Ohio EPA
Division of Environmental Response and Revitalization
Assessment, Cleanup & Reuse Section, Remedial Response Program

TECHNICAL DECISION COMPENDIUM

<u>Title</u>: Use of Background for Remedial Response Sites

<u>Date</u>: 21 August 2009

<u>Key Words</u>: Background, soil, sediment, ground water, surface water

<u>Purpose</u>: The purpose of this guidance is to provide recommendations and a methodology for the determination and use of representative background levels in environmental media which is acceptable by Ohio EPA -DERR for Remedial Response Sites.

<u>Introduction</u>: Background refers to the concentration of chemical substances that have not been affected by current or past site activities. This document provides one specific method for determining background levels in environmental media and general guidance on their use at Remedial Response sits. Background sampling is often conducted to help distinguish site-related contamination from naturally occurring or other non-site-related chemicals. This information is useful in evaluating whether a site has impacted various media and to help in the evaluation and selection of a remedy for the site.

Background information can also assist in a screening step for chemicals during the human health and ecological risk assessments (see: Ohio EPA, 2008; U.S. EPA, 1989 *Chapter 5.7*). Background concentration levels of chemicals have also been used on a site-specific basis as an alternative to risk-based standards where risk-based standards are lower than background levels (U.S. EPA-OERR, 2002).

<u>Decision</u>: Site-specific background concentrations of naturally occurring and anthropogenic chemicals may be used in the risk assessment and risk management processes for all remedial response sites as discussed in this document.

<u>Rationale</u>: The use of background and the recommended methodology for determining background given in this document is not inconsistent with U.S. EPA guidelines and has precedence of usage by multiple Divisions in the Ohio EPA. Its application allows for the reduction of the number of chemicals carried through the quantitative risk

assessment process, in an effort to simplify and focus the evaluation on site-related risk drivers, and allows for the use of background in risk management as part of remedy selection for the site. The Ohio EPA - DERR considers this methodology acceptable for use at all remedial sites. However, DERR would also accept the procedures recommended by U.S. EPA for CERCLA - Superfund sites (U.S. EPA, 1989; U.S. EPA, 2002; U.S. EPA-OERR, 2002) in evaluating and applying background concentrations in the risk assessment process.

Attachments: Glossary of Terms and Definitions; References; and, Attachment A, Example Calculation of Upper Cutoff/Background Level.

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General Recommendations:

The identification of background concentrations has not been required at all sites. If background values are anticipated to be needed or helpful in the assessment and remedy selection process then, it is beneficial to determine background values early in the site characterization process.

Background levels can be determined for most media (*e.g.*, soil, ground water, surface water, and sediment). For mobile media such as surface water, ground water and sediment, the reference location(s) should be up-gradient and upstream in the same water body or saturated zone in areas not affected by site-related activities. Additional guidance may be provided by Ohio EPA on site-specific basis.

To date, many methods have been developed to determine site-specific background concentrations. This document identifies one of the many options that are available for quantifying or evaluating background conditions.

Background sampling should be conducted at locations that have not been affected by the site or site-related anthropogenic activities, and in media of a similar type and horizon. See Section 2.3, in U.S. EPA-OERR 2002 for additional information on selecting appropriate background sample locations.

To calculate chemical-specific background levels, the methodology identified below is recommended. The calculated site-specific background levels should be compared to the maximum concentrations of chemicals of potential concern detected on-site in the screening step of risk assessment process. In contrast, site-related chemicals whose background concentrations are unknown are to be carried through the risk assessment process as chemicals of potential concern.

Naturally occurring chemicals may be eliminated from further consideration as chemicals of potential concern in the risk assessment, provided that on-site maximum concentrations of potentially site-related constituents are comparable to (equal to or less than) background levels.

Concentrations of anthropogenic chemicals that are non site-related (such as certain pesticides, polycyclic aromatic hydrocarbons, dioxins, etc.), may also be screened out by comparison to background levels on a site-specific basis.

