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# Supporting Documentation for the TCEQ's Ecological Benchmark Tables

Remediation Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Prepared by
Remediation Division

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# Overview

**Objective:** to provide supporting documentation for the surface water, sediment, and soil benchmarks used as part of the ecological risk assessment (ERA) process. Conducting Ecological Risk Assessments at Remediation Sites in Texas, TCEQ publication RG-263 is the parent document, and this document, along with the separate Excel file containing the screening-level benchmarks (online at <www.tceq.texas.gov/goto/era>), comprise RG-263b. RG-263c is a case study demonstrating the ERA process.

**Audience**: the regulated community and environmental professionals.

**References:**

- The regulatory citation for the Texas Risk Reduction Program (TRRP) rule is Title 30, Texas Administrative Code [30 TAC, Chapter 350].
- The TRRP rule, together with conforming changes to related rules, is contained in 30 TAC 350 and was initially published in the September 17, 1999, Texas Register (24 Tex. Reg. 7436–766). The rule was amended in 2003 (effective September 1, 2003; 28 Tex. Reg. 6935–37), in 2007 (effective March 19, 2007; 32 Tex. Reg. 1526–79), and in 2009 (effective March 19, 2009, 34 Tex. Reg. 1866–72).
- Find links for the TRRP rule and preamble, Tier 1 PCL tables, and other TRRP information at <www.tceq.texas.gov/remediation/trrp/>.
- TRRP guidance documents undergo periodic revision and are subject to change. Referenced TRRP documents may be in development. Links to current versions appear at: <www.tceq.texas.gov/goto/trrp-guidance>.
- The TCEQ is committed to accessibility. If you are unable to access the information in any portion of this document, please contact the Technical Program Support Team at the phone number or e-mail address below.

**Contact:** TCEQ Remediation Division, Division Support Section, 512-239-2200, or <techsup@tceq.texas.gov>. For mailing addresses, refer to <www.tceq.texas.gov/about/directory/>.

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## Abbreviations

BCG – biota concentration guide

CCME – Canadian Council of Ministers for the Environment

CDPHE – Colorado Department of Public Health and Environment

COC – chemical of concern

Eco-SSL – ecological soil screening level

EqP – equilibrium partitioning

ERA – ecological risk assessment

ERAG – Ecological Risk Assessment Guidance [Conducting Ecological Risk Assessments at Remediation Sites in Texas (TCEQ publication RG-263)]

ER-L – effects range—low

ER-M – effects range—median

HPAHs – high molecular weight polycyclic aromatic hydrocarbons

$LC_{50}$ – lethal concentration, 50 percent

LPAHs – low molecular weight polycyclic aromatic hydrocarbons

MTBE – methyl tert-butyl ether

NOAA – National Oceanic and Atmospheric Administration

ORNL – Oak Ridge National Laboratory

PAHs – polycyclic aromatic hydrocarbons

PCL – protective concentration level

PEC – probable effects concentration

PELs – probable effects levels

PFOS - perfluorooctanesulfonic acid

SLERA – screening-level ecological risk assessment

STORET – U.S. EPA's Storage and Retrieval System

TAC – Texas Administrative Code

30 TAC 350 – Title 30, Texas Administrative Code, Chapter 350

TCEQ – Texas Commission on Environmental Quality

TEC – threshold effects concentration

TOC – total organic carbon

TPAHs – total polycyclic aromatic hydrocarbons

TRRP – Texas Risk Reduction Program

TSS – total suspended solids

TSWQS – Texas Surface Water Quality Standards

U.S. DOE – United States Department of Energy

U.S. EPA – United States Environmental Protection Agency

USGS – United States Geological Survey

VOCs – volatile organic compounds

# 1.0 Introduction

This publication supports the TCEQ's process for ecological risk assessment (ERA) that is applied under the Texas Risk Reduction Program Rule [30 TAC 350]. This publication is also applicable to sites under the Risk Reduction Rule [30 TAC Chapter 335]. This document and the benchmark tables are collectively known as RG-263b. The screening-level benchmark tables for surface water, sediment, and soil are available on the TCEQ's ERA website (<www.tceq.texas.gov/goto/era>).

