GLOSSARY

absorption **(10.3.2):** The uptake of particles of a gas or liquid by a solid or liquid, or uptake of particles of a liquid by a solid, and retention of the material throughout the external and internal structure of the uptaking material. Compare with *adsorption*.

abundance **(16.2.2):** See *emission probability per decay event*.

accreditation **(4.5.3, Table 4.2):** A process by which an agency or organization evaluates and recognizes a program of study or an institution as meeting certain predetermined qualifications or standards through activities which may include performance testing, written examinations or facility audits. *Accreditation* may be performed by an independent organization, or a federal, state, or local authority. *Accreditation* is acknowledged by the accrediting organizations issuing of permits, licences, or certificates.

accuracy **(1.4.8*):*** The closeness of a measured result to the true value of the quantity being measured. Various recognized authorities have given the word *accuracy* different technical definitions, expressed in terms of *bias* and *imprecision*. MARLAP avoids all of these technical definitions and uses the term "accuracy" in its common, ordinary sense, which is consistent with its definition in ISO (1993a).

acquisition strategy options **(2.5, Table 2.1):** Alternative ways to collect needed data.

action level **(1.4.9):** The term *action level* is used in this document to denote the value of a quantity that will cause the decisionmaker to choose one of the alternative actions. The *action level* may be a *derived concentration guideline level (DCGL)*, background level, release criteria, *regulatory decision limit*, etc. The *action level* is often associated with the type of media, *analyte* and concentration limit. Some *action levels*, such as the release criteria for license termination, are expressed in terms of dose or risk. See *total effective dose equivalent (TEDE)* and *committed effective dose equivalent (CEDE)*.

activity, chemical **(*a*) (10.3.5):** (1) A thermodynamic quantity used in place of molal concentration in equilibrium expressions for reactions of real (nonideal) solutions. Activity indicates the actual behavior of *ions* in solution as a result of their interactions with the *solvent* and with each other. *Ions* deviate from ideal behavior as their concentration in solution increases and are not as effective in their chemical and physical behavior as their molar concentration would indicate. Thus, their effective concentration, a, is less than their stoichiometric concentration, c. (2) A measure of the effective molal concentration, c, in moles/Kg, of an *ion* under real (nonideal) solution conditions.

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***activity, of radionuclides* (*A*) (2.5.4.1):** Mean rate of nuclear decay occurring in a given quantity of material.

***activity coefficient* (*γ*) (14.6.1):** (1) A fractional number that represents the extent that *ions* deviate from ideal behavior in solution (see *activity, chemical*). The *activity coefficient* multiplied times the molal concentration of *ions* in solution equals the chemical *activity*: $a = \gamma \cdot c$, where $\gamma \leq 1$; thus, the *activity coefficient* is a correction factor applied to molal concentrations. At infinite dilution where behavior is ideal, $\gamma = 1.0$, but it decreases as the concentration of *ions* increases. (2) The ratio of effective (apparent) concentration of an *ion* in solution to the stoichiometric concentration, $\gamma = a/c$.

***adsorption* (6.5.1.1):** Uptake of particles of a gas, liquid, or solid onto the surface of another substance, usually a solid. Compare with *absorption*.

***adsorption chromatography* (14.7.1):** A chromatographic method that partitions (separates) components of a mixture through their different adsorption characteristics on a stationary solid phase and their different solubilities in a mobile liquid phase.

***affinity chromatography* (14.7.1):** A chromatographic method that partitions (separates) proteins and nucleic acids in a mobile phase based on highly selective, very specific complementary bonds with antibody groups (*ligands*) that are chemically bonded to an inert solid matrix acting as the *stationary phase*.

***aliquant* (3.3.1.2):** A representative portion of a homogeneous *sample* removed for the purpose of analysis or other chemical treatment. The quantity removed is not an evenly divisible part of the whole sample. An "aliquot" (a term not used in MARLAP) by contrast, is an evenly divisible part of the whole.

***alternate analyte* (2.5):** *Analyte* whose concentration, because of an established relationship (e.g., secular equilibrium) can be used to quantitatively determine the concentration of a *target analyte*. An *alternate analyte* may be selected for analysis in place of a *target analyte* because of ease of analysis, lower analytical costs, better methodologies available, etc. (see *alternate radionuclide*).

***alternate radionuclide* (3.3.4):** An "easy-to-measure" *radionuclide* that is used to estimate the amount of a radionuclide that is more difficult or costly to measure. Known or expected relationships between the radionuclide and its alternate can be used to establish a factor for amount of the hard-to-measure radionuclide (see *alternate analyte*).

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***alternative hypothesis* (H_1 *or* H_A) (2.5, Table 2.1):** One of two mutually exclusive statements tested in a statistical hypothesis test (compare with *null hypothesis*). The *null hypothesis* is presumed to be true unless the test provides sufficient evidence to the contrary, in which case the *null hypothesis* is rejected and the *alternative hypothesis* is accepted.

***analyte* (1.4.7):** The component (e.g., a *radionuclide* or chemical compound) for which a *sample* is analyzed.

***analysis* (3.3.1):** Analysis refers to the identification or quantification process for determining a *radionuclide* in a *radionuclide*/matrix combination. Examples of analyses are the measurement of ^{3}H in water, ^{90}Sr in milk, ^{239}Pu in soil, etc.

***analytical data requirements* (1.1):** Measurement performance criteria used to select and decide how the laboratory analyses will be conducted and used for the initial, ongoing, and final evaluation of the laboratory's performance and the laboratory data. The project-specific *analytical data requirements* establish measurement performance criteria and decisions on how the laboratory analyses will be conducted (e.g., method selection, etc.) in a *performance-based approach* to data quality.

***analytical method* (1.4.6):** A major component of an analytical protocol that normally includes written procedures for sample digestion, chemical separation (if required), and counting (*analyte* quantification through radioactive decay emission or atom-counting measurement techniques. Also called *laboratory method*.

***analytical performance measure* (2.3.3):** A qualitative or quantitative aspect of the analysis, initially defined based on the *analyte*, its desired detection level and the sample matrix. See also *measurement quality objectives*.

***analytical plan* (9.6.3):** The portion of the *project plan documents* that addresses the optimized analytical design and other analytical issues (e.g., *analytical protocol specifications*, *standard operating procedures*).

***analytical process* (1.3):** The *analytical process* is a general term used by MARLAP to refer to a compilation of actions starting from the time a *sample* is collected and ending with the reporting of data. These are the actions that must be accomplished once a sample is collected in order to produce analytical data. These actions typically include field sample preparation and preservation, sample receipt and inspection, laboratory sample preparation, *sample dissolution*, *chemical separations*, preparation of samples for instrument measurements, instrument measurements, data reduction, data reporting, and the *quality control* of the process.

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***analytical protocol* (1.4.3):** A compilation of specific procedures/methods that are performed in succession for a particular analytical process. With a performance-based approach, there may be a number of appropriate analytical protocols for a particular analytical process. The *analytical protocol* is generally more inclusive of the activities that make up the analytical process than is the *analytical method*. See also *analytical process*.

***analytical protocol specification* (*APS*) (1.4.10):** The output of a *directed planning process* that contains the project's analytical data needs and requirements in an organized, concise form. The level of specificity in the APSs should be limited to those requirements that are considered essential to meeting the project's *analytical data requirements* to allow the laboratory the flexibility of selecting the protocols or methods that meet the analytical requirements.

***anion* (13.2.2):** An *ion* with a negative charge.

***anion exchanger* (14.7.4.2):** An ion-exchange *resin* consisting of chemical groups, bonded to an inert matrix, with a net positive charge. The positive species are electrostatically bonded to negative, labile *ions* bonded to an inert matrix. *Anions* in solution replace the labile *ions* on the exchanger by forming electrostatic bonds with the charged groups. The strength of attraction, which depends on the charge, size, and degree of solvation of the *anion*, provides a means for separating *analyte ions*.

***aqueous samples* (10.3.1):** Samples for which the matrix is water, including surface water, groundwater, drinking water, precipitation, or runoff.

***arithmetic mean* ($\bar{x}$) (1.4.8):** The sum of a series of measured values, divided by the number of values. The *arithmetic mean* is also called the "average." If the measured values are denoted by $x_1, x_2, \ldots, x_N$, the *arithmetic mean* is equal to $(x_1 + x_2 + \cdots + x_N) / N$. (See also *expectation* and *sample mean*.)

***assessment team* (9.4):** A team of data assessors (or qualified data assessor) who are technically competent to evaluate the project's activities and the impact of these activities on the quality and usability of data.

***audit* (5.3.8):** An assessment to provide assurance that a selected laboratory is capable of or is fulfilling the specifications of the *request for proposals* or *statement of work*. A pre-award *audit* verifies that a laboratory has the ability that it can meet the analytical requirements of the *request for proposals* or *statement of work*. After the award, an *audit* of a laboratory will assess the performance of the laboratory to verify that it is complying with *statement of work* and

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contractual requirements. Thus, the examination of logbooks, charts, or other documentation that are produced as the work progresses.

***authoritative sample collection approach* (9.6.2.1):** An approach wherein professional knowledge is used to choose sample locations and times.

***auto-oxidation-reduction (disproportionation)* (14.2.3):** An *oxidation-reduction reaction* in which a single chemical species acts simultaneously as an oxidizing and reducing agent.

***average* (6.5.1.1):** See *arithmetic mean*.

***background, anthropogenic* (3.3.1):** Background radiation levels caused by *radionuclides* in the environment resulting from human activities, such as the atmospheric testing of nuclear weapons.

***background, environmental* (3.3.1):** See *background level*. The presence of naturally occurring radiation or *radionuclides* in the environment.

***background, instrument* (6.5.5.3):** Radiation detected by an instrument when no *source* is present. The background radiation that is detected may come from *radionuclides* in the materials of construction of the detector, its housing, its electronics and the building as well as the environment and natural radiation.

***background level* (2.5):** This term usually refers to the presence of *radioactivity* or radiation in the environment. From an analytical perspective, the presence of background *radioactivity* in samples needs to be considered when clarifying the radioanalytical aspects of the decision or study question. Many *radionuclides* are present in measurable quantities in the environment. Natural background radiation is due to both primordial and *cosmogenic radionuclides*. Anthropogenic background is due to *radionuclides* that are in the environment as a result of human activities, for example, the atmospheric testing of nuclear weapons.

***basic ordering agreement* (*BOA*) (5.1):** A process that serves to pre-certify potential analytical service providers. A list of approved laboratories is assembled and contacted as needed to support specific needs. A task order is used to define a specific scope of work within a BOA.

***batch processing* (6.4):** A procedure that involves preparing a group of individual samples together for analysis in such a way that allows the group to be associated with a set of *quality control samples*.

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***becquerel* (*Bq*) (1.4.9):** Special name for the SI derived unit of activity (of *radionuclides*), equal to one nuclear transformation per second. The traditional unit is the *curie (Ci)*. The relationship between these units is 3.7×10^{10} Bq = 1 Ci.

***bias (of an estimator)* (1.4.8):** If X is an estimator for the true value of parameter θ, then the *bias* of X is $\mu_X - \theta$, where μ_X denotes the expectation of X.

***bias (of measurement)* (1.4.8):** See *systematic error*.

***bias (of a measurement process)* (1.4.8):** The *bias* of a measurement process is a persistent deviation of the mean measured result from the true or accepted reference value of the quantity being measured, which does not vary if a measurement is repeated. See also *bias (of an estimator)* and *bias (of measurement)*.

***bioassay* (10.2.11.2):** A procedure to monitor internal radiation exposure by performing *in vitro* or *in vivo* measurements, primarily urine analysis, fecal analysis, or whole-body counting.

***blind sample* (18.4.2):** A *sample* whose concentration is not known to the analyst. *Blind samples* are used to assess analytical performance. A double-blind sample is a *sample* whose concentration and identity as a *sample* is known to the submitter but not to the analyst. The double-blind sample should be treated as a routine sample by the analyst, so it is important that the double-blind sample is identical in appearance to routine samples.

***blunder* (7.4.1.1):** A mistake made by a person performing an analytical task that produces an a significant error in the result.

***branching ratio* (7.2.2.2):** See *emission probability per decay event*.

***breakthrough* (14.7.4.1):** Appearance of certain *ions* in the output solution (*eluate*) of an ion-exchange column. These *ions* are not bonded to the exchange groups of the column because the groups are already occupied by these or other *ions*, and the *resin* is essentially saturated.

***calibration* (1.4.8):** The set of operations that establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system, or values represented by a material measure, and the corresponding known value of a *measurand*.

***calibration source* (15.1):** A prepared *source*, made from a *certified reference material* (standard), that is used for calibrating instruments.

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***carrier* (14.1):** (1) A stable isotopic form of a tracer element or nonisotopic material added to effectively increase the quantity of a tracer element during radiochemical procedures, ensuring conventional behavior of the element in solution. (2) A substance in appreciable amount that, when associated with a tracer of a specified substance, will carry the tracer with it through a chemical or physical process, or prevent the tracer from undergoing nonspecific processes due to its low concentration (IUPAC, 1995). A stable isotope of a *radionuclide* (usually the *analyte*) added to increase the total amount of that element so that a measurable mass of the element is present.

***carrier-free tracer* (14.2.6):** (1) A radioactive isotope tracer that is essentially free from stable (nonradioactive) isotopes of the element in question. (2) Addition of a specific, nonradioactive isotope of an element to change the measured isotopic abundance of the element in the *sample*. Such materials are usually designated as nonisotopic material or marked with the symbol "c.f." (see *radiotracer*).

