Glossary

Accelerated Site Characterization

A process for characterizing vadose zone and ground water contaminated sites using primarily professional judgment-based sampling and measurements by an integrated, multidisciplinary core technical team. The team operates within the framework of a **dynamic work strategy** that allows flexibility when selecting the type and location of measurements so that data collection activities can be optimized during a limited number of field mobilizations.

Adaptive Sampling and Analysis Programs

Environmental data collection programs that use **real time measurement technologies** to produce data quickly enough to allow data collection to adapt to encountered conditions. Also known as sequential and directed sampling programs.

Accuracy (of measurement)

A measure of the overall agreement between a measurement and the "true" value.

"Closeness of agreement between the result of a measurement and a true value of the **measurand**. Notes: Accuracy is a qualitative concept. The term "precision" should not be used for accuracy." [IUPAC]

"A measure of the overall agreement of a measurement to a known value. Accuracy includes a combination of random error (**precision**) and systematic error (**bias**) components that are due to sampling and analytical operations; EPA recommends using the terms *"precision"* and *"bias*," rather than "accuracy," to convey the information usually associated with accuracy." [USEPA QA/G-5]

Analytical Bias (for a measurement result)

The difference, on average, between the results from analyses and the "true" value. This is a signed quantity (i.e., bias is either positive or negative) [this paraphrases the mathematically-based definition in IUPAC]. The presence of analytical bias is one of the contributors to poor method accuracy.

Analytical Error

This variability (termed "error" by statisticians) component arises from imperfections in the analysis (chemical or physical) operation. It includes variability (i.e., errors) associated with such activities as chemically extracting the analyte from the **sample** matrix, instrumentation error, operator errors, moisture analysis, gravimetric errors, and other measurement errors. [adapted from USEPA Subsampling Guidance]

Analytical Method

That portion of the sampling/analysis chain that involves measuring analytes to produce information about the chemical composition of **environmental matrix** samples. Measurement of analytes may be performed directly on analytes in the presence of the matrix or after extraction or digestion procedures have freed the analyte from the original matrix. There are three broad categories under the umbrella term of "analytical method": preparative methods, cleanup methods, and determinative methods. Analytical methods are distinguished from sampling methods that precede analysis. See also **chemical measurement process** and **method**.

Analytical Quality

An expression of the **bias**, **precision**, **detection/quantification capability**, susceptibility to **interferences (i.e., selectivity)**, analyte **specificity**, and other characteristics of the measurement process that reflect the ability of the analytical method to produce results that represent the true concentration of the target analyte in the sample that was presented to the analytical method. The adequacy of analytical quality can be assessed only in the context of intended data use. See also **quality** and **data quality**.

Analytical Representativeness

An expression of the degree to which sample analysis and interpretation of the analytical results represent the actual characteristics of the sample or subsample being presented to the analytical method. Examples where analytical representativeness is compromised include 1) unrecognized **interferences** cause sample results to be significantly biased high or low, yet the erroneous results are accepted as "true"; 2) poor **recovery** of target analyte by the sample/subsample **preparation method** or **cleanup method** goes unrecognized and falsely low results are interpreted as representing "true" results; and 3) results from a test method known to be non-specific (e.g., an immunoassay that legitimately responds to a group of closely related compounds for which individual response factors are available) are incorrectly interpreted by a data user as if the test only responded to a single analyte.

Analytical Uncertainty

The uncertainty introduced into decision making by the limitations of analytical preparation and determination methods. Limitations that contribute to analytical variability include analytical **bias**, lack of **precision**, and susceptibility to **interferences** (analytical **selectivity**). Limitations in detection capability create uncertainty when drawing conclusions about the true presence or absence of analytes when results are non-detect or are close to a detection limit. Together, these factors create an uncertainty interval around the analytical result, which is simply a point estimate of the mass of analyte that was presented to the **determinative method**. The width of the uncertainty interval can limit the data user's ability to support a confident decision if the uncertainty interval overlaps a decision threshold or action level.

Analytical Variability

The variability observed in repeated measurements of the same sample. Also known as measurement variability or **measurement error** - the difference between the true or actual state and that which is reported from measurements.

Analyte

A parameter of interest when a sample analysis is performed.

"The component of a system to be analysed." [IUPAC]

Analyte-Specific

Giving analytical responses that distinguish one detected **analyte** from another detected analyte (as distinct from **interferences**—compare **selectivity**). For example, distinguishing trichloroethene (TCE) from perchloroethene (PCE), although both are in the chlorinated volatile organics compounds (chl-VOCs) group. One characteristic of **screening analytical methods** is that they may be non-specific, that is, the method

response only indicates whether any members of a group are present (and may estimate a summed quantity), but the response does not distinguish between the specific analytes belonging to that group. In contrast, analyte-specific responses do allow analytes to be distinguished from each other, with more or less confidence depending on the method.

Bias

The systematic or persistent distortion of a measurement process that causes errors in one direction along a metric away from the true value; that is, bias is a function of systematic error (*e.g.*, the average measured mass differs from the true mass by +0.034 g). [adapted from USEPA Subsampling Guidance]

Calibration (in analysis)

The process by which an analytical response is correlated with known standards.

"The set of operations which establish, under specified conditions, the relationship between values indicated by the analytical instrument and the corresponding known values of an **analyte**." [IUPAC]

Certified Laboratory

A laboratory that is currently certified pursuant to state or federal standards to perform laboratory analysis for a specific certification category and a specific parameter within the certification category.

Chemical Measurement Process

"An **analytical method** of defined structure that has been brought into a state of statistical control, such that its imprecision and bias are fixed, given the measurement conditions. This is prerequisite for the evaluation of the performing characteristics of the method, or the development of meaningful uncertainty statements concerning analytical results." [IUPAC]

Clean-Up Methods (as part of an analytical method)

Clean-up methods are applied to extracts of environmental samples to remove co-extracted interferences. See SW-846 Method 3600 for more information. [USEPA SW-846]

Collaborative Data Sets

Data sets that might not be effective for making project decisions when considered alone, but when considered together they manage all relevant **relational**, **sampling**, and **analytical uncertainties** to the degree necessary to support defensible decision-making. Typically, less expensive **analytical methods** will be used to generate a high sampling density and real-time turnaround so an accurate **conceptual site model** (CSM) can be constructed and sampling uncertainties managed. Any analytical uncertainty remaining from the high density data set is then managed by analyzing selected samples (whose **sample representativeness** has already been established) with more rigorous analytical methods to get lower quantification limits and **analyte-specific** results. Collaborative data sets often are not directly comparable, and if not, should not be mathematically combined together. This may be considered a type of "**weight of evidence**" approach for CSM development. Collaborative data sets are also used to develop field-to-laboratory correlations and **field-based decision criteria**.

Comparability

"A measure of the confidence with which one data set or method can be compared to another." [USEPA QA/G-5]

Comparability for **analytical methods** can be assessed by understanding how the detection mechanism of each method works, as well as the impact of associated sample **preparation** and **cleanup methods**.

