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1 December 1994

Edward J. Hanlon, Remedial Project Manager
United States Environmental Protection Agency
Region 5 (HSRM-6J)
Ohio/Minnesota Remedial Response Branch
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Re: Need for additional data to complete the ecological risk assessment for Fields Brook.

Mr. Hanlon:

In the interest of expediting settlement, but without waiving any defense, the Fields Brook Potentially Responsible Party Organization ("FBPRPO") responds as follows to EPA's comment made at the October 25, 1994 meeting in Chicago. To illustrate the methodology that we believe that we have agreed upon and ensure that there is agreement, Appendix A contains preliminary draft ecological cleanup goals ("ECUGs") for the floodplain/wetland. These preliminary draft ECUGs are based on the existing information. Since the data were not gathered for the purpose of calculating ECUGs and there is a large degree of uncertainty in the 95 percent confidence limits extrapolated from the limited, biased existing soil data, these preliminary draft ECUGs cannot be used as final cleanup criteria. As soon as the Phase III data become available, these preliminary draft ECUGs will be recalculated and the preliminary ECUGs can be used to determine the extent of the remedial action.

Additional data are needed because:

1) Although upper 95 percent confidence limits on concentrations of contaminants of concern in small mammal composites can be extrapolated from existing data, the resulting limits will be very uncertain because there is currently no site-specific information available to verify the estimates. Additional data would allow these upper 95 percent confidence limits to be established based on actual field data rather than on uncertain statistical manipulations of existing data.

2) U.S. EPA has disallowed use of equilibrium partitioning theory (EqP) to estimate concentrations of contaminants in diets of shrews and song birds from soil concentrations. In the interest of settlement, the FBPRPO will not use this methodology. Rather, additional field work (following the U.S. EPA approved ecological risk assessment workplan for Fields Brook) has already been initiated and this sampling includes obtaining samples of these dietary items (terrestrial invertebrates) for direct use in risk and ECUG calculations.

The U.S. EPA comments (received from David W. Charters, August 8, 1994 under an August 10, 1994 cover letter from Ed Hanlon to Joe Heimbuch) support the need for additional information. For example, he requested the use of concentrations of contaminants in individuals rather than composites to assess variability. He also stated that the 95 percent upper confidence level should be determined and used in risk and ECUG calculation.

These issues were not entirely resolved with U.S. EPA during our meeting of 8 September 1994. While we do not necessarily agree with the statements made, EA has expressed a willingness to explore other avenues in an effort to address these comments. The additional data currently being obtained will address many of these comments directly without the need for additional uncertain assumptions. Our understanding of the outcome of the September meeting was that U.S. EPA (in the person of David Charters) would consider accepting the ecological risk assessment if 95% confidence limits are used for mammal composites (direct sampling will support development of these limits) and if 95% confidence limits are used for soils (additional samples are being obtained under the Phase III workplan for this purpose). In addition, to respond to EPA's concerns, terrestrial vertebrate tissue concentration variability will be determined by direct sampling, toxicity test results will be explained, the COC and ROC selections will be made consistent with the U.S. EPA (CH2M-Hill) workplan, extreme unrealistic high exposure assumptions (in our view) will be used to assess exposure of the upper trophic level consumers, HEP, and benthic data will be eliminated, and the requested wording changes will be made.

The approach we recommend to establishing the requested 95% confidence limits on mammal tissue composites entails obtaining a limited amount of field data to determine the shape and variability of the distribution of contaminants in mammal tissues. This approach is described in the October 1994, "Phase III Floodplain Sampling Design for the Fields Brook Site, Ashtabula, Ohio" document prepared by Woodward-Clyde. This text is reproduced here:

> "No additional soil samples are proposed for ecological risk assessment. The samples described in section 2.1.1 will provide sufficient resolution for establishment of ECUGs in Zones I, II, and III. Because Zone IV serves as a reference location and ECUGs need not be established in this Zone, there is no need for additional sampling in Zone IV. No additional plant sampling is proposed for the ecological risk assessment because the existing samples adequately describe contaminant concentrations in the areas of interest in that matrix. U.S. EPA requested that 95 percent confidence limits be placed on the existing composite mammal samples. These confidence limits can be

> established but, additional analysis of individual organisms is needed to confirm the validity of these estimates. For this purpose, collection of several individual mice and shrews is proposed. A sufficient number of individuals will be obtained from Zones II and III to confirm calculated confidence intervals for several of the analyte classes (approximately 10 analytical suites for each of the two zones). The chemicals to be analyzed for are contingent upon the development of acceptable analytical procedures to evaluate samples of the masses obtained. Because no terrestrial invertebrate samples were obtained from the floodplain/wetland area during previous sampling efforts, collection of one composite from each Zone, for a total of 4 composites, is proposed based on the assumption that conditions at the time of sampling are appropriate to support such activities."

In order to place 95% confidence limits on soil concentrations, EA recommends use of the Phase III soils data since this will be consistent with the way that that same statistic will likely be developed for the baseline human health risk assessment being prepared by U.S. EPA. In addition, this sampling methodology can be coordinated with the additional soil sampling so that some of the tissue concentrations may be correlated with soil concentrations (which responds to one of David Charters verbal comments made at the 8 September meeting). It is for this reason that the plan for additional data was submitted together with the Phase III sampling plan rather than in advance (to respond to Mr. Peter Felitti's question made at the 25 October 1994 meeting in Chicago). EA also intends to attempt to obtain terrestrial invertebrate data from each of the four exposure zones (one composite for each of the four zones) so that EqP is no longer required and so that, "reference to this model may be eliminated".