***carrier gas* (14.5.1):** An inert gas, such as nitrogen or helium, serving as the mobile phase in a gas-liquid chromatographic system. The *carrier gas* sweeps the *sample* in through the system.

***cation* (13.2.2):** An *ion* with a positive charge.

***cation exchanger* (14.3.4.2):** An ion-exchange *resin* consisting of chemical groups, bonded to an inert matrix, with a net negative charge. The negative species are electrostatically bonded to positive, labile *ions*. Cations, in solution, replace the labile *ions* on the exchanger by forming electrostatic bonds with the charged groups. The strength of attraction, which depends on the charge, size, and degree of solvation of the cation, provides a means for separating *analyte ions*.

***Cerenkov radiation* (14.10.9.10):** Cerenkov radiation is emitted in the ultraviolet spectrum when a fast charged particle traverses a dielectric medium (like water) at a velocity exceeding the velocity of light in that medium. It is analogous to the "sonic boom" generated by a craft exceeding the speed of sound.

***certified reference material* (*CRM*) (1.6, Figure 1.3):** A reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes its traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence (ISO, 1992).

***chain-of-custody* (1.4.10):** Procedures that provide the means to trace the possession and handling of a *sample* from collection to data reporting.

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***check source* (15.2):** A material used to validate the operability of a radiation measurement device, sometimes used for instrument *quality control*. See *calibration source*, *test source*, and *source, radioactive*.

***chelate* (14.3.2):** A *complex ion* or compound that consists of a *ligand* bonded (coordinated) to a metal atom or *ion* through two or more nonmetal atoms forming a ring structure with the metal atom or *ion*. *Ligands* may be inorganic *ions*, such as Cl, F, or carbonate, or organic compounds of two, four, or six functional groups containing atoms of S, N, O, or P.

***chelating agent* (14.3.2):** The compound containing the *ligand* that forms a chelate with metal atoms or *ions*.

***chemical separations* (1.1):** The removal of all undesirable materials (elements, compounds, etc.) from a *sample* through chemical means so that only the intended *analyte* is isolated and measured.

***chemical speciation* (2.5):** The chemical state or form of an *analyte* in a *sample*. When the chemical species of the *analyte* in a *sample* from a new project varies from the chemical species for which an *analytical method* was validated, then the method should be altered and revalidated.

***chromatography* (6.6.3.4):** A group of separation techniques based on the unequal distribution (partition) of substances between two immiscible phases, one moving past the other. The mobile phase passes over the surfaces of the *stationary phase*.

***coagulation* (14.8.5):** (1) The process in which colloidal particles or macromolecules come together to form larger masses (see *colloid* and *colloidal solution*). (2) Addition of an excess quantity of electrolyte to a *colloidal solution* neutralizing the electrical bilayer of the colloidal particles and permitting their agglomeration to form larger particles that easily settle (precipitate). Also called “flocculation.”

***coefficient of variation* (*CV*) (19.5.2.2):** The *coefficient of variation* of a nonnegative random variable is the ratio of its *standard deviation* to its *mean*.

***coefficient of thermal (volume) expansion* (19E.3):** ratio of the change in volume (of a material) per unit volume to the change in temperature, at constant pressure. If V denotes volume, ρ denotes density, and T denotes temperature, then the coefficient of thermal expansion, β, is given by

$$\beta = \frac{1}{V}\frac{dV}{dT} = -\frac{1}{\rho}\frac{d\rho}{dT}.$$

***collectors* (14.8.5):** Substances used for the unspecific concentration of trace substances. Colloidal precipitates are excellent collectors because of their great adsorption capacity. Unspecific *carriers* such as manganese dioxide, sulfides, and hydrated oxides are frequently used as *collectors* (also called "scavengers").

***colloid* (13.2.5):** Any form of matter with at least one dimension that is less than one micron but more than one nanometer. This dimension is larger in size than that of a true solution but smaller than particles of an ordinary suspension. They are too small to be observed by a light microscope but larger than molecular size. Colloidal particles are usually aggregates of hundreds or thousands of smaller molecules or macromolecules.

***colloidal solution* (13.4.1):** Sometimes called a "colloidal dispersion." (1) A mixture formed from the dispersion of one phase (dispersed phase) within a second phase (continuous phase) in which one phase has colloidal dimensions. A *colloidal solution* contains dispersed particles with a very high surface-area-to-mass ratio and, thus, a great adsorption capacity. The solution will not usually settle by gravity since the colloidal particles are very small and charged by attraction of *ions* to their surfaces, but they will pass through ordinary filter paper. (2) In radiochemistry, a *colloidal solution* refers to the dispersion of solid particles in the solution phase. (*The mixture is not a true solution because particles of the dispersed phase are larger than typical ions and molecules.*)

***column chromatography* (14.3.4.2):** A chromatographic procedure employing a solid phase packed in a glass or metal column. A liquid phase is passed through the column under pressure supplied by gravity or pumping action. Column chromatography can accommodate larger quantities of materials than other methods of chromatography and, thus, can separate larger loads. It can also provide more separating power with an increased ratio of solid phase to *analyte*.

***combined standard uncertainty* (1.4.7):** *Standard uncertainty* of an *output estimate* calculated by combining the standard uncertainties of the *input estimates*. See also *expanded uncertainty and uncertainty (of measurement)*. The *combined standard uncertainty* of y is denoted by $u_c(y)$.

***combined variance* (19.3.3):** The square of the *combined standard uncertainty*. The *combined variance* of y is denoted by $u^2_c(y)$.

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***committed effective dose equivalent* (*CEDE*) (2.5.2.1):** The sum of the committed dose equivalent to various tissues in the body, each multiplied by the appropriate weighting factor (MARSSIM, 2000). CEDE is expressed in units of sievert (Sv) or rem. See *action level*, *dose equivalent*, and *total effective dose equivalent*.

***common ion* (14.8.3.1):** *Ions* that appear in the equilibrium expressions of reactions. The term is often used to refer to an additional source of the reacting *ions*.

***common-ion effect* (14.8.3.1):** An increase in concentration of *ions* participating in a reaction because of the addition of one of the *ions* from another source causing a shift in the equilibrium of the reaction.

***comparability* (1.4.11):** A measure of the confidence with which one data set can be compared to another. *Comparability* is one of the five principal *data quality indicators*, which are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data.

***completeness* (1.4.11):** A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. *Completeness* is one of the five principal *data quality indicators*. See also *comparability*.

***complex* (13.2.4):** Another name for a *coordination compound*.

***complex ion* (13.2.4):** An *ion* formed when a metal atom or *ion* forms *coordination bonds* with one or more nonmetal atoms in molecules or *anions*. Examples are $Th(NO_3)_2^{+2}$, $Ra(EDTA)^{-2}$, $U(CO_3)_5^{-6}$, and $Fe(H_2O)_6^{+2}$.

***compliance* (8.2.2.2):** In terms of data, *compliance* means that the data passes numerical *quality control tests* based on parameters or limits derived from the *measurement quality objectives* specified in the *statement of work*.

***component (of combined standard uncertainty)* (19.2):** The *component* of the comb*ined standard uncertainty* of an output estimate, $u_c(y)$, generated by the *standard uncertainty* of an input estimate, $u(x_i)$, is the product of the *standard uncertainty*, $u(x_i)$, and the absolute value of the *sensitivity coefficient*, $\partial y / \partial x_i$. The uncertainty component generated by $u(x_i)$ may be denoted by $u_i(y)$.

***concentration range* (2.5, Table 2.1):** The minimum and maximum concentration of an *analyte* expected to be present in a *sample* for a given project. While most analytical protocols are

applicable over a fairly large range of concentration for the *radionuclide of interest*, performance over a required concentration range can serve as a measurement quality objective for the protocol selection process and some analytical protocols may be eliminated if they cannot accommodate the expected range of concentration.

***conceptual site model* (2.3.2):** A general approach to planning field investigations that is useful for any type of environmental reconnaissance or investigation plan with a primary focus on the surface and subsurface environment.

***consistency* (8.4.2):** Values that are the same when reported redundantly on different reports or transcribed from one report to another.

***control chart* (18.1):** A graphical representation of data taken from a repetitive measurement or process. *Control charts* may be developed for various characteristics (e.g., *mean*, *standard deviation*, range, etc.) of the data. A *control chart* has two basic uses: 1) as a tool to judge if a process was *in control*, and 2) as an aid in achieving and maintaining *statistical control*. For applications related to radiation detection instrumentation or radiochemical processes, the *mean* (center line) value of a historical characteristic (e.g., *mean* detector response), subsequent data values and *control limits* placed symmetrically above and below the center line are displayed on a *control chart*. See *statistical control*.

***control limit* (3.3.7.3):** Predetermined values, usually plotted on a *control chart*, which define the acceptable range of the monitored variable. There can be both upper and lower limits; however, when changes in only one direction are of concern, only one limit is necessary. When a measured value exceeds the control limits, one must stop the measurement process, investigate the problem, and take corrective action." See *warning limit*.

***coordination bond* (14.3.1):** (1) The chemical bond between the nonmetal atoms of a *ligand* and a metal atom or *ion*, which forms a coordination compound or *complex ion*. The bond is formed when the *ligand* donates one or more electron pairs to the metal atom or *ion*. (2) In more general terms, a covalent bond formed in which one atom donates both of the shared electrons; often called a coordination-covalent bond.

***coordination compound* (14.3.1):** A compound containing *coordination bonds* in a molecule or *ion*; also called a "*complex*."

***coordination number* (14.3.1):** (1) The number of nonmetal atoms donating electrons to a metal atom or *ion* in the formation of a *complex ion* or coordination compound. For example, the

coordination number is five in $U(CO_3)_5^{-6}$ (2) The number of atoms, *ions*, molecules, or groups surrounding an atom or *ion* in a coordination compound, *complex ion*, or crystal structure.

***coprecipitation* (14.1):** A process used to precipitate a *radionuclide* that is not present in sufficient concentration to exceed the solubility product of the *radionuclide* and precipitate. A stable *ion*, chemically similar to the *radionuclide*, is added in a quantity sufficient to precipitate and carry with it the *radionuclide*.

***core group (core team)* (2.4.1):** A subgroup of the *project planning team*, which includes the project manager and other key members of the *project planning team*, who meet at agreed upon intervals to review the project's progress, respond to unexpected events, clarify questions raised, revisit and revise project requirements as necessary, and communicate the basis for previous assumptions.

***correction* (8.2.1):** A value algebraically added to the uncorrected result of a measurement to compensate for a systematic effect.

***correction factor* (8.5.1.12):** A numerical factor by which the result of an uncorrected result of a measurement is multiplied to compensate for a systematic effect.

***corrective action reports* (8.2.2.2):** Documentation of required steps taken to correct an out of control situation.

***correctness* (8.4.2):** The reported results are based on properly documented and correctly applied algorithms.

***correlate* (18.4.5):** Two *random variables* are *correlated* if their *covariance* is nonzero.

***correlation coefficient* (19.3.3):** The *correlation coefficient* of two *random variables* is equal to their *covariance* divided by the product of their *standard deviations*.

***cosmogenic radionuclide* (3.3.1):** *Radionuclides* that result from the collision of cosmic-ray particles with stable elements in the atmosphere, primarily atmospheric gases. See *background, environmental*.

***counting efficiency* (15.2.2):** The ratio of the events detected (and registered) by a radiation detection system to the number of particle or photons emitted from a radioactive *source*. The counting efficiency may be a function of many variables, such as radiation energy, *source* composition, and *source* or detector geometry.

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***counting error* (19.3.5):** See *counting uncertainty*; *error (of measurement)*. MARLAP uses the term *counting uncertainty* to maintain a clear distinction between the concepts of measurement *error* and *uncertainty*.

***counting uncertainty* (18.3.4):** Component of *measurement uncertainty* caused by the random nature of radioactive decay and radiation counting.

***count rate* (14A.2.2):** The number of decay particles detected per unit time of a *source*. Generally the *count rate* is uncorrected for detector efficiency. The *count rate* divided by the detector efficiency for a specific particle and energy will yield the *source activity*.

***count time* (2.5):** The time interval for the counting of a *sample* or *source* by a radiation detector. Depending upon the context used, this can be either the "clock" time (the entire period required to count the *sample*), or "live" time (the period during which the detector is actually counting). Live time is always less than or equal to clock time.

***covariance* (19.3.3):** The *covariance* of two *random variables X* and *Y*, denoted by Cov(*X*,*Y*) or $\sigma_{X,Y}$, is a measure of the association between them, and is defined as $E([X - \mu_X][Y - \mu_Y])$.

***coverage factor* (1.4.7):** The value *k* multiplied by the *combined standard uncertainty* $u_c(y)$ to give the *expanded uncertainty*, *U*.

***coverage probability* (19.3.6):** Approximate probability that the reported uncertainty interval will contain the value of the *measurand*.

***critical level* (20B.1):** See *critical value*.

***critical value* (S_C) (3B.2):** In the context of *analyte* detection, the minimum measured value (e.g., of the instrument signal or the *analyte* concentration) required to give confidence that a positive (nonzero) amount of *analyte* is present in the material analyzed. The critical value is sometimes called the *critical level* or *decision level*.

***cross-contamination* (3.4, Table 3.1):** Cross-contamination occurs when radioactive material in one *sample* is inadvertently transferred to an uncontaminated sample, which can result from using contaminated sampling equipment and chemicals, and improperly cleaned glassware, crucibles, grinders, etc. *Cross-contamination* may also occur from spills, as well as airborne dusts of contaminated materials.