Comparability for sampling methods can be assessed by examining the sample collection mechanism of each with respect to **sample support,** sampling locations, and sample preservation issues to determine whether both data sets come from the same **population**.

Comparability of **data sets** must include evaluation of both sampling and analytical aspects of the data sets. Direct comparisons of values between two environmental data sets is seldom useful unless the full range of sampling and analytical variables have been controlled to ensure that both data sets are from the same population. If the samples are not comparable, any attempt to compare analytical performance is pointless. If sampling comparability is established, analytical comparability can be evaluated by looking at the detection mechanism of the methods and the project-specific method performance. Method performance should have been established through QC checks to determine the *achieved* (not theoretical) reporting limits, **bias**, and **precision** for project-specific samples. If that information is lacking, comparison of different data sets is less informative.

Composite Sample

A **sample** created by combining several distinct **subsamples**. [USEPA Subsampling Guidance]

Conceptual Model

"A description of the expected source of the contaminant and the size and breadth of the area of concern, including relevant fate and transport pathways and potential exposure pathways." [USEPA QA/G-5S]

See also **Conceptual Site Model (CSM).**

Conceptual Site Model (CSM)

Any site depiction(s) or representation(s) used to conceptualize or model contamination concerns to make predictions about nature, extent, exposure, and risk reduction strategies. An accurate CSM will delineate contaminant **populations** for which decisions about risk or remedial action or the project outcome will differ. A complete CSM will identify the uncertainty associated with site depictions or representations that may contribute to **decision uncertainty**. May also be termed a **conceptual model**.

Confirmatory Analyses

A common term that is generally used ambiguously since it can refer to any one of a number of different activities, such as 1) confirmation that cleanup activities were successfully completed; 2) fraud detection or proficiency evaluation by duplicating testing between different laboratories or operators; 3) establishing the **comparability** of different analytical methods; and 4) providing **analyte-specific** results to guide the interpretation of results from non-specific methods. Those using the term "confirmatory analyses" are encouraged to be clear about what activity is intended.

Contaminant

Any hazardous substance, hazardous constituent, hazardous waste or pollutant discharged by any individual or entity to the environment.

Contaminant Delineation

The systematic collection and analysis of samples to determine the vertical and horizontal extent of contamination above some standard.

Contaminant Population (within environmental matrices)

A single contaminant population is created within a particular environmental matrix by some particular release or migration mechanism. Different release and migration mechanisms will create populations having different characteristics. Characteristics include spatial boundaries (in 3 dimensions), time-dependency, concentration variability within the population, bioavailability, differential physical association of contaminants with different matrix constituents (e.g., mineral structures or organic carbon) and different matrix particle sizes. Contaminant partitioning and fate mechanisms may interact with surface area and mineral/organic carbon binding sites to create different contaminant populations based on particle size within the same bulk matrix. The simplest example of different populations within the boundary are on-site matrices impacted by contaminant spills ("contaminated") vs. on-site matrices not impacted by spills ("clean"). Decisions about regulatory compliance and remedial action will usually be different for different populations. The CSM is the tool used to understand and record different populations as they are described and delineated across a given site.

Contaminant Screening

The analysis of environmental media by non-**selective** or non-**analyte**-**specific** instrumentation or methods to make a preliminary determination of the presence of a contaminant above some standard. See also **site screening**.

Continuous Selection Error (CE)

This error is generated by the material selection process and is the sum of three errors, the **short-range fluctuation error (CE_1)**, the **long-range heterogeneity fluctuation error (CE_2)**, and the **periodic heterogeneity fluctuation error (CE_3)**. [adapted from USEPA Subsampling Guidance]

Correct Sampling Practice

Correct sampling gives each item (particle, fragment) of the target population an equal and constant probability of being selected to be part of the **sample**. Likewise, any item that is *not* considered to be part of the population (that is, should *not* be represented by the sample) should have a zero probability of being selected. Correct sampling practices minimize those "controllable" errors through correctly designed sampling devices, common sense, and by correctly taking many random **increments** combined to make up the sample. Correct sampling practices allow a **representative sample** to be taken. [adapted from USEPA Subsampling Guidance]

Data of Known Quality

Data for which the contributions to its uncertainty from **sampling**, **analytical,** and **relational uncertainty**

can be estimated (either qualitatively or quantitatively) with respect to the intended use of the data, and the documentation to that effect is verifiable and recognized by the scientific community as defensible.

Data of Unknown Quality

Data for which critical steps in the data generation process are improperly performed or have not been documented, creating irresolvable uncertainty about whether the data are credible.

Data Point
Analytical results for a single sample.

Data Quality

"A measure of the degree of acceptability or utility of data for a particular purpose." [USEPA QA/G-5]

Data Set

Analytical results for samples that are grouped based on some rationale. Typically, a data set is expected to come from the same **population** under investigation for the purpose of providing input into a specific decision.

Decision Quality

The degree to which an *actual* decision coincides with the decision that *would have been made* if complete and fully accurate information (i.e., the true state) was known (or knowable). Because the "true state" is rarely known at the time of decision-making, decision quality is commensurate with the degree of confidence in the correctness of a decision. That confidence is a function of the extent to which information (as inputs into the decision process) is fairly weighed while acknowledging the assumptions, conditions, and uncertainties that could impact the correctness of the decision.

Decision Quality Data

Term is equivalent to "data effective for decision-making" or "**effective data**."

Decision Unit Support (decision-population interaction)

The spatial dimensions and other physical properties (such as particle size) that define the **population** about which a particular environmental decision will be made. For example, the population of "soil impacted by atmospheric deposition from a smelter" may be of interest for the purpose of determining whether the smelter is/was a source of regional contamination or to decide whether that soil poses a risk to off-site receptors through exposure to wind-blown dust. The decision support for that population can be designated by spatial coordinates (including the depth of the layer of interest) and by the soil particle size corresponding to off-site transport and exposure. Samples representative of those decisions will have to be taken within those spatial boundaries using sampling techniques that can isolate the particle size of interest. See also **Decision Unit**.

Decision Support (aids to decision-making)

Tools (models, methods, analyses, software, etc.) used to assist in the process of making site-specific

decisions.

Decision Uncertainty

The uncertainty associated with decision-making. Decision uncertainty is equivalent to the likelihood of making the wrong decision, such as concluding an area complies with cleanup criteria when in fact it does not. Decision uncertainty is directly related to **decision quality**. When decisions are primarily based on sample results, there are three primary contributors to decision uncertainty: **sampling uncertainty**, **analytical uncertainty**, and **relational uncertainty**.

Decision Unit

A discrete unit about which a decision is made. For example, if decisions about incineration vs. landfill disposal of drummed waste are made on a drum-by-drum basis (i.e., each drum is tested separately and the decision for that drum is based on its individual test results), then the decision unit is a single drum. On the other hand, if drums are grouped in lots of 50, and 20 individual drums are selected randomly for testing, and based on the test results the entire lot of drums is either incinerated or landfilled, then the 50-drum lot is the decision unit. See also **Decision Unit Support**.