To address the concerns raised by U.S. EPA regarding use of the paired comparison technique for selection of COCs and ROCs, EA intends to adopt the COC and ROC lists presented in the CH2M-Hill workplan. EA also intends to adopt the exposure zone designation presented in the CH2M-Hill workplan and the subsequent Phase III floodplain sampling design for the purposes of preparing draft ECUGs and finalizing the ecological risk assessment.

If there are questions or if further information is required, please do not hesitate to contact me at (410) 584-7000 [fax: (410) 771-9148].

Sincerely,

Philip A Clifford

Philip A. Clifford, Ph.D.

CC/
D. Charters,
B. Jones
M. Mischuk,
J. Heimbuch,
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APPENDIX A - PRELIMINARY DRAFT ECOLOGICAL CLEANUP GOALS (ECUGS)

1.0 INTRODUCTION

Calculation of ECUGs in this document follows U.S. EPA recommended methodology. This methodology assumes that concentrations of chemicals of concern in the wildlife in the vicinity of the Brook are linearly related to concentrations of COCs in the soils in the floodplains/wetlands. This assumption ignores the contribution from the sediment in Fields Brook and the source areas, particularly for animals with wide foraging ranges. The method estimates a relationship between soil concentration and organism tissue concentration, and probable degree of effects on receptor organisms. ECUGs are then generated by a comparison of the two.

Numerous assumptions and data gaps exist in the information presented here and as such, the results presented must be assumed to be highly uncertain. It is anticipated that these information gaps will be satisfactorily bridged using information obtained during the Phase III investigations so that uncertainties associated with ECUGs may be constrained to levels which permit informed risk management decision making. Contaminants of concern, receptors of concern, and exposure zones were adopted directly from the CH2M-Hill workplan (U.S. EPA 1994). The volatile contaminants (tetrachloroethylene and 1,2 dichloroethylene) were not included in this evaluation because they were not detected in biotic tissues obtained from the site. Bass, frogs, mallards, and muskrats were not included in this evaluation because they would concentrate activities in the sediment operable unit, not the floodplain/wetland areas. Information not specifically documented herein has not changed from the draft ecological risk assessment prepared by EA Engineering (June 1994) and can be referenced therein.

2.0 METHODS

Calculation of ECUGs following U.S. EPA's requested methodologies required estimation of 95 percent upper confidence limits (UCLs) on concentrations of contaminants in soils, water, vegetation composites, and small mammal composites. For all but small mammal composites, distribution shapes were determined using the "W" statistic for normality. If distributions were determined to be either normal or log-normal, 95 percent UCLs were calculated as:

$$95\%\ UCL = Mean + (1.64 * \genfrac{}{}{0pt}{}{standard}{deviation})$$

where the mean and standard deviation were transformed to the log scale for log-normal distributions. When data did not fit either normal or log-normal distributions, the empirical distribution was used and 95 percent UCLs were determined non-parametrically.

Because actual contaminant concentration distributions in small mammal composites are not known, it was necessary to use the information available (number of individuals in the composite and measured contaminant concentrations) to place an upper bound on the 95 percent UCL. The mathematical formulation requires the following definitions:

(a) x{i,j} = true value for j-th individual of i-th composite.
(b) x{i,.} = total of x{i,j} summed over j.
(c) concentration{i} = measurements, known: x{i,.} = concentration{i}.
(d) 95th% = 95-th percentile of empirical distribution using all x{i,j}.

Where the object is to maximize the 95 percent UCL. This procedure is subject to the following restrictions:

x{i,j} > 0, for all i & j
x{i,.} = concentration{i}, all i

The methodology employed was iterative and monotonically increased the 95 percent UCL. The initial values for x{i,j} were defined by assigning all concentration{i} into a single individual in composite i. These initial values tend to produce a large 95-th percentile, and continued iteration produces even larger 95-th percentiles for alternate values of x{i,j}. The process was repeated by assigning all concentration{i} uniformly across 2 individuals in composite i, 3 individuals, etc. until all possible distributions had been accounted for. The largest 95-th percentile generated by this process was selected as the 95 percent UCL for subsequent calculations. This process generates an estimate of the 95 percent UCL which is known to be larger than the true 95 percent UCL and as such, contributes uncertainty to the final ECUG estimation. Samples currently being collected under the proposed Phase III sampling program will generate actual estimates of the variances present in small mammal populations and these estimates will be used to refine the values presented here.

The 95 percent UCLs for media used in modeling are presented in Table 1. It should be noted that the values presented for soils (based on dry weight concentrations) were based on Phase II data only and as such, due to sample size constraints, are highly uncertain and almost certainly larger than the actual 95 percent UCLs. Samples currently being collected under the proposed Phase III sampling program will generate more accurate estimates of the 95 percent UCLs and will be used to refine the calculations presented here. Water concentrations from the upstream area (Zone 4) were used to reflect probable concentrations in the lower reaches of the Brook following remedial activities associated with the sediment operable unit.

