Pacific Gas and Electric Company

Yvonne Meeks
Manager – Gas T&D
Remediation Projects

Mailing Address
4325 South Higuera Sreet
San Luis Obispo, CA 93401
Location
6588 Ontario Road
San Luis Obispo, CA 93405
Tel: (805) 234-2257
Email: yjm1@pge.com

June 19, 2007

Dr. J. Michael Eichelberger
Associate Toxicologist
Department of Toxic Substances Control, Human and Ecological Risk Division
8800 Cal Center Drive
Sacramento, California 95826

Ms. Carrie Marr
Environmental Contaminants Specialist
United States Fish and Wildlife Service
2321 W Royal Palm Road, Suite 103
Phoenix, Arizona 85021

Subject: Topock Compressor Station – Ecological Exposure Parameters, Bioaccumulation Factors, and Toxicity Reference Values

Dear Dr. Eichelberger and Ms. Marr:

Enclosed is the second technical memorandum prepared as part of the RCRA Facility Investigation (RFI/RI) process to support the soil ecological risk assessment and soil investigation at the Pacific Gas and Electric (PG&E) Topock Compressor Station. This technical memorandum describes ecological exposure parameters and bioaccumulation factors for use in wildlife exposure dose modeling, and toxicity reference values to be compared with modeled doses. This information will also support the development of Comparison Levels for soil for use in making soil sampling decisions. We will be in touch to schedule a conference call and we look forward to discussing this information with you.

If you have any questions regarding this memorandum, please call me at (805) 234-2257.

Sincerely,

Yvonne Meeks
Topock Project Manager

Enclosures:
Technical Memorandum: Topock Compressor Station – Ecological Exposure Parameters, Bioaccumulation Factors, and Toxicity Reference Values

cc: Lynn Wellman, USFWS
Aaron Yue, DTSC
Cathy Wolff-White, BLM
Casey Padgett, USDOI

MEMO

ARCADIS U.S., Inc.
2033 North Main Street
Suite 340
Walnut Creek
California 94596
Tel 925.274.1100
Fax 925.274.1103

To:
Yvonne Meeks/PG&E

Copies:

From:
Bridgette DeShields/Kim Walsh

Date:
19 June 2007

ARCADIS BBL Project No.:
RC000689.0002

Subject:
Topock Compressor Station – Ecological Exposure Parameters, Bioaccumulation Factors, and Toxicity Reference Values

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This is the second technical memorandum in a series, prepared by ARCADIS U.S., Inc. (ARCADIS BBL [ABBL], formerly known as Blasland, Bouck & Lee, Inc.), that describes ecological risk assessment (ERA) components for future evaluation of areas of concern (AOCs) associated with the Pacific Gas and Electric (PG&E) Topock Compressor Station, located in San Bernardino County, California (the facility). The first memorandum (ABBL, 2007), described ecological conceptual site models (CSMs), assessment endpoints, and receptors of concern for the ERA for soil exposures outside the facility fenceline. The purpose of this memorandum is to describe ecological exposure parameters, bioaccumulation factors (BAFs), and toxicity reference values (TRVs) that will be used to estimate potential ecological risks associated with exposure to chemicals of potential concern (COPCs) in soil outside the facility fenceline.

Background

PG&E is conducting investigative and remedial activities at the Topock Compressor Station located in San Bernardino County, California, 15 miles southeast of Needles (Figure 1 from Programmatic Biological Assessment (CH2M Hill, 2006). The facility is currently active and will continue operating into the foreseeable future. Historically, chromium was added to cooling water, and from 1951 to 1964 untreated wastewater was discharged to Bat Cave Wash (AOC-1) (CH2M Hill, 2005). In addition to AOC-1, there are six other AOCs and two undesignated areas outside the developed area of the compressor station (AOCs 4, 9, 10, 11, 12, and 14, and undesignated areas Potential Pipeline Disposal area and the Former

300B Pipeline Liquids Tank area). Please refer to the first technical memorandum for additional site-specific background information (ABBL, 2007).

The soil investigation study area is located in the Mojave Desert west of the Colorado River (Figure 1-3 from the Remedial Investigation Report; CH2M Hill, 2005). The Compressor Station borders the Havasu National Wildlife Refuge (HNWR) and Bureau of Reclamation lands. The ecological components described below are for use in evaluating the upland area comprised of creosote bush scrub and Mojave wash (Bat Cave Wash) (ABBL, 2007). This memorandum provides receptor-specific inputs related to the assessment endpoints for sufficient rates of survival, growth and reproduction to sustain avian and mammalian populations.

To calculate exposures to wildlife receptors, receptor-specific parameters will be used in the dose equation listed below.

$$ADD_t = ADD_f + ADD_s \qquad \text{Equation 1}$$

Where:

ADD_t = Total Average Daily Dose
ADD_f = Average Daily Dose resulting from food
ADD_s = Average Daily Dose resulting from soil

Exposure Parameters

Species presence was previously evaluated and representative receptors were selected, consisting of:

- Gambel's quail (*Callipepla gambelii*) - avian herbivore;
- Cactus wren (*Campylorhynchus brunneicapillus*) – avian insectivore;
- Red-tailed hawk (*Buteo jamaicensis*) – avian carnivore;
- Desert shrew (*Notiosorex crawfordi*) – mammalian insectivore;
- Desert kit fox (*Vulpes macrotis*) – mammalian carnivore; and
- Merriam's kangaroo rat (*Dipodomys merriami*) – mammalian herbivore.

The parameters described below will be used to assess survival, growth, and reproduction endpoints proposed in the first technical memorandum (ABBL, 2007). Exposure parameters were selected from the available literature. Species-specific values are proposed for the following exposure parameters and are presented in Table 1.

Body Weight

Total body weights (BW; in kilograms [kg]) were selected for the red-tailed hawk and desert shrew based on data from the United States Environmental Protection Agency (USEPA) Wildlife Exposure Factors Handbook (USEPA,1993) using an average of adult male and female body weights. For the desert kit fox the body weight was selected from O'Farrell et al. (1986), as cited in the California Wildlife Biology, Exposure Factor, and Toxicity Database (CalEPA/Ecotox database [CalEPA, 2007]), using an average of adult male and female body weights. Body weights for Gambel's quail and the cactus wren were selected from sources cited in Birds of North America (2005). Gorsuch (1934), provided an average body weight for adult males and females for Gambel's quail, and Anderson and Anderson (1973) provided an average body weight of adult males and females for the cactus wren. A body weight for Merriam's kangaroo rat was obtained from Nagy (1999) as cited in Nagy (2001).

