GLOSSARY

91b material: Any material identified under Section 91b of the Atomic Energy Act of 1954 (42 U.S.C. Section 2121).

A$_{min}$: The smallest *area of elevated activity* identified using the DQO Process that is important to identify.

action level: The numerical value that will cause the *decision maker* to choose one of the alternative actions. It may be a regulatory threshold standard (*e.g.*, Maximum Contaminant Level for drinking water), a dose- or risk-based concentration level (*e.g.*, *DCGL*), or a reference-based standard. See *investigation level*.

activity: See *radioactivity*.

ALARA (acronym for As Low As Reasonably Achievable): A basic concept of radiation protection which specifies that exposure to ionizing radiation and releases of radioactive materials should be managed to reduce collective doses as far below regulatory limits as is reasonably achievable considering economic, technological, and societal factors, among others. Reducing exposure at a site to *ALARA* strikes a balance between what is possible through additional planning and management, remediation, and the use of additional resources to achieve a lower collective dose level. A determination of *ALARA* is a site-specific analysis that is open to interpretation, because it depends on approaches or circumstances that may differ between regulatory agencies. An *ALARA* recommendation should not be interpreted as a set limit or level.

alpha (α): The specified maximum probability of a *Type I error*. In other words, the maximum probability of rejecting the *null hypothesis* when it is true. *Alpha* is also referred to as the *size of the test*. *Alpha* reflects the amount of evidence the *decision maker* would like to see before abandoning the *null hypothesis*.

alpha particle: A positively charged particle emitted by some radioactive materials undergoing *radioactive decay*.

alternative hypothesis (H$_a$): See *hypothesis*.

area: A general term referring to any portion of a *site*, up to and including the entire *site*.

area of elevated activity: An *area* over which *residual radioactivity* exceeds a specified value *DCGL$_{EMC}$*.

area factor (A_m): A factor used to adjust $DCGL_W$ to estimate $DCGL_{EMC}$ and the *minimum detectable concentration* for scanning surveys in *Class 1* survey units—$DCGL_{EMC} = DCGL_W \bullet A_m$. A_m is the magnitude by which the *residual radioactivity* in a small *area of elevated activity* can exceed the $DCGL_W$ while maintaining compliance with the *release criterion*. Examples of *area factors* are provided in Chapter 5 of this manual.

arithmetic mean: The average value obtained when the sum of individual values is divided by the number of values.

arithmetic standard deviation: A statistic used to quantify the variability of a set of data. It is calculated in the following manner: 1) subtracting the arithmetic mean from each data value individually, 2) squaring the differences, 3) summing the squares of the differences, 4) dividing the sum of the squared differences by the total number of data values less one, and 5) taking the square root of the quotient. The calculation process produces the Root Mean Square Deviation (RMSD).

assessment: The evaluation process used to measure the performance or effectiveness of a system and its elements. As used in MARSSIM, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, management systems review, peer review, inspection, or surveillance.

attainment objectives: Objectives that specify the design and scope of the sampling study including the radionuclides to be tested, the cleanup standards to be attained, the measure or parameter to be compared to the cleanup standard, and the *Type I* and *Type II* error rates for the selected statistical tests.

audit (quality): A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

background reference area: See *reference area*.

background radiation: Radiation from cosmic sources, *naturally occurring radioactive material*, including radon (except as a decay product of *source* or *special nuclear material*), and global fallout as it exists in the environment from the testing of nuclear explosive devices or from nuclear accidents like Chernobyl which contribute to *background radiation* and are not under the control of the cognizant organization. *Background radiation* does not include radiation from *source*, *byproduct*, or *special nuclear materials* regulated by the cognizant Federal or State agency. Different definitions may exist for this term. The definition provided in regulations or regulatory program being used for a site release should always be used if it differs from the definition provided here.

Becquerel (Bq): The International System (SI) unit of activity equal to one nuclear transformation (disintegration) per second. 1 *Bq* = 2.7x10^{-11} *Curies (Ci)* = 27.03 picocuries (pCi).

beta (β): The probability of a *Type II error*, *i.e.*, the probability of accepting the null hypothesis when it is false. The complement of *beta* (1-β) is referred to as the *power* of the test.

beta particle: An electron emitted from the nucleus during *radioactive decay*.

bias: The systematic or persistent distortion of a measurement process which causes errors in one direction (*i.e.*, the expected sample measurement is different from the sample's true value).

biased sample or measurement: See *judgement measurement*.

byproduct material: Any radioactive material (except *special nuclear material*) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing *special nuclear material*.

calibration: Comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments.

CDE (committed dose equivalent): The *dose equivalent* calculated to be received by a tissue or organ over a 50-year period after the intake into the body. It dose not include contributions from radiation sources external to the body. CDE is expressed in units of Sv or rem.

