Data Needed for the Public Health Assessment (PHA) Process

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Atlanta, Georgia 30333

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INTRODUCTION

ATSDR's approach for examining sampling data during the public health assessment (PHA) process is discussed in depth in the Selecting the Sampling Data section of ATSDR's Public Health Assessment Guidance Manual (PHAGM). Health assessors need to refer to that guidance when examining data for their sites.

This companion reference document describes some of the general site information and data that ATSDR usually obtains during the PHA process. Sources for this information often include the U.S. Environmental Protection Agency (EPA), the potentially responsible party (PRP), or other agencies responsible for conducting environmental investigations. This document is intended for use by not only health assessors, but also by EPA Remedial Project Managers (RPMs), Federal Facility Installation Restoration Program Managers, ATSDR Regional Representatives, potentially responsible parties (PRPs), and others involved in collecting data used in the PHA process.

Recognizing that data are collected at hazardous waste sites for a variety of purposes, ATSDR has focused this guidance on the needs of the environmental public health professional. This guidance is not intended to supplant the professional judgment and discretion of those responsible for sampling and monitoring the environment. Instead, it supplements the sampling guidance in ATSDR's PHAGM and provides a framework for further discussion among health assessors and environmental risk managers.

During the PHA process, ATSDR evaluates data and information on the release of hazardous substances into the environment to assess any past, current, or future effects on public health, to develop health advisories or other recommendations, and to identify studies or actions needed to evaluate and mitigate or prevent human health effects. Further information on the PHA process and ATSDR's process for evaluating public health effects is available from ATSDR's PHAGM. Throughout the PHA process, ATSDR seeks information about the hazardous waste site, site-related contaminants, communities potentially affected by the site (e.g., demographics), possible exposures to site-related contaminants, community health concerns, and health outcome data.

This document covers environmental and biological sampling data, and some other types of data that may be collected during the PHA process. However, it is important to note that ATSDR does not always evaluate or need all the types of data discussed in this reference (e.g., oftentimes biological sampling data are not available for a PHA).

During ATSDR's analysis of human exposure pathways, data are used to determine how human exposure might have occurred, might be occurring, or might occur. An exposure pathway consists of five elements:

1. Contaminant source (e.g., landfill, spill)
2. Environmental fate and transport media (e.g., groundwater, air)

3. Exposure point (e.g., drinking water well, food source, shower)
4. Exposure route (e.g., ingestion, inhalation)
5. Potentially exposed population (e.g., families, schoolchildren)

During the PHA process, ATSDR must evaluate specific data and information to examine the presence or absence of each of the five elements of an exposure pathway, especially related to potential exposure points. Much of that needed information is available in reports of remedial investigations and other environmental studies conducted by EPA, federal facilities, state agencies, and PRPs. Other environmental information critical to exposure pathway analysis, such as contaminant concentrations at off-site human exposure points, is not as likely to be available at the beginning of the remedial investigation process. The following sections describe specific data that are needed for a thorough evaluation of potential human exposure to hazardous substances and the related health effects.

Typically, ATSDR depends on other agencies or corporate PRPs to generate the environmental data needed to determine the degree of public exposure to chemicals at hazardous waste sites. Some of the environmental information that ATSDR needs is the same as that routinely required by EPA at National Priorities List (NPL)/hazardous waste sites. However, to perform the PHA process, ATSDR typically gathers information in the following categories where there is exposure potential:

1. Contamination concentration data sampled in the media to which people might be exposed. Contaminant concentrations in media alone are not sufficient for examining potential exposures during the PHA process. Various considerations apply for completed and potential exposure pathways, such as the following:

    - When surface soil exposure is suspected, surface soil and sediment samples ideally should not be deeper than 3 inches, because deeper depths typically are not accessed in normal residential activities.

    - When exposure to biota is suspected, such as fish, concentrations of contamination should be measured in edible portions of the biota. For instance, analysis of filets might be appropriate when only filets of the fish are consumed. In some fish species, however consumption of the entire fish is typical. In such a case, the concentration in the entire fish would need to be known.

    - When exposure to ambient air is suspected, ambient sampling near residential or other exposure locations is important. Site-specific meteorology is also useful in evaluating ambient air samples. Indoor air sampling might be useful in some cases, along with supplemental sampling to help evaluate the exposure pathway. For instance, in groundwater vapor intrusion studies, outdoor, sub-slab, or crawl space sampling might be useful.

ATSDR has published additional guidance to help health assessors in evaluating data according to an exposure point or area where a person is expected to contact an environmental medium – which we call "exposure units." For more information, see ATSDR's Exposure Unit Guidance.

2. Quality assurance/quality control (QA/QC) documentation, including the data quality objectives, and data quality assessment in samples to evaluate how the data quality affects assessment of possible human exposures. Ideally, we require:
    - the detection and reporting limits,
    - definitions of QA/QC flags in the data, and
    - identification of field duplicates, laboratory replicates, blanks, and analytic spike samples.
3. Lists of physical hazards and barriers to site access.
4. Sociodemographic and geographic data. These data help the health assessor recognize if an exposed or potentially exposed population is experiencing economic or environmental burden or social vulnerability, and factor this information into the PHA process. To evaluate a community's environmental and health burden, health assessors may use the factors identified in CDC's Social Vulnerability Index (SVI) and EPA's Environmental Justice Screen (EJ Screen).

This document provides general guidance for designing site characterizations to include data to best inform ATSDR's PHA process. ATSDR staff members are also available to review draft sampling workplans and give public health input on data needs to characterize site-related exposures.

SAMPLING STRATEGY

Most NPL site sampling plans start at the area or areas where the releases are thought to have occurred and work from that point or those points in an iterative process until the full extent of contamination has been characterized. This process often takes years to progress off-site to collect data at the potential points of public exposure. ATSDR recommends that the initial evaluation of the site include an assessment of probable routes of public exposure and contaminant migration off-site. Sampling should *begin* at the public exposure points to determine if interim actions are needed to reduce or eliminate public exposure. If contamination at public exposure points is determined not to be at levels of health concern, then on-site sampling may proceed to characterize the site fully and determine what remedial actions might be needed. However, during the site characterization, a medium (such as groundwater) might be found to be contaminated on-site at levels of potential public health concern. If that medium was not previously tested off-site, then sampling should be conducted

immediately at any potential public exposure points for that medium (e.g., private or municipal wells downgradient of the site, in the case of groundwater).

Certain information should be included in any sampling plan:

1. Geographic area or source the sampling effort is designed to represent
2. Intent of sampling strategy (e.g., to define the average or range of concentrations)
3. Rationale or statistical method used to select sampling locations (e.g., random, grid, stratified, composite, grab, or time-averaged)
4. Sampling equipment used and method(s) for decontamination between samples
5. Analytical methods to detect the substances within the media sampled
6. Location and rationale for selection of background samples

DATA QUALITY INFORMATION

To determine the likelihood of human exposure, health assessors evaluate all available sampling data. Different organizations collect sampling data for a variety of purposes. Data collected from different sources and for different purposes can be used in your evaluation as long as you deem the data to be appropriate and of sufficient quality for examining site-related exposures. See the Selecting Sampling Data section in PHAGM for more information on evaluating data quality.

