CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL
HUMAN AND ECOLOGICAL RISK DIVISION (HERD)

HERD ECOLOGICAL RISK ASSESSMENT (ERA) NOTE

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ISSUE: Use of Navy/U.S. Environmental Protection Agency (USEPA) Region 9 Biological Technical Assistance Group (BTAG) Toxicity Reference Values (TRVs) for Ecological Risk Assessment.

GUIDANCE: This EcoNOTE encompasses many topics related to the use of Navy/BTAG TRVs in ecological risk assessment. In each section of this document HERD presents rationale and/or recommendations for the following:

> **Section I**. HERD and the BTAG strongly believe that it is important that California responsible parties use the Navy/BTAG TRVs to speed the review process and prevent increased cost and effort in ecological risk assessment at military facilities and other facilities within California.
>
> **Section II**: There is a process agreed upon among the Federal and California regulatory agencies and the natural resource trustees for the revision and updating of the NAVY/BTAG TRVs. Consensus procedures for updating TRVs include regulatory review and close coordination with the BTAG.
>
> **Section III**: Navy/BTAG TRVs are not available for all chemicals of potential ecological concern. A TRV may be proposed for consideration by the BTAG following guidelines presented in Section II. A qualitative risk analysis is proposed for evaluating chemicals for which there is limited toxicological information.
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> **Section IV**: Navy/BTAG TRVs should be used in the predictive assessment phase of the ecological risk assessment.
>
> **Section V**: In addition to the generation of hazard indices, supporting evidence should be documented to substantiate the conclusions of the predictive assessment.
>
> **Section VI**: Hazardous waste sites and permitted facilities frequently include lead as a contaminant of potential ecological concern. The lead TRV is based on lead acetate, a highly bioavailable form of lead. HERD and BTAG recommend that the exposure assessment be refined so that site-specific lead bioavailability is estimated or directly measured.

BACKGROUND

Assessing ecological risk for mammals and birds requires an appropriate toxicity reference value (TRV). For purposes of assessing risk to terrestrial wildlife (mammals and birds) the Navy/BTAG has developed TRVs for a number of inorganic and organic chemicals of concern at hazardous waste sites (Engineering Field Activity West, 1997). A TRV is dose (e.g., mg/kg body wt./day) of a chemical that elicits a particular biological effect (e.g., behavioral abnormality, reproductive failure, altered weight gain). The Navy/BTAG TRV workgroup selected biological effects that primarily related to growth, reproduction, and development; however, all effects deemed ecologically relevant were considered when developing TRVs. TRVs were calculated that represent no-effect levels (TRV-Low) and mid-range adverse effect levels (TRV-High). The TRVs were selected from the published literature following a consensus effort among the Navy, Navy consultants, and several regulatory and natural resource trustee agencies including the USEPA, DTSC, Regional Water Quality Control Board (RWQCB), Office of Environmental Health Hazard Assessment (OEHHA), National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Game (DFG).

I. RATIONALE FOR ADOPTING NAVY/BTAG TRVs FOR ECOLOGICAL RISK ASSESSMENTS CONDUCTED IN CALIFORNIA AND IN USEPA REGION 9

1. *Expedited Review*. The Navy/BTAG TRVs are accepted by regulatory and natural resource trustee agencies for use in predictive ecological risk assessments. The Navy/BTAG TRVs allow responsible parties to expedite agency review and finalization of ecological risk assessments used to support remedial investigations.

2. *Consistency and Efficiency*. It would be very difficult to justify dismissing the Navy/BTAG TRVs at any specific facility when they are currently being used both inside and outside California. If separate values are developed for each site or by each responsible party or contractor, the cost and effort expended in preparing and reviewing sites will be greatly increased. The contractor for each site will develop a large list of reference values and then the regulatory agencies will be required to review the methodology for each of the chemicals at each site. The amount of duplicated effort will be enormous. A similar situation would occur if all the values on the USEPA IRIS database were re-developed at each site for human health risk assessments. Reaching a consensus on alternative values would require an unacceptable expenditure of time and resources, delaying the whole process from site characterization through remediation.

3. *Consensus*. The Navy/BTAG TRVs were developed in a joint effort of the Navy, Navy consultants, and regulatory agencies, including the USEPA, DTSC, RWQCB, NOAA, USFWS, OEHHA, and DFG. A substantial amount of effort went into the development of the TRVs including a comprehensive review of scientific journals by designated working groups. The USEPA, the DTSC, and the other agencies listed

above endorse and recommend the use of the Navy/BTAG toxicity reference values. They have been used or are currently being used for ecological risk assessment at many sites in California and the western US including McClellan Air Force Base, East Fort Baker, Hunters Point Shipyard, the Presidio of San Francisco, Hamilton Army Air Field, Mare Island Naval Shipyard, Naval Air Station Alameda, Naval Weapons Station Concord, Pearl Harbor, Naval Training Center San Diego, Naval Station Treasure Island, Rocketdyne Santa Susana Field Laboratory, and Anderson Air Force Base in Guam. It should be noted that this list includes Air Force and Army facilities as well as Navy facilities, that it includes facilities in southern and northern California and facilities outside of California, and that it includes civilian as well as Department of Defense facilities. It should also be noted that this is not intended to be an exhaustive list, but was compiled from conversations with a few Region 9 BTAG members.

