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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

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MEMORANDUM FOR SEE DISTRIBUTION LIST

FROM: HQ USAF/A7C
1260 Air Force Pentagon
Washington, DC 20330-1260

SUBJECT: Guidance on 1,4 Dioxane, Environmental Restoration Program

This memorandum serves as Air Staff guidance for responding in a standardized way to 1,4 Dioxane, a solvent stabilizer. Some regulatory agencies have expressed concerns regarding 1,4 Dioxane during the cleanup process. Due to evolving science and regulatory standards, 1,4 Dioxane presents a potentially unacceptable human health or environmental risk. As a result, the Air Force will respond to 1,4 Dioxane subject to DoDI 4715.18, *Emerging Contaminants*. The following actions apply:

a. AFCEC and the NGB should implement the DoDI and the attached guidance at active installations, BRAC installations, transferring properties, GOCO properties, NGB properties, other than operational ranges and active ranges (for the non-munitions constituents) accordingly by providing technical guidance to the MAJCOMs and installations as necessary.

b. AFCEC and the NGB should program and budget for appropriate response actions when warranted.

MAJCOMs and installations should refer requests for sampling and other response actions to Mr. William Ryan, AFCEC/CZR, DSN 969-8783, william.ryan.1@us.af.mil. NGB installations should contact Mr. Russ Dyer, NGB/A7OR, DSN 612-8149, russell.dyer@ang.af.mil. and BRAC installations should contact Dr. Steve Termaath, AFCEC/CIB, DSN 969-9428, stephen.termaath@us.af.mil. Any further questions on Emerging Contaminants should be addressed to Ms. Elaine Ross, A7CEV, DSN 612-4260, elaine.ross@pentagon.af.mil.

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The Deputy Civil Engineer
DCS/Logistics, Installations & Mission Support

Attachment:
Interim AF Guidance On Sampling and Response Actions for 1,4-Dioxane at Operational and BRAC Installations

cc:
HQ ACC/A7
HQ AETC/A4/7
HQ AFMC/A6/7
HQ AFRC/A7
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Interim
Air Force Guidance
On Sampling and Response Actions for
1,4-Dioxane at Operational and BRAC Installations

Summary. Consistent with DoDI 4715.18, *Emerging Contaminants*, 1,4-dioxane is considered to be an Air Force emerging contaminant based on changing health screening levels. 1, 4-Dioxane is a "listed" Comprehensive Environmental Response Compensation and Liabilities Act (CERCLA) "hazardous substance" and, thus, the Air Force has an obligation to address environmental releases of 1,4-dioxane above unacceptable risk levels. However, there is currently no federally promulgated regulatory cleanup level.

EPA is currently collecting drinking water occurrence and exposure data to determine if establishment of a maximum contaminant level (MCL) is warranted under the Safe Drinking Water Act based on the occurrence of 1,4-dioxane in drinking water, the number of people potentially being exposed, and observed exposure levels. EPA's 2010 Integrated Risk Information System toxicity assessment has been extrapolated by three EPA Regions[1] to yield a residential tap water screening level of 0.67 µg/L and a soil screening level of 4.9 mg/kg. Additionally, several state governments have implemented screening levels and/or standards for characterizing and remediating 1,4-dioxane, particularly for groundwater contamination; however, few states have promulgated standards or applicable or relevant and appropriate requirements (ARARs).

1. Purpose. The Air Force has developed this guidance to promote consistent response actions applicable to both operational and Base Realignment and Closure (BRAC) installations and to facilitate identification of funding requirements for needed actions for AFCEC Restoration Program Management Office programming purposes. This guidance accomplishes the following:

A. Establishes an Air Force enterprise-wide strategy for sampling and response actions for 1,4-dioxane at applicable Environmental Restoration Program (ERP) sites

B. Provides supporting technical information for analysis and risk assessment.

It will be updated on a periodic basis to reflect applicable regulatory changes.

