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GLOSSARY

Backward Calculation. A procedure that calculates the chemical concentration corresponding to some target risk level. Achieved by combining and rearranging the equations used in forward calculations and substituting a target risk level for chemical concentration. Region IX PRGs were obtained by this procedure. Example equation for target risk of 10^{-6}:

$$10^{-6} \text{ concentration} = \frac{\text{body weight} \times 10^{-6}}{\text{intake level} \times \text{cancer potency factor}}$$

Note that this equation is a rearrangement of the equation shown for the forward calculation.

Baseline Risk Assessment. A comprehensive risk assessment based on conditions existing before remediation. Baseline risk assessments are usually based on information gathered during a remedial investigation (RI) and the results are often used to establish cleanup goals.

Cancer Burden. Obtained by multiplying the cancer risk estimate by the number of people in the population at risk. Identifies the number of individuals in population at risk that will develop cancer. Assumes that all members of the population are exposed in the manner assumed in the risk assessment.

Cancer Risk Estimate. An estimate of the probability that an individual will develop cancer during a lifetime if exposed to a carcinogen or carcinogens in the manner assumed in the risk assessment that produced the estimate. Obtained by multiplying the dose by the CSF.

Cancer Slope Factor (CSF). A term adopted by EPA to identify the cancer risk associated with a unit dose of a carcinogen. It is the slope of the curve representing the relationship between dose and cancer risk. When estimated with the linearized multistage model, the CSF is the upper 95 percent confidence limit of the slope (upper-bound estimate of risk). Also called cancer potency factor (CPF). Expressed as risk per mg/kg-day or risk $(\text{mg/kg-day})^{-1}$.

Chemical of Concern (COC). Defined in A.A.C. R18-12-101 as any regulated substance detected in contamination from the LUST site that is evaluated for potential impacts to public health and the environment. This is similar to the definition found in RAGS Part B for COPC which has an associated cancer risk (ILCR) greater than 10^{-6} or a hazard index (HI) greater than 1.0 on the basis of the results of a baseline risk assessment.

Chemical of Potential Concern (COPC). Defined in RAGS Volume I, Part A, Exhibit 5-1 as a chemical that is potentially site related and of sufficient quality to quantify risk. Chosen primarily on the basis of an evaluation of the chemical analytical data and relationship of measured levels to background levels. Health and ecological effects may be considered in the selection of COPCs, but only to reduce their number to one that is convenient for the baseline risk assessment. Criteria for selection are described in RAGS Volume I, Part A. See also EPA, 1992a, page 40, section 3.2.1, *Chemicals of potential concern are chemicals that may be hazardous to human health or the environment and identified at the site, initially from historical sources*.

Completed Pathway. An exposure pathway that satisfies five criteria: (1) a chemical source, (2) mechanism of chemical release, (3) a retention or transport medium, (4) a point of potential receptor contact with the contaminated medium, and (5) an exposure route.

Data Quality Objectives. The qualitative and quantitative statements that clarify the objectives for site investigation, risk evaluation, remediation, or compliance confirmation. It defines the level and appropriateness of technical procedures, sampling methodologies, data requirements, and decision error for establishing the quality and quantity of data needed.

Exposure Pathway. The mechanism by which a chemical migrates from its source to a biological receptor. Example: source to soil to groundwater to kitchen faucet.

Exposure Route. The route by which a chemical enters or makes contact with the biological receptor. Example: ingestion of contaminated water from a kitchen faucet.

Forward Calculation. A conventional risk assessment procedure that calculates the cancer risk or chronic toxicity hazard presented by any given chemical concentration. Baseline risk assessments and PEAs use this procedure. Example equation:

$$\text{Cancer Risk} = \frac{\text{concentration x intake level x cancer potency factor}}{\text{body weight}}$$

Hazard Index (HI). The sum of the HQs for multiple substances or multiple exposure pathways.

Hazard Quotient (HQ). The ratio of a single substance exposure level (dose or concentration) over a specified period of time to the RfD or RfC derived for the same period of time for the same substance. A ratio larger than unity suggests that the concentration of the chemical is high enough to cause chronic noncarcinogenic effects.

Maximum Contaminant Level (MCL). The maximum concentration of a contaminant allowed in drinking water systems by the National Primary Drinking Water regulations: 40 CFR 141.11 and 141.12.