This supporting documentation will be revised as necessary, but for the most recent updates of the numeric benchmarks and associated references, refer to the latest version of the benchmark tables.

*Ecological risk assessment* is defined as a process that evaluates the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more stressors (U.S. EPA, 1992). U.S. EPA further defines *stressor* as any physical, chemical, or biological entity that can induce an adverse ecological response. The TRRP ERA process focuses on chemical stressors—those subject to risk-management decisions at remediation sites. A risk cannot exist unless the stressor can cause one or more adverse effects and it occurs with, or contacts, an ecological component (*receptor*) long enough and at a sufficient intensity to elicit the identified adverse effect. The primary functions of an ERA are to:

- determine whether actual or potential ecological risk exists at a remediation site;
- screen chemicals of concern (COCs) to identify those that are more likely to pose an ecological risk;
- focus additional assessment; and
- if necessary, determine ecologically protective concentration levels (PCLs) to be used for risk management decisions.

*Ecological benchmarks*, as used in the TRRP ERA process, are defined as the numerical values of surface water, sediment, and soil that are used as screening levels for comparison to site-related media concentrations to identify those that may exceed threshold effects to community-level receptors. Comparison of affected property concentrations to ecological benchmarks is the first required element in a Tier 2 screening level ecological risk assessment (SLERA). This required element is intended to initially identify COCs that are present at concentrations that could be causing unacceptable ecological risk. Required element 1 is specified in the TRRP rule [30 TAC 350.77(c)(1)]. This document discusses the sources of the TCEQ benchmarks for surface water, sediment, and soil. Specifics on benchmark use, determination of alternate benchmarks, and the derivation of benchmarks where none are specified for a COC (and surrogate COCs) are discussed in **5.2** of Conducting Ecological Risk Assessments at Remediation Sites in Texas (TCEQ, 2017) or "ERAG". References to the numbered chapters, sections, subsections, etc., of ERAG are shown in **bold** type.

As needed, the TCEQ will update the benchmark values if it determines that a newer value or derivation process has more merit because of superior quality and accuracy, and in response to rule and policy amendments, such as a change in the Texas Surface Water Quality Standards [TSWQS, 30 TAC Chapter 307, as amended] or changes to federal water quality criteria.

The benchmarks are generally sets obtained from a variety of sources [e.g., surface water values from the listed references including Suter and Tsao (1996); sediment effects levels from MacDonald et al. (2000)], with the assumption that each whole set is preferable, rather than picking and choosing COCs individually. However, to expand the list of COCs that have benchmarks, individual values from other sources were also included. Preference for sets of benchmarks (or individual benchmarks) was based on those:

- containing many COCs.
- developed transparently.
- appropriate for conservative screening.
- used in other TCEQ programs, including regulatory criteria.
- used in other state and federal ERA programs.
- that include species relevant to Texas and the Gulf of Mexico.
- individual values that are based on relatively recent toxicity studies or meet current technical standards.

# 2.0 Surface Water Benchmarks

The benchmarks for surface water are intended to protect aquatic biota (fish and water-column invertebrates)—not necessarily mammals and birds that may be exposed to COCs through ingestion of contaminated food or water. The risks to mammals and birds are evaluated in upper trophic level analyses, as described in ERAG. The benchmark tables for surface water have been placed into three separate worksheets:

- Surface Water Benchmarks for Metals, Inorganics
- Surface Water Benchmarks for Organics
- Hardness or pH-Dependent Formulas

The TSWQS serve as the primary benchmarks for surface water. When there is no state criterion for a COC, the latest version of the federal National Ambient Water Quality Criteria was used when available. The federal and state criteria are generally protective of sensitive aquatic species, have undergone rigorous review and comment, and are generally accepted by the regulated community.