2. Applicability. This guidance excludes ERP sites in response complete (RC), long-term monitoring (LTM), or site closeout (SC) phases per DoDM 4715.20 (*Defense Environmental Restoration Program Management)* and ERP sites on transferred property for which the Air Force no longer has primary responsibility for restoration activities. Also excluded are sites that have ongoing response actions addressing 1,4 dioxane or those that have already tested for 1,4 dioxane using analytical methods with appropriate detection limits (see attachment 1). Specifically included in this guidance are ERP sites

[1] Available: http://www.epa.gov/region9/superfund//prg/index.html

in remedial action operation (RA-O) or earlier phases with any historic validated detection of 1,1,1-trichloroethane (TCA); the TCA degradation products 1,1-dichloroethane (DCA) or 1,1-dichloroethene (DCE); or trichloroethylene (TCE) in groundwater. These sites constitute "applicable sites" for the purpose of this guidance.

3. Process. At ERP sites currently conducting response actions to address 1,4-dioxane, investigations and/or remedial actions will continue according to legal requirements as determined through the applicable cleanup framework (normally CERCLA or RCRA). At remaining "applicable sites," the Air Force should apply the following three steps to evaluate 1,4-dioxane under this guidance:

Step 1. Determine if a release of 1,4-dioxane has occurred;

Step 2. Characterize the extent of release if 1,4-dioxane is present; and

Step 3. Determine if potential response action is warranted based on an unacceptable risk to human health.

Air Force personnel should re-evaluate the characterization and protectiveness of response actions, if any, regarding 1,4-dioxane at applicable sites during five-year reviews. Air Force personnel should also re-evaluate whether there have been promulgated regulations or ARARs in the intervening period and determine if compliance with the new standard would be deemed necessary to achieve protectiveness.

A. **New Regulatory Requests for Sampling.**

i. Upon receiving a new request to sample for 1,4-dioxane, the installation must notify AFCEC/CZR (operational installations) or AFCEC/CIB (BRAC installations) prior to any 1,4-dioxane-related sampling action.

ii. A request for sampling must be in writing (letter or e-mail) from a regulatory agency having jurisdiction over restoration activities or the potentially affected resource, and it must cite the local, state, or federal statute, regulation, or written agreement justifying the request.

iii. The Restoration Program Manager (RPM) or Base Environmental Coordinator (BEC) will coordinate and obtain authorization from the AFCEC/CZR (operational installations), or AFCEC/CIB (BRAC installations). AFCEC/CZR or AFCEC/CIB will validate the legal basis for any requested sampling with AFLOA/JACE-FSC, verify reasonably suspected basis to suspect release, and coordinate technical issues with AFCEC/CZTE before authorizing sampling.

iv. If the request for testing involves an Air Force drinking water supply, the RPM will coordinate with the base BE in addition to AFCEC/CZR.

v. Initial sampling (Step One), when authorized, should be a one-time event to determine if 1,4-dioxane is present in the environment as a result of Air Force-related activities. The quality assurance project plan (QAPP) for the field efforts should comply with the technical guidance in Attachment 1.

B. **Air Force ERP Enterprise-Wide Response to 1,4-Dioxane .** The Air Force will address potential release of 1,4-dioxane at applicable sites as defined above in Section 2.

i. **Step One**. Confirm release of 1,4-dioxane only at sites meeting the applicability criteria above.

1) Air Force RPMs or BECs in the United States, at "applicable sites" must prepare a schedule and Project Cost Estimating Assumptions Document (PCEAD) to program funds for Step One, 1,4-dioxane release confirmation, following AFCEC/CZR guidance. AFCEC/CZR (operational installations) or AFCEC/CIB (BRAC installations) will coordinate and validate the program funding requests and coordinate technical issues with AFCECE/CZTE before authorizing sampling.

2) At "applicable sites" with groundwater contamination impacting drinking water supply wells, Air Force RPMs or BECs in the United States should program funds for release confirmation at the earliest achievable date and, if warranted, continue with Step Two (additional characterization) and Step Three (potential response action) and shall consider whether time-critical removal action (or the RCRA equivalent) is warranted.

