II
			Determinative									8321B (EPA SW-846)	
			Determinative										
N-Methyldiethanolamine (MDEA) (degradation product of HN-2)	105-59-9	HPLC / LC-MS-MS	Sample Prep	3541/3545A (EPA SW-846)	III	D7599-09 (ASTM)	II	D7599-09 (ASTM)	III	TO-10A (EPA ORD)	III	EPA 600/R-11/143 (EPA/NIOSH)	II
			Determinative	8321B (EPA SW-846)									
1-Methylethyl ester ethylphosphonofluoridic acid (GE)	1189-87-3	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A[2] (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Methylphosphonic acid (MPA) (degradation product of VX, GB, & GD)	993-13-5	HPLC	Sample Prep	E2866-12 (ASTM)	II	D7597-09 (ASTM)	II	D7597-09 (ASTM)	III	TO-10A (EPA ORD)	III	3570/8290A Appendix A (EPA SW-846)	II
			Determinative									8321B (EPA SW-846)	
Mustard, nitrogen (HN-1) [bis(2-chloroethyl)ethylamine]	538-07-8	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Mustard, nitrogen (HN-2) [2,2'-dichloro-N-methyldiethylamine N,N-bis(2-chloroethyl)methylamine]	51-75-2	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Mustard, nitrogen (HN-3) [tris(2-chloroethyl)amine]	555-77-1	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	3520C/3535A (EPA SW-846)	III[13]	TO-10A (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Mustard, sulfur / Mustard gas (HD)	505-60-2	GC-MS	Sample Prep	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*
			Determinative										

SAM 2012 Appendix A: Selected Chemical Methods for CWA														
Analyte(s)	**CAS RN**	**Determinative Technique**	**Method Type**	**Solid Samples**		**Aqueous Liquid Samples**		**Drinking Water Samples**		**Air Samples**		**Wipes**	
Sarin (GB)	107-44-8	GC-MS	Sample Prep	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*
			Determinative										
			Determinative	300.1, Rev 1.0 [11] (EPA OW)		300.1, Rev 1.0 [11] (EPA OW)		300.1, Rev 1.0 [11] (EPA OW)					
Soman (GD)	96-64-0	GC-MS	Sample Prep	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*
			Determinative										
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
Tabun (GA)	77-81-6	GC-MS	Sample Prep	3541/3545A (EPA SW-846)	III[13]	3535A (EPA SW-846)	III[13]	3535A (EPA SW-846)	III[13]	TO-10A (EPA ORD)	III[13]	3570/8290A Appendix A (EPA SW-846)	III[13]
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
			Determinative	6010C/6020A (EPA SW-846)						IO-3.4/IO-3.5 (EPA ORD)		6020A/6010C (EPA SW-846)	
Thiodiglycol (TDG) (degradation product of HD)	111-48-8	HPLC / LC-MS-MS	Sample Prep	E2787-11 (ASTM)	II	D7598-09 (ASTM)	II	D7598-09 (ASTM)	III	TO-10A (EPA ORD)	III	E2838-11 (ASTM)	II
			Determinative										
			Determinative	8321B (EPA SW-846)								8321B (EPA SW-846)	
1,4-Thioxane (degradation product of HD)	15980-15-1	GC-MS	Sample Prep	3570 (EPA SW-846)	II	3511 (EPA SW-846)	II	3511 (EPA SW-846)	II	Not of concern	NA	3570/8290A Appendix A (EPA SW-846)	II
			Determinative	8270D[12] (EPA SW-846)		8270D[12] (EPA SW-846)		8270D[12] (EPA SW-846)				8270D[12] (EPA SW-846)	
			Determinative	6010C/6020A (EPA SW-846)								6010C/6020A (EPA SW-846)	
Triethanolamine (TEA) (degradation product of HN-3)	102-71-6	HPLC / LC-MS-MS	Sample Prep	3541/3545A (EPA SW-846)	III	D7599-09 (ASTM)	II	D7599-09 (ASTM)	III	TO-10A (EPA ORD)	III	EPA 600/R-11/143 (EPA/NIOSH)	II
			Determinative	8321B (EPA SW-846)									
			Determinative	8270D (EPA SW-846)		8270D (EPA SW-846)		8270D (EPA SW-846)				8270D (EPA SW-846)	
VX [O-ethyl-S-(2-diisopropylaminoethyl)methyl-phosphonothiolate]	50782-69-9	GC-MS	Sample Prep	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*	CWA Protocol (EPA NHSRC)	*
			Determinative										
			Determinative									7580 (EPA SW-846)	

* Only laboratories approved under the ERLN umbrella are designated for handling the CWA standards needed for this method. For access to the nearest ERLN laboratory specially trained and equipped for CWA analysis, contact the EPA Headquarters Emergency Operations Center (EPA/HQ-EOC) at 202-564-3850.

Footnotes

[1] If problems occur when using this method, TO-10A should be used.

[2] If problems occur when using this method, the canister Method TO-15 should be used.

[3] If problems occur with analyses, lower the injection temperature.

[4] If problems occur when using this method, SW-846 Method 8321B should be used as the Determinative method. Sample preparation methods should remain the same.

[5] If problems occur during measurement of oxon compounds, analysts should consider use of procedures included in Kamal, A. *et al*., "Oxidation of selected organophosphate pesticides during chlorination of simulated drinking water." Water Research. 2009. 43(2): 522–534. http://www.sciencedirect.com/science/journal/00431354.

[6] If problems occur when using this method, NIOSH Method 7906 should be used.

[7] Laboratory testing is currently under way for speciation of Lewisite 1 using GC-MS techniques.

[8] If equipment is not available or problems occur when analyzing solid and wipe samples, use CVAA Method 7471B (EPA SW-846).

[9] If problems occur when using EPA Method 245.1 for these analytes during preparation and analysis of aqueous liquid samples, refer to EPA Method 7470A (SW-846).