The Ohio EPA site coordinator’s concurrence that the chemicals in question are not attributable to the site should be obtained prior to screening out chemicals from the quantitative risk assessment. Chemicals that have been screened out in the quantitative risk assessment process should be qualitatively discussed in the risk characterization section (*e.g.*, as “chemicals not included”, contributing significantly to uncertainty; U.S. EPA, 1989), to facilitate appropriate risk management and risk communication.

Additional guidance on the use of background in ecological risk assessments can be found in the Ohio EPA-DERR Ecological Risk Assessment Guidance document (Ohio EPA, 2008). Information regarding sediments, including generic background values, is also provided in the Ohio EPA ecological risk assessment guidance.

Prior to conducting a sampling and analysis program to determine site-specific background concentrations, Ohio EPA-DERR recommends reviewing existing literature data on the relevant background concentrations in the area. Some general information on this subject is publicly available on the internet (see “General Information” in the reference section). In addition, Ohio EPA maintains (as do other public agencies), various program and project specific data in public files which may provide useful information when planning a data collection program.

Available/existing background information should be reviewed prior to selecting the methodology to be used for gathering background data. Prior to conducting sampling, this information is to be submitted to the Ohio EPA for approval and may be incorporated into the site work plan. The current conceptual site model should be reviewed prior to developing the sampling plan to define all the possible uses of the background data. This includes DQOs and other pertinent information. For example, data may be used for both human health and ecological risk assessments purposes and their required or useful practical quantitation limits may vary dramatically depending on the intended use of those data.

In cases where ground water interim actions or other rapid assessments are needed, alternative background determination methods may be proposed to facilitate timely remedial design and implementation. However, as may be necessary, an appropriate background level should be determined during implementation of the interim action or assessment.

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Sampling:

The collection of background data should not be in areas affected by the site or site-related activities. Some locations to avoid are listed below:

$ areas affected by past or present waste management practices;
$ areas of air pollutant deposition (from a definable localized source);
$ areas affected by runoff;
$ fill areas;
$ roads or roadsides;
$ parking lots or areas surrounding parking lots or other paved areas;
$ railroad tracks or railway areas or other areas affected by their runoff; and,
$ Storm drains or ditches presently or historically receiving industrial or urban runoff.

If an appropriate on-site sampling location cannot be found, then an off-site background location may be selected if approved by Ohio EPA.

For mobile media such as surface water, ground water and sediment, background location(s) should be up-gradient and/or upstream in the same water body or saturated zone in areas not affected by site-related activities.

Ohio EPA develops sampling guidance and utilizes others developed by U.S. EPA and other entities. These guidance documents are usually media specific (see the sampling guidance listed reference section). The sampling procedures and methods described in these documents should be incorporated into the Sampling and Analysis Plan, if they are appropriate for a specific site.

On a case - by - case basis (*e.g.*, when site-specific background sampling is not possible), and with the approval of Ohio EPA-DERR, existing regional soil, sediment, or surface water data may be used to establish relevant background ranges or levels.

After the background data is collected, the data must be evaluated to determine if the samples are representative of background, and if appropriate, the number of representative samples is sufficient to test the statistical assumptions. Additional samples may need to be collected if the useable sample population is not sufficient to give the required degree of statistical confidence.

One method to help determine if samples were taken from appropriate background locations, is to analyze background samples (one or more) for both target analyte list (TAL) and target compound list (TCL) chemicals. The results should indicate whether background locations have been impacted by site-related or other activities. This may be appropriate for sites where the complete nature and extent of contamination may not have yet been fully defined. This approach may not be necessary for sites with defined or site-specific contamination which is not ubiquitous.

Background samples must be validated in accordance with acceptable QA/QC protocol (*e.g.*, substantiated by appropriate chain-of-custody procedure and records, SOPs, field and analytical records, etc.)[1] Ohio EPA-DERR recommends the use of real-time field analytical techniques and dynamic sampling plans when possible to avoid data problems and streamline data collection.