CEDE (committed effective dose equivalent): The sum of the committed *dose equivalent* to various tissues in the body, each multiplied by the appropriate weighting factor (W_t). CEDE is expressed in units of Sv or rem. See *TEDE*.

chain of custody: An unbroken trail of accountability that ensures the physical security of samples, data, and records.

characterization survey: A type of *survey* that includes facility or *site* sampling, monitoring, and analysis activities to determine the extent and nature of contamination. *Characterization surveys* provide the basis for acquiring necessary technical information to develop, analyze, and select appropriate *cleanup* techniques.

Class 1 area: An *area* that is projected to require a *Class 1 final status survey*.

Class 1 survey: A type of *final status survey* that applies to *areas* with the highest potential for contamination, and meet the following criteria: (1) *impacted*; (2) potential for delivering a dose above the *release criterion*; (3) potential for small *areas of elevated activity*; and (4) insufficient evidence to support reclassification as *Class 2* or *Class 3*.

Class 2 area: An *area* that is projected to require a *Class 2 final status survey*.

Class 2 survey: A type of *final status survey* that applies to *areas* that meet the following criteria: (1) *impacted*; (2) low potential for delivering a dose above the *release criterion*; and (3) little or no potential for small *areas of elevated activity*.

Class 3 area: An *area* that is projected to require a *Class 3 final status survey*.

Class 3 survey: A type of *final status survey* that applies to *areas* that meet the following criteria: (1) *impacted*; (2) little or no potential for delivering a dose above the *release criterion*; and (3) little or no potential for small *areas of elevated activity*.

classification: The act or result of separating *areas* or *survey units* into one of three designated classes: *Class 1 area*, *Class 2 area*, or *Class 3 area*.

cleanup: Actions taken to deal with a release or threatened release of hazardous substances that could affect public health or the environment. The term is often used broadly to describe various Superfund response actions or phases of remedial responses, such as remedial investigation/ feasibility study. Cleanup is sometimes used interchangeably with the terms *remedial action*, response action, or *corrective action*.

cleanup standard: A numerical limit set by a regulatory agency as a requirement for releasing a *site* after *cleanup*. See *release criterion*.

cleanup (survey) unit: A geographical *area* of specified size and shape defined for the purpose of survey design and compliance testing.

coefficient of variation: A unitless measure that allows the comparison of dispersion across several sets of data. It is often used in environmental applications because variability (expressed as a standard deviation) is often proportional to the mean. See *relative standard deviation*.

comparability: A measure of the confidence with which one data set can be compared to another.

completeness: 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.

composite sample: A sample formed by collecting several samples and combining them (or selected portions of them) into a new sample which is then thoroughly mixed.

conceptual site model: A description of a site and its environs and presentation of hypotheses regarding the contaminants present, their routes of migration, and their potential impact on sensitive receptors.

confidence interval: A range of values for which there is a specified probability (*e.g.*, 80%, 90%, 95%) that this set contains the true value of an estimated parameter.

confirmatory survey: A type of *survey* that includes limited independent (third-party) measurements, sampling, and analyses to verify the findings of a *final status survey*.

consensus standard: A standard established by a group representing a cross section of a particular industry or trade, or a part thereof.

contamination: The presence of *residual radioactivity* in excess of levels which are acceptable for release of a *site* or facility for *unrestricted use*.

control chart: A graphic representation of a process, showing plotted values of some statistic gathered from that characteristic, and one or two control limits. It has two basic uses: 1) as a judgement to determine if a process was in control, and 2) as an aid in achieving and maintaining statistical control.

core sample: A soil sample taken by core drilling.

corrective action: An action taken to eliminate the causes of an existing nonconformance, deficiency, or other undesirable situation in order to prevent recurrence.

criterion: See *release criterion*.

critical group: The group of individuals reasonably expected to receive the greatest exposure to *residual radioactivity* for any applicable set of circumstances.

critical level (L_c): A fixed value of the *test statistic* corresponding to a given probability level, as determined from the sampling distribution of the *test statistic*. L_c is the level at which there is a statistical probability (with a predetermined confidence) of correctly identifying a background value as "greater than background."

critical value: The value of a statistic (t) corresponding to a given significance level as determined from its sampling distribution; e.g., if Pr (t > t_o) = 0.05, t_o is the critical value of t at the 5 percent level.

curie (Ci): The customary unit of radioactivity. One *curie* (Ci) is equal to 37 billion disintegrations per second (3.7 x 10^{10} dps = 3.7 x 10^{10} *Bq*), which is approximately equal to the decay rate of one gram of ^{226}Ra. Fractions of a *curie*, *e.g.* picocurie (pCi) or 10^{-12} Ci and microcurie (µCi) or 10^{-6} Ci, are levels typically encountered in *decommissioning*.

cyclotron: A device used to impart high energy to charged particles, of atomic weight one or greater, which can be used to initiate nuclear transformations upon collision with a suitable target.

D: The true, but unknown, value of the difference between the mean concentration of *residual radioactivity* in the *survey unit* and the *reference area*.