Defensible

Derived logically with all underlying assumptions and uncertainties openly acknowledged. To the degree feasible, uncertainties are controlled or documented so that the impact on the likelihood of decisions errors is understood. Conclusions are thus able to withstand reasonable challenge.

"The ability to withstand any reasonable challenge related to the veracity or integrity of project and laboratory documents and derived data." [USEPA QA/G-1]

Definitive Method

"A method of exceptional scientific status which is sufficiently **accurate** to stand alone in the determination of a given property for the certification of a reference material. Such a method must have a firm theoretical foundation so that systematic error is negligible relative to the intended use. Analyte masses (amounts) or concentrations must be measured directly in terms of the base units of measurements, or indirectly related through sound theoretical equations. Definitive methods, together with certified reference materials, are primary means for transferring accuracy, i.e. establishing **traceability**." [IUPAC]

This formal scientific definition is very different from the way most in the environmental cleanup field use this term. Few, if any, of the standardized analytical methods considered "definitive" by environmental practitioners (such as many EPA SW-846 methods) measure up to this formal definition. The terms "**reference method** [IUPAC]" or "**standard analytical method**" more accurately reflect traditional environmental laboratory analytical methods such as those described in EPA SW-846. To avoid confusion, some Triad practitioners may avoid this term.

Demonstration of Method Applicability

Also called a "methods applicability study" or "pilot study." This is an early (in the project) testing of proposed sampling or analytical methods to evaluate site-specific performance. Such studies are recommended by EPA prior to finalizing the design of sampling and analyses plans for waste projects [SW-

846 Section 2.1]. These studies can be designed to accomplish several goals:

- Initial evaluation of site-specific heterogeneities that will support further design of the data collection program
  - Sampling design (how many samples to collect and where to collect them)
  - Sample support (what volume of sample to collect and with what collection tool)
  - Sample processing (also can be related to sample support issues)
  - Communicate heterogeneity issues to regulators and stakeholders
- Evaluation of analytical performance on site-specific sample matrices
  - Guides method selection
  - Determine whether and how to modify methods to improve performance and/or cost-effectiveness
- Develop initial method performance/QC criteria based on site-specific data needs
  - During project implementation, both field and analytical QC results will be judged against these criteria to determine whether procedures are "in control" and meeting the defined project needs
  - Develop list of correct actions to be taken if QC criteria exceeded
- Decision thresholds ("action levels" to guide decisions about compliant vs. non-compliant soil or areas, and the routing of materials for final disposal)
- Develop contingency plans for tool or instrument failure

Detection/Quantification Capability

Unfortunately, a host of terms have been used to describe the concepts of "how low can you see an analyte" (i.e., detect) and "how low can you measure an analyte" (i.e., quantify). These terms have led to tremendous confusion for both the environmental and chemical communities. IUPAC has examined this issue is some detail. Resolving this confusion relies on mathematically defined statistical concepts, which means that few pursue an in-depth understanding of the issues. The term **sensitivity** is sometimes used incorrectly when referring generally to detection and quantitation limits. To replace the word "sensitivity" for this usage, IUPAC suggests that the term "detection/quantification capability" be used rather than "sensitivity."

Detection Limit (in analysis)

"The minimum single result which, with a stated probability, can be distinguished from a suitable blank value. The limit defines the point at which the analysis becomes possible and this may be different from the lower limit of the determinable analytical range. See also **limit of detection**, **relative detection limit**." [IUPAC]

The term **sensitivity** is sometimes used incorrectly when referring to detection and quantitation limits. See also **detection/quantification capability.**

Dimension (of a population)

If the components of a **population** are related by location in space or time, then they are associated with a dimension. The dimension of a population is the number of major axes having an ordered metric. Dimensions in the characterization of a population become reduced when one or more dimensions become negligible when compared to the other dimension(s). **Sampling units**, such as bags of charcoal or bottles of beer from a production line, represent one dimensional populations, with the time of production giving order to the individual items. A zero-dimensional population has no order to the sampling units. An elongated pile is a one-dimensional population since it has one major ordered direction. Surface contamination at an electrical transformer storage site represents a two-dimensional population. Higher (two-, and especially three-) dimensional populations tend to be much more difficult to sample in producing laboratory **subsamples**. [adapted from USEPA Subsampling Guidance]

Dynamic Work Strategy

A work strategy for contaminated site characterization, remediation, or monitoring (or a combination thereof) where activities have built-in flexibility guided by a pre-approved decision logic. As information is gathered, it is used to make decisions in real-time about what subsequent activities will best resolve remaining data and decision uncertainties. The goal is to mature the CSM and complete remedial actions in as few field mobilizations as feasible. As with all environmental projects under regulatory oversight, all planned work activities should be described in written work planning documents appropriate to the overseeing program.

Effective Data

Data (points or set) of known quality that can be logically shown as effective for making scientifically defensible project decisions (without requiring additional data or information to back them up), because the **relational, sampling,** and **analytical uncertainties** in the data have been controlled to the degree necessary to meet clearly defined decision goals. Equivalent to "**decision quality data**".

Environmental Matrix(ces)

"The component or substrate (e.g., surface water, drinking water) which contains the analyte of interest." [USEPA SW-846] Environmental matrices include a wide variety of soils, sediments, groundwater, waste materials, sludges, etc. The mineral and chemical components present in environmental matrices interact with chemical contaminants in various ways that make accurate chemical analysis for trace levels of contaminants particularly challenging.

Estimate

A measured value that approximates the true value. In this context, the proportion of the analyte in the **sample** is an estimate of the true proportion of the analyte in the **population**. Measurements are always subject to errors and one can never claim that the measured value is exactly correct. This is also true of any **statistic** based on measured data. Thus, statistics and the data used to calculate them can both be classified as estimates. The statistic (*e.g.,* the sample mean) from a sample (or samples) of a **population** is an estimate of the true value of the parameter (the true mean) of the population. That is, for an estimate to have merit, the sample must mimic (be r**epresentative** of) the population in every way, including the distribution of the individual items or members (particles, analytes, and other fragments or materials) of that population. [adapted from USEPA Subsampling Guidance]

Expedited Site Characterization (ESC)

A process for characterizing vadose zone and groundwater contaminated sites using primarily professional judgment-based sampling and measurements by an integrated, multidisciplinary core technical team. The team operates within the framework of a **dynamic work strategy** that allows flexibility when selecting the type and location of measurements so that data collection activities can be optimized during a limited number of field mobilizations. The ESC process is defined in ASTM Standard D 6235-98.

Exposure Unit

The area and time frame defined by spatial and temporal boundaries that are used to evaluate the potential risks to human or ecological receptors posed by the presence of contamination within the unit. An exposure unit is one kind of **decision unit**.

Field-Based Decision Criteria

Decision (or action) levels that are used to guide in-field decisions based on the real-time results of field methods. These criteria are structured to ensure that the correct decision is made, compensating for any bias or imprecision in the analytical method.

Field Measurement

The determination of physical, biological, or radiological properties, or chemical constituents; that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory. [adapted from NELAC]

Unlike the NELAC definition, Triad usage does not exclude mobile laboratory-generated data from the term "field measurement." The difference between NELAC and Triad terminology is due to their different perspectives on field measurements.