Monte Carlo Simulation. A trend-analyzing procedure adopted for use in performing quantitative uncertainty analyses of risk. An iterative process that combines thousands of risk estimates for the probability density functions of each risk-influencing factor to obtain a final probability distribution. For example, with the conventional method for calculating human health risk, body weight is assumed to be 70 kilograms and concentration of each chemical is the upper 95 percent confidence limits on the mean. This produces a point estimate of risk. The body weights of adults in a typical population may range from 30 to 90 kg. The measured concentrations of any given chemical will also cover a range from low to high. Monte Carlo simulations will calculate the risk based on all combinations of body weights and chemical concentrations within the ranges chosen and produce summary statistics for the distribution of the risk estimates, including the mean, median and other percentiles, maximum, and minimum risk and thereby providing a better estimate of risk than the point estimate produced by the conventional method. Monte Carlo simulation programs for the computer are available, e.g., @Risk for the PC computer and Crystal Ball for the PC and Macintosh computers.

No Further Action (NFA). A contraction of No Further Action Response Planned (NFRAP).

No Further Investigation (NFI). A SouthDiv term meaning that enough data have been collected to make a decision (e.g., removal needed, no action required) about it with reasonable certainty.

Preliminary Remediation Goal (PRG). Defined in RAGS, Volume I, Part B as a chemical-specific initial cleanup goal that (1) is protective of human health and the environment and (2) complies with ARARs. PRGs are initially developed on the basis of readily available information and are later modified to reflect the results of the baseline risk assessment. PRGs are also used during the analysis of remedial alternatives in the RI/FS. Examples: EPA and Cal/EPA Soil Screening Levels and EPA Region IX PRGs.

RAGS. Acronym used to identify **R**isk **A**ssessment **G**uidance for **S**uperfund, a manual entitled, "Superfund Risk Assessment Guidance Manual, Volume I: Human Health Assessment, Interim Final", EPA, 1989, Parts A, B, C, and D.

Reference Concentration (RfC). A term adopted by EPA to identify the estimate of the chemical concentration that will not cause noncarcinogenic effects during a specified exposure period. Developed for air- and waterborne chemicals. Expressed in

micrograms per cubic meter of air (µg/m^3) or micrograms per liter of water (µg/L). Interconvertible with RfDs as follows:

$$RfC(air) = \frac{RfD(inhalation) \times 20 m^3/day \times 10^{-3} mg/\mu g}{70 kg}$$

$$RfC(water) = \frac{RfD(oral) \times 2 L \times 10^{-3} mg/\mu g}{70 kg}$$

Reference Dose (RfD). A term adopted by EPA to identify the estimate of the chemical dose that will not cause noncarcinogenic effects during a specified exposure period. Expressed in milligrams of chemical per kilograms of body weight per day (mg/kg-day). At present, available only for oral and inhalation exposures. Dermal RfDs are derived from oral RfDs after correction for absorbed dose.

Representative. The level at which a measured result accurately reflects the medium being sampled. It is generally qualitative in nature, and is addressed through the robustness of the sampling plan, *i.e*. location of samples, number of samples, and the likelihood that the sampled subpopulation represents the true population of possible samples.

Residual Risk Assessment. A risk assessment performed after cleanup has occurred to determine the effectiveness of the remedial action taken. Requires samples of remediated medium (soil or water) to be analyzed for chemicals of concern. Is usually tied to risk reduction determination for cleanups and removals.

Restrictive Covenant. A recorded restriction to a deed of real property providing notice for perpetuity which runs with the land. Such restrictions may place prohibitions on use, development, or construction.

Risk. The probability of occurrence of an undesirable event, such as a chemically-induced illness or earthquake.

Risk Assessment. A technical evaluation of the nature and magnitude of risk.

Risk Based Concentration (RBC). A calculated chemical-specific concentration corresponding to a target risk level, usually a cancer risk level of 10^{-6} for carcinogens and a hazard index of 1.0 for noncarcinogenic effects. Also called risk-based criterion. RBCs are based on a specific set of exposure scenarios and pathways.

Screening Risk Assessment. A risk assessment performed to determine the need for further action. Employs a process that rapidly and economically produces a preliminary upper-bound estimate of risk. In California, an approach to screening consists of comparing the highest measured concentration of each chemical with EPA Region IX PRGs (defined herein). Another consists of performing a California Preliminary Endangerment Assessment (defined herein).