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***crosstalk* (7.4.2.2):** A phenomenon in gas-proportional counting or liquid-scintillation counting when an emission of an alpha particle is recorded as a beta particle count or vice versa. This is due to the ionization effects of the particles at different energies.

***cumulative distribution function* (19A.1):** See *distribution function*.

***curie* (*Ci*) (1.4.9):** Traditional non-SI unit of activity (of *radionuclides*), equal to 3.7×10^{10} Bq. Because the curie is such a large value, the more common unit is the *picocurie* (pCi), equal to 10^{-12} Ci.

***data assessment* (2.1):** Assessment of environmental data consists of three separate and identifiable phases: data verification, data validation, and *data quality assessment*.

***data collection activities* (1.3):** Examples of *data collection activities* include site-characterization activities, site cleanup and compliance-demonstration activities, decommissioning of nuclear facilities, remedial and removal actions, effluent monitoring of licensed facilities, license termination activities, environmental site monitoring, background studies, routine ambient monitoring, and waste management activities.

***data life cycle* (1.4.1):** A useful and structured means of considering the major phases of projects that involve data collection activities. The three phases of the *data life cycle* are the planning phase, the implementation phase, and the assessment phase.

***data package* (1.4.11):** The information the laboratory should produce after processing samples so that data verification, validation, and quality assessment can be done (see Chapter 16, Section 16.7).

***data qualifier* (8.1):** *Data validation* begins with a review of project objectives and requirements, the *data verification* report, and the identified exceptions. If the system being validated is found to be *in control* and applicable to the *analyte* and matrix, then the individual data points can be evaluated in terms of detection, *imprecision*, and *bias*. The data are then assigned *data qualifiers*. Validated data are rejected only when the impact of an exception is so significant that a datum is unreliable.

***data quality assessment* (1.1):** The scientific and statistical evaluation of data to determine if data are the right type, quality, and quantity to support their intended use.

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***data quality assessment plan* (1.4.1, Figure 1.1):** A *project plan document* that describes the *data quality assessment* process including *data quality assessment* specifications, requirements, instructions, and procedures.

***data quality indicator* (*DQI*) (3.3.7):** Qualitative and quantitative descriptor used in interpreting the degree of acceptability or utility of data. The principal DQIs are *precision*, *bias*, *representativeness*, *comparability*, and *completeness*. These five DQIs are also referred to by the acronym PARCC—the "A" refers to *accuracy* rather than *bias*.

***data quality objective* (*DQO*) (1.4.9):** *DQOs* are qualitative and quantitative statements derived from the *DQO process* that clarify the study objectives, define the most appropriate type of data to collect, determine the most appropriate conditions from which to collect the data, and specify tolerable limits on *decision error rates*. Because DQOs will be used to establish the quality and quantity of data needed to support decisions, they should encompass the total uncertainty resulting from all data collection activities, including analytical and sampling activities.

***data quality objective process* (1.6.3):** A systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use. *DQOs* are the qualitative and quantitative outputs from the *DQO process*.

***data quality requirement* (2.1):** See *measurement quality objective*.

***data reduction* (1.1):** The processing of data after generation to produce a *radionuclide* concentration with the required units.

***data transcription* (8.5):** The component of the analytical process involving copying or recording data from measurement logs or instrumentation.

***data usability* (1.4.11):** The scientific and statistical evaluation of data sets to determine if data are of the right type, quality, and quantity to support their intended use (*data quality objectives*). The data quality assessor integrates the *data validation* report, field information, assessment reports, and historical project data to determine *data usability* for the intended decisions.

***data validation* (1.1):** The evaluation of data to determine the presence or absence of an *analyte* and to establish the uncertainty of the measurement process for contaminants of concern. *Data validation* qualifies the usability of each datum (after interpreting the impacts of exceptions identified during data verification) by comparing the data produced with the *measurement quality objectives* and any other *analytical process* requirements contained in the *analytical protocol specifications* developed in the planning process.

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***data validation plan* (1.4.1, Figure 1.1):** A *project plan document* that ensures that proper laboratory procedures are followed and data are reported in a format useful for validation and assessment, and will improve the cost-effectiveness of the data collection process.

***data verification* (1.2):** Assures that laboratory conditions and operations were compliant with the *statement of work*, *sampling and analysis plan*, and *quality assurance project plan*, and identifies problems, if present, that should be investigated during data validation. *Data verification* compares the material delivered by the laboratory to these requirements (compliance), and checks for consistency and *comparability* of the data throughout the data package and *completeness* of the results to ensure all necessary documentation is available.

***decay chain* (3.3.8):** A *decay chain* or "decay series" begins with a parent radionuclide (also called a "parent nuclide"). As a result of the radioactive decay process, one element is transformed into another. The newly formed element, the decay product or progeny, may itself be radioactive and eventually decay to form another nuclide. Moreover, this third decay product may be unstable and in turn decay to form a fourth, fifth or more generations of other radioactive decay products. The final decay product in the series will be a stable element. Elements with extremely long half-lives may be treated as if stable in the majority of cases. Examples of important naturally occurring *decay chains* include the uranium series, the thorium series, and the actinium series. See *radioactive equilibrium*.

***decay emissions* (6.2):** The emissions of alpha or beta particles (β^+ or β^-) or gamma rays from an atomic nucleus, which accompany a nuclear transformation from one atom to another or from a higher nuclear energy state to lower one.

***decay factor* (14A.2.2):** Also referred to as the "decay-correction factor." The factor that is used to compensate for radioactive decay of a specific *radionuclide* between two points in time.

***decay series* (3.3.4):** See *decay chain*.

***decision error rate* (1.4.9):** The probability of making a wrong decision under specified conditions. In the context of the *DQO process*, one considers two types of decision errors (*Type I* and *Type II*). The *project planning team* determines the *tolerable decision error rates*.

***decision level* (20.2.2):** See *critical value*.

***decision performance criteria* (2.1):** Another way to express the concept of using directed project planning as a tool for project management to identify and document the qualitative and quantitative statements that define the project objectives and the acceptable rate of making

decision errors that will be used as the basis for establishing the quality and quantity of data needed to support the decision. See *data quality objective*.

***decision rule* (2.3.3):** The rule developed during directed planning to get from the problem or concern to the desired decision and define the limits on the *decision error rates* that will be acceptable to the *stakeholder* or customer. Sometimes called a "decision statement." The *decision rule* can take the form of "if …then…" statements for choosing among decisions or alternative actions. For a complex problem, it may be helpful to develop a *decision tree*, arraying each element of the issue in its proper sequence along with the possible actions. The *decision rule* identifies (1) the *action level* that will be a basis for decision and (2) the statistical parameter that is to be compared to the *action level*.

***decision tree* (2.5.3):** See *decision rule.* Also referred to as a "logic flow diagram" or "decision framework."

***decision uncertainty* (1.4.7):** Refers to uncertainty in the decisionmaking process due to the probability of making a wrong decision because of measurement uncertainties and sampling statistics. *Decision uncertainty* is usually expressed as by the estimated probability of a decision error under specified assumptions.

***decommissioning* (1.3):** The process of removing a facility or site from operation, followed by decontamination, and license termination (or termination of authorization for operation) if appropriate. The process of *decommissioning* is to reduce the residual *radioactivity* in structures, materials, soils, groundwater, and other media at the site to acceptable levels based on acceptable risk, so that the site may be used without restrictions.

***deconvolution* (8.5.1.11):** The process of resolving multiple gamma-spectral peaks into individual components.

***deflocculation* (14.8.5):** The process whereby coagulated particles pass back into the colloidal state. Deflocculation may be accomplished by adding a small amount of electrolyte to produce the electrical double-layer characteristic of colloidal particles. Also called "peptization." Also see *coagulation* and *colloidal solution*.

***degrees of freedom* (6A.2):** In a statistical estimation based on a series of observations, the number of observations minus the number of parameters estimated. See *effective degrees of freedom*.

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***dentate* (14.3.1):** Term used to categorize *ligands* that describes the number of nonmetal atoms with electron pairs used by a *ligand* for coordinate bond formation (unidentate, bidentate, etc.).

***derived concentration guideline level (DCGL)* (2.5.2.1):** A derived radionuclide-specific activity concentration within a *survey unit* corresponding to the release criterion. *DCGLs* are derived from activity/dose relationships through various exposure pathway scenarios.

***descriptive statistics* (9.6.4.1):** Statistical methods that are used to determine and use the *mean*, mode, *median*, *variance*, and correlations among variables, tables, and graphs to describe a set of data.

***detection capability* (1.4.7):** The capability of a *measurement process* to distinguish small amounts of *analyte* from zero. It may be expressed in terms of the *minimum detectable concentration*.

***detection limit* (2.5, Table 2.1):** The smallest value of the amount or concentration of *analyte* that ensures a specified high probability of detection. Also called "*minimum detectable value.*"

***deviation reports* (9.2.2.2):** Documentation of any changes from the analysis plan that may affect data utility.

***digestion* (6.6):** (1) Heating a precipitate over time; used to form larger crystals after initial precipitation. (2) The dissolution of a *sample* by chemical means, typically through the addition of a strong acid or base.

***directed planning process* (1.2):** A systematic framework focused on defining the data needed to support an informed decision for a specific project. Directed planning provides a logic for setting well-defined, achievable objectives and developing a cost-effective, technically sound sampling and analysis design that balances the data user's tolerance for uncertainty in the decision process and the available resources for obtaining data to support a decision. Directed planning helps to eliminate poor or inadequate sampling and analysis designs.

***disproportionation (autoxidation-reduction)* (14.2.3):** An oxidation-reduction reaction in which a chemical species is simultaneously oxidized and reduced.

***dissolve* (6.5.1.1):** To form a solution by mixing a *solute* with a *solvent*. The particles of the *solute solvent* mix intimately at the atomic, molecular, and ionic levels with the particles of the *solvent*, and the *solute* particles are surrounded by particles of the *solvent*.

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***distillation* (12.2.1.2):** Separation of a volatile component(s) of a liquid mixture or solution by boiling the mixture to vaporize the component and subsequent condensation and collection of the components as a liquid.

***distribution* (3B.2):** The *distribution* of a *random variable* is a mathematical description of its possible values and their probabilities. The *distribution* is uniquely determined by its *distribution function*.

***distribution (partition) coefficient* (15.4.5.5):** An equilibrium constant that represents the ratio of the concentration of a *solute* distributed between two immiscible *solvents*.

***distribution function* (19A.1):** The *distribution function*, or *cumulative distribution function*, of a *random variable X* is the function F defined by $F(x) = \Pr[X \leq x]$.

***dose-based regulation* (2.3.2):** A regulation whose allowable *radionuclide* concentration limits are based on the dose received by an individual or population.

***dose equivalent* (2.5.2.1):** A quantity that expresses all radiations on a common scale for calculating the effective absorbed dose. This quantity is the product of absorbed dose (grays or rads) multiplied by a quality factor and any other modifying factors (MARSSIM, 2000). The "quality factor" adjusts the absorbed dose because not all types of ionizing radiation create the same effect on human tissue. For example, a *dose equivalent* of one sievert (Sv) requires 1 gray (Gy) of beta or gamma radiation, but only 0.05 Gy of alpha radiation or 0.1 Gy of neutron radiation. Because the sievert is a large unit, radiation doses often are expressed in millisieverts (mSv). See *committed effective dose equivalent* and *total effective dose equivalent*.

***duplicates* (1.4.8):** Two equal-sized samples of the material being analyzed, prepared, and analyzed separately as part of the same batch, used in the laboratory to measure the overall *precision* of the sample measurement process beginning with laboratory subsampling of the field *sample*.

***dynamic work plan* (4.4.2):** A type of work plan that specifies the decisionmaking logic to be used in the field to determine where the samples will be collected, when the sampling will stop, and what analyses will be performed. This is in contrast to a work plan that specifies the number of samples to be collected and the location of each *sample*.

***effective degrees of freedom* (ν_{eff}) (6A.2):** A parameter associated with a combined *standard uncertainty*, $u_c(y)$, analogous to the number of degrees of freedom for a Type A evaluation of *standard uncertainty*, which describes the reliability of the uncertainty estimate and which may

be used to select the coverage factor for a desired coverage probability. The number of effective degrees of freedom is determined using the *Welch-Satterthwaite formula*.

***efficiency* (2.5.4.2):** See *counting efficiency*.

***electrodeposition* (14.1):** Depositing (plating or coating) a metal onto the surface of an electrode by electrochemical reduction of its cations in solution.

***electronegativity* (14.2.2):** The ability of an atom to attract electrons in a covalent bond.

***electron density* (13.2.3):** A term representing the relative electron concentration in part of a molecule. The term indicates the unequal distribution of valence electrons in a molecule. Unequal distribution is the result of *electronegativity* differences of atoms in the bonds of the molecule and the geometry of the bonds; the results is a polar molecule.

***eluant* (14.7.4.1):** A liquid or solution acting as the moving phase in a chromatographic system.

***eluate* (14.7.4.1):** The liquid or solution that has passed over or through the *stationary phase* in a chromatographic system. The *eluate* may contain components of the analyzed solution, analytes, or impurities. In column chromatography, it is the liquid coming out of the column. The process is referred to as "eluting."

***emission probability per decay event* (E_e) (16.2.2):** The fraction of total decay events for which a particular particle or photon is emitted. Also called the "branching fraction" or "branching ratio."