It is important to note that the CH2M-Hill workplan (U.S. EPA 1994) identified two metals (barium and vanadium, which are TAL metals, not priority pollutant metals) as contaminants of concern (Table 2-10). However, chemical analyses to be performed (Table 3-2) include only priority pollutant metals. Table 3-3 of the workplan lists these metals and indicates that soils and tissues will not be analyzed for these contaminants. Because of this inconsistency, samples were not analyzed for these two metals and no ECUGs can be established with

Table 1. Means and upper 95 percent confidence intervals for data used in the ecological risk assessment model. Distribution shapes were determined according to fit with the "W" statistic.

COC	Soil Mean	Soil 95%	Dist. Shape	Water Mean	Water 95%	Dist. Shape	Plant Mean	Plant 95%	Dist. Shape	Mammal Mean	Mammal 95%
Zone 1											
Aroclor 1248	23.6	146.84	L	0.0005	0.0005	*	0.09	0.17	*	0.125	0.825
Aroclor 1254	2.05	9.63	L	0.0005	0.0005	*	0.09	0.17	*	0.125	0.825
Aroclor 1260	2.04	10.29	L	0.0005	0.0005	*	0.09	0.17	*	0.434	3.900
Arsenic	15.55	27.29	L	0.011	0.027	*	0.13	0.15	*	0.093	0.405
Barium	2810.6	15800	*	---	---	---	---	---	---	---	---
Beryllium	0.55	1.3	*	0.001	0.001	*	0.07	0.09	*	0.044	0.200
Cadmium	2.57	7.7	*	0.003	0.003	*	0.22	0.36	L	0.348	2.550
Chromium	73.66	218.2	L	0.007	0.007	*	0.93	1.90	*	0.747	3.350
Hexachlorobutadiene	0.62	1.0	*	0.005	0.005	*	0.54	1.65	*	0.165	0.825
Hexachloroethane	0.29	0.36	*	0.005	0.005	*	0.54	1.65	*	0.165	0.825
Mercury	2.09	10.29	L	0.0002	0.0002	*	0.10	0.10	*	0.095	0.510
Vanadium	99.68	309	*	---	---	---	---	---	---	---	---

---	Not a Priority Pollutant Metal; Data Not Obtained (in Accordance with USEPA 1994)
N	Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Normal
L	Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Lognormal
*	Distribution is Statistically Significantly Different ($\alpha = 0.05$) From Both Normal and Lognormal
R	All Data Rejected for this Parameter in this Zone

Table 1. Continued.

COC	Soil Mean	Soil 95%	Dist. Shape	Water Mean	Water 95%	Dist. Shape	Plant Mean	Plant 95%	Dist. Shape	Mammal Mean	Mammal 95%
Zone 2											
Aroclor 1248	21.21	190.54	L	0.0005	0.0005	*	0.09	0.17	*	0.146	0.825
Aroclor 1254	5.16	28.3	L	0.0005	0.0005	*	0.09	0.17	*	0.146	0.825
Aroclor 1260	5.17	29.0	L	0.0005	0.0005	*	0.09	0.17	*	1.190	11.000
Arsenic	16.0	28.9	L	0.011	0.027	*	0.15	0.18	*	0.170	1.200
Barium	750.4	3231	L	---	---	---	---	---	---	---	---
Beryllium	1.01	5.3	*	0.001	0.001	*	0.07	0.09	*	0.044	0.225
Cadmium	2.45	9.1	*	0.003	0.003	*	0.20	0.31	L	0.282	2.000
Chromium	52.1	210	*	0.007	0.007	*	0.56	0.81	N	0.777	5.200
Hexachlorobutadiene	1.7	7.5	*	0.005	0.005	*	0.62	1.59	N	0.165	0.825
Hexachloroethane	1.21	7.5	*	0.005	0.005	*	0.62	1.59	N	0.165	0.825
Mercury	2.02	8.00	L	0.0002	0.0002	*	0.09	0.10	L	0.287	2.200
Vanadium	96.6	493	*	---	---	---	---	---	---	---	---

---	Not a Priority Pollutant Metal; Data Not Obtained (in Accordance with USEPA 1994)
N	Distribution is not Statistically Significantly Different (∝ =0.05) From Normal
L	Distribution is not Statistically Significantly Different (∝ =0.05) From Lognormal
*	Distribution is Statistically Significantly Different (∝ =0.05) From Both Normal and Lognormal
R	All Data Rejected for this Parameter in this Zone

Table 1. Continued.

COC	Soil Mean	Soil 95%	Dist. Shape	Water Mean	Water 95%	Dist. Shape	Plant Mean	Plant 95%	Dist. Shape	Mammal Mean	Mammal 95%
Zone 3											
Aroclor 1248	10.15	80.36	L	0.0005	0.0005	*	0.10	0.42	L	0.165	0.825
Aroclor 1254	1.13	6.74	L	0.0005	0.0005	*	0.09	0.17	*	0.165	0.825
Aroclor 1260	1.45	5.50	*	0.0005	0.0005	*	0.09	0.17	*	0.981	11.100
Arsenic	16.39	35.66	L	0.011	0.027	*	0.22	0.42	*	0.214	2.280
Barium	291.85	1370	*	---	---	---	---	---	---	---	---
Beryllium	0.58	2.3	*	0.001	0.001	*	0.07	0.12	N	R	R
Cadmium	1.23	4.30	*	0.003	0.003	*	0.22	0.35	N	R	R
Chromium	191.2	748.6	L	0.007	0.007	*	0.69	1.51	L	0.750	3.600
Hexachlorobutadiene	0.63	6.0	*	0.005	0.005	*	0.91	1.65	*	0.165	0.825
Hexachloroethane	0.59	6.0	*	0.005	0.005	*	0.91	1.65	*	0.165	0.825
Mercury	6.93	48.34	L	0.0002	0.0002	*	0.91	1.65	*	0.264	3.000
Vanadium	353	1455	L	---	---	---	---	---	---	---	---

--- Not a Priority Pollutant Metal; Data Not Obtained (in Accordance with USEPA 1994)
N Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Normal
L Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Lognormal
* Distribution is Statistically Significantly Different ($\alpha = 0.05$) From Both Normal and Lognormal
R All Data Rejected for this Parameter in this Zone

Table 1. Continued.