3) Confirmation sampling will include collection and analysis of approximately three existing groundwater monitoring wells (GMW) along the axis of the applicable chlorinated solvent plume at each site: one sample from an existing GMW, located as close as possible to known source contamination; one additional sample from an existing GMW at the down gradient limit of plume migration; and another sample from an existing GMW beyond the plume limit. Sample locations will be selected along the axis of primary groundwater flow direction. It is assumed that results of prior investigation(s) will inform work planning. Sampling activities will be programmed and executed according to the current site status.

4) Data collected from sampling should be of sufficient quality and quantity to definitively assess occurrence of 1,4-dioxane. Data collection must comply with the Uniform Federal Policy UFP-QAPP; data must meet minimum requirements defined in the DoD Quality Systems Manual, current version; and laboratories used for analysis must be accredited by the DoD Environmental Laboratory Accreditation Program (ELAP). It is anticipated that existing work plans at active sites can be adapted to incorporate sampling

and analysis for 1,4-dioxane. Please refer to Attachment 1 "Technical Support Information: Section 4" for information on analytical methods and data quality references.

5) Confirmation of release will be based on measured concentrations in groundwater above the EPA residential tap water screening level of 0.67 µg/L.

6) Once detection over the screening level has been confirmed, the RPM and applicable Air Force offices shall coordinate with regulatory agencies as required and appropriate under the applicable cleanup framework (normally CERCLA or RCRA). At operational installations, notify the installation BE that additional sampling is warranted. If no installation BE exists, then notify USAFSAM/OE.

ii. **Step Two.** If 1,4-dioxane is present, characterize the extent of release.

1) For purposes of this guidance "characterization" is defined as determining the length, depth, and width of contaminant impact(s) to soil and groundwater. The extent of release will be defined by the EPA residential tap water screening level of 0.67 µg/L in groundwater and a soil screening level of 4.9 mg/kg. Results of characterization will support evaluation of potential risk of human exposure to 1,4-dioxane consistent with an appropriate conceptual site model. It is assumed that site-specific information and prior investigation(s) will inform work planning. See "Technical Support Information: Section 5" for information on risk evaluation and pathway assessment.

2) The RPM or BEC will prepare follow-on PCEADs to characterize the nature and extent of 1,4-dioxane release and to evaluate risk to human health. AFCEC/CZR (operational installations) or AFCEC/CIB (BRAC installations) will validate Step Two funding requests and coordinate technical issues with AFCEC/CZTE.

3) When Step Two results indicate potential human exposure at operational installations, the RPM will coordinate with the installation BE flight if there is potential contamination of an Air Force drinking water supply. At BRAC installations, the BEC shall coordinate with regulatory agencies as required and appropriate under the applicable cleanup framework (normally CERCLA or RCRA).

iii. **Step Three**. Potential response action.

1) The decision to conduct a response action should be based on a determination of unacceptable human health risk documented through an appropriate remedy selection document (for example, a removal action memorandum or Record of Decision under CERCLA or a Corrective Measures Study, Statement of Basis,

or Corrective Measures Implementation Plan under RCRA). For discussion of potential response actions see "Technical Support Information, Section 3."

2) At operational installations, restoration staff must coordinate results of environmental sampling with the installation's SG when knowledge gained from environmental investigation indicates a drinking water supply may be impacted. At BRAC installations, the BEC shall coordinate with regulatory agencies as required and appropriate under the applicable cleanup framework (normally CERCLA or RCRA).

3) Programming funds for response actions will be considered at sites where the extent of release is sufficiently delineated and a human exposure pathway is complete that shows unacceptable risk to human health. Requests for funding will be prioritized using the following criteria:

   a) Applicable ERP sites that negatively impact drinking water supply wells or, based on fate and transport assessment, are expected to have an impact within five years.

   b) Applicable sites with an active pump and treat system with reinjection up gradient of an active drinking water supply well. In addition to groundwater sampling, evaluate the treatment system effluent and discharge pathway.

   c) Remaining applicable sites.