4. *Clarity.* The review of literature, discussion of journal publications, data sources, and final selection of TRVs was an open and deliberative process and was known to all participants, rather than to a select few. In contrast, alternative values proposed for various facilities have been developed by one or two consulting firms and in some cases one individual. The TRVs proposed by these individual contractors have not been reviewed by the regulatory agencies; participation in the review and selection process by the regulatory agencies is lacking and therefore the methodology used to derive these additional proposed TRVs is frequently not clear.

5. *Applicability*. The Navy/BTAG TRVs are applicable at any hazardous waste site with ecological exposure pathways to mammals and birds. Chemical toxicity has no direct relationship to its geographical location, so site-specific conditions are irrelevant to toxicity. Exposure to chemicals, on the other hand, depends greatly on local conditions. It is in exposure assessment that site-specific conditions should be taken into account.

6. *Need for Standard Toxicity Criteria*. HERD and the Region 9 BTAG have emphasized the need for a set of standard, consistent toxicity criteria. To illustrate our concern, we have prepared two tables of toxicity criteria, one for mammals (Table 1) and one for birds (Table 2). Each table includes a comparison of proposed toxicity criteria for the 22 compounds that were selected in the Navy/BTAG effort. The first column in each table lists the Navy/BTAG values. The second column lists the alternative values which are proposed by CH2M Hill (2000a) in their review of the Navy/BTAG document, done for the U.S. Army Biological Technical Assistance Group and the U.S. Army Corps of Engineers. The third column lists toxicity criteria proposed by CH2M Hill (2000b) in a remedial investigation report for Air Force Plant 42. The fourth column lists toxicity criteria proposed for Vandenberg Air Force Base by Tetra Tech (1998) in the Draft Ecotoxicity Profiles document. The fifth column lists toxicity criteria proposed for Vandenberg Air Force Base by Tetra Tech (2000). The tables illustrate remarkable differences in proposed values between CH2M Hill (2000a) and CH2M Hill (2000b), between Tetra Tech (1998) and Tetra Tech (2000),

and between values proposed for Air Force Plant 42 and those proposed for Vandenberg Air Force Base.

We have selected some examples to illustrate these differences.

A. Benzo(a)pyrene was evaluated in mammals in all five reports and all chose a mouse study to determine the toxicity criterion. The Navy/BTAG and CH2M Hill (2000a) values are close to each other (1.3 and 1, respectively), while the other three proposed values are ten times higher.

B. Cobalt was evaluated in mammals in four of the five reports and all chose the same rat study to determine the toxicity criterion. The Navy/BTAG and CH2M Hill (2000a) are both 1.2, while both Tetra Tech proposed values are ten times higher.

C. Lead was evaluated in mammals in three of the five reports and three different rat studies were chosen to determine the toxicity criterion. The CH2M Hill (2000a) proposed value is 42 while the CH2M Hill (2000b) proposed value is 8.

D. Mercury was evaluated in mammals in four of the five reports. The Navy/BTAG differentiated between a larger mammal (mink) and a small mammal (rat) because the mink appears to be more sensitive to mercury. The Navy/BTAG values are 0.027 for the mink and 0.25 for the rat. CH2M Hill (2000a) evaluated the same two studies and proposed 0.015 for the mink and 0.032 for the rat. CH2M Hill (2000b) proposed 13.2 based on a mouse study. Finally, Tetra Tech (2000) proposes 1.0, based on the same mink study used by Navy/BTAG and CH2M Hill (2000a).

E. Nickel was evaluated in mammals in four of the five reports and all chose a rat study to determine the toxicity criterion. The proposed toxicity values, 5 in CH2M Hill (2000a), 190 in Tetra Tech (1998), and 15 Tetra Tech (2000), are all based on the same rat study.

F. Lead was evaluated in birds in all five reports. Navy/BTAG and CH2M Hill (2000a) selected two different Japanese quail studies and proposed values of 0.014 and 0.19, respectively. Tetra Tech (1998) and Tetra Tech (2000) proposed values of 15 and 3.8, respectively, based on the same American kestrel study. CH2M Hill (2000b) proposed three different toxicity criteria, which were a value of 1.13 based on the Japanese quail study used by the Navy/BTAG, a value of 3.85 based on the American kestrel study used by Tetra Tech, and a value of 26 based on a *Coturnix* quail study.