[10] Water extraction, filtration and acidification steps from the Journal of Forensic Science. 1998. 43(1): 200-202 should be used for the preparation of solid samples. Filtration and acidification steps from this journal should be used for preparation of aqueous liquid and drinking water samples.

[11] If analyses are problematic, refer to column manufacturer for alternate conditions.

[12] If problems occur when using this method, SW-846 Method 8260C and appropriate corresponding sample preparation procedures (i.e., 5035A for solid samples, and 5030C for aqueous liquid and drinking water samples) should be used.

[13] Data are not available for this analyte/sample type using this method. However, the referenced SW-846 method or the CWA Protocol may be applicable.

APPENDIX 6

DECONTAMINATION GUIDANCE DOCUMENTS
CMAD DECONTAMINATION AND DISPOSAL REFERENCE GUIDES (NERVE AND BLISTER AGENTS)

U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL DECONTAMINATION TEAM

DECONTAMINATION ANALYTICAL AND TECHNICAL SERVICE (DATS) CONTRACT

CONTRACT No.: EP-W-06-089
TDD No. TO-01-08-06-0022

Decontamination and Disposal Reference Guide: Sulfur Mustard

April 23, 2009

Dynamac Technical POC:
Neil Daniell, DATS Scientist III

DYNAMAC® CORPORATION
4900 Olympic Boulevard
Erlanger, KY 41018

Decontamination and Disposal Reference Guide: Sulfur Mustard

Chemical name: Bis(2-chloroethyl) sulfide CAS Number: 505-60-2
Agent Classification: Blister Agent Abbreviation: H/HD/HT

Disclaimer: The information contained in this document provides decontamination and disposal information only. For information on an agents physical properties, chemical properties, and health effects, please refer to the Nation Response Team Quick Response Guide. [1]

Methods of Decontamination

Methods	General Usage	Efficacy	Availability	Cost
Chlorine Based Decontaminants[2-9] High test hypochlorite (HTH) Clorox Bleach® (Bleach) Supertropical Bleach (STB)	Hard Surfaces & Soil; Large Flat Areas	Yes	Nonproprietary	Low
Modified Vaporous Hydrogen Peroxide (mVHP) [7, 10, 11]	Volumetric Surfaces; Sensitive Items	Good	Proprietary; STERIS	Moderate
Peroxide Based Decontaminants[7, 12] Decon Green MDF-200 EasyDECON® DF200	Various surfaces; Well contained and easily accessible; non-sensitive equipment, furnishings (nonfabric)	Good	Proprietary; Edgewood; Proprietary; Modec Inc. Proprietary; Envirofoam Technologies, Inc.	Moderate

Application of Treatment Method

Chlorine Based Decontaminants[2-9]

Application Requirements		Media Specific Applications	
Formulation:	Utilize a ratio of water and chlorine based decontaminant (HTH, STB, Chlorox®, etc.) necessary to prepare a decontamination solution with 5% available chlorine (50,000 ppm); Adjusted pH to 6 or lower.	Porous:	May be deployed as a spray, liquid, fog, or aerosol. Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse. Use of a steam vacuum will improve the effectiveness on porous materials. For VX decontamination to be effective, the pH must be low
Temperature:	Applied as a water based solution; Ambient temperatures of 25° C is sufficient		
Contact Time:	30-minute recommended	Non-Porous:	Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse.
Residuals:	No	Soil:	At moderate temperatures (25°C), HD deposited on the surface of soil will evaporate within 30-50 hr, depending on conditions such as temperature, wind speed, and soil type. However, mustard buried deep in the soil, where it cannot vaporize or undergo weathering, can remain undecomposed for years.

mVHP [7, 10, 11]

Application Requirements		Media Specific Applications	
Formulation:	Flash evaporate 500 ppm hydrogen peroxide + 30 ppm ammonia at relatively low humidity	Porous:	Portable mVHP unit used in combination with a tent system; A treatment chamber may be used for sensitive items
Temperature:	minimum of 30°C and 30% relative humidity		
Contact Time:	Hours	Non-Porous:	Same as above
Residuals:	No	Soil:	Not recommended

Peroxide Based Decontaminants[7, 12]

Application Requirements		Media Specific Applications	
Formulation:	Per manufacturers instructions	Porous:	Aqueous: Apply to the contaminated surface using a wipe (e.g., mop, sponge), and allowed to stand for a period of time. The solution is removed by wiping or wet vacuuming. Mist/Fog: Utilize commercial misting/fog machines. Fan driven air may be introduced behind the mist to propel it directionally Foam: Apply ½ inch foam using standard, commercially available paint sprayers; special nozzles may be utilized to draw air into the spray and increase foaming action.
Temperature:	Applied at room temperature (68 °F, or 20 °C); Foams work best under low to moderate humidity in a temperature range of 45° F to 85°F.;		
Contact Time:	15-minute to 1 hour recommended	Non-Porous:	Same as above.
Residuals:	No	Soil:	Not recommended.

Transportation and Disposal[6, 9]

Decon solutions need to be collected and tested for possible classification as hazwaste. If complete destruction of agent, items are NOT subject to HMR requirements; If incomplete destruction, utilize CFR § 173.133 - Toxic liquids, organic, n.o.s., Poison-Inhalation Hazard, 6.1, UN 2810, I, Zone A; Packaging exemptions listed in 49 CFR 107. D002 corrosive possible with high pH bleach solutions.

Decontamination & Disposal Reference Guides: Sulfur Mustard	Side 2
Venue Descriptions	
Small Building:	A residence or small business, without extensive sensitive electronics, & a similar sized structure that might contain materials or equipment of a potentially sensitive nature, such as electronics or telecommunications, works of art, etc. Major Types of Materials: Painted surfaces, *Wood, Brick & Block, Gypsum Board, Concrete, Plastics, Glass, Metal*
Large & Open Facility:	A relatively large & open facility, such as a sports arena, auditorium, conference center, or transportation terminal. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Large Multiple-Floored Building:	A large multiple-floored building with extensive compartmentalization into offices or residences with a complex floor plan and ventilation system. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Long Extended Space:	A long extended space, such as a below ground rail passageway or tunnel. *Major Types of Materials: Concrete, Brick & Block, Plastics, Glass, Metal*

Venue Considerations

Disclaimer: Multiple treatment methods may be used to decontaminate various surfaces and spaces. The US EPA NDT has attempted to identify the treatment methods that will most likely be used with this agent. The selected treatment methods are based on availability, cost, efficacy, residual development, and contact time. Other technologies are available and should be considered by response personnel as deemed necessary.