Recommended Sample Size for Soil Background Calculation:

Ohio EPA-DERR recommends a minimum sample size of 12 for each horizon or subunit per medium that will be evaluated. The recommended sample size of 12 was selected based on a variety of information including professional judgment. In statistical terms, 12 data points allow for determination of a mean value with 95% probability that it will not exceed a true (population) mean by 50%. In other words, if soil sampling, analysis and the mean value calculations were done repeatedly, in precisely the same manner, the chance of estimating a mean value 50% greater than the true mean is 5%[2]. This is based on an analysis given in Gilbert, 1987.[3]

Although a minimum sample size of 12 is recommended, it is not necessarily the correct sample size for a given remedial response site. If a smaller number of samples are proposed to be used to determine background concentrations, a statistical or technical justification is to be provided to Ohio EPA-DERR via the appropriate work plan.

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[1] U.S. EPA Office of Emergency and Remedial Response: *'Guidance for Data Usability in Risk Assessment (Part A), Final'*, Publication 9285.7-09A, April 1992.

[2] Technically, this is correct only under the assumption that the soil samples (not correlated over time and space) were collected through a simple random sampling process, that the results of laboratory analysis (data) are normally distributed, and that the coefficient of variation (the ratio between the standard deviation and the mean of the collected data) is within 95%. Although these assumptions may not always hold strictly true, they are nevertheless reasonable if one is sampling a true background population.

[3] The methods used to derive the minimum sample number may be found in Chapter Four of Gilbert, R.O., *'Statistical Methods for Environmental Pollution Monitoring'*, Van Nostrand Reinhold, 1987

Calculation of Background Values:

The determination of background levels employs a method commonly associated with a graphical technique for the detection of outliers from a population (*i.e.*, box plot). This methodology also can be used for the selection of a reasonably-protective estimation of an upper-bound value of a data set. Specifically, background concentration levels are to be calculated as the upper cutoff value of the data set defined as the upper quartile + 1.5 (interquartile range).

The upper cutoff value is to be calculated using the following equation:

$$U = Q_3 + k(Q_3 - Q_1) \quad \textit{Equation 1}$$

Where, Q_1 is the lower quartile, Q_3 is the upper quartile, $(Q_3 - Q_1)$ is the interquartile range, and the multiplicative constant k is one of two factors[4] for determining the upper cutoff value.[5] For our purposes (selection of a background concentration), a value of 1.5 is recommended for k.

Many software applications have functions that can be used to identify the quartile values of a data set[6]. Attachment A provides an example of a manual calculation of the upper cutoff value of a data set.

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[4] The common range for k is between 1.5 and 3.0. For the "standard" boxplot, k equals 1.5

[5] The distinction between results of the boxplot method when k takes a value on either side of this range is important. When k is set to 1.5, the boxplot may show a relatively high number of observations as outstanding, some of which may <u>not</u> be true outliers. On the other hand, when k equals 3.0, <u>all</u> observations that fall outside the cutoff points can be "safely" considered as outliers. A shortcoming, in this case, is that some lesser (but true) outliers may fall inside the fences and remain unflagged. In other words, the "standard" boxplot (k = 1.5) is more likely to label an observation as an outlier (albeit possible errors), than a boxplot where k equals 3.0.

[6] Note that commonly available spreadsheet applications will perform these calculations automatically. For example, Microsoft Excel's® QUARTILE function will return results identical to the manual calculations illustrated in Appendix A.

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Comparison of Background to Site Concentrations:

The upper cutoff value is to be used as the background concentration level and it should be compared to samples taken on-site on a point by point basis. No reduction of site data, such as developing an average concentration term, should be considered. Any site concentration exceeding the background level (upper cutoff level) should be considered evidence of contamination.

General Media-specific Comments:

Soil:
Optimally, background soil samples should be collected from the same soil types and soil horizons that occur in suspected contaminated areas on-site. Ohio EPA-DERR recommends using the Unified Soil Classification System as specified in ASTM D2488-90 to compare soil types [7]. The use of soil maps and comparing samples from similar depths may be useful but are not a substitute for the ASTM classification [8].