Dietary Composition

The diet type for each receptor was assumed using information from the California Department of Fish and Game Wildlife Notes (CDFG) (CalEPA, 2005). While dietary composition is likely more complex, following USEPA guidance (USEPA, 1997), it will be conservatively assumed that the diet of each receptor will consist of 100 percent (%) of the most contaminated food item as follows:

- Gambel's quail: 100% plants;
- Cactus wren: 100% invertebrates;
- Red-tailed hawk: 100% mammals;
- Desert shrew: 100% invertebrates;
- Desert kit fox: 100% mammals; and
- Merriam's kangaroo rat: 100% plants.

Food Ingestion Rate

Total daily food ingestion rates (FIR) in kilograms per day (kg/day) were estimated using allometric equations from Nagy (2001). Rates are presented in dry weight and based on body mass, metabolic rates, and dietary habits. Specific equations were available for Gambel's quail, desert kit fox, and Merriam's kangaroo rat. General equations were used for the remaining receptors as indicated in Table 1.

Incidental Soil Ingestion Rate

The incidental soil ingestion rate (SIR) in kg/day for each receptor is based on the FIR multiplied by the percentage of soil in the total daily diet. These values were based on data from Beyer et al. (1994), based on the diet type and feeding habits of each receptor. If soil ingestion data were not available for a specific receptor, surrogate and representative species were used based on similar feeding habits. Surrogates and assumptions are noted in Table 1.

Home Range

Home ranges (acres) are representative of the average area in which receptors normally confine their activity over a specific time period. The size of a home range can be used to determine the proportion of time that an individual is expected to contact contaminated environmental media. Home range for the desert kit fox was selected from Zoellick (1992), and for the rest of the receptors from CDFG (California Environmental Protection Agency [CalEPA], 2005).

Site Use Factor

The site use factor (SUF; unitless) represents the area used by an individual on the site. If the home range of a receptor species is larger than the site acreage, the following equation will be applied:

$$SUF = \text{site acreage} / \text{home range of species} \qquad \text{Equation 2}$$

For the screening level assessment, an SUF of one will be assumed for all species. Site- or area-specific SUFs may be used in latter phases of the ERA.

Bioaccumulation Factors

Biota exposure point concentrations (EPCs) will be developed using literature-derived uptake factors or equations and site-specific soil EPCs that will be provided following soil sampling activities. Most soil-to-tissue uptake factors or equations, which relate soil chemical concentrations to biota tissue chemical concentrations, are provided in the USEPA Ecological Soil Screening Level (Eco-SSL) documents (USEPA, 2005). All equations and uptake factors are from sources as cited in USEPA (2005) unless otherwise noted. These uptake factors will be used in conjunction with AOC soil EPCs to estimate biota EPCs. All values are on a dry weight basis.

Soil-to-biota uptake relationships for plants, invertebrates, and mammals will be evaluated. These relationships are developed as either uptake factors or regression equations. The BAF is the unitless ratio of biota chemical concentration to soil concentration and is expressed as follows:

$$BAF = C_b / C_s \qquad \text{Equation 3}$$

Where:

BAF = Soil-to-biota bioaccumulation factor (unitless);
C_b = Chemical concentration in biota tissue (mg/kg);
C_s = Chemical concentration in soil (mg/kg).

Regression equations are expressed as follows:

$$\ln(C_b) = M*\ln(C_s) + I \qquad \text{Equation 4}$$

Where:

C_b = Chemical concentration in biota tissue (mg/kg);
M = Slope of regression line;
C_s = Chemical Concentration in soil (mg/kg);
I = y-intercept of regression line (unitless).

Soil-to-Plant Uptake

Uptake relationships for plants were available for all constituents and are presented in Table 2. Regression equations were available for antimony, beryllium, cadmium, copper, lead, mercury, nickel, selenium, and zinc. The remaining constituents have a calculated BAF based on empirical data.

Soil-to-Invertebrate Uptake

Uptake relationships for invertebrates were available for all constituents. Regression equations were available for arsenic, cadmium, lead, mercury, selenium, and zinc. BAFs were not available for molybdenum and thallium. However, based on a similar approach described by the USEPA Region 6 ERA guidance (USEPA, 1999a), BAFs for molybdenum and thallium were estimated by calculating the mean of the available empirical invertebrate BAFs for metals. The remaining constituents have a calculated BAF based on empirical data.

Soil-to-Mammal Uptake

Uptake relationships for mammals were available for all constituents. Regression equations were available for arsenic, cadmium, chromium, hexavalent chromium, cobalt, copper, lead, nickel, selenium, and zinc. The remaining constituents have a calculated BAF based on empirical data.

Toxicity Reference Values

The toxicity of a constituent is assessed by identifying a TRV specific to the constituents and receptors being evaluated. TRVs are conservative literature derived toxicity values and are biased toward protection of the individual, when ecological risk assessments are generally designed to protect species at the population level of ecological organization. Therefore, estimated exposure doses exceeding TRVs do not necessarily indicate adverse effects to populations of receptor species at the site.

Daily dose TRVs will be used to evaluate risk to avian and mammalian species via the ingestion pathway. TRVs are expressed in milligram per kilogram body weight per day (mg/kg-bw/day), and represent a dose associated with no-effect (no-observed-adverse-effect-level [NOAEL]) or effect threshold (lowest-observable-adverse-effects-level [LOAEL]).

Following USEPA guidance (USEPA, 1997), wildlife TRVs were developed based on population level assessment endpoints such as survival, reproductive, development, and growth for wildlife. TRVs were developed for the protection of birds and mammals following appropriate guidance (USEPA, 1999b; USEPA, 2005). TRV selection included a review of toxicity benchmarks from standard sources with appropriate endpoints. Following CalEPA guidance (CalEPA, 1996, 1999), TRVs were adjusted for differences in body weight between the site-specific wildlife receptor and the laboratory animals used in the studies to develop the TRVs was significant (i.e., greater than two orders of magnitude). Thus, literature derived mammalian TRVs for arsenic, copper, and silver were allometrically adjusted for the desert shrew and Merriam's kangaroo rat using the allometric equation from Sample and Arenal (1999):

$$Aw = At * (BWt/BWw)^{1-b} \qquad \text{Equation 5}$$

Where:

Aw = toxicity value of wildlife species
At = toxicity value of test species (TRV)
BWt = body weight of test species
BWw = body weight of wildlife species
b = allometric scaling factor (1.2 for birds, 0.94 for mammals)

The literature sources used to identify and develop TRVs for the avian and mammalian receptors included the following in order of preference:

- USEPA Eco-SSL Guidance (USEPA, 2005);
- USEPA Region IX Biological Technical Assistance Group (BTAG) and U.S. Navy (CalEPA, 2002);
- ORNL: Toxicological Benchmarks for Wildlife (Sample et al., 1996);
- Other published sources (e.g., USEPA Region 6 Ecological Risk Assessment guidance [USEPA, 1999a]).