**Freshwater vs. Saltwater:** According to the TSWQS, *marine waters* (saltwater) are **coastal** waters with measurable elevation changes due to normal tides, typically having salinities of 2 parts per thousand or greater in a significant portion of the water column. This definition should be used to select the appropriate freshwater or saltwater benchmark. Hence, saltwater benchmarks are inappropriate for the highly saline waters in West Texas because they are **inland**. However, some coastal water bodies may experience tidal elevation changes, yet support a freshwater community due to marginal salinity levels. In such cases, the person may use freshwater surface water (and sediment) benchmarks, if information is presented to demonstrate that the water body supports freshwater organisms.

**In no cases** should freshwater and saltwater benchmarks ever be used interchangeably where a benchmark is unavailable for the appropriate medium.

**Hardness for Freshwater Benchmarks:** For many metals, the freshwater criterion or the benchmark is a function of hardness (50 mg/L $CaCO_3$ is the default). The person has several options for using an alternate hardness value to calculate the benchmark value. The person may use the segment-specific $15^{th}$ percentile hardness value (for the nearest downstream segment) or property-specific hardness data using site-sample results in accordance with the Procedures to Implement the Texas Surface Water Quality Standards or “Implementation Procedures” (TCEQ, 2010) or latest approved revision. Be aware that derivation of a site-specific hardness value would necessitate a sizeable data set (a minimum of 30 samples from the receiving water representing a range of seasonal conditions). See the Implementation Procedures for information on development of a site-specific hardness value.

**Dissolved vs. Total:** Numeric aquatic-life criteria for metals and metalloids apply to dissolved concentrations where noted. Dissolved concentrations can be estimated by filtration of samples—using a 0.45 µm filter per TCEQ (2012)—before analysis, or by converting from total recoverable measurements in accordance with the latest approved revision of the Implementation Procedures. The TCEQ prefers dissolved-metals data for surface water rather than the mathematical conversion. If the conversion method is used, the person must use either the concentration of total suspended solids (TSS) for the nearest classified downstream or downgradient segment (as listed in the Implementation Procedures), or site-specific TSS data in accordance with the Implementation Procedures. The dissolved criterion is converted to a total number so that the total criterion can be compared with total surface water data.

**Site-Specific Criteria:** Be aware that the TSWQS define site-specific criteria for aquatic-life protection for selected water bodies [30 TAC 307, Appendix E]. As these values are higher (less conservative) than those in the benchmark tables, the person should determine if there is a site-specific criterion for the surface water and COC in question. In most cases, the site-specific criterion is only relevant to a facility-specific permit under the Texas Pollutant Discharge Elimination System, rather than an entire water body, and would not be applicable to a TRRP site. Unless specifically noted in Appendix E, the Water Effects Ratio or Biotic Ligand multiplier used in some criteria formulas is 1.

**Silver:** Since the Texas silver criterion is for the free-ion form, the person should convert the standard from dissolved to total silver, in addition to the chloride-dependent estimation of the percentage of silver in the free-ion form (see footnote *o* on the surface water benchmark table for metals, inorganics). Note that this equation in the benchmark table differs slightly from the equation in the 2010 Implementation Procedures, correcting an error in the formula. Alternatively, the person may use the federal silver benchmark for freshwater.

**Livestock:** Surface water and groundwater used by livestock for drinking can be impacted by COCs. The TCEQ reviewed many resources to identify drinking-water screening levels for livestock. These drinking-water levels, which are largely for metals and metalloids, were compared to the freshwater chronic criteria. If the livestock drinking-water value is lower than the freshwater chronic criteria, the person should use the livestock-protective concentration. These values only apply when water ingestion by livestock is a complete or potentially complete exposure pathway. Only total metal values should be used for the livestock drinking-water evaluation. See **6.6.2**, **9.2.3.3**, **Table 10.2**, and **10.4.6.2** in ERAG for more information on the evaluation of risk to livestock.