DQA (Data Quality Assessment): The scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support their intended use.

DQOs (Data Quality Objectives): Qualitative and quantitative statements derived from the DQO process that clarify study technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

Data Quality Objectives Process: 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. The key elements of the process include:

- concisely defining the problem
- identifying the decision to be made
- identifying the inputs to that decision
- defining the boundaries of the study
- developing the decision rule
- specifying tolerate limits on potential decision errors
- selecting the most resource efficient data collection design

DQOs are the qualitative and quantitative outputs from the DQO process. The DQO process was developed originally by the U.S. Environmental Protection Agency, but has been adapted for use by other organizations to meet their specific planning requirement. See also *graded approach*.

data quality indicators: Measurable attributes of the attainment of the necessary quality for a particular decision. *Data quality indicators* include *precision, bias, completeness, representativeness, reproducibility, comparability*, and statistical confidence.

data usability: The process of ensuring or determining whether the quality of the data produced meets the intended use of the data.

DCGL (derived concentration guideline level): A derived, radionuclide-specific activity concentration within a *survey unit* corresponding to the *release criterion*. The *DCGL* is based on the spatial distribution of the contaminant and hence is derived differently for the *nonparametric* statistical test (DCGL$_W$) and the *Elevated Measurement Comparison* (DCGL$_{EMC}$). *DCGLs* are derived from activity/dose relationships through various *exposure pathway* scenarios.

decay: See *radioactive decay*.

decision maker: The person, team, board, or committee responsible for the final decision regarding disposition of the *survey unit*.

decision rule: A statement that describes a logical basis for choosing among alternative actions.

decommission: To remove a facility or *site* safely from service and reduce *residual radioactivity* to a level that permits release of the property and termination of the *license* and other authorization for site operation.

decommissioning: 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 objective of *decommissioning* is to reduce the *residual radioactivity* in structures, materials, soils, groundwater, and other media at the *site* so that the concentration of each radionuclide contaminant that contributes to *residual radioactivity* is indistinguishable from the *background radiation* concentration for that radionuclide.

decontamination: The removal of radiological contaminants from, or their neutralization on, a person, object or area to within levels established by governing regulatory agencies. *Decontamination* is sometimes used interchangeably with *remediation*, remedial action, and *cleanup*.

delta (δ): The amount that the distribution of measurements for a *survey unit* is shifted to the right of the distribution of measurements of the *reference area*.

delta (Δ): The width of the *gray region*. **Δ** divided by σ, the *arithmetic standard deviation* of the measurements, is the *relative shift* expressed in multiples of standard deviations. See *relative shift, gray region*.

derived concentration guideline level: See *DCGL*.

design specification process: The process of determining the sampling and analysis procedures that are needed to demonstrate that the attainment objectives are achieved.

detection limit: The net response level that can be expected to be seen with a detector with a fixed level of certainty.

detection sensitivity: The minimum level of ability to identify the presence of radiation or *radioactivity*.

direct measurement: Radioactivity measurement obtained by placing the detector near the surface or media being surveyed. An indication of the resulting radioactivity level is read out directly.

distribution coefficient (K_d): The ratio of elemental (*i.e.*, radionuclide) concentration in soil to that in water in a soil-water system at equilibrium. K_d is generally measured in terms of gram weights of soil and volumes of water (g/cm^3 or g/ml).

dose commitment: The dose that an organ or tissue would receive during a specified period of time (*e.g.*, 50 or 70 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from a given release.

dose equivalent (dose): A quantity that expresses all radiations on a common scale for calculating the effective absorbed dose. This quantity is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. Dose is measured in *Sv* or *rem*.

double-blind measurement: Measurements that cannot be distinguished from routine measurements by the individual performing the measurement. See *non-blind measurement* and *single-blind measurement*.

effective probe area: The *physical probe area* corrected for the amount of the probe area covered by a protective screen.

elevated area: See *area of elevated activity*.

elevated measurement: A measurement that exceeds a specified value $DCGL_{EMC}$.

Elevated Measurement Comparison (EMC): This comparison is used in conjunction with the Wilcoxon test to determine if there are any measurements that exceed a specified value $DCGL_{EMC}$.

exposure pathway: The route by which radioactivity travels through the environment to eventually cause radiation exposure to a person or group.

exposure rate: The amount of ionization produced per unit time in air by X-rays or gamma rays. The unit of exposure rate is Roentgens/hour (R/h); for decommissioning activities the typical units are microRoentgens per hour (µR/h), *i.e.*, 10^{-6} R/h.

external radiation: Radiation from a source outside the body.

false negative decision error: The error that occurs when the null hypothesis (H_0) is not rejected when it is false. For example, the false negative decision error occurs when the decision maker concludes that the waste is hazardous when it truly is not hazardous. A statistician usually refers to a false negative error as a *Type II decision error*. The measure of the size of this error is called *beta*, and is also known as the complement of the power of a hypothesis test.

false positive decision error: A false positive decision error occurs when the null hypothesis (H_0) is rejected when it is true. Consider an example where the decision maker presumes that a certain waste is hazardous (*i.e.*, the null hypothesis or baseline condition is "the waste is hazardous"). If the decision maker concludes that there is insufficient evidence to classify the waste as hazardous when it truly is hazardous, the decision maker would make a false positive decision error. A statistician usually refers to the false positive error as a *Type I decision error*. The measure of the size of this error is called *alpha*, the level of significance, or the size of the critical region.