The selected TRVs and respective references are presented in Table 3. Allometric conversions for appropriate TRVs and representative receptors are presented in Table 4.

NOAEL and LOAEL TRVs were developed to estimate a range of risks. Low TRVs were preferably based on chronic NOAELs, with an emphasis on studies that measured effects on survival, reproduction, development, and growth endpoints, applicable to the protection of wildlife populations. A NOAEL is defined as the highest level (or dose) at which no adverse effects are observed. Some of the low TRVs from USEPA Eco-SSL guidance (USEPA, 2005) are based on geometric means of multiple NOAELs for growth and reproductive study endpoints. High TRVs are based on LOAELs, defined as the lowest level (or dose) at which adverse effects are observed. For high TRVs, the following hierarchy was used:

For TRVs based on USEPA Eco-SSL guidance (USEPA, 2005):

- If a LOAEL was reported for the study used to derive the NOAEL-based TRV, that LOAEL value was used;
- In the case where a geometric mean of several NOAELs for growth and reproductive endpoints (from USEPA, 2005) was used as the low TRV, the geometric mean of the LOAELs for growth and reproduction was calculated and used for the high TRV; and
- In two cases (arsenic for birds and beryllium for mammals), where there was a single NOAEL used for the low TRV and there was no corresponding LOAEL, the lowest LOAEL greater than the selected NOAEL for growth and reproduction was used. In one case (chromium for mammals), the lowest LOAEL was used as the high TRV to be conservative, since no paired NOAELs and LOAELs are available.

- If NOAELs were not available or reported, (as was the case for silver for birds and mammals) the LOAELs were extrapolated to develop NOAELs using an uncertainty factor (UF) of 10 following USEPA guidance (USEPA, 1997, 1999a).

For TRVs not based on the Eco-SSL TRVs:

- If a LOAEL was reported for the study used to derive the NOAEL-based TRV, that LOAEL value was used; and

- If there was no paired LOAEL, an uncertainty factor of 10 was applied to the NOAEL to estimate a LOAEL. In one case, no chronic toxicity data were available to develop thallium TRVs for birds. However, an acute study on starlings was reported (USEPA, 1999a) which was extrapolated to a NOAEL-based TRV using an uncertainty factor of 100 and a LOAEL-based TRV using an uncertainty factor of 10.

Antimony

Avian TRVs could not be derived for antimony due to a lack of available data.

The mammalian NOAEL TRV of 0.059 mg/kg-bw/day was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The NOAEL TRV was selected from a study examining reproductive effects on rats and is the highest bounded[a] NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints based on a study by Rossi et al. (1987*)*. The LOAEL TRV was the bounded value of 0.59 mg/kg-bw/day from the same study.

Arsenic

The NOAEL TRV of 2.24 mg/kg-bw/day for arsenic for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV for arsenic could not be derived by calculating a geometric mean of NOAELs, therefore the lowest NOAEL value for growth and reproduction was selected based on a study examining reproductive, growth, and survival effects on chickens based on a study by Holcman and Stibiju (1997). The LOAEL TRV of 3.55 mg/kg-bw/day was the lowest bounded LOAEL greater than the selected NOAEL for reproduction and growth, based on a study by Hoffman et al. (1992) examining growth effects on the mallard duck.

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[a] Bounded refers to NOAEL values that have a corresponding LOAEL value from the same ecological endpoint of a study.

The NOAEL TRV of 1.04 mg/kg-bw/day for arsenic for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was selected from a study examining growth effects on dogs and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints based on a study by Neiger and Osweiler (1989). The LOAEL TRV of 1.66 mg/kg-bw/day was the bounded value from the same study. The body weight of the test species was 10.1 kg, which is significantly greater than the body weights of the desert shrew (0.0168 kg) and Merriam's kangaroo rat (0.0343 kg) and therefore, the mammalian TRVs for arsenic will require allometric conversions using Equation 5; allometrically adjusted TRVs are presented in Table 4.

Barium

Avian TRVs for barium could not be derived due to a lack of available data.

The NOAEL TRV of 51.8 mg/kg-bw/day for barium for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A mammalian LOAEL TRV of 82.6 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

Beryllium

Avian TRVs for beryllium could not be derived due to a lack of available data.

The NOAEL TRV of 0.532 mg/kg-bw/day for beryllium for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). Since a sufficient number of NOAEL values for reproduction and growth endpoints were not available to calculate a geometric mean, the mammalian NOAEL TRV of 0.532 mg/kg-bw/day was selected from a study by Shroeder and Mitchner (1975), examining survival effects on rats and is the lowest NOAEL for reproduction, growth, and survival endpoints. There were no bounded LOAELs for comparison, therefore a LOAEL TRV of 0.63 mg/kg-bw/day was selected from the same study and is the lowest LOAEL greater than the selected NOAEL for growth, reproduction, and survival endpoints.

Cadmium

The NOAEL TRV of 1.47 mg/kg-bw/day for cadmium for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV for cadmium was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 6.35 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 0.77 mg/kg-bw/day for cadmium for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was selected from a study by Yuhas et al. (1979), examining the growth effects on rats and is the highest bounded NOAEL lower than the lowest bounded LOAEL. The LOAEL TRV of 7.7 mg/kg-bw/day is the bounded value from the same study.

Chromium

The NOAEL TRV of 2.66 mg/kg-bw/day for chromium for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV for chromium (based on trivalent chromium) was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. The LOAEL TRV of 15.6 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 2.4 mg/kg-bw/day for chromium for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). A mammalian NOAEL TRV for chromium was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. As mentioned earlier, the LOAEL TRV of 9.62 mg/kg-bw/day was selected using a conservative value of the lowest LOAEL for reproduction and growth, since no bounded NOAELs were available for comparison. The LOAEL TRV was selected from a study by Zahid et al. (1990), examining reproductive effects on mice.

Hexavalent Chromium

Avian TRVs could not be calculated for hexavalent chromium due to a lack of available data.

The NOAEL TRV of 5.66 mg/kg-bw/day for hexavalent chromium for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV for hexavalent chromium was selected from a study by Wolfe (1997), examining growth effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 12 mg/kg-bw/day is the bounded value from the same study.

Cobalt

The NOAEL TRV of 7.61 mg/kg-bw/day for cobalt for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.3 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 7.33 mg/kg-bw/day for cobalt for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.8 mg/kg-bw/day was also derived by calculating a geometric mean of LOAEL values for reproduction and growth endpoints.