Treatment Methods:	*Chlorine Based Decontaminants*[2-9]	*mVHP* [7, 10, 11]	*Peroxide Based Decontaminants*[7, 12]
Preferred Venue(s):	Small building; Large & open facility	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space
Treatment Area:	Zonal Treatment	Whole Building	Zonal Treatment
Limitations:	Less effective on porous materials	Silicone and viton provide challenges	Hydrogen peroxide breaks down above 120°F
Sensitive Items:	Not Recommended; Highly corrosive	No visible effects on electronics	Can be used on equipment and non-fabric furnishings; may cause slight rusting of metallic surfaces.
Risk Level:			
Decontamination Considerations[9]	Small areas of spilt agent: Cover with vermiculite, diatomaceous earth, clay, or fine sand and neutralized as soon as possible using large amounts of 5% sodium hypochlorite solution. Scoop up all material and place in an approved container. After sealing, decontaminate the exterior and label. Dispose according to regulations.		
	Keep this sulfur mustard out of confined spaces, such as a sewer, because of the possibility of an explosion, unless the sewer is designed to prevent the build up of explosive concentrations		

References:

1. NRT, U., *Quick Reference Guides (QRGs) for Chemical Warfare Agents - GB (Sarin), VX, and H/HD/HT (Sulfur Mustard).* 2007.
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U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL DECONTAMINATION TEAM

DECONTAMINATION ANALYTICAL AND TECHNICAL SERVICE (DATS) CONTRACT

CONTRACT No.: EP-W-06-089
TDD No. TO-01-08-06-0022

Decontamination and Disposal Reference Guide: Sarin

April 23, 2009

Dynamac Technical POC:
Neil Daniell, DATS Scientist III

DYNAMAC® CORPORATION
4900 Olympic Boulevard
Erlanger, KY 41018

Decontamination and Disposal Reference Guide: Sarin

Chemical name: 2-(Fluoro-methylphosphoryl)oxypropane CAS Number: 107-44-8
Agent Classification: Nerve Agent Abbreviation: GB

Disclaimer: The information contained in this document provides decontamination and disposal information only. For information on an agents physical properties, chemical properties, and health effects, please refer to the Nation Response Team Quick Response Guide. [1]

Methods of Decontamination

Methods	General Usage	Efficacy	Availability	Cost
Chlorine Based Decontaminants[2-9] High test hypochlorite (HTH) Clorox Bleach® (Bleach) Supertropical Bleach (STB)	Hard Surfaces & Soil; Large Flat Areas	Yes	Nonproprietary	Low
Modified Vaporous Hydrogen Peroxide (mVHP) [7, 10, 11]	Volumetric Surfaces; Sensitive Items	Good	Proprietary; STERIS	Moderate
Peroxide Based Decontaminants[7, 12] Decon Green MDF-200 EasyDECON® DF200	Various surfaces; Well contained and easily accessible; non-sensitive equipment, furnishings (nonfabric)	Good	Proprietary; Edgewood; Proprietary; Modec Inc. Proprietary; Envirofoam Technologies, Inc.	Moderate

Application of Treatment Method

Chlorine Based Decontaminants[2-9]

Application Requirements		Media Specific Applications	
Formulation:	Utilize a ratio of water and chlorine based decontaminant (HTH, STB, Chlorox®, etc.) necessary to prepare a decontamination solution with 5% available chlorine (50,000 ppm); Adjusted pH to 6 or lower.	Porous:	May be deployed as a spray, liquid, fog, or aerosol. Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse. Use of a steam vacuum will improve the effectiveness on porous materials. For VX decontamination to be effective, the pH must be low
Temperature:	Applied as a water based solution; Ambient temperatures of 25° C is sufficient		
Contact Time:	30-minute recommended	Non-Porous:	Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse.
Residuals:	No	Soil:	Studies indicate that approximately 90% or more of GB added to soil is lost in the first 5 days. At low temperatures, GB is more persistent. GB degradation products sorb to soil depending on the soluble organic carbon content of the soil.

mVHP [7, 10, 11]

Application Requirements		Media Specific Applications	
Formulation:	Flash evaporate 500 ppm hydrogen peroxide + 30 ppm ammonia at relatively low humidity	Porous:	Portable mVHP unit used in combination with a tent system; A treatment chamber may be used for sensitive items
Temperature:	minimum of 30°C and 30% relative humidity		
Contact Time:	Hours	Non-Porous:	Same as above
Residuals:	No	Soil:	Not recommended

Peroxide Based Decontaminants[7, 12]

Application Requirements		Media Specific Applications	
Formulation:	Per manufacturers instructions	Porous:	Aqueous: Apply to the contaminated surface using a wipe (e.g., mop, sponge), and allowed to stand for a period of time. The solution is removed by wiping or wet vacuuming. Mist/Fog: Utilize commercial misting/fog machines. Fan driven air may be introduced behind the mist to propel it directionally Foam: Apply ½ inch foam using standard, commercially available paint sprayers; special nozzles may be utilized to draw air into the spray and increase foaming action.
Temperature:	Applied at room temperature (68 °F, or 20 °C); Foams work best under low to moderate humidity in a temperature range of 45° F to 85°F.;		
Contact Time:	15-minute to 1 hour recommended	Non-Porous:	Same as above.
Residuals:	No	Soil:	Not recommended.