***emulsion* (14.4.3):** (1) A *colloidal solution* in which both the dispersed phase and continuous phase are immiscible liquids (2) A permanent *colloidal solution* in which either the dispersed phase or continuous phase is water, usually oil in water or water in oil. See *gel*.

***environmental compliance* (4.2):** Agreement with environmental laws and regulations.

***environmental data collection process* (2.1):** Consists of a series of elements (e.g., planning, developing *project plan documents*, contracting for services, sampling, analysis, data verification, data validation, and *data quality assessment*), which are directed at the use of the data in decisionmaking.

***error (of measurement)* (1.4.7):** The difference between a measured result and the value of the *measurand*. The error of a measurement is primarily a theoretical concept, since its value is never known. See also *random error, systematic error,* and *uncertainty (of measurement)*.

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***estimator* (18B.2):** A *random variable* whose value is used to estimate an unknown parameter, θ, is called an *estimator* for θ. Generally, an estimator is a function of experimental data.

***exception* (8.2.3):** A concept in *data verification* meaning a failure to meet a requirement.

***excluded particles* (14.7.6):** Chemical components in a *gel-filtration chromatographic* system that do not enter the solid-phase matrix during separation; these components spend less time in the system and are the first to be eluted in a single fraction during chromatography.

***exclusion chromatography* (14.7.6):** See *gel-filtration chromatography*.

***excursion* (1.6.2):** Departure from the expected condition during laboratory analysis.

***expanded uncertainty* (1.4.7):** "The product, U, of the *combined standard uncertainty* of a measured value y and a *coverage factor k* chosen so that the interval from $y - U$ to $y + U$ has a desired high probability of containing the value of the *measurand*" (ISO, 1995).

***expectation* (19.2.2):** The *expectation* of a *random variable X*, denoted by $E(X)$ or μ_X, is a measure of the center of its *distribution* (a measure of central tendency) and is defined as a probability-weighted average of the possible numerical values. Other terms for the expectation value of X are the *expected value* and the *mean*.

***expected value* (18.3.2):** See *expectation*.

***expedited site characterization* (2.3.2):** A process used to identify all relevant contaminant migration pathways and determine the distribution, concentration, and fate of the contaminants for the purpose of evaluating risk, determining regulatory compliance, and designing remediation systems.

***experimental standard deviation* (6A.2):** A measure of the dispersion of the results of repeated measurements of the same quantity, given explicitly by

$$s(q_k) = \sqrt{\frac{1}{n-1}\sum_{k=1}^{n}(q_k - \bar{q})^2}$$

where $q_1, q_2, \ldots, q_n$ are the results of the measurements, and $\bar{q}$ is their arithmetic mean (ISO, 1993a).

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***external assessment* (4.2):** Part of the evaluation process used to measure the performance or effectiveness of a system and its elements. As an example, this could be information (audit, performance evaluation, inspection, etc.) related to a method's development, validation, and control that is done by personnel outside of the laboratory and is part of the laboratory *quality assurance* program.

***extraction chromatography* (14.4.4):** A solid-phase extraction method performed in a chromatographic column that uses a *resin* material consisting of an extractant absorbed onto an inert polymeric support matrix.

***false acceptance* (20.2.2):** See *Type II decision error*.

***false negative* (20.2.1):** See *Type II decision error*. MARLAP avoids the terms "*false negative*" and "*false positive*" because they may be confusing in some contexts.

***false positive* (14.10.9.9):** See *Type I decision error*. MARLAP avoids the terms "*false negative*" and "*false positive*" because they may be confusing in some contexts.

***false rejection* (20.2.1):** See *Type I decision error*.

***femtogram* (*fg*) (6.5.5.5):** Unit of mass equal to 10^{-15} grams.

***flocculation* (14.8.5):** See *coagulation* and *deflocculation*.

***formation constant* (14.3.2):** The equilibrium constant for the formation of a *complex ion* or coordination molecule. The magnitude of the constant represents the stability of the *complex*. Also called "stability constant."

***fractional distillation* (14.5.2):** Separation of liquid components of a mixture by repeated *volatilization* of the liquid components and condensation of their vapors within a *fractionation column*. Repeated *volatilization* and condensation produces a decreasing temperature gradient up the column that promotes the collection of the more volatile components (lower boiling point components) at the upper end of the column and return of the less volatile components at the lower end of the column. The process initially enriches the vapors in the more volatile components, and they separate first as lower boiling point fractions.

***fractionation column* (14.5.3):** A *distillation* column that allows repeated *volatilization* and condensation steps within the length of the column, accomplishing *fractional distillation* of components of a mixture in one *distillation* process by producing a temperature gradient that

decreases up the length of the column (see *fractional distillation*). The column is designed with plates or packing material inside the column to increase the surface area for condensation.

***frequency plots* (9.6.3):** Statisticians employ *frequency plots* to display the *imprecision* of a sampling and analytical event and to identify the type of distribution.

***fusion* (1.4.10):** See *sample dissolution*.

***full width of a peak at half maximum* (*FWHM*) (8.5.11):** A measure of the resolution of a spectral peak used in alpha or gamma spectrometry: the full peak-width energy (FW) at one-half maximum peak height (HM).

***full width of a peak at tenth maximum* (*FWTM*) (15.1):** A measure of the resolution of a spectral peak used in alpha or gamma spectrometry: the full peak-width energy (FW) at one-tenth maximum peak height (TM).

***gas chromatography* (*GC*) (14.5.2):** See *gas-liquid phase chromatography*.

***gas-liquid phase chromatography* (*GLPC*) (14.7.1):** A chromatographic separation process using a mobile gas phase (*carrier gas*) in conjunction with a low-volatility liquid phase that is absorbed onto an inert, solid-phase matrix to produce a *stationary phase*. The components of the analytical mixture are vaporized and swept through the column by the *carrier gas*.

***gel* (14.7.4.2, Table 14.9):** (1) A *colloidal solution* that is highly viscous, usually coagulated into a semirigid or jellylike solid. (2) Gelatinous masses formed from the *flocculation* of *emulsions*.

***gel-exclusion chromatography* (14.7.6):** See *gel-filtration chromatography*.

***gel-filtration chromatography* (14.7.6):** A column chromatographic separation process using a solid, inert polymeric matrix with pores that admit molecules less than a certain hydrodynamic size (molecular weight) but exclude larger molecules. The excluded molecules are separated from the included molecules by traveling only outside the matrix and are first eluted in bulk from the column. The included molecules, depending on size, spend different amounts of time in the pores of matrix and are separated by size.

***general analytical planning issues* (3.3):** Activities to be identified and resolved during a *directed planning process*. Typically, the resolution of *general analytical planning issues* normally results, at a minimum, in an *analyte* list, identified matrices of concern, *measurement*

quality objectives, and established frequencies and acceptance criteria for *quality control samples*.

***graded approach* (2.3):** A process of basing the level of management controls applied to an item or work on the intended use of the results and the degree of confidence needed in the quality of the results. MARLAP recommends a *graded approach* to project planning because of the diversity of environmental data collection activities. This diversity in the type of project and the data to be collected impacts the content and extent of the detail to be presented in the *project plan documents*.

***gray region* (1.6.3):** The range of possible values in which the consequences of decision errors are relatively minor. Specifying a *gray region* is necessary because variability in the *target analyte* in a population and *imprecision* in the measurement system combine to produce variability in the data such that the decision may be "too close to call" when the true value is very near the *action level*. The *gray region* establishes the minimum distance from the *action level* where it is most important that the *project planning team* control *Type II errors*.

***GUM* (1.4.7):** *Guide to the Expression of Uncertainty in Measurement* (ISO, 1995).

***half-life* ($T_{½}$ *or* $t_{½}$) (1.4.8):** The time required for one-half of the atoms of a particular *radionuclide* in a *sample* to disintegrate or undergo nuclear transformation.

***heterogeneity* (2.5):** (1) "Spatial heterogeneity," a type of distributional heterogeneity, refers to the nonuniformity of the distribution of an *analyte* of concern within a matrix. Spatial heterogeneity affects sampling, sample processing, and sample preparation. See *homogenization*. (2) The "distributional heterogeneity" of a lot depends not only on the variations among particles but also on their spatial distribution. Thus, the distributional heterogeneity may change, for example, when the material is shaken or mixed. (3) The "constitutional" (or "compositional") heterogeneity of a lot is determined by variations among the particles without regard to their locations in the lot. It is an intrinsic property of the lot itself, which cannot be changed without altering individual particles.

***high-level waste* (*HLW*) (1.3):** (1) irradiated reactor fuel; (2) liquid wastes resulting from the operation of the first-cycle *solvent* extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel; (3) solids into which such liquid wastes have been converted.

***high-pressure liquid chromatography* (*HPLC*) (14.7.7):** A column chromatography process using various solid-liquid phase systems in which the liquid phase is pumped through the system at high pressures. The process permits rapid, highly efficient separation when compared to many

other chromatographic systems and is, therefore, also referred to as "high-performance liquid chromatography."

***holdback carrier* (14.8.4.4):** A nonradioactive *carrier* of a *radionuclide* used to prevent that particular radioactive species from contaminating other radioactive species in a chemical operation (IUPAC, 2001).

***homogeneous distribution coefficient* (*D*) (14.8.4.1):** The equality constant in the equation representing the *homogeneous distribution law*. Values of *D* greater than one represent removal of a foreign *ion* by inclusion during *coprecipitation* (see *homogeneous distribution law*).

***homogeneous distribution law* (14.8.4.1):** A description of one mechanism in which *coprecipitation* by inclusion occurs (the less common mechanism). The amount of *ion* coprecipitating is linearly proportional to the ratio of the concentration of the *ion* in solution to the concentration of the coprecipitating agent in solution. Equilibrium between the precipitate and the solution is obtained (during digestion) and the crystals become completely homogeneous with respect to the foreign *ions* (impurities) (see *homogeneous distribution coefficient* and *digestion*).

***homogenization* (3.4, Table 3.1):** Producing a uniform distribution of analytes and particles throughout a *sample*.

***hydration* (14.3.1):** Association of water molecules with *ions* or molecules in solution.

***hydration sphere* (14.3.1):** Water molecules that are associated with *ions* or molecules in solution. The inner-hydration sphere (primary hydration sphere) consists of several water molecules directly bonded to *ions* through ion-dipole interactions and to molecules through dipole-dipole interactions including hydrogen bonding. The outer hydration sphere (secondary hydration sphere) is water molecules less tightly bound through hydrogen bonding to the molecules of the inner-hydration sphere.

***hydrolysis*:** (1) A chemical reaction of water with another compound in which either the compound or water is divided. (2) A reaction of water with *ions* that divides (lyses) water molecules to produce an excess of hydrogen *ions* or excess of hydroxyl *ions* in solution (an acidic or basic solution). Cations form *complex ions* with hydroxyl *ions* as *ligands* producing an acidic solution: $Fe^{+3} + H_2O \rightarrow Fe(OH)^{+2} + H^{+1}$. Anions form covalent bonds with the hydrogen *ion* producing weak acids and a basic solution: $F^{-1} + H_2O \rightarrow HF + OH^{-1}$.

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***hypothesis testing* (2.5, Table 2.1):** The use of statistical procedures to decide whether a *null hypothesis* should be rejected in favor of an *alternative hypothesis* or not rejected (see also *statistical test*).

***immobile phase* (14.7.1):** See *stationary phase*.

***imprecision* (1.4.8):** Variation of the results in a set of *replicate* measurements. This can be expressed as the *standard deviation* or coefficient of variation (*relative standard deviation*) (IUPAC, 1997). See *precision*.

***included particle* (14.7.6):** The chemical forms that are separated by *gel-filtration chromatography*. They enter the solid-phase matrix of the chromatographic system and are separated by hydrodynamic size (molecular weight), eluting in inverse order by size.

***inclusion* (14.7.1):** Replacement of an *ion* in a crystal lattice by a foreign *ion* similar in size and charge to form a mixed crystal or solid solution. Inclusion is one mechanism by which *ions* are *coprecipitated* with another substance precipitating from solution.

***in control* (1.6.2):** The analytical process has met the *quality control* acceptance criteria and project requirements. If the analytical process is *in control*, the assumption is that the analysis was performed within established limits and indicates a reasonable match among matrix, *analyte*, and *method*.

***independent* (19.2.2):** A collection of *random variables* $X_1, X_2, \ldots, X_n$ is *independent* if $\Pr[X_1 \le x_1, X_2 \le x_2, \ldots, X_n \le x_n] = \Pr[X_1 \le x_1] \cdot \Pr[X_2 \le x_2] \cdots \Pr[X_n \le x_n]$ for all real numbers $x_1, x_2, \ldots, x_n$. Intuitively, the collection is said to be *independent* if knowledge of the values of any subset of the variables provides no information about the likely values of the other variables.

***inferential statistics* (9.6.4.1):** Using data obtained from samples to make estimates about a population (inferential estimations) and to make decisions (*hypothesis testing*). Sampling and *inferential statistics* have identical goals: to use samples to make inferences about a population of interest and to use *sample* data to make defensible decisions.

***inner (primary) hydration sphere* (14.3.1):** See *hydration sphere*.

***input estimate* (3A.5):** Measured value of an input quantity. See *output estimate*.

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***input quantity* (6.5.5.1):** Any of the quantities in a mathematical measurement model whose values are measured and used to calculate the value of another quantity, called the *output quantity*. See *input estimate*.