G. Polychlorinated biphenyls were evaluated in birds in all five reports. Navy/BTAG and CH2M Hill (2000a) selected the same chicken study and proposed the same value of 0.09. CH2M Hill (2000b) and Tetra Tech

(1998) selected the same pheasant study, but CH2M Hill (2000b) proposed a value of 0.14 while Tetra Tech (1998) proposed a value of 1.6. Tetra Tech (2000) chooses a screech owl study and proposes a value of 0.42.

In summary, quite different toxicity criteria have been proposed by the same consulting firms [compare CH2M Hill (2000a) with CH2M Hill (2000b) or Tetra Tech (1998) with the Tetra Tech (2000) document], and quite different toxicity criteria have been proposed for different Air Force bases [compare CH2M Hill (2000b) with Tetra Tech (1998) and Tetra Tech (2000)]. The purpose of this exercise is not to demonstrate that these proposed sets of criteria are wrong. Rather, this exercise demonstrates the need for a standard set of criteria that can be applied to all facilities in California. The Navy/BTAG criteria have the advantage of having been derived by consensus, with careful review over several months by participants from the Department of Defense and their contractors, and several federal and state regulatory agencies.

TABLE 1
COMPARISON OF MAMMALIAN TOXICITY CRITERIA (mg/kg body wt./ day)

Analyte	BTAG[1]	CH2M –R[2]	CH2M-AF[3]	TTech-1[4]	TTech-2[5]
Aldrin	0.1	0.2	---	0.2	0.1
Arsenic	0.32	0.396	---	1.0	1.0
B(a)P	1.31	1	10	10	10
Butyltin	0.25	23.4	---	---	---
Cadmium	0.06	1	1	1.0	1.0
Cobalt	1.2	1.2	---	12	12
Copper	2.67	6.34	---	8.5	12
DDT/E/D	0.8	0.8	---	---	0.8
Heptachlor	0.13	0.2	---	---	1.0
Lead	0.0015	42	8	---	---
Lead-organic	---	---	---	5.0	1.0
Lindane	0.05	8	---	3.2	2.4
Manganese	13.7	88	---	88	88
Mercury (large mam.)	0.027	0.015	---	---	1.0
Mercury (small mam.)	0.25	0.032	13.2	---	---
Mercury-organic	---	---	---	0.02	0.024
Methoxychlor	2.5	4	---	---	---
Naphthalene	50	71	50	50	50
Nickel	0.133	5	---	190	15
PCB	0.36	0.068	0.14	0.14	0.14
Selenium	0.05	0.2	---	0.15	0.15
Thallium	0.48	0.0074	0.074	0.7	0.74
Zinc	9.6	160	160	150	120

1. Navy/BTAG Low TRVs (Engineering Field Activity West, 1997).
2. CH2M Hill criteria from the review of the Navy/BTAG TRVs (U.S. Army BTAG & U.S. Army Corps of Engineers, March, 2000a).
3. CH2M Hill criteria from the Air Force Plant 42 RI for OUs 1, 2, 3 (U.S. Air Force, January, 2000b).
4. Tetra Tech Ecotoxicity Profiles, Version 1, for Vandenberg AFB (Tetra Tech, Inc., May 14, 1998).
5. Tetra Tech Ecotoxicity Profiles, Version 2, for Vandenberg AFB (Tetra Tech, Inc., January 26, 2000).

TABLE 2
COMPARISON OF AVIAN TOXICITY CRITERIA (mg/kg body wt./day)

Analyte	BTAG[1]	CH2M –R[2]	CH2M-AF[3]	TTech-1[4]	TTech-2[5]
Aldrin	---	---	---	5.0	5.0
Arsenic	5.5	9.3	---	2.5	5.5
B(a)P	---	---	39.37	---	---
Butyltin	0.73	12.4	---	---	---
Cadmium	0.08	1.45	1.45	1.9	2.1
Cobalt	---	---	---	---	---
Copper	2.3	2.3	---	1.0	33
DDT/DDE/DDD	0.009	0.009	---	---	0.028
Heptachlor	---	---	---	---	11
Lead	0.014	0.19	1.13, 3.85, 26[6]	15	3.8
Lead-organic				0.11	0.11
Lindane	---	5.71	---	5.7	5.7
Manganese	77.6	977	---	977	980
Mercury	0.039	0.068	0.45	---	0.45
Mercury-organic				0.05	0.06
Methoxychlor	---	---	---	---	---
Naphthalene	---	---	40	---	---
Nickel	1.38	17.6	---	77	18
PCB	0.09	0.09	0.14	1.6	0.42
Selenium	0.23	0.4	---	0.5	0.5
Thallium	---	---	36.7	---	---
Zinc	17.2	14.5	14.5	228	14

1. Navy/BTAG Low TRVs (Engineering Field Activity West, 1997)
2. CH2M Hill criteria from the review of the Navy/BTAG TRVs (U.S. Army BTAG & U.S. Army Corps of Engineers, March, 2000a).
3. CH2M Hill criteria from the Air Force Plant 42 RI for OUs 1, 2, 3 (U.S. Air Force, January, 2000b).
4. Tetra Tech Ecotoxicity Profiles, Version 1, for Vandenberg AFB (Tetra Tech, Inc., May 14, 1998).
5. Tetra Tech Ecotoxicity Profiles, Version 2, for Vandenberg AFB (Tetra Tech, Inc., January 26, 2000).
6. Three different toxicity criteria were reported for lead, based on studies with the Japanese quail, the American kestrel and the *Coturnix* quail.