Copper

The NOAEL TRV of 4.05 mg/kg-bw/day for copper for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV was selected for copper from a study by Ankari et al. (1998), examining reproductive effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 12.1 mg/kg-bw/day was the bounded value from the same study.

The NOAEL TRV of 5.6 mg/kg-bw/day for copper for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was selected from a study by Allcroft et al. (1961), examining growth and survival effects on pigs and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 9.34 mg/kg-bw/day is the bounded value from the same study. The test species had a body weight of 100 kg, which is significantly greater than the body weights of the desert shrew (0.0168 kg) and Merriam's kangaroo rat (0.0343 kg) and therefore, the mammalian TRVs for copper will require allometric conversions using Equation 5; allometrically adjusted TRVs are presented in Table 4.

Lead

The NOAEL TRV of 1.63 mg/kg-bw/day for lead for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV was selected from a study by Edens and Garlich (1983), examining the reproductive effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The selected LOAEL TRV of 3.26 mg/kg-bw/day was the bounded value from the same study.

The NOAEL TRV of 4.7 mg/kg-bw/day for lead for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was selected from a study by Kimmel et al. (1980), examining growth effects on rats and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints. The LOAEL TRV of 8.9 mg/kg-bw/day was the bounded value from the same study.

Mercury

Avian TRVs could not be derived for mercury from USEPA Eco-SSL guidance (USEPA, 2005); therefore BTAG values (CalEPA, 2002) were used. The avian NOAEL TRV of 0.039 mg/kg-bw/day was obtained from a study examining reproductive effects on mallards by USEPA Great Lakes (USEPA, 1995). The avian LOAEL TRV of 0.18 mg/kg-bw/day was obtained from a study examining mortality and neurological effects on mallards USEPA Great Lakes (USEPA,1995).

Similarly, BTAG values (CalEPA, 2002) for mercury were used for mammalian TRVs. A mammalian NOAEL TRV of 0.25 mg/kg-bw/day and LOAEL TRV of 4.0 mg/kg-bw/day based on reproductive effects on mice were obtained from a study by USEPA Great Lakes (USEPA, 1995).

Molybdenum

Avian TRVs could not be derived for molybdenum from USEPA Eco-SSL guidance (USEPA, 2005) nor from CalEPA (2002), due to a lack of available data. Therefore, avian NOAEL TRV of 3.5 mg/kg-bw/day and LOAEL TRV of 35.3 mg/kg-bw/day based on reproductive effects on chickens were obtained from a study by Lepore and Miller (1965), presented in Sample et al. (1996).

Similarly, mammalian NOAEL TRV of 0.26 mg/kg-bw/day and LOAEL TRV of 2.6 mg/kg-bw/day based on reproductive effects on mice were obtained from a study by Schroeder and Mitchner (1971), presented in Sample et al. (1996).

Nickel

The NOAEL TRV of 6.71 mg/kg-bw/day for nickel for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV was derived by calculating a geometric mean of NOAEL values for reproduction and growth endpoints. A LOAEL TRV of 18.6 mg/kg-bw/day was also derived by calculating a geometric mean for LOAEL values for reproduction and growth endpoints.

The NOAEL TRV of 1.7 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The mammalian NOAEL TRV was selected from a study by Pandey and Srivastava (2000), examining reproductive effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth and survival endpoints. The LOAEL TRV of 3.4 mg/kg-bw/day was the bounded value from the same study.

Selenium

Avian TRVs could not be derived for selenium from USEPA Eco-SSL guidance (USEPA, 2005), therefore BTAG values (CalEPA, 2002) were used. Avian NOAEL TRV of 0.23 mg/kg-bw/day and LOAEL TRV of 0.93 mg/kg-bw/day based on reproductive effects on mallards were obtained from a study by Heinz et al. (1989).

Similarly, BTAG values (CalEPA, 2002) for selenium were used for the mammalian TRVs. A mammalian NOAEL TRV of 0.05 mg/kg-bw/day was obtained from a study examining liver effects on mice by Harr et al. (1967). A LOAEL TRV of 1.21 mg/kg-bw/day based on reproductive effects on mice was obtained from a study by Schroeder and Mitchener (1971).

Silver

The low TRV of 2.02 mg/kg-bw/day for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2006). There was insufficient NOAEL data for silver, therefore a low TRV value was extrapolated from the lowest LOAEL of 20.2 mg/kg-bw/day for reproduction and growth endpoints using an uncertainty factor of 10. This low TRV was selected from a study by Jensen et al. (1974), examining the reproductive effects on turkeys.

The low TRV of 6.02 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2006). There was insufficient NOAEL data for reproduction or growth endpoints and therefore, a low TRV value was extrapolated from the lowest LOAEL of 60.2 mg/kg-bw/day for reproduction and growth endpoints using an uncertainty factor of 10. This low TRV was selected from a study by Van Fleet (1976), examining the growth effects on pigs. The test species had a body weight of 8.86 kg, which is significantly greater than the body weights of the desert shrew (0.0168 kg) and Merriam's kangaroo rat (0.0343 kg) and therefore, the mammalian TRVs for silver will require allometric conversions using Equation 5; allometrically adjusted TRVs are presented in Table 4.

Thallium

Avian TRVs could not be derived for thallium from USEPA Eco-SSL guidance (USEPA, 2005), CalEPA (2002), nor from Sample et al. (1996), due to a lack of available data. However, a NOAEL based TRV of was available in USEPA Region 6 ERA guidance (USEPA, 1999a). This TRV was derived from an acute study on starlings by Schafer (1972), where an uncertainty factor of 100 was applied to the acute dose of 35 mg/kg-bw/day to extrapolate to a NOAEL based low TRV of 0.35 mg/kg-bw/day. As no LOAELs were reported, an uncertainty factor of 10 was applied to the acute dose of 35 mg/kg-bw/day to extrapolate to a LOAEL based high TRV of 3.5 mg/kg-bw/day.

Mammalian TRVs could not be derived for thallium from USEPA Eco-SSL guidance (USEPA, 2005), therefore CalEPA (2002) BTAG values were used. Mammalian NOAEL TRV of 0.48 mg/kg-bw/day and LOAEL TRV of 1.43 mg/kg-bw/day based on hair loss effects on rats were obtained from a study by Downs et al. (1960).

Vanadium

The NOAEL TRV of 0.344 mg/kg-bw/day for avian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). The avian NOAEL TRV for vanadium was selected from a study by Hill (1979), examining the growth effects on chickens and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth and survival endpoints. The LOAEL TRV of 0.688 mg/kg-bw/day is the bounded value from the same study.