Transportation and Disposal[6, 9]

Decon solutions need to be collected and tested for possible classification as hazwaste. If complete destruction of agent, items are NOT subject to HMR requirements; If incomplete destruction, utilize CFR § 173.133 - Toxic liquids, organic, n.o.s., Poison-Inhalation Hazard, 6.1, UN 2810, I, Zone A; Packaging exemptions listed in 49 CFR 107. D002 corrosive possible with high pH bleach solutions.

Decontamination & Disposal Reference Guides: Sarin

Side 2

Venue Descriptions

Small Building:	A residence or small business, without extensive sensitive electronics, & a similar sized structure that might contain materials or equipment of a potentially sensitive nature, such as electronics or telecommunications, works of art, etc. Major Types of Materials: Painted surfaces, *Wood, Brick & Block, Gypsum Board, Concrete, Plastics, Glass, Metal*
Large & Open Facility:	A relatively large & open facility, such as a sports arena, auditorium, conference center, or transportation terminal. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Large Multiple-Floored Building:	A large multiple-floored building with extensive compartmentalization into offices or residences with a complex floor plan and ventilation system. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Long Extended Space:	A long extended space, such as a below ground rail passageway or tunnel. *Major Types of Materials: Concrete, Brick & Block, Plastics, Glass, Metal*

Venue Considerations

Disclaimer: Multiple treatment methods may be used to decontaminate various surfaces and spaces. The US EPA NDT has attempted to identify the treatment methods that will most likely be used with this agent. The selected treatment methods are based on availability, cost, efficacy, residual development, and contact time. Other technologies are available and should be considered by response personnel as deemed necessary.

Treatment Methods:	*Chlorine Based Decontaminants*[2-9]	*mVHP* [7, 10, 11]	*Peroxide Based Decontaminants*[7, 12]
Preferred Venue(s):	Small building; Large & open facility	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space
Treatment Area:	Zonal Treatment	Whole Building	Zonal Treatment
Limitations:	Less effective on porous materials	Silicone and viton provide challenges	Hydrogen peroxide breaks down above 120°F
Sensitive Items:	Not Recommended; Highly corrosive	No visible effects on electronics	Can be used on equipment and non-fabric furnishings; may cause slight rusting of metallic surfaces.
Risk Level:			
Decontamination Considerations[9]	Spilt agent: Cover with vermiculite, diatomaceous earth, clay, fine sand, sponges, and paper or cloth towels. Treat with large amounts of aqueous sodium hydroxide solution (minimum 10 % by weight). Scoop decontaminated material and place in approved container. If aqueous sodium hydroxide is not available, use following in the order of preference: Sodium Carbonate, and Supertropical Bleach Slurry (STB).		
	Removal of porous material, including painted surfaces, that may have absorbed nerve agent liquid may be required as these materials could continue to re-release liquid and/or vapor after exposure has ceased.		

References:

1. NRT, U., *Quick Reference Guides (QRGs) for Chemical Warfare Agents - GB (Sarin), VX, and H/HD/HT (Sulfur Mustard).* 2007.
2. Chinn, K.S.K., *Effectiveness of U.S. Standard And Nonstandard Decontaminants and Decontamination Efficiency (u)*, U.S.A.D.P. GROUND, Editor. 1987, TECHNICAL ANALYSIS AND INFORMATION OFFICE. p. 1-68.
3. Yu-Chu Yang, J.A.B., and J. Richard Ward, *Decontarnination of Chemical Warfare Agents.* Chemical Reviews, 1992. 92(8): p. 1729-1743.
4. Nancy B. Munro, S.S.T., Guy D. Griffin, Larry C. Waters, Annetta P. Watson, Joseph F. King, and Veronique Hauschild, *The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products.* Environmental Health Perspectives, 1999. 107(12): p. 933-974.
5. Department of Army, U.S.A.E.C.B.C., Aberdeen Proving Ground, MD. , *US Army Material Safety Data Sheets for GB, HD, and VX.* 2004.
6. Services, D.o.H.a.H. *CDC Emergency Preparedness and Response website and associated agent fact sheets for sulfur mustard and nerve agents - CDC Agent Fact Sheet, NIOSH Emergency Response Fact Sheet, ATSDR Toxicology FAQs, ATSDR Toxicological Profile (sulfur mustard, 2003), Medical Management Guidelines (MMGs), Case Definition and Toxic Syndrome Description*. 2004 [cited; •]. Available from: http://www.bt.cdc.gov/agent/.
7. EPA, *Compilation of Available Data On Building Decontamination Alternatives*. 2005. p. 3, 23-31.
8. Department of Army, H., *Technical Escort Battalion Operations*, Headquarters, Editor. 2007. p. D-1-D-19.
9. Department of Health and Human Services, N.I.o.H., National Library of Medicine *WebWiser website: Vx – HazMat/CleanUp, Sarin – HazMat/CleanUp, Sulfur Mustard – HazMat/Cleanup*. 2008 [cited; Available from: http://webwiser.nlm.nih.gov/getHomeData.do.
10. George Wagner; Larry Procell; David Sorrick; Brian MacIver; Abe Turetsky; Jerry Pfarr; Diane Dutt; Mark Brickhouse; U. S. A. E. C. B. C., A., *Large Scale Tests of Vaporous Hydrogen Peroxide (VHP) for Chemical and Biological Weapons Decontamination*. 2004. p. 5.
11. Wagner GW, S.D., Procell LR, Brickhouse MD, McVey IF, Schwartz LI., *Decontamination of VX, GD, and HD on a surface using modified vaporized hydrogen peroxide. .* Langmuir, 2007. 23 (3): p. 1178–1186.
12. EFT Holdings, *Frequently Asked Questions*. 2009 [cited; Available from: http://www.envirofoam.com/EasyDecon/FactSheet.aspx?ID=17.