To assess data quality, the following information should accompany data sent to ATSDR:

1. Data quality objectives — The anticipated use for which samples were taken, which then determines the types of laboratory analysis used; sensitivity of the analytical technique; detection limits; confidence limits; precision, accuracy, representativeness, completeness, and comparability; appropriate sampling design; and resulting data quality.
2. QA/QC requirements — The criteria by which data accuracy and precision are judged.

Per *EPA's Guidance for Data Quality Objectives Process*, whenever possible, data users (which can include health assessors) should have a role in the planning of the sampling design for the site. Remember: Just because a site has a lot of data, it does not mean the data available are useful for assessing exposure during ATSDR's PHA process.

Some examples of data quality objective errors to be mindful of when reviewing sampling studies include the following:

- Lack of control samples
- Judgmental (convenience) sampling
- Failing to randomize over potentially influential errors

- Collecting too few samples to support reasonably precise statistical confidence intervals in decisions made with the data

The ATSDR data evaluation process is discussed in detail in the Selecting Sampling Data section of PHAGM.

ELECTRONIC DATA TRANSFER

Until the early 2000s, health assessors received most of their information from EPA and other organizations in written reports (e.g., remedial investigations, feasibility studies, and data sheets, with accompanying maps, figures, and tables). Back then, only a few sites made their databases available to ATSDR in machine-readable formats or through communication linkages.

Today, electronic transfer greatly speeds the review and analysis process by eliminating the need for duplicative data entry and verification. Data in an electronic format also can be imported to a geographic information system (GIS) so that disparate, geographically based information, such as contaminant distributions, census data, and land uses, can be integrated and interpreted. Generally, the entire analytical data set should be transmitted, rather than only selected or summary data. Sufficient metadata and accompanying data dictionaries should fully describe the data fields. The metadata should include relevant sampling parameters and analytic methods. The health assessor can use this information, if available for a data set, to readily identify replicate samples, duplicate analysis, analytic spikes, and blanks, and any laboratory or data validation flags and their interpretation. It is critical that a health assessor understands these various aspects for each data set examined during the PHA process. Note: Health assessors need to be mindful of any data use agreements or sharing requirements. Ensure you are aware of and sensitive to privacy protections and any other rules regarding the data you obtain via electronic transfer.

GENERAL INFORMATION NEEDS

ATSDR needs background information and analytical data for each site it evaluates. Health assessors perform research to find this information, but when not readily available, they might need to request the information from other sources, such as EPA. Data should include the following:

A. SITE IDENTIFIERS

1. Site name and alias
2. Site address or location
3. Site type (e.g., mine tailings, landfill, surface impoundment, spill)
4. EPA technical contact's name, email address, and phone number (e.g., remedial project manager, on-scene coordinator)
5. Descriptions of problems and concerns and site conceptual model
6. Current owner's name

B. SITE HISTORY

1. Dates of operation and significant events (e.g., fires, changes in ownership or products)
2. Descriptions and dates of previous releases and actions taken by EPA or the facility to remedy them
3. NPL listing document, i.e., why the site was listed on the NPL
4. Descriptions of physical barriers to prevent pollutant transport (e.g., liners, slurry walls, fences, dikes, vapor barriers)
5. Current regulatory status of site, such as EPA's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and Clean Air Act status of site
6. Current structural condition of containers, vessels, and buildings holding substances
7. Current and past operational information regarding the treatment, storage, or disposal of hazardous waste at the site
8. Current use (and past uses, if different) of all buildings and areas where the public or workers might be exposed to contaminants (e.g., a former pesticide formulation building and outside rinse area converted to a day care center or office space)

C. GEOGRAPHIC, CLIMATE, AND DEMOGRAPHIC DATA

1. Site boundaries and locations of major sources and features of the site for use in developing GIS maps. Maps developed by ATSDR's Geospatial Research, Analysis and Services Program (GRASP) can include features such as the following:
    - Political geography (i.e., town, city, county, state)
    - Residences near the site
    - Demographics of the population living near the site, including nearby sensitive populations (children, older people) and characteristics relevant for understanding economic, social, and environmental burdens of the exposed or potentially exposed community (e.g., social vulnerability indices)
2. Sensitive land uses and features within 1 mile of the site or within the potentially affected area (e.g., schools, day care facilities, hospitals, retirement homes, streams, rivers, wetlands, aquifer recharge zones, water wells)
3. Copies of photographs or databases that depict past or current site conditions, including aerial photographs, satellite imagery, and GIS coverage (databases)
4. Proposed land transfers
5. Sensitive or potentially affected land leases on-site or off-site
6. Distance from site to schools, playgrounds, child care facilities, elder care facilities, hospitals, and other places where potentially suspectable populations might visit or reside
7. Rainfall rates, groundwater flow, wind flow, and seasonality

D. RELATIONSHIP TO NEARBY COMMUNITY

1. On-site activities and the estimated number of people involved in each activity (e.g., working, dirt-biking, camping, hunting, fishing)
2. Copy of the community relations plan
3. Types of barriers or signs used to prevent public access
4. Estimated frequency of on-site activities
5. Number and types of other potential environmental contamination sources within 1 mile of the site (or within the potentially affected area), including Resource Conservation and Recovery Act (RCRA) operating industrial facilities, other NPL or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Information System sites, and other major environmental pollution sources (e.g., a power plant, trash incinerator, sludge combustor, sewage-treatment plant, transfer or recycling station, landfill, or major source of air pollution)

E. SUBSTANCES IDENTIFIED

1. List of chemical names and Chemical Abstract System (CAS) numbers (if known)
2. Estimate of the quantities of contaminants released to each medium (e.g., soil, air, surface water, groundwater)
3. Maximum concentration, range, extent of contamination, and number of samples in each medium
4. Identification of solid waste materials (e.g., debris) and quantities
5. Documentation of any chemical, mechanical, meteorological, or other phenomena that might rapidly alter the current physical state of the chemicals present or the general condition of the site (e.g., earthquake zone, flood plain, subsurface fissures, or drains)

F. ANALYTICAL INFORMATION

1. All analytical results for each sample taken (raw data may be requested under certain circumstances), in addition to documents that summarize data. Some substances are analyzed as found in the field, others undergo pretreatment before analysis. Some are stabilized and others are inferred because of an element that they contain (e.g., lead in all forms is oxidized using atomic absorption and reported as lead)
2. Detection and quantitation limits for all analytical data, and the number of direct calibrations with the same substance
3. Description of the level of QA/QC used and copies of the QA/QC results and data validation reports
4. Blank, replicate or duplicate, and spike sample results (specify lab or field samples)
5. Care and decontamination of tools, instruments, and sampling equipment in the field to prevent cross-contamination of samples
6. Sample storage protocol and holding times