The NOAEL TRV of 4.16 mg/kg-bw/day for mammalian species was recommended by USEPA Eco-SSL guidance (USEPA, 2005). A mammalian NOAEL TRV was selected from a study by Sanchez (1991), examining the reproductive, growth, and survival effects on mice and is the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival endpoints The LOAEL TRV of 8.31 mg/kg-bw/day is the bounded value from the same study.

Zinc

Avian TRVs could not be derived for zinc from USEPA Eco-SSL guidance (USEPA, 2005), therefore BTAG values (CalEPA, 2002) for zinc were used. Avian NOAEL TRV of 17.2 mg/kg-bw/day and LOAEL TRV of 172 mg/kg-bw/day based on growth, reproductive, and multiple organ effects on mallards were obtained from a study by Gasaway and Buss (1972).

Similarly, BTAG values (CalEPA, 2002) for zinc were used for the mammalian TRVs. A mammalian NOAEL TRV of 9.61 mg/kg-bw/day based on a study examining pancreas and adrenal cortex endpoints on mice was obtained from a study by Aughey et al. (1977). A LOAEL TRV of 411.4 mg/kg-bw/day based on developmental effects on rats was obtained from a study by Schlicker and Cox (1968).

Closing

The exposure parameters, BAFs, and TRVs discussed above will be used to evaluate potential ecological effects associated with exposure to site-specific COPCs in soil. The values selected were based on the most appropriate and recent data available, specific to each receptor and COPC.

References

Allcroft, R, Burns, KN, and Lewis, G. 1961. The effects of high levels of copper in rations for pigs. *Vet. Rec*. 73: 714. Ref ID: 14387

Anderson A. A. and A. Anderson 1973. The Cactus Wren. Univ. of Arizona Press, Tucson.

Ankari, A., Najib, H., and al Hozab, A. 1998. Yolk and serum cholesterol and production traits, as affected by incorporating a supraoptimal amount of copper in the diet of the leghorn hen. *Br. Poult. Sci*. 39(3): 393-397. Ref ID: 2006

ARCADIS BBL. (ABBL). 2007. Topock Compressor Station – Ecological Conceptual Site Models, Assessment Endpoints, and Receptors of Concern (TM 1). Prepared for Pacific Gas and Electric. April.

Aulerich, R. J., R. K. Ringer, and S. Iwamoto. 1974. Effects of dietary mercury on mink. *Arch. Environ. Contam. Toxicol.* 2: 43-51.

Baes, C.F., R. Sharp, A. Sjoreen and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp.

Bechtel Jacobs Company LLC. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, Tennessee. BJC/OR-133.

Beyer, W. N., E. Connor, and S. Gerould. 1994. Survey of soil ingestion by wildlife. *Journal of Wildlife Management* 58:375-382.

Birds of North America. 2005. Cornell Lab of Ornithology. http://bna.birds.cornell.edu/BNA/

California Environmental Protection Agency (CalEPA). 1996. Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities. Department of Toxic Substances Control: Human and Ecological Risk Division.

_________ 2005. California Department of Fish and Game (CDFG). Biogeographic Data Branch: Wildlife Notes. http://www.dfg.ca.gov/bdb/html/cawildlife.html

______1999. Guidance for Ecological Risk Assessments (EcoNOTEs): EcoNOTE 2. Department of Toxic Substances Control: Human and Ecological Risk Division. June 9...

______2002. Currently Recommended U.S. Environmental Protection Agency Region 9 Biological Technical Assistance Group (BTAG) Mammalian and Avian Toxicity Reference Values (TRVs). Department of Toxic Substances Control: Human and Ecological Risk Division. November 21.

______2007. California Wildlife Biology, Exposure Factor, and Toxicity Database (CalEPA/Ecotox). http://www.oehha.ca.gov/scripts/cal_ecotox/species.asp

CH2M Hill. 2005. RCRA Facility Investigation/Remedial Investigation Report; Prepared for Pacific Gas and Electric. February.

CH2M Hill. 2006. Programmatic Biological Assessment; Prepared for Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions. June.

Downs et al., 1960. Acute and sub-acute toxicity studies of thallium compounds. *Industrial Hygiene Journal*, 21:399-406.

Edens, F. W. and Garlich, J. D. 1983. Lead-induced Egg Production Decrease in Leghorn and Japanese Quail Hens. *Poult. Sci.* 62(9): 1757-1763. Ref ID: 2608

Gasaway & Buss, 1972. Zinc toxicity in the mallard duck. *Journal of Wildlife Management*, 36(4): 1107-1117.

Gorsuch, D.M. 1934. Life History of the Gambel Quail in Arizona. *University of Arizona Bull*. 2: 1-89.

Gullion, G. W. 1962. Organization and movements of coveys of a Gambel quail population. Condor 64:402-415.

Harr et al., 1967. Selenium toxicity in rats. International Symposium on Selenium in Biomedicine 1966 (Oregon State University). Editor: O. H. Muth. Westport, Conn., Avi Pub. Co. 445 p.

Hawes, M. L. 1977. Home range, territoriality, and ecological separation in sympatric shrews, Sorex vagrans and Sorex obscurus. J. Mammal. 58:354-367.

Heinz et al., 1989. Impaired reproduction of mallards fed an organic form of selenium. *Journal of Wildlife Management*, 53(2):418-428.

Hill, C. H. 1979. Studies on the ameliorating effect of ascorbic acid on mineral toxicities in the chick. *J Nutr.* 109(1): 84-90. Ref ID: 1370

Hoffman, D. J., Sanderson, C. J., LeCaptain, L. J., Cromartie, E., and Pendleton, G. W. 1992. Interactive effects of arsenate, selenium, and dietary protein on survival, growth, and physiology in mallard ducklings. *Arch Environ Contam Toxicol*. 22(1): 55-62. Ref ID: 1376

Holcman, A. and Stibilj, V. 1997. Arsenic residues in eggs from laying hens fed with a diet containing arsenic (iii) oxide. *Arch. Environ. Contam. Toxicol*. (1997) 32(4): 407-410. Ref ID: 5305

Jensen, L. S., Peterson, R. P., and Falen, L. 1974. Inducement of Enlarged Hearts and Muscular Dystrophy in Turkey Poults with Dietary Silver. *Poultry Science. 53(1): 57-64.* Ref Id: 9892

Kimmel, C. A., Grant, L. D., Sloan, C. S., and Gladen, B. C. 1980. Chronic Low Level Lead Toxicity in the Rat. 1. Maternal Toxicity and Peri Natal Effects. *Toxicol. Appl. Pharmacol*. 56(1): 28-41. Ref ID: 2737

Lepore, P. D., and R. F. Miller, 1965. Embryonic viability as influenced by excess molybdenum in chicken breeder diets. *Proc. Soc. Exp. Biol. Med.* 118: 155-157

Nagy, K.A., I. A. Girard, T. K. Brown. Annual Review of Nutrition, July 1999. Energetics of Free-Ranging Mammals, Reptiles, and Birds. Vol. 19, Pages 247-277 (doi: 10.1146/annurev.nutr.19.1.247)

Nagy KA, 2001. Food Requirements of Wild Animals: Predictive equations for the free-living mammals, reptiles, and birds. *Nutrition Abstracts and Reviews, Series* B71, 21R-31R.