II. Consensus Procedure for Updating TRVs

There is a process agreed upon among the Federal and California regulatory and natural resource trustee agencies for the revision and updating of the NAVY/BTAG TRVs. USEPA Region 9 BTAG members have discussed the process for revising the NAVY/BTAG TRVs at BTAG meetings and the process involves the following submissions to the Region 9 BTAG Coordinator:

1. Copies of substantiating primary literature and data that would cause reconsideration of the NAVY/BTAG.

2. Written justification for exclusion of any primary literature that currently serves as the basis for setting the NAVY/BTAG TRV.

3. The proposed assessment of the primary literature sources, as well as ecological assessment of any impact of that proposed change in the TRV.

4. The summary of all critical experiment parameters (e.g., form of compound, route of administration and vehicle, period of dosing, organism and strain tested, toxic end point, and statistical difference in toxic endpoint between groups dosed and control).

5. Specific calculations of any bioavailability factor differences, including bioavailability measurements during the toxicity experiment setting the TRV.

6. A request to present the proposed data in the context of the data used to set the NAVY/BTAG TRV. Example charts, in the graphical format preferred, are available for examination (contact the USEPA Region 9 BTAG Coordinator).

A face-to-face Region 9 BTAG meeting should be scheduled to discuss any differences of scientific opinion regarding interpretation of the data in the primary literature.

III. Proposed Methodology for Developing TRVs for Chemicals That Do Not Have a Navy/BTAG TRV

HERD recommends consultation and regulatory review of TRVs developed by responsible parties or their consultants for chemicals that do not have an established Navy/BTAG TRV. The process should follow the steps outlined above (Section II) for updating TRVs.

If TRVs can not be derived because of unsatisfactorily high uncertainty (e.g., limited or equivocal studies), HERD recommends a qualitative assessment of toxicity. For receptors and chemicals of concern for which no TRVs are derived, site-specific doses should be estimated, but no HQs calculated. Instead, the site-specific high and low doses should be plotted with available data to determine where the site-specific doses fall in comparison to the range of published effects. In the absence of calculating HQs for a particular chemical of concern and/or receptor (i.e., those lacking TRVs), a qualitative comparison of doses and toxicological data can be used in a weight-of-evidence analysis.

IV. Use of Navy/BTAG TRVs in Ecological Risk Assessment

Navy/BTAG TRVs should be used to estimate risk at hazardous waste and permitted facilities in California. The following discussion presents a very brief overview of estimating risk with the Navy/BTAG TRVs. For more detailed and comprehensive information the reader is referred to DTSC (1996a,b) and USEPA (1997, 1998) ERA Guidance.

1. Perform the scoping or problem formulation phase of the ERA (see applicable guidance listed above). Select representative species of concern for the assessment.

2. Perform the Phase I Predictive Assessment of the ERA (see applicable guidance listed above). Navy/BTAG TRV-Low and TRV-High values are presented in Table 3 (from Engineering Field Activity West, 1997).

   A. Quantify risk following a hazard quotient approach which is based on estimated exposure point concentrations and the Navy/BTAG TRV-Low and TRV-High values. The Navy/BTAG TRVs may need to be allometrically adjusted if the body weight of the selected representative species is significantly larger or smaller (i.e., 2 orders of magnitude) than the body weight of the species used to develop the TRV.

   B. TRVs are allometrically adjusted by scaling factors. Justification and methods for performing the adjustments should be discussed with the DTSC ecological risk assessor.

   C. Calculate an adult intake and juvenile intake with ingestion rate separately correlated to body weight for adults and juveniles (see HERD EcoNOTE2). Typically, the EPC for mammals or birds is estimated with the 95th upper confidence interval on the arithmetic mean for soil/sediment concentrations and with literature-derived and chemical-specific uptake factors for plants, invertebrates, or small mammals. When no chemical-specific uptake data are available, a default value of 1.0 is applied. EPCs are also modified by area-use factors, as appropriate.

   D. Calculate hazard quotients as described in HERD EcoNOTE2. Briefly:

$$HQ_1 = EPC/\ TRV_{low}$$
$$HQ_2 = EPC/\ TRV_{high}$$

where,

HQ_1 = hazard quotient based on the Navy/BTAG TRV-Low (no observable adverse effect level, allometrically adjusted as necessary)
HQ_2 = hazard quotient based on Navy/BTAG TRV-High (mid-range adverse effect level, allometrically adjusted as necessary)
EPC = exposure point concentration (i.e., typically 95th upper confidence interval on the arithmetic mean) based on juvenile or adult intakes.