4) When characterization and pathway assessment indicate a response action is warranted, consult with AFCEC/CZR (operational installations), and AFCEC/CIB (BRAC installations) to determine how programming and execution of the response action will be accomplished.

5) Programming funds for response actions will be approved by AFCEC/CZR or AFCEC/CIB on a case-specific basis.

4. Reporting and Data Management. Operational and BRAC installations will submit data on 1,4-dioxane sampling (e.g., location and media sampled, results) to AFCEC/CZRA (ERPIMS data group). AFCEC/CZR, in coordination with AFCEC/CZTE, will validate the accuracy of the data and compliance with Air Force and DoD policies. All validated 1,4-dioxane sampling data submitted to ERPIMS and reports of potential release investigations submitted to AFCEC/CZR will be retained as part of the installation or BRAC Administrative Record.

5. Public Affairs. Development of a strategic communications plan shall begin if presence of 1,4 dioxane is confirmed at Step One. At operational installations, any communication with the public and/or the media regarding potential or confirmed 1,4-dioxane contamination shall be reviewed and approved prior to release by the BE flight and the Air Force Public Affairs office responsible for the installation in question. Any

communication with the public and/or media regarding potential or confirmed 1,4-dioxane contamination at BRAC installations shall follow proper AFCEC/CIB channels. AFCEC/CZR (operational installations) and AFLOA/JACE-FSC must also review and approve communication with the public and/or the media before release. The responsible Public Affairs office shall furnish a copy of this information to SAF/PAO. Risk communication support will be considered during response planning and implementation for sites involving human exposure when appropriate. AFCEC/CZR and AFCEC/CI will develop generic communications materials that can be tailored for installation-specific situations.

Attachment1: Supporting Technical Information

1. Background. 1,4-dioxane is a cyclic ether with many current and former industrial applications. Most relevant to the Air Force ERP is the historic use as an additive to chlorinated solvent formulations, primarily TCA, to increase shelf live and prevent corrosion of metal surfaces during various degreasing operations (known to concentrate trace-level additives). 1,4-Dioxane is a listed CERCLA hazardous substance. The Office of the Secretary of Defense (OSD) Materials of Evolving Regulatory Interest Team (MERIT) Phase I assessment rated 1,4-dioxane as "high risk" to DoD Cleanup programs in 2007, and since then, the Air Force Emerging Issues Program has evaluated the potential impact of 1,4-dioxane on the Air Force ERP.

2. Regulatory Authority and Management for 1,4-dioxane. 1,4-dioxane may be regulated as either F or U coded waste under RCRA (per 40 CFR Part 261.33 and 40 CFR Part 261.31). If responding under RCRA, consult an environmental attorney. 1,4-dioxane is a "listed" CERCLA "hazardous substance" (40 CFR 302.4) and has a Reportable Quantity (RQ) under CERCLA and Emergency Planning and Community Right-to-Know Act (EPCRA). 1,4-dioxane is also regulated as a Hazardous Air Pollutant (HAP) under the Clean Air Act. RCRA corrective actions and/or CERCLA response actions require consideration of the USEPA Integrated Risk Information System (IRIS) toxicity values. The EPA 1,4-dioxane IRIS evaluation for oral exposures was finalized in 2010 and three EPA Regions have extrapolated that value into groundwater and soil screening levels. In addition, several states have established cleanup levels based on drinking water action levels and health advisories. These levels vary between 0.35 and 50 ug/L. RPMs and BECs should ensure the hierarchy of provisional toxicity values established in DoDI 4715.18 is followed when determining applicable screening and cleanup levels.

3. Remediation Technologies. Because of its physical and chemical properties (high miscibility in water and low adsorption factor), 1,4-dioxane is not amenable to conventional ex-situ treatment technologies used for chlorinated solvents, nor does it readily biodegrade in environmental media. In general, the physical properties of 1,4-dioxane promote substantial migration in groundwater from release areas. Currently, advanced oxidation processes using hydrogen peroxide with ultraviolet light or ozone are generally recognized as the most efficient remediation technologies in groundwater. Other groundwater remediation technologies such as enhanced biological degradation using ex-situ bioreactor technology or filtration treatment by granular activated carbon are technically feasible but efficiency is limited. Interim response actions to reduce risk may include plume migration control, discontinuing use of supply well(s), provision of alternate drinking water supply, land use controls, or installation of validated remediation technologies for 1,4-dioxane (e.g., advanced oxidation processes).