Field-Based Measurement Technologies

Equivalent term to on-site analytical methods, field analytical methods, field analytics, and a host of similar terms that are used to denote the instrumentation and methods used to perform real-time analyses in close proximity to the actual location of sample collection. Implementation ranges from hand-held instruments used outdoors to full-scale mobile laboratories.

Field Duplicates

"Independent samples which are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently. These duplicates are useful in documenting the precision of the sampling process." [USEPA SW-846]

The procedure used for collection of duplicates can vary by site and must be defined in the planning documents. How duplicate samples are collected and prepared is directly determined by what variability will be measured.

Field Portable

An instrument that is durable and relatively simple to move between facilities for on-site analysis.

Focused Quality Control

This refers to quality control (QC) that is focused on managing the data uncertainty that directly impacts the intended decision. Although this can be done under non-real-time scenarios, it is most efficiently done when data are generated and interpreted in real-time. Real-time data collection programs allow for immediate review and assessment of QC results, with interaction of the analyst with the project team to identify when and where excessive data uncertainty could impact decision. Rapid identification of uncertainty allows the reason(s) for it to be found and addressed. Focused QC supports higher frequencies of QC samples when the uncertainty is high, and lower frequencies when there is greater confidence in analytical performance and the usability of the data for decision-making purposes. Typically, QC protocols for Triad projects will

have higher QC frequencies and more types of QC at the beginning of a project, and lower frequencies over the course of the project as warranted. QC is usually intensive during the **Demonstration of Method Applicability,** which occurs either as a separate activity before actual project field work begins or as the initial phase of project field work.

For example, excessive **sampling uncertainty** might be detected when the analyst runs field and/or laboratory duplicates. A change in **sample or subsample support** or sampling design might be required, along with additional duplicate analyses to verify that the new sampling procedures are controlling for matrix heterogeneity effects.

Reasons for excessive **analytical uncertainty** include observations of matrix **interferences**, instrument or operator problems, a greater number of either non-detects or higher concentration hits than expected, and an evolving CSM with modified decision criteria. Focused QC allows the addition of system blanks after high-level field samples to control for carryover, extra calibration checks to verify performance at high or low concentration levels, or shifting of the calibration range to improve analyte quantitation.

Focused Sampling

This refers to real-time iterative modification of sampling to respond to refinement of the CSM to increase sampling locations, numbers, and design to focus on areas where uncertainty is greatest. Also referred to as **adaptive sampling and analysis plans**, directed sampling, or sequential sampling. Focused sampling may have a statistical, quantitative basis or be judgmental for the purpose of filling data gaps.

Fundamental Error (FE)

This error is called “fundamental” because it is associated with the basic makeup of all heterogeneous materials and can never be eliminated. Environmental matrices such as soils are made of particles composed of a wide range of constituents: minerals, natural organic carbon, anthropogenic materials and chemicals, microorganisms, etc. Each particle is different from it neighbors in the same matrix. Therefore it is impossible to have two samples that are completely identical to each other.

This error is fundamental to the composition of the particles (or other items or fractions) of the **population** being chemically or physically different; that is, it is a result of the constitution **heterogeneity** of the population. Thus, this is the only sampling error that can never cancel out. To get an accurate representation of this constitutional **heterogeneity**, one must be sure that the **samples** are always **representative** of all particle size fractions that are part of the population. This relative variance of the fundamental error can be estimated before sample selection and may be reduced by decreasing the diameter of the largest particles to be represented or by increasing the mass of the sample. [adapted from USEPA Subsampling Guidance]

Grab Sample

A nonprobabilistic selection of a **sample**, usually chosen on the basis of being the most accessible or by some judgment of the operator. A grab sample is taken with no consideration for obtaining a **representative sample**. Grab sampling has been shown to be associated with very high **uncertainty** and **bias**. It should only be used on sample matrices that have been extensively studied and shown to provide adequate data quality. Even then, great caution should be exercised as grab sampling may not provide an indication of matrix changes resulting in non-representative sampling. [USEPA Subsampling Guidance]

Granulometric Factor (g)

Sometimes called the **particle size distribution factor**, the granulometric factor is a particle size factor based on the particle size distribution. The size of each particle is not a constant. This factor accounts for the varying particle sizes when estimating the **fundamental error**. [USEPA Subsampling Guidance]

Gray Region (as defined as part of the decision performance goal diagram (DPGD) supporting statistical hypothesis testing per EPA's DQO guidance)

"The range of possible parameter values near the action level where the cost of determining that the alterative condition is true outweighs the expected consequences of a decision error. It is an area where it will not be feasible to control the false acceptance decision error limits to low levels because the high costs of sampling and analysis outweigh the potential consequences of choosing the wrong course of action. It is sometimes referred to as the region where it is 'too close to call.'" [USEPA QA/G-4HW]

When setting the gray region, the prediction of the DPGD model is that statistical results (i.e., after the data have been collected) that fall within this region are not expected to support decision-making at a pre-specified level of confidence, since the UCL calculated for the resulting data set will probably fall above the action level even though the true mean of the data set is suspected to be below the action level.

In practice, it is very difficult or impossible to set the gray region following the above description because it requires quantifying the consequences of a potential decision error in order to maintain the quantitative (as opposed to subjective, judgmental or qualitative) nature of statistical analysis. Since the site is not already characterized, calculating the costs of consequences (i.e., calculating the cost of ineffective or unnecessary remediation, possible receptor exposures, loss of property values, etc.) is highly uncertain, making the establishment of one of the most critical inputs to the DPGD non-quantitative and subjective.

One way around this dilemma is to set the gray region by estimating how close the true mean (of the population being investigated) is expected to be to the action level. Predicting where the true mean is expected to fall also requires some knowledge about the site (i.e., a preliminary CSM or progressive refinement during a dynamic investigation), but the prediction is less fraught with uncertainty than guessing what the cost ramifications of improperly designed cleanup or inappropriate NPL listing decisions will be in order to compare that cost to the cost of taking more samples. For almost all projects, the fully considered costs of a decision error will indicate that taking huge numbers of samples is cost-effective. But in truth, if the decision truly rests on showing that the UCL is less than a threshold, the number of samples will depend on how close the mean is to the threshold. The wider the gap between the mean and the threshold, the fewer the samples needed to demonstrate that the UCL is less than the threshold.