Field Sampling Plan: As defined for Superfund in the Code of Federal Regulations 40 CFR 300.430, a document which describes the number, type, and location of samples and the type of analyses to be performed. It is part of the *Sampling and Analysis Plan*.

final status survey: Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if any) in preparation for release.

fluence rate: A fundamental parameter for assessing the level of radiation at a measurement site. In the case of *in situ* spectrometric measurements, a calibrated detector provides a measure of the *fluence rate* of primary photons at specific energies that are characteristic of a particular radionuclide.

gamma (γ) radiation: Penetrating high-energy, short-wavelength electromagnetic radiation (similar to X-rays) emitted during *radioactive decay*. Gamma rays are very penetrating and require dense materials (such as lead or steel) for shielding.

graded approach: The process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and the degree of confidence needed in the quality of the results. See *data quality objectives process*.

gray region: A range of values of the parameter of interest for a *survey unit* where the consequences of making a decision error are relatively minor. The upper bound of the gray region in MARSSIM is set equal to the *DCGL$_W$*, and the *lower bound of the gray region (LBGR)* is a site-specific variable.

grid: A network of parallel horizontal and vertical lines forming squares on a map that may be overlaid on a property parcel for the purpose of identification of exact locations. See *reference coordinate system*.

grid block: A square defined by two adjacent vertical and two adjacent horizontal reference grid lines.

half-life (t$_{1/2}$): The time required for one-half of the atoms of a particular radionuclide present to disintegrate.

Historical Site Assessment (HSA): A detailed investigation to collect existing information, primarily historical, on a *site* and its surroundings.

hot measurement: See *elevated measurement*.

hot spot: See *area of elevated activity*.

hypothesis: An assumption about a property or characteristic of a set of data under study. The goal of statistical inference is to decide which of two complementary hypotheses is likely to be true. The *null hypothesis* (H$_0$) describes what is assumed to be the true state of nature and the *alternative hypothesis* (H$_a$) describes the opposite situation.

impacted area: Any *area* that is not *classified* as *non-impacted*. Areas with a reasonable possibility of containing *residual radioactivity* in excess of natural background or fallout levels.

independent assessment: An assessment performed by a qualified individual, group, or organization that is not part of the organization directly performing and accountable for the work being assessed.

indistinguishable from background: The term indistinguishable from background means that the detectable concentration distribution of a radionuclide is not statistically different from the background concentration distribution of that radionuclide in the vicinity of the site or, in the case of structures, in similar materials using adequate measurement technology, survey, and statistical techniques.

infiltration rate: The rate at which a quantity of a hazardous substance moves from one environmental medium to another—*e.g.*, the rate at which a quantity of a radionuclide moves from a source into and through a volume of soil or solution.

inspection: An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic.

inventory: Total residual quantity of formerly licensed radioactive material at a site.

investigation level: A derived media-specific, radionuclide-specific concentration or activity level of radioactivity that: 1) is based on the release criterion, and 2) triggers a response, such as further investigation or cleanup, if exceeded. See *action level*.

isopleth: A line drawn through points on a graph or plot at which a given quantity has the same numerical value or occurs with the same frequency.

judgment measurement: Measurements performed at locations selected using professional judgment based on unusual appearance, location relative to known contaminated areas, high potential for residual radioactivity, general supplemental information, *etc*. Judgment measurements are not included in the statistical evaluation of the survey unit data because they violate the assumption of randomly selected, independent measurements. Instead, judgment measurements are individually compared to the $DCGL_W$.

karst terrain: A kind of terrain with characteristics of relief and drainage arising from a high degree of rock solubility. The majority of karst conditions occur in limestone areas, but karst may also occur in areas of dolomite, gypsum, or salt deposits. Features associated with karst terrain may include irregular topography, abrupt ridges, sink holes, caverns, abundant springs, and disappearing streams. Well developed or well integrated drainage systems of streams and tributaries are generally not present.

klystron: An electron tube used in television, *etc*., for converting a stream of electrons into ultra high-frequency waves that are transmitted as a pencil-like radio beam.

less-than data: Measurements that are less than the *minimum detectable concentration*.

license: A license issued under the regulations in parts 30 through 35, 39, 40, 60, 61, 70 or part 72 of 10 CFR Chapter I.

licensee: The holder of a *license*.

