APPENDIX E

TECHNICAL INFORMATION

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CONTENTS

E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND CONCENTRATIONS

As early as the late 1950s, the U.S. Department of Energy (DOE) and its predecessor organization determined the importance of identifying background concentrations for metals and radionuclides in the environment. Routine monitoring programs were established for air and grass. In 1971, the monitoring program was expanded to include surface soil samples taken at four locations at the plant perimeter, with the only analyte being total uranium.

In 1973, the locations of sampling were changed from the perimeter locations mentioned herein to four locations five miles from the plant perimeter. The only analyte was total uranium. From 1975 until 1985, the environmental monitoring program for soils continued as described.

The environmental report for 1986 states that the analyte list for soil samples was expanded from only uranium to thorium-230, neptunium-237, plutonium-239, and isotopic uranium. Starting in 1988, the radionuclide analyte list for soil samples taken as part of the environmental monitoring programs was expanded to include total uranium, uranium-238, cesium-237, potassium-40, neptunium-237, plutonium-239, thorium-230, and technetium-99. Also, beginning in 1988, analyses were performed for 36 metals. Metals included in the analyte list were aluminum, antimony, arsenic, barium, beryllium, bismuth, calcium, cadmium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, niobium, phosphorus, potassium, ruthenium, silver, sodium, silicon, strontium, tantalum, thallium, thorium, tin, titanium, tungsten, vanadium, zinc, and zirconium.

PHASE I AND II SITE INVESTIGATIONS REFERENCE SAMPLING

In 1988, DOE and the U.S. Environmental Protection Agency (EPA) entered into a Consent Order that defined the mutual objectives of the EPA and DOE to study groundwater contamination and the threat of releases from the Paducah Gaseous Diffusion Plant (PGDP). A copy of that Consent Order can be found at the following link: http://www.paducaheic.com/media/32632/I-02004-0002-ARI52.PDF.

As part of the effort to address the Consent Order, a Site Investigation was performed in two phases. The *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (ER/KY-4) was completed in 1991; and *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, was completed in 1992. During the completion of Phase I and II Site Investigations, the need for background or reference concentrations for inorganic analytes and reference activities radionuclides was recognized. To meet this need, the Site Investigations included the collection of soil samples from areas outside known plant influence. To establish reference activities for radionuclides, 33 surface soil samples (from 0 to 12 inches in depth) were collected from areas at least 5 miles east and southeast of PGDP in May and June of 1990. The analytes for this sampling effort included gross alpha and gross beta, neptunium-237, technetium-99, plutonium-239, thorium-230, uranium-238, uranium-234, and uranium-235.

To establish reference concentrations for inorganic and metals, five surface samples (from 0 to 6 inches in depth) were taken during the Phase II Site Investigation in areas near the PGDP, but outside areas suspected to be influenced by the plant operations. The metals included aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium and zinc. A report entitled *Inorganic Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky*, ORNL/TM-12897, was prepared and sent to the regulatory agencies for information purposes.

While this report was not prepared to establish background groundwater and soil concentrations, it did discuss potential background concentrations for soil and groundwater at PGDP.

In response to comments on *Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky*, ORNL/TM-12897 (1996), DOE prepared another internal report with a more extensive evaluation of existing data (primarily data from the Phase I and II Site Investigations, entitled *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant*, KY/EM-77&D1. The report contained data for 146 surface sampling locations and 597 samples for subsurface soils for metals analysis. The metals included all of those analyzed in the Phase II report with the exception of cyanide in surface and subsurface soils and thallium in subsurface soils. A consensuses of reviewers believed that the data evaluation in this report was not sufficient to establish background of metals in soil and requested that the document be revised.

In response, a revised report, *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1417&D2, was prepared (DOE 1996). EPA conditionally approved this revised document. The conditions included the reanalysis of four metals including antimony, beryllium, cadmium, and thallium. Also in 1996, the Commonwealth of Kentucky accepted the revised report. The Commonwealth also called for additional sampling to verify the background concentrations of antimony, beryllium, cadmium, and thallium.

DOE issued the final revision of a work plan entitled *Project Plan for the Background Soils Project for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1414&D2 (DOE 1996). As described in this work plan, DOE was to verify with additional sampling the background concentrations for the four metals listed in the conditional approval letters for DOE/OR/07-1417&D2 and to determine the background concentrations of selected radionuclides.

DOE issued the final revision of the report for the background soils project entitled, *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1586&D2. In this report, the values selected by DOE as background concentrations for soil in the DOE/OR/07-1417 report were combined with the background concentrations analyzed for antimony, beryllium, cadmium, thallium, and selected radionuclides, and final background concentration data sets were established. This report included 15 surface soil and 41 subsurface soil sampling locations for the four metals listed above. In addition the significant radionuclides included cesium-137, neptunium-237, plutonium-239, plutonium-238, potassium-40, radium-226, strontium-90, technetium-99, thorium-228, thorium-230, thorium-232, uranium-238, uranium-234, and uranium-235. A variety of statistical methods as described in *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1586&D2, were used to evaluate the data and ultimately these data were used with data from previous investigations to establish the background values for soils at PGDP. The background values are presented in Appendix A.

E.2. SITE-SPECIFIC EXPOSURE INFORMATION

This section of the appendix contains copies or excerpts of reports, memoranda, articles, and links to reports that are useful in developing exposure assessments for PGDP and justifying various assumptions made when completing risk assessments and analyses. These include the following:

- Site Investigation surface water and groundwater users survey to determine groundwater use near PGDP (CH2M HILL 1991);
- Summary of agricultural practices in Ballard County, Kentucky;
- Summary agricultural practices in McCracken County, Kentucky;
- Area of crop land in Ballard and McCracken Counties, Kentucky;
- Recreational use of Bayou and Little Bayou Creeks near PGDP;
- Annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, Kentucky; and
- Reports entitled, "Planning Issues for Superfund Site Remediation," and "Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study," from *Hazardous Materials Control* regarding use of exposure units in risk calculations and remedial decisions.

E.2.1 PHASE I SITE INVESTIGATION RESULTS OF SURFACE WATER AND GROUNDWATER USERS SURVEY TO DETERMINE GROUNDWATER USE NEAR PGDP

A surface water and groundwater user's survey was conducted as part of the Site Investigation Phase I, and is included in the document's Appendix 2B-15 (CH2M HILL 1991). The appendix in its entirety can be found at the following link: http://www.paducaheic.com/media/45063/i-02300-0001f-ARI14.pdf. Appendix 2B-15 begins on page 276 of the pdf.

E.2.2 SUMMARY OF AGRICULTURAL PRACTICES IN BALLARD COUNTY, KENTUCKY

This section summarizes information obtained from a 2013 search of various public records to identify the parameters of agricultural practices in Ballard County, Kentucky.

Population. Population information for Ballard County is taken from http://www.city-data.com/county/Ballard_County-KY.html, accessed December 2013.

- 8,333 population (as of 2012)
- Size of family households: 1,179 2-persons; 552 3-persons; 405 4-persons; 157 5-persons; 52 6-persons; 27 7-or-more-persons

- Size of nonfamily households: 881 1-person; 131 2-persons; 5 3-persons; 6 4-persons; 1 5-persons; 1 6-persons

Agriculture in Ballard County. Agriculture information for Ballard County is taken from http://www.city-data.com/county/Ballard_County-KY.html, accessed December 2013.

- Average size of farms: 233 acres
- Average value of agricultural products sold per farm: $70,647
- Average value of crops sold per acre for harvested cropland: $213.68
- The value of nursery, greenhouse, floriculture, and sod as a percentage of the total market value of agricultural products sold: 0.18%
- The value of livestock, poultry, and their products as a percentage of the total market value of agricultural products sold: 55.27%
- Average total farm production expenses per farm: $60,366
- Harvested cropland as a percentage of land in farms: 63.59%
- Irrigated harvested cropland as a percentage of land in farms: 0.29%
- Average market value of all machinery and equipment per farm: $50,268
- The percentage of farms operated by a family or individual: 91.56%
- Average age of principal farm operators: 55 years
- Average number of cattle and calves per 100 acres of all land in farms: 8.31
- Milk cows as a percentage of all cattle and calves: 5.09%
- Corn for grain: 22,422 harvested acres
- All wheat for grain: 10,372 harvested acres
- Soybeans for beans: 39814 harvested acres
- Vegetables: 15 harvested acres
- Land in orchards: 5 acres

Gardening. Gardening information was updated from a 1994 interview with the Agricultural Extension Agent of Ballard County. The current Ballard County Agricultural Extension Agent confirmed in December 2013 that most of the information is feasible; however, the percentage of the population with a garden has dropped considerably.

(1) Approximately 25–30% of the population have a garden
(2) Commonly grown garden vegetables are squash, corn, tomatoes, green beans, and peas
(3) The average garden site is one-fourth acre
(4) Approximately 0.1 to 0.2 pounds of garden grown vegetables are consumed per individual per day

(5) Approximately 80% of gardeners can their produce
(6) Growing season is April 5 to October 12: 4,560 hours

E.2.3 SUMMARY OF AGRICULTURAL PRACTICES IN MCCRACKEN COUNTY, KENTUCKY

This section summarizes information obtained from a 2013 search of various public records to identify the parameters of agricultural practices in McCracken County, Kentucky.

Population. Population information for McCracken County is taken from http://www.city-data.com/county/McCracken_County-KY.html, accessed December 2013.

- 65,549 population (as of 2012)

- Size of family households: 8,862 2-persons; 4,185 3-persons; 3,035 4-persons; 1,200 5-persons; 411 6-persons; 198 7-or-more-persons

- Size of nonfamily households: 8,993 1-person; 1,153 2-persons; 119 3-persons; 50 4-persons; 11 5-persons; 5 6-persons; 5 7-or-more-persons

Agriculture in McCracken County: Agriculture information for McCracken County is taken from http://www.city-data.com/county/McCracken_County-KY.html, accessed December 2013.

- Average size of farms: 161 acres

- Average value of agricultural products sold per farm: $29,777

- Average value of crops sold per acre for harvested cropland: $215.65

- The value of nursery, greenhouse, floriculture, and sod as a percentage of the total market value of agricultural products sold: 11.92%

- The value of livestock, poultry, and their products as a percentage of the total market value of agricultural products sold: 26.35%

- Average total farm production expenses per farm: $22,605

- Harvested cropland as a percentage of land in farms: 63.19%

- Irrigated harvested cropland as a percentage of land in farms: 0.21%

- Average market value of all machinery and equipment per farm: $34,300

- The percentage of farms operated by a family or individual: 96.80%

- Average age of principal farm operators: 55 years

- Average number of cattle and calves per 100 acres of all land in farms: 3.63

- Corn for grain: 9160 harvested acres

- All wheat for grain: 3899 harvested acres

- Soybeans for beans: 37579 harvested acres
- Vegetables: 85 harvested acres
- Land in orchards: 122 acres

Gardening. Gardening information was updated from a 1994 interview with the Agricultural Extension Agent of McCracken County. The current McCracken County Agricultural Extension Agent confirmed in January 2014, that most of the information still is feasible; however, the percentage of the population with a garden has dropped considerably, as has the average garden size.

(1) Approximately 10% of the population have a garden.

(2) Common grown garden vegetables are squash, com, tomatoes, green beans, and lettuce.

(3) The average garden size is one-eighth acre.

(4) During harvest season (three months), approximately 2 pounds of garden grown vegetables are consumed per individual per day.

(5) Approximately all gardeners can their produce.

E.2.4 AREA OF CROP LAND IN BALLARD AND MCCRACKEN COUNTY, KENTUCKY

The following information is taken from USDA's National Agricultural Statistics Service in cooperation with the Kentucky Department of Agriculture, published in June 2009. The information is available at the following Web sites, accessed December 12, 2013:

- http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/State_Census_Summaries/Historical_Ag_Statistics/BALLARD.pdf
- http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/State_Census_Summaries/Historical_Ag_Statistics/MCCRACKEN.pdf

	Harvested Acres	
Year	**Ballard**	**McCracken**
1982	80,133	45,870
1987	62,583	40,444
1992	69,662	36,450
1997	74,158	46,291
2002	71,870	54,003
2007	70,700	43,272

E.2.5 RECREATIONAL USE OF BAYOU AND LITTLE BAYOU CREEKS NEAR PGDP

The usage information originally was provided by Charlie Logsdon, West Kentucky Wildlife Management Area (WKWMA) Supervisor, in November 1995, in response to a questionnaire sent to him by Fuller, Mossbarger, Scott, and May Engineers, Inc., of Lexington, Kentucky (see Attachment E1). The information was used by the United States Army Corps of Engineers to support a preliminary risk calculation for Bayou and Little Bayou Creeks that was completed in 1997. In response to a recommendation from the Paducah Risk Assessment Working Group in October 2013, the information was provided to Tim Kreher, the current WKWMA Manager, for review and update. Mr. Kreher returned the updated information to the Risk Assessment Working Group on January 21, 2014. Mr. Kreher's e-mail to LeAnne Garner, chair of the Risk Assessment Working Group, is included in Attachment E2.The information below provides a summary of the updated information.

E.2.5.1 Bayou Creek

1. What is the average number of visitors per year to Bayou Creek?

The number of visits by people using Bayou Creek specifically is estimated to be 225 visits. This is for a specific activity involving Bayou Creek, such as fishing. More people may be in the vicinity while using the WKWMA, but their use of Bayou Creek maybe for only an instant (i.e., using a log to cross Bayou Creek to hunt on the other side of the creek).

2. Of this number, how many are adults and how many are children?

Of the 225 visits of people using Bayou Creek, 150 are adults and 75 are children. This is an estimate based on our observations of people using the area.

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

Most of these people would be one-time users; however, 10% of the total number of users could be classified as repeat users. The highest number of visits by one person specifically using Bayou Creek would probably be < 15.

4. What is the average time (hours) spent in Bayou Creek? Is there a difference in average time spent between adult and child usage?

The average time spent in Bayou Creek by users is unknown; however, the amount of time spent/trip would be similar to other activities. An estimate of the average number of hours spent/trip for activities were as follows: Quail hunting ~ 5, rabbit hunting ~ 5, bowhunting for deer ~ 5, duck hunting ~ 4, and raccoon hunting ~ 4. Raccoon hunting and duck hunting would be the activities most likely associated with Bayou Creek. There would be little, if any, difference between adult and child usage of the area.

Actual time spent in the creek may be cases where hunters cross one or both creeks by wading through shallow spots; in most cases, these people are wearing rubber boots or waders. When hunters do wade through the creeks, again it is a brief exposure of less than 30 seconds each time.

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e., what percentage of visitors fish, hunt, hike, swim. etc.)?

WKWMA is used heavily by a wide variety of users. Annually, the estimated number of visits for the following activities are the following: fishing ~ 7,500 visits/year; hunting and dog training ~ 6,000-9,000; field trials ~ 2,250; hiking ~ 150; berry and nut picking ~ 300; driving through for a variety of reasons ~ 75,000.

There are brief exposures to both Bayou and Little Bayou Creeks by dog trainers riding horses where they cross the creek via the method of the horse and dog wading through the creek while the rider is mounted (i.e., the riders does not have contact with the water for the most part). Such crossings are brief, less than 10 seconds at a time. For activities involving Bayou Creek alone: fishing—225 (see Question 1).

6. What is the number of repeat visits per year by anyone individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

Refer to Questions 3 and 4.

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

Most, if not all, would be bank fishermen. Most of the fishing would occur at three points: (1) where the iron bridge in Tract 4 crosses Bayou Creek, (2) where the collapsed bridge in Tract 4 crosses Bayou Creek (by weir constructed by PGDP), and (3) where the concrete crossing bridges Bayou Creek in Tract 6. While it may occur, no wade fishing has been observed. No actual data are available, but should be similar to the length of visits noted in Question 4.

8. Is there a harvestable fish population in Bayou Creek? If there is, is there enough to support subsistence fishing (i.e., 0.284 kg of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

There is a harvestable fish population in Bayou Creek. A person potentially could expect to catch 0.284 kg of fish on a regular basis; however, this is assuming that the person is not culling (throwing back extremely small fish). The frequency of being able to catch 0.248 kg of fish would increase as one approaches the mouth of Bayou Creek. Also, the only way the creek could support 128 meals a year is if there were a major influx of fish from the Ohio River. This does occur when there is a backwater. During the backwater periods, catches of 50 to several hundred pounds of catfish can be taken (this has been observed) on trotlines. This would not be indicative of risks associated with the plant.

Fishing activity in the creeks rarely is observed outside of the portion that crosses through TVA-owned property near where the creeks join and meet the Ohio River (referred to as Tract 6 of the WKWMA).

E.2.5.2 Little Bayou Creek

1. What is the average number of visitors per year to Little Bayou Creek?

The number of people visiting Little Bayou Creek essentially is zero, with the exception of PGDP personnel and a few fishermen (maybe 30 visits annually) who fish a large beaver pond above the outfalls of the plant. A few people (bowhunters and dog trainers) may cross the creek occasionally, but these visits would be brief (the majority would be measured in seconds or minutes). Field trial galleries do cross the creek (over a large dirt-covered culvert) north of McCaw Road; however, they do not enter the creek, and the whole process takes seconds.

2. Of this number, how many are adults and how many are children?

The visitors would be adults.

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

Refer to Bayou Creek Question 3 (Section E.2.5.1). Visitors to Little Bayou Creek would be repeat users, probably less than 15 visits per year, and most of them fall into the brief encounter scenario described in Question 1.

4. What is the average time (hours) spent in Little Bayou? Is there a difference in average time spent between adult and child usage?

Most encounters with Little Bayou Creek would be measured in seconds. Fishermen who use the beaver pond above the outfalls may fish on average 3 hours.

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?

See Bayou Creek Question 5 (Section E.2.5.1).

6. What is the number of repeat visits per year by anyone individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

Field trials that cross the creek may occur 12–15 weekends of the year. Most of the participants would be repeat users. The sum of all the encounters with Little Bayou Creek would be measured in minutes for the most frequent user, and most would cross the creek only on the culvert and dirt crossings.

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

All fishermen in the beaver pond would be bank fishermen because the pond is too deep to wade.

8. Is there a harvestable fish population in Little Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

Other than the beaver pond above the outfalls, it would be nearly impossible to catch 0.284 kgs of fish from Little Bayou Creek. There is a fish population, but most would fall in the minnow category and are not desirable by fishermen. In the beaver pond, it would be possible to catch this amount, but it would not support subsistence fishing (128 meals/year).

E.2.5.3 Annual Harvests of Turkeys, Deer, Geese, and Ducks in McCracken and Ballard Counties, Kentucky

PGDP is surrounded by the WKWMA (Figure E.1). Additionally, several solid waste management units (SWMUs) (currently listed as no further action) are located in the Ballard Wildlife Management Area (Figure E.2). Figure E.3 provides a legend for features in the wildlife management areas. Both of these areas are home to hunting and fishing. Huntable populations of turkey, deer, dove, squirrel, rabbits, and quail exist in the area. Migratory geese and ducks also are abundant in the area. Table E.1 and Figure E.4 and Table E.2 and Figure E.5 show the hunting statistics for turkey and deer in western Kentucky.

The figures and tables within this subsection include additional information regarding wildlife harvests of turkey and deer recorded by Kentucky's telecheck program. Additionally, the reported inventories of ducks and geese found in the Ballard Wildlife Management Area during the 2010/2011 and 2011/2012 hunting seasons are presented in Table E.3. Maps and information regarding game were taken from the Kentucky Department of Fish and Wildlife Resources Web site, http://fw.ky.gov accessed in October 2013.

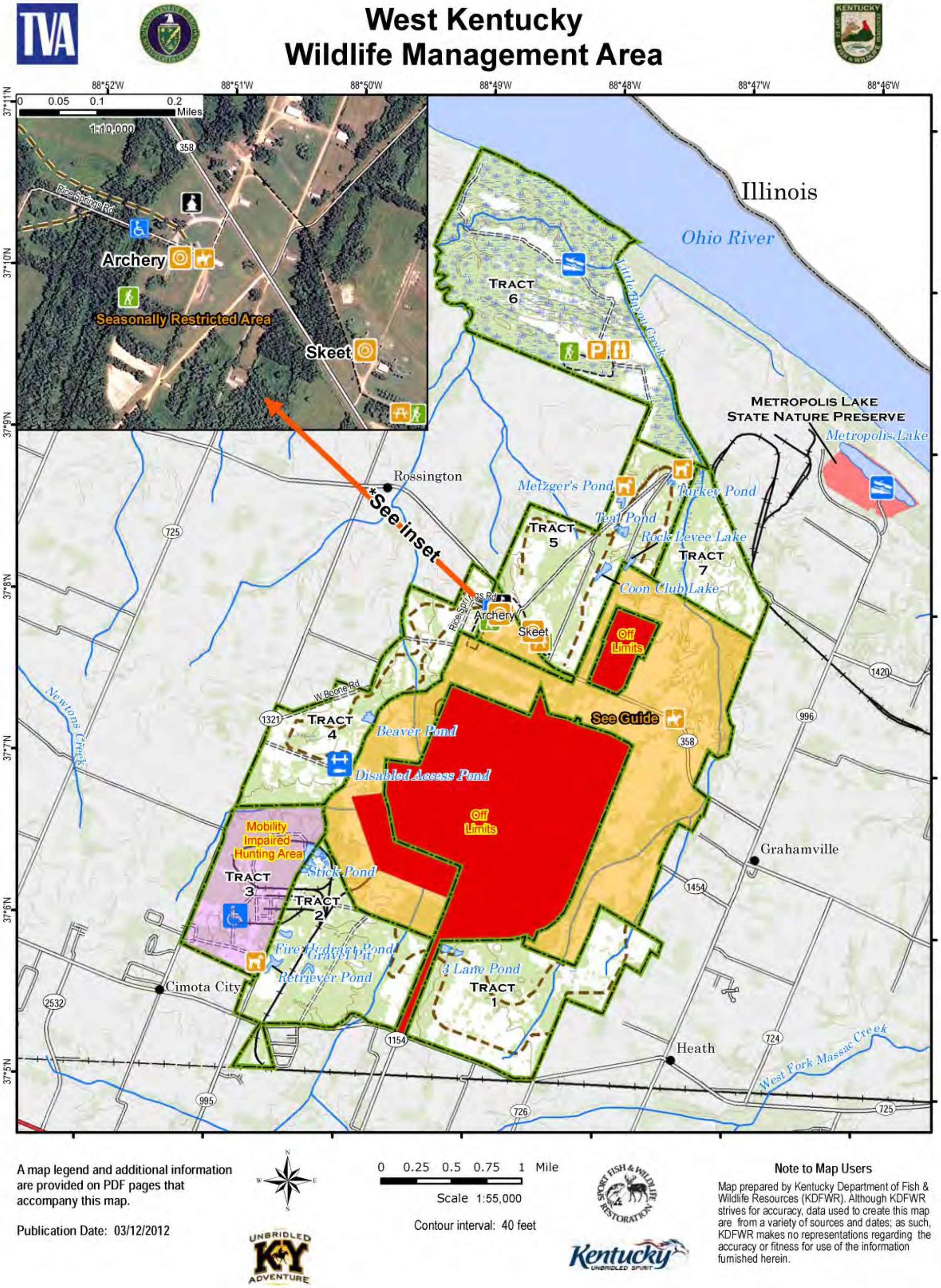
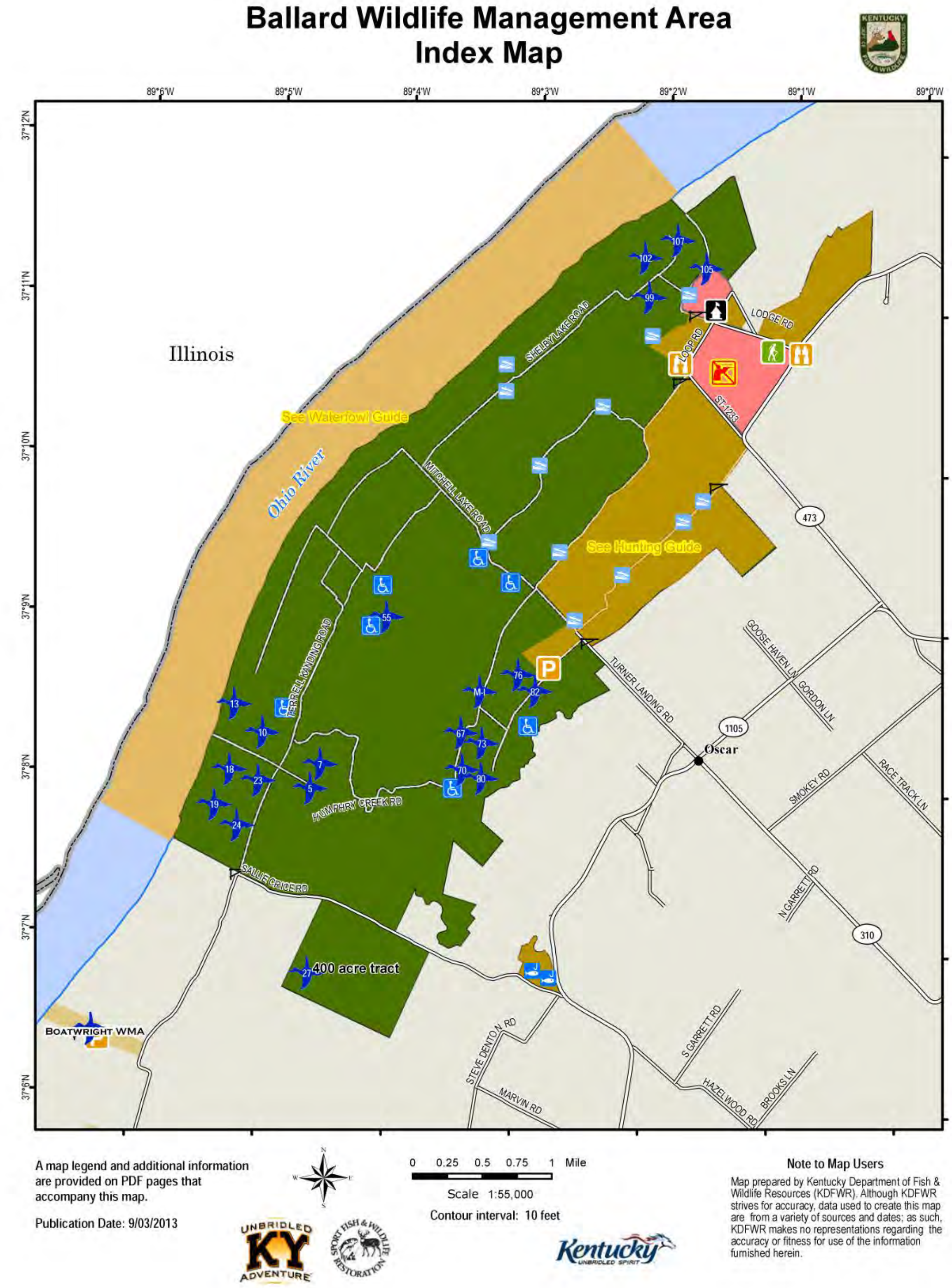


Figure E.1. Map of West Kentucky Wildlife Management Area



A map legend and additional information are provided on PDF pages that accompany this map.

Publication Date: 9/03/2013

Note to Map Users

Map prepared by Kentucky Department of Fish & Wildlife Resources (KDFWR). Although KDFWR strives for accuracy, data used to create this map are from a variety of sources and dates; as such, KDFWR makes no representations regarding the accuracy or fitness for use of the information furnished herein.

Figure E.2. Map of Ballard Wildlife Management Area

Wildlife Management Area Map Notes & Legend

NOTE TO MAP USERS:

For most WMA maps the landscape is depicted using a combination of elevation contours, hillshading and a green tint indicating woodland areas that is derived from satellite imagery. On WMAs that are relatively small or have a history of surface mining aerial photography is used.