Grouping and Segegration Error (GE)

This error is due to the distributional **heterogeneity** of the particles (or other items) of the **population**. The relative **variance** of GE is due to the constitution **heterogeneity**, as well as to grouping and segregation (usually because of gravity). [adapted from USEPA Subsampling Guidance]

Heterogeneity (in analytical chemistry)

The condition of a **population** when all of the individual items are not identical with respect to the characteristic of interest. Often due to differences in the chemical and physical properties (which are responsible for the constitution heterogeneity) of the particulate material and the distribution of the particles (which leads to the distribution heterogeneity). [adapted from USEPA Subsampling Guidance]

"See **homogeneity**." [IUPAC]

Homogeneity (in analytical chemistry)

"The degree to which a property or a constituent is uniformly distributed throughout a quantity of material. A material may be homogeneous with respect to one analyte or property but heterogeneous with respect to another. The degree of **heterogeneity** (the opposite of homogeneity) is the determining factor of sampling error." [IUPAC]

Increment

A segment, section, or small volume of material removed in a single operation of the sampling device from the **population** or from a subset of the population (that is, the material to be represented); many increments ($N \geq 30$ increments are recommended) taken randomly are combined to form the **sample** (or **subsample**). [USEPA Subsample]

Increment Delimitation Error (DE)

This **increment materialization error (ME)** involves the physical aspects of selecting the **increment** using a correctly designed sampling device. The volume boundaries of a correct sampling device must give all fractions collected an equal and constant chance of being part of the sample. For example, a "one-dimensional" pile should be completely transected perpendicularly by a scoop with parallel sides. The increment delimitation error occurs when an incorrectly designed sampling device delimits (boundary limits of the extended **increment**) the volume of the increment giving a nonuniform probability for each item (fraction or particle) to be collected within the boundaries of the sampling device. [USEPA Subsampling Guidance]

Increment Extraction Error (EE)

This **increment materialization error (ME)** also involves the physical aspects of selecting the **increment** using a correctly designed sampling device. For a correctly designed sampling device, there must be an equal chance for all of the parts of the extended **increment** to be part of the sample or part of the rejects. The shape of the sampling device's edges is important to the center of gravity of each the particles and for each particle's chance to be part of the sample or part of the rejects. [USEPA Subsampling Guidance]

Increment Materialization Error (ME)

This error involves the physical process of selecting and combining the **increments** in preparing the **sample** (or **subsample**), and is *technically* the sum of three errors: the **increment delimitation error (DE)**, the **increment extraction error (EE)**, and the **preparation error (PE)**. [USEPA Subsampling Guidance]

Interference (in analysis)

"A systematic error in the measure of a signal caused by the presence of concomitants in a sample." [IUPAC]

Interferences may cause a test result to appear to be much higher or lower than the true value in the test sample.

Investigation Level (upper and lower)

Also referred to as “field-based action levels.” Decision levels used during a field investigation to demarcate different contaminant populations in the context of a dynamic work strategy. Typically, on-site results will be compared to the investigation level for the purpose of deciding whether a waste or matrix volume is contaminated or not, or should be relegated to one disposal option vs. another.

Judgmental Sampling

“Use of professional judgment to select sampling locations.” [USEPA QA/G-5S]

A sampling program whose design (e.g., methods, sample numbers, and sample locations) is determined by professional judgment. Within a Triad approach this professional judgment would be reflected in the conceptual site model.

Laboratory Control Sample

A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system. [NELAC]

Laboratory Duplicate

Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently. [NELAC]

Laboratory Sample

“The sample or subsample(s) sent to or received by the laboratory. When the laboratory sample is further prepared (reduced) by subdividing, mixing, grinding or by combinations of these operations, the result is the **test sample**. When no preparation of the laboratory sample is required, the laboratory sample is the test sample. A **test portion** is removed from the test sample for the performance of the test or for analysis. The laboratory sample is the final sample from the point of view of sample collection but it is the initial sample from the point of view of the laboratory. Several laboratory samples may be prepared and sent to different laboratories or to the same laboratory for different purposes. When sent to the same laboratory, the set is generally considered as a single laboratory sample and is documented as a single sample.” [IUPAC]

Liberation Factor

An estimate of the fraction of analyte that is separated (liberated or extracted) as a pure constituent from the matrix. The liberation factor takes on values 0 (l (1; when l = 1, the analyte is completely liberated. [USEPA Subsampling Guidance]

Limit of Detection (in analysis)

“The limit of detection, expressed as the concentration, cL, or the quantity, qL, is derived from the smallest measure, xL, that can be detected with reasonable certainty for a given analytical procedure. The value of xL is given by the equation xL = xbi + ksbi ; where x_{bi} is the mean of the blank measures, s_{bi} is the standard deviation of the blank measures, and k is a numerical factor chosen according to the confidence level

desired." [IUPAC]

Also LOD. An estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte- and matrix-specific and may be laboratory-dependent. [NELAC]

See also **detection/quantification capability**.

Limit of Quantitation

The analyte concentration below which there is an unacceptable error in determining a quantitative value. [USEPA Subsampling Guidance]

Also LOQ. The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. [NELAC]

Long-range Heterogeneity Fluctuation Error (CE_2)

The essentially nonrandom error associated with long-range local trends (e.g., local concentration trends) across the population. The relative variance of this error is identified by variographic experiments and may be better characterized by reducing the size of the strata or taking many increments to form the sample. [adapted from USEPA Subsampling Guidance]

Matrix (in analysis)

"The components of the sample other than the analyte." [IUPAC]

See also **environmental matrix.**

Matrix Effect

"The combined effect of all components of the sample other than the analyte on the measurement of the quantity. If a specific component can be identified as causing an effect then this is referred to as interference." [IUPAC]

Measurand

"Particular quantity subject to measurement." [IUPAC]

In other words, the thing being measured. Depending on the analytical method, the measurand may be a single, specific target compound (such as 1,1-dichloroethene or 4,4'-DDT) or a group of related compounds (such as chlorinated volatile organic compounds or a DDT-related group of parent and daughter compounds and isomers).

Measurement Error

"The difference between the true or actual state and that which is reported from measurements. Also known as measurement variability." [EPA QA/G-4HW]

"The difference between an observed (estimated) value and the true value. This is a signed quantity that generally has two components, **bias** and random error [related to **precision**]." [IUPAC]

Measurement Result

"The outcome of an analytical measurement (application of the **chemical measurement process**), or value attributed to a **measurand**. This may be the result of direct observation, but more commonly it is given as a statistical estimate derived from a set of observations. The distribution of such estimates (estimator distribution) characterizes the chemical measurement process, in contrast to a particular estimate, which constitutes an experimental result." [IUPAC]

Compare **analytical result**.

Method

"A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed." [USEPA QA/G-1]

MDL (Method Detection Limit)

"The minimum concentration of a substance that can be measured and reported with [a specified] confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte." [SW-846]

One way to establish a **limit of detection** (LOD), defined as the minimum concentration of a substance (an analyte) that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. [NELAC]

See **detection/quantification capability.**

Outlier

A statistical outlier is an observation that can be shown to belong to a population distribution other than the population distribution in question (usually the underlying dominant population) or shown not to belong to the population distribution in question. An outlier sample is a sample that is not representative of the distribution of the results from a particular population of samples. [USEPA Sampling Guidance]

Particle Size Distribution Factor

See **granulometric factor**.