license termination: Discontinuation of a *license*, the eventual conclusion to *decommissioning*.

lower bound of the gray region (LBGR): The minimum value of the gray region. The width of the *gray region* (*DCGL-LBGR*) is also referred to as the shift, Δ.

lower limit of detection (L_D): The smallest amount of radiation or radioactivity that statistically yields a net result above the method background. The critical detection level, L_C, is the lower bound of the 95% detection interval defined for L_D and is the level at which there is a 5% chance of calling a background value "greater than background." This value should be used when actually counting samples or making direct radiation measurements. Any response above this level should be considered as above background; *i.e.*, a net positive result. This will ensure 95% detection capability for L_D. A 95% confidence interval should be calculated for all responses greater than L_C.

m: The number of measurements from the reference area used to conduct a statistical test.

magnetron: A vacuum tube in which the flow of ions from the heated cathode to the anode is controlled by a magnetic field externally applied and perpendicular to the electric field by which they are propelled. Magnetrons are used to produce very short radio waves.

measurement: For the purpose of MARSSIM, it is used interchangeably to mean: 1) the act of using a detector to determine the level or quantity of radioactivity on a surface or in a sample of material removed from a media being evaluated, or 2) the quantity obtained by the act of measuring.

micrometeorology: The study of weather conditions in a local or very small area, such as immediately around a tree or building, that can affect meteorological conditions.

minimum detectable concentration (MDC): The minimum detectable concentration (MDC) is the *a priori* activity level that a specific instrument and technique can be expected to detect 95% of the time. When stating the detection capability of an instrument, this value should be used. The *MDC* is the detection limit, L_D, multiplied by an appropriate conversion factor to give units of activity.

minimum detectable count rate (MDCR): The minimum detectable count rate (MDCR) is the *a priori* count rate that a specific instrument and technique can be expected to detect.

missing or unusable data: Data (measurements) that are mislabeled, lost, or do not meet quality control standards. *Less-than data* are not considered to be missing or unusable data. See *R*.

munitions: Military supplies, especially weapons and ammunition.

N: $N = m + n$, is the total number of measurements required from the reference area and a *survey unit*. See *m* and *n*.

n: Number of measurements from a survey unit used to conduct a statistical test.

n_f: The number of samples that should be collected in an *area* to assure that the required number of measurements from that area for conducting statistical tests is obtained. $n_f = n/(1-R)$.

NARM: Naturally occurring or accelerator-produced radioactive material, such as radium, and not classified as *source material*.

naturally occurring radionuclides: Radionuclides and their associated progeny produced during the formation of the earth or by interactions of terrestrial matter with cosmic rays.

non-blind measurement: Non-blind measurements are measurements that have a concentration and origin that are known to the individual performing the measurement. See *single-blind measurement* and *double-blind measurement*.

nonconformance: A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate; nonfulfillment of a specified requirements.

non-impacted area: Areas where there is no reasonable possibility (extremely low probability) of residual contamination. Non-impacted areas are typically located off-site and may be used as background *reference areas*.

nonparametric test: A test based on relatively few assumptions about the exact form of the underlying probability distributions of the measurements. As a consequence, nonparametric tests are generally valid for a fairly broad class of distributions. The *Wilcoxon Rank Sum test* and the *Sign test* are examples of nonparametric tests.

normal (gaussian) distribution: A family of bell shaped distributions described by the mean and variance.

organization: a company, corporation, firm, government unit, enterprise, facility, or institution, or part thereof, whether incorporated or not, public or private, that has its own functions and administration.

outlier: Measurements that are unusually large or small relative to the rest and therefore are suspected of misrepresenting the population from which they were collected.

p: The probability that a random measurement from the *survey unit* is less than Δ.

p′: The probability that the sum of two independent random measurements from the *survey unit* is less than 2Δ.

P_r: The probability that a measurement performed at a random location in the *survey unit* is greater than a measurement performed at a random location in the *reference area*.

peer review: A documented critical review of work generally beyond the state of the art or characterized by the existence of potential uncertainty. The peer review is conducted by qualified individuals (or organization) who are independent of those who performed the work, but are collectively equivalent in technical expertise (*i.e.*, peers) to those who performed the original work. The peer review is conducted to ensure that activities are technically adequate, competently performed, properly documented, and satisfy established technical and quality requirements. The peer review is an in-depth assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and conclusions pertaining to specific work and of the documentation that supports them. Peer reviews provide an evaluation of a subject where quantitative methods of analysis or measures of success are unavailable or undefined, such as in research and development.

performance evaluation: A type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory.

physical probe area: The physical surface area assessed by a detector. The physical probe area is used to make probe area corrections in the activity calculations.