Ground water:
If it is not possible to find an appropriate location to determine background levels in ground water on or underlying the site, Ohio EPA DERR may approve the use of ground water data from other sources.

Surface Water and Sediment:
Ohio EPA has evaluated the data in the Agency's sediment database and generated generic Sediment Reference Values (SRVs) for certain chemicals to facilitate site-specific sediment characterization in lotic (flowing) water systems. The SRVs are eco-region based, and should be used appropriately (*i.e.*, the site sediment data should be compared to the appropriate eco-regional SRV). DERR has determined that the SRVs can be used as a substitute for site-specific background data to determine if the site has impacted sediment. The SRVs are available in Attachment H of the 'Guidance for Conducting Ecological Risk Assessments', April 2008, DERR-00-RR-031.

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[7] ASTM, Method D2488-00, 2000. '*Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)'*. Annual Book of American Society for Testing and Materials Standards, West Conshohocken, PA.

[8] One such depth-based strategy may be to compare sample sets taken in a zero to one foot range, and a different pair of sample sets taken from the two foot to four foot range.

Glossary of terms and definitions:

Background refers to concentrations of chemicals at locations that are unaffected by any current or past site activities involving the management, handling, treatment, storage or disposal of hazardous substances. Background includes concentrations of both anthropogenic and naturally occurring chemicals:

> 1) *Anthropogenic* – natural and human-made substances present in the environment as a result of human activities (not specifically related to the site in question); and,
>
> 2) *Naturally occurring* – substances present in their unaltered form or altered solely through naturally occurring processes or phenomena, in a location where they are naturally found.

Background levels include only substances, sampled from unaffected portions of the site and areas surrounding the site ("background reference locations"), whose upper boundaries (upper cutoff values) have been evaluated.

Background concentration is the concentration of constituents found in media such as air, water, soil or sediments at or surrounding a waste site, but which are not influenced by site activities or releases. [Note: The distinction between background concentrations and background levels in this TDC is that the former refers to actual measured data, while the latter refers to the upper limit of the population of background concentration values.]

A "*background reference location*" should be a site that is geologically similar and has similar biological, physical, and chemical characteristics (*e.g.*, particle size, percent organic carbon, pH) as the contaminated site but also should be upstream, upgradient, or upwind of the site. Samples taken from a site to determine background concentrations are referred to as *background samples*.

Screening is a common approach used by risk assessors to refine the list of potential chemicals of concern to those hazardous substances, pollutants, and contaminants that may pose substantial risks to health and the environment (risk drivers). Screening involves a comparison of site media concentrations with *background* and *risk-based* values.

Site refers to the aerial extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action, as defined in the National Contingency Plan (NCP: 40 CFR, Ch. I (7/1/03 Edition), § 300.5).

Upgradient refers to areas that are topographically and/ or hydraulically upgradient of the site, and thus could not be impacted by site-related contamination. Upgradient concentrations are generally necessary to determine whether contamination in mobile media such as surface water, sediment or groundwater is attributable to the site.

References:

- Ohio EPA, Division of Environmental Response and Revitalization: 'Guidance for Conducting Ecological Risk Assessments', April 2008, DERR-00-RR-031.
- U.S. EPA, Office of Emergency and Remedial Response: 'Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)', December 1989, EPA/540/1-89/002.
- U.S. EPA, Office of Solid Waste and Emergency Response and Office of Emergency and Remedial Response: 'Role of Background in the CERCLA Cleanup Program'. April 26, 2002. OSWER 9285.6-07P.
- U.S. EPA-OERR, Office of Emergency and Remedial Response: Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites, EPA 540-R-01-003, OSWER 9285.7-41 September 2002.
- Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance), U.S. EPA, Office of Resource Conservation and Recovery, Program Implementation and Information Division, EPA 530-R-09-007, March 2009. ASTM guidance document number D 6312-98 entitled: "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs."
- Ohio EPA Division of Surface Water, Sediment Sampling Guide and Methodologies 3rd addition, March 2012. (see Other Published Guidance #10).