Periodic Heterogeneity Fluctuation Error (CE_3)

The error due to large-scale periodic or cyclical, but essentially nonrandom, fluctuations across the **population** (*e.g.*, periodic analyte concentrations due to a process). The relative **variance** of this error is identified by variographic experiments and may be "smoothed out" by reducing the size of the strata or taking many **increments** to form the **sample**. [USEPA Subsampling Guidance]

Population

"The total collection of objects or people to be studied and from which a sample is to be drawn." [USEPA

QA/G-4HW] For chemically contaminated environmental matrices, a grouping of matrices based on their having similar defining characteristics for the purpose of making a particular decision. The spatial boundaries of populations are often determined by contaminant release and migration mechanisms that create spatial relationships for contaminant concentrations. Characteristics other than spatial distribution may also define populations, such as bioavailability or toxicity. Distinct **contaminant populations** may have sharp borders or may blend into each other or be interspersed, depending on the dominant deposition or transport mechanism. Variables that help create and define distinct contaminant populations must be considered alongside the intended decision in order to devise a sampling plan that can target data collection from that population and avoid including non-representative populations in the sample set. For contaminated sites, it is the intended decision that defines the population of interest. A task of **systematic project planning** is to understand the decisions to be made, and the population(s) of interest to those decisions. See also **contaminant population.**

Preparation Error (PE)
This error involves gross errors such as losses, contamination, and alteration (*e.g.,* **sample** degradation). [USEPA Subsampling Guidance]

Preparation Method or Preparative Method (as part of the analytical method)
Part of the **chemical measurement process.** A step (or steps) in the analytical chain that frees analytes from the original matrix to facilitate detection. This may be done by extraction or digestion methods. The goal is to isolate the analytes from components of the parent matrix that would present physical or chemical interference to the detection device. Analyte concentration and/or derivatization procedures may also be employed to bring the analytes within the capability of the detection device.

PQL (Practical Quantitation Level)
The lowest quantitation level of a given analyte that can be reliably achieved among laboratories within the specified limits of precision and accuracy of a given analytical method during routine operating conditions.

Precision

"The closeness of agreement between independent test results obtained by applying the experimental procedure under stipulated conditions. The smaller the random part of the experimental errors which affect the results, the more precise the procedure. A measure of precision (or imprecision) is the standard deviation. Comment: Precision is sometimes misused for accuracy. This problem will be avoided if one recognizes that precision relates only to dispersion, not to deviation from the (conventional) true value." [IUPAC]

A data quality indicator. The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms. [NELAC]

The term "**variability**" is also used to convey the concept of dispersion. The precision in environmental data sets is affected by a range of sampling and analytical variables.

Primary Project Decision

For projects involving the cleanup and closeout of a contaminated site, these are decisions that drive resolution of that project. Generally these decisions are based on demonstrating the presence/absence of pollutants above/below certain thresholds. Contaminant data generated from environmental matrices by analytical chemistry methods usually drive primary project decisions.

Qualitative Analysis

"Analysis in which substances are identified or classified on the basis of their chemical or physical properties, such as chemical reactivity, solubility, molecular weight, melting point, radiative properties (emission, absorption), mass spectra, nuclear half-life, etc." [IUPAC]

Compare to **quantitative analysis**.

Qualitative Results

Analytical results expressed in terms of whether an analyte can be identified as present or not. See **qualitative analysis**.

Quality

"The totality of features and characteristics of a product or service that bears on its ability to meet the stated or implied needs and expectations of the user." [USEPA QA/G-1]

Quality Assurance

"An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client." [USEPA QA/G-1]

Quality assurance is the management-related umbrella under which more technical activities fall (such as quality control procedures, training, supervision, etc.).

Quality Assurance Project Plan

"A formal document describing in comprehensive detail the necessary quality assurance, quality control, and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. The QA Project Plan components are divided into four classes: (1) Project Management, (2) Measurement/Data Acquisition, (3) Assessment/Oversight, and (4) Data Validation and Usability. Requirements for preparing [EPA-compliant] QA Project Plans can be found in *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)*." [USEPA QA/G-1]

More generally, any document which presents in specific terms the policies, organization, objectives, functional activities and specific quality assurance/quality control activities designed to achieve the quality goals or objectives of a specific project or operation.

Quality Control

"The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality. The system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring the results are of acceptable quality." [USEPA QA/G-1]

Real-time checks evaluating the compatibility between newly-acquired data and the current CSM to detect deficiencies in one or both is a powerful QC procedure that is seldom available to traditional projects, but is

central to cost-effective uncertainty management. See also **focused quality control**.

Quantitative Analysis

"Analyses in which the amount or concentration of an **analyte** may be determined (estimated) and expressed as a numerical value in appropriate units. **Qualitative analysis** may take place without quantitative analysis, but quantitative analysis requires the identification (qualification) of the analytes for which numerical estimates are given." [IUPAC]

Quantitative Results

Analytical results expressed in terms of a numerical value (with appropriate units) that reflects a "best estimate" of a measured parameter. Uncertainty in the estimate may be expressed as an associated confidence interval or by the number of significant figures provided in the value or by another device. See **quantitative analysis.**

Real-Time Decision-Making

Decisions are made while the work crew is still in the field. Typical decisions entail 1) remediation implementation (such as precision excavation); and 2) adaptive sampling and analysis plans (ASAPs) which include selecting subsequent sampling locations, which samples are analyzed by which analytical method(s), and/or increasing or decreasing the frequency of QC checks.

Recovery (of the target analyte)

"Term used in analytical and preparative chemistry to denote the fraction of the total quantity of a substance recoverable following a chemical procedure." [IUPAC]

"The act of determining whether or not the methodology measures all of the **analyte** contained in a sample." [USEPA QA/G-5]

Reference Method

"A method having small, estimated inaccuracies relative to the end use requirement. The accuracy of a reference method must be demonstrated through direct comparison with a **definitive method** or with a primary reference material." [IUPAC]

Real-Time Measurement Technologies

Term covers any data generation and interpretation mechanisms that support real-time decision-making (i.e., a dynamic work strategy). The term includes geophysics and other "imaging" techniques that can support real-time CSM development. The term also includes chemical data generation with rapid turn around from a fixed laboratory (using either **standard** or **screening analytical methods**), or **field-based measurements technologies**. The term also includes databases and software that permit real-time data management, review, assessment, reduction, mapping, decision assistance, and sharing of data between data users.

Relational Uncertainty

The uncertainty associated with the relationship between a parameter being measured, and the true

parameter of interest from a decision-making perspective.

Relative Detection Limit

"(Often incorrectly referred to as **sensitivity**). Smallest amount of material detectable (3 □-criterion) in a matrix relative to the amount of material analysed — given in atomic, mole or weight fractions." [IUPAC]

Relative Response Factor

A measure of the relative response of the instrument detector to an **analyte** compared to an internal or external standard. Relative response factors are determined by the analysis of standards and are used to calculate the concentrations of analytes in samples.

Remediation Unit

The area and time frame defined by spatial and temporal boundaries to which basic remedial decisions will be applied (e.g., does this unit of soil require excavation?). Remediation units are examples of **decision units**.