7. Analyses of total concentrations, not only RCRA extraction analyses concentrations
8. Analyses that identify which form of a chemical is present if toxicity of the agent's various forms is significantly different (e.g., chromium III and chromium VI, elemental mercury and methylated mercury)

SOIL EXPOSURE PATHWAY

Contaminated soils might expose persons who live, play, or work near the site to multiple contaminants at levels of health concern. Incidental ingestion of contaminated surface soil, particularly by children, is a primary concern. Breathing contaminated dusts and direct skin contact with contaminated soils also can lead to adverse health effects. Generally, the public is exposed to only the top few inches of soil; therefore, ATSDR has defined surface soil as the top 0–3 inches. For its evaluation, ATSDR needs concentrations of contaminants found in surface soil reported separately from those found in subsurface soil. Exposures from subsurface soil could occur from activities such as gardening, digging, and construction. Because ATSDR considers past, current, and future exposure scenarios, the agency needs to know the concentrations of contaminants in the soil before and after removal or remedial actions. Information relevant to ATSDR's evaluation of the soil pathway includes the following:

1. Exact sample locations, including descriptions and map locations, and the purpose of the sampling
2. Depth of sampling points: specify if sample is a vertical composite of soil between specified depth ranges (e.g., 0–2 inches, 0–3 inches, 0–12 inches, 3–12 inches, 1–3 feet)
3. Selective prefiltering (or sieving) scheme. Prefiltering (sieving) removes unwanted material from soil samples such as grass, roots, and rocks. Prefiltering can also remove contaminated material (e.g., lead shot) from soil samples, which may lead to an underestimate of exposure. When examining sieved samples, be sure to indicate the size of mesh used.
4. Type of sample (e.g., discrete, grab, or composite)
5. Sampling scheme for composite samples (e.g., composite of five grab samples from a 100-square-foot grid)
6. Homogenization scheme. Discrete samples may be homogenized in-situ (i.e., in place) or collected in a jar and later homogenized in a pan by itself or with other samples
7. Particle size and size of sieve used to remove larger particles
8. Constituents analyzed for, analytical methods used, detection limits, and concentrations detected
9. Mass of sample
10. Date of sampling
11. Number of samples
12. Type of soil (e.g., sandy, silty, clayey)
13. Description of vegetative cover
14. Land use or special features during sampling

See more information related to evaluating soil samples in ATSDR's EPC Guidance for Non-Discrete Sampling, ATSDR's EPC Guidance for Discrete Sampling, and ATSDR's Selecting Sampling Data section of PHAGM.

SURFACE WATER EXPOSURE PATHWAY

Representative sampling of surface water on-site, as well as upgradient and downgradient of the site, is needed to distinguish health implications associated with the site. All surface water bodies on or affected by the site should be sampled, including ditches, gullies, arroyos, and perennial and intermittent streams that could transport contaminants away from the site. Samples should be taken in areas where people might be exposed. Information relevant to ATSDR's evaluation of the surface water pathway includes the following:

1. Indication on map(s) of site location, boundaries of the 100-year flood plain, location of surface waters, and all surface water samples
2. Locations of all downstream surface water intakes potentially affected by the site
3. Identification and descriptions of National Pollution Discharge Elimination System (NPDES) effluents from the site and sources upstream and downstream of the site at distances potentially affecting the surrounding community (copies of NPDES permits and compliance reports may also be requested)
4. Past, current, and future uses of surface water on-site and downstream (e.g., recreational, agricultural, drinking water, livestock watering)
5. Hydrologic characteristics
6. Relationship of surface water to groundwater
7. Copies of surface water sampling record and log, including sample locations and site conditions (e.g., water flow rate and depth, visual observations)
8. pH and specific contaminant concentrations
9. Sampling and analytical methods used, detection limits, QA/QC data, and concentrations detected
10. Identification and description (including a map when appropriate) of any stormwater drainage system on or next to the site

SEDIMENT EXPOSURE PATHWAY

Residents might be exposed to contaminated sediment through direct skin contact, incidental ingestion, and inhalation, or through a secondary pathway (e.g., ingestion of contaminated biota). Sediment sampling is needed at possible human exposure points, such as recreational areas or children's play areas, and at locations where contaminated sediment might enter the food chain. Potential sampling sites might include known fishing and hunting areas and those where wildlife, fish, or shellfish exposed to the sediment might later be eaten by people. Upstream sediments may be collected to determine background concentrations of the contaminants.

Dredging also might mechanically disturb and transport sediment to possible human exposure points. Therefore, sampling and analysis of the dredged sediments and the stream channels and impoundments might be needed at some sites.

Contaminated sediments are not always found in constantly wet drainage areas. Many drainage ditches, surface impoundments, and ephemeral streams associated with releases of hazardous waste are dry part of the year. ATSDR defines sediment to be any solid material, other than waste material or waste sludge, that lies below a water surface; that has been naturally deposited in a waterway, water body, channel, ditch, wetland, or swell; or that lies on a bank, a beach, or floodway land where solids are deposited. For best evaluation of the potential exposure of the public, sediment samples, like soil samples, should be shallow (0–3 inches). Information on the following is relevant to ATSDR's evaluation of the sediment pathway:

1. Descriptions and mapped locations of samples obtained
2. Depths of sampling points: specify if sample is a composite of soil between specified depth ranges (e.g., 0–3 inches, 3–12 inches, 1–3 feet)
3. Type of sample (e.g., discrete, grab, or composite)
4. Sampling scheme for composite samples (e.g., composite of five grab samples from a 100-foot length of stream, whether the sampling program was designed to collect samples at regular intervals or from depositional areas)
5. Constituents analyzed for, analytical methods used, detection limits, QA/QC data, and concentrations detected
6. Date of sampling event and site conditions at that time
7. Particle size and size of sieve used to remove larger particles
8. Mass of sample
9. Number of samples

Additional considerations for sediment samples are outlined in ATSDR's EPC Guidance for Non-Discrete Sampling and ATSDR's EPC Guidance for Discrete Sampling.

GROUNDWATER EXPOSURE PATHWAY

Direct human exposure to contaminated groundwater from water supply wells is a common public health problem associated with hazardous waste sites. To prevent or mitigate such exposure, the location and use of potentially contaminated wells or springs should be identified as soon as possible after discovery of the hazardous waste problem. Characterization of the vertical and lateral extent of the groundwater contamination plume is also needed to evaluate the groundwater exposure pathway, but only as it relates to past, present, and future contaminant movement to human exposure points.

Vapors from the surface of groundwater aquifers also migrate through soil pores and enter building indoor air by diffusion and active air flow. Groundwater wells must be screened across the surface of the aquifer to best characterize this potential source for vapor intrusion.