U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL DECONTAMINATION TEAM

DECONTAMINATION ANALYTICAL AND TECHNICAL SERVICE (DATS) CONTRACT

CONTRACT No.: EP-W-06-089
TDD No. TO-01-08-06-0022

Decontamination and Disposal Reference Guide: VX

April 23, 2009

Dynamac Technical POC:
Neil Daniell, DATS Scientist III

DYNAMAC® CORPORATION
4900 Olympic Boulevard
Erlanger, KY 41018

Decontamination and Disposal Reference Guide: VX

Chemical name: Ethyl {[2-[di(propan-2-yl)amino]ethylsulfanyl} methylphosphinate CAS Number: 50782-69-9
Agent Classification: Nerve Agent Abbreviation: VX

Disclaimer: The information contained in this document provides decontamination and disposal information only. For information on an agents physical properties, chemical properties, and health effects, please refer to the Nation Response Team Quick Response Guide. [1]

Methods of Decontamination

Methods	General Usage	Efficacy	Availability	Cost
Chlorine Based Decontaminants[2-9] High test hypochlorite (HTH) Clorox Bleach® (Bleach) Supertropical Bleach (STB)	Hard Surfaces & Soil; Large Flat Areas	Yes; Household bleach is less effective on V-series agents	Nonproprietary	Low
Modified Vaporous Hydrogen Peroxide (mVHP) [7, 10, 11]	Volumetric Surfaces; Sensitive Items	Good	Proprietary; STERIS	Moderate
Peroxide Based Decontaminants[7, 12] Decon Green MDF-200 EasyDECON® DF200	Various surfaces; Well contained and easily accessible; non-sensitive equipment, furnishings (nonfabric)	Good	Proprietary; Edgewood; Proprietary; Modec Inc. Proprietary; Envirofoam Technologies, Inc.	Moderate

Application of Treatment Method

Chlorine Based Decontaminants[2-9]

Application Requirements		Media Specific Applications	
Formulation:	Utilize a ratio of water and chlorine based decontaminant (HTH, STB, Chlorox®, etc.) necessary to prepare a decontamination solution with 5% available chlorine (50,000 ppm); Adjusted pH to 6 or lower.	Porous:	May be deployed as a spray, liquid, fog, or aerosol. Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse. Use of a steam vacuum will improve the effectiveness on porous materials. For VX decontamination to be effective, the pH must be low
Temperature:	Applied as a water based solution; Ambient temperatures of 25° C is sufficient		
Contact Time:	30-minute recommended	Non-Porous:	Application may be by hand sprayers, buckets, mops, rags, brushes, etc. followed by scrubbing and a water rinse.
Residuals:	Acidic solutions solubilize VX better and forms less EA2192. Alkaline hydrolysis of VX is more complete but does form more EA2192	Soil:	Degradation is greatly influenced by soil type, soil properties, the amount of moisture, and bacteria. Studies indicate that approximately 90% of VX is lost from soil in 15 days.

mVHP [7, 10, 11]

Application Requirements		Media Specific Applications	
Formulation:	Flash evaporate 500 ppm hydrogen peroxide + 30 ppm ammonia at relatively low humidity	Porous:	Portable mVHP unit used in combination with a tent system; A treatment chamber may be used for sensitive items
Temperature:	minimum of 30°C and 30% relative humidity		
Contact Time:	Hours	Non-Porous:	Same as above
Residuals:	No	Soil:	Not recommended

Peroxide Based Decontaminants[7, 12]

Application Requirements		Media Specific Applications	
Formulation:	Per manufacturers instructions	Porous:	Aqueous: Apply to the contaminated surface using a wipe (e.g., mop, sponge), and allowed to stand for a period of time. The solution is removed by wiping or wet vacuuming. Mist/Fog: Utilize commercial misting/fog machines. Fan driven air may be introduced behind the mist to propel it directionally Foam: Apply ½ inch foam using standard, commercially available paint sprayers; special nozzles may be utilized to draw air into the spray and increase foaming action.
Temperature:	Applied at room temperature (68 °F, or 20 °C); Foams work best under low to moderate humidity in a temperature range of 45° F to 85°F.;		
Contact Time:	15-minute to 1 hour recommended	Non-Porous:	Same as above.
Residuals:	No	Soil:	Not recommended.

Transportation and Disposal[6, 9]

Decon solutions need to be collected and tested for possible classification as hazwaste. If complete destruction of agent, items are NOT subject to HMR requirements; If incomplete destruction, utilize CFR § 173.133 - Toxic liquids, organic, n.o.s., Poison-Inhalation Hazard, 6.1, UN 2810, I, Zone A; Packaging exemptions listed in 49 CFR 107. D002 corrosive possible with high pH bleach solutions.

Decontamination & Disposal Reference Guides: VX

Side 2

Venue Descriptions

Small Building:	A residence or small business, without extensive sensitive electronics, & a similar sized structure that might contain materials or equipment of a potentially sensitive nature, such as electronics or telecommunications, works of art, etc. Major Types of Materials: Painted surfaces, *Wood, Brick & Block, Gypsum Board, Concrete, Plastics, Glass, Metal*
Large & Open Facility:	A relatively large & open facility, such as a sports arena, auditorium, conference center, or transportation terminal. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Large Multiple-Floored Building:	A large multiple-floored building with extensive compartmentalization into offices or residences with a complex floor plan and ventilation system. *Major Types of Materials: Brick & Block, Gypsum, Concrete, Plastics, Glass, Metal*
Long Extended Space:	A long extended space, such as a below ground rail passageway or tunnel. *Major Types of Materials: Concrete, Brick & Block, Plastics, Glass, Metal*

Venue Considerations

Disclaimer: Multiple treatment methods may be used to decontaminate various surfaces and spaces. The US EPA NDT has attempted to identify the treatment methods that will most likely be used with this agent. The selected treatment methods are based on availability, cost, efficacy, residual development, and contact time. Other technologies are available and should be considered by response personnel as deemed necessary.