WMA Map Legend

- WMA Office
- ? Information Kiosk
- ✓ Check station
- ♿ Mobility-impaired Hunting Blind
- Trailhead
- Horseback Trailhead
- P Parking Lot
- Picnic Area
- Restrooms
- Wildlife Viewing Site
- Interpretive Site
- Retriever Training Site
- Gate
- Δ Campground
- Cemetery
- Corps of Engineers Office
- Waterfowl Blind
- ◎ Shooting Range
- Established Bank Access
- Fishing Pier
- Carrydown Launch
- Small Boat Ramp
- Large Boat Ramp
- State Park Office

- ▭ WMA Boundary
- Aerial photograph
- Other Public Hunting Areas
- Off Limits Area Off Limits
- No Hunting
- Sea Guide Seasonally Restricted Access
- ♿ Mobility Impaired Hunting Area
- Primitive Hunting Only
- Foot Traffic Only
- 🟦 Open Water
- Wetland
- 🟩 Woodland

- ● Populated Place
- Kentucky Boundary
- 75 Interstate Highway
- Kentucky Parkway
- 60 U.S. Highway
- 169 State Highway
- Named Road Local Road
- 4596 Forest Service Road
- Active Railroad
- Abandoned Railroad
- ------ Federal Recreation Trail
- ====== WMA Road
- ------ WMA Foot Trail
- – – – WMA Horse Trail
- •—•— Gas Pipeline
- =:=:= Powerline
- Rivers and Streams
- Dam
- Trout Waters
- Elevation Contour

Figure E.3. Wildlife Management Area Map Legend

Table E.1 Turkey Harvested on Public Land in Western Kentucky in 2013[a]

Public Land	Male	Female	Total	Archery	Firearm	Muzzleloader	Crossbow
Ballard WMA	15	0	15	0	15	0	0
Beechy Creek WMA	2	0	2	0	2	0	0
Boatwright WMA	2	0	2	0	2	0	0
Clarks River NWR	19	2	21	0	20	1	0
Coil Estate WMA	3	0	3	0	3	0	0
Doug Travis WMA	9	0	9	0	9	0	0
Jones-Keeney WMA	2	0	2	0	2	0	0
Kaler Bottoms WMA	3	0	3	0	3	0	0
Kentucky Lake WMA	4	0	4	1	2	1	0
Lake Barkley WMA	16	0	16	1	15	0	0
Land Between The Lakes NRA	56	2	58	3	55	0	0
Livingston County WMA and SNA	2	1	3	0	3	0	0
Obion Creek WMA	1	0	1	0	1	0	0
Ohio River Islands WMA	0	0	0	0	0	0	0
Pennyrile State Forest	31	1	32	0	32	0	0
Reelfoot NWR	3	0	3	0	3	0	0
Tradewater WMA	2	0	2	0	2	0	0
West Kentucky WMA	18	2	20	2	18	0	0
Winford WMA	0	0	0	0	0	0	0
Totals	188	8	196	7	187	2	0

[a] Numbers are indicative of telechecked game (http://app.fw.ky.gov/harvestweb/TurkeyPublicLandRegion.aspx accessed 5/23/2014). Both spring and fall hunting seasons are included.

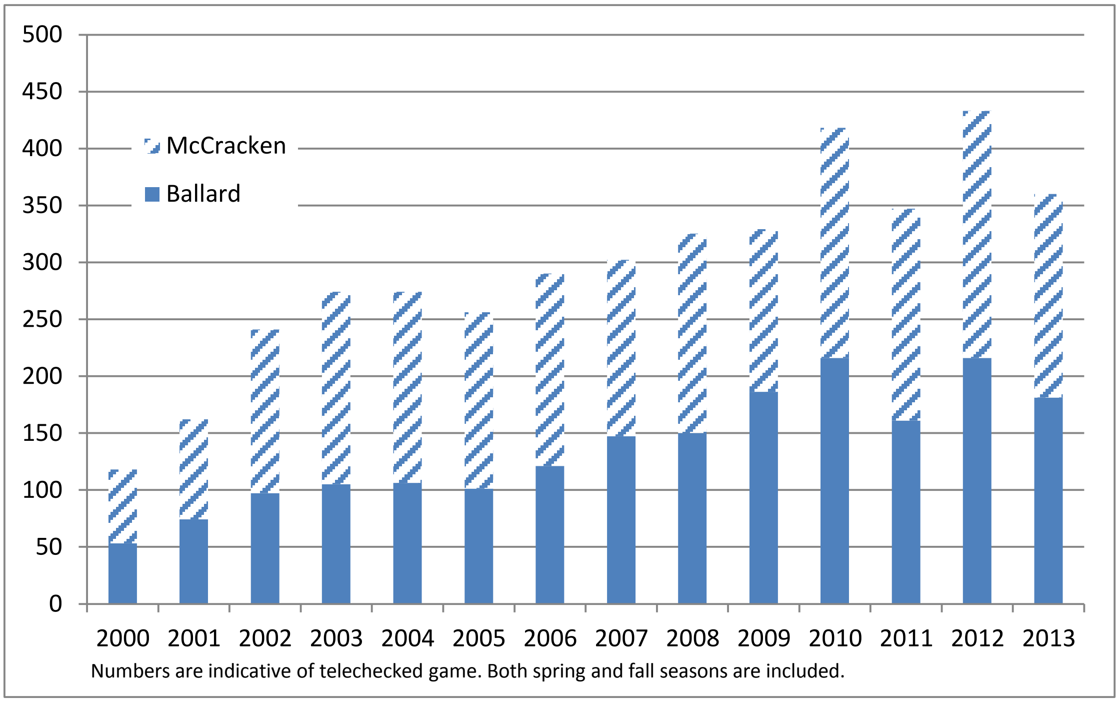


Figure E.4. Total Turkey Harvest in Ballard and McCracken Counties 2000–2013

Table E.2 Deer Harvested on Public Land in Western Kentucky in 2013[a]

Public Land	Male	Female	Quota	Total	Archery	Firearm	Muzzleloader	Crossbow
Ballard WMA	21	30	35[b]	86	16	30	5	0
Beechy Creek WMA	6	11	not available	17	3	11	3	0
Boatwright WMA	24	36	not available	60	7	43	8	2
Clarks River NWR	62	65	not available	127	16	105	5	1
Coil Estate WMA	1	1	not available	2	0	1	1	0
Doug Travis WMA	18	17	not available	35	3	26	6	0
Jones-Keeney WMA	7	4	not available	11	1	7	3	0
Kaler Bottoms WMA	19	17	not available	36	7	29	0	0
Kentucky Lake WMA	27	23	not available	50	4	39	4	3
Lake Barkley WMA	41	39	not available	80	21	57	1	1
Land Between The Lakes NRA	129	102	not available	231	183	27	4	17
Livingston County WMA and SNA	30	21	not available	51	7	7	37	0
Obion Creek WMA	24	16	not available	40	4	36	0	0
Ohio River Islands WMA	3	0	not available	3	0	3	0	0
Pennyrile State Forest	23	22	not available	45	26	15	0	4
Reelfoot NWR	0	0	not available	0	0	0	0	0
Tradewater WMA	3	2	not available	5	2	1	2	0
West Kentucky WMA	18	28	28[b]	74	36	2	0	8
Winford WMA	4	3	not available	7	2	3	2	0
Totals	**460**	**437**	**63[b]**	**897**	**338**	**442**	**81**	**36**

[a] Numbers are indicative of telechecked game (http://app.fw.ky.gov/harvestweb/deerpubliclandregion.aspx accessed 5/23/2014).

[b] Quota deer hunt numbers from Kentucky Department of Fish and Wildlife Resources (KDWFR) 5/23/2014.

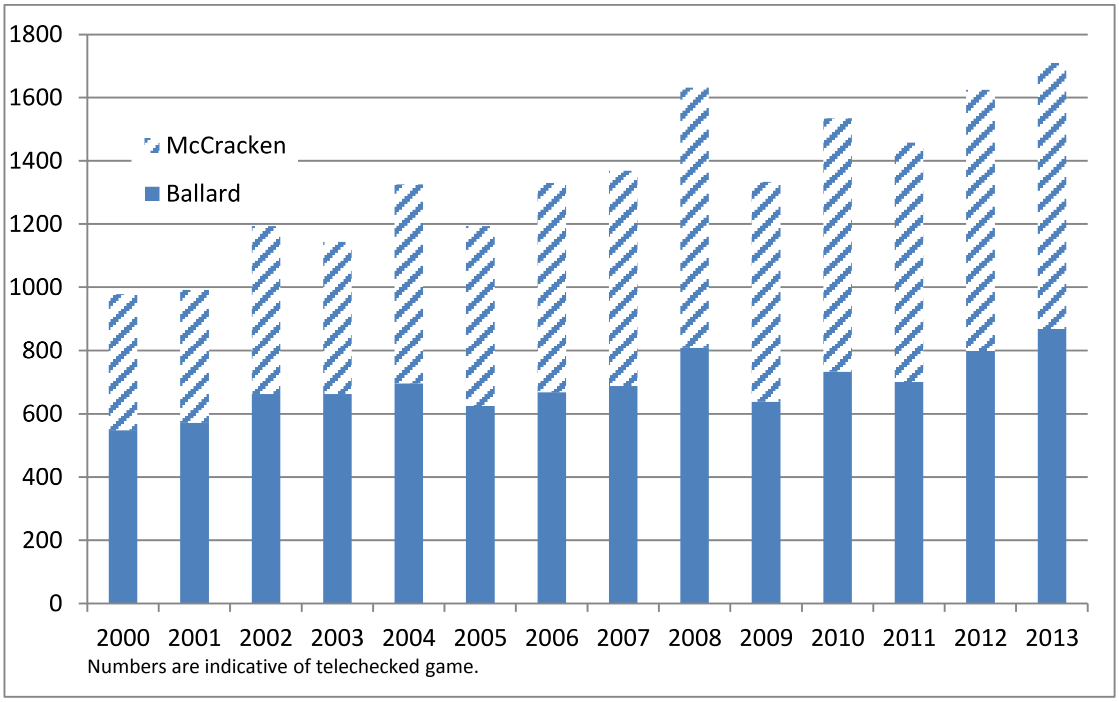


Figure E.5. Total Deer Harvest in Ballard and McCracken Counties 2000–2013

Table E.3 Waterfowl Counts in Ballard Wildlife Management Area

Date	Population Count		Harvest			Date	Population Count		Harvest		
	Ducks	Geese	Ducks	Canadas	Other		Ducks	Geese	Ducks	Canadas	Other
12/8/2010	57,000	3000	34	0	0	12/7/2011	21,000	100	Ballard closed due to flooding		
12/9/2010	57,000	3000	19	0	0	12/8/2011	21,000	100	Ballard closed due to flooding		
12/10/2010	57,000	3000	36	0	0	12/9/2011	21,000	100	Ballard closed due to flooding		
12/11/2010	57,000	3000	139	1	0	12/10/2011	21,000	100	Ballard closed due to flooding		
12/12/2010	57,000	3000	172	4	0	12/11/2011	21,000	100	Ballard closed due to flooding		
12/15/2010	57,000	3000	67	0	0	12/14/2011	16,000	100	Ballard closed due to flooding		
12/16/2010	57,000	3000	105	1	0	12/15/2011	16,000	100	Ballard closed due to flooding		
12/17/2010	57,000	3000	33	0	0	12/16/2011	16,000	100	Ballard closed due to flooding		
12/18/2010	107,700	4800	31	3	1	12/17/2011	16,000	100	Ballard closed due to flooding		
12/19/2010	107,700	4800	23	5	2	12/18/2011	16,000	100	Ballard closed due to flooding		
12/22/2010	107,700	4800	96	2	1	12/21/2011	52,000	1,000	112	0	0
12/23/2010	107,700	4800	68		0	12/22/2011	52,000	1,000	72	0	0
12/24/2010	107,700	4800	63	3	1	12/23/2011	52,000	1,000	56	0	0
12/25/2010	NA	NA	NA	NA	NA	12/24/2011	52,000	1,000	56	0	0
12/26/2010	54,000	14000	234	5	16	12/25/2011	52,000	1,000	Ballard closed for Christmas		
12/29/2010	54,000	14,000	68	0	3	12/28/2011	20,000	500	58	0	0
12/30/2010	54,000	14,000	71	0	1	12/29/2011	20,000	500	38	0	1
12/31/2010	54,000	14,000	49	1	0	12/29/2011	43,000	200	44	0	0
1/1/2011	58,000	52,000				12/30/2011	23,000	500	59	0	0
1/2/2011	58,000	52,000	54	7	3	12/31/2011	23,000	5,000	20	0	0
1/5/2011	58,000	52,000	88	5	53	1/1/2012	Closed		Closed		
1/6/2011	58,000	52,000	62	4	2	1/4/2012	23,000	100	58	0	1
1/7/2011	58,000	52,000	32	3	4	1/5/2012	23,000	100	32	0	0
1/8/2011	58,000	52,000	75	3	3	1/6/2012	23,000	100	7	0	0
1/9/2011	81,000	11,000	19	1	3	1/7/2012	32,000	200	33	0	0
1/12/2011	81,000	11,000	46	2	20	1/8/2012	32,000	200	8	0	1
1/13/2011	81,000	11,000	4	0	0	1/11/2012	32,000	100	77	0	3
1/14/2011	81,000	11,000	11	4	12	1/12/2012	32,000	100	123	0	2
1/15/2011	81,000	11,000	16	0	2	1/13/2012	32,000	100	26	1	2
1/16/2011	58,000	12,500	13	0	0	1/14/2012	79,000	300	31	2	3
1/19/2011	58,000	12,500	97	0	10	1/15/2012	79,000	300	10	0	1
1/20/2011	58,000	12,500	112	2	9	1/18/2012	79,000	1,000	81	1	3
1/21/2011	58,000	12,500	14	0	2	1/19/2012	79,000	1,000	52	0	0
1/22/2011	58,000	12,500	34	1	5	1/20/2012	79,000	1,000	47	0	1
1/23/2011	65,155	3,105	32	3	0	1/21/2012	79,000	1,000	65	0	0
1/26/2011	65,155	3105	122	4	5	1/22/2012	41,000	500	59	0	2
1/27/2011	65,155	3105	108	2	4	1/25/2012	41,000	500	78	0	1
1/28/2011	65,155	3105	98	0	1	1/26/2012	41,000	500	71	0	3
1/29/2011	65,155	3105	88	4	3	1/27/2012	41,000	500	50	0	1
1/30/2011	44,500	3,000	113	2	10	1/28/2012	43,000	200	75	0	1

E.2.5.4 Use of Exposure Units in Risk Calculations and Remedial Decisions

According to two reports ("Planning Issues for Superfund Site Remediation" and "Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study," from *Hazardous Materials Control*) received by the risk analysis section, industrial workers range 0.5 acres per day. This area is where the worker may be exposed to contamination. This area is called an exposure unit. For risk assessment purposes, it is reasoned that an exposure unit of 0.5 acres is consistent with the activities at PGDP. Exposure was weighted based on the size of the SWMU and the 0.5-acre exposure units. If the size of the SWMU was smaller than the 0.5-acre exposure unit, then the fraction was introduced into the chronic daily intake equation. The fraction, however, cannot exceed 1. Copies of the two reports are provided as references.

PLANNING ISSUES FOR SUPERFUND SITE REMEDIATION

Randall T. Ryti
Dean Neptune

Abandoned drums located behind the "burn shed" at the site

One function of the Superfund program is to assess the risk posed by hazardous waste sites. Sites that merit inclusion on the National Priorities List (NPL) are analyzed intensively through the Remedial Investigation/Feasibility Studies (RI/FS) process, which provides estimates of the risk posed by the site and the cost of cleanup. In this article we will review the planning issues for RI/FS through a case study of a specific Superfund site—a former transformer storage and rehabilitation facility in North Carolina.

The planning process used for this example is the Data Quality Objectives (DQO) process, which consists of the following steps: define the problem, define the question, define the data needs (the domain and decision rule), and define the data performance for the main question (*1,2*).

The planning approach is flexible; we have successfully applied the DQO process to two other Superfund sites. This site differed in the complexity of the problem, as well as the time frame within the Superfund assessment and cleanup process. We have observed that using the DQO process has not increased the resources expended (either time or money). Indeed, the process has resulted in substantial savings at a dioxin site in Missouri (*3,4*).

Another advantage of the planning process is that data collection can be focused. If one or a few contaminants are of interest, then more specific tests can be used. The planning process also sets goals for data collection, so that a criterion for the adequacy of data collection can be specified. The question of "how much is enough" develops naturally during the planning process.

Site history

The site is a former transformer storage and rehabilitation facility located on 4.8 acres of swampy terrain. The site lies within the 100 year floodplain of the Cape Fear River. Rebuilding of transformers was discontinued in 1982, but storage of transformers continued until 1986 when the site was abandoned. The initial sampling in 1978 found chlorobenzene in the well water on the site. Adjacent residences were placed on city water at that time. In 1979, PCBs were found in both the soil and well water, but no other action was taken. An Emergency Removal Action (ERA) was conducted in 1984 to remove contaminated soil. Sampling after the ERA detected PCBs at up to 140 ppm in the sub-surface soil.

The United States Environmental Protection Agency (EPA) Region 4 is administering the assessment and cleanup activities at the site. Discussions with the Region indicated that there were two phases to these activities. In Phase 1, the short list of contaminants of concern (COCs) and the general location of these COCs are determined. In Phase 2, the locations of the COCs are determined more precisely and the costs of various remedial alternatives are estimated. Through the steps of the DQO process, these general statements were refined and quantitative error tolerances were specified.

Phase 1

Discussion with EPA Region 4 indicated that Phase 1 of the assessment should answer two questions: What is the list of COCs at the Carolina Transformer site, and what is the x, y and z location of these contaminants?

Determining the list of COCs and the spatial scale of the contamination are essentially interrelated. For example, a "hot spot" of dioxin at a concentration of 10 ppb, but only in a few grams of soil at one location is not a threat to human health. Thus a contaminant causes concern if it exists above a specific concentration over an area where exposure is possible.

What logic can be used to define the area and concentration that makes a particular contaminant a concern? One approach is to compute the concentration and exposure area from a risk perspective. A second approach is to consider the way that the contaminant came to be distributed on the site.

EPA policy puts an acceptable risk level between 1 in 10,000 and 1 in 10,000,000 additional cancers (*5*). In this case, Region 4 decided that an acceptable risk is an additional 1 in 1,000,000 cancer incidence.

For PCBs in soil, the likely exposure route is through ingestion of contaminated soil. Exposure scenarios were investigated for adult workers on the site or children trespassers.

A risk scenario is based on assumptions about the absorption rate of the contaminant, the soil ingestion rate, and the length of the exposure. For example, a 70 kg adult is assumed to absorb 30% of the PCBs ingested. Adults are assumed to ingest a total of 100 mg of soil per day. These PCBs accumulate over 30 years, where the worker is present at the site 5 days a week for 50 weeks a year. Based on laboratory models and these exposure assumptions, an additional one in one million risk is equivalent to a PCB concentration of 1 ppm in the soil. For children trespassers, the end concentration is roughly the same, although the assumptions are different.

Over what area is this exposure accumulated? Some construction workers work over (and thus integrate exposure) an area of 1/2 acre. Children playing on a baseball field would also cover about 1/2 acre. We define an exposure unit (EU) as 1/2 acre. Since exposure is integrated over a large area (1/2 acre), small "hot spots" are only important if the overall average in a 1/2 acre area is greater than 1 ppm.

The preceding scenario was based on ingestion of surface soil. Based on CFR guidelines (an ARAR for PCBs), subsurface soil can be backfilled with clean soil if the concentration of PCBs are less than 10 ppm at a depth of 10 inches; thus <1 ppm PCBs is acceptable for soil in the 0–10 in. layer, and <10 ppm PCBs is acceptable below 10 in.

The likely source of the contamination was from leaking transformers. Thus a "hot spot" could result from a single leaking transformer. The Region decided that a leaking transformer would likely result in a 10 ft by 10 ft footprint. This implies that the smallest area that should need remediation is also a 10-ft square. The spatial scale is now bounded between 100 ft^2 and 22,500 ft^2. (1/2 acre). What concentration of PCBs in 100 ft^2 would result in an average of 1 ppm over 1/2 acre? If the remainder of the 1/2 acre were clean, then a single hot spot would have to measure more than 225 ppm for that EU to pose an unacceptable risk.

The main goal of Phase 1 is to define the list of COCs for the site and estimate the risk posed to the public. To address these goals, some information on the spatial distribution of the contaminants must be collected. Based on the historical use of the site and aerial photos, the site was divided into three areas: administration, operations and storage; PCB contamination was expected to be lowest in administration, intermediate in storage, and highest in operations. This stratification should lead to a more precise estimate of the average PCB concentration on the site. The lis [illegible] COCs was confirmed on a subse[illegible] samples submitted for the full scan analysis. Region 4 had expected that PCBs would be the sole COC on the site. The initial data also indicated that PCBs were much greater than 1 ppm in the surface soil. If these expectations are met, then the data collected in Phase 1 will only have to describe the general location of PCBs across the site.

Because no reliable information on the distribution of PCBs and the presence of other contaminants was available, a pilot study was recommended. In the case that the problem was truly as simple as described above, the pilot study could give enough information to lead to the second phase of the RI/FS.

Before describing the development of the pilot and the results obtained, let us consider the decision rule and the data quality required in Phase 1. The decision is to find if any area of the Carolina Transformer site poses an unacceptable health risk to the public. The data quality for the decision are the acceptable probabilities of maki[illegible] [illegible]e positive or false negative errors. [illegible] [illegible]e positive is where the actual risk posed by the site is *less than* 1 in 1,000,000 addi-

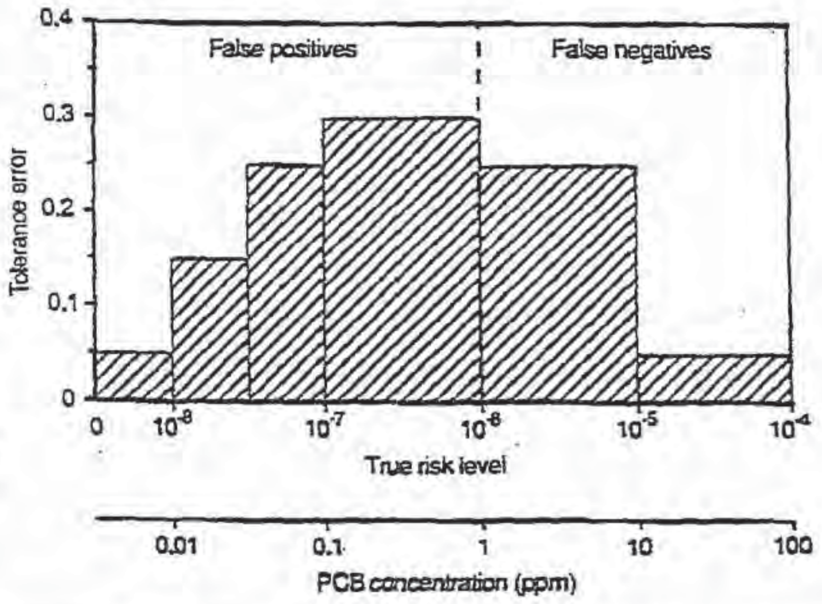
TABLE 1

Assumptions about the site used to design the pilot

Sub-unit	Area/acres	Probability 10' x 10' is contaminated	Number of samples
Administration	0.75	0.05	5
Storage	1.5	0.25	15
Operations	0.75	0.50	25

FIGURE 1

"Discomfort curve," or acceptable error rate for decision



onal cancers, but the risk is measured as being greater than 1 in 1,000,000 additional cancers. The consequences of a false positive are that resources (time and money) are diverted to sites that do not pose a significant risk. The possible consequences of a false negative (actual risk posed by the site is greater than 1 in 1,000,000 additional cancers but is measured as less) are additional cancers. Region 4 stated their *quantitative* discomfort with various magnitudes of false negatives and false positives (Figure 1).

The pilot survey was designed by using *simple assumptions* about the site. Based on the historical activities at the site, PCBs were assumed to be the most important (or only) contaminants on the site. Thus the Region agreed to run most of the soil samples through a quick-turnaround (QT) analysis procedure for PCBs. In addition to providing results more quickly, the QT method was also less expensive per analysis than the total contaminant list (TCL) scan ($150 vs. $1250). Based on the amount of data collected in other RI/FS Phase 1 surveys, approximately 45 QT soil samples could be analyzed. This amount is based on $30,000 total for Phase 1 analyses; spending one-half of the total in the pilot at $350 per analysis. An additional 10 samples were run by the TCL method to search for other contaminants. The 45 QT samples were allocated based on simple assumptions of the distribution of PCBs. PCB presence or absence was assumed to follow a binomial distribution on the scale of 10 ft by 10 ft areas (with no spatial correlation beyond 10 ft). The probability of presence was assumed to vary according to the sub-units of the site (Table 1).

The TCL samples taken in the pilot confirmed that PCBs were the only significant COC. The QT samples showed that the magnitude of PCB concentration did vary in the predicted manner among the three sub-units of the site. Table 2 shows these concentrations.

The concentration of PCBs was variable both within and between sub-units of the site. For example, stations close to a hot spot (e.g., 10 ppm) were not likely to measure 10 ppm. The spatial pattern of PCBs fits a "hot spot model"; the contamination is located in a binomial fashion, either contaminated or not contaminated. The most important result is that 41 of 45 samples were greater than 1 ppm PCBs; nearly the entire site is a "hot spot" from a risk perspective. Thus the initial assumptions about the frequency of "hot spots" were not correct.

Because the pilot identified PCBs as the only significant contaminant, we can restate the decision as: do any 1/2-acre areas of the site exceed 1 ppm PCBs? What is the approximate location of the contaminated soil? The Region had two options at *this point*: accept the results of the pilot survey for Phase 1, or conduct a Phase 1 survey where the number of samples is based on the results of the pilot.

Based on the laboratory measurement error for PCBs and the spatial sampling variation, the number of samples taken in the pilot did not meet all of the error constraints set by the Region. The false negative error rate for the Phase 1 decision based on the pilot data was slightly larger than the rate specified by the discomfort curve (7.5% vs. 5%). The advantage of accepting the pilot for the Phase 1 results is that Phase 2 can be started more quickly. False negatives are not important, since all 1/2 acre units were positives (i.e., PCBs >1 ppm), the Region decided to accept the results of the pilot in making the preliminary risk assessment for the site.

Phase 2

The purpose of the Phase 2 RI/FS survey is to define the location of the contamination and the cleanup costs. The cleanup costs are based on two components: a per unit volume cost and the total volume to remediate. The per volume remedial cost is dependent on the particular remedial sequence selected (for example: excavation, incineration, disposal, and back-filling with clean soil). We assume that the per volume remedial cost can be estimated exactly, so the only error is in the estimate of the volume of soil to be remediated. Thus the total volume can be computed from the location estimate.

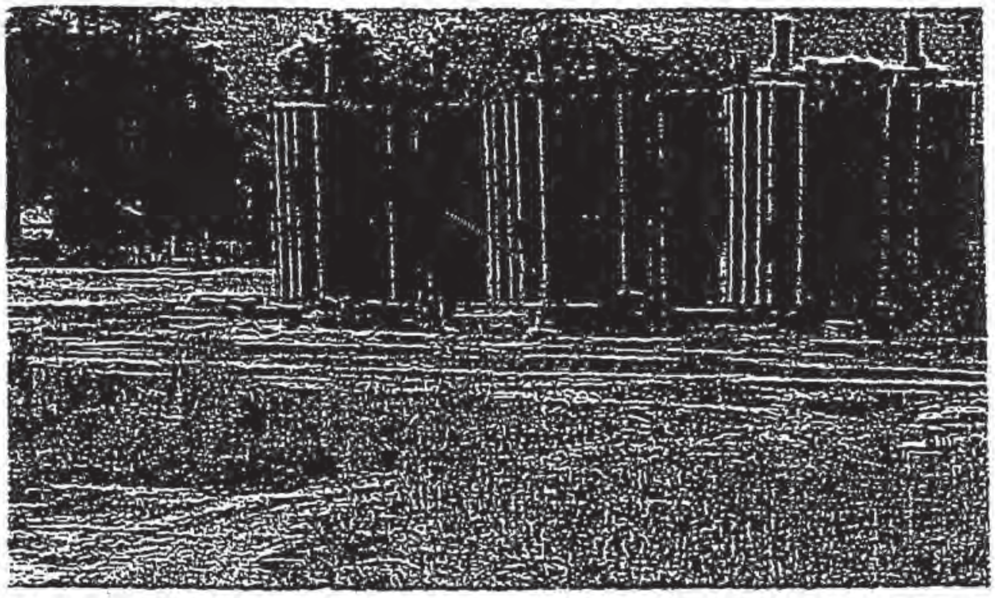
EPA policy states that the cost should be estimated to within +30% and -50% of the actual RD/RA cost. To simplify the problem, the Region wanted the Phase 2 survey to be designed to estimate the cleanup cost to within 30% with 90% or greater probability. An obvious difficulty is that sub-surface contamination must be estimated before the surface soil is remediated. A simplifying assumption is that two discrete soil layers will be sampled. Soil above 1 ppm PCBs in the top 10 in. and soil below 10 in. and containing more than 10 ppm PCBs will be remediated.

TABLE 2

Results of the pilot survey

Sub-unit	Mean concentration (standard deviation, n)	Median
Administration	7.5 (10.7, 5)	1.1
Storage	19.3 (21.4, 15)	11.3
Operations	34.7 (24.5, 25)	32.4

The data resolution needed for the location question is dependent on the spatial distribution of the contaminant within the exposure units (EU) (1/2 acres units in this example). Should an all-or-none approach be used for EU cleanup, or should remediation units (RUs) be defined as sub-units of EUs? In some cases, the additional sampling is cost-effective in that a "surgical" cleanup can remove hot spots of contamination (4). At a dioxin contaminated site in Missouri, the lowest total cost for sampling and cleanup was for RUs that were 1/24th the size of EUs (4). But in the present case, the pilot data indicated that there was little local pattern in the contamination, and that PCBs were nearly uniformly above 1 ppm. Field sampling and laboratory analysis costs were estimated for four sizes of RUs (1/2 acre, 1/8 acre, 1/18 acre, and 1/32 acre). Designs were evaluated by a Monte Carlo simulation approach (see Ref. 6 for additional examples; contact Dean Neptune for details on the simulations). Based on cost considerations, Region 4 selected 50 ft by 50 ft (about 1/18th acre) as the remedial unit size. This design has a cost of about $50,000 for sampling and laboratory analyses.