COC	Soil Mean	Soil 95%	Dist. Shape	Water Mean	Water 95%	Dist. Shape	Plant Mean	Plant 95%	Dist. Shape	Mammal Mean	Mammal 95%
Zone 4											
Aroclor 1248	0.04	0.11	*	0.0005	0.0005	*	0.09	0.17	*	0.165	0.825
Aroclor 1254	0.03	0.11	*	0.0005	0.0005	*	0.09	0.17	*	0.165	0.825
Aroclor 1260	0.03	0.11	*	0.0005	0.0005	*	0.09	0.17	*	0.165	0.825
Arsenic	9.14	15.72	L	0.011	0.027	*	0.16	0.17	*	0.188	0.960
Barium	177.3	360.0	L	---	---	---	---	---	---	---	---
Beryllium	0.68	1.12	N	0.001	0.001	*	0.06	0.09	*	R	R
Cadmium	0.44	0.90	*	0.003	0.003	*	0.23	0.33	*	0.341	1.950
Chromium	29.4	59.5	L	0.007	0.007	*	0.52	0.76	*	0.541	2.550
Hexachlorobutadiene	0.28	0.43	L	0.005	0.005	*	0.59	0.80	*	0.537	4.125
Hexachloroethane	0.28	0.43	L	0.005	0.005	*	0.59	0.80	*	0.537	4.125
Mercury	4.47	57.2	*	0.0002	0.0002	*	0.09	0.10	*	0.137	1.080
Vanadium	79.1	411.0	*	---	---	---	---	---	---	---	---

---	Not a Priority Pollutant Metal; Data Not Obtained (in Accordance with USEPA 1994)
N	Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Normal
L	Distribution is not Statistically Significantly Different ($\alpha = 0.05$) From Lognormal
*	Distribution is Statistically Significantly Different ($\alpha = 0.05$) From Both Normal and Lognormal
R	All Data Rejected for this Parameter in this Zone

existing information. Samples obtained under the proposed Phase III sampling program will produce information for these contaminants which can be used to generate ECUGs. Information will not be obtained for concentrations of these contaminants in water and plant tissue (not target media of the Phase III sampling program) and it will be necessary to make assumptions regarding concentrations of these contaminants in these media. The impacts of these assumptions will affect the uncertainty surrounding ECUGs for those two metals but, it is anticipated that this contribution to the overall uncertainty will be small.

2.1 Exposure Assumptions

In response to comments received from U.S. EPA and other agencies, several of the model parameters used in the draft ecological risk assessment prepared by EA Engineering (June 1994) were modified for this evaluation. Specifically, the diet of mink was shifted from 50% fish and 50% small mammals to all small mammals, ingestion rates were modified for mink and red-tailed hawks, and the foraging range for robins was reduced.

Other comments provided required that several highly uncertain assumptions be made in lieu of the information currently being collected under the proposed Phase III sampling program. It was assumed that 95 percent UCLs for small mammals were representative of concentrations of contaminants potentially present in terrestrial invertebrates. While there is little or no justification for such an assumption, it is the best information that is available until results of the Phase III sampling program are known. Also, it was assumed that the Great Blue Heron would obtain all of its food resources from the Fields Brook floodplain/wetland (none from the Brook) and dietary apportioning was adjusted so that small mammals replace the fish portion of the diet.

The resulting model parameter list is presented in Table 2. These parameters will be modified to reflect the new data being obtained during Phase III prior to revision of ECUGs. Table 3 presents the portion of each receptor's activities which will be conducted in each Zone based on the data presented in Table 2 (assuming 195 acres are represented by the four zones). The values presented are used as multipliers to decrement the dose calculated by the food-web model presented in EA (1994).

2.2 Toxicity Reference Values (TRVs)

Because the current COC list differs to some degree from that presented in EA (1994), additional information was required for this evaluation. This information is summarized in Table 4. The following text presents the supporting information for TRV development which is not contained in EA (1994).

Table 2. Biological parameters used in the ecological risk model.

Receptor Group	Fraction of Diet	Feeding Rate (kg/kg/day)	Body Weight (kg)	Foraging Range (Ha)
Mink	0.906 Sm. Mammals (1) 0.094 Soil (3)	0.220 Food (1) 0.075 Water (4)	0.93 (2)	211 (5)
Red-Tailed Hawk	0.590 Med. Mammals (6) 0.328 Sm. Mammals (6) 0.082 Soil (7)	0.100 Food (1) 0.056 Water (4)	1.26 (8)	400 (9)
Great Blue Heron	0.900 Sm. Mammals (10) 0.100 Soil (11)	0.080 Food (12) 0.041 Water (4)	2.9 (8)	496 (13)
Song Birds (Robin)	0.306 Earthworms (14) 0.306 Insects (14) 0.306 Plants (14) 0.082 Soil (7)	0.084 Food (8) 0.133 Water (4)	0.075 (8)	0.81 (1)
Eastern Cottontail	0.950 Vegetation (15) 0.050 Soil (15)	0.080 Food (15) 0.142 Water (4)	1.5 (15)	3.00 (1)
Mice	0.46 Vegetation (16) 0.46 Insects (16) 0.08 Soil (16)	0.06 Food (16) 0.14 Water (4)	0.03 (16)	(17)
Shrew	0.590 Insects (16) 0.114 Plants (16) 0.072 Worms (16) 0.080 Soil (16)	0.49 Food (12) 0.15 Water (4)	0.017 (R)	(17)

Table 2. Continued.