Neiger, RD and Osweiler, GD. 1989. Effect of subacute low level dietary sodium arsenite on dogs. *Fund. Appl. Toxicol.* 13: 439-451. Ref ID: 14583

O'Farrell, Thomas P. and Larry Gilbertson. 1986. Ecology of the desert kit fox, Vulpes macrotis arsipus, in the Mojave Desert of southern California. *Bull. South. Calif. Acad. Sci.* 85(1):1-15.q

Pandey, R. and Srivastava S. P. 2000. Spermatotoxic effects of nickel in mice. Bull. *Environ. Contam. Toxicol.* 64[2]: 161-167. Ref ID: 36722

Rossi, F., R. Acampora, C. Vacca, S. Maione, M. G. Matera, R. Servodio, and E. Marmo. 1987. Prenatal and postnatal antimony exposure in rats: effect on vasomotor reactivity development of pups. *Teratog. Carcinog. Mutagen. 7*(5): 491-496.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3.

Sample, B.E. and C.A. Arenal. 1999. Allometric Models for Interspecies Extrapolation of Wildlife Toxicity Data. Bull. Environ. Contam. Toxicol. (1999) 62: 653-663.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998a. Development and Validation of Bioaccumulation Models for Small Mammals. February. Prepared for the U.S. Department of Energy. ES/ER/TM-219.

Sample, B., J.J. Beauchamp, R. Efroymson, G.W. Suter, II, and T. Ashwood. 1998b. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory. ES/ER/TM-220.

Sanchez, D., Ortega, A., Domingo, J. L., and Corbella, J. 1991. development toxicity evaluation of orthovanadate in the mouse. *Biol. Trace Elem. Res*. (1991) 30(3): 219-26. Ref ID: 17465

Schafer, E.W. 1972. "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical and Other Chemicals to Wild Birds." *Toxicological and Applied Pharmacology*. Volume 21. Pages 315-330.

Schlicker & Cox, 1968. Maternal dietary zinc and development: Zinc, iron, and copper content of the rat fetus. *Journal of Nutrition*, 92:245-252

Schroeder, H. A and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health*. 23: 102-106.

Schroeder, Henry A. and Mitchener, Marian. 1975. Life-term studies in rats. Effects of aluminum, barium, beryllium, and tungsten *J. Nutr*. 105(4): 421-7. Ref ID: 17086

Soholt, L. F. 1973. Consumption of primary production by a population of kangaroo rats (Dipodomys merriami) in the Mojave Desert. Ecol. Monogr. 43:357-376.

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. U.S. Environmental Protection Agency. EPA/600/R-93/187a. Washington, DC.

______1995. Great Lakes Water Quality initiative Criteria Documents for the Protection of Wildlife. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-820\b-95\008.

______1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC. EPA 540-R-97-0C5.

______1999a. Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. August.

______1999b. Ecological Risk Assessment and Risk Management Principles for Superfund Sites. Office of Emergency and Remedial Response, Washington, DC. OSWER Directive 9285.7-28.P.

______2005. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. November 2003, revised March, 2005. http://www.epa.gov/ecotox/ecossl/

______2006. Eco-SSL for Silver. Interim Final OSWER Directive 9285.7-77. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. October 2006.

Van Vleet, J. F. Induction of Lesions of Selenium Vitamin E Deficiency in Pigs Fed Silver. 1976. *American Journal of Veterinary Research.* 37(12): 1415-1420. Ref Id: 22589

Wolfe, G. W. 1997. Final report on the reproductive toxicity of potassium dichromate (hexavalent) (CAS No. 7778-50-9) administered in diet to BALB/c mice. National Toxicology Program RACB95002. 181 p. Ref ID: 25927

Yuhas, E. M., Schnell, R. C., and Miya, T. S. 1979. Dose-related alterations in growth and mineral disposition by chronic oral cadmium administration in the male Rat. *Toxicology.* 12(1): 19-29. Ref ID: 776

Zahid, Z. R., Al Hakkak, Z. S., Kadhim, A. H. H., Elias, E. A., and Al Jumaily, I. S. 1990. Comparative effects of trivalent and hexavalent chromium on spermatogenesis of the mouse. *Toxicol. Environ. Chem.* 25(2-3): 131-136.Ref ID: 3098

Zoellick, Bruce W. and Norman S. Smith. 1992. Size and spatial organization of home ranges of kit foxes in Arizona. J. Mammal. 73(1): 83-88.

Table 1
Exposure Parameters for Representative Receptors
Pacific Gas and Electric Topock Compressor Station
Needles, California