Large electrical transformers at the site—a former transformer rehabilitation and storage facility

Each EU (or 1/2 acre) contains a three by three grid of RUs. Partial RUs (containing less than 1250 ft^2) are lumped with an adjacent RU. Sixty-two RUs were sampled in the legal boundaries of the site. Two soil samples were taken: a 0–2 in. sample that represented the 0–8 in. soil layer, and a 8–10 in. sample that represented the 8–16 in. soil layer. For each layer, 14 grab samples were taken in the Administration area, and 4 grabs elsewhere (Storage/Operations). The grabs were homogenized, and a single aliquot was bagged for laboratory analysis. Each aliquot contained enough material for four laboratory analyses. Two laboratory analyses were made of each aliquot in the Administration area and one analysis elsewhere.

The results of the Phase 2 RI/FS survey showed that PCBs are highly variable over the site (Table 3).

PCB concentration varied over four orders of magnitude in both soil layers. There was greater contamination in the 0–2 in. layer on average, as compared with the 8–10 in. layer (compare Figures 2,3). But in 13 of 61 RUs the 8–10 in. layer was more contaminated (in many locations, by an order of magnitude) than the 0–2 in. layer. We would expect that PCBs would ordinarily migrate slowly down through the soil profile, without some kind of mechanical disturbance (or churning) of the soil. To what extent the soil was churned as a result of the operations at the facility or by the actions taken during the Emergency Removal Action is not known.

To estimate the volume of contaminated soil, the following cleanup strategy (Figure 4) was developed. It was based on the depth that can excavated by a backhoe (about 8 and the two cleanup criteria. The surfac soil is considered to be clean if the PCB concentration is less than 1 ppm. An excavated area can be backfilled with clean soil if the PCB concentration is less than 10 ppm at a depth below 10 inches. Three different depths are excavated (8, 10 or 16 in.), or no soil is removed based on the PCB concentration (Table 4). The total amount of soil to be excavated is estimated at 5389 yd^3.

In the Administration area, 6 of 16 RUs (62.5%) were greater than 1 ppm in the 0–2 in. layer, and in the Operations/Storage all 46 RUs measured greater than 1 ppm in the 0–2 in. layer. These numbers are similar to the assumptions used in the volume estimation design computations (50% contaminated assumed for Administration and 90% contaminated assumed for Operations/Storage).

Fifteen quality assessment (QA) samples were analyzed. The QA samples were laboratory sub-samples of the core composites. The relative standard deviation of these QA samples was 15%, excluding one outlie

Discussion

The goal of Superfund program is to

remediate sites that pose an unacceptable health hazard. Because resources nited, the Superfund program must be able to rank sites and to rank the hazards within sites. The information for these rankings becomes more detailed at each step in the process. Three main questions about sites are: Does the site pose a hazard? What remedial plan will remove the hazard? How will I verify the site is "clean?"

The Data Quality Objectives (DQO) process provides a way for managers to define a general question about a site that is later refined to a quantitative decision rule. The other parallel effort in the DQO process is to define error tolerances. The initial error tolerances are qualitative, and these are later quantified. These two components (decision rule and error tolerances), are the building blocks for a statistically-based design.

In the case of the North Carolina transformer site, the managers in Region 4 asked for the lowest cost designs that would meet their error tolerances for selected cleanup unit (RU) sizes. They were able to compare the cost of these surveys against a survey that would estimate the volume of soil that was contaminated. In this way they could balance the importance of these main questions in the Phase 2 survey.

The advantage of the DQO process is that the decision constraints (the decision rule and the error tolerances) are based on the initial responses of the decision-maker. The decision-maker can see how different ways of stating the decision rule can have profound implications on the proposed survey design. Where no proposed sampling design is within budget, then the decision-maker has the option to either increase the budget or modify some of the constraints (look at larger RUs).

Conclusions

We have shown that the Data Quality Objectives process can help define questions and the data quality in ways that can lead to statistically-based sampling designs. The DQO process allowed Region 4 to collect the right data at the right time. It should be noted that at each step from the pilot survey to the Phase 1 design, and finally for the Phase 2 study design, the question was further clarified and more information was gathered about PCB distribution across the site. One problem with the Superfund program in general has been to decide when enough data has been collected.

TABLE 3

Results of Phase 2 survey

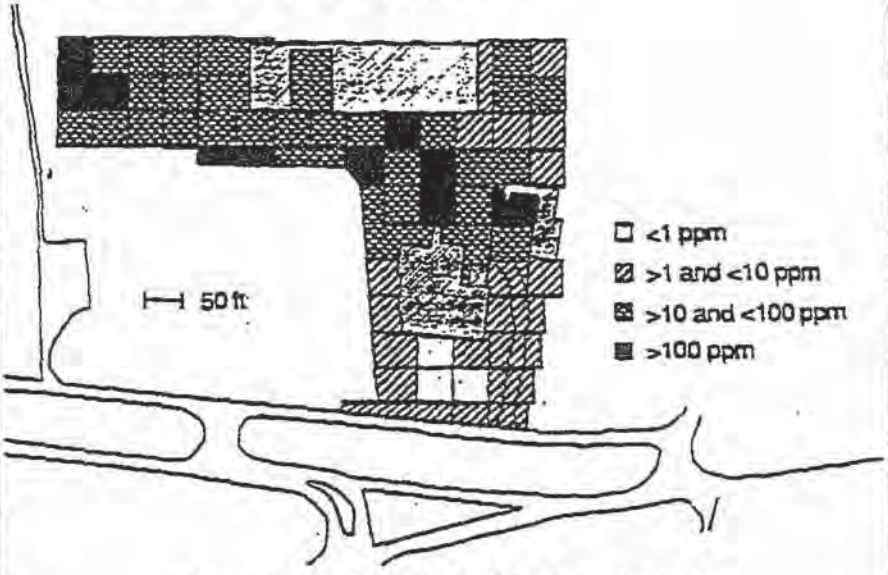
		Range		Number of RUs	
Soil layer	Median	low	high	<1 ppm	<10 ppm
0–2"[1]	21	0.4	2500	3	21
8–10"[2]	7.25	0.2	1100	18	36

[1] n=62

[2] n=61, one RU was concrete below the top 8"

FIGURE 2

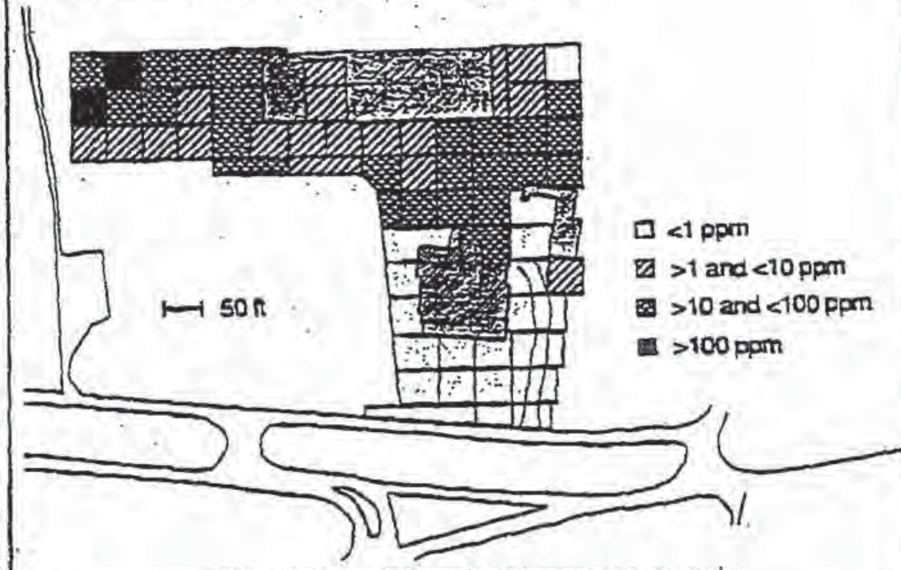
PCB concentrations in 0–2 in. soil layer



Hatched areas represent buildings or concrete pads

FIGURE 3

PCB concentrations in 8–10 in. soil layer



Hatched areas indicate buildings or concrete pads

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TABLE 4

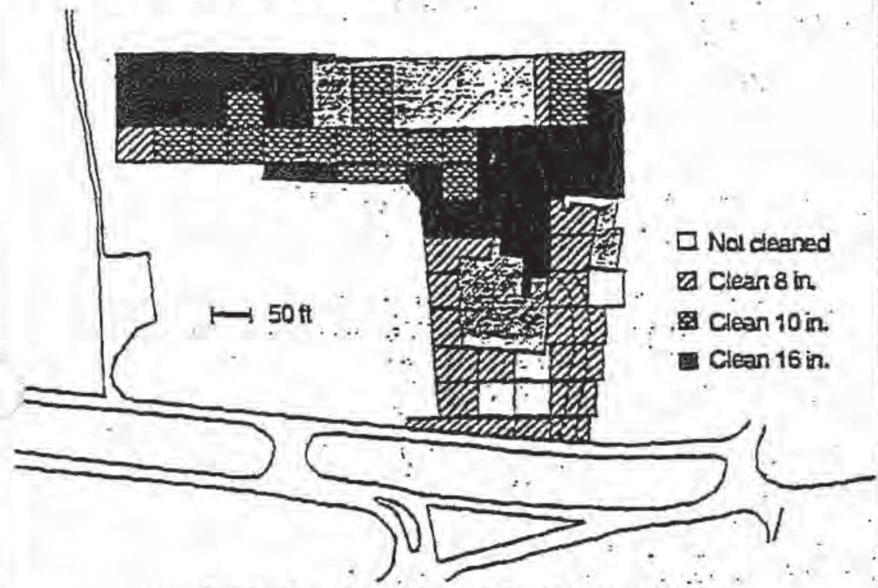
mmary of cleanup strategy

Soil depth and concentration	Depth to excavate	Number of RUs	Volume cubic yards
0–2" <1 ppm	0"	3	—
8–10" <1 ppm	8"	18	969
8–10" < 10 ppm	10"	18	1297
8–10" >10 ppm[1]	16"	22	3123

[1] These RUs need to be sampled at 16–18" to verify PCBs are <10 ppm

FIGURE 4

Cleanup strategy for the site



Hatched areas represent buildings or concrete pads

It is through the steps of the DQO process that the data user specifies the stopping point (the decision rule with error tolerances).

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Quantitative Decision Making in Superfund:

A Data Quality Objectives CASE STUDY

What type and quality of data are needed to answer key questions and how do we know when we have enough? Data quality objectives (DQOs) offer decision makers a tool to answer both questions. DQOs provide a qualitative and quantitative framework around which data collection surveys are designed, and can serve as performance criteria for assessing ongoing or completed remedial investigation/feasibility studies (RI/FSs). DQOs allow remedial project managers to make decisions based on RI/FS data with a predetermined and acceptable level of confidence.

Here we present a case study demonstrating the practicality and benefits of using the DQO process as an up-front planning tool for designing RI/FS data collection activities. The RI/FS decision maker and technical support staff (typically including environmental toxicologists and field and laboratory scientists) must work together to develop DQOs and associated RI/FS survey designs. With these individuals in mind, this article illustrates the issues raised during the DQO process, and demonstrates how the process can help resolve them at a Superfund site before an RI survey design is developed.

Development of DQOs involves a step-wise planning process (see box, "Data quality objectives") that may be applied to any problem involving the collection and use of environmental data (*1*). We begin the DQO process by carefully stating the environmental problem to be addressed or the decision to be made; then we identify the information required to select an appropriate course of action and carefully articulate the specific role data will play in making the selection. Specifications regarding the type of data needed, the way data will be used, and the desired degree of certainty in conclusions to be derived from the data are then developed through an iterative process that involves the decision maker and data generators (technical support staff).

When applied to Superfund sites, the DQO process provides a quantitative basis for designing rigorous, defensible, and cost-effective remedial investigations. The DQO planning process recognizes that decision making in Superfund is driven by risks to public health and that the uncertainty in decisions will be affected by the type and quality of data collected. The focus on planning, as presented here, is consistent with ideas developed as part of Superfund's endeavor to streamline its remedial process (*2*).

The case study was developed cooperatively by EPA's Region IV Waste Management Division and Environmental Services Division, and the Quality Assurance Management Staff. Our study involved a retrospective application of the DQO process to an actual Superfund site that had already been studied and the remedial investigation design already implemented. (The RI designs reported here were not actually implemented.) By using a completed site, Region IV expects to compare and contrast the DQO process with the current approach to planning such investigations. All decisions regarding the DQOs were made by Region IV personnel, just as they would for other sites where RIs are planned. We chose an actual site for several reasons: to avoid a purely hypothetical exercise; to ensure that realistic issues were confronted; and to facilitate an objective assessment of the practicality of implementing the DQO process for Superfund problems. Here we report the results of our planning efforts, following the generic structure illustrated in the box "Data quality objectives."

Problem statement

The starting point for any planning process is gathering background information on the specific problem at hand. The site addressed in this case study was used for storing and burning railroad ties and creosote-soaked timbers (*3*) (see photo). Information collected at various times (e.g., during previous site studies and during the Superfund site listing process) suggested that a logical exposure scenario consistent with future use of the site includes site workers and visitors as hazard targets.

Toxicologists determined that the exposure route of greatest concern for these targets is direct ingestion of contaminated surface soils; other routes of exposure are not addressed in the case study. Existing data from preliminary investigations and site visits also suggested that while several contaminants are to be expected in such surface soils, the most toxic are polyaromatic hydrocarbons (PAHs) associated with creosote.

Decisions and decision elements

The key decision posed by the RI/FS is: "What remedial actions, if any, must be taken to reduce the risk posed by the site to an acceptable level?" A logical starting point, and the focus of this study, is to determine whether the site poses an unacceptable risk in its current state—whether it is a problem.

The next step is to work logically toward increasingly specific and hence focused questions that will require environmental data for resolution. We know that PAH contamination of soil is the most likely source of public health risk from the site. Thus, the element of interest can be restated as a question: "Which, if any, surface soil areas have PAHs at concentrations that pose an unacceptable risk to the hazard targets?"

Domain and logic statement

The next step was to determine the concentrations of PAHs that, if present over some defined area, would pose an unacceptable risk. This approach to the problem raised three related questions:

- What level of public health risk from this site is acceptable to the remedial project manager?
- What concentration of PAHs is associated with the acceptable level of risk, given reasonable assumptions about target exposure?
- What is the smallest area on the site over which we can reasonably assume that the targets' exposure to contaminants may occur?

Addressing these issues required assumptions about the population at risk (people), their activities, exposure routes, and the risks associated with specific contaminants. Recognizing that the number of samples ultimately collected at a site depends in part on the smallest area of concern, we focused attention on defining the size of this area first, and then dealt with the issues of acceptable risk and corresponding concentrations.

To divide the site into discrete areas for study in a manner consistent with our interest in controlling risk, assumptions about exposure and activity patterns were used to define an area called an "exposure unit" (EU). An EU is the area over which people are expected to integrate exposure when routinely working at or visiting the site (see white grid on site photo).

A separate decision will be made for each EU: if an area is found to contain PAHs at a concentration that poses an unacceptable risk, that EU (and thus the site) will be considered a problem. Further investigations and remedial alternatives will address only the EUs found to

Data quality objectives

To build total quality into data operations, EPA quality assurance management staff have developed a planning tool for assuring that key planning steps are taken in a thoughtful, methodical manner. This tool, known as the Data Quality Objectives (DQO) process, begins with a careful statement of the environmental problem and produces a design for collecting the information needed to make an informed decision with a desired degree of confidence. The stepwise structure of the DQO process is to:

- state the problem, then
- identify decisions that address the problem, then
- select elements or factors that affect the decision, then
- specify the domain of the decision.
- Then develop a logic statement.
- establish constraints on uncertainty, and, finally,
- optimize the design for data collection.

The DQO process provides a logical, objective, and quantitative framework for finding an appropriate balance between the time and resources that will be used to generate the product (data) and the quality of that product.

DQOs enable EPA to develop, optimize, and evaluate statistically valid sampling and analysis designs that achieve the constraints on uncertainty. In general several options are developed for a range of costs that will generate the type and quality of data required to make a reliable decision. In the final step of the DQO process, the decision maker selects the design option that best fits his or her needs.

contain PAHs at concentrations posing unacceptable risks. If no such EUs are found, then a "no-action" alternative may be appropriate for the entire site.

Superfund risk assessment guidance stresses the importance of considering future land use and related reasonable exposure scenarios (*4*). According to the National Utility Contractor's Association, people working at or visiting a site such as this, where light industrial equipment is operated, would typically work within or traverse an area roughly one-half acre in size (about 2,000 m^2) on a given day (*5*). This is the area in which people can be expected to receive their daily dose of contamination. In a very real sense, people "sample" surface soil contaminants over this half-acre; hence the average concentration of contaminants over each half-acre is a meaningful basis for assessing risk. Thus, for this site, a half-acre area of soil is an EU. Since a separate estimate of the average surface soil concentration will be generated for each EU, and a separate decision made about whether each EU poses an unacceptable risk, the EU defines the spatial domain of the decision.

Based on discussions of the potential risks posed by the site, the EPA Region IV remedial staff decided that remedial action should be taken if the site (i.e., any EU at the site) poses an increased cancer risk greater than 10^{-4}. The 10^{-4} risk level is therefore the decision point between acceptable and unacceptable risk. This decision point is consistent with EPA's policy that 10^{-4} and 10^{-7} is the range for acceptable risk limits (*6*). (*Note:* The 10^{-4} level was used specifically for this case study and does not necessarily reflect EPA Region IV policy or standard practice for other sites.)

We used exposure assumptions and standard Superfund risk equations (*6*) to determine the surface soil contaminant concentration that corresponds to a risk level of 10^{-4}. Region IV typically treats total PAHs as though the sole contaminant is benzo[*a*]pyrene, the most toxic of the PAH family of compounds. This approach is conservative in that it will generally overestimate the risk posed by total PAHs. Risk calculations indicate that an EU is a problem (i.e., presents a 10^{-4} increased risk of cancer) when the average PAH concentration in the EU is at or above 122 ppm.

A "logic statement" is a concise quantitative summary of how data will be used to reach a decision. The logic statement follows directly from the formulation of the problem above.

Data collected during the remedial investigation will be used to determine the average surface soil concentration of PAHs within each half-acre. Average PAH concentrations will be compared to the risk-derived concentration of concern, 122 ppm, to determine which, if any, surface soil EUs have PAHs at concentrations that would pose an unacceptable risk.

If an EU has an unacceptable average PAH concentration ≥122 ppm, then further study should be undertaken to develop a list of remedial alternatives. This "if-then" logic statement will be applied for each of the EUs, and any EU posing an unacceptable risk will need to be remediated.

Constraints on uncertainty

If the estimates of average PAH concentration within EUs are inaccurate, decisions about whether an EU poses unacceptable risk may be incorrect. The remedial investigation should be designed to limit the probability of incorrect decisions to an acceptable level. After the logic statement was specified, the project manager developed constraints on uncertainty, expressed as acceptable false positive and false negative error rates. These are shown in Figure 1. The *y*-axis provides the acceptable error rates (probability of making an incorrect decision) given various possible true risk levels, shown on the upper *x*-axis.

Acceptable error rates were not assigned in the 61–122-ppm range because the manager considered either decision would acceptable in this range. The error rates expressed in Figure 1 provided the statistician with quantitative constraints to be used in developing survey designs, which specify the number, location, and type of samples needed in the remedial investigation.

Stated in terms of the risk-based decision point, decisions about EUs may be incorrect in two ways:

The first type of error occurs when it is decided that an EU does not pose an unacceptable risk when, in fact, the risk posed by the EU exceeds 10^{-4}. This is a false negative error. If the investigation leads to this false conclusion, the project manager may stop further investigations at the EU and people eventually may be exposed to unacceptable risks. The seriousness of this type of error, and therefore the project manager's desire to avoid it, becomes greater as the true level of risk gets larger and larger. To help the manager establish limits on false negatives, a toxicologist was consulted to assess the consequences for three ranges of incremental risk, all of which exceed 10^{-4}:

- 1.0×10^{-4} to 5.0×10^{-4};
- 5.0×10^{-4} to 1.0×10^{-3}; and
- above 1.0×10^{-3}.

After carefully considering the human health consequences, the project manager assigned acceptable probabilities for failing to detect a problem if the risk posed by the EU is actually within each of the above ranges (shown in the right-hand portion of Figure 1). The manager expressed differing levels of acceptable error rates for the three risk ranges. These error rates (probabilities), which reflect the manager's increasing desire to avoid false negative errors at higher and higher contaminant concentrations, are the maximum acceptable rates established for this type of error. Notice that the manager desired lower false negative rates when the true risk is above 1.0×10^{-3} because the consequences to the public and to workers on-site are potentially much more serious than the consequences associated with the other ranges of risk.

The second type of error occurs when it is decided that an EU poses an unacceptable risk when, in fact, the risk posed by the EU is less than 10^{-4}. This is a false positive error. If data collected during the remedial investigation lead to this false conclusion, the manager will decide, unnecessarily, to continue to study the EU. New data may eventually reveal that an EU is not a problem, and hence, correct the false positive error. Otherwise, unnecessary remedial action will be taken. A false positive error results in wasted time, money, and effort on EUs that are actually not a problem. The manager consulted with the toxicologist and site engineers to assess the consequences of such error for three risk ranges, all of which are below 10^{-4}:

- below 5×10^{-6};
- 5.0×10^{-6} to 1.0×10^{-5}; and
- 1.0×10^{-5} to 5.0×10^{-5}.

The project manager stated that the remedial investigation should be designed to have a low probability of false positives when very low risk levels exist at an EU (e.g., when the EU is "clean"). The manager was willing to tolerate higher probabilities of false positives for risk levels near the threshold. The manager assigned acceptable probabilities for determining when an EU is a problem when in reality it is not for each of the above ranges (shown in the left-hand portion of Figure 1). These values are the acceptable rates for this type of error.

Risk equations (*6*) were used to determine the PAH concentrations that correspond to the risk ranges for which acceptable error rates had been defined. These concentrations are shown on the lower *x*-axis in Figure 1.

The logic statement, discussed earlier, indicated that we want to conclude that an EU is a problem if the true average PAH concentration in the EU is >122 ppm. Figure 1 indicates that the project manager is willing to accept a 0.15 probability or less for making an incorrect decision at true concentrations of 122 ppm. It also indicates the manager's desire to avoid developing remedial alternatives for EUs that have PAH concentrations below 61 ppm. The figure specifies that for PAH concentrations falling between 122 ppm and 61 ppm, the manager will accept either decision (indicated by the grey region in Figure 1).

Because the project manager is indifferent about the decision in the range of 61–122 ppm, but wants to limit the probability of a false negative at 122 ppm or above, our original question was refined as follows: "Which, if any, surface soil EUs have an average PAH concentration above 61 ppm?" At 122 ppm and above, the manager has specified the false negative error rates that are acceptable. At values below 61 ppm, the manager also specified the false positive error rates that are acceptable. The qualitative and quantitative criteria established for addressing this question are the DQOs for the remedial investigation, and will focus the statistician's search for an optimal design (see box, "DQOs for case study").

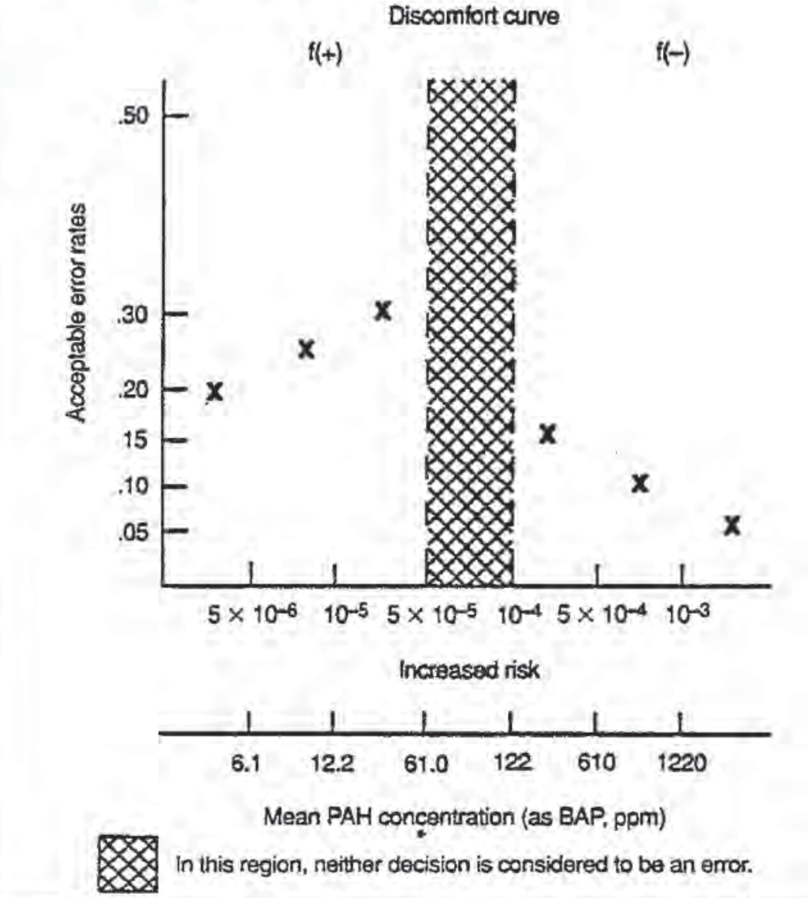
Design and optimization

After the DQOs were established, a statistician applied conventional techniques to explore and evaluate various designs for data collection. The statistician was asked to design a survey that, first, would attempt to identify any EUs that have average PAH concentrations >61 ppm; and second, would be subject to error rates no greater than those specified in the DQO statement from the project manager.

One concern the statistician noted was

FIGURE 1

Acceptable limits for decision error



Workers collect soil samples at the Superfund site

that any attempt to divide the site into spatially distinct, uniform exposure units for testing runs the risk of missing an unacceptably contaminated area which lies across two or more EUs. This weakness is more than offset by two conservative measures included earlier: the assumption that the only PAH present is benzo[*a*]pyrene (the most toxic of the PAHs), and the decision to test for concentrations above 61 ppm when concern for false negative errors begins above 122 ppm.

The statistician framed the if–then logic statement as a statistical test that would allow us to determine whether PAHs within an EU are greater than 61 ppm, and began the search for designs that would control the decision uncertainty to the levels specified in the DQOs. To develop a statistically based sampling and analysis plan (the design), the statistician needed rough estimates of the spatial pattern and variability of the distribution of contaminant concentrations within EUs. He also required an estimate of the additional variability that would be introduced through the process of taking samples and analyzing them in the laboratory. Finally, since the statistician was asked to find the least expensive design that meets all the DQOs (the optimal solution), estimates of the costs of taking and analyzing a sample were required.

Since prior data on average PAHs across half-acre units were not available, the statistician used prior data from ran-

DQOs for case study

Decision: Determine whether sections of the site pose unacceptable risks to human health or the environment and require remediation.

Domain: Exposure units are half-acre areas of surface soils. (Temporal aspects of the domain are not at issue because the contaminant of concern at this site is stable, not mobile.)

Logic statement: If the mean PAH concentration in an exposure unit exceeds 122 ppm (10^{-4} risk), then the exposure unit will require remediation.

Uncertainty constraints

PAH risk range	Concentration range (ppm)	Acceptable probability for false positives (%)
Below 5×10^{-6}	Below 6.1	20
5×10^{-6} to 1×10^{-5}	6.1–12.2	25
1×10^{-5} to 5×10^{-5}	12.2–61	30

PAH risk range	Concentration range (ppm)	Acceptable probability for false negatives (%)
1×10^{-4} to 5×10^{-4}	122–610	15
5×10^{-4} to 1×10^{-3}	610–1,220	10
Above 1×10^{-3}	Above 1,220	5

dom samples of surface soils across the site (Figure 2). The statistician assumed that point-by-point spatial variability of PAHs within half-acre EUs was identical to the point-by-point variability of samples taken across the entire site, without grouping into half-acre units. This is probably a conservative assumption, since it is likely that there is some degree of similarity within EUs as compared to points that are more widely separated.