E. Evaluate risk. HQ_1 and HQ_2 should be calculated at adult and juvenile intakes. When the risk assessment includes multiple exposure routes and chemicals of concern, HQ_1s or HQ_2s should be summed, respectively, to calculate hazard indices (HIs). First, adult and/or juvenile HIs are created by summing HQs across each exposure route (i.e., ingestion, inhalation, dermal) evaluated. Second, HIs are summed among chemicals when the chemicals have a mode of action or target organ in common. The four point estimates of risk ($HI_{1\ adult}$, $HI_{1\ juvenile}$ and $HI_{2\ adult}$, $HI_{2\ juvenile}$) should be used to present a range of risk that can be evaluated by the DTSC project manager.

For the juvenile or adult, if HI_1 is <1 (based on the no observable adverse effect level), HERD recommends documenting supporting evidence, as discussed in Section V below, to consider no further action with respect to protection of mammals and/or birds. A Phase II Validation Study as described in DTSC Guidance (1996b) may be recommended if high amount of uncertainty is identified in the supporting evidence/uncertainty analysis.

For the juvenile or adult, if HI_1 is > 1 (based on the no observable adverse effect level), HERD recommends a Phase II Validation Study (validation study) and/or Phase III Impact Assessment (impact assessment) as described in DTSC Guidance (1996b). The level-of-effort proposed for the validation study or impact assessment should be based on supporting evidence (Section V). A validation study is most often performed to develop site-specific bioconcentration/ bioaccumulation factors and tissue concentrations for refinement of the predictive assessment. The validation assessment need not include all investigational sites at a facility. Most often, a few sites are selected that are representative of the facility as a whole, in terms of habitats and chemicals of concern. Implementation of a validation study or impact assessment should be discussed with the DTSC project manager.

TABLE 3: NAVY / BTAG TOXICITY REFERENCE VALUES

		Regional TRVs - Mammals		Regional TRVs - Birds	
Contaminant		High TRV (mg/kg – day)	Low TRV (Unadjusted*) (mg/kg – day)	High TRV (mg/kg – day)	Low TRV (Unadjusted*) (mg/kg – day)
PESTICIDES, PCBs					
DDT, DDE DDD[2]	Dose	*16*	*0.8*[3]	*DDT – 1.5 DDE – 0.6*	*0.009*[3] *(0.027)*
	Reference	EPA – Great Lakes, Clement and Oakley 1974	EPA – Great Lakes, Fitzhugh 1948	EPA – Great Lakes, Heath et al. 1969	EPA – Great Lakes, Anderson et al. 1975
	Confidence	N/A		N/A	
PCBs	Dose	*1.28*	*0.36*	*1.27*	*0.09*[1] *(0.88)*
	Reference	Linzey 1987	Simmons and McKee 1992	Britton and Huston 1973	Platonow & Reinhart 1973
	Confidence	$+_S+_C$3/3		$+_S+_C$14/5	
Aldrin	Dose	*1.0*	*0.1*[1] *(1.0)*	No Avian TRV: Insufficient Data[11]	
	Reference	Paul & others 1992	Paul & others 1992		
	Confidence	$+_S+_C$2/2			
Lindane	Dose	*3.75*	*0.05*	No Avian TRV: Insufficient Data[11]	
	Reference	Sircaar & Lahiri 1989	Naishtein and Leibovich 1971		
	Confidence	$+_S+_C$4/3			
Heptachlor	Dose	*6.8*	*0.13*[1] *(1.29)*	No Avian TRV: Insufficient Data[11]	
	Reference	Norotsky & others 1995	Shain & others 1977		
	Confidence	$+_S+_C$4/2			
Methoxychlor	Dose	*50.0*	*2.5*[1] *(25)*	No Avian TRV: Insufficient Data[11]	
	Reference	Gray & others 1989	Gray & others 1989		
	Confidence	$+_S+_C$2/2			
ORGANOTINS					
Dibutyltin and Tributyltin	Dose	*15.0*	*0.25*[5] *(2.5)*	*45.85*	*0.73*[5] *(7.34)*
	Reference	Ema & others 1995	Smialowicz & others 1989	Schlatterer & others 1993	Schlatterer & others 1993
	Confidence	$+_S-_C$5/2		$+_S-_C$1/1	