Exposure Parameters for Topock Representative Receptors														
Parameter	**Symbol**	**(units)**	**Gambel's Quail**	**Source**	**Cactus Wren**	**Source**	**Red-tailed Hawk**	**Source**	**Desert Shrew**	**Source**	**Desert Kit Fox**	**Source**	**Merriam's Kangaroo Rat**	**Source**
Diet														
Proportion of Diet Containing Plants	pla	(proportion)	1	CDFG (CalEPA, 2005)	--		--	--	--	--	--	--	1	CDFG (CalEPA, 2005)
Proportion of Diet Containing Invertebrates	inv	(proportion)	--	--	1	CDFG (CalEPA, 2005)	--	--	1	CDFG (CalEPA, 2005)	--	--	--	--
Proportion of Diet Containing Mammals	mam	(proportion)	--	--	--	--	1	CDFG (CalEPA, 2005)	--	--	1	Assumed based on information presented for the kit fox in CDFG, (CalEPA, 2005)	--	--
Ingestion Rate of Food	IR	(kg/day)	0.00649	Nagy, 2001; Table 1: Species-specific feeding rates.	0.00713	Nagy, 2001; ingestion equation for insectivorous birds	0.0899	Nagy, 2001; ingestion equation for carnivorous birds	0.00216	Nagy, 2001; ingestion equation for insectivores	0.0702	Nagy, 2001; Table 1: Species-specific feeding rates.	0.00282	Nagy, 2001; Table 1: Species-specific feeding rates.
			(dry weight)		(dry weight)		(dry weight)		(dry weight)		(dry weight)		(dry weight)	
Body Weight	bw	(kg)	0.1693	Based on average weight for M/F adults from Gorsuch, 1934; cited in Birds of North America, 2004-2005	0.0389	Based on average weight for M/F adults from Anderson 1973; cited in Birds of North America, 2004-2005	1.134	Based on average weight for M/F adults; USEPA, 1993	0.0168	Based on average weight for M/F adults for short-tailed shrew; USEPA, 1993	1.985	Based on the average weight for M/F adults; O'Farrell et al., 1986 cited in Cal/Ecotox (CalEPA, 2007).	0.0343	Nagy, 1999 cited in Nagy, 2001
Media Uptake														
Percent Soil in Diet			10.4		9.3		1.4		2		2.8		2.4	
Incidental Soil Ingestion Rate	SIR	(kg/day)	0.000675	Based on American Woodcock; EPA, 1993	0.000663	Based on wild turkey; Beyer et al., 1994	0.00126	Assumed to be no greater than 1/2 soil intake of red fox; Beyer et. al., 1994	0.0000432	Based on white-footed mouse; Beyer et al., 1994	0.00197	Based on the red fox; Beyer et al., 1994	0.0000677	Based on the meadow vole; Beyer et al., 1994
Site Usage														
Site Use Factor (assumed)	SUF	(unitless)	1		1		1		1		1		1	
Home Range*	HR	acres	35.7	Gullion, 1962; cited in CDFG (CalEPA, 2005)	4.8	Anderson and Anderson, 1973; cited in CDFG (CalEPA, 2005)	2471	CDFG, 2005	0.1	Based on dusky shrew; (Hawes, 1977; cited in CDFG (CalEPA, 2005)	3039	Zoellick, 1992	0.13	Based on 7.6 individuals per acre; (Soholt, 1973; cited in CDFG (CalEPA, 2005)

Table 1
Exposure Parameters for Representative Receptors
Pacific Gas and Electric Topock Compressor Station
Needles, California

Notes:

* Home ranges were converted to acres if presented in units other than acres in respective sources.

Sources:

Anderson A. A. and A. Anderson 1973. The Cactus Wren. Univ. of Arizona Press, Tucson.

Beyer, W. N., E. Connor, and S. Gerould. 1994. Survey of soil ingestion by wildlife. Journal of Wildlife Management 58:375-382.

California Environmental Protection Agency (CalEPA). 2005. California Department of Fish and Game (CDFG). Biogeographic Data Branch: Wildlife Notes. http://www.dfg.ca.gov/bdb/html/cawildlife.html

CalEPA. 2007. California Wildlife Biology, Exposure Factor, and Toxicity Database (CalEPA/Ecotox). http://www.oehha.ca.gov/scripts/cal_ecotox/species.asp

Gorsuch, D.M. 1934. Life History of the Gambel Quail in Arizona. University of Arizona Bull. 2: 1-89.

Gullion, G. W. 1962. Organization and movements of coveys of a Gambel quail population. Condor 64:402-415.

Hawes, M. L. 1977. Home range, territoriality, and ecological separation in sympatric shrews, Sorex vagrans and Sorex obscurus. J. Mammal. 58:354-367.

Nagy, K.A., I. A. Girard, T. K. Brown. Annual Review of Nutrition, July 1999. Energetics of Free-Ranging Mammals, Reptiles, and Birds. Vol. 19, Pages 247-277 (doi: 10.1146/annurev.nutr.19.1.247)

Nagy KA, 2001. Food Requirements of Wild Animals: Predictive equations for the free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B71, 21R-31R

O'Farrell, Thomas P. and Larry Gilbertson. 1986. Ecology of the desert kit fox, Vulpes macrotis arsipus, in the Mojave Desert of southern California. Bull. South. Calif. Acad. Sci. 85(1):1-15.

Soholt, L. F. 1973. Consumption of primary production by a population of kangaroo rats (Dipodomys merriami) in the Mojave Desert. Ecol. Monogr. 43:357-376.

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. U.S. Environmental Protection Agency. EPA/600/R-93/187a. Washington, DC.

Zoellick, Bruce W. and Norman S. Smith. 1992. Size and spatial organization of home ranges of kit foxes in Arizona. J. Mammal. 73(1): 83-88.

Table 2
Bioaccumulation Factors
Pacific Gas and Electric Topock Compressor Station
Needles, California

Constituent	**Soil-to-Biota Bioaccumulation Factors***		
	BAF_{plant} (dw) (unitless)	**BAF_{invert} (dw) (unitless)**	**BAF_{mammal} (dw) (unitless)**
Antimony	$\ln(C_p) = 0.938 * \ln(Cs) - 3.233$	1.00	0.05
Arsenic	0.03752	$\ln(C_i) = 0.706 * \ln(Cs) - 1.421$	$\ln(C_m) = 0.8188 * \ln(Cs) -4.8471$
Barium	0.156	0.091	0.0075
Beryllium	$\ln(C_p) = 0.7345 * \ln(Cs) - 0.5361$	0.045	0.05
Cadmium	$\ln(C_p) = 0.546 * \ln(Cs) - 0.475$	$\ln(C_i) = 0.795 * \ln(Cs) + 2.114$	$\ln(C_m) = 0.4723 * \ln(Cs) - 1.2571$
Total Chromium	0.041	0.306	$\ln(C_m) = 0.7338 * \ln(Cs) - 1.4599$
Hexavalent Chromium	0.041	0.306	$\ln(C_m) = 0.7338 * \ln(Cs) - 1.4599$
Cobalt	0.0075	0.122	$\ln(C_m) = 1.307 * \ln(Cs) - 4.4669$
Copper	$\ln(C_p) = 0.394 * \ln(Cs) + 0.668$	0.515	$\ln(C_m) = 0.1444 * \ln(Cs) + 2.042$
Lead	$\ln(C_p) = 0.561 * \ln(Cs) - 1.328$	$\ln(C_i) = 0.807 * \ln(Cs) - 0.218$	$\ln(C_m) = 0.4422 * \ln(Cs) + 0.0761$
Mercury	$\ln(C_p) = 0.544 * \ln(Cs) - 0.996$[b]	$\ln(C_i) = 0.3369 * \ln(Cs) - 0.078$[d]	0.192[c]
Molybdenum	0.25[a]	0.55[e]	$\ln(C_m) = 0.006*50*C_d$[a]
Nickel	$\ln(C_p) = 0.748 * \ln(Cs) - 2.223$	1.059	$\ln(C_m) = 0.4658 * \ln(Cs) - 0.2462$
Selenium	$\ln(C_p) = 1.104 * \ln(Cs) - 0.677$	$\ln(C_i) = 0.733 * \ln(Cs) - 0.075$	$\ln(C_m) = 0.3764 * \ln(Cs) - 0.4158$
Silver	0.014	2.045	0.004
Thallium	0.004[a]	0.55[e]	0.112[c]
Vanadium	0.00485	0.042	0.0123
Zinc	$\ln(C_p) = 0.554 * \ln(Cs) + 1.575$	$\ln(C_i) = 0.328 * \ln(Cs) + 4.449$	$\ln(C_m) = 0.0706 * \ln(Cs) + 4.3632$