Site Evaluation Accomplished (SEA). A term for "sites that EPA decides do not warrant moving further in the site evaluation process" (NCP, Section 300.5). Applies to NPL as well as non-NPL sites.

Target Organ Analysis. An analysis performed when the HQ of each chemical is less than unity, but the sum of the HQs exceeds unity. Groups the chemicals according to the effects on which their respective RfDs are based and calculates the HQs by group. Often causes the HQ of all groups to be less than unity. Assumes that the effects of different chemicals are additive only if each chemical produces the same effect, i.e. impacts the same target organ.

Uncertainty Analysis. A process by which factors that affect the estimates of risk are identified and the degree to which they cause risk to be overestimated or underestimated identified. Is site-specific. May be qualitative or quantitative. Examples of factors that often affect risk are body weight, exposure regimen, toxicity estimates, and the information used in fate and transport modeling.

Unit Risk Factor (URF). A term adopted by the EPA to identify the cancer risk associated with a unit concentration of a carcinogen in air and water. Permits calculation of cancer risk directly from exposure point concentrations for chemicals in water and air. Expressed as risk per µg/m^3 for air and risk per µg/L for water. With rare exceptions, interconvertible with CSF values. The relationship follows.

$$URF(air) = \frac{CSF(inhalation) \times 20 m^3/day \times 10^{-3} mg/\mu g}{70 kg}$$

$$URF(water) = \frac{CSF(oral) \times 2 L/day \times 10^{-3} mg/\mu g}{70 kg}$$

REFERENCES

API, see American Petroleum Institute.

ASTM, see American Society for Testing and Materials.

ATSDR, see Agency for Toxic Substances Disease Registry.

American Petroleum Institute, 1998, Assessing The Significance Of Subsurface Contaminant Vapor Migration to Enclosed Spaces, Site-Specific Alternatives To Generic Estimates, Publication Number 4674, P.C. Johnson, M.W. Kemblowski, and R.L. Johnson, API Publishing Services, 1220 L Street, Washington, D.C. 20005.

American Society for Testing and Materials, 1995, Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, E 1739-95^{e1}, West Conshohocken, PA 19428, November 1995 with editorial corrections in December 1996.

American Society for Testing and Materials, 1997, Terminology Relating to Soil, Rock, and Contained Fluids, D 653-97, Revised 2002.

American Society for Testing and Materials, 1998a, Provisional Standard Guide for Risk-Based Corrective Action, PS 104-98, West Conshohocken, PA 19428, approved Jan. 10, published July.

American Society for Testing and Materials, 1998b, Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites, E 1943-98, West Conshohocken, PA 19428, approved April 10, published August.

American Society for Testing and Materials, 1999, RBCA Fate and Transport Models: Compendium and Selection Guidance, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, 610-832-9686, *http://www.astm.org*, May.

American Society for Testing and Materials, 2001, Test Method for pH of Soils, D 4972-01, Revised 2002.

American Society for Testing and Materials, 2001, Test Method for Determining Anaerobic Biodegradation Potential of Organic Chemicals Under Methanogenic Conditions, F 1570-01, editorial change 2002.

Agency for Toxic Substances Disease Registry, 1999, Public Health Statements Data Base, *http://www.atsdr.cdc.gov/search?NS-collection=pha-html*, Search in: ToxFAQs and PHSs.

Burmaster, D.E. and R.H. Harris, 1993, The Magnitude of Compounding Conservatisms in Superfund Risk Assessments, Risk Analysis, Vol. 13, No. 2, pp. 131-134.

Casarett and Doull, 1986, Toxicology, The Basic Science of Poisons, Third Edition, Klaassen, C.D., Amdur, M.O., and J. Doull, eds., IBSN 0-02-364650-0, Macmillan Publishing Company, New York.

CFR, see Code of Federal Regulations.

Code of Federal Regulations, Volume 40, Part 141, National Primary Drinking Water Regulations; Part 142, National Primary Drinking Water Regulations Implementation.

D.W. Rice, et al., 1995, California leaking underground fuel tank historical case analyses, UCRL-AR-122207, Lawrence Livermore National Laboratory, November 16; *ibid.*, Recommendations to improve the cleanup process for California's leaking underground fuel tanks, UCRL-AR-121762, October 16.