Treatment Methods:	*Chlorine Based Decontaminants*[2-9]	*mVHP* [7, 10, 11]	*Peroxide Based Decontaminants*[7, 12]
Preferred Venue(s):	Small building; Large & open facility	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space	Small Building; Large & Open facility; Large Multiple-Floored Building; Long Extended Space
Treatment Area:	Zonal Treatment	Whole Building	Zonal Treatment
Limitations:	Less effective on porous materials;	Silicone and viton provide challenges	Hydrogen peroxide breaks down above 120°F
Sensitive Items:	Not Recommended; Highly corrosive	No visible effects on electronics	Can be used on equipment and non-fabric furnishings; may cause slight rusting of metallic surfaces.
Risk Level:			
Decontamination Considerations[9]	Cover spilt agent with vermiculite, diatomaceous earth, clay or fine sand. Large scale procedure (greater than 50 g) -- use both calcium hypochlorite (HTH) and NaOH. The small-scale decontamination procedure uses sufficient alcoholic HTH to oxidize. An alcoholic HTH mixture is prepared by adding 100 milliliters of denatured ethanol to a 900-milliliter slurry of 10% HTH in water just prior to use since the HTH can react with the ethanol. Mix 14 g of alcoholic HTH solution for each 1 g of VX and agitate as added for a minimum of 1 hr. The mixture will give off heat and gas which should be routed through a decontaminate filled scrubber before release through filtration systems.		
	Vaporized hydrogen peroxide (VHP) is effective against VX. Simple addition of ammonia gas to VHP further enhances efficacy for VX. Thus, modified VHP is a broad-spectrum decontaminant suitable for fumigant-type decontamination scenarios, i.e., building, aircraft, and vehicle interiors and sensitive equipment.		

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1. NRT, U., *Quick Reference Guides (QRGs) for Chemical Warfare Agents - GB (Sarin), VX, and H/HD/HT (Sulfur Mustard).* 2007.
2. Chinn, K.S.K., *Effectiveness of U.S. Standard And Nonstandard Decontaminants and Decontamination Efficiency (u)*, U.S.A.D.P. GROUND, Editor. 1987, TECHNICAL ANALYSIS AND INFORMATION OFFICE. p. 1-68.
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4. Nancy B. Munro, S.S.T., Guy D. Griffin, Larry C. Waters, Annetta P. Watson, Joseph F. King, and Veronique Hauschild, *The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products.* Environmental Health Perspectives, 1999. 107(12): p. 933-974.
5. Department of Army, U.S.A.E.C.B.C., Aberdeen Proving Ground, MD. , *US Army Material Safety Data Sheets for GB, HD, and VX.* 2004.
6. Services, D.o.H.a.H. *CDC Emergency Preparedness and Response website and associated agent fact sheets for sulfur mustard and nerve agents - CDC Agent Fact Sheet, NIOSH Emergency Response Fact Sheet, ATSDR Toxicology FAQs, ATSDR Toxicological Profile (sulfur mustard, 2003), Medical Management Guidelines (MMGs), Case Definition and Toxic Syndrome Description*. 2004 [cited; •]. Available from: http://www.bt.cdc.gov/agent/.
7. EPA, *Compilation of Available Data On Building Decontamination Alternatives*. 2005. p. 3, 23-31.
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9. Department of Health and Human Services, N.I.o.H., National Library of Medicine *WebWiser website: Vx – HazMat/CleanUp, Sarin – HazMat/CleanUp, Sulfur Mustard – HazMat/Cleanup*. 2008 [cited; Available from: http://webwiser.nlm.nih.gov/getHomeData.do.
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APPENDIX 7

GENERAL LIST OF WASTE DISPOSAL REGULATIONS
SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
Alabama	Federal only	Yes[b]		EPCRA planning and reporting
Alaska	Federal only	Yes[c]		Emergency release notification; Imminent danger response
Arizona	Federal only	Yes[b]	State-specific definition of *acute hazardous waste* follows RCRA statutory criteria (e.g., LD50).	EPCRA planning and reporting; Pollution prevention planning
Arkansas	Federal only	Yes[b]		Emergency release notification
California	Federal only	No	State definition of *hazardous waste* specifically includes chemical warfare agents. State definition of *characteristic toxic waste* and *extremely hazardous waste* also includes chemical weapons/agents.	Proposition 65 Toxic Chemical Warnings requirement includes mustard gas; Hertzberg-Alarcon California Prevention of Terrorism Act Regulation makes possession of chemical weapons illegal.
Colorado	Federal and: (1) Mustard gas H and HD (P909) (2) Mustard gas HT (P910) (3) Sarin (P911) (4) Waste chemical weapons and environmental media, debris, and contaminated containers (K901 and K902) (H)	Yes, selective, partial adoption[b]		Emergency release notification

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
Florida	Federal only	Yes[b]		EPCRA emergency release notification
Georgia	Federal only	Yes	A *designated hazardous waste* is any substance EPD concludes is capable of posing a substantial threat, if it contains substances from six lists of chemicals, including EPCRA's List of Lists, Appendix VIII to 40 CFR 261, and a List of Regulated Pesticides (40 CFR 180).	Emergency release notification; Corrective action requirements
Hawaii	Federal only	Yes		Emergency release notification
Idaho	Federal only	Yes[b]		EPCRA emergency release notification
Illinois	Federal only	Yes[b]		EPCRA emergency release notification
Indiana	Federal and: (1) GA (2) GB (3) H, HD (4) HT (60% HD and 40% T) (5) L (6) VX (I001)	Yes		Emergency release notification

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
Iowa	Federal only	Yes[c]		Emergency release notification; Hazardous condition response/ remediation
Kansas	Federal only	No		EPCRA emergency release notification; Kansas Emergency Management Act release notification
Kentucky	Federal and: (1) GB (N001) (2) VX (N002) (3) H (N003)	No		EPCRA planning and reporting
Louisiana	Federal	Yes		Contaminated site remediation; EPCRA planning and reporting
Maryland	Federal and: (1) GA and tabun (K991) (H) (2) GB and sarin (K992) (H) (3) GD and soman (K993) (H) (4) VX (K994) (H) (5) L and lewisite (K995) (H) (6) Adamsite (K996) (H) (7) Sulfur mustard HD (K997) (H) (8) T (K998) (H) (9) Waste military chemical warfare agents (chemical surety agents) having	No		Chemical surety materials are Class 1 Toxic Air Pollutants under MDE air quality regulations.