**Data Sources:** The surface water benchmark tables reflect the values that should be used for comparison to site-specific surface water data. When Texas or federal water quality criteria were not available, the following sources were used for benchmarks:

- Criteria were derived by using the $LC_{50}$ (lethal concentration to 50 percent of the test population) in accordance with methodology defined in the TSWQS [30 TAC 307.6(c)(7)]. Some of these values were developed by the TCEQ for wastewater permits, while others were derived using $LC_{50}$ data available in the open literature. Supporting information for each value is available upon request from the TCEQ Technical Program Support Team <techsup@tceq.texas.gov>.
- The Tier II secondary acute and chronic values developed by Suter and Tsao (1996) of the Oak Ridge National Laboratory were also a source for freshwater benchmark values. Note that the boron value has been recalculated due to an error in the ORNL derivation.
- The Canadian Council of Ministers for the Environment (CCME, 2016) has developed water quality criteria for numerous COCs. There are instances when only a chronic value is listed by CCME (e.g., demeton).
- Finally, other miscellaneous individual benchmark sources included:

- Giesy et al. (2010) developed freshwater benchmarks and a surface water value protective of predatory birds (bald eagle, belted kingfisher, and herring gull) for perfluorooctanesulfonic acid (PFOS.)
- McPherson et al. (2014a) developed a chronic freshwater benchmark for strontium. McPherson et al. (2014b) developed a chronic freshwater benchmark for fluoride.
- The State of Colorado developed hardness-based freshwater standards for uranium and manganese (CDPHE, 2013).
- Heijerick et al. (2017) provided the chronic benchmarks for molybdenum.
- The U.S. EPA developed acute and chronic surface water values for the derivation of sediment quality criteria for acenaphthene (U.S. EPA, 1993a) and fluoranthene (U.S. EPA, 1993b).
- Mancini et al. (2002) developed ambient water criteria for methyl-*tert*-butyl ether (MTBE).
- Nipper et al. (2001) and Talmage et al. (1999) derived surface water values for munitions.
- Livestock drinking water values were taken from the open literature for cobalt (ANZECC, 2000), manganese (Lewis, 1996; Higgins et al., 2008), molybdenum and uranium (ANZECC, 2000).

The surface water benchmark tables also present acute surface water values for application to intermittent drainage ditches, intermittent streams without perennial pools, unclassified playa lakes, and freshwater wetlands that are not permanently inundated. See Determining PCLs for Surface Water and Sediment [TCEQ, (2007, publication no. RG-366/TRRP-24)] on using the acute or chronic surface water values.

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# 3.0 Sediment Benchmarks and Second Effects Levels

The benchmarks for sediment are intended to protect benthic invertebrates, not necessarily mammalian and avian receptors that may be exposed to COCs through the food chain or via the incidental ingestion of sediment. The risks to mammals and birds are evaluated in upper trophic level analyses, as described in ERAG. The sediment benchmark table presents the benchmarks for both freshwater and saltwater systems. For convenience, the table also contains the second effects levels and the corresponding default benthic invertebrate PCLs. Following the methodology discussed in **13.4** in ERAG, the PCLs are simply the midpoint between the benchmark and the second effects level.

Although there are a variety of sources for sediment benchmarks, most presented in the benchmark table use one of two basic approaches:

1. The correlative or integrative approach relies largely on paired field and laboratory toxicity data to relate the incidence of adverse biological effects to the dry-weight sediment concentration of a COC. It derives screening values using several approaches, including toxicity tests on spiked sediment and field sediment, and benthic community surveys. This is the TCEQ's preferred method for selecting sediment benchmarks.

2. Equilibrium partitioning (EqP) is theoretically based and relies on the physical and chemical properties of sediment and COCs to predict the concentration that would not cause an adverse effect on aquatic life. In selecting the sediment benchmarks, the TCEQ used EqP to develop benchmarks for volatile organic compounds (VOCs) and munitions using their corresponding surface water benchmark values (acute and chronic).

The sediment benchmark table lists the values that should be used for comparison to site-sediment concentrations (required element 1) in a Tier 2 SLERA. The table also presents the benthic PCLs that can be used for required elements 9 and 10 in the SLERA. The second effects levels are also presented to facilitate the development of the benthic PCL and are not themselves to be used for comparison to site concentrations. The following is an overview of the sources used to obtain the freshwater and saltwater sediment benchmarks, the second effects levels, and describes the EqP methodology.