Edwards, D.A., M.D. Andriot, M.A. Amoruso, A.C. Tummey, C.J. Bevan, A. Tveit, L.A. Hayes, S.H. Youngren, and D.V. Nakles, 1997, Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH), Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 4, Amherst Scientific Publishers, Amherst, Massachusetts.

EPA, see United States Environmental Protection Agency.

ESE, see Environmental Science & Engineering, Inc.

Gustafson, J.B., J.G. Tell, and D. Orem, 1997, Selection of Representative TPH Fractions Based on Fate and Transport Considerations, Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 3, Amherst Scientific Publishers, Amherst, Massachusetts, July.

HSDB, see Hazardous Substance Data Base.

Hazardous Substance Data Base, (periodic online updates) http://chem.sis.nlm.nih.gov/hsdb.

Howard, P.H., 1989, Handbook of Environmental Fate and Exposure Data of Environmental Chemicals, Vol. I: Large Production and Priority Pollutants, Lewis Publishers, Inc., Chelsea, MI.

Howard, P.H., G.W. Sage, W.F. Jarvis, and D.A. Gray, 1990, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. II: Solvents, Lewis Publishers, Inc., Chelsea, MI.

Howard, P.H., ed., 1991a, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. III: Pesticides, Lewis Publishers, Inc., Chelsea, MI.

Howard, P.H., et al., 1991b, Handbook of Environmental Degradation Rates, Lewis Publishers, Chelsea, MI.

Keith, Lawrence H., 1991, Environmental Sampling and Analysis: A Practical Guide, Lewis Publishers, 121 South Main Street, Chelsea, MI 48118; Keith, Lawrence H., ed., 1988, Principles of Environmental Sampling, ACS Professional Reference Book, American Chemical Society.

Kreeger, K.Y., 1996, Of Mice and Humans, The Scientist, Vol. 10, No. 11, May 27, http://www.the-scientist.com/yr1996/may/epa_960527.html.

Lawrence Livermore, see D.W. Rice, *et al*.

Milloy, Steven J., 1995, Science-Based Risk Assessment, A Piece of the Superfund Puzzle, National Environmental Policy Institute, ISBN 0-9647463-0-1, Washington, DC; *ibid*, 1994, Choices in Risk Assessment, The Role of Science Policy in the Environmental Risk Management Process, prepared for Sandia National Laboratories, sponsored by the U.S. Department of Energy, Office of Environmental Management and Office of Environment, Safety and Health.

NRC, see National Research Council.

National Research Council, 1983, Risk Assessment in the Federal Government: Managing the Process, National Academy Press, Washington, DC.

National Research Council, 1994, Science and Judgment in Risk Assessment, National Academy Press, Washington, DC.

Ney, R.E., Jr., 1990, Where Did That Chemical Go? A Practical Guide to Chemical Fate and Transport in the Environment, Van Nostrand Reinhold, New York, NY.

Paustenbach, D.J., R. Kalmes, J.D. Jernigan, R. Bass, and P. Scott, 1993, A Proposed Approach to Regulating Contaminated Soil: Identify Safe Concentrations for Seven of the Most Frequently Encountered Exposure Scenarios, in E.J. Calabrese, and P.T. Kostecki, eds., Principals and Practices for Petroleum Contaminated Soils, Lewis Publishers, Boca Raton, Florida, pp. 511-552.

Potter, T.L. and K.E. Simmons, 1998, Composition of Petroleum Mixtures, Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 2, Amherst Scientific Publishers, Amherst, Massachusetts, May.

Seiler, Fritz A. and Alvarez, Joseph L., 1994, Definition of a Minimum Significant Risk, Technology: Journal of the Franklin Institute, Vol. 331A, pp. 83-95.

United States Environmental Protection Agency, 1985, Rapid Assessment of Exposure to Particulate Emissions From Surface Contamination Sites, EPA/600/8-85/002 (NTIS PB85-192219), Office of Health and Environmental Assessment, Washington, DC 20460, February.

United States Environmental Protection Agency, 1986, Guidelines for Carcinogen Risk Assessment, Federal Register, Vol. 51 (September 24), page 33992.

United States Environmental Protection Agency, 1987, The Risk Assessment Guidelines of 1986, EPA/600/8-87/045, Office of Health and Environmental Assessment, Washington, DC 20460, August.

United States Environmental Protection Agency, 1988, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final,-EPA/540/G-89/004, OSWER Directive 9355.3-01, Office of Emergency and Remedial Response, Washington, DC 20460, October.