***interferences* (1.4.9):** The presence of other chemicals or *radionuclides* in a *sample* that hinder the ability to analyze for the *radionuclide of interest*. See *method specificity*.

***ion-exchange chromatography* (6.6.2.3):** A separation method based on the reversible exchange of *ions* in a mobile phase with *ions* bonded to a solid ionic phase. *Ions* that are bonded less strongly to the solid phase (of opposite charge) are displaced by *ions* that are more strongly bonded. Separation of *analyte ions* depends on the relative strength of bonding to the solid phase. Those less strongly bonded *ions* are released from the solid phase earlier and eluted sooner.

***ion-product* (14.8.3.1):** The number calculated by substituting the molar concentration of *ions* that could form a precipitate into the solubility-product expression of the precipitating compound. The *ion-product* is used to determine if a precipitate will form from the concentration of *ions* in solution. If the *ion-product* is larger than the *solubility-product constant*, precipitation will occur; if it is smaller, precipitation will not occur.

***isomeric transition* (14.10.9.12):** The transition, via gamma-ray emission (or internal conversion), of a nucleus from a high-energy state to a lower-energy state without accompanying particle emission, e.g., $^{99m}Tc \rightarrow {}^{99}Tc + \gamma$.

***isotope* (3.3.4):** Any of two or more nuclides having the same number of protons in their nuclei (same atomic number), but differing in the number of neutrons (different mass numbers, for example ^{58}Co, ^{59}Co, and ^{60}Co). See *radionuclide*.

***isotope dilution analysis* (14.10.7):** A method of quantitative analysis based on the measurement of the isotopic abundance of an element after isotopic dilution of the test portion.

***key analytical planning issue* (1.6.1):** An issue that has a significant effect on the selection and development of analytical protocols or an issue that has the potential to be a significant contributor of uncertainty to the analytical process and ultimately the resulting data.

***laboratory control sample* (2.5.4.2):** A standard material of known composition or an artificial *sample* (created by fortification of a clean material similar in nature to the sample), which is prepared and analyzed in the same manner as the sample. In an ideal situation, the result of an analysis of the *laboratory control sample* should be equivalent to (give 100 percent of) the *target*

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analyte concentration or *activity* known to be present in the fortified sample or standard material. The result normally is expressed as percent *recovery*. See also *quality control sample*.

***Laboratory Information Management System* (*LIMS*) (11.2.1):** An automated information system used at a laboratory to collect and track data regarding sample analysis, laboratory *quality control* operability information, final result calculation, report generation, etc.

***laboratory method* (6.2):** Includes all physical, chemical, and radiometric processes conducted at a laboratory in order to provide an analytical result. These processes may include sample preparation, dissolution, chemical separation, mounting for counting, nuclear instrumentation counting, and analytical calculations. Also called *analytical method*.

***law of propagation of uncertainty* (19.1):** See *uncertainty propagation formula*.

***level of confidence* (1.4.11):** See *coverage probability*.

***ligand* (14.3.1):** A molecule, atom, or *ion* that donates at least one electron pair to a metal atom or *ion* to form a coordination molecule or *complex ion*. See *dentate*.

***linearity* (7.2.2.5):** The degree to which the response curve for a measuring device, such as an analytical balance, follows a straight line between the calibration points. The *linearity* is usually specified by the maximum deviation of the response curve from such a straight line.

***liquid chromatography* (*LC*) (14.7.1):** A chromatographic process using a mobile liquid-phase.

***liquid-phase chromatography* (*LPC*) (14.7.1):** A chromatographic process in which the mobile and *stationary phases* are both liquids. Separation is based on relative solubility between two liquid phases. The *stationary phase* is a nonvolatile liquid coated onto an inert solid matrix or a liquid trapped in or bound to a solid matrix. Also called "liquid-partition chromatography."

***logarithmic distribution coefficient* (λ) (14.8.4.1):** The equality constant in the equation representing the *Logarithmic Distribution Law*. Values of λ greater than one represent removal of a foreign *ion* by inclusion during *coprecipitation*, and the larger the value, the more effective and selective the process is for a specific *ion*. Generally, the *logarithmic distribution coefficient* decreases with temperature, so *coprecipitation* by inclusion is favored by lower temperature.

***Logarithmic Distribution Law* (14.8.4.1):** A description of one mechanism by which *coprecipitation* by inclusion occurs (the more common mechanism). The amount of *ion* coprecipitated is logarithmically proportional to the amount of primary *ion* in the solution during

crystallization. Crystal are grown in a slow and orderly process, such as precipitation from homogeneous solution, and each crystal surface, as it is formed, is in equilibrium with the solution. As a result, the concentration of a foreign *ion* (impurity) varies continuously from the center to the periphery of the crystal (see *logarithmic distribution coefficient*).

***logic statement* (2.6):** The output from the *directed planning process* about what must be done to obtain the desired answer.

***lower limit of detection* (*LLD*) (14.10.9.5):** (1) "The smallest concentration of radioactive material in a *sample* that will yield a net count, above the measurement process (MP) blank, that will be detected with at least 95 percent probability with no greater than a 5 percent probability of falsely concluding that a blank observation represents a 'real' signal" (NRC, 1984). (2) "An estimated detection limit that is related to the characteristics of the counting instrument" (EPA, 1980).

***low-pressure chromatography* (14.7.1):** Column chromatography in which a liquid phase is passed through a column under pressure supplied by gravity or a low-pressure pump.

***Lucas cell* (10.5.4.4):** A specially designed, high-efficiency cell for the analysis of radon gas with its progeny. The cell is coated with a zinc sulfide phosphor material that releases ultraviolet light when the alpha particles from radon and its progeny interact with the phosphor.

***Marinelli beaker* (6.5.3):** A counting container that allows the *source* to surround the detector, thus maximizing the geometrical efficiency. It consists of a cylindrical sample container with an inverted well in the bottom that fits over the detector. Also called a "reentrant beaker."

***MARLAP Process* (1.4):** A performance-based approach that develops *Analytical Protocol Specifications*, and uses these requirements as criteria for the analytical protocol selection, development, and evaluation processes, and as criteria for the evaluation of the resulting laboratory data. This process, which spans the three phases of the *data life cycle* for a project, is the basis for achieving MARLAP's basic goal of ensuring that radioanalytical data will meet a project's or program's data requirements or needs.

***masking* (14.4.3):** The prevention of reactions that are normally expected to occur through the presence or addition of a masking agent (reagent).

***masking agent* (14.4.3):** A substance that is responsible for converting a chemical form, which would have otherwise participated in some usual chemical reaction, into a derivative that will not participate in the reaction.

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***matrix of concern* (1.4.10):** Those matrices identified during the directed project planning process from which samples may be taken. Typical matrices include: surface soil, subsurface soil, sediment, surface water, ground water, drinking water, process effluents or wastes, air particulates, biota, structural materials, and metals.

***matrix-specific analytical planning issue* (3.1):** Key analytical planning issue specific to that matrix, such as filtration and preservation issues for water samples.

***matrix spike* (3.3.10):** An *aliquant* of a *sample* prepared by adding a known quantity of *target analytes* to specified amount of matrix and subjected to the entire analytical procedure to establish if the method or procedure is appropriate for the analysis of the particular matrix.

***matrix spike duplicate* (*MSD*) (9.6.3):** A second *replicate* matrix spike prepared in the laboratory and analyzed to evaluate the *precision* of the measurement process.

***Maximum Contaminant Level* (*MCL*) (2.5.2.1):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close as feasible to the level believed to cause no human health impact, while using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

***mean* (1.4.8):** See *expectation* (compare with *arithmetic mean* and *sample mean*).

***mean concentration* (2.5.2.3):** A weighted average of all the possible values of an *analyte* concentration, where the weight of a value is determined by its probability.

***measurand* (1.4.7):** "Particular quantity subject to measurement"(ISO, 1993a).

***measurement performance criteria* (1.2):** See *measurement quality objectives*.

***measurement process* (1.3):** *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 (IUPAC, 1995).

***measurement quality objective* (*MQO*) (1.4.9):** The analytical data requirements of the *data quality objectives* are project- or program-specific and can be quantitative or qualitative. These analytical data requirements serve as *measurement performance criteria* or objectives of the analytical process. MARLAP refers to these performance objectives as *measurement quality objectives (MQOs)*. Examples of quantitative *MQOs* include statements of required *analyte* detectability and the uncertainty of the analytical protocol at a specified *radionuclide* concentra-

tion, such as the *action level*. Examples of qualitative *MQOs* include statements of the required specificity of the analytical protocol, e.g., the ability to analyze for the *radionuclide of interest* given the presence of interferences.

***measurement uncertainty* (1.4.7):** See *uncertainty (of measurement)*.

***measurement variability* (2.5.2.2):** The variability in the measurement data for a *survey unit* is a combination of the *imprecision* of the measurement process and the real spatial variability of the *analyte* concentration.

***median* (9.6.4.1):** A *median* of a distribution is any number that splits the range of possible values into two equally likely portions, or, to be more rigorous, a 0.5-*quantile*. See *arithmetic mean*.

***method* (1.4.5):** See *analytical method*.

***method blank* (Figure 3.3):** A *sample* assumed to be essentially *target analyte*-free that is carried through the radiochemical preparation, analysis, mounting and measurement process in the same manner as a routine sample of a given matrix.

***method control* (6.1):** Those functions and steps taken to ensure that the validated method as routinely used produces data values within the limits of the *measurement quality objectives*. *Method control* is synonymous with process control in most *quality assurance* programs.

***method detection limit* (*MDL*) (3B.4):** "The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the *analyte* concentration is greater than zero … determined from analysis of a *sample* in a given matrix containing the *analyte*" (40 CFR 136, Appendix B).

***method performance characteristics* (3.3.7):** The characteristics of a specific *analytical method* such as *method uncertainty*, *method range*, *method specificity*, and *method ruggedness*. MARLAP recommends developing *measurement quality objectives* for select *method performance characteristics*, particularly for the *uncertainty (of measurement)* at a specified concentration (typically the *action level*).

***method range* (1.4.9):** The lowest and highest concentration of an *analyte* that a method can accurately detect.

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***method ruggedness* (1.4.9):** The relative stability of method performance for small variations in method parameter values.

***method specificity* (1.4.9):** The ability of the method to measure the *analyte* of concern in the presence of interferences.

***method uncertainty* (3.3.7):** Method uncertainty refers to the predicted uncertainty of the result that would be measured if the method were applied to a hypothetical laboratory *sample* with a specified *analyte* concentration. Although individual measurement uncertainties will vary from one measured result to another, the required *method uncertainty* is a target value for the individual measurement uncertainties, and is an estimate of *uncertainty (of measurement)* before the sample is actually measured. See also *uncertainty (of measurement)*.

***method validation* (5.3):** The demonstration that the radioanalytical method selected for the analysis of a particular *radionuclide* in a given matrix is capable of providing analytical results to meet the project's *measurement quality objectives* and any other requirements in the *analytical protocol specifications*. See *project method validation*.

***method validation reference material* (*MVRM*) (5.5.2):** Reference materials that have the same or similar chemical and physical properties as the proposed project samples, which can be used to validate the laboratory's methods.

***metrology* (1.4.7):** The science of measurement.

***minimum detectable amount* (*MDA*) (3B.3):** The minimum detectable value of the amount of analyte in a sample. Same definition as the *minimum detectable concentration* but related to the quantity (activity) of a *radionuclide* rather than the concentration of a *radionuclide*. May be called the "minimum detectable activity" when used to mean the *activity* of a radionuclide (see ANSI N13.30 and N42.23).

***minimum detectable concentration* (*MDC*) (2.5.3):** The *minimum detectable value* of the analyte concentration in a sample. ISO refers to the MDC as the *minimum detectable value of the net state variable*. They define this as the smallest (true) value of the net state variable that gives a specified probability that the value of the response variable will exceed its critical value—i.e., that the material analyzed is not blank.

***minimum detectable value* (20.2.1):** An estimate of the smallest true value of the *measurand* that ensures a specified high probability, $1 - \beta$, of detection. The definition of the *minimum*

detectable value presupposes that an appropriate detection criterion has been specified (see *critical value*).

***minimum quantifiable concentration* (*MQC*) (3.3.7):** The *minimum quantifiable concentration*, or the *minimum quantifiable value* of the *analyte* concentration, is defined as the smallest concentration of *analyte* whose presence in a laboratory *sample* ensures the relative *standard deviation* of the measurement does not exceed a specified value, usually 10 percent.

***minimum quantifiable value* (20.2.7):** The smallest value of the *measurand* that ensures the *relative standard deviation* of the measurement does not exceed a specified value, usually 10 percent (see also *minimum quantifiable concentration*).

***mixed waste* (1.3):** Waste that contains both radioactive and hazardous chemicals.

***mobile phase* (14.7.1):** The phase in a chromatographic system that is moving with respect to the *stationary phase*; either a liquid or a gas phase.

***moving phase* (14.7.1):** See *mobile phase*.

***net count rate*: (16.3.2):** The *net count rate* is the value resulting form the subtraction of the background count rate (instrument background or appropriate blank) from the total (gross) count rate of a *source* or sample.

***nonaqueous samples* (10.3.5):** Liquid-sample matrices consisting of a wide range of organic/ *solvents,* organic compounds dissolved in water, oils, lubricants, etc.

***nonconformance* (5.3.7):** An instance in which the contractor does not meet the performance criteria of the contract or departs from contract requirements or acceptable practice.