4. Analysis. Traditionally, the analysis of 1,4-dioxane has been performed using purge and trap techniques in conjunction with a gas chromatograph/mass spectrometer (GC/MS) (e.g., EPA Method 8260); however, because 1,4-dioxane has high water solubility, the purging efficiency is poor, leading to low recoveries, and elevated

detection and quantitation limits. Other methods employing liquid-liquid extraction, vacuum distillation, and solid phase extraction yield higher recoveries as well as lower detection limits. The analysis selected will depend on programmatic and regulatory requirements, ability to achieve detection and quantitation limits that are below required regional screening levels (RSL), and site-specific considerations that may influence the analysis of the sample.

A. For drinking water samples, EPA Method 522 should be used. It employs a solid phase extraction and the gas chromatography–mass spectrometry (GC-MS) is operated in Selective Ion Monitoring (SIM) mode. Method 522 is the most sensitive of the 1,4-dioxane methods and is able to achieve the 0.67 µg/L RSL.

B. For other environmental samples (soils, groundwater, surface water), low detection limits are accomplished most often using EPA Method 8270 (a liquid-liquid extraction), in conjunction with isotope dilution and SIM mode. It should be noted that 1,4-dioxane is not in the method 8270 analyte list. Laboratories using this method can often achieve 1.0 µg/L and may be able to achieve the required RSL, although this method is not as sensitive as Method 522.

   Some labs and regulatory programs have modified the Method 522 for the analysis of groundwater. These modifications are necessary to accommodate routine groundwater sampling and preservation techniques while still adhering to procedural and quality control requirements of Method 522. Per the method, accuracy and precision data were generated in reagent water, finished ground and surface waters. Unfinished water from groundwater or surface water sources may contain matrix interferences. If Method 522 is used for these matrices, the laboratory should be consulted on their ability to achieve project required detection limits as well as any possible modifications to the method to overcome interferences.

   Another method that may achieve low quantitation limits is EPA Method 8261, which employs vacuum distillation in combination with GC/MS. However, this method is less common and few labs may be accredited for this method. Consult with AFCEC/CZTE for laboratory availability.

Table 1 – Recommended Methods for 1,4-Dioxane Analysis

Matrix	Method	Limit of Detection	Limit of Quantitation
Soil	EPA SW 846 Method 8270	0.0234 - 0.33 mg/kg	0.0667 - 0.33 mg/kg
	EPA SW 846 Method 8270SIM	0.01 - 0.05 mg/kg	0.02 - 0.1 mg/kg
	EPA SW 846 Method 8260	0.025 - 0.25 mg/kg	0.05 - 1 mg/kg

Water	EPA 522 (Approved for DW, can be used for groundwater)	<0.025 µg/L	<0.05 µg/L
	EPA SW 846 Method 8270 Modified	0.25 µg/L	1.0 µg/L
	EPA SW 846 Method 8270	0.324 - 10 µg/L	1.0 - 10 µg/L
	EPA Method 625 (Validated for waste water)	0.324 - 10 µg/L	1.0 - 10 µg/L
	EPA SW 846 Method 8270SIM	0.4 - 1 µg/L	1 - 3 µg/L
	EPA SW 846 Method 8260	1.5 - 320 µg/L	3 - 1000 µg/L
	EPA SW 846 Method 8260SIM	1 µg/L	2 µg/L

Should installation RPMs or BEs or BRAC BECs have questions or concerns regarding sample collection techniques, sample volumes required, analysis method, etc., prior to conducting 1,4-dioxane sampling, they should contact AFCEC/CZTE or the approved laboratory conducting the analyses. If groundwater sample concentrations of 1,4-dioxane are found to exceed 0.67 µg/L, they should consult with AFCEC/CZR (operational installations) or AFCEC/CIB (BRAC installations) to determine a recommended course of action. The table above lists the limit of detection (LOD) and limit of quantification (LOQ) for each recommended analytical method.