United States Environmental Protection Agency, 1989a, Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC 20460, December.

United States Environmental Protection Agency, 1989b, Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities -- Interim Final Guidance, EPA/530-SW-89-026 (NTIS PB89-151047), Office of Solid Waste, Waste Management Division, Washington, DC 20460, February.

United States Environmental Protection Agency, 1990, National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300, Environmental Protection Agency, Washington, DC.

United States Environmental Protection Agency, 1991a, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, Office of Solid Waste and Emergency Response, Washington, DC 20460, March 25.

United States Environmental Protection Agency, 1991b, Human Health Evaluation Manual, Part B: "Development of Risk-based Preliminary Remediation Goals", OSWER Directive 9285.7-01B, Office of Solid Waste and Emergency Response, Washington, DC 20460, December 13.

United States Environmental Protection Agency, 1992a, Guidance for Data Useability in Risk Assessment (Part A), Final, Publication No. 9285.7-09A, Office of Emergency and Remedial Response, Washington, DC, 20460, 279 pp., April.

United States Environmental Protection Agency, 1992b, Guidance on Risk Characterization for Risk Managers and Risk Assessors, memorandum from F. Henry Habicht II, Deputy Administrator, Office of the Administrator, Washington, DC 20460, February 26.

United States Environmental Protection Agency, 1992c, National Primary Drinking Water Regulations, Synthetic Organic Chemicals and Inorganic Chemicals, Final Rule, Federal Register 57, No. 138, July 17, 1992, pp. 31777-31849.

United States Environmental Protection Agency, 1996a, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, Office of Solid Waste and Emergency Response, Washington, DC 20460.

United States Environmental Protection Agency, 1996b, Soil Screening Guidance: User's Guide, EPA/540/R-96/018, Publication 9355.4-23, Office of Solid Waste and Emergency Response, Washington, DC 20460, July.

United States Environmental Protection Agency, 1996c, Drinking Water Regulations and Health Advisories, EPA 822-B-96-002, Office of Water, Washington, DC, October.

United States Environmental Protection Agency, 1996, Proposed Guidelines for Carcinogen Risk Assessment, EPA/600/P-92/003C, April, http://www.epa.gov/ncea/cancer.htm.

United States Environmental Protection Agency, 1997a, Exposure Factors Handbook, EPA/600/P-95/002Fa, 3 Volumes, Update to Exposure Factors Handbook, EPA/600/8-89/043, May 1989, Office of Research and Development, National Center for Environmental Assessment, Washington, DC 20460, August.

United States Environmental Protection Agency, 1997b, Health Effects Assessment Summary Tables - FY-1997 Update, NTIS PB97-921199LEU, Washington, DC 20460, July, 420 pp.

United States Environmental Protection Agency, 1998, Monitored Natural Attenuation for Ground Water, EPA/625/K-98/001, Office of Research and Development, Washington, DC 20460, September; download at http://www.epa.gov/swerust1/mna/mnasemho.htm.

United States Environmental Protection Agency, 1999a, Integrated Risk Information System, Internet URL: http://www.epa.gov/ngispgm3/iris/index.html.

United States Environmental Protection Agency, 1999b, Region 9 Preliminary Remediation Goals (PRGs) 1999, Stanford J. Smucker, Ph.D., Regional Toxicologist, San Francisco, CA 94105-3901, October 1.

United States Environmental Protection Agency, 2000, Integrated Risk Information System, Internet URL: http://www.epa.gov/ngispgm3/iris/index.html.

University of Texas at Austin, Bureau of Economic Geology, 1997, Geological Circular 97-1, Extent, Mass and Duration of Hydrocarbon Plumes from Leaking Petroleum Storage Tank Sites in Texas.

UTA, see University of Texas at Austin, Bureau of Economic Geology.

Vorhees, D.J., W.H. Weisman, and J.B. Gustafson, 1999, Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 5, Amherst Scientific Publishers, Amherst, Massachusetts, June.

Weisman, W., 1998a, Analysis of Petroleum Hydrocarbons in Environmental Media, Total Petroleum Hydrocarbon Criteria Working Group Series, Volume 1, Amherst Scientific Publishers, Amherst, Massachusetts, March.