### *3.1. Freshwater Values*

- The primary source of freshwater sediment benchmarks and second effects levels is MacDonald et al. (2000). Two sediment standards were developed: (1) a threshold effect concentration (TEC) used as the benchmark, and (2) a probable effect concentration (PEC) used as the second effects level. The TEC represents a sediment concentration below which adverse effects are not expected to occur; the PEC, a concentration above which adverse effects are expected to occur often.
- The Ontario Ministry of the Environment (Persaud et al., 1993) defined a lowest-effects level as a level of freshwater sediment contamination tolerated by most benthic organisms, and a severe-effects level as the level at which a pronounced disturbance of the benthic community can be expected. These benchmarks

were derived from matching sediment-chemistry and benthic-community data from various geographic areas. Screening values for iron, manganese, numerous pesticides, and individual polychlorinated biphenyl Aroclors were used as benchmarks and second effects levels.

- As described for surface water, the CCME has also developed sediment criteria for numerous COCs. The CCME's interim sediment-quality guidelines were used as benchmarks and the probable effects levels (PELs) were used as second effects levels (for example, heptachlor) (CCME, 2016).
- The incidence and severity of sediment contamination in surface waters of the United States, National sediment quality survey (U.S. EPA, 2004) is a screening-level assessment of sediment quality that compiles and evaluates sediment chemistry, and related biological data from various databases including, but not limited to, the EPA's Storage and Retrieval System (STORET), the NOAA Query Manager Data System, and databases belonging to the Chesapeake Bay Program and Indiana Department of Environmental Management Sediment Sampling Program, as well as the Houston Ship Channel Toxicity Study. The objective of the EPA report is to develop screening-level assessment protocols to identify potentially contaminated sediment. In this report, EPA associated sampling stations with their "probability of adverse effects on aquatic life." Data from sampling stations that were associated with probable adverse effects on aquatic life were used as second effects levels. Data from those sampling stations where adverse effects were possible were used as sediment benchmarks (e.g., carbon tetrachloride, malathion, and methoxychlor). All values were corrected to bulk sediment values by assuming 1 percent total organic carbon (TOC) (value × 0.01).
- NYSDEC (1999) Technical guidance for screening contaminated sediments was used for benchmarks and second effect levels for hexachlorobutadiene and toxaphene. These values were converted to bulk sediment values by assuming 1 percent TOC (value × 0.01).
- The Washington State Sediment Management Standards were used as a source for the benchmarks and second effects levels for numerous organic compounds such as benzoic acid, bis(2-ethylhexyl)phthalate, di-*n*-octyl phthalate, dibenzofuran, 4-methylphenol, pentachlorophenol, and phenol. See Chapter 173-204, Washington Administrative Code; February 25, 2013.
- The freshwater sediment value for antimony was taken from the Washington State Department of Ecology 2011 document Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho.

### 3.2. Saltwater Values

- The primary source of saltwater sediment benchmarks and second effects levels are the effects range—low (ER-L) and effects range—median (ER-M) values developed by Long et al. (1995), who established ER-L values and ER-M values using an updated version of the database developed by Long and Morgan (1991). Effects studies in the more recent data set included paired chemistry and bioassay data from field samples, toxicity tests using spiked sediments, benthic community analyses, and equilibrium-partitioning modeling much like those used in Long and Morgan (1991). COC concentrations (dry-weight normalized) observed or predicted by these methods to be associated with biological effects were ranked using percentiles. The lower $10^{th}$ percentile concentration for those sediment COC concentrations associated with biological effects was chosen as the ER-L value. Values below the ER-L were considered to represent the “no effects” range. The 50th percentile concentration for the ranked sediment COC concentrations associated with biological effects was defined as the ER-M. ER-Ls were used as benchmarks and ER-Ms were used as second effects levels.