***nuclear decay* (15.3):** A spontaneous nuclear transformation.

***nuclear counting* (1.6):** The measurement of alpha, beta or photon emissions from *radionuclides*.

***nuclide* (1.1):** A species of atom, characterized by its mass number, atomic number, and nuclear energy state, providing that the mean *half-life* in that state is long enough to be observable (IUPAC, 1995).

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***nuclide-specific analysis* (3.3.8.3):** Radiochemical analysis performed to isolate and measure a specific *radionuclide*.

***null hypothesis* (H_0) (2.5, Table 2.1):** One of two mutually exclusive statements tested in a statistical *hypothesis test* (compare with *alternative hypothesis*). The *null hypothesis* is presumed to be true unless the test provides sufficient evidence to the contrary, in which case the *null hypothesis* is rejected and the *alternative hypothesis* is accepted.

***occlusion* (14.8.3.1):** The mechanical entrapment of a foreign *ion* between subsequent layers during crystal formation. A mechanism of *coprecipitation*.

***Ostwald ripening* (14.8.3.2):** Growth of larger crystals during precipitation by first dissolving smaller crystals and allowing the larger crystals to form.

***outer (secondary) hydration sphere* (14.3.1):** See *hydration sphere*.

***outlier* (9.6.4.1):** A value in a group of observations, so far separated from the remainder of the values as to suggest that they may be from a different population, or the result of an error in measurement (ISO, 1993b).

***output estimate* (3A.5):** The calculated value of an output quantity (see *input estimate*).

***output quantity* (19.3.2):** The quantity in a mathematical measurement model whose value is calculated from the measured values of other quantities in the model (see *input quantity* and *output estimate*).

***oxidation* (6.4):** The increase in oxidation number of an atom in a chemical form during a chemical reaction. Increase in oxidation number is a result of the loss of electron(s) by the atom or the decrease in electron density when the atom bonds to a more electronegative element or breaks a bond to a less electronegative element.

***oxidation-reduction (redox) reaction* (10.3.3):** A chemical reaction in which electrons are redistributed among the atoms, molecules, or *ions* in the reaction.

***oxidation number* (6.4):** An arbitrary number indicating the relative electron density of an atom or *ion* of an element in the combined state, relative to the electron density of the element in the pure state. The oxidation number increases as the electron density decreases and decreases as the electron density increases.

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***oxidation state* (6.4):** See *oxidation number*.

***oxidizing agent* (10.5.2):** The chemical species in an oxidation-reduction reaction that causes oxidation of another chemical species by accepting or attracting electrons. The oxidizing agent is reduced during the reaction.

***paper chromatography* (14.7.1):** A chromatographic process in which the *stationary phase* is some type of absorbent paper. The *mobile phase* is a pure liquid or solution.

***parameter of interest* (2.5, Table 2.1):** A descriptive measure (e.g., *mean*, median, or proportion) that specifies the characteristic or attribute that the decisionmaker would like to know and that the data will estimate.

***PARCC* (3.3.7):** "Precision, accuracy, representativeness, comparability, and completeness." See *data quality indicators*.

***parent radionuclide* (3.3.4):** The initial *radionuclide* in a *decay chain* that decays to form one or more *progeny*.

***partition (distribution) coefficient*:** See *distribution coefficient*.

***peptization*:** See *deflocculation*.

***percentile* (19A.1):** If X is a random variable and p is a number between 0 and 1, then a $100p^{th}$ percentile of X is any number x_p such that the probability that $X < x_p$ is at most p and the probability that $X \le x_p$ is at least p. For example, if $x_{0.95}$ is a 95th percentile of X then $\Pr[X < x_{0.95}] \le 0.95$ and $\Pr[X \le x_{0.95}] \ge 0.95$. See *quantile*.

***performance-based approach* (1.2):** Defining the analytical data needs and requirements of a project in terms of measurable goals during the planning phase of a project. In a *performance-based approach*, the project-specific analytical data requirements that are determined during a *directed planning process* serve as measurement performance criteria for selections and decisions on how the laboratory analyses will be conducted. The project-specific analytical data requirements are also used for the initial, ongoing, and final evaluation of the laboratory's performance and the laboratory data.

***performance-based approach to method selection* (6.1):** The process wherein a validated method is selected based on a demonstrated capability to meet defined quality and laboratory performance criteria.

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***performance evaluation program* (5.3.5):** A laboratory's participation in an internal or external program of analyzing performance testing samples appropriate for the analytes and matrices under consideration (i.e., *performance evaluation (PE) program* traceable to a national standards body, such as the National Institute of Standards and Technology in the United States).

***performance evaluation sample* (3.3.10):** Reference material samples used to evaluate the performance of the laboratory. Also called *performance testing (PT)* samples or materials.

***performance indicator* (1.6.2):** Instrument- or protocol-related parameter routinely monitored to assess the laboratory's estimate of such controls as chemical yield, instrument background, *uncertainty (of measurement)*, *precision*, and *bias*.

***performance testing (PT)*:** See *performance evaluation program*.

***picocurie* (*pCi*) (1.4.9):** 10^{-12} *curie*.

***planchet* (10.3.2):** A metallic disk (with or without a raised edge) that is used for the analysis of a radioactive material after the material has been filtered, evaporated, electroplated, or dried. Evaporation of water samples for gross alpha and beta analysis often will take place directly in the planchet.

***Poisson distribution* (18.3.2):** A random variable X has the *Poisson distribution* with parameter λ if for any nonnegative integer k,

$$\Pr[X = k] = \frac{\lambda^k e^{-\lambda}}{k!}$$

In this case both the *mean* and *variance* of X are numerically equal to λ. The *Poisson distribution* is often used as a model for the result of a nuclear counting measurement.

***polymorphism* (14.8.3.1):** The existence of a chemical substance in two or more physical forms, such as different crystalline forms.

***postprecipitation* (14.8.4.3):** The subsequent precipitation of a chemically different species upon the surface of an initial precipitate; usually, but not necessarily, including a common *ion* (IUPAC, 1997).

***precision* (1.4.8):** The closeness of agreement between independent test results obtained by applying the experimental procedure under stipulated conditions. *Precision* may be expressed as the *standard deviation* (IUPAC, 1997). See *imprecision*.

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***prescribed methods* (6.1):** Methods that have been selected by the industry for internal use or by a regulatory agency for specific programs. Methods that have been validated for a specific application by national standard setting organizations, such as ASTM, ANSI, AOAC, etc., may also be used as prescribed methods by industry and government agencies.

***primary (inner) hydration sphere* (14.3.1):** See *hydration sphere*.

***primordial radionuclide* (3.3.1):** A naturally occurring *radionuclide* found in the earth that has existed since the formation (~4.5 billion years) of the Earth, e.g., ^{232}Th and ^{238}U.

***principal decision* (2.7.3):** The *principal decision* or study question for a project is identified during Step 2 of the *data quality objectives* process. The *principal decision* could be simple, like whether a particular discharge is or is not in compliance, or it could be complex, such as determining if an observed adverse health effect is being caused by a nonpoint source discharge.

***principal study question* (2.7.3):** See *principal decision*.

***probabilistic sampling plan* (9.6.2.3):** Using assumptions regarding average concentrations and variances of samples and matrix by the planning team during the development of the sampling plan.

***probability* (1.4.7):** "A real number in the scale 0 to 1 attached to a random event" (ISO, 1993b). The probability of an event may be interpreted in more than one way. When the event in question is a particular outcome of an experiment (or measurement), the probability of the event may describe the relative frequency of the event in many trials of the experiment, or it may describe one's degree of belief that the event occurs (or will occur) in a single trial.

***probability density function* (*pdf*) (19A.1):** A *probability density function* for a *random variable* X is a function $f(x)$ such that the probability of any event $a \le X \le b$ is equal to the value of the integral $\int_a^b f(x)\,dx$. The *pdf*, when it exists, equals the derivative of the distribution function.

***process knowledge* (1.4.10):** Information about the *radionuclide*(s) of concern derived from historical knowledge about the production of the sampled matrix or waste stream.

***progeny* (3.3.4):** The product resulting from the radioactive disintegration or nuclear transformation of its parent *radionuclide*. See *decay chain*.

***project method validation* (6.1):** The demonstrated method applicability for a particular project. See *method validation*.

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project narrative statement **(4.3):** Description of environmental data collection activities, such as basic studies or small projects, which only require a discussion of the experimental process and its objectives. Other titles used for project narrative statements are *quality assurance* narrative statement and proposal *quality assurance* plan. Basic studies and small projects generally are of short duration or of limited scope and could include proof of concept studies, exploratory projects, small data collection tasks, feasibility studies, qualitative screens, or initial work to explore assumptions or correlations.

project plan documents **(1.1):** Gives the data user's expectations and requirements, which are developed during the planning process, where the *Analytical Protocol Specifications* (which include the *measurement quality objectives*) are documented, along with the *standard operating procedures*, health and safety protocols and *quality assurance/quality control* procedures for the field and laboratory analytical teams. Project plan, work plan, *quality assurance project plan*, field sampling plan, *sampling and analysis plan*, and *dynamic work plan* are some of the names commonly used for *project plan documents*.

project planning team **(2.1):** Consists of all the parties who have a vested interest or can influence the outcome (*stakeholders*), such as program and project managers, regulators, the public, project engineers, health and safety advisors, and specialists in statistics, health physics, chemical analysis, radiochemical analysis, field sampling, *quality assurance*, *quality control*, data assessment, hydrology and geology, contract management, and field operation. The *project planning team* will define the decision(s) to be made (or the question the project will attempt to resolve) and the inputs and boundaries to the decision using a *directed planning process*.

project quality objectives **(2.1):** See *decision performance criteria* and *data quality objective*.

project specific plan **(4.3):** Addresses design, work processes, and inspection, and incorporates, by citation, site-wide plans that address records management, quality improvement, procurement, and assessment.

propagation of uncertainty **(15.2.5):** See *uncertainty propagation*.

protocol **(1.4.3):** See *analytical protocol*.

protocol performance demonstration **(3.1):** See *method validation*.

qualifiers **(8.1):** Code applied to the data by a data validator to indicate a verifiable or potential data deficiency or *bias* (EPA, 2002).

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***quality assurance* (*QA*) (1.3):** 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.

***quality assurance project plan* (*QAPP*) (1.4.11):** A formal document describing in 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 QAPP describes policy, organization, and functional activities and the *data quality objectives* and measures necessary to achieve adequate data for use in selecting the appropriate remedy.

***quality control* (*QC*) (1.4.3):** The overall system of technical activities whose purpose is to measure and control the quality of a process or service so that it meets the needs of the users or performance objectives.

***quality control sample* (1.4.3):** Sample analyzed for the purpose of assessing *imprecision* and *bias*. See also *blanks*, *matrix spikes*, *replicates*, and *laboratory control sample*.

***quality control test* (8.5.1):** Comparison of *quality control* results with stipulated acceptance criteria.

***quality indicator* (2.5.4.2):** Measurable attribute of the attainment of the necessary quality for a particular environmental decision. *Precision*, *bias*, *completeness*, and *sensitivity* are common *data quality indicators* for which quantitative *measurement quality objectives* could be developed during the planning process.

***quality system* (9.2.2.3):** The *quality system* oversees the implementation of *quality control samples*, documentation of *quality control sample* compliance or noncompliance with *measurement quality objectives*, audits, surveillances, performance evaluation sample analyses, corrective actions, quality improvement, and reports to management.

***quantification capability* (1.4.9):** The ability of a measurement process to quantify the *measurand* precisely, usually expressed in terms of the *minimum quantifiable value*.

***quantification limit* (20.2.1):** See *minimum quantifiable value*.

***quantile* (6.6.2, Table 6.1):** A *p-quantile* of a *random variable X* is any value x_p such that the probability that $X < x_p$ is at most p and the probability that $X \leq x_p$ is at least p. (See *percentile*.)

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***quench* (7.2):** A term used to describe the process in liquid-scintillation counting when the production of light is inhibited or the light signal is partially absorbed during the transfer of light to the photocathode.

***radioactive* (1.1):** Exhibiting *radioactivity*, or containing *radionuclides*.

***radioactive decay* (3A.4):** "Nuclear decay in which particles or electromagnetic radiation are emitted or the nucleus undergoes spontaneous fission or electron capture." (IUPAC, 1994)

***radioactive equilibrium* (3.3.4):** One of three distinct relationships that arise when a radionuclide decays and creates progeny that are also radioactive: (1) secular equilibrium occurs when *half-life* of the progeny is much less than the *half-life* of the parent (for a single progeny, the total activity reaches a maximum of about twice the initial activity, and then displays the characteristic *half-life* of the parent—usually no change over normal measurement intervals); (2) transient equilibrium occurs when the *half-life* of the progeny is less than the *half-life* of the parent (for a single progeny, total activity passes through a maximum, and then decreases with the characteristic *half-life* of the parent); and (3) no equilibrium occurs when the *half-life* of the progeny is greater than the *half-life* of the parent (total activity decreases continually after time zero).

***radioactivity* (2.5.4.1):** The property of certain nuclides of undergoing *radioactive decay*.

***radioanalytical specialist* (2.1):** Key technical experts who participate on the *project planning team*. *Radioanalytical specialists* may provide expertise in radiochemistry and radiation/nuclide measurement systems, and have knowledge of the characteristics of the analytes of concern to evaluate their fate and transport. They may also provide knowledge about sample transportation issues, preparation, preservation, sample size, subsampling, available analytical protocols, and achievable analytical data quality.