Groundwater pathway analysis and public health recommendations can be enhanced by the following approaches to groundwater monitoring:

1. Screen some of the site monitoring wells in the same groundwater zone as the water supply wells to better correlate groundwater contaminants measured in site monitoring wells to those measured in water supply wells.
2. Because of the heterogeneous nature of groundwater systems, water supply wells and springs within or at the leading fringe of a groundwater contamination plume usually need more than a one-time sampling to be evaluated for possible human exposure. Quarterly monitoring for at least one year is preferred.
3. For metals, valid comparisons of analytical results from groundwater samples and ATSDR drinking water comparison values (CVs) and non-ATSDR screening levels can be made if the groundwater samples are filtered or not filtered during sampling. ATSDR prefers to receive unfiltered samples. ATSDR can make conclusions about filtered samples when concentrations meet or exceed ATSDR CVs or non-ATSDR screening levels, but cannot make definitive conclusions when concentrations are below them. Unfiltered samples should always be taken at points of exposure (e.g., private wells, municipal drinking water systems). All groundwater data, for filtered and unfiltered samples, should be provided to ATSDR.
4. Include a few tap water samples in any sampling of contaminated municipal or community wells. Concentrations of contaminants measured at the wellhead might vary by an order of magnitude or more from concentrations measured at the drinking water taps in the system. ATSDR would use flushed samples to learn what is coming from the outside source, but first-draw and flushed samples if lead or other plumbing-related contaminants are a concern. Environmental samples at human exposure points (drinking water taps) provide a better data set than wellhead samples to evaluate actual human exposure.

Several types of information are relevant to ATSDR's groundwater exposure pathway evaluation:

A. WELL SURVEY

1. Well survey and inventory within at least 1 mile of the site or within the potentially affected area, whichever is greater.
2. The well survey should include the following categories:
    a. Monitoring wells
    b. Facility water supply wells
    c. Municipal and utility wells, springs, or reservoirs
    d. Residential wells or springs or small, unregulated water systems
    e. Commercial and industrial production wells
    f. Irrigation wells (including wells that are part of lawn-watering systems)

   g. Community wells (e.g., wells serving mobile home parks)
   h. Piezometers
   i. Livestock water wells and springs
3. As much as possible, the well inventory should include the number, total depth, screen interval, well use, yield, status, installation date, pump type and age, and location of all local wells and developed springs.

B. HYDROGEOLOGY

Descriptions of site-specific and regional hydrogeology, including these characteristics:

1. Depth, thickness, extent, name, and characteristics (including flow direction) of all groundwater zones and aquifers affected or potentially affected by contaminants
2. Depth, thickness, extent, name, and characteristics (including flow directions) of all local drinking-water aquifers
3. Vertical and lateral extent of groundwater contamination
4. Natural geochemistry (might be the same as background) of all contaminated groundwater zones and drinking water aquifers

C. GROUNDWATER MONITORING

Descriptions of past and current groundwater monitoring, including the following information:

1. Dates and frequency of past and current monitoring
2. List of analytes and detection limits
3. Sampling procedures
4. Water level measurement procedures
5. Dates of and procedures used for aquifer tests

D. ANALYTICAL DATA

Analytical results of groundwater monitoring, including the following information:

1. For each sample, field measurements for temperature, conductivity, and pH
2. Tables of analytical results listed by sample location
3. Any available summaries of analytical results in which the maximum concentrations of contaminants are identified
4. QA/QC analyses for different sampling episodes
5. Analytical results of metal contaminants derived from **unfiltered** groundwater samples; if both filtered and unfiltered metal results are available, those results could provide evidence to the metal forms present

6. Groundwater analysis of volatile organic compound (VOC) data is important to help justify additional analysis. Data can be grouped into categories (fuels, chlorinated compounds, or by molecular weight) to help with follow-up sample recommendations.

E. NATURE AND EXTENT OF CONTAMINATION

1. Water level measurements, calculated gradients, potentiometric contour maps, and figures
2. Monitoring well construction logs, boring logs, and site-specific cross-sectional maps
3. Descriptions of past, current, or planned groundwater remedial actions, including provision of alternative water supplies
4. Descriptions and results of any geophysical, geochemical (including tracer studies), or soil gas surveys performed to define sources and extent of groundwater contamination (Signs of contamination include characteristics such as an odor, sheen, discoloration, turbidity, or effervescence.)
5. Descriptions and locations of all known or surmised facility- or site-related sources of groundwater contamination; non-site-related sources may also be included if pertinent to contamination of water supply wells or springs
6. Descriptions and locations of any on-site or near-site groundwater or surface water recharge or discharge areas (e.g., sinkholes, sinking or disappearing streams, stream bank or drainage ditch seeps, leachate seeps, or undeveloped springs)

AIR EXPOSURE PATHWAY

Adverse health effects (acute, intermediate, and chronic) associated with breathing air contaminants are a common concern of people living and working near hazardous waste sites. Air emissions from past or current production processes, volatilized organic compounds, airborne particulates, and acid gases from hazardous waste areas, might expose people who live or work near the sites to contaminants at levels of health concern.

Hazardous waste areas from which air releases might be significant include

- surface impoundments that have leaking drums or tanks containing volatile organic compounds,
- landfills that produce methane gas,
- waste piles of materials that might be easily carried by winds or that contain volatile organic contaminants, and
- contaminated soils that might become airborne by winds or vehicular traffic.

Air emissions might also result from excavation, farming, bioremediation, air stripping, pond aeration, incinerator stack emissions and ash, and handling of decontaminated soil.

Vapor intrusion into indoor air can be of public health concern if people might inhale that air. Intrusion of vapors from contaminated soil, groundwater, or sewers into indoor air can cause

fires, explosions, and acute, intermediate, and chronic health effects. Asphyxiation is possible, but less likely. Vapor intrusion is a complex problem with multiple variables, but often, sampling measurements are limited. See ATSDR's Vapor Intrusion Guidance for more information on this topic.

In addition to chemical-specific exposure hazards posed through air or vapor intrusion pathways, odors might be present. Odors can result in harmful health effects, and many people report that odors reduce their quality of life.

Air releases from past or current production processes, or both, might cause off-site deposition of contaminants. Soil, biota, and surface water contamination can result, which might cause secondary exposure to people near the site. Therefore, site characterization should include an evaluation of production area air releases, meteorological data (including wind rose, pollution rose, or wind speeds and directions), and possibly, modeling of those releases to determine potential off-site air-exposure points and deposition areas that might need to be sampled. Temperature data are key for determining vaporization of volatiles from liquids that might be in the soil or in water. Grab samples are generally not very representative of the long-term exposure the public might receive from a facility, because air concentrations can vary widely. If grab samples are taken, ATSDR recommends that several samples representative of the area be taken over time to assess the distribution and variation in concentration of the contaminants.