5. Risk Evaluation and Pathway Assessment. When warranted, a site-specific risk assessment will be accomplished to evaluate the extent of actual or potential exposure and risk.

A. The most current risk-based EPA Regional Screening Levels (RSL), based on recent USEPA IRIS "Tier 1" toxicity values, are appropriate for screening-level human health risk assessments. Screening levels from the EPA RSL Summary Table (November 2012) are as follows:

1. Resident soil 4.9 mg/kg

2. Industrial soil 17 mg/kg

3. Tap water 0.67 µg/L

These levels are appropriate to use for screening out applicable sites (i.e., if samples show results below these levels, one can apply the RSLs as a surrogate for site-specific risk assessment to conclude that no further action is needed). If detected levels are above these RSLs, the installation should apply the normal processes under CERCLA or RCRA (usually including a site-specific risk assessment) to determine whether response or corrective action is necessary.

B. State regulatory agencies may have also established their own advisory/guidance levels for 1,4-dioxane in drinking water, groundwater, or soil, or have set enforceable remedial objectives (e.g., 0.35 µg/L in drinking water in Colorado). Consult AFLOA/JACE-FSC for assistance in determining whether such levels are ARARs under CERCLA or enforceable via RCRA corrective action.

C. Pathway assessment shall include the development of a conceptual site model (CSM) to verify and evaluate completed exposure pathways. At a minimum, CSMs should accomplish the following:

1. Determine whether a release of 1,4-dioxane has occurred and determine if a drinking water source has been or may be impacted.

2. Verify whether any likely impacted drinking water systems on or near the Air Force installation have been sampled for 1,4-dioxane.

3. Establish through personal knowledge/interviews and record searches whether any soil or sediment potentially contaminated with 1,4-dioxane that may threaten public health, although 1,4-dioxane readily leaches through soil, has or could be used for material, topsoil, or other uses on or off the installation.

4. Review existing documentation of environmental sampling/testing and/or hydrogeological investigations conducted for other contaminants at the site and other relevant information provided by personnel. Determine the direction of groundwater flow and proximity of potential 1,4-dioxane sources to drinking water wells on and/or off the Air Force installation. Note: sampling and analysis for 1,4-dioxane has not always been accomplished during previous investigations using analytical methods with detection limits sensitive enough to detect the screening value.

5. Confirm that an actual exposure pathway exists from source to receptor.

6. Provide data to regulators and the public, as appropriate, to discuss potential exposure scenarios and pathways.

6. Remedial Investigation/Site-Specific Risk Assessment. The EPA Integrated Risk Information System (IRIS) program oral cancer and non-cancer Tier 1 toxicity values for 1,4-dioxane will be used for site-specific risk assessment purposes; however, toxicity values are the focus of significant scientific debate and are subject to change.

A. The following toxicity values are based on the US EPA IRIS assessment (as of Aug 2012):

1. Noncancer RfD 0.03 mg/kg-day

2. Oral Cancer Slope Factor 1x10-1 per mg/kg-day

B. Any site-specific risk assessment will be based on delineation of the release (extent of impact to soil and groundwater at the site) and appropriate site-specific assumptions about exposure.

C. Where a site-specific risk assessment indicates 1,4-dioxane concentrations could potentially result in unacceptable risk, the site will be prioritized for potential response action in accordance with the DoD relative risk assessment process. Risk shall be assessed using the toxicity values approved by AFCEC/CZTE in accordance with DoDI 4715.18 Enclosure 3, unless there are promulgated ARARs that dictate the use of another value. Coordinate with AFCEC/CZR (active installations), AFCEC/CIB (BRAC installations), and AFCEC/CZTE to identify the most scientifically valid and appropriate toxicity values and risk assessment methodologies.