TABLE 3 (CONTINUED): NAVY / BTAG TOXICITY REFERENCE VALUES

Contaminant		Regional TRVs - Mammals: High TRV (mg/kg – day)	Regional TRVs - Mammals: Low TRV (Unadjusted*) (mg/kg – day)	Regional TRVs - Birds: High TRV (mg/kg – day)	Regional TRVs - Birds: Low TRV (Unadjusted*) (mg/kg – day)
PAHs					
Benzo(a)pyrene	Dose	*32.79*	*1.31*	No Avian TRV: Insufficient Data	
	Reference	Rigdon & Neal 1969	Neal & Rigdon 1967		
	Confidence	$+_{S}+_{C}$ 2/2-			
Napthalene	Dose	*150.0*	*50.0*	No Avian TRV: Insufficient Data	
	Reference	Navarro & others 1991	Navarro & others 1991		
	Confidence	$+_{S}+_{C}$ 2/2			
METALS					
Arsenic	Dose	*4.70*	*0.32*	*22.01*[9]	*5.5*[9]
	Reference	Brown & others 1976	Schroeder & others 1968	Stanley, Jr. & others 1994	Stanley, Jr. & others 1994
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}+_{C}$ 1/1	
Barium	Dose	No Mammalian TRV: Insufficient Data		No Avian TRV: Insufficient Data	
	Reference				
	Confidence				
Beryllium	Dose	No Mammalian TRV: Insufficient Data		No Avian TRV: Insufficient Data	
	Reference				
	Confidence				
Cadmium	Dose	*2.64*	*0.06*	*10.43*	*0.08*[1] *(0.78)*
	Reference	Schroeder & Mitchener 1971	Webster 1988	Richardson & others 1974	Cain & others 1983
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}+_{C}$ 4/2	
Cobalt	Dose	*20*	*1.2*[1] *(12.0)*	No Avian TRV: Insufficient Data	
	Reference	Mollenhauer & others 1985	Domingo & others 1985		
	Confidence	$+_{S}+_{C}$ 2/2			

TABLE 3 (CONTINUED): NAVY / BTAG TOXICITY REFERENCE VALUES

Contaminant		Regional TRVs - Mammals High TRV (mg/kg – day)	Regional TRVs - Mammals Low TRV (Unadjusted*) (mg/kg – day)	Regional TRVs - Birds High TRV (mg/kg – day)	Regional TRVs - Birds Low TRV (Unadjusted*) (mg/kg – day)
Copper	Dose	*631.58*	*2.67*[5, 6] *(26.67)*	*52.26*	*2.3*[5, 10] *(22.99)*
	Reference	Hebert & others 1993	Pocino & others 1991	Jensen & Maurice 1978	Norvell & others 1975
	Confidence	$-_{S}+_{C}$ 2/2		$+_{S}-_{C}$ 3/2	
Lead	Dose	*240.64*	*0.0015*	*8.75*	*0.014*[1] *(0.14)*
	Reference	Wise 1981	Krasovskii & others 1979	Edens & Garlich 1983	Edens & others 1976 Edens & Garlich 1983
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}+_{C}$ 8/4	
Manganese	Dose	*159.09*	*13.7*[1] *(135.56)*	*776*	*77.6*[1] *(776)*
	Reference	Gray & Laskey 1980	Gray & Laskey 1980	Laskey & Edens 1985	Laskey & Edens 1985
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}-_{C}$ 2/1	
Mercury[4]	Dose	*4 – rodents* *0.27 – lg mammals*	*0.25 – rodents* *0.027*[1] *(0.27) – lg mammals*	*0.18*	*0.039*[7] *(0.078)*
	Reference	EPA – Great Lakes, Fuyuta & others 1978	EPA – Great Lakes, Khera and Tabacova 1973	EPA – Great Lakes, Heinz & Locke 1976	EPA – Great Lakes, Heinz 1974, 1975, 1976, 1979
	Confidence	N/A		N/A	
Molybdenum	Dose	No Mammalian TRV: Insufficient Data		No Avian TRV: Insufficient Data	
	Reference				
	Confidence				
Nickel	Dose	*31.6*	*0.133*[1] *(1.33)*	*56.26*	*1.38*[5] *(13.79)*
	Reference	Smith & others 1993	Smith & others 1993	Cain & Pafford 1981	Cain & Pafford 1981
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}-_{C}$ 2/2	
Silver	Dose	No Mammalian TRV: Insufficient Data		No Avian TRV: Insufficient Data	
	Reference				
	Confidence				

TABLE 3 (CONTINUED): NAVY / BTAG TOXICITY REFERENCE VALUES

Contaminant		Regional TRVs - Mammals		Regional TRVs - Birds	
		High TRV (mg/kg – day)	Low TRV (Unadjusted*) (mg/kg – day)	High TRV (mg/kg – day)	Low TRV (Unadjusted*) (mg/kg – day)
Selenium	Dose	*1.21*	*0.05*	*0.93*	*0.23*
	Reference	Schroeder & Mitchener 1971	Harr & others 1967	Heinz & others 1989	Heinz & others 1989
	Confidence	$-_{S}+_{C}$ 2/2		$+_{S}+_{C}$ 2/2	
Thallium	Dose	*1.43*	*0.48*	No Avian TRV: Insufficient Data	
	Reference	Downs & others 1960	Downs & others 1960		
	Confidence	$-_{S}-_{C}$ 1/1			
Zinc	Dose	*411.43*	*9.60[1, 6] (96.03)*	*172*	*17.2[1] (172)*
	Reference	Shlicker & Cox 1968	Aughey & others 1977	Gasaway & Buss 1972	Gasaway & Buss 1972
	Confidence	$+_{S}+_{C}$ 2/2		$+_{S}+_{C}$ 3/2	

Notes:

* The unadjusted TRV appears in parentheses. This dose is the TRV without uncertainty factors applied.
See Section 3.4 for an explanation of confidence characterization for TRVs.