(1) USEPA 1993
(2) Burt and Grossenheider 1976
(3) From raccoon data reported in Beyer et al. 1991
(4) From regressions in Calder and Braun 1983 and body weights listed
(5) Assumed that foraging range equals site size
(6) Adapted from ferruginous hawk information in Fitch et al. 1946
(7) From Canada Goose information in Beyer et al. 1991
(8) Terres 1982
(9) Craighead and Craighead 1969
(10) Adapted from Martin et al. 1961.
(11) Reeder 1951
(12) From Nagy 1987 assuming 10% dry matter in bulk food
(13) Assumed to spend 1/2 of foraging time on-site
(14) Adapted from (8)
(15) Nagy 1987
(16) Palmer and Fowler 1975.
(17) Assumed to restrict activities to individual reaches

Table 3. Fraction of receptor exposure from individual Reaches.

Receptor	Range (Ha)	Zone 1	Zone 2	Zone 3	Zone 4	Total
Mink	195	0.31	0.21	0.27	0.21	1.00
Hawk	400	0.15	0.10	0.13	0.10	0.48
Heron	496	0.12	0.08	0.11	0.08	0.39
Robin	*	1.00	1.00	1.00	1.00	*
Rabbit	*	1.00	1.00	1.00	1.00	*
Mouse	*	1.00	1.00	1.00	1.00	*
Shrew	*	1.00	1.00	1.00	1.00	*

* Assumed that these receptors forage 100% of time in study area.

Table 4. Matrix of toxicity reference values (TRVs) for COCs and ROCs (mg/kg-bw/day).

Contaminant of Concern (COC)	Receptor of Concern (ROC)				
	Small Mammals (mouse, shrew)	Medium Mammals (mink, rabbit)	Raptors (hawk)	Great Blue Heron	American Robin
Arsenic	0.34	1.2	1.3	1.4	1.3
Barium	11.6	2.32	*	*	*
Beryllium	0.80	0.16	0.08	0.08	0.08
Cadmium	1.9	0.75	0.56	0.56	0.56
Chromium	0.46	0.09	1.28	1.28	*
Aroclor 1248	11.0	2.2	0.45	27.9	0.09
Aroclor 1254	0.25	0.019	0.68	3.4	1.2
Aroclor 1260	0.35	0.04	1.0	19.8	1.0
Hexachlorobutadiene	0.2	0.04	*	*	*
Hexachloroethane	1.0	0.2	*	*	*
Mercury	0.05	0.05	0.01	0.014	0.023
Vanadium	0.7	0.14	*	*	*

* No information located to-date. Investigation is continuing.

Barium - Small Mammals (11.6 mg/kg-bw/day)

This value was based on a 92 d NOAEL (115.8 mg/kg-bw/day) in mice (Dietz et al. 1992). The NOAEL was based on survival, weight loss, various behavioral and reproductive endpoints, and lack of histopathologic lesions. This value was divided by 10 to estimate a chronic NOAEL of 11.6 mg/kg-bw/day. Rats were also exposed in the same study with similar results. The mouse value was similar to other values reported for barium chloride in ATSDR (1990). Rats exposed to barium chloride for 13 wk via water resulted in a NOAEL of 35 mg/kg-bw/day (ATSDR, 1990). However, studies reporting NOAEL values for serious effects in rats and mice exposed to barium acetate were considerably lower than those for barium chloride, ranging from 0.7 to 0.95 (ATSDR, 1990). As reported in ATSDR (1990), barium chloride is more commonly used in manufacturing processes than barium acetate. Hence, barium chloride exposure to terrestrial ROCs in NECOU are more likely to occur than exposure to barium acetate. Therefore, the chloride form of barium was used to develop the TRV.

Barium - Medium Mammals (2.32 mg/kg-bw/day)

No data were found regarding barium exposure to medium or large mammals. The medium mammal and deer TRVs were extrapolated from the small mammal TRV of 11.6 mg/kg-bw/day by dividing by 5 to account for inter-taxon variability.

Barium - All Birds (ND)

No data were found regarding barium exposure to birds.

Chromium - Small Mammals (0.46 mg/kg-bw/day)

This value was based on a 3 yr NOAEL value of 0.46 mg/kg-bw/day for rats (Schroeder et al. 1965). The endpoints were lack of hematological, hepatic, and renal effects. The compound used in this study was a trivalent form of chromium (chromium acetate monohydrate), which is considered less toxic than hexavalent forms to terrestrial plants and animals (Bartlett and James 1979). This value is a factor of 10 to 1000 lower than other published NOAELs for both trivalent and hexavalent chromium to small mammals (ATSDR, 1991). As such, this value should be considered conservative.