FIGURE 2

Frequency distribution of soil PAH concentrations

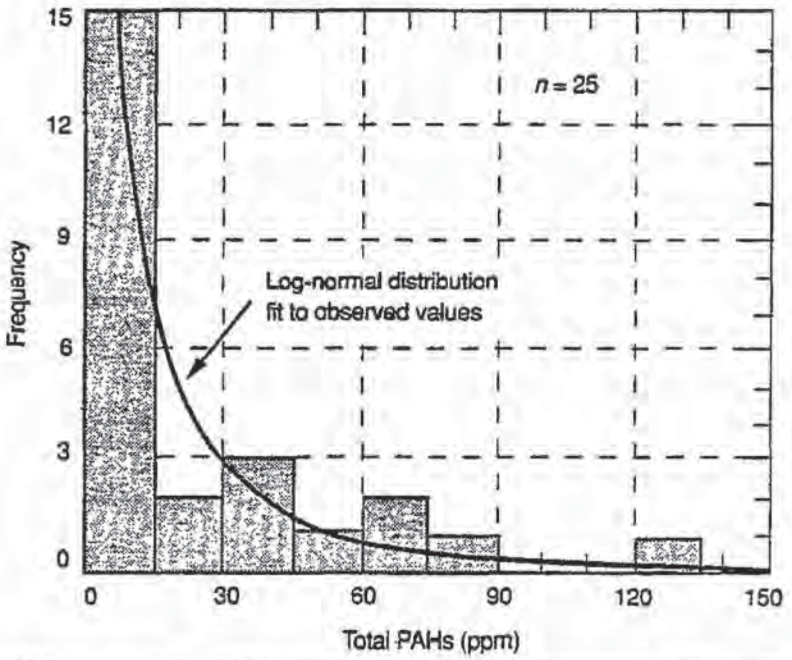


TABLE 1

Results of initial power calculations

No. scoops /analysis	No. analyses/EU	Cost /EU ($)	Probability of error[a]
1	4	3,520	.53
3	5	5,200	.15
4	2	2,240	.27
4	3	3,360	.18
4	4	4,480	.12
5	2	2,400	.20
5	3	3,600	.11

[a] When $\mu = 122$ ppm and $\alpha = .30$.

Note: α = probability of concluding EU is a problem when μ is 61 ppm.

These data indicated the form of the distribution of contaminant concentrations (in this case a log-normal distribution) and provided the basis for estimating the variability of contaminant concentrations across the site. An estimate of the most probable total variance (on a log scale) is $\sigma_T^2 = 1.64$ (24 degrees of freedom). Quality control data from analyses of PAHs, using the same analytical methods as those used to generate historical data for this site, indicate that analytical imprecision is on the order of 25% relative standard deviation. If the statistician had determined the historical data were not suitable for estimating the distribution and variability of concentrations within EUs, a pilot study would have been required to obtain these estimates.

Using the above information and the approximate per-sample costs of sampling ($80) and analysis ($800), the statistician began to evaluate various statistical sampling designs that would allow us to achieve the desired control over uncertainty. Recall that uncertainty is measured in terms of the probability of reaching an incorrect conclusion about whether an EU is a problem, i.e., the probability of false positives and false negatives. Among the options considered were uniform random sampling across the site, systematic sampling, stratified sampling, and sample compositing within each EU. After considering these options, the statistician recommended an approach that uses a compositing technique in which 10 or more scoops of soil, taken randomly within each EU, are combined, homogenized, and subsampled for analysis. When the potential difficulties and errors introduced through mixing and subsampling were recognized, five soil scoops were considered to be an efficient, practical number that could be combined routinely.

A statistical evaluation of several different designs, presented in Table 1, led to the following conclusions:

First, the expected performance data indicate that two survey designs have favorable cost and acceptable performance (i.e., were expected to meet or come close to meeting the 0.15 acceptable false negative and 0.3 false positive error rates specified over the range of important concentrations). The most favorable designs involved compositing five scoops per analytical sample. One design required the analysis of two composited samples per EU, while the other required three. Our notation for these designs are (5,2) and (5,3), respectively.

Second, compositing five scoops transformed the underlying log-normal distribution into one that is more like a normal distribution in shape. A computer simulation was needed to assess more accurately the anticipated performance of the two designs, i.e., the "power" or capability of each design to detect EUs with PAH concentrations above the criterion. (Details on the statistical evaluation may be obtained by writing author Dean Neptune.)

The (5,2) and (5,3) designs were evaluated by simulation to determine how well they can be expected to perform at the critical values of 122 and 61 ppm, and at other concentrations higher and lower than these values. The rough estimates of performance in Table 1 were based on the assumption that the distribution of total PAHs was log-normal with a total variability of 1.64. The true variability of concentrations within EUs may prove to be greater or less than this estimate. To determine the effect that more or less variability might have on reaching a correct conclusion with either of these designs, the performance of each design was evaluated at three different levels of total variability: 1.64 (most probable—our estimate of variability based on historical data), 1.00 (assumes less variability—a lower 95% confidence limit on the historical estimate), and 3.17 (assumes more variability—an upper 95% confidence limit on the historical estimate).

Figures 3 and 4 show the results of the simulations presented as expected performance curves. The shaded regions of the two figures are areas in which the constraints on uncertainty—control on false negative and false positive error rates—are achieved. In the region between 61 and 122 ppm, the shaded area shows that any amount of error can be tolerated. The shaded regions above 122 and below 61 ppm are those for which the error rates are of concern. A design performance curve that lies entirely in the shaded regions would satisfy all the DQOs (see box, "DQOs for the case study").

The figures show that the two designs can be expected to perform similarly and to achieve most of the constraints on uncertainty (most of the curve appears in the shaded region). If variability is 1.64, the figures reveal that both designs fail slightly when the true average PAH concentrations are between 50 and 60 ppm. Neither of the designs is likely to meet uncertainty constraints if the total variability is high (3.17). Points labeled "A" and "B" are slightly outside the regions of desired performance. Points labeled "A" are of concern if the variability is lower than we anticipate (1.00). Points labeled "B" are of concern if the variability is greater than we anticipate (3.17). Thus, if we use either the (5,2) or (5,3) design, and the variability of PAH concentrations within an EU is substantially lower or higher than assumed (1.64), we can expect slightly higher error rates than specified by the DQOs.

Considering the conservative measures built into the designs, the project manager determined that failing to meet uncertainty constraints at these specific points is not serious. Finally, because the design (5,2) represents a 33% cost savings over the (5,3) design, and its ability to achieve the uncertainty constraints is approximately equal to that of the (5,3) design, the (5,2) design was recommended for the remedial investigation.

Summary

The data quality objectives produced in the manner described do much more than simply guide the survey design. The DQOs provide a focused decision statement, boundaries on the domain of interest (the EU), an "if-then" logic statement that specifies how data will be used in the decision, and constraints on the amount of uncertainty (limits on both false positives and false negatives) acceptable. They provide the information needed to ensure that the number of samples per EU is adequate and the sampling and analysis methods used will provide the

FIGURE 3

Results of simulation for the (5,2) design

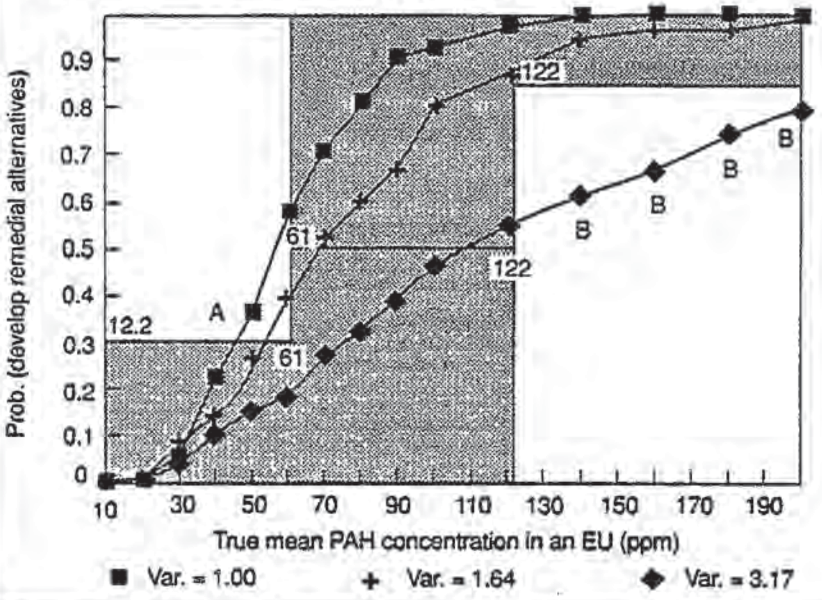
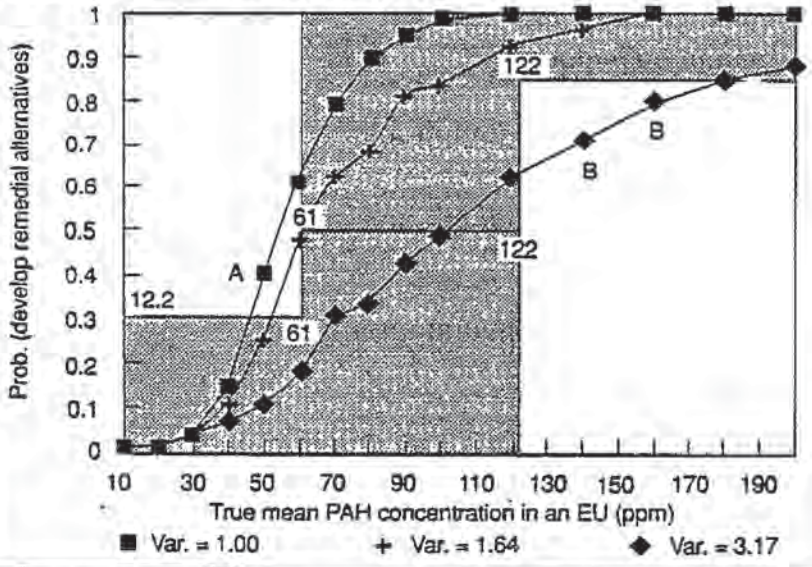


FIGURE 4

Results of simulation for the (5,3) design



quality of data required to support decisions with the desired certainty. The most important benefits of this approach are that the decisions regarding Superfund site remediation can be made at the desired level of certainty, and that the project manager has specific quantitative criteria for deciding how much data is enough.

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(4) Environmental Protection Agency. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual:* EPA: Washington, D.C., June 30, 1989; draft. *Note:* The calculations used to estimate reasonable maximum exposure in this case study are found in Reference 6.

(5) Connor, B., National Utility Contractor's Association, Arlington, Va., personal communication. Reasonableness of this estimate was confirmed by EPA ORD and Region IV risk assessment experts.

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Acknowledgments

The individuals listed below played a substantive role in the development of the DQOs for this hazardous waste site. Region IV used the planning issues raised through the DQO process to set survey design constraints (the DQOs) for the case study. The DQOs then were used as the basis for optimizing the possible survey designs for this site. The DQO process and its adaptation to Superfund planning issues for the remedial investigation/feasibility study was led by the quality assurance management staff, with DQO application support from Research Triangle Institute, Montana State University, and NUS Corp. The authors of this paper have summarized the outputs of a series of activities in which all of these individuals participated directly: James Pickett, Ph.D., and Randall Ryti, Ph.D., Montana State University; Robert Hubbard, NUS Corp.; Eugene P. Brantly, C. Andrew Clayton, Daniel I. Michael, Michael Messner, Research Triangle Institute; Elmer Akin, Meredith Anderson, William Bokey, Beverly Houston, David Kleusner, M.D. Lair, William Patton, EPA Region IV; Dean Neptune, Ph.D., EPA Headquarters quality assurance management staff.

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E.3. KENTUCKY REGULATORY GUIDANCE

The following copies of regulatory guidance are presented in this chapter.

- Kentucky Risk Assessment Guidance, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, June 8, 2002.
- Kentucky Guidance for Ambient Background Assessment, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 8, 2004.
- Kentucky Guidance for Groundwater Assessment Screening, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 15 2004.
- Trichloroethylene Environmental Levels of Concern, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, April 2004.

Kentucky Risk Assessment Guidance

June 8, 2002

Natural Resources and
Environmental Protection Cabinet

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Section 1. Introduction

Risk assessment is a formalized process for evaluating the potential human health and ecological impacts based on the concentration of, exposure to, and toxicity of environmental contaminants. Risk assessment has been used in environmental decision-making since the process was outlined in a publication by the National Research Council – National Academy of Sciences (1983) Red Book. The United States Environmental Protection Agency (U.S. EPA) produced several guidance documents to assist in assessing risks (U.S. EPA, 1989; 1991).

Human health risk assessment, as outlined, is a four-part process. The first step, Data Collection and Evaluation, assesses the available data and identifies chemicals of potential concern (COPCs). The next part, Exposure Assessment, identifies potential receptors and calculates their exposure to the COPCs. Toxicity Assessment, the third process, quantifies the toxicity of the COPCs for carcinogenic and noncarcinogenic effects. The final step, Risk Characterization, is the calculation of the potential effects on the receptors identified in the Exposure Assessment, based on the toxicity of the chemicals identified in the Data Collection and Evaluation step.

Risk assessment procedures are used in several stages of site assessment and closure. During site scoping Preliminary Remediation Goals may be used to determine preferred detection limits and to screen initial data to focus on areas of concern. Data from Site Characterization are often screened against target risk-based concentrations (Preliminary Remediation Goals) to identify whether a baseline risk assessment or further evaluation is needed and, if so, which chemicals should be further assessed. Risk assessment is also used in setting remedial goals, and as an exit criterion for closure of remediation activities. Risk assessment is used as part of activities related to the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Clean Water Act, and Clean Air Act.

This document details the application of risk assessment to environmental remediation. The document can be used to determine if site conditions are protective of human health and the environment, or that risks are reduced to acceptable levels through removal of contaminants or management. The risk-based procedures for the program are based on a tiered approach allowing for screening against default risk-based screening values in lower tiers and incorporating more site-related data in the higher tiers.

This document outlines the procedures for:

1. Comparing site data against risk-based screening values.
2. Preparing a baseline risk assessment to determine protectiveness of human health and the environment.
3. Evaluating when an ecological assessment is necessary
4. Evaluating when to compare site soil data to Soil Screening Levels for protection of groundwater.
5. Selecting remedial cleanup goals.

The following sections describe the process of evaluating the site data that were collected during the site characterization. The data must be representative and complete. If statistical procedures are used, a sufficient number of samples should be collected to meet the needs of those statistical tests. Human health risk assessment is described in Section 2.0. The subsections within Section 2.0 describe the application of risk assessment to the processes of environmental assessment and remediation including: tiered risk assessment, groundwater evaluation, risk management, selection of remedial goals, and presenting the results of the two tiers of risk assessment. Section 3.0 details the ecological risk assessment procedures.

Section 2. Human Health Risk Assessment

This section provides methods for screening environmental data to identify Contaminants of Concern, performing screening and baseline risk assessment, evaluating groundwater, managing risks, and selecting remedial goals. Figures 1 and 2 outline the process for risk-based procedures for residential and commercial/industrial scenarios in environmental remediation. The remedial options listed in Figures 1 and 2 are those listed in KRS 224.01-400 (18)-(21).

Figure 1. Flowchart for Residential Cleanup Options

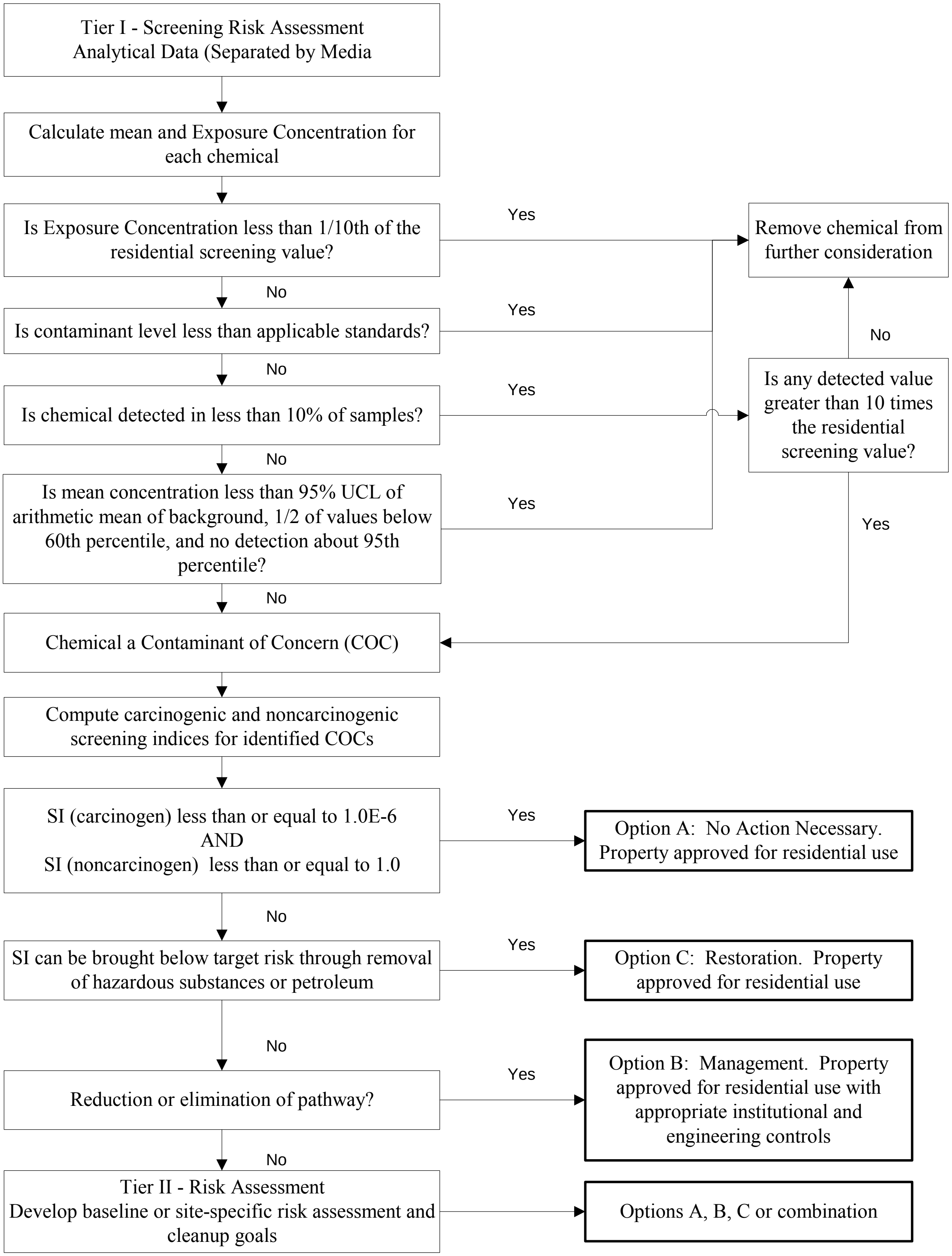
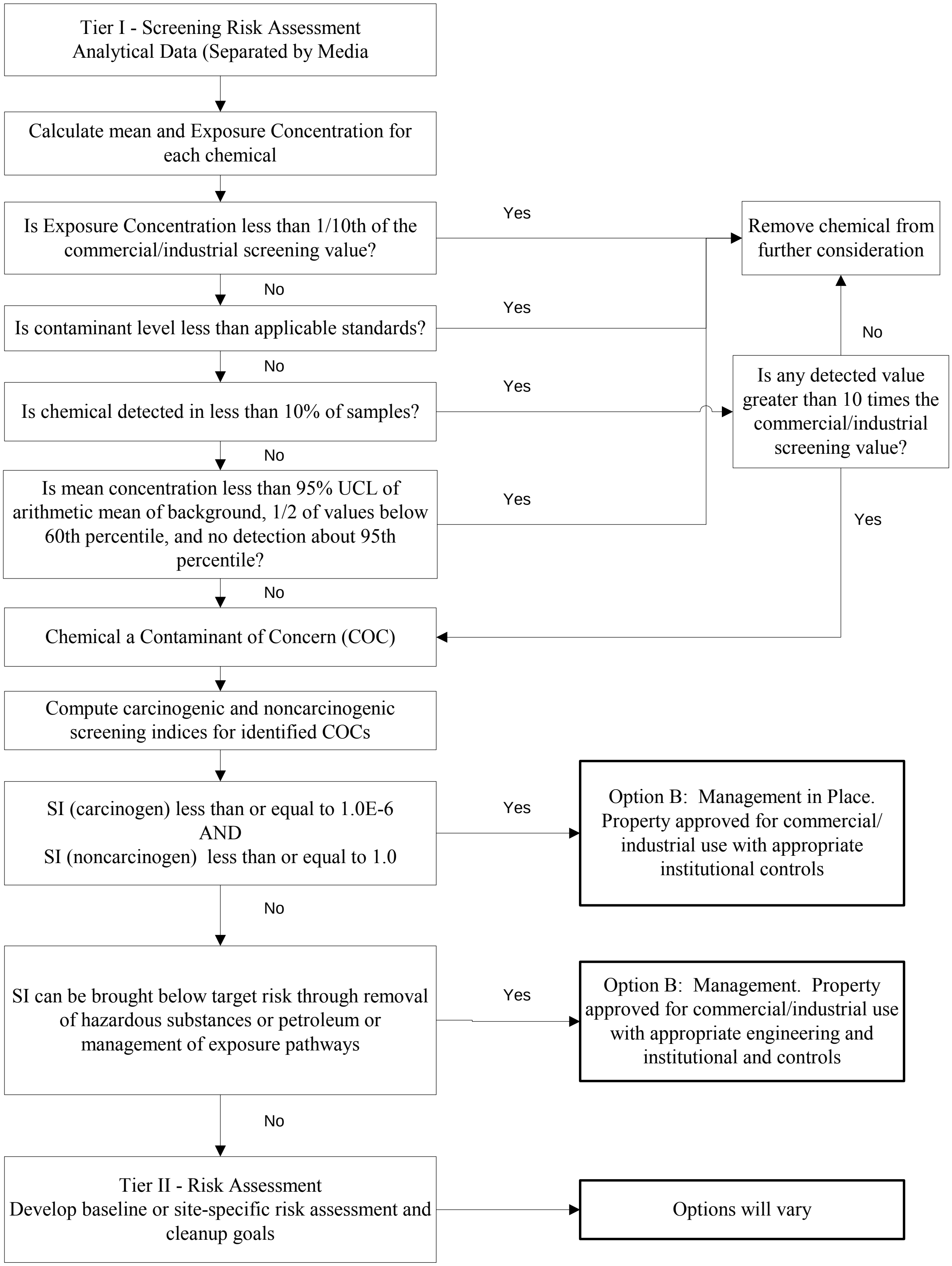


Figure 2. Flowchart for Commerical/Industrial Cleanup Options



Section 2.1. Tier I. Human Health Risk-Based Screening

This initial tier identifies which contaminants contribute significantly to the risks associated with the property and calculates the cumulative risk for all Contaminants of Concern (COCs). For this guidance, hazardous substance or petroleum shall have the meaning as defined in KRS 224.01-512. The screening-level risk assessment should be completed for residential land use as a baseline, and commercial or industrial land use if commercial or industrial use is part of the management plan. The following steps should be followed when completing a screening-level risk assessment for human health.

1. Segregate analytical data by medium. Further segregate soil data into surface (0-1 foot depth) and subsurface (greater than one foot depth).
2. Calculate 95% Upper Confidence Limit (UCL) of the arithmetic mean as described in U.S. EPA, 1992 (Supplemental Guidance to RAGS: Calculating the Concentration Term). Use all samples of the property and site(s). Use one-half of the detection limit for non-detect sample results. The Exposure Concentration shall be the lower of the 95% UCL of the arithmetic mean and the maximum detected value for that medium (and horizon, for soil). Calculate the mean of the site data for inorganic compounds in addition to the 95% UCL.
3. Compare the Exposure Concentration to 1/10th of the residential or commercial/industrial screening value, as appropriate. When screening, use the Total Chromium value for chromium, use carcinogenic effects for arsenic, and use Toxicity Equivalency Factors (TEFs) to calculate a Toxicity Equivalency Quotient (TEQ) for dioxins. Instead of 1/10th of the screening value for lead, use the Kentucky Lead Action Level of 50 mg/kg for soils for residential, and 400 mg/kg for commercial/industrial soils. Appendix E contains the KY Radiological Risk-Based Preliminary Remediation Goals, if applicable. Compare the Exposure Concentration to the following standards when applicable: Maximum Contaminant Levels (MCLs) for surface and ground water (401 KAR 8:250, 401 KAR 8:300, 401 KAR 8:400, 401 KAR 8:420), National Ambient Air Quality Standards (NAAQS) for air, and Surface Water Standards (401 KAR 5:031) for surface water.
4. Calculate the frequency of detection of the hazardous substance or petroleum constituent. Identify those compounds that are detected in at least 10 percent of the samples. If there is any detection above ten times the residential or commercial/industrial screening value, as

appropriate, then the hazardous substance or petroleum should remain a Contaminant of Concern (COC) regardless of the frequency of detection.

5. Compare the mean of the site data to the 95% UCL of background for inorganics. The background value shall be the generic statewide background number listed on Table G-2 in Appendix G, or site-specific background may be determined using the methods described in 401 KAR 100:100 Section 7 (6). In addition to the site mean being less that the 95% UCL of background, at least half of the samples should fall below the 60th percentile on Table G-2 or site-specific background, and no sample should exceed the 95th percentile listed on Table G-2 or site-specific background. The cabinet may approve other statistical methods proposed by the VERP applicant or party.

6. Produce a summary table that lists each hazardous substance or petroleum, site mean, Exposure Concentration, 1/10th of the screening value, frequency of detection (as a fraction), and, for inorganics, 95% UCL of the arithmetic mean of background. Include MCLs, Surface Water Standards, and NAAQS, if applicable. Identify those compounds as Contaminants of Concern (COCs) that exceeds the values in all applicable screens (i.e., is not eliminated by any screen). Highlight or denote with bold text the screen that eliminates the COPC from further evaluation, if applicable. Table 1 is an example of the summary table for soil.

Table 1. Summary of Results of Tier I Screening

Hazardous Substance	Mean	Exposure Concentration	1/10th Screening Value	Frequency of Detection	95% UCL of Background	COC?
Benzene	--	0.8 mg/kg	0.03 mg/kg	(8/30)	---	Yes
Arsenic	7.9 mg/kg	9.3 mg/kg	0.019 mg/kg	(24/30)	**9.4**	No

7. Segregate the COCs into carcinogens and noncarcinogens as described in the Preliminary Remediation Goals table in Appendix C. Radionuclides should be evaluated in the Tier I Screen using the screening values in Appendix E, if applicable. Calculate a Screening Index for all COCs by dividing the Exposure Concentration by the chemical-specific Preliminary Remediation Goal from Appendix C and summing the carcinogens and noncarcinogens:

$$\text{Screening Index (SI)} = \sum \frac{\text{Exposure Concentration x}}{\text{Screening Value x}} + \frac{\text{Exposure Concentration y}}{\text{Screening Value y}} + \frac{\text{Exposure Concentration z}}{\text{Screening Value z}} + etc.$$

For noncarcinogens, a Screening Index of less than 1.0 indicates that exposure to all noncarcinogenic contaminants, when summed, do not exceed a HQ of 1.0. Likewise the carcinogenic constituents should also use the SI approach and multiply the result by 10^{-6} to determine the additive risk in the media. This approach should be used for all applicable media at a site and then summing the indices of the individual media. The VERP applicant or party may calculate a site-specific PRG for a Tier I risk assessment screen.

8. Present the results of the Screening Index in the risk assessment report (Section 2.6).
9. If the cumulative Screening Index (SI) exceeds 1.0 for noncarcinogens or 1×10^{-6} for carcinogens, a VERP Applicant or party should select the next course of action. They may select to complete a risk management plan (Section 2.4), initiate remedial action(s) (Section 2.5), or evaluate the risks further through a baseline risk assessment (Section 2.2).

Section 2.2. Tier II. Baseline Human Health Risk Assessment.

1. Based on the COCs that were identified in Tier I (Risk-Based Screening), conduct a baseline risk assessment.
2. Risk assessment guidance documents from the United States Environmental Protection Agency should be used in preparing the risk assessment. Primary guidance is the "Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual. (Part A)" (RAGS Part A) and RAGS Part B (U.S. EPA, 1989; 1991), the "Soil Screening Guidance: Technical Background Document" (U.S. EPA, 1996a), the "Soil Screening Guidance: Users Guide" (U.S. EPA, 1996b), the "Soil Screening Guidance for Radionuclides: Users Guide" (U.S. EPA, 2000), and the Supplemental Guidance to RAGS: Region 4 Bulletins (U.S. EPA, 2001c). Other supporting guidance documents should be used as needed.
3. Describe the collection of sampling data and the procedures used to evaluate the data that are included in the risk assessment. Evaluation is completed as described in RAGS Part A (U.S. EPA, 1989) and involves evaluating analytical methods, quality of data, quantitation limits, data qualifiers, and blanks.
4. Identify and calculate exposure to current and future receptors. Potential land uses should be identified including, but not limited to: residential, industrial, recreational, commercial, or

agricultural. The baseline risk assessment should address all current and potential future receptors including trespassers and residents. Exposure factors for common receptors are listed in Appendix A. Site-specific factors may be used, subject to cabinet approval. The factors and the rationale for their use should be documented in the risk assessment report.