[1] Uncertainty factor of 10 for low-effect to no-effect level conversion applied to arrive at low TRV.

[2] EPA's Great Lakes Water Quality Initiative Wildlife Values were used as low TRVs. The low dose was adjusted for subchronic to chronic and LOAEL to NOAEL conversions as applied by EPA. The high dose was selected from data presented in EPA's summary tables. Confidence ratings were not applied to these TRVs.

[3] EPA applied an uncertainty factor of 3 to the dose for low-effect to no-effect level conversion.

[4] Mercury TRVs were selected from data in Great Lakes summary tables. See Section 5.8.2.1 for rationale behind selection of these TRVs. Confidence ratings were not applied to these TRVs.

[5] Uncertainty factor of 10 for subchronic to chronic conversion applied to arrive at a low TRV.

[6] Low TRV was adjusted for or is close to nutritional requirements.

[7] EPA applied to the dose an uncertainty factor of 2 for low-effect to no-effect level conversion.

[8] Dibutyltin and tributyltin databases were combined to arrive at a single TRV for for butyltins.

[9] The diversity of test organisms in the cadmium data set was limited. The workgroup had high confidence in the TRV for waterfowl, but lower confidence if the TRV is applied to other birds.

[10] The work group considered this TRV to be very conservative for granivorous birds.

[11] As a course screen for risk characterization, avian TRVs for DDT may be used as surrogate TRVs for aldrin, lindane, heptachlor and methoxychlor.

V. Supporting Evidence for the Predictive Assessment

Ecological decisions made with the information provided in ERA should be based on a supporting evidence analysis (DTSC, 1996a,b; USEPA, 1997; USEPA, 1998). Information that should be synthesized and evaluated in the analysis includes:

- magnitude of the HI_1 and HI_2
- identified chemicals of concern and potential exposure pathways
- persistence and bioaccumulation potential of chemical(s) of concern
- range of representative species evaluated
- life history, home range and foraging habits of representative species of concern
- uncertainty contained in exposure models
- estimated and/or field-verified exposure point concentrations (e.g., related to food chain transfer)
- estimated and potentially field-verified toxicity evaluations
- toxicological endpoint of the toxicity value used to calculate the HQ or HI
- magnitude of any uncertainty factors used to develop the final toxicity value
- current and future land use.

After this supporting evidence analysis is completed, risk, relative to selected assessment endpoints, should be characterized and presented to the DTSC project manager.

VI. Special Situations: Lead Bioavailability

Hazardous waste sites and permitted facilities frequently include lead as a contaminant of potential ecological concern. The Navy/BTAG TRV-Low for lead is 0.0015 mg/kg body wt./day in mammals and 0.014 mg/kg body wt./day for birds. When applied in the Phase I Predictive Assessment using conservative exposure assumptions (e.g., high site fidelity and/or intake rates), soil concentrations within or approaching ambient or background conditions may appear to pose risk. Since the lead TRV-Low is based on lead acetate, a highly bioavailable form of lead, HERD and BTAG recommend that the exposure assessment be refined so that site-specific lead bioavailability is estimated or directly measured. Implementation of the refined exposure assessment and subsequent risk characterization can follow the Data Quality Objectives (DQO) process outlined by the USEPA (1993).

Inorganic lead may be found in the environment in various chemical forms (e.g., lead carbonate, lead oxides, lead sulfate, elemental lead). These chemical forms of lead will have different levels of bioavailability based on water solubility, amount bound to organic/inorganic matter, and particle size. If lead is identified as a chemical of potential ecological concern (e.g., greater than background or ambient conditions), HERD recommends the following phased analysis be conducted:

1. Scoping or Problem Formulation Phase: Perform an *in vitro* lead bioavailability test on representative soil types from the facility, preferably with low, medium, and high concentrations of lead. Procedures for conducting the analysis are available in NAVFAC (2000). For further information on laboratories that can conduct this analysis, contact Dr. John Drexler (drexlerj@spot.colorado.edu) or Dr. Chris Weis (weis.chris@epa.gov). The *in vitro* analysis should be conducted under acidic conditions present in the stomach of mammals and birds. Stomach acidity in animals can range from below pH 1 to pH 5 based on feeding strategy. The following presents the measured ranges of stomach acidity (with food in stomach) in animals:

   - CARNIVORE: Less than or equal to pH 1 [e.g., pH measured in stomach of shrike (predatory bird) 0.2]
   - HERBIVORE: pH 4 to 5
   - OMNIVORE: Less than or equal to pH 1.