Chromium - Medium Mammals (0.09 mg/kg-bw/day)

No data were found exposing medium or large mammals to chromium. The medium mammal and deer TRVs were extrapolated from the small mammal TRV of 0.46 mg/kg-bw/day by dividing by 5 to account for inter-taxon variability.

Chromium - Birds (6.4 mg/kg-bw/day)

This value was based on a 5 mo NOAEL for black ducks reported in Eisler (1986). No effects were observed with respect to survival, reproduction, and blood chemistry at this dose. A TRV of 6.36 mg/kg-bw/day was calculated from the 50 mg Cr/kg value reported in Eisler (1986) by multiplying by 0.15 kg of food eaten daily (Welty, 1982) and then dividing by 2.60 lb (1.18 kg) weight for an average adult black duck (Terres, 1982). This was the only value found for ducks exposed to chromium.

Chromium - Heron (1.28 mg/kg-bw/day)

No data were found exposing waterbirds to chromium. This value was based on the duck TRV of 6.4 mg/kg-bw/day. This value was divided by 5 to account for inter-taxon variation, resulting in a TRV of 1.28 mg/kg-bw/day.

Chromium - Raptors (1.28 mg/kg-bw/day)

No data were found regarding raptor exposure to chromium. The duck TRV was used to extrapolate to raptors because it was the most rigorous avian exposure to chromium found. The raptor TRV was extrapolated from the duck TRV of 6.4 mg/kg-bw/day by dividing by 5 to account for inter-taxon variability.

Mercury (Organic) - Small Mammals (0.05 mg/kg-bw/day)

This value was based on 11-12 wk LOAELs for rats of 0.5 mg/kg-bw/day (Ilback, 1991; Ilback et al. 1991). Immunological and developmental effects observed at this dose included reduced natural killer T-cell activity, decreased thymus weight and cell number, decreased cell-mediated cytotoxicity, increased thymus lymphocyte activity in fetuses. These effects are considered less serious but are the most scientifically sound data found for small mammal exposure to organic mercury compounds. Neurotoxic effects in the form of arched backs and ataxia were observed at 0.8 mg/kg-bw/day (LOAEL) in mice exposed to methylmercuric chloride in drinking water for 110 d (Ganser and Kirschner, 1985). The LOAEL of 0.5 mg/kg-bw/day was divided by 10 to estimate a chronic NOAEL.

Mercury (Organic) - Medium Mammals (0.05 mg/kg-bw/day)

This value was based on the study of Borg et al. (1974), which examined the dietary effects of mercury and methylmercury (MeHg) on mink. Methylmercury was considerably more toxic than mercury to mink, with a LC100 of 5 mg MeHg/kg in 37 days of exposure, compared to a 5 mo NOAEL of 1.01 mg Hg/kg-bw/day as mercuric chloride (Borg et al. 1974). Extrapolating from a LC100, the mink MeHg value was divided by 100 to estimate a chronic NOAEL of 0.05 mg/kg-bw/day. Hanko et al. (1970) reported a 58 d LC50 value of 5 mg MeHg/kg for ferrets, similar to the Borg et al. (1974) MeHg value reported for mink. A 2 yr NOAEL for domestic cats of 0.02 mg/kg-bw/day based on food consumption, body weight gain, and various neurological endpoints was found in Charbonneau et al. (1976), similar to the TRV. A LOAEL for dogs of 0.1 mg/kg-bw/day exposed during pregnancy was also found (endpoint was stillbirths) (Eisler, 1987). The mink value was used to generate the TRV because it is more taxonomically similar to ROCs than domestic cats.

Mercury (Organic) - Birds (0.068 mg/kg-bw/day)

This value was based on a 12 mo NOAEL for mallard ducks (Heinz, 1974). The value reported in Heinz (1974) as 0.5 mg MeHg/kg feed (methylmercury dicyandiamide, or Morsodren) was multiplied by the amount of feed consumed daily by an adult mallard (0.15 kg; Welty, 1982; page 113) and divided by the weight of an adult mallard (2.4 lb or 1.1 kg; Terres, 1982) to achieve a TRV of 0.068 mg/kg-bw/day. The endpoints measured included mortality and reproductive success. This value was lower than the 21 wk NOAEL reported for mallard ducks (Scheuhammer, 1987) as 3.0 mg/kg feed (0.41 mg/kg-bw/day), the 85 d NOAEL value obtained by Haegele et al. (1974) of 6.2 mg/kg diet (0.75 mg/kg-bw/day), and the 214 d NOAEL of 0.28 mg/kg-bw/day by Pass et al. (1975) for mallards exposed to methyl mercury. Based on these supporting data, the TRV appears sufficiently protective.

Mercury (Organic) - Herons (0.014 mg/kg-bw/day)

This value was based on the TRV for ducks of 0.068 mg/kg-bw/day. The duck TRV of 0.068 mg/kg-bw/day was divided by 5 to account for inter-taxon variability, resulting in a TRV of 0.014 mg/kg-bw/day for herons.