- As described for surface water, the CCME (2016) has also developed sediment criteria for numerous COCs. The CCME’s interim sediment-quality guidelines were used as benchmarks, and the PELs were used as second effects levels (e.g., gamma-BHC).
- An additional Canadian reference: The development and implementation of Canadian sediment quality guidelines (Smith et al., 1996) was used to augment the saltwater benchmark and second effects level database. Threshold effect levels were used as benchmarks, and PELs as second effects levels.
- The Washington State Sediment Management Standards were used as a source for the benchmarks and second effects level for numerous organic compounds and silver. See Chapter 173-204, Washington Administrative Code (February 25, 2013).

### 3.3. Equilibrium Partitioning

The TCEQ used EqP to develop sediment benchmarks for VOCs and munitions. The EqP approach, as described by Fuchsman (2003), U.S. EPA (2008), and Pascoe et al. (2010), was used to develop freshwater and marine sediment benchmarks and second effects levels for volatile COCs and munitions where preferred values were unavailable from other sources. The EqP theory states that a nonionic chemical partitions between sediment organic carbon, interstitial (pore) water, and benthic organisms (U.S EPA, 2008). As stated above, the EqP process was primarily applied to volatiles and munitions. These chemicals are expected to be more water soluble and more available in pore water than hydrophobic chemicals that are bound to sediment particles (where ingestion of sediment would be a pathway of concern for benthics).

The EqP approach was chosen because it accounts for the varying biological availability of chemicals in different sediments and allows for the incorporation of the appropriate biological effects concentrations. EqP can be used for any toxicity endpoint for which there are water-only toxicity data (U.S. EPA, 2008). Thus, a toxicity threshold for sediment pore water can be established based on the surface water effect thresholds (i.e., the TCEQ’s acute and chronic benchmarks for surface water). The TCEQ used the EqP equation published by Fuchsman (2003) coupled with the TCEQ surface water acute and chronic screening values to calculate sediment benchmarks and second effect levels for these VOCs and munition COCs:

$$\mathrm{SQB\ (mg/kg)} = \mathrm{WQB\ (mg/L)} \times \left[ (f_{oc} \times K_{oc}) + \frac{1\text{-}f_{solids}}{f_{solids}} \right]$$

where:

SQB = sediment quality benchmark (mg/kg)

WQB = acute or chronic water quality benchmark (mg/L)

$K_{oc}$ = organic carbon partition coefficient (unitless, taken from the Chemical and Physical Properties PCL table)

$f_{oc}$ = fraction organic carbon (0.01 kg organic carbon/kg sediment, TCEQ (2007) default.

$f_{solids}$ = fraction solids = 1 – porosity; porosity = 0.37, TCEQ (2007) default.

# 4.0 Soil Benchmarks

For the most part, the soil benchmarks are the lower of the terrestrial plant or earthworm (or other soil invertebrate) benchmark values from Efroymson et al. (1997) and Efroymson, Will and Suter (1997). The soil benchmark values and their respective target receptors (plants, earthworms, or soil invertebrates) appear in the soil benchmark table, along with the median Texas background concentrations for most metals. To supplement the median Texas background concentrations specified in the TRRP rule, the TCEQ has also developed statewide soil background values based on data from the National Geochemical Survey (USGS, 2008) for cadmium, lithium, molybdenum, silver, and uranium that were not available in the original median Texas background dataset. If the maximum concentration of a COC at an affected property is at or below the median Texas background or an approved site-specific background, the benchmark value may be disregarded and the COC can be eliminated for this medium, even if the COC is bioaccumulative in soil [see 30 TAC 350.51(l–m) for a discussion of background concentrations].

The EPA has released a set of risk-based ecological soil screening levels (Eco-SSLs) for plant or soil invertebrate endpoints for 15 contaminants that are frequently of ecological concern (U.S. EPA, 2003a, b; 2005a–g; 2006; 2007a–g). Eco-SSLs were derived by a work group consisting of federal, state, consulting, industry, and academic stakeholders led by the U.S. EPA Office of Superfund Remediation and Technology Innovation. When an Eco-SSL is available for either plants or soil invertebrates, it has been incorporated into the soil benchmark table (antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, manganese, nickel, polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol, selenium, silver, and zinc). Discussions are included for aluminum and iron that do not use numeric criteria. The U.S. EPA has also developed Eco-SSLs for the protection of birds and mammals. These values can be used as screening levels to evaluate potential risks to higher trophic levels.