Pitman efficiency: A measure of performance for statistical tests. It is equal to the reciprocal of the ratio of the sample sizes required by each of two tests to achieve the same power, as these sample sizes become large.

power (1-β): The probability of rejecting the *null hypothesis* when it is false. The power is equal to one minus the *Type II* error rate, *i.e.* (1-β).

precision: A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions, expressed generally in terms of the *standard deviation*.

process: A combination of people, machine and equipment, methods, and the environment in which they operate to produce a given product or service.

professional judgement: An expression of opinion, based on technical knowledge and professional experience, assumptions, algorithms, and definitions, as stated by an expert in response to technical problems.

qualified data: Any data that have been modified or adjusted as part of statistical or mathematical evaluation, data *validation*, or data *verification* operations.

quality: The totality of features and characteristics of a product or service that bear on its ability to meet the stated or implied needs and expectations of the user.

quality assurance (QA): An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality Assurance Project Plan (QAPP): A formal document describing in comprehensive detail the necessary *QA*, *QC*, and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria. As defined for Superfund in the Code of Federal Regulations 40 CFR 300.430, the Quality Assurance Project Plan 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. The

QAPP is a plan that provides a process for obtaining data of sufficient quality and quantity to satisfy data needs. It is a part of the *Sampling and Analysis Plan*.

quality control (QC): The overall system of technical activities that measure the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer, operational techniques and activities that are used to fulfill requirements for *quality*.

quality indicators: Measurable attributes of the attainment of the necessary quality for a particular environmental decision. Indicators of quality include precision, bias, completeness, representativeness, reproducibility, comparability, and statistical confidence.

Quality Management Plan (QMP): A formal document that describes the quality system in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces for those planning, implementing, and assessing all activities conducted.

quality system: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

R: The rate of missing or unusable measurements expected to occur for samples collected in *reference areas* or *survey units*. See *missing or unusable data*. See n_f. (Not to be confused with the symbol for the radiation exposure unit Roentgen.)

R_A: The acceptable level of risk associated with not detecting an *area of elevated activity* of area A_{min}.

radiation survey: Measurements of radiation levels associated with a *site* together with appropriate documentation and data evaluation.

radioactive decay: The spontaneous transformation of an unstable atom into one or more different nuclides accompanied by either the emission of energy and/or particles from the nucleus, nuclear capture or ejection of orbital electrons, or fission. Unstable atoms decay into a more stable state, eventually reaching a form that does not decay further or has a very long *half-life*.

radioactivity: The mean number of nuclear transformations occurring in a given quantity of radioactive material per unit time. The International System (SI) unit of radioactivity is the *Becquerel (Bq)*. The customary unit is the *Curie (Ci)*.

radiological survey: Measurements of radiation levels and radioactivity associated with a *site* together with appropriate documentation and data evaluation.

radioluminescence: Light produced by the absorption of energy from ionizing radiation.

radionuclide: An unstable nuclide that undergoes *radioactive decay*.

random error: The deviation of an observed value from the true value is called the error of observation. If the error of observation behaves like a random variable (*i.e.*, its value occurs as though chosen at random from a probability distribution of such errors) it is called a *random error*. See *systematic error*.

readily removable: A qualitative statement of the extent to which a radionuclide can be removed from a surface or medium using non-destructive, common, housekeeping techniques (*e.g.*, washing with moderate amounts of detergent and water) that do not generate large volumes of radioactive waste requiring subsequent disposal or produce chemical wastes that are expected to adversely affect public health or the environment.

reference area: Geographical *area* from which representative reference measurements are performed for comparison with measurements performed in specific *survey units* at remediation site. A site radiological *reference area* (background area) is defined as an area that has similar physical, chemical, radiological, and biological characteristics as the site area being remediated, but which has not been contaminated by site activities. The distribution and concentration of *background radiation* in the *reference area* should be the same as that which would be expected on the *site* if that *site* had never been contaminated. More than one *reference area* may be necessary for valid comparisons if a *site* exhibits considerable physical, chemical, radiological, or biological variability.

reference coordinate system: A *grid* of intersecting lines referenced to a fixed site location or benchmark. Typically the lines are arranged in a perpendicular pattern dividing the survey location into squares or blocks of equal areas. Other patterns include three-dimensional and polar coordinate systems.

reference region: The geographical region from which *reference areas* will be selected for comparison with *survey units*.

regulation: A rule, law, order, or direction from federal or state governments regulating action or conduct. Regulations concerning radioisotopes in the environment in the United States are shared by the Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE), and many State governments. Federal regulations and certain directives issued by the U.S. Department of Defense(DOD) are enforced within the DOD.

relative shift (Δ/σ): Δ divided by σ, the *standard deviation* of the measurements. See *delta*.

relative standard deviation: See *coefficient of variation*.

release criterion: A regulatory limit expressed in terms of dose or risk.

rem (radiation equivalent man): The conventional unit of *dose equivalent*. The corresponding International System (SI) unit is the *Sievert (Sv)*: 1 Sv = 100 rem.

remedial action: Those actions that are consistent with a permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. See *remedy*.

remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.