Replicate Analysis

The measurements of the variable of interest performed identically on two or more subsamples of the same sample within a short time interval. [NELAC]

Representativeness

"A measure of the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is also the correspondence between the analytical result and the actual environmental quality or condition experienced by a contaminant receptor." [USEPA QA/G-5S]

Representative Sample

"A sample resulting from a sampling plan that can be expected to adequately reflect the properties of interest of the parent population. A representative sample may be a random sample or, for example, a stratified sample, depending upon the objective of sampling and the characteristics of the population. The degree of representativeness of the sample may be limited by cost or convenience." [IUPAC]

To be truly representative, the **sample** must mimic (be representative of) the **population** in every way, including the distribution of the individual items or
members (particles, analytes, and other fragments or materials) of that population. However, depending on predefined specifications, the sample may only have to be representative of only one (or more) characteristics of the population, and estimated within acceptable bounds. [USEPA Subsampling Guidance]

For the highly heterogeneous environmental matrices routinely encountered at contaminated sites, attention to a suite of sampling-related variables (including **sample support**, sample location, sample preservation, and subsampling) is required before any sample can be assumed to represent the population of interest (i.e., the population about which decisions are to be made). If the decision (i.e., the objectives for data collection and associated data use) is not clearly defined the representativeness of a data set cannot be

assessed.

Result (analytical result)

"The final value reported for a measured or computed quantity, after performing a measuring procedure including all subprocedures and evaluations." [IUPAC]

Compare **measurement result.**

Sample

Since it is often too difficult to analyze an entire **population**, a sample (a portion) is taken from the population in order to make estimations about the characteristics of that population; *e.g.*, sample **statistics**, such as the **sample** mean and sample variance, are used to **estimate** population parameters, such as the population mean and population variance. Because sampling is never perfect and because there is always some degree of **heterogeneity** in the population, there is always a sampling error. To get accurate estimates of the population by the sample(s) and to minimize the **total sampling error**, a **representative sample** is sought using **correct sampling practices**. Thus, a sample is made from the combination of many correctly selected **increments**. To be truly representative, the sample must mimic (be representative of) the population in every way, including the distribution of the individual items or members (particles, analytes, and other fragments or materials) of that population. However, depending on predefined specifications, the sample may only have to be representative of only one (or more) characteristics of the population, and estimated within acceptable bounds. [USEPA Subsampling Guidance]

Sample (or Subsample) Support

The support is the size (mass or volume), shape, and orientation of the **sampling unit** or that portion of the **population** that the **sample** is selected from. If a soil sample is taken as section of a 2.5 cm diameter core sample from 10 to 15 cm depth, then it will have a slightly different support compared to first digging a trench and then acquiring 10 **increments** of soil along a 2 m traverse at 10 to 15 cm depth. In one case the support is a compact geometric shape while in the other case the support represents an average behavior over a short distance. The support affects the estimation of the **population** parameters. [USEPA Subsampling Guidance]

A suite of physical properties of environmental matrices that impact the **representativeness** of chemical contaminant data from environmental samples/subsamples. Physical properties bearing on sample collection and processing include sample size (as volume or mass), shape and orientation (length, width and height dimensions) and particle size. Sample support is one of the variables that must be addressed when designing a plan to collect data that are representative for a particular decision. For a data set or data point to be representative, the sample support must mirror the **decision support**.

Sample Representativeness

The ability of a sample to represent properties of interest of the parent population. For heterogeneous matrices, confidence in sample representativeness depends on a having a **CSM** that predicts the spatial orientation of different **contaminant populations** and the impact of other physical sample properties such as particle size. The physical properties of the population of interest are equivalent to the **decision support**. After an understanding of contaminant populations is develop (through a mature CSM), representative samples are collected to determine population characteristics (such as the mean, extremes, or other distribution characteristics of a population) pertinent to the required decision.

Sampling Design Error

"The error due to observing only a limited number of the total possible values that make up the population being studied. Sampling errors are distinct from those due to imperfect selection; bias in response; and mistakes in observation, measurement, or recording. Also known as field variability." [USEPA QA/G-4HW]

Sampling Error or Selection Error (SE)

"That part of the total error (the estimate from a sample minus the population value) associated with using only a fraction of the population and extrapolating to the whole, as distinct from analytical or test error. It arises from a lack of homogeneity in the parent population. In chemical analysis, the final test result reflects the value only as it exists in the test portion. It is usually assumed that no sampling error is introduced in preparing the test sample from the laboratory sample. Therefore, the sampling error is usually associated exclusively with the variability of the laboratory sample. Sampling error is determined by replication of the laboratory samples and their multiple analyses. Since sampling error is always associated with analytical error, it must be isolated by the statistical procedure of analysis of variance." [IUPAC]

"The difference between an estimate of a population value and its true value. Sampling error is due to observing only a limited number of the total possible values and is distinguished from errors due to imperfect selection, bias in response, errors of observation, measurement or recording, etc." [EMAP]

The sampling or selection error refers to the relative difference between the expected (true or assumed) value of the proportion of the analyte in the **population** and the estimated value of the proportion of the analyte in the **sample** (when there is no **preparation error, PE**). [USEPA Subsampling Guidance]

Sampling errors occur when analytically correct results are erroneously extrapolated (or assumed) to represent the concentrations for a much larger volume of matrix or a different fraction of matrix.

Sampling Uncertainty

An inclusive, catch-all phrase referring to all non-analytical method factors contributing to a lack of confidence in taking data results at face value for decision-making purposes. It includes "uncertainty" as **variability,** and as unknowns (such as unknown **sample representativeness** because the **CSM** is incomplete and the population the sample was collected from is poorly defined or delineated). The term may also be used to include aspects of sample processing that occur in the field, such as improper or undocumented handling of samples that permits avoidable analyte loss or degradation. The primary cause of sampling uncertainty stems from the interaction of **heterogeneity** and too few sample numbers to assess the impacts of that heterogeneity. Sampling uncertainty is reduced by increasing the number of samples collected, and by controlling for sampling-related variables such as sample collection procedures and **sample support**.

Sampling Unit

A volume, mass, or item of material being sampled, in part or in total. If one is characterizing a pile of 55-gal drums, then the sampling unit might be an individual drum. Sampling units are not necessarily identical with the **samples** themselves, but an (often naturally) delineated fraction of the **population**. [USEPA Subsampling Guidance]

Sampling Variability

The variability observed in a set of sample results that arises from the spatial or temporal heterogeneity of

the population being sampled, or from the inadvertent merging of two or more distinct populations in the same data set.

Screening Analytical Method

Analytical methods for which higher levels of **analytical uncertainty** or **relational uncertainty** are expected in the results because the method is limited in its ability to reliably quantify or identify specific analytes. Characteristics of methods relegated to "screening analytical methods" status include **non-specific** response, higher **practical quantitation levels**, greater **analytical bias**, poorer **precision**, and greater susceptibility to **interferences** than analytical methods considered to be more "definitive." Note that for a method to be considered "screening," a more rigorous method for the targeted analytes must already be available. Example: immunoassay kit for DDT.