Information relevant to ATSDR's evaluation of the air pathway includes the following:.

A. AMBIENT AIR DATA

1. Locations where samples were taken, including descriptions and illustrations on maps
2. Meteorological conditions, temperature, wind speed, and wind direction when samples were taken (i.e., which samples were upwind, and which were downwind), cloud cover (i.e., sunny, overcast), time of year, and time of day or night. Rainfall rates and seasonality are important factors for determining if dust will easily transport or if there are times when the water table might be close to the surface. Consider using multiple sources of weather data (e.g., Citizen Science, National Weather Service) to help determine local conditions.
3. Sampling log, including descriptions of activities in the area during sampling that might have contributed to concentrations of constituents detected (e.g., 10 feet from busy intersection, 20 feet downwind from bulldozers excavating contaminated soil), and descriptions of measures taken to reduce emissions if ambient air monitoring occurs during remediation activities (e.g., dust-control measures)
4. Height at which samples were taken. Samples should be taken in the usual breathing zone (4–5 feet above ground) or closer to the floor if children might play or crawl in the presence of heavier-than-air constituents and poor circulation

5. Descriptions of sampling methods used, constituents collected by each method, and the different levels of confidence in the sampling methods (e.g., reference methods, low-cost sensors)
6. Sampling frequency and dates (e.g., duration of continuous or integrated composite sampling, grab samples). If grab samples are taken, samples might need to be taken at night and during the day, and even during different seasons, in case the concentrations are affected by the change in meteorological conditions.
7. Constituents analyzed for, analytical methods used, detection limits, QA/QC, and concentrations detected
8. Type of ambient air sample collected to evaluate potential exposures to site emissions (e.g., on-site, at the fence line, a maximum predicted off-site exposure location, in the community, a background sample, for modeling confirmation, to address community concerns)
9. Citizen Science data submitted by the public, obtained using various smart sensors that provide real-time data. Although the data quality varies, the information often can reveal trends for some contaminants. Citizen Science particulate data have helped in discerning variability of 1–10 microns of dust during dry days.

B. EMISSIONS DATA

1. Detailed descriptions of the treatment technology or manufacturing process associated with each stack (e.g., design drawings, raw feed materials, operating temperatures and conditions, products and by-products of the system, and any air pollution control equipment)
2. All permits (e.g., state and federal, Clean Air Act, hazardous waste [RCRA]), if permitted under those programs or, if a CERCLA unit, all documents relevant to the unit's design and operating requirements
3. All compliance reports required under any of the previously described permits and any other documents that discuss past planned and unplanned air releases.
4. All stack testing or trial burn results for the units, including testing or trial burn plans; sampling, analytical, and QA/QC reports; and any written reviews of the data
5. Identification of the closest meteorological station and general meteorological conditions, including wind rose, prevalence of air stagnation events, or other unusual conditions for that area, and a determination that the information is representative of the meteorological conditions at the site and surrounding areas
6. Any air modeling for the stack(s) and fugitive emissions at the site (e.g., all parameters used in the modeling, such as land use, terrain features, nearby building dimensions, meteorological conditions used or dates and source of meteorological data used in the modeling, flue gas temperature and velocity, stack height, and contaminant emission rate).

EPA has various online sources for information on emissions, such as the Toxic Releases Inventory (TRI) Program and the National Emissions Inventory (NEI).

C. SOIL GAS DATA

1. Analytical results and dates of any subslab or exterior soil gas surveys
2. Sample dates, locations, durations, and collection methods. Field notes often contain information on sample depths, preferential pathways, weather conditions, geology and lithology, pressure differentials, and water infiltration.
3. Subslab gas samples — consider the number adequate for the building footprint, different building pressure zones, vapor entry points, and occupant use; identify collocated (paired) indoor air data
4. Exterior soil gas samples — sample depth (5 feet minimum), depth of building foundation, distance to groundwater or source, distance to buildings, and locations of low-permeability surfaces (pavement, ice and snow pack). Exterior soil gas surveys are useful for delineation but generally do not accurately estimate subslab gas or indoor air concentrations. During the PHA process Screening Analysis, ATSDR suggests using near-source exterior soil gas samples (i.e., those collected immediately above groundwater). Health assessors who have soil gas samples collected from other areas of the subsurface should consult with an ATSDR subject matter expert before using them for screening. The samples might not accurately represent vapor intrusion potential because of different soil conditions outside the building footprint.
5. Measurements of flammable and explosive gases (e.g., methane or ethylbenzene) at landfills, other waste source areas, and nearby buildings where such gases might be generated, migrate, or accumulate
6. Measurement of oxygen and biodegradation products (e.g., carbon dioxide, methane, and vinyl chloride) as indicators of biodegradation
7. Descriptions of calibration gases and concentrations needed in addition to the instrument readings of a combustible gas meter or other instrument calibrated to determine concentrations at or above the lower explosive limit of gases under investigation
8. Gas pressure measurements to estimate how far soil gas contaminants might migrate from their source to human exposure points, such as occupied residences
    a. Permanent gas monitoring wells should be equipped with a permanent pressure gauge that should be read before sampling.
    b. Vertical and lateral zones of soil gas movement can best be determined when gas monitoring wells are screened in the most likely subsurface zone of movement and not over the entire depth of the unsaturated zone.
9. Investigation of sewer or utility lines buried beneath or adjacent to the hazardous waste area to determine if they serve as preferential pathways for soil gas movement from the source area into occupied buildings

D. INDOOR VAPOR DATA

Indoor air sampling data might be needed to determine potential health effects on building occupants (workers or residents) if on-site buildings that are or might at some point be occupied are built of contaminated materials or the buildings became contaminated during use. Indoor air sampling also might be needed if gases or volatile organic compounds are potentially migrating through the soil (from soil or shallow groundwater contamination) or preferential pathways or if soil gas measurements around the building indicate that gases might accumulate in the building. If flammable or explosive atmospheres are possible, use instruments that can detect flammable and explosive gases at and above the lower explosive limit.