5. Describe the toxicity of the COCs that were identified in Section 2.1. List the toxicity values that are associated with the COCs. The hierarchy for sources of toxicity values is: (1) U.S. EPA's Integrated Risk Information System (IRIS), (2) U.S. EPA's Health Effects Assessment Summary Tables (HEAST), (3) provisional values from U.S. EPA's National Center for Environmental Assessment (NCEA), and (4) Other sources. Other sources may include Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, World Health Organization (WHO) documents, publications in the primary toxicological literature, or values withdrawn from IRIS or HEAST, with cabinet approval.
6. Calculate the risks associated with the receptors that were identified in Step 4.
7. Identify and describe the uncertainties associated with the risk assessment. Potential sources of uncertainty include COC selection, range of values for exposure parameters, characterization of the site, and interaction between chemicals (additivity, synergism). Uncertainty analysis is further discussed in RAGS Part A (U.S. EPA, 1989).

Section 2.3. Groundwater Evaluation.

Groundwater data from monitoring wells are evaluated in Tier I and II risk evaluations. Recoverable water from soil borings can also be evaluated with groundwater numbers (Preliminary Remediation Goals, MCLs) as described in Section 2.1 and 2.2. If no groundwater monitoring data are available, or data are not adequate, then compare Exposure Concentration(s) for soil to the Soil Screening Level(s) from the Preliminary Remediation Goals table in Appendix C as described in 401 KAR 100:100 Section 5 (5). Radionuclides should be evaluated using the Soil Screening Levels in Appendix E, if applicable.

If the bottom two sampling intervals in the soil boring do not exceed the SSL, modified SSL, site-specific SSL, or subsurface background, then further groundwater evaluation of soil as a potential source for groundwater contamination is not necessary. If soil concentrations in the bottom two sampling intervals of the soil boring do exceed the Soil Screening Level, Modified SSLs, or site-specific SSLs for protection of groundwater resources, and subsurface background, then this indicates a need to manage for migration of contaminants to groundwater or for a groundwater investigation. Submit a plan to assess and protect groundwater or provide site-specific information that contamination doesn't pose a threat to groundwater.

Identify if the site is in an area where contamination of a karst aquifer is possible, or the contaminant(s) could result in a dense non-aqueous phase liquid (DNAPL) layer, or any other circumstances exist that would indicate a higher potential for contamination of groundwater. If such conditions exist, submit a plan for groundwater assessment and protection.

Section 2.4. Management of Risks.

1. Property Use. Management of risks can be accomplished by ensuring that a property is only used by a certain receptor. For example, a property that meets criteria for commercial or industrial use, but not residential, must remain commercial or industrial. Alternate land uses can be evaluated by using commercial/industrial screening values in place of the residential screening values that were used in Section 2.1, or in a baseline risk assessment.
2. Physical and Institutional Controls. Management of risks can be accomplished if exposure to contaminated media is controlled using a combination of soil cover, restrictive covenants, dig restrictions, fencing, or other approved methods.
3. Submit Corrective Action Plan for approval as described in 401 KAR 100:100 Section 8.

Section 2.5. Selection of Remedial Goals.

1. The primary goals of remediation is protection of human health at the hazard index of 1.0 and the carcinogenic risk of 1×10^{-6} at the point of exposure, and protection of ecological health. Ecological risks are addressed in Section 3.0.
2. The primary goals of remediation do not excuse compliance with other applicable standards, such as the National Ambient Air Quality Standards and the surface water standards.
3. The intended use must be ensured through physical and institutional controls and described in the Corrective Action Plan. The risk-based Preliminary Remediation Goals are found in the Appendix C table or derived based on approved receptor-specific values. Remedial goals

for radionuclides will be developed on a site-specific basis in consultation with the Kentucky Cabinet for Health Services. Generic inorganic background values are listed in Appendix G or may be derived using the guidance in 401 KAR 100:100 Section 7 (6).

4. The applicable risk-based remedial goals for surface soils are the residential and commercial/industrial soil numbers in the Appendix C Preliminary Remediation Goals table or those calculated based on approved receptor-specific values. Appendix E contains the risk-based concentrations for radionuclides, if applicable. The remedial goal for certain organic chemicals may be based on site-specific concentrations if it can be demonstrated to the cabinet that concentrations are the result of natural sources or are a by-product of combustion of fuels and not the result of activities on the property or site. For subsurface soils, a VERP applicant or party may select ten times the surface soil risk-based concentrations as an initial remedial goal with implementation of the institutional and physical controls and should not be a source of groundwater contamination. If contaminants are in the surface soil horizon, this can be attained through the use of cover (6 inches of pavement (e.g., asphalt or concrete), 12 inches of soil, or other approved method). For example, if the commercial/industrial soil number is 1.3 mg/kg on the risk-based PRGs table in Appendix C, and the contamination is more than a foot below the surface or is covered with a foot of clean soil, then the concentration that is left in place can be 13 mg/kg and the use of the site would need to be restricted to commercial or industrial use with the soil cover maintained in place.

Section 2.6. Human Health Risk Assessment Report Format.

The risk assessment results should be presented as part of the environmental remediation process wherever risk assessment is used for environmental decision-making. This may be included as part of the site characterization report, corrective action completion report, in an appendix to those reports, or as a separate document.

1. Screening. The screening report should consist of a brief description of the property, site characterization activities, a summary of the analytical data along with the statistical calculations of the 95% UCL, the summary table as described in Section 2.1 6., and results of the Screening Index.

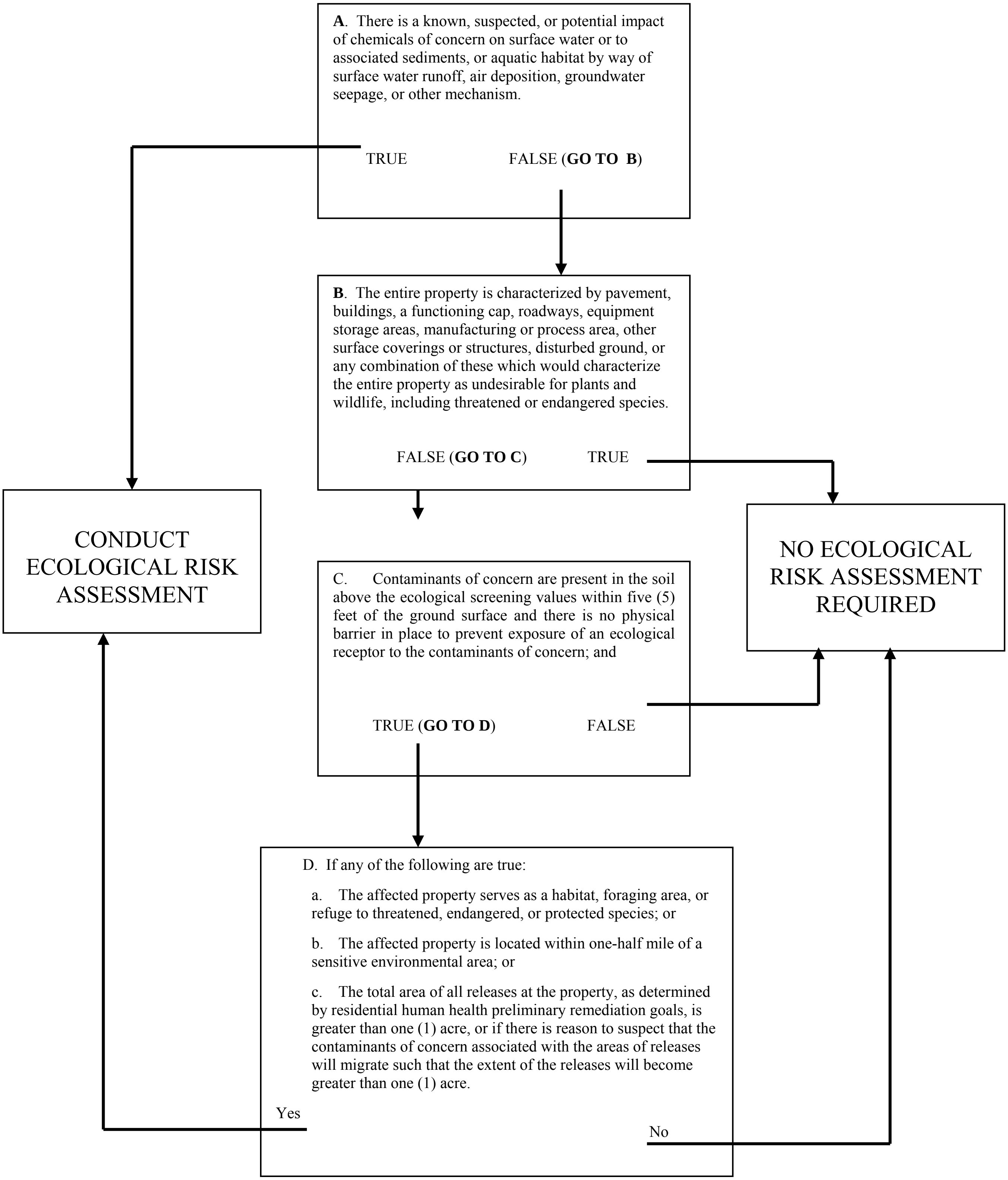
2. Baseline Risk Assessment. The baseline risk assessment report should follow the general outline shown in Appendix B. A copy of the screening risk assessment may be included with the baseline risk assessment to provide information that was used in the baseline risk assessment (selection of COCs, calculation of 95% UCL).

Section 3.0 Ecological Risk Assessment

If it has been determined that an Ecological Risk Assessment (ERA) needs to be conducted (401 KAR 100:100 Section 5 (8)), this document provides the outline for that process. The flowchart in Figure 3 is the process for determining if an ERA needs to be conducted. The checklist in Appendix F can be used to identify features of the environmental setting that are related to ecological receptors.

The phrase "ecological risk assessment" refers to a qualitative and/or quantitative appraisal of the actual or potential impacts from a hazardous compound or physical stressor on plants and animals. Documents from various federal programs (Simini et. al., 2000; USEPA 1993; USEPA 1997a; USEPA 1998) were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations. Figure 4 outlines the process of the ERA.

Figure 3. Flowchart For Determining An Ecological Risk Assessment



A. There is a known, suspected, or potential impact of chemicals of concern on surface water or to associated sediments, or aquatic habitat by way of surface water runoff, air deposition, groundwater seepage, or other mechanism.

TRUE FALSE (**GO TO B**)

B. The entire property is characterized by pavement, buildings, a functioning cap, roadways, equipment storage areas, manufacturing or process area, other surface coverings or structures, disturbed ground, or any combination of these which would characterize the entire property as undesirable for plants and wildlife, including threatened or endangered species.

FALSE (**GO TO C**) TRUE

C. Contaminants of concern are present in the soil above the ecological screening values within five (5) feet of the ground surface and there is no physical barrier in place to prevent exposure of an ecological receptor to the contaminants of concern; and

TRUE (**GO TO D**) FALSE

D. If any of the following are true:

a. The affected property serves as a habitat, foraging area, or refuge to threatened, endangered, or protected species; or

b. The affected property is located within one-half mile of a sensitive environmental area; or

c. The total area of all releases at the property, as determined by residential human health preliminary remediation goals, is greater than one (1) acre, or if there is reason to suspect that the contaminants of concern associated with the areas of releases will migrate such that the extent of the releases will become greater than one (1) acre.

The ERA process is based on two major elements: characterization of effects and characterization of exposure. These provide the focus for conducting the phases of risk assessment: planning, problem formulation, analysis, risk characterization, and risk management.

a) Planning – The Planning phase involves the determination of level-of-effort necessary for the ERA. ERA management goals and objectives are determined (i.e., what plant, animal, or ecosystem is at risk and might need protection), the focus of the ERA is laid out, and the time frame for the assessment is set.

b) Problem Formulation – The overall strategy for estimating risk at a site is developed in Problem Formulation. During this phase, the Conceptual Site Model (CSM) is created, the receptors potentially at risk are defined, and a plan is written that describes the data to be analyzed and the process to be used to calculate risk.

c) Analysis – This component of the ERA consists of data collection, the technical evaluation of the data, the calculation of the existing and potential exposures, and corresponding ecological effects.

d) Risk Characterization – The likelihood and severity of the risk is evaluated for the assessment endpoints, and the ERA's uncertainty is described in the Risk Characterization. A good description of the risk, including the level of adverse effects, is important for interpreting the risk results.

e) Risk Management – In this component, the results of the ERA are integrated with other considerations to make and justify remedial decisions. In a screening level ERA, the risk management decision is whether a baseline ERA is needed.

Section 3.1. Tier 1. Screening-Level Ecological Risk Assessment.

The purpose of the screening-level risk assessment is to evaluate whether existing data justify a decision that site contaminants do not pose a risk to ecological receptors or whether additional evaluation is necessary. If no potential for risk is identified in a screening-level risk assessment, then risk managers can confidently conclude that no further action is required at the site. Tier 1 of ERA consists of two steps:

Step 1. Screening-Level Problem Formulation and Ecological Effects Evaluation.

Step 2. Screening-Level Preliminary Exposure Estimate and Risk Calculation.

Steps 1 and 2 of the ERA process contain the following elements:

- Site visit
- Screening-level problem formulation (preliminary Conceptual Site Model)
- Exposure pathways and endpoints
- Screening-level effects evaluation (toxicity threshold benchmarks)
- Screening-level exposure estimate (site concentration data)
- Screening-level risk calculation (site concentration data screens)
- Documentation

a) Preliminary Conceptual Site Model (CSM). As part of Tier 1, Step 1 of the ERA, use available information to develop a preliminary CSM. Available information may include observations made during site visits, historical documents, existing data, and professional judgement of technical experts who are familiar with the site. The preliminary CSM should describe the environmental setting of the individual site, the site's immediate surroundings, and the contaminants known to exist at the site. The preliminary CSM should identify fate and transport mechanisms of contaminants potentially moving off-site, and briefly discuss the ways that site contaminants act on likely receptors.

b) Exposure Pathways and Endpoints. Based on the preliminary CSM, the ecological risk assessor should identify the potentially complete exposure pathways and endpoints for the screening assessment. The exposure pathways and endpoints for the site specify which ecological effects data are required. The screening-level effects data are screening-level benchmarks and concentrations of substances in the abiotic media (e.g., soil, air or water). If groundwater potentially discharges to surface water, groundwater concentrations are compared to surface water screening benchmarks.

c) Identify Chemicals of Potential Concern. As part of Tier 1, Step 2, determine (COPCs) by eliminating COPCs from further evaluation:

- Background Comparisons**.** Compare the mean concentration for inorganic constituents on-site against the 95% UCL of the mean concentrations of background for inorganic constituents. At least ½ of the data points should be less than the 60th percentile, and no data point above the 95th percentile. Generic inorganic background values are listed in Appendix G or may be derived in accordance with 401 KAR 100:100 Section 7 (6).

- Screening Table Comparison. Compare the lesser of the maximum concentration or 95% UCL on site for substances in a given exposure medium to the screening-level benchmarks (Appendix D) for those substances. Compare site concentrations to screening-level benchmarks for surface soil, sediment, surface water, and groundwater (if site conditions will potentially result in exposure to ecological receptors).

d) Retaining Chemicals of Concern. If any constituent in an abiotic medium to which organisms are potentially exposed is present at a concentration exceeding screening-level benchmark and ambient background or if there is not a screening-level benchmark, then further evaluation of the potential risk will be required. Chemicals with known synergistic effects or that bioaccumulate will be retained as COPCs. If existing data does not have adequate detection limits (i.e., detection limits above screening benchmarks) new data must be collected to replace it.

e) Documentation. The documentation of Steps 1 and 2 should include the following:

- Brief habitat description, and map;
- Preliminary CSM;
- Tables of screening results;
- List of wildlife species actually or potentially occurring at the site, including threatened and endangered plant and animal species;
- Discussion of uncertainties. The discussion of the uncertainties should identify constituents for which there are no screening-level benchmarks or analytical chemistry data.

At the end of Tier 1, the decision whether to collect additional data for screening, to proceed with the ERA, or to take no further action can be documented in the report.

Section 3.2. Tier 2 Baseline Ecological Risk Assessment

The baseline ecological risk assessment is a continuation of the screening ERA. It consists of 6 steps:

Step 3. Baseline Risk Assessment Problem Formulation
Step 4. Study Design and Data Quality Objectives
Step 5. Field Verification of Sampling Design
Step 6. Site Investigation and Analysis of Exposure and Effects
Step 7. Risk Characterization
Step 8. Risk Management

a) Step 3. Baseline Risk Assessment Problem Formulation. The Baseline Risk Assessment Problem Formulation should provide sufficient information to support a risk management decision concerning the need for additional evaluation of ecological risk. Further evaluation may mean site-specific ecological investigation at the site. This will require a work plan, documenting Step 4 of the process, and describing how the data will be used in Step 7 to make a remedial decision for the site. Important inputs to this decision are:

- Site concentration data;
- Conceptual Site Model;
- Habitat Description;
- Preliminary Hazard Quotients. The Hazard Quotient should be calculated for COPCs using toxicity values from current literature and intake factors from the Wildlife Exposure Factors Handbook (USEPA 1993) for the species listed below. A Hazard Quotient is calculated by dividing the site concentration (the lessor of the 95% UCL of the mean or maximum) by the No-Observed Adverse Effect Level (NOAEL). If the Hazard Quotient is above 1.0, that compound continues through the baseline ERA.

  For terrestrial habitats, receptors must include (1) earthworm (Lumbricus terrestris), (2) short-tailed shrew (Blarina brevicauda), (3) long-tailed weasel (Mustela frenata), (4) meadow vole (Microtus pennsylvanicus) or prairie vole (Microtus ochrogaster), and (5) American woodcock (Scolopax minor). For aquatic habitats, receptors must include; mink (Mustela vison) little brown bat (Myotis lucifugus), and belted kingfisher (Cerlye alcyon). The above list of species should not be considered exclusive. If there are other species on site that exposure factors, intake rates, and toxicity values are known, those species should be included in the ERA. Species that are on the Federal and/or State Threatened or Endangered Species List and either known to have been on or in the vicinity of the site or if the site contains habitat known to support those species, then they should also be included in the ERA.

- The identification of COPCs that warrant further evaluation.
- An understanding of the effects of COPCs on ecological receptors (including toxicity reference values).
- The identification of complete exposure pathways by which COPCs are brought into contact with ecological receptors (include bioaccumulation factors and ingestion rates for wildlife receptors).
- The identification of assessment endpoints (e.g., protection of fish eating birds from eggshell thinning due to DDT exposure) and measurement endpoints (e.g., natural population structure, feeding, resting, and reproductive cycles).
- Discussion of uncertainties should include the lack of site concentration or toxicity data for COPCs.

b) In Step 4, the process identifies the study design and data quality objectives (DQOs) for the site investigation. The work plan (WP) and the sampling and analysis plan (SAP) are the primary products of Step 4. The WP and SAP must specify the study design in sufficient detail to evaluate its adequacy for collecting the data necessary to answer the risk questions.

The WP or SAP should include the following:

- The number and location of samples of each medium for each purpose
- The comparison of analytical detection limits and threshold concentrations
- The full description of toxicity tests and population/community study designs
- A description of how the results of site investigations will be used in the risk characterization (Step 7) to answer risk questions.

c) In Step 5, the Verification of Field Sampling Design process evaluates the probability of successfully completing the study as designed. The WP or SAP should describe the methods for verifying the study design. The verification process and any remaining uncertainties about the study design should be discussed when the results of the site investigation are reported.

d) Step 6, the Site Investigation and Data Analysis, is the implementation of the site investigation designed in Step 4 and verified in Step 5. Approved alterations in the work plan should be documented in the report containing the risk characterization (i.e., the baseline risk report).

e) Risk Characterization (Step 7) is conducted after data collected during the site investigation have been analyzed. The risk characterization evaluates the exposure and effects data to assess the risk to the assessment endpoints (risk estimation). The risk characterization also presents information necessary to interpret the risk assessment and to decide upon adverse effect thresholds for the assessment endpoints (risk description). This presentation should include a qualitative and quantitative summary of risk results and uncertainties.

   In risk estimation, the lines of evidence, for which data were collected in the site investigation, are integrated in the risk characterization to support a conclusion about the significance of ecological risk. The different possible lines of evidence could be tissue concentration data, toxicity test results, and/or population/community data.

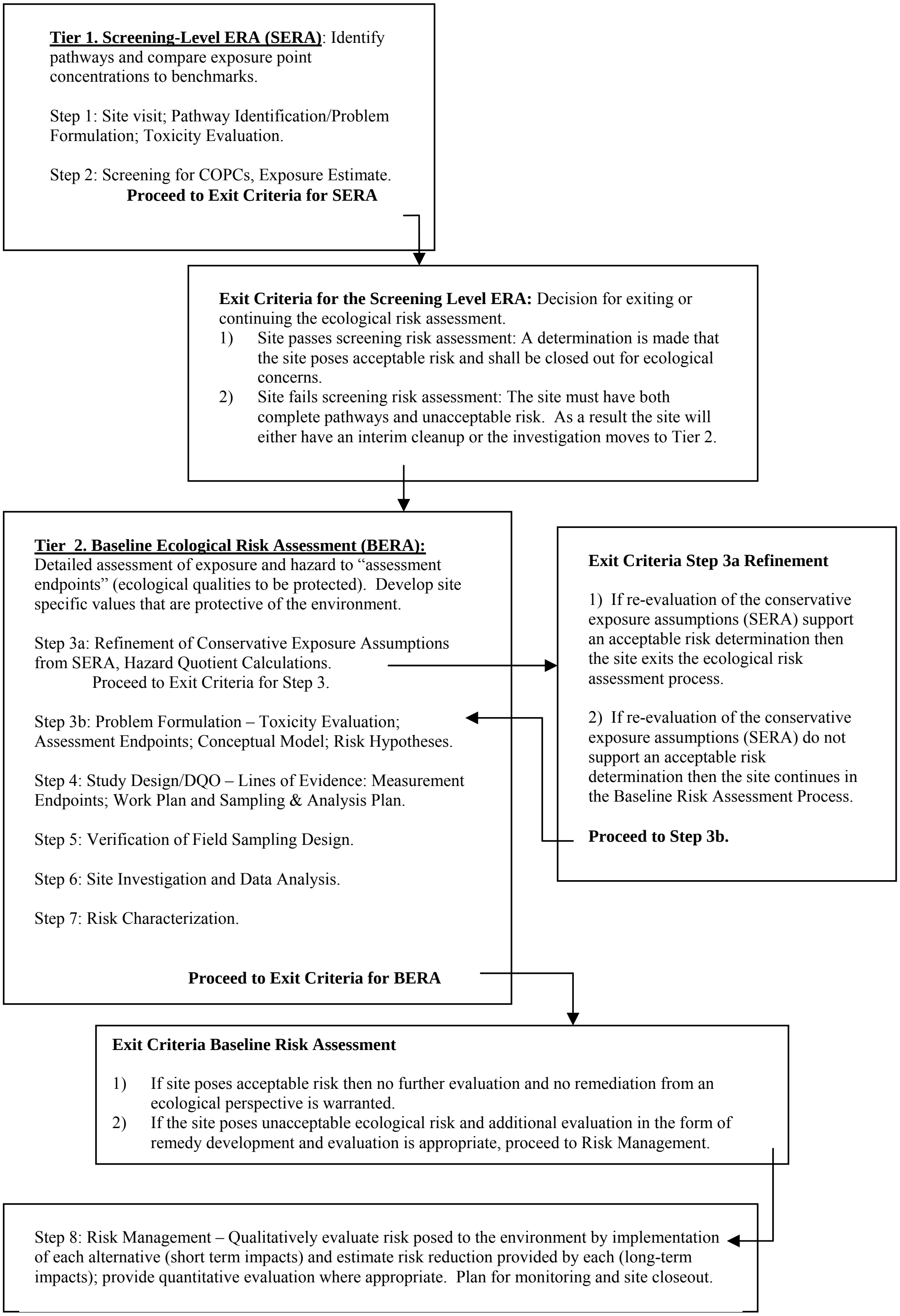
   If site-specific tissue concentration data are available from the site investigation, HQs for wildlife receptors preying on those tissues are calculated. These HQs are calculated using appropriate exposure estimates and toxicity reference values.

   In the ERA, the risk characterization should put the level of risk at the site in context. The risk description should identify threshold concentrations in source or exposure media for effects on the assessment endpoint. All site-specific parameter values used to calculate HQs must be described and the source of the values identified.

   At Step 7, the uncertainty about the risk posed by a substance should have been reduced to a level that allows risk managers to make a technically defensible remedial decision. The risk characterization provides information to judge the ecological significance of the estimated risk to assessment endpoints in the absence of any remedial action.

f) Step 8 of the ERA is Risk Management. The role of ecological risk assessors is to advise the risk managers during the final actions. If the risk characterization concludes there is a risk to ecological receptors, the risk management decision is whether to remediate the site or to leave the constituents of concern in place with controls on exposure and monitoring.

Figure 4. Ecological Risk Assessment Flow Chart



Tier 1. Screening-Level ERA (SERA): Identify pathways and compare exposure point concentrations to benchmarks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation.

Step 2: Screening for COPCs, Exposure Estimate.

Proceed to Exit Criteria for SERA

Exit Criteria for the Screening Level ERA: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening risk assessment: A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.
2) Site fails screening risk assessment: The site must have both complete pathways and unacceptable risk. As a result the site will either have an interim cleanup or the investigation moves to Tier 2.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions from SERA, Hazard Quotient Calculations.

Proceed to Exit Criteria for Step 3.

Step 3b: Problem Formulation – Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypotheses.

Step 4: Study Design/DQO – Lines of Evidence: Measurement Endpoints; Work Plan and Sampling & Analysis Plan.

Step 5: Verification of Field Sampling Design.

Step 6: Site Investigation and Data Analysis.

Step 7: Risk Characterization.

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

1) If re-evaluation of the conservative exposure assumptions (SERA) support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions (SERA) do not support an acceptable risk determination then the site continues in the Baseline Risk Assessment Process.

Proceed to Step 3b.

Exit Criteria Baseline Risk Assessment

1) If site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.
2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to Risk Management.

Step 8: Risk Management – Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term impacts) and estimate risk reduction provided by each (long-term impacts); provide quantitative evaluation where appropriate. Plan for monitoring and site closeout.

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Appendix A

Exposure Factors

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Table 1 Incidental Soil Ingestion Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Ingestion Rate:	
Child less that 7 years	200 mg/day
Child 7 through 18 years, and Adult	100 mg/day
Adult Worker (8 hour work day)	50 mg/day
Outdoor Adult (landscaping, construction, Rural outdoor activities, tilling and gardening)	480 mg/day
Exposure Frequency:	
Resident	350 days/year
General Workers	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 2 Dermal Contact with Stressors in Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Skin Surface Area:	
Child less than 7 years	2800 cm^2/day (face, forearms, hands, lower legs, and feet)
Child 7 through 18 years	7500 cm^2/day (arms, hands, legs, and feet)
Residential Adult	5700 cm^2 (face, hands, forearms, and lower legs)
Adult (Industrial)	3300 cm^2/day (face, forearms, and hands)
Outdoor Worker	4700 cm^2/day (arms, hands, and head)
Exposure Frequency:	
Resident	350 days/year
General Workers	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Dermal Absorption Factor	0.25 Volatile Organics (unitless) 0.1 Semivolatiles (unitless) 0.05 Inorganics (unitless)
Skin Contact Time (fraction of day soil remains on skin):	
Residential	12 hours/24 hours (0.5 unitless)
Worker	8 hours/24 hours (0.33 unitless)
Recreational or Trespasser	12 hours/24 hours (0.5 unitless)
Soil to Skin Adherence Factor	1.0 mg/cm^2
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 3 Inhalation of Particulate-phase Stressors from Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate:	
Resident (Children and Adults)	20 m^3/day (0.833m^3/hour, 24 hr/day)
Trespasser	20 m^3/day (2.5 m^3/hour, 8 hr/day)
Worker (Indoor and Outdoor)	12.5 m^3/day (2.5 m^3/hour, 5 hr/day)
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adults	12 years
Residential Rural Adults	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Particulate Emission Factor:	
Residential	9.3 x 10^8 m^3/kg or site-specific
Commercial/Industrial	6.2 x 10^8 m^3/kg or site-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 4 Inhalation of Airborne (Vapor Phase) Stressors from Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate:	
Resident (Children and Adults)	20 m^3/day (0.833 m^3/hour, 24 hr/day)
Trespasser	20 m^3/day (2.5 m^3/hour, 8 hr/day)
Worker (Indoor and Outdoor)	12.5 m^3/day (2.5 m^3/hour, 5 hr/day)
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Volatilization Factor	Derived using Equation 8 of the Soil Screening Level Guidance User's Guide (U.S. EPA 1996b)
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 5 Ingestion of Stressors from Water Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate:	
Child less than 3 years old	1.0 liter/day
Child 3 through 18 years and Adult	2.0 liters/day
Adult Worker (up to an 8 hour work day)	1.0 liter/day
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 6 Ingestion of Stressors in Surface Water While Swimming Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate:	50 milliliters/hour
Exposure Time:	2.6 hours/day
Exposure Frequency:	45 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 7 Dermal Contact with Stressors in Water while Swimming or Wading Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area:	
Child swimmer 3 through 6 years	0.6500 m^2/day
Child swimmer 7 through 18 years	1.3100 m^2/day
Adult swimmer	1.8150 m^2/day
Child wader 1 through 6 years	0.3300 m^2/day (arms, hands. legs and feet)
Child wader 7 through 18 years	0.7500 m^2/day (arms, hands. legs and feet)
Adult wader	1.0600 m^2/day (arms, hands. legs and feet)
Exposure Time	2.6 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K_ps are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency:	
Swimming	45 days/year
Child and Adolescent Wading	140 days/year
Adult Wading	52 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Dermal Absorbed Dose per Event (DA_{event})	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 8 Dermal Contact with Stressors in Water during Showering or Bathing Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area:	
Child 3 through 6 years	0.6500 m^2/day
Child 7 through 18 years	1.3100 m^2/day
Adult	1.8150 m^2/day
Exposure Time	0.2 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K_ps are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency:	
Residents	350 days/year
Workers in the work place	250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Dermal Absorbed Dose per Event (DA_{event})	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 9 Inhalation of Airborne (Vapor Phase) Stressors in Water during Showering Pathway

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum, et al., 1994, Showering Exposure
Inhalation Rate	0.833 m^3/day
Exposure Time	0.2 hours/day (12 minutes/day)
Exposure Frequency:	
Residents	350 days/year
Workers in the work place	250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adults	12 years
Residential Rural Adults	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 10 Inhalation of Airborne (Vapor Phase) Stressors in Water during General Home Use Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum et al., 1994, Whole House Model
Inhalation Rate	20 m^3/day
Water Flow Rate	890 L/day
House Volume	450 m^3
Air Exchange Rate	10 changes/day
Fraction Volatilized	0.5 (unitless)
Mixing Coefficient (how well mixed in the home)	0.5 (unitless)
Exposure Frequency:	
Resident	350 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Other Pathways. Other pathways may be used at sites that have current or potential future pathways that are not listed in this Appendix. Examples include: consumption of contaminated fish, produce, and livestock. Exposure factors should be based on site-specific conditions and may be obtained from U.S. EPA documents including Exposure Factors Handbook, Risk Assessment Guidance for Superfund (Part A), and Risk Assessment Guidance for Superfund (Part B).