***radiochemical analysis* (5.3.5):** The analysis of a sample matrix for its *radionuclide* content, both qualitatively and quantitatively.

***radiocolloid* (14.4.6.2):** A colloidal form of a *radionuclide* tracer produced by sorption of the *radionuclide* onto a preexisting colloidal impurity, such as dust, cellulose fibers, glass fragments, organic material, and polymeric metal hydrolysis products, or by polycondensation of a monomeric species consisting of aggregates of a thousand to ten million radioactive atoms.

***radiological holding time* (6.5):** The time required to process the *sample*. Also refers to the time differential between the sample collection date and the final sample counting (analysis) date.

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***radiolysis* (14.1):** Decomposition of any material as a result of exposure to radiation.

***radionuclide* (1.1):** A nuclide that is *radioactive* (capable of undergoing *radioactive decay*).

***radionuclide of interest* (1.4.10):** The *radionuclide* or *target analyte* that the planning team has determined important for a project. Also called *radionuclide of concern* or *target radionuclide*.

***radiotracer* (6.5.2):** (1) A radioactive isotope of the *analyte* that is added to the *sample* to measure any losses of the *analyte* during the *chemical separations* or other processes employed in the analysis (the chemical yield). (2) A radioactive element that is present in only extremely minute quantities, on the order of 10^{-15} to 10^{-11} Molar.

***random effect* (3A.4):** Any effect in a measurement process that causes the measured result to vary randomly when the measurement is repeated.

***random error* (3A.4):** A result of a measurement minus the mean that would result from an infinite number of measurements of the same *measurand* carried out under repeatability conditions (ISO, 1993a).

***random variable* (19.3.1):** The numerical outcome of an experiment, such as a laboratory measurement, that produces varying results when repeated.

***reagent blank* (12.6.5):** Consists of the analytical reagent(s) in the procedure without the *target analyte* or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

***recovery* (2.5.4.2):** The ratio of the amount of *analyte* measured in a spiked or *laboratory control sample*, to the amount of *analyte* added, and is usually expressed as a percentage. For a matrix spike, the measured amount of *analyte* is first decreased by the measured amount of *analyte* in the sample that was present before spiking. Compare with *yield*.

***redox* (13.2.3):** An acronym for *oxidation-reduction*.

***reducing agent* (13.4.1, Table 13.2):** The chemical in an oxidation-reduction reaction that reduces another chemical by providing electrons. The *reducing agent* is oxidized during the reaction.

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***reducing; reduction* (13.4.1, Table 13.2):** The decrease in oxidation number of an atom in a chemical form during a chemical reaction. The decrease is a result of the gain of electron(s) by an atom or the increase in electron density by an atom when it bonds to a less electronegative element or breaks a bond to a more electronegative element.

***regulatory decision limit* (2.5.2.1):** The numerical value that will cause the decisionmaker to choose one of the alternative actions. An example of such a limit for drinking water is the *maximum contaminant level (MCL)*. See *action level*.

***rejected result* (8.3.3):** A result that is unusable for the intended purpose. A result should only be rejected when the risks of using it are significant relative to the benefits of using whatever information it carries. *Rejected data* should be qualified as such and not used in the *data quality assessment* phase of the *data life cycle*.

***relative standard deviation* (*RSD*) (6.5.5.2):** See *coefficient of variation*.

***relative standard uncertainty* (3.3.7.1.2):** The ratio of the *standard uncertainty* of a measured result to the result itself. The relative *standard uncertainty* of x may be denoted by $u_r(x)$.

***relative variance* (19A.1):** The *relative variance* of a *random variable* is the square of the coefficient of variation.

***release criterion* (1.3):** A regulatory limit expressed in terms of dose or risk. The release criterion is typically based on the *total effective dose equivalent (TEDE)*, the *committed effective dose equivalent (CEDE)*, risk of cancer incidence (morbidity), or risk of cancer death (mortality), and generally can not be measured directly.

***repeatability (of results of measurement)* (6.6):** The closeness of the agreement between the results of successive measurements of the same *measurand* carried out under the same "repeatability conditions" of measurement. "Repeatability conditions" include the same measurement procedure, the same observer (or analyst), the same measuring instrument used under the same conditions, the same location, and repetition over a short period of time. *Repeatability* may be expressed quantitatively in terms of the dispersion characteristics of the results (Adapted from ISO, 1993a.).

***replicates* (3.3.10):** Two or more *aliquants* of a homogeneous *sample* whose independent measurements are used to determine the *precision* of laboratory preparation and analytical procedures.

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***representativeness* (2.5.4):** (1) The degree to which samples properly reflect their parent populations. (2) A representative *sample* is a sample collected in such a manner that it reflects one or more characteristics of interest (as defined by the project objectives) of a population from which it was collected. (3) One of the five principal *data quality indicators* (*precision*, *bias*, *representativeness*, *comparability*, and *completeness*).

***reproducibility (of results of measurement)* (6.4):** The closeness of the agreement between the results of measurements of the same *measurand* carried out under changed conditions of measurement. A valid statement of *reproducibility* requires specification of the conditions changed. The changed conditions may include principle of measurement, method of measurement, observer (or analyst), measuring instrument, reference standard, location, conditions of use, and time. *Reproducibility* may be expressed quantitatively in terms of the dispersion characteristics of the results. Results are usually understood to be corrected results. (Adapted from ISO, 1993a.).

***request for proposals* (*RFP*) (5.1):** An advertisement from a contracting agency to solicit proposals from outside providers during a negotiated procurement. See *statement of work*.

***required minimum detectable concentration* (*RMDC*) (8.5.3.2):** An upper limit for the *minimum detectable concentration* required by some projects.

***resin* (14.4.5.1):** A synthetic or naturally occurring polymer used in *ion-exchange chromatography* as the solid *stationary phase*.

***resolution* (8.5.1.11):** The peak definition of alpha, gamma-ray, and liquid-scintillation spectrometers, in terms of the *full width of a peak at half maximum (FWHM)*, which can be used to assess the adequacy of instrument setup, detector *sensitivity*, and chemical separation techniques that may affect the identification, specification, and quantification of the *analyte*.

***response variable* (20.2.1):** The variable that gives the observable result of a measurement—in radiochemistry, typically a gross count or count rate.

***robustness* (5.3.9):** The ability of a method to deal with large fluctuations in interference levels and variations in matrix. (See *method ruggedness*.)

***ruggedness* (1.4.9):** See *method ruggedness*.

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***sample* (1.1):** (1) A portion of material selected from a larger quantity of material. (2) A set of individual samples or measurements drawn from a population whose properties are studied to gain information about the entire population.

***sample descriptors* (8.5.1.1):** Information that should be supplied to the laboratory including sample ID, *analytical method* to be used, *analyte*, and matrix.

***sample digestion* (1.4.6):** Solubilizing an *analyte* or analytes and its host matrix. Acid digestion, fusion, and microwave digestion are some common *sample digestion* techniques.

***sample dissolution* (1.1):** See *sample digestion*.

***sample management* (2.7.2):** Includes administrative and *quality assurance* aspects covering sample receipt, control, storage, and disposition.

***sample mean* (9.6.4.2):** An estimate of the mean of the *distribution* calculated form a statistical sample of observations. The *sample mean* equals the sum of the observed values divided by the number of values, *N*. If the observed values are $x_1, x_2, x_3, \ldots, x_N$, then the *sample mean* is given by

$$\text{sample mean} = \frac{\sum_{i=1}^{N} x_i}{N}$$

***sample population* (3.3.7.1.2):** A set of individual samples or measurements drawn from a population whose properties are studied to gain information about the entire population.

***sample processing turnaround time* (5.3.6):** The time differential from the receipt of the sample at the laboratory to the reporting of the analytical results.

***sample tracking* (1.4.5):** Identifying and following a *sample* through the steps of the analytical process including: field sample preparation and preservation; sample receipt and inspection; laboratory sample preparation; *sample dissolution*; chemical separation of *radionuclides of interest*; preparation of sample for instrument measurement; instrument measurement; and data reduction and reporting.

***sample variance* (9.6.4.2):** An estimate of the *variance* of a distribution calculated from a statistical sample of observations. If the observed values are $x_1, x_2, x_3, \ldots, x_N$, and the sample mean is $\bar{x}$, then the *sample variance* is given by:

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$$s^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$$

***sampling and analysis plan* (*SAP*) (1.5):** See *project plan documents*.

***saturated solution* (14.8.2):** A solution that contains the maximum amount of substance that can dissolve in a prescribed amount of *solvent* at a given temperature. The dissolved substance is in equilibrium with any undissolved substance.

***scale of decision* (2.5, Table 2.1):** The spatial and temporal bounds to which the decision will apply. The *scale of decision* selected should be the smallest, most appropriate subset of the population for which decisions will be made based on the spatial or temporal boundaries.

***scavengers* (14.8.5):** See *collectors*.

***screening method* (6.5.5.3):** An economical gross measurement (alpha, beta, gamma) used in a tiered approach to method selection that can be applied to *analyte* concentrations below an *analyte* level in the *analytical protocol specifications* or below a fraction of the specified *action level.*

***secondary (outer) hydration sphere* (14.3.1):** See *hydration sphere*.

***self absorption* (6.4):** The absorption of nuclear particle or photon emissions within a matrix during the counting of a *sample* by a detector.

***sensitivity* (2.5.4.2):** (1) The ratio of the change in an output to the change in an input. (2) The term "sensitivity" is also frequently used as a synonym for "*detection capability*." See *minimum detectable concentration*.

***sensitivity analysis* (2.5.4):** Identifies the portions of the analytical protocols that potentially have the most impact on the decision.

***sensitivity coefficient* (19.4.3):** The *sensitivity coefficient* for an input estimate, x_i, used to calculate an output estimate, $y = f(x_1,x_2,\ldots,x_N)$, is the value of the partial derivative, $\partial f / \partial x_i$, evaluated at $x_1, x_2, \ldots, x_N$. The *sensitivity coefficient* represents the ratio of the change in y to a small change in x_i.

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***separation factor* (14.4.3):** In *ion-exchange chromatography*, the ratio of the distribution coefficients for two *ions* determined under identical experimental conditions. Separation factor (α) = $K_{d,1}/K_{d,2}$. The ratio determines the separability of the two *ions* by an ion-exchange system; separation occurs when $\alpha \neq 1$.

***serial correlation* (9.6.4.1):** When the characteristic of interest in a *sample* is more similar to that of samples adjacent to it than to samples that are further removed, the samples are deemed to be correlated and are not independent of each other (i.e., there is a *serial correlation* such that samples collected close in time or space have more similar concentrations than those samples further removed.).

***sigma* (σ) (3A.3):** The symbol σ and the term "sigma" are properly used to denote a true *standard deviation*. The term "sigma" is sometimes used informally to mean "*standard uncertainty*," and "*k*-sigma" is used to mean an *expanded uncertainty* calculated using the coverage factor *k*.

***significance level* (α) (6A.2):** In a *hypothesis test*, a specified upper limit for the probability of a *Type I decision error*.

***smears* (10.6.1):** See *swipes*.

***solid-phase extraction* (*SPE*) (14.4.5):** A *solvent* extraction system in which one of the liquid phases is made stationary by *adsorption* onto a solid support. The other phase is mobile (see *extraction chromatography*).

***solid-phase extraction membrane* (14.4.5):** A solid-phase extraction system in which the adsorbent material is embedded into a membrane producing an evenly distributed phase, which reduces the channeling problems associated with columns.

***solubility* (14.2.1):** The maximum amount of a particular *solute* that can be dissolved in a particular *solvent* under specified conditions (a *saturated solution*) without precipitating. *Solubility* may be expressed in terms of concentration, molality, mole fraction, etc.

***solubility equilibrium* (14.8.3.1):** The equilibrium that describes a solid dissolving in a *solvent* to produce a saturated solution.

***solubility-product constant* (14.8.3.1):** The equilibrium constant (K_{sp}) for a solid dissolving in a *solvent* to produce a saturated solution.

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***solute* (10.3.3.2):** The substance that dissolves in a *solvent* to form a solution. A *solute* can be a solid, liquid, or gas. In radiochemistry, it is commonly a solid or liquid.

***solution* (10.2.9):** A homogeneous mixture of one substance with another, usually a liquid with a gas or solid. The particles of the *solute* (molecules, atoms, or *ions*) are discrete and mix with particles of the *solvent* at the atomic, ionic, or molecular level.

***solvent* (10.2.9):** The substance that dissolves the *solute* to form a solution. The *solvent* can be a solid, liquid, or gas; but in radiochemistry, it is commonly a liquid.

***solvent extraction* (10.5.4.1):** A separation process that selectively removes soluble components from a mixture with a solvent. The process is based on the solubility of the components of the mixture in the *solvent* when compared to their solubility in the mixture. In liquid-liquid extraction, the process is based on an unequal distribution (partition) of the *solute* between the two immiscible liquids.

***source, radioactive* (3.3.4):** A quantity of material configured for radiation measurement. See also *calibration source*, *check source*, and *test source*.

***spatial variability* (2.5.2.2):** The nonuniformity of an *analyte* concentration over the total area of a site.

***specificity* (1.4.9):** See *method specificity*.

***spike* (1.4.8):** See *matrix spike*.

***spillover* (15.4.2.1):** See *crosstalk*.

***spurious error* (18.3.3):** A measurement error caused by a human blunder, instrument malfunction, or other unexpected or abnormal event.