Mercury (Organic) - Raptors (0.01 mg/kg-bw/day)

This value was based on a 47 d LC100 of 0.92-1.2 mg/kg-bw/day for goshawks exposed to methylmercury (MeHg) (Borg et al. (1970). The dietary dose of 10-13 mg MeHg/kg was multiplied by the average daily goshawk feeding rate of 0.093 kg/d and then divided by the average mass of the goshawks exposed (1.0 kg) to achieve 0.92-1.2 mg/kg-bw/day. This value was divided by 100 to estimate a chronic NOAEL of 0.01 mg/kg-bw/day. A LOAEL of unknown exposure duration of kestrels to mercury was also found (Scheuhammer, 1987). Considerable mortality was observed in kestrels exposed to 13 mg Hg/kg as feed. This value was multiplied by the amount of feed consumed daily by an adult kestrel (10% of body weight or 0.011 kg; Welty, 1982) and divided by the weight of an adult kestrel (0.113 kg; Terres, 1982) to achieve a LOAEL of 1.26 mg/kg-bw/day.

Mercury (Organic) - Other Birds (0.023 mg/kg-bw/day)

This value was based on an 8 wk LOAEL of 0.23 mg/kg-bw/day for starlings (Nicholson and Osborn 1984). The dietary dose of 1.1 mg/kg feed was multiplied by the estimated starling feeding rate of 0.0147 kg/d (Nagy 1987) and then divided by the estimated mass of the starlings exposed (0.070 kg; Terres 1982) to achieve 0.23 mg/kg-bw/day. The endpoint was the presence of numerous kidney lesions, although no outward signs of toxicity were observed. The value obtained by Nicholson and Osborn (1984) was divided by 10 to account for uncertainty, as there was only one dose level and only 10 birds were exposed.

Vanadium - Small Mammals (0.7 mg/kg-bw/day)

This value was based on a chronic NOAEL of 0.7 mg/kg-bw/day for mice reported in U.S. EPA (1994). Exposure duration and endpoints were not provided.

Vanadium - Medium Mammals (0.14 mg/kg-bw/day)

No data were found regarding medium mammal exposure to vanadium. The small mammal TRV of 0.7 mg/kg-bw/day was used to extrapolate to the medium mammal TRV by dividing by 5 to account for inter-taxon variability.

Vanadium - All Birds (ND)

No data were found regarding vanadium exposure to birds.

Hexachlorobutadiene - Small Mammals (0.2 mg/kg-bw/day)

This value was based on a chronic NOAEL of 0.2 mg/kg-bw/day for rats as reported in U.S. EPA (1994). Exposure duration and endpoints were not provided.

Hexachlorobutadiene - Medium Mammals (0.04 mg/kg-bw/day)

No data were found regarding medium mammal exposure to hexachlorobutadiene. The small mammal TRV of 0.2 mg/kg-bw/day was used to extrapolate to the medium mammal TRV by dividing by 5 to account for inter-taxon variability.

Hexachlorobutadiene - All Birds (ND)

No data were found regarding hexachlorobutadiene exposure to birds.

Hexachloroethane - Small Mammals (1.0 mg/kg-bw/day)

This value was based on a chronic NOAEL of 0.7 mg/kg-bw/day for rats as reported in U.S. EPA (1994). Exposure duration and endpoints were not provided.

Hexachloroethane - Medium Mammals (0.2 mg/kg-bw/day)

No data were found regarding medium mammal exposure to hexachloroethane. The small mammal TRV of 1.0 mg/kg-bw/day was used to extrapolate to the medium mammal TRV by dividing by 5 to account for inter-taxon variability.

Hexachloroethane - All Birds (ND)

No data were found regarding hexachloroethane exposure to birds.

2.3 Calculation of ECUGs

Using the information described above and the food-web model presented in EA (1994), hazard quotients (HQs) were calculated for each receptor, COC, and zone when sufficient information existed to do so. Because soils are the contaminant source media for other environmental compartments, it was assumed that a reduction in concentrations in this medium will cause a concomitant decrease in concentrations in other media (e.g., small mammals and plants). Based on this assumption, ECUGs were calculated using the following relationship:

$$ECUG = \frac{\begin{matrix}Exposure\\Concentration\end{matrix}}{HQ}$$

The HQs selected were the highest values for any receptor in any zone for each contaminant (except Zone 4 values which represent upstream conditions). These values are highlighted in Table 5. The exposure concentrations used for ECUG calculation were the 95 percent UCLs for soil which match the selected HQs. These values are presented in Table 6.

3. CONCLUSIONS

Given the large degree of uncertainty in the calculations presented above due to limitations of the existing data base and the conservative assumptions, no clear conclusions regarding ecological risks or ecological cleanup goals can be made at this time. Although it appears from the information presented in Table 6 that hazard quotients for 6 of the 12 COCs exceed 1.0, thereby requiring some level of risk management action, the data upon which the ECUG derivation is based are biased, incomplete, and too limited to place any degree of confidence in. It is anticipated that the Phase III data currently being obtained will bridge data gaps as well as reduce and quantify these uncertainties. In addition, it should be recognized that the toxicity reference values (TRVs) used contain a (in some cases substantial) degree of protective conservatism and in some instances where the HQ exceeds 1.0 (and consequently the ECUG is exceeded), ecological impacts due to remedial activities may outweigh risks associated with no action. As such, ECUGs calculated in the manner described should be viewed as screening criteria rather than as strict "not-to-exceed" values.

Table 5. Hazard quotients (HQs) calculated for Fields Brook using upper 95 percent confidence limits on all exposure media. Shaded values are the highest HQs for the indicated compound. Zone 4 data were excluded from further evaluation because these data represent upstream conditions.