Notes:

BAF_{invert} = Soil-to-invertebrate uptake bioaccumulation factor (unitless).
BAF_{mammal} = Soil-to-mammal uptake bioaccumulation factor (unitless).
BAF_{plant} = Soil-to-plant uptake bioaccumulation factor (unitless).
dw = Dry weight.
C_p = Constituent concentration in plants.
C_i = Constituent concentration in invertebrates.
C_s = Constituent concentration in soil.
C_m = Constituent concentration in mammals.
C_d = Concentration in diet.

Sources:

*All BAFs from USEPA, 2005, except as otherwise noted. Ecological Soil Screening Levels. March. http://www.epa.gov/ecotox/ecossl/
(a) Baes, C.F., R. Sharp, A. Sjoreen and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp.

(b) Bechtel Jacobs Company LLC. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, Tennessee. BJC/OR-133.

(c) Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998a. Development and Validation of Bioaccumulation Models for Small Mammals. February. Prepared for the U.S. Department of Energy. ES/ER/TM-219.

(d) Sample, B., J.J. Beauchamp, R. Efroymson, G.W. Suter, II, and T. Ashwood. 1998b. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory. ES/ER/TM-220. Sample et al, 1998b.

(e) Mean of available metal BAFs (invertebrates only). This follows approach in USEPA (1999a).

Table 3
Toxicity Reference Values
Pacific Gas and Electric Topock Compressor Station
Needles, California

Constituent	Wildlife TRVs (mg/kg-bw/day)							
	Birds				Mammals			
	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source	Low TRV (NOAEL)	Source	High TRV (LOAEL)	Source
Metals								
Antimony	NA	--	NA	--	0.059	USEPA, 2005	0.59	USEPA, 2005
Arsenic	2.24	USEPA, 2005	3.55	USEPA, 2005	1.04	USEPA, 2005	1.66	USEPA, 2005
Barium	NA	--	NA	--	51.8	USEPA, 2005	82.6	USEPA, 2005
Beryllium	NA	--	NA	--	0.532	USEPA, 2005	0.630	USEPA, 2005
Cadmium	1.47	USEPA, 2005	6.35	USEPA, 2005	0.770	USEPA, 2005	7.7	USEPA, 2005
Chromium	2.66	USEPA, 2005	15.6	USEPA, 2005	2.40	USEPA, 2005	9.62	USEPA, 2005
Hexavalent Chromium	NA	--	NA	--	5.66	USEPA, 2005	12	USEPA, 2005
Cobalt	7.61	USEPA, 2005	18.3	USEPA, 2005	7.33	USEPA, 2005	18.8	USEPA, 2005
Copper	4.05	USEPA, 2005	12.1	USEPA, 2005	5.60	USEPA, 2005	9.34	USEPA, 2005
Lead	1.63	USEPA, 2005	3.26	USEPA, 2005	4.70	USEPA, 2005	8.90	USEPA, 2005
Mercury	0.039	CalEPA BTAG (2002)	0.2	CalEPA BTAG (2002)	0.25	CalEPA BTAG, 2002	4	CalEPA BTAG, 2002
Molybdenum	3.5	Sample et al., 1996	35.3	Sample et al., 1996	0.26	Sample et al., 1996	2.6	Sample et al., 1996
Nickel	6.71	USEPA, 2005	18.6	USEPA, 2005	1.70	USEPA, 2005	3.40	USEPA, 2005
Selenium	0.23	CalEPA BTAG, 2002	0.93	CalEPA BTAG, 2002	0.05	CalEPA BTAG, 2002	1.21	CalEPA BTAG, 2002
Silver	2.02	USEPA, 2006	20.2	USEPA, 2006	6.02	USEPA, 2006	60.2	USEPA, 2006
Thallium	0.35	USEPA, 1999b	3.5	USEPA, 1999b	0.48	CalEPA BTAG, 2002	1.43	CalEPA BTAG, 2002
Vanadium	0.344	USEPA, 2005	0.688	USEPA, 2005	4.16	USEPA, 2005	8.31	USEPA, 2005
Zinc	17.2	CalEPA BTAG, 2002	172	CalEPA BTAG, 2002	9.61	CalEPA BTAG, 2002	411.4	CalEPA BTAG, 2002

Notes:

kg	kilograms
mg/kg-bw/day	Milligrams per kilogram body weight per day
NA	Not available.
LOAEL	Lowest Observable Adverse Effects Level
NOAEL	No Observable Adverse Effects Level
TRV	Toxicity Reference Value
UF	Uncertainty factor.
--	Not applicable.

Sources:

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3.

CalEPA 2002. Currently Recommended U.S. Environmental Protection Agency Region 9 Biological Technical Assistance Group (BTAG) Mammalian and Avian Toxicity Reference Values (TRVs). Department of Toxic Substances Control: Human and Ecological Risk Division. November 21.

USEPA 1999a. Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities: Appendix E Toxicity Reference Values. August.

USEPA 2005, 2006. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 9285.7-55. United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Washington, DC. November 2003, revised March, 2005. http://www.epa.gov/ecotox/ecossl/

Table 4
Allometrically Converted TRVs for Representative Receptors
Pacific Gas and Electric Topock Compressor Station
Needles, California

	Wildlife Receptors			
	Desert Shrew		Merriam's Kangaroo Rat	
Constituent	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	1.53	2.44	1.46	2.33
Copper	9.43	15.73	9.04	15.07
Silver	8.77	87.68	8.40	84.01

Notes:
"--" = not applicable
Equation used: Aw = At * (BWt/BWw)^1-b
Where:
Aw=toxicity value of wildlife species
At=toxicity value of test species (TRV)
BWt=body weight of test species
BWw=body weight of wildlife species
b=allometric scaling factor (1.2 for birds, 0.94 for mammals)

Source:

Sample, B.E. and C.A. Arenal. 1999. Allometric Models for Interspecies Extrapolation of Wildlife Toxicity Data. Bull. Environ. Contam. Toxicol. (1999) 62: 653-663.