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Appendix B

General Outline for Baseline Risk Assessment

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Outline of Components of a Human Health Baseline Risk Assessment

This is a general outline and not all components of the outline are applicable to all sites.

1.0 INTRODUCTION

- 1.1 Overview
    - 1.1.a General Problem at site
    - 1.1.b Site-specific objectives of risk assessment
- 1.2 Scope of Risk Assessment
    - 1.2.a Complexity of risk assessment and rationale
    - 1.2.b Overview of study design

2.0 IDENTIFICATION OF STRESSORS OF POTENTIAL CONCERN

- 2.1 General Site-Specific Data Collection Considerations
    - 2.1.a Preliminary identification of potential human exposure
    - 2.1.b Modeling parameter needs
- 2.2 General Site-Specific Data Evaluation Considerations
    - 2.2.a Steps used (including statistical methods used for evaluation and data selection)
    - 2.2.b Criteria employed in evaluating data
    - 2.2.c Discussion of data uncertainty
- 2.3 Stressor Analytical Data (Complete for All Media)
    - 2.3.a Listing of analytical methods used
    - 2.3.b Evaluation of chemical limits
    - 2.3.c Evaluation of qualified and coded data
    - 2.3.d Contaminants in field and laboratory blanks
    - 2.3.e Tentatively identified compounds
    - 2.3.f Further limitation of number of stressors
    - 2.3.g Uncertainties, limitations, gaps in quality of collection or analysis
- 2.4 Summary of Stressors of Potential Concern

3.0 EXPOSURE ASSESSMENT

- 3.1 Characterization of Exposure Setting
    - 3.1.a Summary of Physical Setting
    - 3.1.b Potentially Exposed Individuals, Populations, and Communities (Human)
        - 3.1.b.1 Relative locations of individuals, populations, and communities with respect to site
        - 3.1.b.2 Current land use

3.1.b.3 Potential alternate future land uses

3.1.b.4 Subpopulations of potential concern

3.2 Identification of Exposure Pathways

3.2.a Sources of the release and receiving media

3.2.b Fate and transport in release media

3.2.c Exposure points and exposure routes

3.2.d Integration of sources, releases, fate and transport mechanisms, exposure points, and exposure routes into complete exposure pathways

3.2.e Summary of exposure pathways to be quantified in this assessment

3.3 Quantification of Exposure

3.3.a Exposure concentrations

3.3.b Estimation of chemical intakes for individual pathways

3.4 Identification of Uncertainties

3.4.a Current and future land-use

3.4.b Environmental sampling and analysis

3.4.c Exposure pathways evaluated

3.4.d Fate and transport modeling

3.4.e Parameter values

3.5 Summary of Exposure Assessment

4.0 TOXICITY ASSESSMENT

4.1 Toxicity Information for Noncarcinogenic Effects (Human Health)

4.1.a Appropriate exposure periods for toxicity values

4.1.b Up-to-date reference doses (RfDs) for all stressors

4.1.c One-and ten-day health advisories for shorter-term oral exposures

4.1.d Overall data base and the critical study on which the toxicity value is based (including the critical effect and the uncertainty and modifying factors used in the calculation)

4.1.e Effects that may appear at doses higher than those required to elicit the critical effect

4.1.f Absorption efficiency considered

4.2 Toxicity Information for Carcinogenic Effects

4.2.a Exposure averaged over a lifetime

4.2.b Up-to-date slope factors for all carcinogens

4.2.c Weight-of-evidence classification for all carcinogens (Groups A, B, and C)

4.2.d Type of cancer for Group A, B, and C carcinogens

    - 4.2.e Concentration above which the dose-response curve is no longer linear, if applicable
    - 4.3 Stressors for Which No EPA Toxicity Values are Available
    - 4.3.a Sources of values
    - 4.3.b Qualitative evaluation
    - 4.3.c Documentation or justification of any new toxicity values developed
  - 4.4 Uncertainties Related to Toxicity Information
    - 4.4.a Quality of the individual studies
    - 4.4.b Completeness of the overall data base
  - 4.5 Summary of Toxicity Information

5.0 RISK CHARACTERIZATION

  - 5.1 Current Land-use Conditions (Human Health)
    - 5.1.a Carcinogenic risk of individual stressors in individual pathways
    - 5.1.b Chronic hazard quotient calculation (individual stressors, individual pathways)
    - 5.1.c Subchronic hazard quotient calculation (individual stressors, individual pathways)
    - 5.1.d Shorter-term hazard quotient calculation (individual stressors, individual pathways)
    - 5.1.e Noncarcinogenic hazard index (individual stressors, all pathways)
    - 5.1.f Carcinogenic risk (individual stressors, all pathways)
    - 5.2 Future Land-Use Conditions (Human Health)
    - 5.2.a Carcinogenic risk of individual stressors in individual pathways
    - 5.2.b Chronic hazard quotient calculation (individual stressors, individual pathways)
    - 5.2.c Subchronic hazard quotient calculation (individual stressors, individual pathways)
    - 5.2.d Noncarcinogenic hazard index (individual stressors, all pathways)
    - 5.2.e Carcinogenic risk (individual stressors, all pathways)
  - 5.3 Uncertainties
    - 5.3.a Site-specific uncertainty factors
      - 5.3.a.1 Definition of physical setting
      - 5.3.a.2 Model applicability and assumptions
      - 5.3.a.3 Parameter values for fate or transport and exposure calculations
    - 5.3.b Summary of toxicity assessment uncertainty
      - 5.3.b.1 Uncertainty and identification of potential human health effects

        - 5.3.b.2 Derivation of toxicity value including completeness of overall database
        - 5.3.b.3 Potential for synergistic or antagonistic interactions
        - 5.3.b.4 Uncertainty in evaluating less-than-lifetime exposures
- 5.4 Comparison of Risk Characterization Results to Human Studies (if available)
    - 5.4.a Health assessment from the Agency for Toxic Substances and Disease Registry (ATSDR)
    - 5.4.b Site-specific health studies (pilot studies or epidemiological studies)
    - 5.4.c Incorporation of studies into the overall risk characterization
- 5.5 Summary Discussion and Tabulation of the Risk Characterization
    - 5.5.a Key site-related stressors and key exposure pathways identified
    - 5.5.b Types of health risk of concern
    - 5.5.c Level of confidence in the quantitative information used to estimate risk
    - 5.5.d Presentation of qualitative information on toxicity
    - 5.5.e Confidence in the key exposure estimates for the key exposure pathways
    - 5.5.f Magnitude of the carcinogenic and noncarcinogenic risk estimates
    - 5.5.g Magnitude of chronic and subchronic risk estimates
    - 5.5.h Major factors contributing to risk
    - 5.5.i Major factors (COCs and Pathways) contributing to uncertainty
    - 5.5.j Exposed population and community characteristics
    - 5.5.k Comparison with site-specific health studies
    - 5.5.l Comparison of chemical concentrations with natural background

6.0 SUMMARY AND CONCLUSIONS

- 6.1 Stressors of Potential Concern
- 6.2 Exposure Assessment
- 6.3 Toxicity Assessment
- 6.4 Risk Characterization
- 6.5 Uncertainties

Outline of Components of an Ecological Baseline Risk Assessment

This is a general outline and not all components of the outline are applicable to all sites.

STEP 1: SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

1.1 INTRODUCTION

1.2 SCREENING-LEVEL PROBLEM FORMULATION

- 1.2.1 Environmental Setting and Contaminants at the Site
- 1.2.2 Contaminant Fate and Transport
- 1.2.3 Ecotoxicity and Potential Receptors
- 1.2.4 Complete Exposure Pathways
- 1.2.5 Assessment and Measurement Endpoints

1.3 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION

- 1.3.1 Preferred Toxicity Data
- 1.3.2 Dose Conversions
- 1.3.3 Uncertainty Assessment

1.4 SUMMARY

STEP 2: SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

2.1 INTRODUCTION

2.2 SCREENING-LEVEL EXPOSURE ESTIMATES

- 2.2.1 Exposure Parameters
- 2.2.2 Uncertainty Assessment

2.3 SCREENING-LEVEL RISK CALCULATION

2.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

2.5 SUMMARY

STEP 3: BASELINE RISK ASSESSMENT PROBLEM FORMULATION

3.1 THE PROBLEM-FORMULATION PROCESS

3.2 REFINEMENT OF PRELIMINARY CONTAMINANTS OF CONCERN

3.3 LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS

- 3.4 CONTAMINANT FATE AND TRANSPORT, ECOSYSTEMS POTENTIALLY AT RISK, AND COMPLETE EXPOSURE PATHWAYS
    - 3.4.1 Contaminant Fate and Transport
    - 3.4.2 Ecosystems Potentially at Risk
    - 3.4.3 Complete Exposure Pathways
- 3.5 SELECTION OF ASSESSMENT ENDPOINTS
- 3.6 THE CONCEPTUAL MODEL AND RISK QUESTIONS
    - 3.6.1 Conceptual Model
    - 3.6.2 Risk Questions
- 3.7 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)
- 3.8 SUMMARY

STEP 4: STUDY DESIGN AND DATA QUALITY OBJECTIVE PROCESS

- 4.1 ESTABLISHING MEASUREMENT ENDPOINTS
    - 4.1.1 Species/Community/Habitat Considerations
    - 4.1.2 Relationship of the Measurement Endpoints to the Contaminant of Concern
    - 4.1.3 Mechanisms of Ecotoxicity
- 4.2 STUDY DESIGN
    - 4.2.1 Bioaccumulation and Field Tissue Residue Studies
    - 4.2.2 Population/Community Evaluations
    - 4.2.3 Toxicity Testing
- 4.3 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS
    - 4.3.1 Data Quality Objectives
    - 4.3.2 Statistical Considerations
- 4.4 CONTENTS OF WORK PLAN AND SAMPLING AND ANALYSIS PLAN
    - 4.4.1 Work Plan
    - 4.4.2 Sampling and Analysis Plan
    - 4.4.3 Field Verification of Sampling Plan and Contingency Plans
- 4.5 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)
- 4.6 SUMMARY

STEP 5: FIELD VERIFICATION OF SAMPLING DESIGN

- 5.1 PURPOSE

5.2 DETERMINING SAMPLING FEASIBILITY

5.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

5.4 SUMMARY

STEP 6: SITE INVESTIGATION AND ANALYSIS PHASE

6.1 INTRODUCTION

6.2 SITE INVESTIGATION

- 6.2.1 Changing Field Conditions
- 6.2.2 Unexpected Nature or Extent of Contamination

6.3 ANALYSIS OF ECOLOGICAL EXPOSURES AND EFFECTS

- 6.3.1 Characterizing Exposures
- 6.3.2 Characterizing Ecological Effects

6.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

6.5 SUMMARY

STEP 7: RISK CHARACTERIZATION

7.1 INTRODUCTION

7.2 RISK ESTIMATION

7.3 RISK DESCRIPTION

- 7.3.1 Threshold for Effects on Assessment Endpoints
- 7.3.2 Likelihood of Risk
- 7.3.3 Additional Risk Information

7.4 UNCERTAINTY ANALYSIS

- 7.4.1 Categories of Uncertainty
- 7.4.2 Tracking Uncertainties

7.5 SUMMARY

STEP 8: RISK MANAGEMENT

8.1 INTRODUCTION

8.2 ECOLOGICAL RISK MANAGEMENT

- 8.2.1 Other Risk Management Considerations
- 8.2.2 Ecological Impacts of Remedial Options
- 8.2.3 Monitoring

8.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

8.4 SUMMARY

Appendix C

Human Health Screening Values

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Development of Risk Based Concentrations for Environmental Remediation in Kentucky

Introduction

This appendix details the procedures used to develop risk-based concentrations that will be used for the Voluntary Environmental Remediation Program, KRS 224.01-400 and KRS 224.01-405 cleanups, and other programs where risk-based concentrations are needed. Documents from the United States Environmental Protection Agency were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations.

Application

It is intended for this table to have several applications to sites undergoing environmental remediation. Applications include: preliminary screening of site contaminants, closure of small spills, determination of potential toxic conditions, and reduction and refinement of the number of Chemicals of Concern (COCs) at a site during a baseline risk assessment. The values are also one of the factors that should be considered when selecting remedial goals. The values consider the more common exposure routes but if an individual site has other exposure routes that play a major role in the site-related exposures, these values may underestimate the risk.

Calculation of Risk-Based Values

The formulae for calculating the risk-based concentrations are primarily from U.S. EPA guidance including Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A), commonly referred to as RAGS Part A (U.S. EPA, 1989), RAGS part B (U.S. EPA, 1991), Soil Screening Guidance: Users Guide (U.S. EPA, 1996c), and Soil Screening Guidance: Technical Background Document (U.S. EPA, 1996b). "Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water" (Schaum *et al.*, 1994) was used to represent the inhalation exposure to water based on the Whole House Dispersion Model. The assumptions that are used in estimating the risk-based concentrations are selected to be protective of sensitive subpopulations.

KYDEP incorporated applicable exposure routes into each medium of exposure. For residential and occupational exposure to soil; ingestion, dermal and inhalation exposure was considered. Dermal exposure to soil used default absorption values of 0.25 for volatiles, 0.1 for semivolatiles, and 0.05 for metals. Default dermal absorption factors were derived from literature reviews of dermal absorption. The Agency for Toxic Substances and Disease Registry

(ATSDR) Toxicological Profiles were a valuable source of absorption and chemical specific data. Ten compounds had chemical-specific dermal absorption rates as listed in RAGS Part E (U.S, EPA, 2000a). Inhalation of contaminants found in soil used two factors: a Volatilization Factor (VF), and a Particulate Emission Factor (PEF). Potential volatilization from soil to air was represented for volatiles by the volatilization factor that was calculated using the formula in the Soil Screening Guidance: User's Guide (U.S. EPA, 1996c). A compound was assumed to be volatile when the molecular weight was less than 200 mg/mol and the Henry's Law Constant (H) was greater than 10^{-5} atm-m^3/mol. The respective default dispersion factor for residential and commercial/industrial exposures were derived for Kentucky sites using exhibit 11 in U.S. EPA, 1996c. Climatic zone VII was used to calculate the dispersion factor term since that is the logical zone for Kentucky sites. For a residential dispersion factor, the 90% lower confidence limit was calculated for a 0.5-acre site size. A commercial/industrial value for dispersion factor was calculated based the 90% lower confidence limit of the values listed under a site size of 5 acres.

Inhalation was the route that was used for air exposures. Tap water exposure used ingestion and inhalation, the latter using the Schaum (1994) Whole House Exposure Model. The model describes the average indoor air concentration as a result of water use throughout the house. This model considers water use such as washing dishes, bathing, washing clothes, and cooking. The formula is:

$$C_a = \frac{WHF \times C_w \times f}{HV \times ER \times MC}$$

where:

Ca = concentration in air, mg/m^3
Cw = concentration in water, mg/L
WHF = water flow rate in whole house, 890 L/day
HV = house volume, 450 m^3
ER = exchange rate, 10 air changes/day
MC = mixing coefficient, 0.5 (unitless)
f = fraction of contaminant that volatilizes, 0.5 (unitless)

The default values for these parameters were selected from the text of the Schaum (1994) chapter and are listed following the description.

Formulae

The formulae for calculation of the risk-based values are the result of taking the standard exposure equations used in risk assessments and solving for the concentration term. Toxicity values were used to represent the potential toxicity of each compound. These values are obtained from several sources. The source is listed next to each toxicity value. The abbreviations in order of preference are: "i" U.S. EPA's Integrated Risk Information System (IRIS), "h" U.S. EPA's Health Effects Assessment Summary Tables (HEAST), "n" U.S. EPA's National Center for Environmental Assessment (NCEA), "w" withdrawn from IRIS or HEAST, "o" other EPA documents, "r" route extrapolation, and "s" when the toxicity value of a surrogate compound was used based on physicochemical characteristics. The Risk-Based Screening Values are based on a target risk of 1 x 10^{-6} for carcinogens and a Hazard Index of 1.0 for noncarcinogens in each media. The carcinogenic risk of 1 x 10^{-6}, or one excess cancer in one million is standard practice in risk assessment for *de minimis* risk. The target Hazard Index of 1.0 indicates that the noncarcinogenic risk is below a toxicity threshold represented by the reference dose. The basis for each screening value in the table is denoted by "ca" for a carcinogenic endpoint, and "nc" for a noncarcinogenic endpoint. A soil saturation limit was derived using the formula in U.S. EPA, 1996c. A ceiling limit was set at 10^{+5} as a maximum soil concentration. If the risk-based screening value exceeded the saturation limit or the maximum, then the soil screening value was set at the saturation limit (denoted as "sat") or the maximum ceiling limit (denoted as "max") The following formulae were used to calculate the risk-based screening values for each media.

Noncarcinogenic Effects

Residential Soil

$$\frac{(ED\_c \times BW\_c \times 365 \times THQ)}{(IRA\_c \times (1/VF + 1/PEF\_r) \times EF\_r \times ED\_c \times 1/RfDi) + (SA\_c \times AF \times ABS \times EF\_r \times ED\_c \times 0.000001 \times 1/RfDo) + (IRS\_c \times EF\_r \times ED\_c \times 0.000001 \times 1/RfDo)}$$

Commercial/Industrial Soil

$$\frac{(ED\_a \times BW\_a \times 365 \times THQ)}{(IRA\_a \times (1/VF + 1/PEF\_o) \times EF\_o \times ED\_o \times 1/RfDi) + (SA\_i \times AF \times ABS \times EF\_o \times ED\_o \times 0.000001 \times 1/RfDo) + (IRS\_o \times EF\_o \times ED\_o \times 0.000001 \times 1/RfDo)}$$

Ambient Air

$$\frac{(ED\_c \times BW\_c \times 365 \times THQ \times RfDi \times 1000)}{(IRA\_c \times EF\_r \times ED\_c)}$$

Tap Water

$$\frac{(BW\_c \times ED\_c \times 365 \times THQ \times 1000)}{\left(\frac{(IRW\_c<3 \times 3)+(IRW\_c>3 \times 3)}{ED\_c} \times EF\_r \times ED\_c \times 1/RfDo\right)+\left(\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times IRA\_c \times EF\_r \times ED\_c \times 1/RfDi\right)}$$

Carcinogenic Effects

Residential Soil

$$\frac{(AT \times 365 \times TR)}{(InF\_adj \times (1/VF+1/PEF\_r) \times EF\_r \times SFi)+(SFS\_adj \times AF \times ABS \times EF\_r \times 0.000001 \times SFo)+(IFS\_adj \times EF\_r \times 0.000001 \times SFo)}$$

Commercial/Industrial Soil

$$\frac{(AT \times BW\_a \times 365 \times TR)}{(IRA\_a \times (1/VF+1/PEF\_o) \times EF\_o \times ED\_o \times SFi)+(SA\_i \times AF \times ABS \times EF\_o \times ED\_o \times 0.000001 \times SFo)+(IRS\_o \times EF\_o \times ED\_o \times 0.000001 \times SFo)}$$

Ambient Air

$$\frac{(AT \times 365 \times TR \times 1000)}{(InhF\_adj \times EF\_r \times SFi)}$$

Tap Water

$$\frac{(AT \times 365 \times TR \times 1000)}{(IFW\_adj \times EF\_r \times SFo)+\left(\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times InhF\_adj \times EF\_r \times SFi\right)}$$

Four age adjusted factors were calculated for carcinogenic exposure calculations. The formula for each factor is shown below.

Ingestion Factor for Soil

$$\left(\frac{IRS\_c \times ED\_c}{BW\_c}\right)+\left(\frac{IRS\_a \times ED\_adol}{BW\_adol}\right)+\left(\frac{IRS\_a \times ED\_a}{BW\_a}\right)$$

Skin Contact Factor for Soil

$$\left(\frac{SA\_c \times ED\_c}{BW\_c}\right)+\left(\frac{SA\_adol \times ED\_adol}{BW\_adol}\right)+\left(\frac{SA\_a \times ED\_a}{BW\_a}\right)$$

Inhalation Factor

$$\left(\frac{IRA\_c \times ED\_c}{BW\_c}\right) + \left(\frac{IRA\_a \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRA\_a \times ED\_a}{BW\_a}\right)$$

Ingestion Factor for Water

$$\left(\frac{IRW\_c < 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a, c > 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a, c > 3 \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRW\_a, c > 3 \times ED\_a}{BW\_a}\right)$$

Table 1 summarizes the exposure factors that were used to calculate the risk-based screening values.

Table 1. Exposure Factors

Parameter (units)	**Value**	**Abbreviation**
Target Cancer Risk	1 x 10^{-6}	TR
Target Hazard Quotient	1	THQ
Body weight, age 1-6 (kg)	15	BW_c
Body weight adolescent (kg)	43	BW_adol
Body weight, adult (kg)	70	BW_a
Surface area , child (cm^2/day)	2800	SA_c
Surface area , adolescent (cm^2/day)	7500	SA_adol
Surface area , adult resident (cm^2/day)	5700	SA_a
Surface area , adult industrial (cm^2/day)	3300	SA_i
Adherence factor (mg/cm^2)	1	AF
Dermal absorption in soil (volatiles)	0.25	ABS_vol
Dermal absorption in soil (semivolatiles)	0.1	ABS_semi
Dermal absorption in soil (metals)	0.05	ABS_met
Averaging time (years)	70	AT
Inhalation rate (m^3/d)	20	IRA_a
	20	IRA_c
Drinking water ingestion (L/d)	2	IRW_a, c>3
	1	IRW_c<3
	1	IRW_o
Volatilization factor - soil (m^3/kg)	Chemical specific	VF_S
Particulate emission factor (m^3/kg)	9.3E+08	PEF_r
	6.2E+08	PEF_o
Soil ingestion - adolescent & adult resident (mg/d)	100	IRS_a
Soil ingestion - age 1-6 (mg/d)	200	IRS_c
Soil ingestion – commercial/industrial (mg/d)	50	IRS_o
Exposure frequency (d/yr)	350	EF_r
Commercial/Industrial Exposure Frequency (d/yr)	250	EF_o
Exposure duration, age 1-6 (yr)	6	ED_c
Exposure duration, age 7-18 (yr)	12	ED_adol
Exposure duration, adult (yr)	12	ED_a
Commercial/Industrial Exposure Duration (yr)	25	ED_o
Total residential duration (yr)	30	ED_total
Age-adjusted factors (for carcinogens only)		
Ingestion factor for soils ([mg*yr]/[kg*d])	125.050	IFS_adj
Skin contact factor for soils ([cm^2*yr]/[kg*d])	4190.166	SFS_adj
Inhalation factor ([m^3*yr]/[kg-d])	17.010	InhF_adj
Ingestion factor for water ([L*yr]/[kg-d])	1.501	IFW_adj

The formulae for calculating the volatilization factor (VF), particulate emission factor (PEF), and soil screening levels (SSL) are contained in the Soil Screening Guidance: Users Guide (U.S. EPA, 1996c) and are listed below. The assumptions for those calculations are listed in the Soil Screening Guidance: Users Guide. The only factors in this document that were different were the dispersion factor (Q/C) values for residential (64.177) and commercial/industrial (43.07). The Kentucky-specific values for Q/C were estimated based on the 90% Lower Confidence Level of the mean dispersion factor of Climatic Zone VII of Table 3 of the SSL Technical Background Document (U.S. EPA, 1996b). Volatilization Factors are used in the soil exposure scenario to estimate partitioning between soil and vapor in the exposure zone, and the particulate emission factor represents the concentration of respirable particulates in air. The chemical specific values of D_i in the VF calculation were obtained from the U.S. EPA Region 9 Preliminary Remediation Goals Table dated November 1, 2000. Region 9 used several sources: Superfund Exposure Assessment Manual (U.S. EPA, 1988), Subsurface Contamination Reference Guide (U.S. EPA, 1990c), Fate and Exposure Data (Howard, 1991), and the Superfund Chemical Data Matrix (U.S. EPA 1994). Some chemicals required the use of a surrogate for physicochemical data based on chemical structure and characteristics.

The Soil Screening Level uses modeling to estimate soil concentrations that are protective of human health exposure to groundwater with a Dilution and Attenuation Factor of 1. The endpoint that was chosen for the SSL was the MCL from U.S. EPA (2001b) or the risk-based tap water concentration as calculated in the table if an MCL was not available.

Volatilization Factor

$$VF(m^3/kg) = \frac{Q/C \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4}(m^2/cm^2)}{2 \times \rho_b \times D_A}$$

where

$$D_A = \frac{\left(\theta_a^{10/3} \times D_i \times H' + \theta_w^{10/3} \times D_w\right)/n^2}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

and:

Q/C = *64.177 (residential)*
43.07 (commercial/industrial)
T = *9.5E+8 seconds*
ρ_b = *1.5 g/cm3*
θ_a = *0.28* L_{air}/L_{soil}
D_i = *chemical-specific*
H' = *H x 41*
H = *Henry's Law Constant (chemical-specific)*
θ_w = *0.15* L_{water}/L_{soil}
D_w = *chemical-specific*
n = *0.43* L_{pore}/L_{soil}
K_d = *chemical-specific*

Particulate Emission Factor

$$PEF(m^3/kg) = Q/C \times \frac{3600s/h}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

where:

Q/C = *64.177 (residential)*
43.07 (commercial/industrial)
V = *0.5 (unitless)*
U_m = *4.69 m/s*
U_t = *11.32 m/s*
$F(x)$ = *0.194 (unitless)*

Soil Screening Level

$$SSL(mg/kg) = C_w\left[K_d + \frac{\theta_w + \theta_a \times H'}{\rho_b}\right]$$

where the C_w is the MCL or risk-based tap water value in mg/L from the table.

and:

K_d = *chemical-specific*
θ_w = *0.3* L_{water}/L_{soil}
θ_a = *0.13* L_{air}/L_{soil}
H' = *H x 41*
H = *Henry's Law Constant (chemical-specific)*
ρb = *1.5 g/cm3*

Exceptions

There are a few exceptions to the standard procedures described in this document where modifications in the exposure assumptions or toxicity value were necessary to meet a certain class of chemicals.

Metals. Many of the metals only have oral toxicity values listed in IRIS or HEAST. In order to have complete information, it was necessary to extrapolate the oral toxicity values to inhalation exposures as well. The exposure routes were also modified based on the characteristics of metals. Soil exposure included ingestion, dermal exposure, and particulate inhalation. Exposure to tap water considered only ingestion. Elemental mercury, even though it is a metal, was assumed to be a volatile for exposure to soil and water. These conditions fit typical exposure conditions for tap water. If a site has potential exposure to mists containing metals in water, then exposure via inhalation should be considered in a site-specific tap water screening value calculated for the site using the formulae contained in this document.

Gases. Some of the constituents on the table are considered to be gases or vapors at standard temperature. In consideration of their physical state, both soil and water exposure consider only inhalation since their residence time in soil would not be expected to be long for ingestion or dermal exposure.

Extrapolation. Some chemicals had only oral or inhalation toxicity values listed on the Region IX PRGs Table. In those cases, extrapolation was necessary. Literature reviews were done to verify the potential for effects in other media of exposure.