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
	substances K991 through K998 as active or principal ingredients or ingredients of K991 through K998 with a characteristic of hazardous waste (K999) (H) (10) Residues from the treatment of wastes K991 through K999 (MD02) (H)			
Massachusetts	Federal and: (1) Residues from incineration or thermal treatment of soil contaminated with halogenated organic carbon wastes (F028) (2) Waste oil (MA01) (3) PCBs equal to or greater than 50 ppm (MA02) (4) Waste generated in the manufacture of paint formulated with ingredients which are listed as hazardous constituents (MA04) (5) Any waste that meets the MDEP criteria of hazardous waste and poses an imminent threat (MA00)	No		Emergency release notification and remediation activities, specifically including the release of chemical weapons or chemical warfare agents

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
Michigan	Federal and: (1) Mustard gas (093U)	Yes[b]		EPCRA emergency release notification; Michigan polluting material release notification, which includes phosgene and mustard gas
Mississippi	Federal only	Yes[b]		Hazardous waste minimization planning
Missouri	Federal and: (1) Any residue or contaminated soil, water, or other debris resulting from the cleanup of a spill of HOC wastes (MH01) (2) 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (MH02)	No		Emergency release notification
Nebraska	Federal only	No		EPCRA emergency release notification
Nevada	Federal only	Yes		EPCRA emergency release notification
New Jersey	Federal only	Yes[b]		EPCRA emergency release notification, and additional NJ hazardous substance release notification, including

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
				phosgene, mustard gas, sarin, tabun, VX, and GB
New Mexico	Federal only	Yes[b]		EPCRA emergency release notification; Notification to NM Dept. of Health of any illness suspected to be caused by the intentional or accidental release of biologic or chemical agents
New York	Federal and: (1) PCB wastes (B001–B007)	Yes[b]		Emergency release notification (chemical agents specifically listed)
North Carolina	Federal only	Yes[b]		Emergency release notification
Ohio	Federal only	No		EPCRA emergency release notification
Oregon	Federal and: (1) HD and HT (blister agents) (P998) (2) GB and VX (nerve agents) (P999) (3) Residues from demilitarization, treatment, and testing of blister agents (such as mustard agent) (F998)	Yes, with additional stricter require-ments for chemical agents[b]	State-specific definition of *demilitarization* and *demilitarization residue*	Emergency release notification (specifically references chemical agents); Special regulations for remediation and recovery activities at facilities used for storage and disposal of chemical agents

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
	(4) Residues from demilitarization, treatment, and testing of nerve agents (such as GB [sarin] and VX) (F999) (5) Any residue that contains 3% or greater concentration of P-coded wastes or 10% or greater concentration of U-coded wastes or any residue or contaminated soil, water or debris resulting from the cleanup of a spill of P- or U-coded wastes into or on any land or water (e.g., ORP095, ORP998, ORP999)			
Pennsylvania	Federal only	Yes		EPCRA emergency release notification; Public sector employers (not governmental) must post hazardous substance survey form every year if using listed hazardous substances, including phosgene, tabun, sarin, mustard gas, lewisite, and VX.
South Carolina	Federal and: (1) Any solid waste the Department (SCDHEC) determines constitutes a	Yes[b]		EPCRA emergency release notification

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
	hazard and requires greater control (Section 5555)			
South Dakota	Federal only	Yes[b]		Emergency release notification (specific references to warfare chemical agents)
Tennessee	Federal only	Yes		EPCRA planning and reporting
Texas	Federal only	Yes[b]	Chemical weapons or chemical warfare agents could be designated Class 1 nonhazardous wastes.	Emergency release notification
Utah	Federal and: (1) Residues from demilitarization, treatment, and testing of nerve, military, and chemical agents CX, GA, GB, GD, H, HD, HL, HN-1, HN-2, HN-3, HT, L, T, and VX (F999) (H) (2) Nerve, military, and chemical agents (i.e., CX, GA, GB, GD, H, HD, HL, HN-1, HN-2, HN-3, HT, L, T, and VX) (P999)	No		Emergency release notification
Virgin Islands (United States)	Federal only	Yes[c]		EPCRA emergency release notification

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
Virginia	Federal only	Yes[b]		EPCRA emergency release notification
Washington	Federal and: (1) Toxic Dangerous Waste – NIOSH RTECS (or available data) or 100 mg/L acute static fish test or 5,000 mg/kg oral rat test (mixtures by equivalent concentration) (WT02) (2) Extremely Hazardous Waste – NIOSH RTECS (or available data) or 100 mg/L fish bioassay or 50 mg/kg rat bioassay (mixtures by equivalent concentration) (WT01) (3) HOC Persistent Dangerous Waste – 0.01% to 1.0% HOC (WP02) (4) HOC Persistent Extremely Hazardous Waste – greater than 1.0% HOC (WP01) (5) PAH Persistent Extremely Hazardous Waste – greater than 1.0% PAH (WP03) (6) Special Wastes – solid-only corrosive wastes, toxic wastes (less than 0.1% equivalent concentration of	Yes[b]		EPCRA emergency release notification

SUMMARY OF APPLICABLE PROVISIONS IN 40 STATES AND JURISDICTIONS
Statutory or Regulatory Provisions Applicable to Waste Chemical Weapons or Chemical Warfare Agents (Cont.)