remediation control survey: A type of survey that includes monitoring the progress of remedial action by real time measurement of areas being decontaminated to determine whether or not efforts are effective and to guide further *decontamination* activities.

remedy: See *remedial action*.

removable activity: Surface activity that is *readily removable* by wiping the surface with moderate pressure and can be assessed with standard radiation detectors. It is usually expressed in units of dpm/100 cm^2.

removal: The cleanup or removal of released hazardous substances, or pollutants or contaminants which may present an imminent and substantial danger; such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the threat of release of hazardous substances; the removal and disposal of material, or the taking of other such actions as may be necessary to prevent, minimize or mitigate damage to the public health or welfare or the environment.

replicate: A repeated analysis of the same sample or repeated measurement at the same location.

representative measurement: A measurement that is selected using a procedure in such a way that it, in combination with other representative measurements, will give an accurate representation of the phenomenon being studied.

representativeness: A measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

reproducibility: The precision, usually expressed as a standard deviation, that measures the variability among the results of measurement of the same sample at different laboratories.

residual radioactivity: Radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the cognizant organization's control. This includes radioactivity from all sources used by the cognizant organization, but excludes background radioactivity as specified by the applicable regulation or standard. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

restoration: Actions to return a remediated area to a usable state following decontamination.

restricted use: A designation following *remediation* requiring radiological controls.

robust: A statistical test or method that is approximately valid under a wide range of conditions.

run chart: A chart used to visually represent data. Run charts are used to monitor a process to see whether or not the long range average is changing. Run charts are points plotted on a graph in the order in which they become available, such as parameters plotted versus time.

s: The *arithmetic standard deviation* of the mean.

S+: The *test statistic* used for the *Sign test*.

sample: (As used in MARSSIM) A part or selection from a medium located in a *survey unit* or *reference area* that represents the quality or quantity of a given parameter or nature of the whole area or unit; a portion serving as a specimen.

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

Sampling and Analysis Plan (SAP): As defined for Superfund in the Code of Federal Regulations 40 CFR 300.430, a plan that provide a process for obtaining data of sufficient quality and quantity to satisfy data needs. The sampling and analysis plans consists of two parts: 1) the *Field Sampling Plan*, which describes the number, type, and location of samples and the type of analyses; and 2) the *Quality Assurance Project Plan*, which describes policy, organization, functional activities, the Data Quality Objectives, and measures necessary to achieve adequate data for use in selecting the appropriate remedy.

scanning: An evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation.

scoping survey: A type of *survey* that is conducted to identify: 1) radionuclide contaminants, 2) relative radionuclide ratios, and 3) general levels and extent of contamination.

self-assessment: Assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing and/or performing the work.

shape parameter (S): For an elliptical area of elevated activity, the ratio of the semi-minor axis length to the semi-major axis length. For a circle, the shape parameter is one. A small shape parameter corresponds to a flat ellipse.

shift: See *delta (Δ)*.

Sievert (Sv): The special name for the International System (SI) unit of *dose equivalent*. 1 Sv = 100 *rem* = 1 Joule per kilogram.

Sign test: A *nonparametric* statistical test used to demonstrate compliance with the release criterion when the radionuclide of interest is not present in background and the distribution of data is not symmetric. See also *Wilcoxon Rank Sum test*.

single-blind measurement: A measurement that can be distinguished from routine measurements but are of unknown concentration. See *non-blind measurement* and *double-blind measurement*.

site: Any installation, facility, or discrete, physically separate parcel of land, or any building or structure or portion thereof, that is being considered for survey and investigation.

site reconnaissance: A visit to the *site* to gather sufficient information to support a site decision regarding the need for further action, or to verify existing site data. Site reconnaissance is not a study of the full extent of contamination at a facility or site, or a risk assessment.

size (of a test): See *alpha*.

soil: The top layer of the earth's surface, consisting of rock and mineral particles mixed with organic matter. A particular kind of earth or ground—*e.g.*, sandy soil.

soil activity (soil concentration): The level of radioactivity present in soil and expressed in units of activity per soil mass (typically Bq/kg or pCi/g).

source material: Uranium and/or Thorium other than that classified as *special nuclear material*.

source term: All residual radioactivity remaining at the *site*, including material released during normal operations, inadvertent releases, or accidents, and that which may have been buried at the site in accordance with 10 CFR Part 20.

special nuclear material: Plutonium, ^{233}U, and Uranium enriched in ^{235}U; material capable of undergoing a fission reaction.

split: A sample that has been homogenized and divided into two or more aliquots for subsequent analysis.

standard normal distribution: A *normal (Gaussian) distribution* with mean zero and variance one.

standard operating procedure (SOP): A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks.