   For purposes of a conservative screen, HERD recommends the *in vitro* analysis be conducted at a pH concentration of 1.5 (as recommended by NAVFAC, 2000) with site-specific lead-contaminated soil and with lead acetate (form of lead that the Navy/BTAG TRV-Low is derived).

2. Phase I Predictive Assessment: Calculate hazard quotients based on the estimated solubility of lead provided in the *in vitro* analysis, concentration of lead in surface water (if applicable exposure route), and the modeled or estimated uptake of lead in plant and/or animal food items. First, calculate a soil ingestion exposure point concentration (EPC) based on the estimated solubility of site-specific lead as follows:

   $EPC_{soil\ lead} = EPC * \ Solubility\ Lead_{site} / Solubility\ Lead_{acetate}$

   Where,

   $EPC_{soil\ lead}$ = Exposure point concentration for lead modified by *in vitro* solubility test
   EPC = Exposure point concentration (i.e., typically 95^{th} upper confidence interval on the arithmetic mean) calculated from site-specific data
   Solubility $Lead_{site}$ = Estimated solubility of site-specific lead under *in vitro* test conditions (%)
   Solubility $Lead_{acetate}$ = Estimated solubility of lead acetate under *in vitro* test conditions (%)

   Second, calculate a food ingestion EPC based on the estimated or measured lead content in food (and water, if applicable). The lead content in food can be estimated by literature uptake factors for lead or by direct measurement of tissue concentrations in the field. Sum the EPCs for soil and food ingestion. Calculate hazard quotients as follows:

$$HQ_1 = EPC_{sum\ lead} / TRV_{low}$$
$$HQ_2 = EPC_{sum\ lead} / TRV_{high}$$

where,

HQ_1 = hazard quotient for lead based on soil *in vitro* solubility test, food ingestion, and TRV-Low (no observable adverse effect level, allometrically adjusted as necessary)
HQ_2 = hazard quotient for lead based on soil *in vitro* solubility test, food ingestion, and TRV-High (mid-range adverse effect level, allometrically adjusted as necessary)
$EPC_{sum\ lead}$ = Exposure point concentration for lead modified by *in vitro* solubility test and modeled or measured concentrations of lead in food items.

Notes: (1) Adult and juvenile estimates of intake may be calculated following previous HERD guidance (EcoNOTE2). (2) This analysis does not evaluate lead by the inhalation or dermal exposure routes. In situations where lead particles could be inhaled or in contact with the skin (e.g., burrowing organisms), the inhalation and dermal exposure routes should be evaluated. (3) In wetland or subtidal environments where waterfowl are ecological receptors of concern, incidental ingestion of large particles of inorganic lead in the form of lead shot or bullet fragments should be factored into the ERA.

As described in Section IV above, HQs developed for each exposure route and for each chemical of concern with a similar mode of action or target organ should be summed to calculate the HI.

If HI_1 is <1 (based on the no observable adverse effect level and the cumulative effects among chemicals of concern), HERD recommends that following the supporting evidence analysis as discussed above (Section V), consider no further action with respect to protection of mammals and/or birds.

If HI_1 is > 1 (based on the no observable adverse effect level), HERD recommends a Phase II Validation Study as described in DTSC Guidance (1996a). The scope of the validation study should be developed using information documented in the supporting evidence analysis. Implementation of a validation study should be discussed with the DTSC project manager.

3. Phase II Validation Study for Lead. The purpose of the Phase II Validation Study is to field verify exposure and/or toxicity assumptions made during the predictive assessment. For example, lead uptake factors for plant, invertebrate, and higher trophic-level animals can be measured in field collected organisms. This information can be used to refine the predictive risk assessment with ‘real world’ values, rather than modeled or estimated uptake values. A supporting evidence analysis should

be conducted as described above (Section V). This phase of the ERA can significantly reduce uncertainty in the evaluation, however a Phase III Impact Assessment (DTSC, 1996a) may be recommended in situations where the results of the Phase I and II ERA indicate significant risk (e.g., HQ > 1). Implementation of an impact assessment should be authorized by the DTSC project manager.

4. Impact Assessment for Lead. The purpose of an impact assessment for lead would be the following:

   A. Determine site-specific media concentrations of lead consistent with no adverse lead effects by intensive field and/or laboratory investigations. For example, this may include plant toxicity bioassay, invertebrate bioassay, amphibian bioassay, or the field collection of higher trophic level representative species for biomarker analyses (e.g., bioindicators of exposure and effect as determined by biochemical, physiological, or histopathological analysis). Field studies of higher trophic level representative species also may include quantitative measurements of species richness and abundance, population levels, or age-class distribution assessment of representative species of concern

   B. Determine if remediation is feasible and will have minimal impacts on existing habitats at the site or that the habitats can be reliably and reasonably restored to their native condition. Conduct analysis based on the nine risk management 'balancing criteria' presented in the National Contingency Plan.

   C. Establish a site-monitoring plan based on the selected remedial action.

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