Weisman, W., 1998b, Total Petroleum Hydrocarbon Criteria Working Group: A Risk-Based Approach for the Management of Total Petroleum Hydrocarbons in Soil, Journal of Soil Contamination, Vol. 7, No. 1, pp. 1-15.

ACKNOWLEDGMENTS

Many individuals contributed to the preparation and review of this guidance document. This document was prepared by the Underground Storage Tank (UST) Corrective Action Section of the Waste Programs Division within the Arizona Department of Environmental Quality (ADEQ). On June 21, 2002, the UST Policy Commission approved this document. The ADEQ wishes to thank all past and present ADEQ staff and all of the UST stakeholders for their hard work and assistance to the Department in the creation of this document.

Authors: Joseph K. Drosendahl, Arizona Department of Environmental Quality
Jeanene P. Hanley, Arizona Department of Environmental Quality

Contractor: Larry Froebe, Harding ESE

Reviewers and Other Contributors:

Gavin Bai,	Tierra Dynamic Company
Brian Beck,	Beck Environmental
Scott Burge,	Burge and Associates
Hal Gill,	ATC
J. Dan Kelley,	Tierra Dynamic Company
John Kennedy,	EnTech
Jim Kirschner,	ATC
Emmerich Knoebl,	Talus Earth and Environmental, Inc.
Chris Miller,	Tierra Dynamic Company
John Pearce,	Fennemore Craig
Phil Schneider,	SECOR
Myron Smith,	Phillips Petroleum
Donn Stoltzfus,	City of Phoenix
Jeff Trembly,	Mogollon Env. Services
James Vieregg	Stinson, Morrison & Hecker, LLP
Ian Bingham,	Arizona Department of Environmental Quality
Bill Engstrom,	Arizona Department of Environmental Quality
Al Johnson,	Arizona Department of Environmental Quality
Phil McNeely,	Arizona Department of Environmental Quality
Heather Fazzio,	Attorney General's Office
Barbara Pashkowski,	Attorney General's Office

DISCLAIMER

This guidance document for the Underground Storage Tank (UST) Program is submitted in conjunction with the rule filed with the Secretary of State [Arizona Administrative Code (A.A.C.) Title 18, Chapter 12, Articles 1 and 2] which became effective August 20, 2002. The contents of this guidance are general in nature, reflect the administrative and technical components of the program as described in rule, and are subject to revision in keeping with the latest developments in technology, professional practices and statutory changes. Comments are welcome and should be submitted to Joseph Karl Drosendahl (drosendahl.joseph@ev.state.az.us) or Jeanene P. Hanley (hanley.jeanene@ev.state.az.us) at ADEQ Underground Storage Tank Program, 1110 West Washington Street, Phoenix, Arizona 85007. This document and subsequent revisions may become available from the UST website at http://www.adeq.state.az.us/environ/waste/ust/lust.html.

The following document was developed to provide the regulated community with guidance in complying with the release reporting and corrective action requirements for USTs as provided for in Arizona statutes and rules, and is to be utilized by ADEQ staff as an aid in determinations regarding adequacy of site investigation and remediation activities. It creates no substantive or procedural rights in any person. The mention of trade names, commercial products, or private entities does not constitute an endorsement.

Nothing in this document supercedes any state or federal regulation. Complete conformity with the information in this document does not guarantee acceptance of all results by ADEQ, nor does it establish that all corrective actions undertaken are reasonable and necessary. Site-specific variances from the details of this document may be warranted, and will require use of professional judgement. This guidance document is a basic application for generalities encountered at most UST sites, and does not constitute an account for all site-specific conditions. As such, some of the guidance provided in this document may not be applicable to a given LUST site, and consequently, such activities may not be reasonable, necessary or cost-effective depending upon site-specific conditions.

The guidance provided in this document is also intended to be applicable for single UST releases. All of the guidance may not be reasonable, necessary or cost-effective if multiple UST releases, which occur in close proximity, are being investigated or remediated at the same time.

If the regulated community chooses not to follow this guidance, any corrective actions must be performed in accordance with A.A.C. R18-12-260 *et.seq*. and pursuant to Arizona Revised Statute (A.R.S.) § 49-1005. Corrective actions must:

- assure the protection of public health and welfare and the environment;

- to the extent practicable, provide for the control, management or cleanup of regulated substances so as to allow the maximum beneficial use of the water and soil of this state; and
- be reasonable, necessary, cost-effective and technically feasible.