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

stratification: The act or result of separating an area into two or more sub-areas so as each sub-area has relatively homogeneous characteristics such as contamination level, topology, surface soil type, vegetation cover, *etc*.

subsurface soil sample: A soil sample that reflects the modeling assumptions used to develop the *DCGL* for subsurface soil activity. An example would be soil taken deeper than 15 cm below the soil surface to support surveys performed to demonstrate compliance with 40 CFR 192.

surface contamination: *Residual radioactivity* found on building or equipment surfaces and expressed in units of activity per surface area (Bq/m^2 or dpm/100 cm^2).

surface soil sample: A soil sample that reflects the modeling assumptions used to develop the *DCGL* for surface soil activity. An example would be soil taken from the first 15 cm of surface soil to support surveys performed to demonstrate compliance with 40 CFR 192.

surveillance (quality): Continual or frequent monitoring and verification of the status of an entity and the analysis of records to ensure that specified requirements are being fulfilled.

survey: A systematic evaluation and documentation of radiological measurements with a correctly calibrated instrument or instruments that meet the sensitivity required by the objective of the evaluation.

survey plan: A plan for determining the radiological characteristics of a *site*.

survey unit: 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.

systematic error: An error of observation based on system faults which are biased in one or more ways, *e.g.*, tending to be on one side of the true value more than the other.

T+: The *test statistic* for the *Wilcoxon Signed Rank test*.

tandem testing: Two or more statistical tests conducted using the same data set.

technical review: A documented critical review of work that has been performed within the state of the art. The review is accomplished by one or more qualified reviewers who are independent of those who performed the work, but are collectively equivalent in technical expertise to those who performed the original work. The review is an in-depth analysis and evaluation of documents, activities, material, data, or items that require technical verification or validation for applicability, correctness, adequacy, completeness, and assurance that established requirements are satisfied.

technical systems audit (TSA): A thorough, systematic, on-site, qualitative audit of facilities, equipment, personnel, training, procedures, recordkeeping, data validation, data management, and reporting aspects of a system.

TEDE (total effective dose equivalent): 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 Sv or rem. See *CEDE*.

test statistic: A function of the measurements (or their ranks) that has a known distribution if the *null hypothesis* is true. This is compared to the *critical level* to determine if the *null hypothesis* should be accepted or rejected. See *S+*, *T+*, and *W$_r$*.

tied measurements: Two or more measurements that have the same value.

traceability: The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughput the project back to the requirements for quality for the project.

triangular sampling grid: A grid of sampling locations that is arranged in a triangular pattern. See *grid*.

two-sample t test: A parametric statistical test used in place of the *Wilcoxon Rank Sum (WRS) test* if the *reference area* and *survey unit* measurements are known to be *normally (Gaussian) distributed* and there are no *less-than measurements* in either data set.

Type I decision error: A decision error that occurs when the *null hypothesis* is rejected when it is true. The probability of making a *Type I decision error* is called *alpha* (α).

Type II decision error: A decision error that occurs when the *null hypothesis* is accepted when it is false. The probability of making a *Type II decision error* is called *beta* (β).

unity rule (mixture rule): A rule applied when more than one radionuclide is present at a concentration that is distinguishable from background and where a single concentration comparison does not apply. In this case, the mixture of radionuclides is compared against default concentrations by applying the unity rule. This is accomplished by determining: 1) the ratio between the concentration of each radionuclide in the mixture, and 2) the concentration for that radionuclide in an appropriate listing of default values. The sum of the ratios for all radionuclides in the mixture should not exceed 1.

unrestricted area: Any *area* where access is not controlled by a *licensee* for purposes of protection of individuals from exposure to radiation and radioactive materials—including areas used for residential purposes.

unrestricted release: Release of a *site* from regulatory control without requirements for future radiological restrictions. Also known as unrestricted use.

validation: Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. In design and development, validation concerns the process of examining a product or result to determine conformance to user needs.

verification: Confirmation by examination and provision of objective evidence that the specified requirements have been fulfilled. In design and development, verification concerns the process of examining a result of given activity to determine conformance to the stated requirements for that activity.

W_r: The sum of the ranks of the adjusted measurements from the reference area, used as the *test statistic* for the *Wilcoxon Rank Sum test*.

W_s: The sum of the ranks of the measurements from the survey unit, used with the *Wilcoxon Rank Sum test*.

weighting factor (W_t): The fraction of the overall health risk, resulting from uniform, whole-body radiation, attributable to specific tissue. The dose equivalent to tissue is multiplied by the appropriate weighting factor to obtain the effective dose equivalent to the tissue.

Wilcoxon Rank Sum (WRS) test: A *nonparametric* statistical test used to determine compliance with the *release criterion* when the radionuclide of concern is present in background. See also *Sign test*.

working level: A special unit of radon exposure defined as any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. This value is approximately equal to the alpha energy released from the decay of progeny in equilibrium with 100 pCi of ^{222}Ra.

$Z_{1-\varphi}$: The value from the standard normal distribution that cuts off 100 φ % of the upper tail of the standard normal distribution. See *standard normal distribution*.