Specific indoor air sampling data relevant to ATSDR's evaluation of this pathway include the following:

1. Type of instruments and sample collection methods used (include air volume sampled)
2. Analytical data and analytical methods used, including detection limits for all contaminants, calibration of equipment, and QA/QC procedures and results (for vapor intrusion, organizing the volatiles by molecular weight can be helpful, as solubility and vapor pressure are also related)
3. Odor logs, outdoor air data, radon zone, and sample and monitoring data
4. Date, time, duration, and recent meteorological (e.g., temperature) data for when samples were taken
5. Diagram of building showing sampling locations and building dimensions
6. Descriptions of building construction materials and significant construction features (e.g., on concrete slab, basement, number of stories, below grade, on stilts, vapor barrier, sumps, crawl space vents)
7. Descriptions of sampling locations, including type of room (e.g., bedroom, den, garage, basement, attic, process area, or storage area); height in the room; and distances from significant structures in the room (e.g., ceilings, hoods, vents, workbenches, chemical storage or use areas, doors or other large openings)
8. Descriptions of building air flow before and during the sampling (e.g., Was the building unoccupied and closed with no air circulation? Was there a whole-building heating, ventilation, and air conditioning [HVAC] system? Was the HVAC system operating for sufficient time to reach equilibrium in air quality? Was a mitigation system on?)
9. Descriptions of other contaminants that might be present in the air because of normal building use (especially important for residential sampling) (e.g., chemicals or solvents used for hobbies, freshly painted surfaces, cleaners, lawn care products, and tobacco smoke)

E. INDOOR DUST DATA

In some cases, indoor air sampling might not be appropriate or possible. If sampling must be done while the building is occupied, aggressive air sampling for particulate and fiber contaminants might increase exposure of occupants by making contaminants airborne. If this is

a concern, dust sampling should be used to determine the potential for exposure and whether sensitive occupants need to be relocated during sampling.

A typical scenario for which indoor dust sampling might be appropriate would be a residential setting where soil lead contamination is at or near levels of health concern. In this case, lead contamination being tracked indoors and ingested by infants or young children would warrant indoor dust sampling. Another example is lead assessments, where health assessors might see indoor dust used as an input for uptake models (e.g., the Integrated Exposure Uptake Biokinetic Model for Lead in Children [IEUBK]). Any contaminant that can be analyzed from dust, including particulate dust (PM_{10} or $PM_{2.5}$), can be measured via dust sampling. Some contaminants (e.g., polycyclic aromatic hydrocarbons [PAHs] and pesticides) will be in particulate (dust) and vapor form; thus, a portion of them can be detected in dust samples.

If indoor dust sampling is conducted, gather as much specific information as possible about the dust sampling procedures. The type of information and level of detail desired for ATSDR's evaluation of indoor dust sampling include the following:

1. Type of sampling equipment (e.g., vacuums or vacuum pumps) and sampling media (e.g., filter cassettes, including flow rates, calibration methods), and, if used, type of surface wipes (e.g., fiberglass, cloth)
2. Surface areas sampled (e.g., square feet or square centimeters) and sample mass collected (e.g., number of grams)
3. Analytical methods used (e.g., measurement method, contaminant-specific detection limits) and QA/QC procedures
4. Analytical data (e.g., measurement values and units, QA/QC result, data flags, morphology data)
5. Date, time, and duration for when samples were taken
6. Diagram of building showing sampling locations, including different types of surfaces, and building dimensions
7. Descriptions of building construction materials and significant construction features
8. Descriptions of the sampling locations, including type of room (e.g., bedroom, den, garage, basement, attic, process area, or storage area), height in the room, locations where children spend most of their time, frequently used entrance, high or low activity area, accessible or inaccessible area (e.g., kitchen floor vs. behind couch); type of floors in sampled area (e.g., carpeted, hardwood, concrete, linoleum), and distances from significant structures in the room (e.g., ceilings, hoods, vents, workbenches, chemical storage or use areas, doors or other large openings)
9. Descriptions of building air flow before and during the sampling (e.g., Was the building unoccupied and closed with no air circulation? Was there a whole-building HVAC system? Was the HVAC system operating for sufficient time to reach equilibrium in air quality?)
10. Descriptions of other contaminants that might be present in the air because of normal building use (especially important for residential sampling) (e.g., chemicals or solvents

used for hobbies, freshly painted surfaces, cleaners, lawn care products, and tobacco smoke).

11. A copy of the indoor dust sampling plan. The detection limits that will dictate how large a sample to collect must be at or below the level of health concern for the contaminants present.
12. Are there any other possible contributing factors to the contamination besides surface loading (e.g., hobbies, lead paint)?

Even with complete information, dust sampling results are difficult to interpret because health-based dust concentrations for contaminants of potential concern are unavailable. In some cases (e.g., where activity-based exposure information is needed), ATSDR has recommended agitating dust and sampling the air to allow comparison of contaminant concentrations of potential concern with health-based air concentrations (e.g., ATSDR air CV). ATSDR would evaluate results of such "aggressive air sampling" using air pathway methods.

FOOD CHAIN EXPOSURE PATHWAY

People might be exposed to site contaminants by eating plants or animals that have incorporated the contaminants into their bodies. On- and off-site hunting, fishing, foraging, and farming activities might bring people into contact with those contaminants. Some contaminants, particularly fat-soluble substances and heavy metals, can reach concentrations in animal tissues that are thousands of times higher than those found in water, soil, and sediment.

For evaluation during the PHA process, it is important that the *edible portions* of such food items be analyzed for potential contaminants of concern. Edible portions of food items need to be determined at each site based on the eating habits of the populations likely to eat the various food items being analyzed. For example, residents of one community might eat skinned fillets of fish, whereas those in another community might eat the whole fish. If several ethnic groups are present in the potentially exposed community, samples should be analyzed based on each ethnic group's eating habits. If that is not possible, the worst-case eating habits should be used to determine the samples to be analyzed. It is hard to draw meaningful human food-safety conclusions when the whole body of a fish is analyzed, but the community typically eats fillets, or when a whole plant is analyzed, but people only eat the fruits.

When planning and designing an investigation of food-chain contamination, have a well-designed biota sampling protocol, with sample size large enough to be statistically significant. More than eight discrete or at least three composite samples per location per sampling episode are recommended when statistical methods will be used (see more information related to statistical approaches for samples in ATSDR's EPC Guidance for Discrete Sampling and ATSDR's EPC Guidance for Non-Discrete Sampling. Organisms of different species, ages, or reproductive status should not be sampled without strong justification. For example, when assessing the effect of contaminated sediment on the edible fish populations in a stream, results of analyses

of tissues from bottom-feeding fish should not be combined with those from water-column feeders. Because of their different feeding habits, very different effects might be expected.

The species of some animals can be important to note. Fish are often referred to by their family and not species. Some species grow faster than others, so exposures might be underestimated or comparisons between species of a fish family might be inappropriate. For instance, even though an older French Grunt fish is small, it might contain higher contaminant levels than a faster growing young Blue Grunt fish. Discrete (grab) samples are preferred because ATSDR tries to determine the maximum contamination to model worst-case scenarios.

Special handling of food chain samples needs to be considered. Some analytical procedures require that live or fresh-frozen fish be transported to the laboratory immediately for analysis. The accuracy of other procedures might not be affected if formalin-preserved specimens or those held frozen for weeks or months are used. Such considerations, along with any special problems encountered, should be included in an appendix to the document for quality assurance review.