Lead. U.S. EPA has implemented use of the IEUBK Model to estimate environmental levels that will result in a target blood lead level. KYDEP performed a review of lead issues (KYDEP, 1996) and determined that the most appropriate metric for lead risk assessment was the RfD_o and RfD_i derived based on the LOAEL in laboratory rats. For further discussion of lead see the Lead Issues document (KYDEP, 1996). KYDEP also has an action level of 50 ppm in residential or unrestricted use in soil, 400 ppm in commercial or industrial soils, and a tap water action level of 0.015 mg/L that are listed on the table. The soil value of 50 mg/kg was originally developed in the UST program.

MTBE. Methyl t-Butyl Ether had an oral RfD issued by NCEA, which was withdrawn. The RfD was retained and listed as withdrawn on the table. U.S. EPA has a Drinking Water Advisory: Consumer Acceptability Advisory level in water of 20 µg/L to 40 µg/L based on odor and taste, respectively. This is below the carcinogenic and noncarcinogenic risk-based numbers.

PCBs. PCBs also received special consideration. KYDEP has used the high risk value of 2.0 $(mg/kg\text{-}day)^{-1}$ based on the observation that as a mixture of PCBs weathers, the lower chlorinated biphenyls are more likely to degrade, leaving the higher chlorinated biphenyls in a higher proportion. Since the higher chlorinated biphenyl mixture (Arochlor 1260) exhibit more toxicity, the high-risk value was used for the screening values. For noncarcinogenic effects, the table has two mixtures listed. Arochlor 1254 is applied by KYDEP for the higher chlorinated mixtures (Arochlor 1260, 1254, and 1248) and the Arochlor 1016 value is applied to mixtures that are less chlorinated (1242, 1016).

How To Use the Table

When evaluating an area using the screening values, it is useful to develop a Conceptual Site Model to verify that it fits into the assumptions that were used to derive the screening values. The first step is to identify the areas of potential contamination and analyze grab samples for a broad range of potential contaminants (typically the HSL, TAL/TCL, etc.) in several samples to refine analytical parameters. The contaminants of potential concern are then identified. The potential ecological and human health receptors should be determined and also the potential pathways of exposure.

The screening values table is organized with the toxicity values in the left-hand columns, each one followed by the source of the RfD or Slope Factor. The VOC Column identifies (with "1" being volatile) which compounds use a volatilization factor in the soil exposure. The soil dermal absorption value is shown for each compound, and the Chemical Abstract Service (CAS) registry number and contaminant name are shown. The next four columns represent the risk-based concentration associated with each of the contaminants for soil, air, and water.

The Soil Screening Levels are determined for most volatiles and the compounds listed in the Soil Screening Guidance (U.S. EPA, 1996c). The Dilution and Attenuation Factor (DAF) of 1 is applicable for a screening value where there is the potential for shallow aquifers, karst terranes (a major factor in Kentucky), and areas of significant permeability. It is possible to develop Soil Screening Values for a higher DAF if site-specific information indicates that the depth to groundwater, soil type, and geological formations support that there is significant dilution between the contaminated zone and the groundwater. 401 KAR 100:100 Section 5(5) establishes procedures to modify the SSL based on site-specific conditions.

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Appendix D

Ecological Screening Values

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Appendix E

Radionuclide Screening Values

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Appendix F

Checklist for Ecological Assessment/Sampling

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Checklist for Ecological Assessment/Sampling

I. SITE DESCRIPTION

1. Site Name: ____

   Location: ____

   ____

   County: ______________ City: ______________ State: __________

2. Latitude: ____________________ Longitude: ____________________

3. What is the approximate area of the site? ______________________________

4. Please attach to the checklist USGS topographic map(s) of the site, if available.

5. Are aerial or other site photographs available? ☐ yes ☐ no If yes, please attach any available photo(s).

6. What type of facility is located at the site?

   ☐ Chemical ☐ Manufacturing ☐ Mixing ☐ Waste disposal

   ☐ Other (specify) ____

7. What are the suspected contaminants of concern at the site? If known, what are the maximum concentration levels?

8. Do any potentially sensitive environmental areas exist adjacent to or in proximity to the site, e.g., Federal and State parks, National and State monuments, wetlands, lakes, streams? *Remember, flood plains and wetlands are not always obvious; do not answer "no" without confirming information.*

9. Please provide the source(s) of information used to identify these sensitive areas, and indicate their general location on the site map.

10.

The land use on the site is:	The area surrounding the site is:
	____________________ mile radius
_____% Urban	_____% Urban
_____% Rural	_____% Rural
_____% Residential	_____% Residential
_____% Industrial (☐ light ☐ heavy)	_____% Industrial (☐ light ☐ heavy)
_____% Agricultural	_____% Agricultural
(*Crops*:_______________________)	(*Crops*:_______________________)
_____% Recreational	_____% Recreational
(Describe; note if it is a park, etc.)	*(Describe; note if it is a park, etc.)*
______________________________	______________________________
______________________________	______________________________
_____% Undisturbed	_____% Undisturbed
_____% Other	_____% Other

11. If known, what is the approximate depth to the water table? ________________________________

12. Is the direction of surface runoff apparent from site observations? ☐ yes ☐ no If yes, to which of the following does the surface runoff discharge? Indicate all that apply.

☐ Surface water ☐ Groundwater ☐ Sewer ☐ Collection impoundment

13. Is there a navigable waterbody or tributary to a navigable waterbody? ☐ yes ☐ no

14. Is there a waterbody anywhere on or in the vicinity of the site?

☐ yes (approx. distance____________________) ☐ no

15. Is there evidence of flooding? ☐ yes ☐ no *Wetlands and flood plains are not always obvious; do not answer "no" without confirming information.*

16. Are any threatened and/or endangered species (plant or animal) known to inhabit the area of the site?

☐ yes ☐ no

17. Are there any wooded areas at the site? ☐ yes ☐ no.

18. What percentage or area of the site is wooded? (_____% _____ acres). Indicate the wooded area on the site map which is attached to a copy of this checklist.

19. Is shrub/scrub vegetation present at the site? ~ yes ~ no.

20. What percentage of the site is covered by scrub/shrub vegetation? (_____% _____ acres). Indicate the areas of shrub/scrub on the site map.

21. Are there open (bare, barren) field areas present at the site? ~ yes ~ no

22. What percentage of the site is open field? (_____% _____ acres). Indicate the open fields on the site map.

23. Based on observations and/or available information, are designated or known wetlands definitely present at the site? ~ yes ~ no

24. Please note the sources of observations and information used (e.g., USGS Topographic Maps, National Wetland Inventory, Federal or State Agency, etc.) to make this determination.

25. CONTINUE WITH ECOLOGICAL RISK ASSESSMENT. **YES_____** **NO_____**

Record weather conditions at the time this checklist was prepared:

DATE: ______________________

______________Temperature (EC/EF) ______________Normal daily high temperature

______________Wind (direction/speed) ______________Precipitation (rain, snow)

______________Cloud cover

Completed by ____ Affiliation ___________________

Additional Preparers ____

Site Manager____

Date ___

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Appendix G

Development of Generic Background Concentrations for Kentucky Soils

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Development of Generic Background Concentrations for Kentucky Soils

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.

b) Ambient background means the concentrations of naturally-occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to activities on the property.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide a party or VERP applicant an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.

To address this issue, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or citywide activity. Therefore, these samples represent “ambient,” as opposed to “natural,” background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60th Percentile, and 95th percentile were calculated. The 95% UCL is the value that represents that the mean of the data set falls below that value with 95% confidence. The 60th and 95th percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as "non-detected" were retained in the database at ½ the reporting limit (USEPA, 1998).

2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb's test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb's test formula is as follows:

$$Z = \frac{\left| \text{population mean} - \text{value of individual sample} \right|}{\text{standard deviation}}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table G-1. Parametric methods were used to allow for comparisons between NREPC background values and other published values.

   a. Standard deviation was calculated by the "nonbiased" method employing the formula:

$$S.D. = \sqrt{\frac{\sum \left(X_i - \overline{X} \right)^2}{n-1}}$$

   b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor's test for normality. Since the data sets are not normally or log normally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60th percentile and 95th percentile) were calculated by nonparametric methods and are listed in Table G-2.

5. The 95% upper confidence limit of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.

6. The 60th percentile value is used as the midpoint for each constituent. It was calculated as follows:
    a. The constituent values were ranked in increasing order of magnitude.
    b. The quantity 60(n)/100 was used to identify the measurement with the resulting rank.

7. The 95th percentile value is used as the upper bound value for each constituent and was calculated as follows:
    a. The constituent values were ranked in increasing order of magnitude.
    b. The quantity 95(n)/100 was used to identify the measurement with the resulting rank.

The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as ½ the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that the recorded values skew thallium concentrations upward, only the 95th percentile of the total data is cited in table G-2.

Comparison to Background

- The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents. At least ½ of the data points should be less than the midpoint (60th percentile), and no data point above the upper bound value (95th percentile). The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table G-2, or to site-specific background samples.

Horizontal and Vertical Extent

401 KAR 100:100 Section 5(4) states that during site characterization, a minimum of two additional sampling locations is required for each sampling point at the edge of an area of concern that exceeds the method detection limit or ambient background and shall be located at a

minimum distance of ten (10) feet from the previous sampling point that had a confirmed exceedance of method detection limits, or ambient background. The following criteria may be used to determine if the sampling point exceeds generic or site-specific ambient background.

- If the value for the individual sample is less than the 95% UCL of the arithmetic mean of background, then no additional samples are required.
- If the sampling point is greater than the 95th percentile of background, then a minimum of two additional sampling points are required.
- If the sampling point is between the 95% UCL of background and the 95th percentile of background, then the complete dataset needs to be evaluated to determine if two additional sampling locations are required. If at least half of all data points at the edge of the AOC are at or below the 95% UCL of background and the remaining data points are between the 95% UCL of background and the 95th percentile of background, then no additional samples are required. If this criteria is not met, then two additional sampling points are required.

The cabinet may require additional sample locations if the data indicate that the extent of contamination has not been determined.

Literature Cited

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

United States Environmental Protection Agency (USEPA), 1998. Statistical Tests for Background Comparison at Hazardous Waste Sites. Supplemental Guidance to RAGS: Region 4 Bulletins – Addition #1. Interim Draft. USEPA Region 4, Waste Management Division. Atlanta, Georgia. November, 1998.

Table G-1. Summary Statistics for Ambient Inorganic Chemicals

Element	**Number of Samples**	**Range (mg/kg)**	**Mean (mg/kg)**	**Standard Deviation (mg/kg)**
Aluminum	679	1290 - 38,100	10969	5462.9
Arsenic	539	0.059 - 55.5	8.9	7
Barium	756	6.14 – 1160	111.3	92.4
Beryllium	696	0.061 - 3.57	0.8	0.5
Cadmium	701	0.004 - 9.46	0.68	1.4
Chromium	771	2.83 - 168	20.5	13.9
Cobalt	649	0.29 - 67.6	11.9	8.1
Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Manganese	685	8.43 - 5100	1017	854.9
Mercury	459	0.007 - 0.721	0.06	0.1
Nickel	716	0.39 - 83.7	20.9	13.1
Selenium	714	0.001 - 3.93	0.94	0.7
Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table G-2. Generic Statewide Ambient Background for Kentucky

Element	**Mean (mg/kg)**	**95% UCL of Mean (mg/kg)**	**60th Percentile (mg/kg)**	**95th Percentile (mg/kg)**
Aluminum	10969	11314	10800	21000
Arsenic	8.9	9.4	8.3	21.2
Barium	111.3	116.9	100	241
Beryllium	0.8	0.83	0.75	1.8
Cadmium	0.68	0.78	0.27	3.9
Chromium	20.5	21.3	19.3	40
Cobalt	11.9	12.4	13.1	25.1
Copper	18.9	21.3	13.8	41.7
Iron	22456	23284	22000	47600
Lead	30	33	20.9	84.6
Manganese	1017	1071	948	2620
Mercury	0.06	0.07	0.059	0.14
Nickel	20.9	21.7	20.2	46.8
Selenium	0.94	0.99	1.38	2.1
Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115

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Kentucky Guidance for Ambient Background Assessment

January 8, 2004

Natural Resources and
Environmental Protection Cabinet

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Introduction

This guidance document is intended to assist in comparing site data and background data for sites undergoing environmental assessment. These procedures provide a simplified statistical procedure for determining if the site data is part of the background population. It also provides generic statewide background values for inorganic chemicals that may be used in lieu of collecting site-specific background samples. The statistical procedures may be used for site-specific data or the generic statewide values in Tables 1 and 2. This guidance does not preclude other appropriate statistical comparisons from being made, but rather a simplified screening method that does not require a deep knowledge of statistics. If the site data set fails the statistical procedures in this guidance, it may be appropriate to perform a more complete statistical comparison.

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.

b) Ambient background means the concentrations of naturally occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to an identifiable release.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.

Methodology

To provide an alternative to site-specific background sampling, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or urban activity. Therefore, these samples represent "ambient," as opposed to "natural," background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60th percentile, and 95th percentile were calculated. The 95% UCL is the value below which the true mean of the data set falls, with 95% confidence. The 60th and 95th percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as "non-detected" were retained in the database at half the reporting limit (USEPA, 1998).

2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb's test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb's test formula is as follows:

$$Z = \frac{|\mathit{population\ mean} - \mathit{value\ of\ individual\ sample}|}{\mathit{standard\ deviation}}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table 1. Parametric methods were used to allow for comparisons between these generic ambient background values and the results of other published studies of background.

a. Standard deviation was calculated by the “nonbiased” method employing the formula:

$$S.D. = \sqrt{\frac{\sum \left(X_i - \overline{X} \right)^2}{n-1}}$$

b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor’s test for normality. Since the data sets are not normally or lognormally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60th percentile and 95th percentile) were calculated by nonparametric methods and are listed in Table 2.

5. The 95% UCL of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.

6. The 60th percentile value is used as the midpoint for each constituent. It was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 60(n)/100 was used to identify the measurement with the resulting rank.

7. The 95th percentile value is used as the upper bound value for each constituent and was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 95(n)/100 was used to identify the measurement with the resulting rank.

The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as ½ the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that the recorded values skew thallium concentrations upward, only the 95th percentile of the total data is cited in Table 2.

Procedure for Comparison to Background

The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table 2, or to site-specific background samples. The following three criteria may be used to demonstrate that the site data is background:

1. The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents.
2. At least half of the data points should be less than the 60th percentile.
3. No data points should be above the upper bound value (95th percentile).

These procedures provide a tool for comparing site data with either generic statewide or site-specific background using the statistical characteristics of the two populations. Other statistical comparisons may be used, if appropriate.

Determining Site-specific Background

Site-specific ambient background levels may be determined at the site. The site-specific ambient background data set shall consist of an appropriate number of samples for the statistical method employed. The number of samples necessary to characterize site-specific background will vary based on the variability of the data. Twenty data points may be used as a minimum number of samples per horizon (surface and subsurface) as a default number, unless other statistical methods can be used to develop a different number. A site-specific determination of the number of required samples may be calculated based on the statistical characteristics of the background population.

Upgradient groundwater samples are to be obtained from the same hydrogeological unit as the groundwater contamination at the site. The background monitoring wells shall be located hydrogeologically upgradient from the release(s) of concern, unless it can be demonstrated to the cabinet that the upgradient location is undefinable or infeasible.

Background soil samples should be collected from native soil in areas of similar soil type as found at the site. Background concentrations should be determined separately for surface and subsurface areas that are consistent with the on-site investigation.

The following areas are inappropriate to sample when determining soil background unless otherwise necessary to reach a corrective action decision or identify potential sources of contamination:

1. Fill areas;
2. Areas in which management, treatment, handling, storage or disposal activities of any of the following are known or suspected to have occurred: hazardous substances or petroleum, solid or hazardous wastes, or waste waters;
3. Areas within three feet of a roadway;
4. Parking lots and areas surrounding parking lots or other paved areas;
5. Railroad tracks or railway areas or other areas affected by their runoff;
6. Areas of concentrated air pollutant depositions or areas affected by their runoff;
7. Storm drains or ditches presently or historically receiving industrial or urban runoff; or
8. Areas within three feet of any current structure, or the former location of any structure, which is likely to have been painted with lead-based paint.

Literature Cited

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

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Cadmium	701	0.004 - 9.46	0.68	1.4
Chromium	771	2.83 - 168	20.5	13.9
Cobalt	649	0.29 - 67.6	11.9	8.1
Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Manganese	685	8.43 - 5100	1017	854.9
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Nickel	716	0.39 - 83.7	20.9	13.1
Selenium	714	0.001 - 3.93	0.94	0.7
Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table 2. Generic Statewide Ambient Background for Kentucky

Element	**Mean (mg/kg)**	**95% UCL of Mean (mg/kg)**	**60th Percentile (mg/kg)**	**95th Percentile (mg/kg)**
Aluminum	10969	11314	10800	21000
Arsenic	8.9	9.4	8.3	21.2
Barium	111.3	116.9	100	241
Beryllium	0.8	0.83	0.75	1.8
Cadmium	0.68	0.78	0.27	3.9
Chromium	20.5	21.3	19.3	40
Cobalt	11.9	12.4	13.1	25.1
Copper	18.9	21.3	13.8	41.7
Iron	22456	23284	22000	47600
Lead	30	33	20.9	84.6
Manganese	1017	1071	948	2620
Mercury	0.06	0.07	0.059	0.14
Nickel	20.9	21.7	20.2	46.8
Selenium	0.94	0.99	1.38	2.1
Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115

Kentucky Guidance for Groundwater Assessment Screening

January 15, 2004

Environmental and
Public Protection Cabinet

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Introduction

This document provides guidance for evaluating contaminated sites to determine whether superficial and shallow contamination in soils indicates an existing or potential groundwater contamination problem, and whether a direct assessment of groundwater conditions is necessary. This method is intended to provide the party or applicant a cost-effective approach using soils data collected as part of the site characterization for determining the need to assess groundwater quality.

Methodology

An assessment of the effect of a release of a hazardous substance or petroleum on groundwater quality may not be necessary at all sites. This process is intended for sites that lack adequate groundwater monitoring data and where the party or applicant anticipates to leave in place contaminants of concern (COCs).

This approach to evaluating impacts and potential impacts of a release on groundwater is based on the attenuation of contaminants moving through the soil profile by means of biodegradation, hydrolysis, volatilization, adsorption, and dilution. Contaminants may not attenuate similarly in all situations, and therefore conservative Dilution Attenuation Factor (DAF) values are applied. However, conditions at some sites may result in contaminant migration through the soil profile in a manner that bypasses physical, chemical, and biological processes in the soils. Caution should be applied to use of this methodology at sites where normal physical, chemical, and biological processes in the soils are bypassed, including sites underlain by soils with large, interconnected pores (macropores) that provide for the rapid transport of water and contaminants through the soil profile, sites underlain by well-developed karst terrane, sites underlain by highly fractured media, or where contamination extends to the soil-bedrock interface. These types of sites may not provide for the soil processes assumed to be in effect in this method. In addition, this process is primarily intended for COCs that are relatively insoluble and are expected, under normal conditions, to remain in the soil profile and not to migrate to groundwater. Therefore, caution should be used in applying this methodology at sites where soluble or mobile COCs such as volatile organic compounds, nitrates, or dense non-aqueous phase liquids (DNAPL) are present; the presence of such COCs in the soils may indicate that a groundwater assessment may be necessary. The cabinet reserves the authority to require a direct assessment of groundwater at sites where it deems such investigation is prudent to understanding the extent of contamination and the risks associated with the release.

To determine whether a direct assessment of groundwater conditions is necessary, analytical data from the soil profile may be evaluated by the methods outlined in this document in combination with an evaluation of other soil conditions, and the geology and hydrology of the site. These data can be used to determine whether groundwater was likely to have been impacted, and whether these soils will serve as a future source of groundwater contamination.

In order to use this method, the horizontal and vertical extent of soil contamination must be known. An adequate number of soil borings with multiple, discreet sampling intervals of sufficient length and spacing to characterize vertical distribution of contamination are also necessary.

If it can be demonstrated using one of the following options that a release has not had and will not have an adverse effect on groundwater quality, a direct assessment of groundwater impacts may not be necessary.

1. An assessment of groundwater for a release may not be necessary if the applicable Soil Screening Levels, or SSL (DAF 1), in the U.S. EPA Region 9 Preliminary Remediation Goals (October 1, 2002) are not exceeded in the bottom two (2) sampling intervals of each soil boring.

2. Rather than using the default SSLs (DAF 1), a modified SSL may be used. This modified SSL takes into account the surface area of the site, the vertical separation between the contamination in the soil profile and groundwater, and the underlying bedrock conditions. The appropriate modified SSL is equivalent to the SSL (DAF 1) referenced in the U.S. EPA Region 9 Preliminary Remediation Goals, (October 1, 2002) multiplied by the applicable value in Table 1, below. An assessment of groundwater for a release may not be necessary if the applicable modified SSLs are not exceeded in samples from the bottom two (2) sampling intervals.

Table 1.

Vertical Separation Between Contamination in the Soil Profile and the Zone of Saturation	**Surface Area of Site and other considerations**		
	< 0.5 acres	**0.5-10 acres**	**> 10 acres, or site underlain by karst or highly fractured media**
0-5 ft	1	1	1
5-10 ft	5	2.5	1
10-15 ft	10	5	1
15-20 ft	15	7.5	2.5
Greater than 20 ft	20	10	5

3. A site-specific SSL may be developed and applied based on site-specific conditions, including soil types, characteristics of COCs, total organic carbon in the soil, soil porosity, infiltration rate, and the vertical separation between the contamination in the soil profile and groundwater. If the analytical results in the bottom two (2) sampling intervals do not exceed the site-specific SSLs, a groundwater assessment may not be necessary for that site.

4. A fate and transport evaluation may be developed to demonstrate that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary. If a fate and transport evaluation adequately demonstrates that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary, a groundwater assessment may not be necessary. However, a direct groundwater assessment will be required to make such a determination in most situations.

5. An analysis of the results of current and historical groundwater monitoring may be used to determine whether groundwater has been adequately characterized. Such an analysis shall contain sufficient information to determine whether groundwater has been affected by any releases at the site. The report of this analysis shall include:

a. The location of monitoring wells relative to the location of the soil contamination at the site, and to groundwater flow direction at the property;

b. Monitoring well construction details, including diameter of the annulus, diameter of the well casing, the depth and length of the screened interval, construction of the sand pack, and the type and manner of sealing materials used;

c. The proximity of wells to one another and to the property boundary; and

d. The results of all groundwater analyses conducted to date on samples collected at the property, including sample dates, the parameters analyzed, and the methods of collection and analysis.

A groundwater assessment is necessary and prudent in some circumstances. Any direct evidence of groundwater contamination, including seeps, contaminated wells and springs, or other similar information is compelling evidence to conduct a thorough groundwater investigation. The cabinet may direct a person or applicant to conduct a groundwater assessment in regards to a known or suspected release, regardless of the results of the methods employed above.

References

1. U.S. EPA 1996. Soils Screening Guidance: Technical Background Document, May 1996. United States Environmental Protection Agency 9355.-17a, EPA/540/R-95/128, PB96-963502.

2. U.S. EPA 2002. Region 9 Preliminary Remediation Goals and the Region 9 PRGs Table User's Guide/Technical Background Document (October 1, 2002).

Trichloroethylene Environmental Levels of Concern

Kentucky Department for Environmental Protection
Division of Environmental Services
Risk Assessment Branch
Jeri W. Higginbotham, Ph.D.

April 21, 2004

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Kentucky Risk Based Screening Values for Trichloroethylene

Based on a Slope Factor of 3.22E-01 per mg/kg-d

Ambient Air – 0.013 ug/m^3

Tap Water – 0.046 ug/l

Residential Soil – 0.031 mg/kg

Industrial Soil – 0.077 mg/kg

Rural Residential Soil – 0.027 mg/kg

Recreational Soil – 0.5 mg/kg

Farmer Exposure Soil – 0.089 mg/kg

Outdoor Worker Soil – 0.1 mg/kg

Short-Term Outdoor Worker Soil – 2.5 mg/kg

Ambient Air (Child age 1 to 18) – 0.00084 ug/m^3

Tap Water (Child age 1 to 18) – 0.0018 ug/l

Trichloroethylene (TCE) is a colorless liquid with a somewhat sweet odor (ATSDR 1997a) similar to that of chloroform (Plunkett 1987). Synonyms are 1,1,2-trichloroethylene, trichloroethene, acetylene trichloride, and ethylene trichloride (Proctor, Hughes, and Fischman 1989). Registered trade names include Algylen, Blacosolv, Dow-Tri, Perma-A-Chlor, Trilene, and Vestrol (ATSDR 1997a). It has been produced commercially since the 1920's (IARC 1997) and is commonly used as a cleaning and degreasing agent in the manufacture of furniture and fixtures, fabricated metal products, electric and electronic equipment, transport equipment, and, to a lesser extent, textiles, paper, and glass (HSDB 2004). It is an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers (ATSDR 2003). Between the 1930's and 1950's, it was used in the dry cleaning industry (IARC 1997). In 1977, the United States Food and Drug Administration (FDA) banned the use of TCE as a grain fumigant, disinfectant, anesthetic, and as an extraction solvent to extract caffeine from coffee, oleoresins from spices, and oil from palm, coconut, and soybean seed (ATSDR 1997a).

Due to its long history of use, TCE is a widespread environmental contaminant. Between 1988 and 2001, total on-site and off-site releases of TCE in the United States decreased from 57,445,582 pounds to 8,484,115 pounds (Table 1). In every year, at least 97% was in the form of air emissions (TRI 2003) but there were also releases to land, surface water discharge, and underground injection. It has been found at 861 Superfund National Priorities List (NPL) sites (ATSDR 1997a). And not surprisingly, by leaching through soil, the rate of which is dependent on organic matter and soil moisture content, it has contaminated underground water sources (ATSDR 1997a).

Table 1. Releases of trichloroethylene by year from 1988 to 2001 in the United States. All values are reported in pounds. Data from TRI, 2003.

total air emissions	surface water discharge	under-ground injection	releases to land	total on-site releases	total off-site releases	total on- and off-site releases	year	air/total
8,249,587	406	98,220	12,609	8,360,822	123,296	8,484,118	2001	0.972356
9,759,536	593	47,877	9,713	9,817,719	159,396	9,977,115	2000	0.978192
10,605,822	1,034	0	148,867	10,755,723	168,374	10,924,097	1999	0.970865
13,265,539	882	593	800	13,267,814	126,053	13,393,867	1998	0.990419
18,224,059	568	986	3,975	18,229,588	182,423	18,412,011	1997	0.989792
21,886,451	541	1,291	9,740	21,898,023	89,527	21,987,550	1996	0.995402
26,282,939	1,477	550	3,577	26,288,543	74,145	26,362,688	1995	0.996975
30,948,761	1,671	288	4,070	30,954,790	96,312	31,051,102	1994	0.996704
31,007,030	5,220	460	8,212	31,020,922	233,561	31,254,483	1993	0.992083
30,838,983	8,606	466	20,726	30,868,781	248,714	31,117,495	1992	0.99105
36,356,277	12,784	800	62,991	36,432,852	115,973	36,548,825	1991	0.994732
40,028,932	14,285	805	12,554	40,056,576	753,864	40,810,440	1990	0.98085
49,798,528	15,849	390	8,686	49,823,453	1,250,933	51,074,386	1989	0.97502
55,943,736	13,801	390	21,186	55,979,113	1,466,469	57,445,582	1988	0.973856

TCE is degraded most rapidly in the air and least rapidly in groundwater. Degradation products depend on the medium and have adverse health effects of their own. In air, TCE persists for 11 to 14 days before decomposing to hydrochloric acid, dichloroacetyl chloride, phosgene, and carbon monoxide (Cal/EPA 1999). It rapidly evaporates from surface water but may persist in groundwater and soil for prolonged periods (ATSDR 2003). There is some evidence for microbiological degradation to cis and trans 1,2-dichloroethylene in soil and groundwater. In one study, a half-life of 1.0 to 1.5 years in groundwater was calculated (Cal/EPA 1999). Other studies have calculated half-lives in groundwater of 10.7 months and 4.5 years (Howard 1991). Rate of degradation depends on the presence of organisms capable of degrading the chemical, the availability of other metabolic requirements, and the amount of chemical present. In the absence of appropriate microflora or appropriate microfloral habitat, TCE may persist for centuries as a dense nonaqueous phase liquid (DNAPL) in subsurface pools and lenses. With a solubility of 1.1 grams per liter (Verschueren 1983), DNAPL TCE slowly dissolves into groundwater over prolonged periods, creating contaminant plumes (Newell and Ross 1992).

In mammals, the liver is the primary site of TCE metabolism with trichloroacetic acid (TCA) being the major end product. Other metabolic products are trichloroethanol, trichloroethanol-glucuronide, dichloroacetic acid, and dichlorovinyl cysteine. In addition to the liver, TCE metabolism occurs in the lungs and kidneys (EPA 2001). Blood and urine tests can detect TCE and many of its metabolic products for up to a week after exposure (ATSDR 2003).