***stability constant* (14.3.2):** See *formation constant.*

***stakeholder* (2.2):** Anyone with an interest in the outcome of a project. For a cleanup project, some of the *stakeholders* could be federal, regional, state, and tribal environmental agencies with regulatory interests (e.g., Nuclear Regulatory Commission or Environmental Protection Agency); states with have direct interest in transportation, storage and disposition of wastes, and a range of other issues; city and county governments with interest in the operations and safety at sites as well as economic development and site transition; and site advisory boards, citizens groups,

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licensees, special interest groups, and other members of the public with interest in cleanup activities at the site.

***standard deviation* (3A.3):** The *standard deviation* of a *random variable X*, denoted by σ_X, is a measure of the width of its *distribution*, and is defined as the positive square root of the *variance* of *X*.

***standard operating procedure* (*SOP*) (4.1):** Routine laboratory procedures documented for laboratory personnel to follow.

***standard reference material (SRM)* (6A.1):** A *certified reference material* issued by the National Institute of Standards and Technology (NIST) in the United States. A SRM is certified by NIST for specific chemical or physical properties and is issued with a certificate that reports the results of the characterization and indicates the intended use of the material.

***standard uncertainty* (1.4.7):** The uncertainty of a measured value expressed as an estimated *standard deviation*, often call a "1-sigma" (1-σ) uncertainty. The *standard uncertainty* of a value *x* is denoted by $u(x)$.

***statement of work* (*SOW*) (1.4.11):** The part of a *request for proposals*, contract, or other agreement that describes the project's scope, schedule, technical specifications, and performance requirements for all radioanalytical laboratory services.

***stationary phase* (14.7.4.1):** The phase in a chromatographic system that is not moving with respect to the mobile phase. The *stationary phase* can be a solid, a nonvolatile liquid coated onto an inert matrix, or a substance trapped in an inert matrix.

***statistical control* (1.4.8):** The condition describing a process from which all special causes have been removed, evidenced on a *control chart* by the absence of points beyond the *control limits* and by the absence of nonrandom patterns or trends within the *control limits*. A special cause is a source of variation that is intermittent, unpredictable, or unstable. See *control chart*, *in control*, and *control limits*.

***statistical parameter* (2.5, Table 2.1):** A quantity used in describing the probability distribution of a *random variable*" (ISO, 1993b).

***statistical test* (4.6.2.3):** A statistical procedure to decide whether a *null hypothesis* should be rejected in favor of the *alternative hypothesis* or not rejected." This also can be called a *hypothesis test*.

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***subsample* (12.3.1.4):** (1) A portion of a *sample* removed for testing. (2) To remove a portion of a *sample* for testing.

***subsampling factor* (19.5.12):** As used in MARLAP, a variable, F_S, inserted into the mathematical model for an analytical measurement to represent the ratio of the *analyte* concentration of the subsample to the *analyte* concentration of the original *sample*. The *subsampling factor* is always estimated to be 1 but has an uncertainty that contributes to the combined *standard uncertainty* of the measured result.

***surface adsorption* (14.8.3.3, Table 14.12):** (1) *Adsorption* of particles of a substance onto the surface of another substance. (2) A mechanism of *coprecipitation* in which *ions* are adsorbed from solution onto the surfaces of precipitated particles.

***survey* (2.3.2):** "An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive materials or other sources of radiation. When appropriate, such an evaluation includes the a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations of quantities of radioactive material present" (Shleien, 1992). A *survey* is a semiquantitative measure of the gross radiological conditions of a material or area (for dose and contamination). A *screen* is a qualitative assessment to determine the type of *radionuclides* (alpha, beta, gamma) and the relative amount (high, medium, low) of each that might be present.

***survey unit* (2.5.2.4):** A geographical area consisting of structures or land areas of specified size and shape at a remediated site for which a separate decision will be made whether the unit attains the site-specific reference-based cleanup standard for the designated pollution parameter. *Survey units* are generally formed by grouping contiguous site areas with a similar use history and the same classification of contamination potential. *Survey units* are established to facilitate the survey process and the statistical analysis of survey data. (MARSSIM, 2000)

***suspension* (10.3.3.2):** A mixture in which small particles of a solid, liquid, or gas are dispersed in a liquid or gas. The dispersed particles are larger than colloidal particles and produce an opaque or turbid mixture that will settle on standing by gravity and be retained by paper filters. See *colloids* and *colloidal solution*.

***swipes* (10.6.1):** A filter pad used to determine the level of general radioactive contamination when it is wiped over a specific area, about 100 cm^2 in area. Also called *smears* or wipes.

***systematic effect* (3A.4):** Any effect in a measurement process that does not vary randomly when the measurement is repeated.

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***systematic error* (3A.4):** The mean value that would result from an infinite number of measurements of the same *measurand* carried out under repeatability conditions minus a true value of the *measurand* (ISO, 1993a).

***systematic planning process* (1.4.2):** See *directed planning process*.

***target analyte* (3.3.1):** A *radionuclide* on the *target analyte list*. Also called *radionuclide of interest* or "radionuclide of concern." See *analyte*.

***target analyte list* (3.3.1):** A list of the *radionuclides* of concern for the project.

***target radionuclide* (18.4.1):** See *radionuclide of interest*.

***technical evaluation committee* (*TEC*) (5.3.9):** A team of technical staff members that assists in the selection of a contract laboratory by reviewing proposals and by auditing laboratory facilities.

***technical proposal* (5.5.1.):** A document, submitted by a laboratory bidding on a contract, which addresses all of the technical and general laboratory requirements within a *request for proposals* and *statement of work*.

***temporal trend* (2.5, Table 2.1):** Effects that time have on the *analyte* concentration in the matrix or *sample*. The *temporal boundaries* describe the time frame the study data will represent (e.g., possible exposure to local residents over a 30-year period) and when samples should be taken (e.g., instantaneous samples, hourly samples, annual average based on monthly samples, samples after rain events).

***tests of detection* (8.3.1):** *Tests of detection* determine the presence or absence of *analytes*. Normally, only numerous *quality control* exceptions and failures in one or more of the *tests of detection* and uncertainty are sufficient reason to reject data.

***tests of unusual uncertainty* (8.3.1):** Part of the validation plan that specifies the level of *measurement uncertainty* considered unusually high and unacceptable.

***test source* (14.10.9.7):** The final radioanalytical processing product or matrix (e.g., precipitate, solution, filter) that is introduced into a measurement instrument. A *test source* is prepared from laboratory sample material for the purpose of determining its radioactive constituents. See *calibration source*, *check source*, and *source, radioactive*.

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***thin-layer chromatography* (14.7.3):** A chromatographic process in which a thin layer of a *stationary phase* in coated onto a solid support such as a plastic or glass plate. The stationary material is an absorbing solid and the mobile phase is a liquid.

***tolerable decision error rates* (2.3.3):** The limits on *decision error rates* that will be acceptable to the *stakeholder*/customer.

***tolerance limit* (18.3.3):** A value, that may or may not have a statistical basis, which is used as the measure of acceptable or unacceptable values. A *tolerance limit* is sometimes referred to as a "Go/No Go" limit. See *warning limit*, *control chart*.

***total effective dose equivalent* (*TEDE)* (2.5.2.1):** The sum of the effective dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposure). TEDE is expressed in units of sievert (Sv) or rem (MARSSIM, 2000). See *action level*, *dose equivalent*, and *total effective dose equivalent*.

***total propagated uncertainty* (*TPU)* (19.2):** See *combined standard uncertainty*, which is the preferred term.

***traceability* (8.5.1.5):** "Property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties" (ISO, 1993a).

***tracer* (1.4.8):** See *radiotracer*.

***Type A evaluation (of uncertainty)* (19.3.3):** "Method of evaluation of uncertainty by the statistical analysis of series of observations" (ISO, 1995).

***Type B evaluation (of uncertainty)* (19.3.3):** "Method of evaluation of uncertainty by means other than the statistical analysis of series of observations" (ISO, 1995); any method of uncertainty evaluation that is not a Type A evaluation.

***Type I decision error* (2.5.3):** In a hypothesis test, the error made by rejecting the null hypothesis when it is true. A *Type I decision error* is sometimes called a "*false rejection*" or a "*false positive*."

***Type II decision error* (2.5.3):** In a hypothesis test, the error made by failing to reject the null hypothesis when it is false. A *Type II decision error* is sometimes called a "*false acceptance*" or a "*false negative*."

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***uncertainty* (1.4.7):** The term "uncertainty" is used with several shades of meaning in MARLAP. In general it refers to a lack of complete knowledge about something of interest; however, in Chapter 19 it usually refers to "*uncertainty (of measurement*)."

***uncertainty (of measurement)* (3.3.4):** "Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the *measurand*" (ISO, 1993a).

***uncertainty interval* (19.3.6):** The interval from $y - U$ to $y + U$, where y is the measured result and U is its *expanded uncertainty*.

***uncertainty propagation* (19.1):** Mathematical technique for combining the *standard uncertainties* of the input estimates for a mathematical model to obtain the combined *standard uncertainty* of the output estimate.

***uncertainty propagation formula (first-order)* (19.4.3):** the generalized mathematical equation that describes how standard uncertainties and *covariances* of input estimates combine to produce the combined *standard uncertainty* of an output estimate. When the output estimate is calculated as $y = f(x_1, x_2, ..., x_N)$, where f is a differentiable function of the input estimates $x_1, x_2, \ldots, x_N$, the uncertainty propagation formula may be written as follows:

$$u_c^2(y) = \sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i} \right)^2 u^2(x_i) + 2 \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{\partial f}{\partial x_i} \frac{\partial f}{\partial x_j} u(x_i, x_j).$$

This formula is derived by approximating the function $f(x_1, x_2, ..., x_N)$ by a first-order Taylor polynomial. In the *Guide to the Expression of Uncertainty of Measurement*, the uncertainty propagation formula is called the "law of propagation of uncertainty" (ISO, 1995).

***unsaturated solution* (14.8.2):** A solution whose concentration of *solute* is less than that of a saturated solution. The solution contains less *solute* than the amount of *solute* will dissolve at the temperature of the solution, and no solid form of the *solute* is present.

***validation* (1.1):** See *data validation*.

***validation criterion* (2.5.4.2):** Specification, derived from the *measurement quality objectives* and other analytical requirements, deemed appropriate for evaluating data relative to the project's analytical requirements. Addressed in the *validation plan*.

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***validation flags* (1.4.11):** Qualifiers that are applied to data that do not meet the acceptance criteria established to assure data meets the needs of the project. See also *data qualifier*.

***validation plan* (2.7.4.2):** An integral part of the initial planning process that specifies the data deliverables and *data qualifiers* to be assigned that will facilitate the *data quality assessment*.

***variance* (9.6.2.3):** The *variance* of a *random variable X*, denoted by Var(X), σ_X^2, or $V(X)$, is defined as $E[(X - \mu_X)^2]$,where μ_X denotes the mean of X. The *variance* also equals $E(X^2) - \mu_X^2$.

***verification* (1.2):** See *data verification.*

***volatility* (10.3.4.1):** The tendency of a liquid or solid to readily become a vapor (evaporates or sublimes) at a given temperature. More volatile substances have higher vapor pressures than less volatile substances.

***volatilization* (10.3.3.2, Table 10.1):** A separation method using the volatility of liquids or solids to isolate them from nonvolatile substances, or to isolate a gas from a liquid.

***warning limit* (3.3.7.3):** Predetermined values plotted on a *control chart* between the central line and the *control limits*, which may be used to give an early indication of possible problems with the monitored process before they become more significant. The monitored variable will occasionally fall outside the warning limits even when the process is *in control*; so, the fact that a single measurement has exceeded the warning limits is generally not a sufficient reason to take immediate corrective action. See *tolerance limit*.

***weight distribution coefficient* (14.7.4.1):** In *ion-exchange chromatography*, the ratio of the weight of an *ion* absorbed on one gram of dry ion-exchange *resin* to the weight of the *ion* that remains in one milliliter of solution after equilibrium has been established. The ratio is a measure of attraction of an *ion* for a *resin*. Comparison of the weight distribution coefficient for *ions* in an analytical mixture is a reflection of the ability of the ion-exchange process to separate the *ions* (see *separation factor*).

***Welch-Satterthwaite formula* (19C.2):** An equation used to calculate the *effective degrees of freedom* for the combined *standard uncertainty* of an output estimate when the number of degrees of freedom for the *standard uncertainty* of each input estimate is provided (ISO, 1995).

***work plan* (1.6.1):** The primary and integrating plan document when the data collection activity is a smaller supportive component of a more comprehensive project. The *work plan* for a site investigation will specify the number of samples to be collected, the location of each *sample*, and

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the analyses to be performed. A newer concept is to develop a *dynamic work plan* that specifies the decisionmaking logic used to determine where the samples will be collected, when the sampling will stop, and what analyses will be performed, rather than specify the number of samples to be collected and the location of each sample.

***year*:** (1) Mean solar or tropical year is 365.2422 days (31,556,296 seconds) and is used for calculations involving *activity* and *half-life* corrections. (2) Calendar year, i.e., 12 months, is usually used in the regulatory sense when determining compliance.

***yield* (1.6.2):** The ratio of the amount of *radiotracer* or *carrier* determined in a sample analysis to the amount of *radiotracer* or *carrier* originally added to a *sample*. The yield is an estimate of the *analyte* during analytical processing. It is used as a correction factor to determine the amount of *radionuclide* (*analyte*) originally present in the sample. *Yield* is typically measured gravimetrically (via a *carrier*) or radiometrically (via a *radiotracer*). Compare with *recovery*.

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