When contamination of consumable plants or animals is suspected, ATSDR needs specific data to evaluate the food-chain pathway:

A. FOOD CHAIN PATHWAY INFORMATION (past and present)

1. Animal and plant species that people might eat, if these species are potentially affected by the site (e.g., annual animal population or crop volume harvested)
2. Descriptions of populations consuming each potentially contaminated crop and animal (e.g., residential gardens containing tomatoes, corn, and peas consumed by owners [include ethnicity, if known]; local subsistence hunting for rabbits, dove, and deer; commercial and subsistence fishing for salmon and catfish [include species and size they eat]; commercial beef cattle ranches and feedlots in the area)
3. Descriptions of past, present, and intended future land use

B. SAMPLING INFORMATION FOR ON- AND OFF-SITE CONTAMINATION

For on-site contamination, sampling and analysis should include the following:

1. On-site edible plants and on-site edible animal species
2. Sample size. Sometimes a sampling plan will dictate the size of a fish sample to collect. Be mindful, however, that a local subsistence population might choose other sizes or catch other sizes as a result of the capture device or method they use.
3. Sampling and analysis of off-site edible animal species likely to pass through the contaminated area

For off-site contamination, sampling and analysis should include all plant and animal species believed to be exposed to contaminated media if they are likely to be used as food by humans.

C. BIOTA SAMPLE COLLECTION INFORMATION

When biota studies are performed, ATSDR recommends providing the following:

1. A copy of the protocol used, such as
    a. how each species was harvested;
    b. how representative samples were selected of each species;
    c. what portions were sampled and analyzed;
    d. size of samples;
    e. special specimen-handling procedures, including sample storage procedures;
    f. contaminants analyzed for and rationale for their selection;
    g. methods used and their detection limits; and
    h. wet and dry weight basis for tissue samples.
2. All analytical results and reports, including any QA/QC data and reports, and a list of samples and their corresponding sample number

ATSDR generally recommends that biota studies include the following:

1. A sample size of at least eight individuals per species, per episode for discrete samples (for more information, refer to ATSDR's EPC Guidance for Discrete Sampling)
2. A sample size of at least three for composite samples (for more information, refer to ATSDR's EPC Guidance for Non-Discrete Sampling)
3. Analysis of edible portions
4. Background concentration samples collected during the same study as the contaminant concentration samples (e.g., use the same approach in terms of methods, samplers, time frame)

HUMAN BIOLOGICAL SAMPLING DATA CONSIDERATIONS

In addition to collecting environmental data during the PHA process, biological sampling is a useful tool to help define and better understand a community's exposure to environmental contaminants. Biological sampling, such as through an ATSDR exposure investigation, involves the collection of a bodily fluid (e.g., blood or urine) or tissue in which a biomarker is measured in potentially exposed persons. The biomarker might be an environmental chemical of potential concern, its metabolite, or another specific marker that serves as a surrogate for the chemical of concern.

Indications that biological sampling of a population as part of an exposure investigation could be useful include the following:

1. Identification of a completed or potentially completed exposure pathway
2. Crucial data gaps that would otherwise limit our ability to make a public health determination about a completed or potential exposure pathway

3. Concentration of the environmental chemical of concern in the exposure pathway at the site being investigated exceeds established health and environmental guidelines (noting that guidelines might not exist for the contaminant of concern)
4. Community health concerns
5. At-risk vulnerable populations or sensitive stages of life cycle (e.g., infants, children, pregnant or lactating persons) where exposure to hazardous substances is known to be associated with greater harm
6. Site contamination with an environmental chemical shown to be associated with significant adverse health outcomes in human epidemiologic or medical studies (e.g., lead contamination in an area where children play)

When added to larger scientific investigations or health studies, biological sampling for environmental chemicals evaluated during the PHA process can enhance existing knowledge to better understand exposure pathways and the effects of environmental chemicals on human health. When performed as part of an exposure investigation, results can help

1. determine if persons in a community have been exposed,
2. define the range of chemical levels among persons in a community,
3. compare how levels vary among demographic groups within a community, and
4. determine how levels compare with those of other communities with and without similar exposures.

Results of biological sampling can also be compared with known health-based thresholds and might help to inform exposure reduction measures and public health recommendations that are protective of human health.

Testing every member of a community or every community with exposure concerns might not be feasible. Persons from whom biological samples are collected should be representative of the exposed population. However, representative sampling (i.e., participants are chosen at random to estimate exposure across a community — people cannot simply volunteer) can be difficult to accomplish in an exposure investigation, so convenience sampling (i.e., participants are those who are easy to reach and available) is often performed. ATSDR uses questionnaires to help the exposure investigation team interpret the biological sampling results. These questionnaires use a standard set of questions to obtain participant information (e.g., age, sex, smoking status), and often include tailored site- and contaminant-specific questions to help characterize potential exposures.

Measurement of most environmental chemicals in biological samples is not routine, and analysis might not be performed by most commercial laboratories. It is imperative that trained professionals use standardized and tested field methods to collect samples. Likewise, the laboratory performing the analysis needs to use validated methods with quality-controlled established protocols.

Through rigorous scientific research, the CDC's Division of Laboratory Sciences has developed standardized methods for detection and quantification of environmental chemicals in various

biological samples (e.g., blood, urine). CDC's National Biomonitoring Program has validated methods for measurement of more than 400 environmental chemicals in human biological samples and established U.S. population-based, nationally representative reference ranges for these chemicals. The information is published in the *National Report on Human Exposure to Environmental Chemicals* and *Updated Tables*. If biological sampling is planned as part of the PHA process, the data in the report and updated tables can help heath assessors in choosing the most appropriate biological media in which to collect the sample(s) from potentially exposed persons. It also allows for results of biological samples collected at a site to be compared to an established reference range.

Not all environmental chemicals that might be of concern have a known biomarker, an established or reliable method of detection, or a reference range for comparison. The best biological medium in which to measure the chemical or the method for analysis might not yet be determined. Moreover, an association of the chemical of concern with clinical or adverse health effects might be unknown or poorly understood.

When conducting the PHA process, the presence of an environmental chemical biomarker in a biological sample indicates evidence of exposure to that chemical and allows for quantification of the chemical and comparison with a reference range, if available. However, even with an established population-based reference range for comparison, there are limitations to consider, and results of biological sampling should be interpreted with caution.

Limitations associated with detection of an environmental chemical in a biological sample include the following:

- Results reflect the level of the chemical in the sample at the time it was collected. Metabolism and excretion levels will change over time.
- Results might represent current or recent exposure, not long-term exposures. This is influenced by the biological half-life and toxicokinetic properties of the chemical.
- Detection of an environmental chemical cannot definitively identify the source of exposure. There may be undetermined sources and pathways in addition to the established exposure pathway(s) at the site. All potential sources of exposure must be considered (e.g., a child might be exposed to lead from soil at a contaminated site and from mouthing a toy that contains lead).
- Detection cannot determine exactly when an exposure occurred, and it cannot determine the frequency or duration of exposure.
- It is often difficult or impossible to determine if a level of the chemical in a biological sample is safe or unsafe, but it provides information that allows for comparison with the great U.S. population exposures.