Screening Quality Data

Data (points or set) that may provide some useful information, but that information by itself is not sufficient to support project decision-making because the amount of uncertainty (stemming from **sampling**, **analytical**, **relational uncertainty**, or other considerations) in the data set is greater than what is tolerable. When data that would be considered screening quality (if considered in isolation) are combined with other information or additional data that manages the relevant uncertainties, the combined data/information package may become effective for decision-making (see **collaborative data sets** and **effective data**).

Selectivity (in analysis)

The ability of a particular analysis method or technology to identify and quantify a particular compound in the presence of other, potentially interfering compounds.

"1. (qualitative): The extent to which other substances interfere with the determination of a substance according to a given procedure.
2. (quantitative): A term used in conjunction with another substantive (e.g. constant, coefficient, index, factor, number) for the quantitative characterization of **interferences**." [IUPAC]

Semi-Quantitative Results

Analytical results expressed in terms of a numerical range with appropriate units. Examples of how such results may be presented: 10-25 mg/L; [1, 10) ppm; between 10 and 50 mg/kg; less than 10 ppb; greater than 50 µg/L.

Sensitivity (in analytical chemistry)

"Sensitivity is defined as the slope of the **calibration** curve. If the curve is in fact a 'curve', rather than a straight line, then of course sensitivity will be a function of analyte concentration or amount. If sensitivity is to be a unique performance characteristic, it must depend only on the **chemical measurement process**, not upon scale factors." [IUPAC]

"The capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest." [USEPA QA/G-5]

This term should not be used to refer to **detection** or **quantitation capability**.

Short-range Fluctuation Error (CE_1)

This short scale error is the sum of the **fundamental error (FE)** and the **grouping and segregation error (GE)**. [USEPA Subsampling Guidance]

Site Screening

Term commonly used to describe rapid or partial surveying of a site, possibly employing some chemical analysis instrumentation or methods, in an effort to estimate worst case environmental conditions or to develop a preliminary **CSM** estimating the presence and extent of contaminated vs. non-contaminated matrix populations. See also **contaminant screening**.

Specific (in analysis)

"A term which expresses qualitatively the extent to which other substances interfere with the determination of a substance according to a given procedure. Specific is considered to be the ultimate of **selective**, meaning that no **interferences** are supposed to occur." [IUPAC]

Standard Analytical Method

Methods that determine the identity and concentration of **analytes** with "reasonable" and known certainty. This term is a better descriptor for the familiar fixed-laboratory methods often referred to (incorrectly) as "**definitive methods**."

Standard Operating Procedure (SOP)

"A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps and that is officially approved as the method for performing routine or repetitive tasks." [USEPA QA/G-1]

Statistic

A summary value calculated from a **sample**, usually as an estimator (*e.g.*, the sample mean or the sample variance) of a **population** parameter (*e.g.*, the population mean or the population variance). [USEPA Subsampling Guidance]

Statistical Power

The ability of a statistical test (using a set of sample data) to identify a difference from what is presumed when that difference actually exists.

Statistical Sampling

A sampling program whose design (e.g., analytical methods, sample numbers, and sample locations) is driven by the requirements of a statistical analysis that will be performed to support a specific decision.

Subsample

A subsample is simply a **sample** of a sample. This term is used when one wants to distinguish the *parent* sample (from which the subsample is taken) from the primary **population**. An example would be that the

site is the primary lot, the bottle coming to the laboratory is the (parent) sample, and the portion taken for analysis is the subsample. In **correct sampling practices**, the parent sample is considered the (new) population from which a **representative sample** is to be taken. Less confusing may be to use terms for successive sampling stages: lot, primary sample, secondary sample, etc. [USEPA Subsampling Guidance]

Survey Instrument

An instrument designed to detect compounds as a group or class without necessarily providing **analyte-specific** data. Some survey instruments may also have poor **selectivity**. These instruments may provide **qualitative** or **quantitative results**. If quantitative results are provided, the results often represent a single summation of all responding analytes.

Systematic Project Planning

A planning process that lays a scientifically defensible foundation for proposed project activities. Systematic project planning usually includes identification of key decisions to be made, the development of a **conceptual site model** to support decision-making, and an evaluation of **decision uncertainty** along with approaches for managing that uncertainty in the context of the conceptual site model. If the collection of environmental data from representative **populations** is desired to support decision-making, then sampling, analytical, and relational uncertainties in the data generation process must be managed. Systematic planning is an iterative process that continues throughout the lifecycle of a project.

Test Portion

"The amount or volume of the **test sample** taken for analysis, usually of known weight or volume." [IUPAC]

Test Sample

"The sample, prepared from the **laboratory sample**, from which **test portions** are removed for testing or for analysis." [IUPAC]

Total Recoverable

The amount of a contaminant that is extractable from the sample as measured relative to the amount the sample is known to contain.

Total Sampling Error (TE)

This sampling error refers to the relative difference between the expected (true or assumed) value of the proportion of the analyte in the population, and the estimated value of the proportion of the analyte in the sample. It includes preparation error (PE). [adapted from USEPA Subsampling Guidance]

Traceability

"The property of a result or measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons." [IUPAC]

"The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it

relates calculations and data generated throughout the project back to the requirements for the quality of the project." [USEPA QA/G-1]

Triad Approach

An approach to environmental decision-making that is grounded in the management of **decision uncertainty**. Where decisions are based on environmental data, sampling, analytical, and relational uncertainties of that data must be managed. The most cost-effective way to accomplish uncertainty management is by using modern technologies and strategies to rapidly and efficiently build a **CSM** tailored to support site-specific risk and remedial decision-making needs. These concepts are captured in the 3 elements of the Triad, which are **systematic project planning**, **real-time measurement technologies**, and **dynamic work strategies**.

Uncertainty

This is a broad term that can be used to convey a number of ideas. Within the Triad approach, it is generally used to convey the idea of something that is unknown or lacking confidence. **Variability** is one factor that contributes to uncertainty.

Decision uncertainty relates to the confidence and scientific **defensibility** of decisions about contaminant presence and extent, the likelihood of intolerable exposures, and the most cost-effective means to achieve risk-reduction. Decision uncertainty may be managed through a decision strategy that may or may not involve the collection of data.

Data uncertainty relates to the ability to draw confident decisions based on the data set in hand. Where sophisticated analytical methods are available for environmental analysis, more data uncertainty stems from **sampling error** and **sampling uncertainty** as a consequence of environmental **heterogeneity** and complex **populations** than from analytical limitations.

Analytical uncertainty can be high and significant where analytical techniques are immature or where the analytical technique used is poorly matched to the application or to matrix **interferences**.

Variability

"Observed difference attributable to heterogeneity or diversity in a population. Sources of variability are the results of natural random processes and stem from environmental differences among the elements of the population." [USEPA QA/G-1]

Although every natural population contains some variability, variability in a data set can be much larger than it should be if more than one distinct **population** has been inadvertently included in the data set because of an incomplete or inaccurate **CSM**.

Weight of Evidence Approach

An approach to addressing decision uncertainty for complex environmental systems that pools and compares information from a variety of sources to reach defensible decisions. **Collaborative data sets** are a key component of a weight of evidence approach to decision-making for contaminated sites.