Analyte	Reach	Mink	Hawk	Shrew	Mouse	Heron	Robin	Rabbit
Aroclor-1248	Zone 1	0.473	0.426	0.030	0.067	< 0.001	0.062	0.291
Aroclor-1248	Zone 2	0.416	0.370	0.029	0.086	< 0.001	0.042	0.373
Aroclor-1248	Zone 3	0.233	0.212	0.031	0.039	< 0.001	0.065	0.170
Aroclor-1248	Zone 4	0.016	0.017	0.029	0.003	< 0.001	0.042	0.006
Aroclor-1254	Zone 1	6.046	0.034	1.289	0.297	0.002	0.005	2.851
Aroclor-1254	Zone 2	8.565	0.045	1.296	0.660	0.001	0.003	6.923
Aroclor-1254	Zone 3	4.426	0.025	1.288	0.239	0.002	0.004	2.201
Aroclor-1254	Zone 4	1.842	0.011	1.290	0.112	0.001	0.003	0.706
Aroclor-1260	Zone 1	7.703	0.066	4.251	0.461	0.002	0.025	1.423
Aroclor-1260	Zone 2	14.623	0.126	11.814	1.276	0.003	0.045	3.442
Aroclor-1260	Zone 3	15.660	0.138	12.134	0.975	0.004	0.063	0.915
Aroclor-1260	Zone 4	0.872	0.008	0.917	0.081	< 0.001	0.004	0.333
Arsenic	Zone 1	0.174	0.032	0.481	0.432	0.005	0.002	0.108
Arsenic	Zone 2	0.153	0.028	1.367	0.519	0.007	0.004	0.116
Arsenic	Zone 3	0.279	0.051	2.622	0.729	0.015	0.011	0.154
Arsenic	Zone 4	0.095	0.018	1.098	0.319	0.006	0.004	0.068

Table 5. Continued.

Analyte	Reach	Mink	Hawk	Shrew	Mouse	Heron	Robin	Rabbit
Barium	Zone 1	---	---	---	---	---	---	---
Barium	Zone 2	---	---	---	---	---	---	---
Barium	Zone 3	---	---	---	---	---	---	---
Barium	Zone 4	---	---	---	---	---	---	---
Beryllium	Zone 1	0.132	0.055	0.102	0.018	0.023	0.019	0.077
Beryllium	Zone 2	0.209	0.081	0.113	0.043	0.018	0.014	0.185
Beryllium	Zone 3	---	---	---	---	---	---	0.118
Beryllium	Zone 4	---	---	---	---	---	---	0.072
Cadmium	Zone 1	0.276	0.079	0.519	0.062	0.040	0.030	0.080
Cadmium	Zone 2	0.167	0.046	0.406	0.056	0.021	0.016	0.084
Cadmium	Zone 3	---	---	---	---	---	---	0.060
Cadmium	Zone 4	0.114	0.034	0.398	0.036	0.021	0.016	0.038
Chromium	Zone 1	18.622	0.246	3.019	2.571	0.023	---	11.940
Chromium	Zone 2	13.192	0.172	4.409	2.547	0.024	---	10.769
Chromium	Zone 3	50.814	0.660	3.184	8.165	0.023	---	36.489
Chromium	Zone 4	4.177	0.056	2.199	0.821	0.012	---	3.489
Hexachlorobutadiene	Zone 1	1.440	---	2.108	0.366	---	---	3.229
Hexachlorobutadiene	Zone 2	1.731	---	2.085	0.513	---	---	3.831

Table 5. Continued.

Analyte	Reach	Mink	Hawk	Shrew	Mouse	Heron	Robin	Rabbit
Hexachlorobutadiene	Zone 3	1.999	---	2.097	0.487	---	---	3.771
Hexachlorobutadiene	Zone 4	4.330	---	8.040	0.683	---	---	1.562
Hexachloroethane	Zone 1	0.266	---	0.422	0.070	---	---	0.633
Hexachloroethane	Zone 2	0.345	---	0.419	0.104	---	---	0.765
Hexachloroethane	Zone 3	0.398	---	0.424	0.097	---	---	0.756
Hexachloroethane	Zone 4	0.871	---	1.606	0.139	---	---	0.314
Mercury	Zone 1	2.028	1.983	4.042	1.331	0.316	0.151	1.026
Mercury	Zone 2	2.573	2.707	16.742	2.036	0.903	0.403	0.837
Mercury	Zone 3	8.887	8.754	24.801	7.177	1.699	0.941	6.645
Mercury	Zone 4	6.147	5.688	8.331	6.186	0.446	0.202	5.079
Vanadium	Zone 1	---	---	---	---	---	---	---
Vanadium	Zone 2	---	---	---	---	---	---	---
Vanadium	Zone 3	---	---	---	---	---	---	---
Vanadium	Zone 4	---	---	---	---	---	---	---

--- Missing information, no HQ calculated.

Table 6. Preliminary draft ecological cleanup goals.

Analyte	Hazard Quotient	95% Soil Concentration	ECUG (ppm)
Aroclor-1248	0.473	146.84	310.44
Aroclor-1254	8.565	28.30	3.30
Aroclor-1260	15.660	5.50	0.35
Arsenic	2.622	35.66	13.60
Barium	---	---	---
Beryllium	0.209	5.30	25.36
Cadmium	0.519	7.70	14.84
Chromium	50.814	748.60	14.73
Hexachlorobutadiene	3.831	7.50	1.96
Hexachloroethane	0.765	7.50	9.80
Mercury	24.801	48.34	1.95
Vanadium	---	---	---

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