State	Federal and State Listed Hazardous Waste Designation[a]	Military Munitions Rule in Effect?	Other State-Specific Hazardous Waste Regulations	Other Potentially Applicable Non-RCRA Regulations
	toxic dangerous waste), PCB waste, and persistent but not extremely hazardous waste (less than 1.0% PAH)			
Washington, D.C.	Federal only	Yes[b]		EPCRA emergency release notification
Wyoming	Federal only	No		EPCRA release notification and release of any hazardous substance that enters the waters of the state, including any substance, which after release, constitutes a threat to public health or welfare, or other aquatic life or wildlife because of its quantity, concentration, chemical, corrosive, flammable, reactive, toxic, infectious, or radioactive characteristics

[a] The only chemical agent listed as a federal hazardous waste is phosgene (EPA Hazardous Waste Number P095). All listed wastes designated with a P waste code are acute hazardous wastes. Listed wastes from specific or nonspecific sources (K- and F-coded wastes) that have been designated as acute hazardous wastes are indicated with an (H). Also, wastes may exhibit one or more of the RCRA hazardous waste characteristics.

[b] State has adopted all or part of the EPA regulations; however, EPA authorization has not been granted.

[c] State has not received EPA authorization for its RCRA program; therefore, EPA Regional Office implements and enforces RCRA in the state.

APPENDIX 8

WASTE DISPOSAL

Table 1 – Inhalation Exposure Guidelines for Selected CWAs

Table 2 - Environmental Screening and Exposure Guidelines for Selected CWAs

Table 1 – Inhalation Exposure Guidelines for Selected CWAs

Guideline	Duration (hr)	Sarin (mg/m3)	Sulfur Mustard (mg/m3)	Lewisite (mg/m3)	VX (mg/m3)
IDLH[1]	0.5	0.1	0.7	0.36	0.003
STEL[1]	0.25	0.0001	0.003	NA	0.00001
AEGL-1[2]	0.17	0.0069	0.4	NA	0.00057
AEGL-1	0.5	0.004	0.13	NA	0.00033
AEGL-1	1	0.0028	0.067	NA	0.00017
AEGL-1	4	0.0014	0.017	NA	0.00010
AEGL-1	8	0.001	0.0083	NA	0.000071
AEGL-2	0.17	0.087	0.6	NA	0.0072
AEGL-2	0.5	0.05	0.2	0.47	0.0042
AEGL-2	1	0.035	0.1	0.25	0.0029
AEGL-2	4	0.017	0.025	0.070	0.0015
AEGL-2	8	0.013	0.013	0.037	0.0010
AEGL-3	0.17	0.38	3.9	3.9	0.029
AEGL-3	0.5	0.19	2.7	1.4	0.015
AEGL-3	1	0.13	2.1	0.74	0.010
AEGL-3	4	0.07	0.53	0.21	0.0052
AEGL-3	8	0.051	0.27	0.11	0.0038
PAL-1[3]	24	0.0002	0.0008	NA	0.000017
PAL-1	720	0.000018	0.0001	NA	0.0000018
PAL-1	2160	0.000018	0.0001	NA	NA
PAL-2	24	0.001	0.013	0.01	0.00063
PAL-2	720	0.00073	0.0029	NA	0.000073
PAL-2	2160	0.0002	0.00097	NA	NA
PAL-3	24	0.015	0.35	0.037	0.0022
PAL-3	720	NA	NA	NA	NA
PAL-3	2160	NA	NA	NA	NA
MRL acute [4]	24	NA	0.0007	NA	NA
MRL acute	336	NA	0.0007	NA	NA
MRL intermed.	360	NA	0.00002	NA	NA
MRL intermed.	8760	NA	0.00002	NA	NA
WPL	8760	0.00003	0.0004	NA	0.000001
WPL[1]	219000	0.00003	0.0004	NA	0.000001
GPL	8760	0.000001	0.00002	NA	0.0000007
GPL[1]	613200	0.000001	0.00002	NA	0.0000007

NA = not available

[1] Chemical Exposure Guidelines - available at http://cdc.gov/NIOSH/ershdb/index_name.htm

[2] Acute Exposure Guideline Levels (AEGLs) – available at http://www.epa.gov/opptintr/aegl/

[3] Provisional Advisory Levels (PAL) – available at http://www.epa.gov/nhsrc/index.html

[4] ATSDR Minimal Risk Levels (MRL) – available at http://www.atsdr.cdc.gov/mrls

Table 2 - Environmental Screening and Exposure Guidelines for Selected CWAs					
Drinking Water - (µg/L)	Duration	Sarin	Mustard	Lewisite	VX
RBC [1]	Lifetime	0.7	0.25	3.5	0.021
MEG 5L/day [2]	7 years	28	140	28	15
MEG 15L/day	7 years	9.3	47	27	8
PAL-1 2L/day [3]	1 day	37	NA	NA	2.7
PAL-1 2L/day	30 days	8.1	NA	NA	0.21
PAL-1 2L/day	90 days	2	NA	NA	0.21
Soil - (mg/kg)	Duration	Sarin	Mustard	Lewisite	VX
PRG – Residential [4]	Lifetime	1.3	0.01	0.3	0.042
PRG – Industrial	24 years	32	0.3	3.7	1.1
Surface - (µg/cm^2)	Duration	Sarin	Mustard	Lewisite	VX
PRG Residential [5]	Lifetime	4.3×10^{-3}	8.1×10^{-5}	6.0×10^{-2}	1.3×10^{-4}
PRG Occupational	24 years	1.2×10^{-2}	2.2×10^{-4}	2.0×10^{-2}	3.6×10^{-4}

1. Risk Based Criteria (RBCs) - values calculated for chronic exposure calculated akin to EPA's Maximum Contaminant Levels (MCLs), see: http://water.epa.gov/drink/contaminants/index.cfm
2. Military Exposure Guidelines (MEG), The Medical NBC Battle Book, Technical Guide 244, USACHPPM, 2008
3. Provisional Advisory Levels, no adverse effects (PAL-1) - available at http://www.epa.gov/nhsrc/index.html
4. Preliminary Remediation Goals (PRG) risk based goals for soils - available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
5. Preliminary Remediation Goals (PRG), risk based goals for surfaces calculated via EPA's Risk Assessment Guide for Superfund (RAGS) methodologies, available at http://www.epa.gov/oswer/riskassessment/ragse/

NA Not available due to rapid decomposition of agent in water