The Eco-SSLs for PAHs (U.S. EPA, 2007e) list values for soil invertebrates and mammals for both low and high molecular weights (LPAHs and HPAHs). The values for soil invertebrates (29 mg/kg LPAHs and 18 mg/kg HPAHs), exceed that for the mammalian value of 1.1 mg/kg. As stated in the TRRP rule at 350.4(a)(27), the TCEQ does not develop PCLs for soil invertebrates. Therefore, using soil invertebrate values to screen-out site concentrations of PAHs that may impart risk to upper trophic-level receptors is not appropriate. As a result, the TCEQ has replaced all soil PAH benchmarks with the lowest Conservative PCL of 2.8 mg/kg for total PAHs (TPAHs) for wildlife from the Ecological PCL Database[1]. As stated in **10.5.3** of ERAG, TCEQ prefers that PAHs are evaluated as TPAHs and not LPAHs and HPAHs. This is because PAHs almost always occur in the environment as mixtures and, as such, the piecemeal elimination of components that constitute the mixture should be avoided.

[1]The TCEQ and its contractor (West Texas A&M University) have developed an Ecological PCL Database that provides default ecological PCLs for soil and sediment for a variety of wildlife receptors and COCs, see <pcl.wtamu.edu/pcl/login.jsp>.

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# 5.0 Radiation Doses to Aquatic and Terrestrial Biota

Radioactive materials are regulated primarily under 30 TAC Chapter 336 (Radioactive Substances Rules). Pursuant to these rules, contamination limits are specified for media and vegetation, and are based on the protection of human health. As a source of screening values for the protection of fish and wildlife, the person should consider the following discussion (see **10.5.6** for additional information). The U.S. Department of Energy (U.S. DOE, 2002) has developed a graded approach for evaluation of radiological contamination in soil, water, and sediment. The first step in the graded approach is the comparison of the radiological concentrations in soil, water, and sediment to the DOE conservative screening values, the biota concentration guides. The BCGs are radionuclide concentrations in environmental media that represent recommended dose rate guidelines. The TCEQ has incorporated the BCGs as benchmarks. For each medium, for radionuclide a, b, …*n*, with concentrations $C_a$, $C_b$ …$C_n$, and for corresponding screening BCG values $BCG_a$, $BCG_b$ …$BCG_n$, the relationship for aquatic and terrestrial systems is as follows:

$$\left[\frac{C_a}{BCG_a} + \frac{C_b}{BCG_b} + \ldots + \frac{C_n}{BCG_n}\right] \text{water} + \left[\frac{C_a}{BCG_a} + \frac{C_b}{BCG_b} + \ldots + \frac{C_n}{BCG_n}\right] \text{sediment} < 1.0$$

$$\left[\frac{C_a}{BCG_a} + \frac{C_b}{BCG_b} + \ldots + \frac{C_n}{BCG_n}\right] \text{water} + \left[\frac{C_a}{BCG_a} + \frac{C_b}{BCG_b} + \ldots + \frac{C_n}{BCG_n}\right] \text{soil} < 1.0$$

If the sum of the fractions (the summed ratios between the radionuclide concentrations in environmental media and the radionuclide-specific BCGs) is less than 1.0, the dose is below the biota dose limit. Receptors are organized as simply terrestrial or aquatic at this level of assessment, without consideration of combined pathways. Note that BCGs for water are included in both aquatic and terrestrial evaluations, accounting for the total exposure that an organism would encounter. If the sum of the ratios for all media is greater than 1.0 then the person should consider using RESRAD-BIOTA (a program publicly available from the DOE) for further evaluation beyond the screening step. RESRAD-BIOTA is a user-friendly tool that implements the graded approach methodology described in DOE (2002) and the program can be downloaded from: <web.evs.anl.gov/resrad/RESRAD_Family/>.

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