- Detection cannot determine if the exposure is associated with a past or current health condition, nor predict with certainty if the exposure will be associated with a future health outcome.

Depending on the level of an environmental chemical detected in a biological sample and current scientific research findings, the result might or might not support an association between the chemical and health concerns of a person or the community.

In most cases, the presence of an environmental chemical in a biological sample is not diagnostic of a health condition and might not determine a course of treatment. Important exceptions include exposure to metals such as lead or mercury. If during the PHA process a child's blood lead level is found to be elevated above CDC's reference value, a diagnosis of lead poisoning may be established, and depending on the level, treatment might be warranted. Appropriate public health experts and health care provider(s) should be contacted without delay.

Medical professionals, laboratory specialists, or toxicologists can assist with planning biological sampling, developing a protocol, obtaining the appropriate U.S. Office of Management and Budget (OMB) and Internal Review Board IRB (IRB) clearance (or waiver), interpreting results, and determining next steps. All research conducted or supported by NCEH/ATSDR that involves human participants must comply with the U.S. Department of Health and Human Services (HHS) Policy for Protection of Human Research Subjects. The NCEH/ATSDR Office of Science (OS) is responsible for ensuring that all NCEH/ATSDR staff adhere to the laws, regulations, policies, and procedures for protecting human subjects. In addition, the NCEH/ATSDR OS provides guidance and technical assistance on the development and submission of appropriate documentation to meet the requirements of human subjects review. Prior to beginning work, you must receive a Research Determination or an IRB approval, which you request through your Associate Director for Science (ADS).

IDENTIFICATION OF PHYSICAL HAZARDS

Another component of the PHA process is evaluating site hazards that might endanger human populations that live or work on or near the sites. Physical hazards at hazardous waste sites are often overlooked during initial site documentation and remediation activities. The absence of an adequate barrier between the site hazards and the community often is the single most important factor in determining whether members of the community are likely to enter the site and risk physical injury. A gate or fence that can be entered or climbed easily is not an adequate barrier to curious children. On-site workers are issued appropriate personal protective equipment and made aware of the on-site hazards, community members are not.

Listed below are data needed for identification and evaluation of physical hazards.

1. Descriptions and locations of physical barriers that would prevent access to on-site physical hazards
2. Descriptions and locations of on-site and perimeter warning signs that would warn trespassers of dangerous conditions. Descriptions should specify language(s) in which the signs are written and whether the signs are sufficient to warn all subpopulations in the surrounding communities.
3. Descriptions of all potential physical hazards at the site, such as the following:
    a. Confined spaces, especially underground areas (danger of entrapment and accumulation of toxic or suffocating gases)
    b. Industrial equipment (danger of falls from such equipment or of unsecured equipment falling onto people)
    c. Explosive or hazardous vapors, especially soil gases
    d. Explosive, shock-sensitive, air- or water-reactive, or incompatible materials stored on-site
    e. Electrocution hazards (e.g., exposed wires and unsecured fuse boxes)
    f. Structures that are unsafe or deteriorating because of poor repair or weather damage
    g. Open pits or vats containing chemicals or water
    h. Sinkholes or soil erosion
    i. Stored materials (danger of collapse because of deteriorating packaging)
    j. Leachate (may be strongly acidic or caustic, causing chemical burns)
    k. Medical waste (e.g., syringes)
    l. Sharp metals and rusted debris
    m. Cables, chains, wires, ropes (danger of entanglement, breaking under loads)

RADIOLOGICAL PARAMETERS AND SAMPLES

Interpretation of radiologic samples can be quite difficult if certain important information is not included in the data package. In some cases, improper calibration standards might be used, resulting in erroneous readings. In many cases, it is unclear if the readings are gross (including background) or net. Efficiencies of the field equipment can vary. Radiation detection meters can be more specific for certain types of radiation than others. Those and other factors must be clarified for ATSDR to evaluate the field-collected information.

ATSDR needs the specific information listed below for review of radiologic data. Health assessors engage ATSDR's health physicists when evaluating these types of samples.

1. For radiation readings collected in the field —
    a. The types of field instruments used (e.g., solid state, ionization, scintillation, tissue equivalent) and the manufacturer and model number for each type of detector and probe
    b. Calibration information, such as the radioisotope used (e.g., cesium [Cs]/radium [Ra]/cobalt [Co]), date of last calibration, and the instrument efficiency for each radioisotope
    c. Specific units of exposure rate (microroentgens [mR/h] or milliroentgens [µR/h]) or dose rate (rads or rem per hour or gray and sieverts per hour and the appropriate prefix)
    d. Distance from surface or source for the measurement (inches, centimeters, foot, or meters)
    e. Background reading for each instrument used, where the background data were collected
2. For recorded data — specify as gross readings or net (background subtracted)
3. For surface smear sampling — the level of uncertainty can be high because of variability in the sampling technique; these are indicative of the mobility of radioactive materials from surfaces. The results should indicate the area covered by smears (e.g., 100 square centimeter) and the type of laboratory instrument (e.g., gas flow proportional counter for alpha beta [a/ß]) used to analyze the samples.
4. Air sample reports — include a description of the sampler, the height above ground of the sampling system, volumetric flow through the filter, sample time, and the area, pore size, and type of filter used (e.g., charcoal, above ground level [AGL]). See the Air Exposure Pathway section for additional information needs.
5. Soil sample reports — include information about the area represented by the sample (grid size) and sampling depths. The number of samples collected should be stated, and if the results are for composite samples, reports should reflect the number of individual samples that made up the composite before sample counting. See the Soil Exposure Pathway section and the Sediment Exposure Pathway section for additional information needs.
6. Water sample reports — include information on whether the sample was filtered before counting and how the samples were prepared (e.g., ashed, co-precipitated and radioisotope percent recovery, distilled). Information on the type of EPA method used to analyze the water sample is also needed. See the Surface Water Exposure Pathway section and the Groundwater Exposure Pathway section for additional information needs.
7. For isotope results obtained from radiochemistry laboratories, the following data should be available for proper environmental evaluations:

   a. For laboratory results — detection limits for each radioisotope, including length of time the sample was counted, statistical error, total counts, and counts per minute
   b. For laboratory instruments — the average background value and how often the background was determined
   c. For multi-channel analyzers (MCA) — specification of channels and whether a standard was run before or after, and the isotope library and MCA analysis program used to ascertain the energy peaks

8. Radon level determinations — state what type of detector was used (e.g., charcoal canisters, alpha track). If indoor measurements were taken, was the house or building vacant, sealed, or inhabited? What time of year was the sample collected, and what were the indoor and outdoor temperatures during the collection period? How long was the detector in the structure? Was the laboratory that performed the monitoring approved by the EPA radon program? When was the most recent calibration, for continuous monitors?