General Information on Literature Background Levels:

Background Levels of Heavy Metals in Ohio Farm Soils, Ohio State University Research Bulletin, Research Circular 275-83.

Water Resources of Ohio, United States Geological Survey, Ohio Water Science Center.

Background Comparison Sources, Risk Assessment Information System, University of Tennessee.

Ground Water Quality Trends and Maps by Parameter, Ohio Environmental Protection Agency, Ambient Groundwater Monitoring Network Locations.

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Attachment A
Example Calculation of the Upper Cutoff/Background Level

The following is an example of the numerical method to be used to calculate the upper cutoff values.

First, calculate the upper and lower quartiles. The upper quartile ($Q_{.75}$ or Q3) equals the observation in the background data set which divides the data so that 25% of the data are greater than Q3 and 75% of the data are less than or equal to Q3. The lower quartile ($Q_{.25}$ or Q1) equals the observation in the background data set which divides the data so that 75% of the data are greater than Q1 and 25% of the data are less than or equal to Q1.

Next, calculate an upper cutoff value:

Upper cutoff = upper quartile + 1.5 (interquartile range) *Equation 2*

(Remembering that the interquartile range = Q3 - Q1).

Example for <u>even</u> numbers of background data:

Given the following data set consisting of twelve data points,

1.3	0.8	0.6	0.2	0.1	0.025
0.9	2.5	0.6	0.4	1.7	5.7

First, order the data from least to greatest:

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
0.025	0.1	0.2	0.4	0.6	0.6	0.8	0.9	1.3	1.7	2.5	5.7

For an even number of data points, the quartiles are determined by splitting the ordered data set twice equally (*i.e.*, into fourths). The quartiles are found at the splits and can be adequately estimated by averaging the data points on either side of the split. Using the above data set, Q1 falls between the 3rd and 4th observation and is therefore calculated as:

$$(0.2 + 0.4) / 2 = 0.3$$

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Similarly, Q3 falls between the 9th and 10th observation and can be calculated as:

$$(1.3 + 1.7) / 2 = 1.5$$

This can be demonstrated visually as follows:

					Q1				(Q2 or median)			**Q3**		
(1)	(2)	(3)	|	(4)	(5)	(6)	|	(7)	(8)	(9)	|	(10)	(11)	(12)
0.025	0.1	0.2		0.4	0.6	0.6		0.8	0.9	1.3		1.7	2.5	5.7
							|			|			|
							0.3			(0.7)				**1.5**

After calculating the quartiles, calculate the interquartile range (IQR), or the difference between Q3 and Q1:

$$IQR = Q3 - Q1, \text{ i.e.}$$

$$IQR = 1.5 - 0.3 = 1.2$$

The final step is to calculate the Upper cutoff as defined by the Equations *2* above:

$$\text{Upper cutoff} = 1.5 + 1.5(1.2) = 3.3$$

In this case, the background level would equal 3.3.

Example for odd number of background data:

For odd numbered data sets, the lower quartile (Q1) can be found by multiplying the number of observations (n) by 0.25, and then rounding the result to the next largest integer. The resulting number indicates the observation which corresponds to Q1. Similarly, Q3 can be found by multiplying n by 0.75, and rounding to the next larger integer. This number refers to the observation which corresponds to Q3. For example, with the following data set (where n = 13):

(1)	(2)	(3)	(4)	(5)	(6)	(7)
0.1	0.2	0.4	0.6	0.6	0.8	0.9

(8)	(9)	(10)	(11)	(12)	(13)
1.3	1.7	1.8	2.1	2.5	5.7

For Q1:

0.25 x 13 = 3.25; rounded up = 4

So, Q1 is the 4th observation or 0.6.

Likewise for Q3:

0.75 x 13 = 9.75; rounded up = 10

So, Q3 is the 10th observation or 1.8.

Q2 (the median) is the value in the middle - 7th observation or 0.9.

The rest of the procedure remains the same as in the previous example for an even number of data.