Exposure to TCE has been linked to adverse health effects including liver and neurological dysfunction (ATSDR 1997a) and, accordingly, occupational and drinking water standards have been set. Based on adverse central nervous system effects, the Occupational Safety and Health Administration has established a time-weighted average permissible exposure limit (TWA PEL) of 50 ppm and a short term exposure limit (STEL) of 200 ppm (NIOSH 2001). The maximum contaminant level (MCL) for trichloroethylene in drinking water is 0.005 mg/L and the maximum contaminant level goal (MCLG) is zero. The basis for the MCL and MCLG was its potential to cause liver damage and certain cancers from a lifetime exposure above 0.005 mg/L (EPA 2002a).

However, carcinogenicity data for TCE was withdrawn from the United States Environmental Protection Agency (EPA) Integrated Risk Information System in 1989. The most recent EPA document concerning TCE is a preliminary draft entitled, "Trichloroethylene Health Risk Assessment: Synthesis and Characterization," from the National Center for Environmental Assessment (EPA 2001). It draws on 16 state-of-the-science papers published as a supplemental issue of Environmental Health Perspectives (volume 108, supplement 2, May 2000) as well as many other papers and was reviewed by a panel of the EPA Science Advisory Board's Environmental Health Committee (EPA 2002b).

In this draft, EPA concludes that TCE is "highly likely to produce cancer in humans" and can be classified as a "probable human carcinogen" (group B1). The International Agency for Research on Cancer (IARC), also, classifies TCE as "probably carcinogenic to humans" (Group 2A). Their evaluation was based on limited evidence in humans and sufficient evidence in experimental animals for the carcinogenicity of trichloroethylene (IARC 1997).

Many epidemiological studies are reported for the effects of TCE, but their quality and informational content vary considerably. One of the less informative studies concerned a cohort of workers at one manufacturing plant in Roscoe, Illinois (Shindell et al. 1985). As compared to the entire U.S. population, fewer individuals than expected died, and this was true for every cause of death (cardiovascular, respiratory cancer, nonrespiratory cancer, stroke, trauma, and other). Statistically significant deficits were in overall mortality, nonrespiratory cancer, and trauma. That there were deficits for every cause of death suggests that other parameters besides TCE exposure were varying between the cohort and the comparison group (healthy worker effect). The authors end by postulating the presence of "some other factor contributing to the favorable experience." Furthermore, cancers were only categorized as respiratory or nonrespiratory and exposure data were not provided. This study is simply not informative and provides no evidence for TCE health effects of any kind. Wartenberg (2000) placed it in his Tier II group of cohort studies, Tier I being composed of the most informative studies. The Science Advisory Board review panel endorsed

Wartenberg's classification system and went on to recommend that EPA weight the Tier I studies more strongly than other studies (EPA 2002b).

Of the four epidemiological studies discussed by EPA (2001), three were Tier I cohort studies and one was community based (Wartenberg 2000). A New Jersey study tracked individuals in a 75-town area affected by drinking water contamination (Cohn et al. 1994). Occupational exposure of Finnish workers to three halogenated hydrocarbons, tetrachloroethylene (PCE), 1,1,1-trichloroethane, and TCE was reported by Anttila et al. (1995). Blair et al. (1998) followed a cohort of workers who were employed at Hill Air Force Base for at least one year and who were exposed by vapour inhalation. A fourth and final study reported on the incidence of kidney cancer in German cardboard workers (EPA 2001).

In the New Jersey study, female residents had statistically significant excesses of leukemia and non-Hodgkin lymphoma where relative risks (RR), 95% confidence intervals (CI), and the number of cases (N) were RR=1.43, 95% CI=1.07-1.90, N=56 and RR=1.36, 95% CI-1.08-1.70, N=87 respectively (Cohn et al. 1994). Epidemiological studies often report data as relative risk where the probability of disease in the study group is divided by the probability of disease in the control group. A RR value above 1.0 indicates an excess of disease in the study group while a RR value below 1.0 indicates a deficit of disease in the study group. If the confidence interval does not contain 1.0, then the relative risk is statistically significant at the stated level of confidence which is usually 95%.

Based on this study, a unit risk estimate and slope factor for non-Hodgkin lymphoma was calculated by EPA (2001) using the following rationale. A relative risk factor of 1.36 is interpreted as a 36% increased risk of getting this disease. (EPA actually rounded up the relative risk to 1.40.) By multiplying the background risk of getting non-Hodgkin lymphoma by 0.36 and dividing by the average concentration of TCE in those homes where the concentration exceeded the MCL of 5 ppb a unit risk estimate was calculated. The background risk was given as 6E-04 (prevalence of the disease in the United States), and the average concentration was 23.4 ug/L. The unit risk is 9.2E-06 per ug/L. The resulting slope factor based on a 70 kg adult drinking 2 L/d is 3.22E-01 per mg/kg-d average lifetime exposure to TCE for non-Hodgkin lymphoma. (EPA, using 1.4 as the relative risk and rounding up, listed 4.00E-01 per mg/kg-d in Table 4-9.) Dividing this slope factor into 10^{-6} yields a risk-specific dose of 3.1E-06 mg/kg-d. For a 70 kg individual, the maximum daily dose is 2.2E-04 mg/d (0.22 ppb) which is well below the routine detection limit of 1.0E-03 mg/l (1.0 ppb) in water (King County 2002).

One weakness of this study was that it was impossible to control for other impurities in the water, some of which might contribute to the risk of developing these two cancers. Though TCE was present in the greatest concentration, PCE was also a common contaminant. Both are thought to exert carcinogenic effects through common metabolites. To that end, it is estimated that only from 1-3% of the absorbed PCE is metabolized (ATSDR 1997b), whereas from 40-75% of the absorbed TCE is metabolized (ATSDR 1997a). Furthermore, very little research has been done to confirm or refute the hypothesis that combinations of compounds act in an additive or greater-than-additive (synergistic) manner. Certain combinations might act in a less-than-additive (antagonistic) manner. And there is one report indicating that PCE inhibits the metabolism of TCE in humans (ATSDR 2002). As for other contaminants, no association was detected between leukemia or non-Hodgkin lymphoma incidence and trihalomethanes, benzene, 1,1,1-trichloroethane, carbon tetrachloride, and trans-1,2-dichloroethylene. The apparent risk seems largely attributable to TCE.

A strength of the study was the socio-economic similarity of the municipalities compared. And, as with any epidemiological study, uncertainties in extrapolating from animal to human effects and from high to low doses are avoided (EPA 2001).

In the Finnish study, the following statistically significant standardized incidence ratios (SIRs) and 95% CI were reported for the entire cohort of 3974 workers: 2.35 for cervical cancer (95% CI-1.08-4.46), 2.13 for non-Hodgkin's lymphoma (95% CI-1.06-3.8), and 1.63 for lymphohematopoietic cancers (95% CI-1.06-2.41). Standardized incidence ratios are the ratio of observed cancer incidence in the cohort to the expected cancer incidence based on the population of Finland adjusted for age and sex. The cohort was subdivided according to exposure and duration of exposure. One subgroup was monitored for urinary TCA, a major metabolite of TCE, and had been followed for at least 19 years since the first measurement. This subgroup had statistically significant SIRs of 1.57 for all cancers (95% CI-1.2-2.02), 2.98 for stomach cancer (95% CI-1.2-6.13), 6.07 for liver cancer (95% CI-1.25-17.7), 3.57 for prostate cancer (95% CI-1.54-7.02), and 2.98 for lymphohematopoietic cancers (95% CI-1.2-6.14). Among a subgroup who were monitored for blood PCE levels, no statistically significant SIRs were reported. By the author's calculations though, exposure was greatest for TCE accounting for 80% of the person-years at risk (Anttila et al. 1995).

Using urinary TCA to quantify exposure, slope factors were calculated for liver cancer (7.0E-02), kidney cancer (2.0E+00), and non-Hodgkin lymphoma (7.0E+00) (EPA 2001). However, only liver cancer was statistically significantly elevated among those workers with known exposure to trichloroethylene. Of the 11 cases of non-Hodgkin lymphoma, 3 were attributed to exposure to PCE resulting in a statistically non-significant excess in those exposed to TCE (SIR=1.81, 95% CI-0.78-3.56). In addition to the small number of cancer cases, exposure duration was uncertain (Anttila et al. 1995). Even though the comparison group was generated from the Finnish population, Anttila (1995) argues that, "It is not probable that chemicals other than solvents, or life-style patterns (such as alcohol consumption, smoking, sexual habits) explain the excesses in the present cohort, because excesses of the same primary sites were not seen in a parallel, in many respects comparable, cohort of workers monitored for lead exposure."

In the Hill Air Force Base study, statistically non-significant excesses of non-Hodgkin lymphoma (RR=2.0, 95% CI=0.9-4.6), multiple myeloma (RR=1.3, 95% CI=0.5-3.4), breast cancer (RR=1.8, 95% CI=0.9-3.3), kidney cancer (RR=1.6, 95% CI=0.5-5.1), and cancer of the liver (RR=1.7, 95% CI=0.2-16.2) and biliary passages (RR=1.3, 95% CI=0.5-3.4) were reported. It is, perhaps, timely to note here that a trend may be biologically significant but not statistically significant. Strengths of this study include it's size (n=14,457), the extended follow up that enables inclusion of effects with long latent periods, and the use of an internal control group to "minimise the potential for selection and socioeconomic problems associated with the use of the general population for comparison." Limitations of the study include the fact that other solvents were used on base, though TCE was the main solvent used historically, and exposure estimates were qualitative rather than quantitative (Blair et al. 1998). Without quantitative exposure estimates, risk estimates cannot be derived.

The fourth study discussed by EPA (2001) tracked German cardboard workers exposed to TCE. This study noted an increased incidence of kidney cancer but may have been initiated after the observation of a cluster (IARC 1997). Problems associated with this study include a lack of exposure data, the use of other solvents in addition to TCE, an unadjusted incidence (EPA 2001), and differing diagnostic methodology between the cohort and comparison group (EPA 2002b).

More recently, Raaschou-Nielsen et al. (2003) reported on a Danish cohort of 40,049 blue-collar workers in 347 Danish companies with documented TCE use. The SIR for all cancers was 1.08 (95% CI-1.04-1.12). Other statistically significant SIRs were:

- 1.8 for esophageal adenocarcinoma (95% CI-1.15-2.73) among men,
- 2.8 for primary liver cancer (95% CI-1.13-5.80) among women,
- 2.8 for gallbladder and biliary passage cancer (95% CI-1.28-5.34) among women,
- 1.4 for lung cancer (95% CI-1.28-1.51) among men and
- 1.9 (95% CI-1.48-2.35) among women,
- 1.9 for cervical cancer (95% CI-1.42-2.37),
- 1.2 for non-Hodgkin's lymphoma (95% CI-1.0-1.5) among the entire cohort, and
- 1.8 for esophageal adenocarcinoma (95% CI-1.2-2.7) among the entire cohort.

A non-significant SIR of 1.7 was noted for leukemia (95% CI-0.89-2.86) in women. An obvious strength of this study is its large cohort size. Unfortunately, it suffers from a poorly chosen control group, the Danish population. The authors admit that their experimental and control groups probably differed in the proportion of individuals in each socio-economic group. Cigarette smoking is known to be higher in the least educated groups in Denmark and may be a confounding factor in this study weakening the association between TCE and lung cancer. The authors note that social class is probably a confounding factor for cervical cancer as well. And because exposure was not quantified, risk estimates cannot be calculated.

Raaschou-Nielsen et al. (2003) as well as the three studies used by EPA (2001) report increased incidence of lymphohematopoietic cancers (non-Hodgkin's lymphoma, multiple myeloma, and leukemia). Three studies noted excesses of liver cancer. Leukemia and myeloma originate in the bone marrow while lymphoma originates in lymphatic tissues. These cancers are considered to be related because they involve the uncontrolled growth of cells with similar functions and origins. The diseases are not thought to be heritable, although a few cases of familial lymphoma have been reported, but rather to result from acquired injury to the cell, which becomes abnormal (malignant) and multiplies continuously (Bock 2004). Lymphohematopoietic cancers are basically environmentally caused diseases. Known environmental risk factors for liver cancer include aflatoxin, anabolic steroids, arsenic, cirrhosis, hepatitis, thorium dioxide, tobacco use, and vinyl chloride (ACS 2003).

Furthermore, three of these cancers have increased in incidence over the last 30 years as reported by the Surveillance, Epidemiology, and End Results (SEER) database. The incidence of non-Hodgkin's lymphoma across all races in the US increased from 11.1 per 100,000 in 1975 to 19.9 per 100,000 in 1994 with a subsequent decline to 19.0 per 100,000 in 2000. Incidence of myeloma followed a similar pattern increasing from 4.65 per 100,000 in 1973 to 6.0 per 100,000 in 1997 with a subsequent decline to 5.47 per 100,000 in 2000. Leukemia incidence actually declined from12.5 per 100,000 in 1973 to 11.9 per 100,000 in 2000, but not by much (SEER 2003). Liver cancer has increased from 2.7 per 100,000 in

1973 to 5.3 per 100,000 in 2000 (SEER 2003). All of the above-mentioned rates are age adjusted with all age groups, 0 to 85+, used.

Genetic toxicity studies using cultured cells from exposed and unexposed individuals lend support to the epidemiological connection between TCE and lymphohematopoietic cancers in humans. As reviewed by the California Environmental Protection Agency (Cal/EPA), in some, but not all, studies using peripheral lymphocyte cultures, genetic effects were noted. These included hyperdiploidy, hypodiploidy, sister chromatid exchanges, and chromosome structural anomalies including breaks, deletions, gaps, inversions, and translocations (Cal/EPA1999).

The epidemiological evidence is, also, supported by studies in rats and mice. Cal/EPA noted, "The principal findings are: 1) liver carcinomas in male mice by inhalation and in both sexes by gavage administration; 2) lung carcinomas in female mice by inhalation; and 3) kidney tubular carcinoma in male rats by inhalation and gavage dosing." In one study, an increased incidence of malignant lymphoma was observed in TCE-exposed female Han:NMR1 mice and, in another, TCE was associated with the development of testicular interstitial cell tumors in Marshall rats (Cal/EPA 1999).

Cal/EPA (1999) used data from two liver tumor studies in mice to generate slope factors. Using total amount of TCE metabolized by the liver, the lower 95% confidence limit on the dose associated with a 10% tumor incidence (LED_{10}) was calculated (EPA 1996). The following four slope factors were calculated as $0.1/LED_{10}$:

- 2.1E-02 in females by gavage,
- 7.7E-02 in males by gavage,
- 4.7E-03 in females by inhalation, and

- 3.4E-03 in males by inhalation.

The geometric mean of these slope factors is 1.3E-02 per mg/kg-d which is what Cal/EPA used to calculate their public health goal for the concentration of TCE in drinking water. The author admits ignorance as to how an average value can be protective of sensitive populations. On the other hand, their public health goal of 0.8 ppb is below the routine detection limit of 1.0 ppb. Moreover, this is the slope factor which was endorsed by EPA Region 4 last year (email from Ted Simon 2003).

Risk estimates associated with the rat and mice studies were reported by EPA (2001) as well. The slope factor and risk-specific dose for kidney cancer in rats was 3.0E-04 and 3.3E-03 respectively. Slope factors and risk-specific doses for liver cancer in mice using internal TCA as the dose metric ranged from 3.0E-02 to 2.0E-01 per mg/kg-d and from 0.5E-05 to 3.1E-05 mg/kg-d respectively.

Considering both the epidemiological studies and the rat and mice studies, slope factors range from 7.0 to 3.0E-04 per mg/kg-day which is a 23,000 fold difference. EPA proposed ignoring the lowest and highest estimates. The remaining slope factors range from 4.0E-01 (3.22E-01 as calculated here) to 2.0E-02 per mg/kg-d which is a 20 fold difference. This is slightly higher than EPA's previous slope factor of 1.1E-02 and Cal/EPA's, 1.3E-02.

EPA (2001), following National Research Council recommendations, did not consolidate these slope factors into a single estimate. They advise selecting an appropriate slope factor from the range. For example, "Risk assessments involving the presence of risk factors such as diabetes or alcohol consumption, or high background exposure to TCE or its metabolites, would more appropriately choose a higher slope factor." An estimated 6.3% of the population in this country have diabetes (NIDDK 2003) and in Kentucky, 6.8% have been diagnosed with it (CDC 2003). Given that diabetes is so prevalent, the higher slope factor should be chosen all the time.

Historically, EPA (1989) has been protective of sensitive populations and, in calculating reference doses, has recommended an uncertainty factor of 10 to account "for variation in the general population….intended to protect sensitive subpopulations." Moreover, the Science Advisory Board review panel (EPA 2002b) expressed concern "for diseased individuals (diabetes, hepatitis, HIV positive, etc.), who may be especially susceptible to TCE exposure." We are only just beginning to understand the range of human metabolic variation, the frequency of metabolic variants within the population, and what amount and kind of variation would cause susceptibility to the effects of chronic exposure to TCE (see Lipscomb et al. 2003 for an example). Until we know the frequency of metabolic variants susceptible to low level exposure to TCE we must assume that the frequency is greater than 1.0E-06.

The Science Advisory Board review panel (EPA 2002b) recognized the importance of epidemiological studies, stating that they "merit special attention because they may be potentially important in terms of population-attributable risk." Furthermore, the panel recommended that where such studies are the basis of risk estimates, they should be the ones, "among the studies that are well designed, that would generate the most health-protective number."

EPA Region 9 (2002) lists 4.00E-01 per mg/kg-d as both the oral and inhalation slope factor for TCE citing NCEA as the source. In an effort to find the origin of that slope factor, I contacted EPA Environmental Health Scientist, Dr. Weihsueh Chiu, who thought it came from the 2001 draft assessment (EPA 2001 and email from Weihsueh Chiu 2004). EPA

(2001) provides two slope factors using data from Cohn et al. (1994), 4.00E-01 per mg/kg-d in Table 4-9 and 3.5E-01 per mg/kg-d in Section 4.5.1.3. A slope factor of 4.00E-01 per mg/kg-d is not associated with any other study in EPA (2001). Using the original paper (Cohn et al. 1994), it is calculated as 3.22E-01 per mg/kg-d here.

The choice of a higher slope factor (3.22E-01 per mg/kg-d) seems easily justified. It is being used in EPA Region 9 and EPA Region 10 (2004) who uses Region 9's values. The higher risk estimates are protective of sensitive populations. This specific risk estimate is based on an epidemiological study. The epidemiological studies are supported by evidence from rat, mice, and cell culture studies.

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E.4. FLOWCHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION

The annotated flowchart presented in this section was provided to KDWM under cover letter from the DOE Paducah Site Lead on April 1, 2008, (PPPO-02-130-08) as a condition to be met for DOE to receive an Environmental Indicator of “Yes” with regard to the Government Performance and Results Act milestone of having human exposures under control. The flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licenses for use at PGDP, which are outside the controlled area and not currently assigned to an operable unit under the Federal Facility Agreement (FFA). The flowchart describes the uncertainty management for nonworker exposures associated with DOE-owned property described above.

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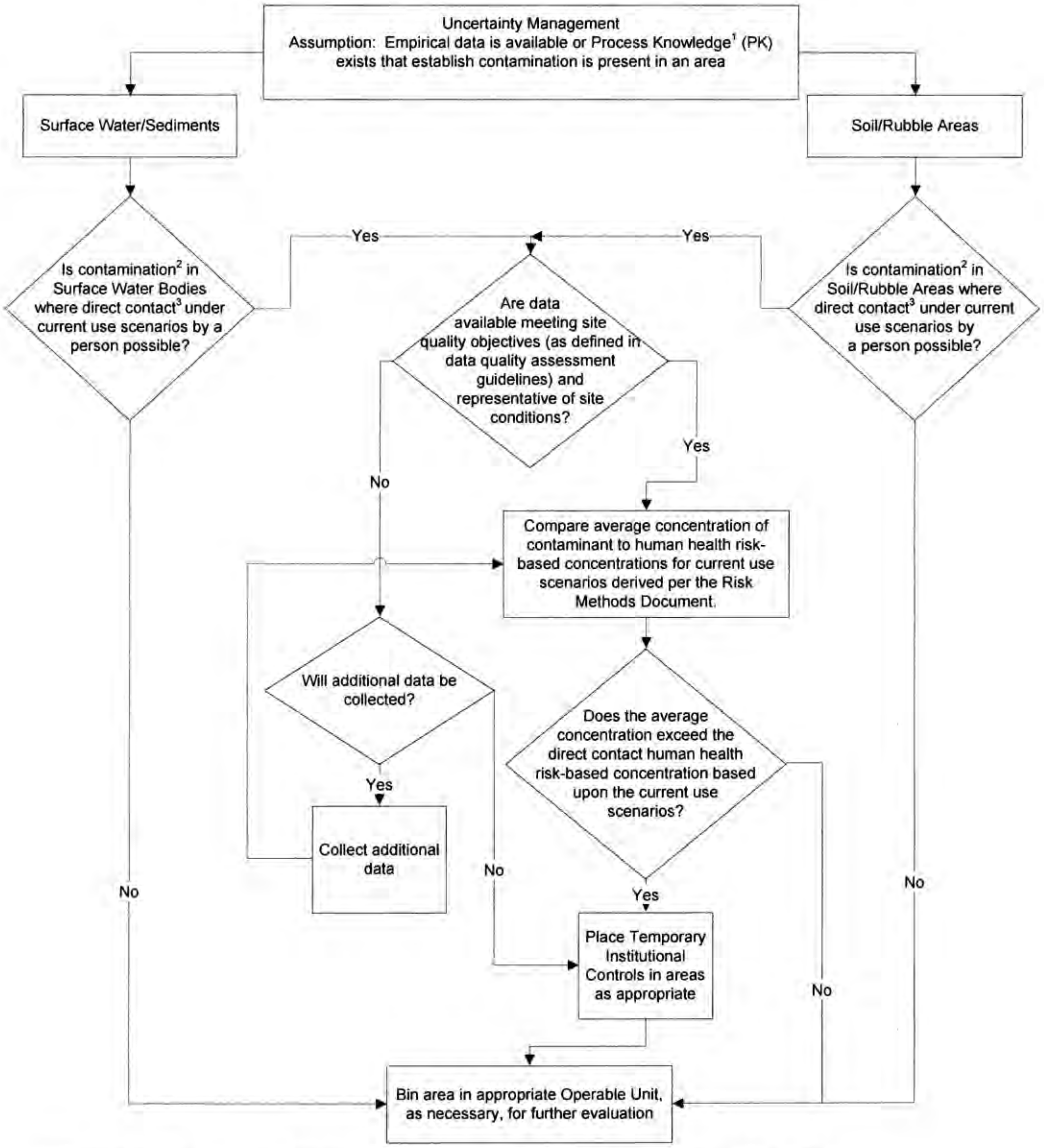
Enclosure

Flow Chart for Uncertainty Management

This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above.



1 "Process Knowledge" is defined as information identifying releases from past or current processes at the PGDP.

2 "Contamination" is defined in the Risk Methods Document as the presence of a constituent at a concentration greater than background.

3 "Direct contact" is exposure by a human to environmental medium [i.e., surface soil, sediment, debris (e.g., rubble), and surface water] through ingestion, dermal contact, inhalation (particulates and vapors), or external exposure.

Enclosure
(Cont)
Further Explanation of Flow Chart Steps

Uncertainty Management Assumption: Empirical data is available or Process Knowledge[1] (PK) exists that establish contamination is present in an area	This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above. Sufficient data or credible Process Knowledge must exist for this process to be activated.
Is contamination[2] in Surface Water Bodies or Soil/Rubble Areas where direct contact[3] under current use scenarios by a person possible?	Contamination definition is identified in Footnote 2. This process focuses on areas of surface soil, sediment, debris (e.g., rubble), and surface water that are located in the licensed area and available for direct contact exposure. Examples of exposure scenarios are riding horses or ATVs in the creek and bank areas, walking or hiking through wildlife habitat, or hunting.
Are data available meeting site quality objectives (as defined in data quality assessment guidelines) and representative of site conditions?	An evaluation of the available data will be performed to determine if data are of sufficient quality to be used for risk assessment. Additional data may be collected to determine appropriate protective actions.
Compare average concentration of contaminant to human health risk-based concentrations for current use scenarios derived per the Risk Methods Document.	Average concentrations from existing data will be compared to the human health risk-based concentrations. Risk-based concentrations used will be based on guidance in the current site Risk Methods Document.
Place Temporary Institutional Controls in areas as appropriate	Temporary institutional controls may vary depending on the nature of contamination. DOE may place temporary institutional controls under CERCLA, perform a maintenance action, or post under 10 *CFR* 835.
Bin area in appropriate Operable Unit, as necessary, for further evaluation	DOE, EPA, and KY will determine the appropriate Operable Unit under which the area may be placed for future evaluation in accordance with the FFA. These agencies will determine if immediate actions such as sampling or removal actions are warranted based on potential risk and exposure to the public.

E.5. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS

A probabilistic risk assessment (PRA) of migration of contaminants to groundwater was conducted for the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky,* DOE/OR/07-2180&D2 (issued May 2006). The parameters used in that modeling effort were presented in Attachment 2 of Appendix F of the site investigation report. This set of parameter values is appropriate for use in modeling for other PRAs, though the information on these values should be reviewed during the PRA development to ensure the assumptions made in setting the values are appropriate for each site being evaluated. Parameter values should be modified, if necessary, to reflect conditions for the individual site under consideration.

Appendix F, Attachment 2, of the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2.

INPUT PARAMETERS FOR PROBABILISTIC MODELING

1. INTRODUCTION

Probabilistic (stochastic) modeling was performed for the trichloroethene (TCE) sources at (Solid Waste Management Unit (SWMU) 1 and the C-720 Building areas in order to understand better the uncertainties in the transport modeling for these sources, to estimate the likely TCE concentrations at the points of exposure (POEs) using the most likely input parameters, and to determine the error bounds on the predicted TCE concentrations. This modeling was based upon the nature and extent discussion in the Site Investigation (SI) Report and the transport modeling results completed earlier.

The fate and transport modeling was performed using Spatial Analysis/Decision Assistance (SADA) software (UT 2002); Crystal Ball® (Decisioneering, Inc. 2000), an add-in to Microsoft Excel®; Seasonal Soil Compartment Model (SESOIL) (GSC 1996, Bonazountas and Wagner 1984); and Analytical Transient One-, Two-, and Three-Dimensional Simulation Model (AT123D) (GSC 1998, Yeh 1981). The key input parameters for the modeling were developed using SADA and Crystal Ball®, while the modeling itself was performed using SESOIL and AT123D.

2. INPUT PARAMETERS

The input parameters for the modeling were in two groups: fixed and variable. The values of the fixed parameters were from earlier work (DOE 2003). The values of the variable parameters were set considering earlier work and employing a probabilistic method. This was done by developing a distribution for each variable parameter and sampling the distribution using the Monte Carlo sampling technique provided in Crystal Ball®.

3. PARAMETER DISTRIBUTIONS

Several distributions were considered when selecting the best distribution for each of the variable input parameters. A general discussion of each distribution considered is provided below.

1. **Triangular Distribution:** This distribution is used to describe a variable with known minimum, maximum, and most likely values (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:

    - The minimum value of the variable is fixed.
    - The maximum value of the variable is fixed.

- The most likely value of the variable falls between the minimum and maximum values forming a triangular-shaped distribution and showing that values near the minimum and maximum are less likely to occur than those near the most likely values.

2. **Normal Distribution:** This is the most important distribution in the probability theory because it describes many natural phenomena (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:

    - Some value of the variable is the most likely (the mean of the distribution).
    - The value of the variable could as likely be below the mean as it could be above the mean (symmetrical about the mean).
    - The value of the variable is more likely to be near the mean than far away.

    Generally, if the coefficient of variability is less than 30%, a normal distribution is recommended. A skewness value between -0.5 and +0.5 indicates a fairly symmetrical distribution (Decisioneering, Inc. 2000).

3. **Log-Normal Distribution:** This distribution is widely used to describe a variable with values that are positively skewed (Decisioneering, Inc. 2000). The three conditions underlying this distribution are as follows:

    - The variable can increase without limits but cannot fall below zero.
    - The variable is positively skewed with most of the values near the lower limit.
    - The natural logarithm of the variable yields a normal distribution

    Generally, if the coefficient of variability is greater than 30%, a log-normal distribution is recommended. A skewness value less than -1 or greater than +1 indicates a highly skewed distribution (Decisioneering, Inc. 2000).

4. **Uniform Distribution:** This distribution is used to describe a variable when each value of the variable has the same probability of occurrence within a selected range. This distribution is often used when no information about variable's distribution is available. The three conditions underlying this distribution are as follows:

    - The minimum value of the variable is fixed.
    - The maximum value of the variable is fixed.
    - The probability of any value being selected within the range between the minimum and maximum values is equal.

4. SESOIL PARAMETERS

The SESOIL software was used to simulate contaminant transport through the Upper Continental Recharge System (UCRS) to the Regional Gravel Aquifer (RGA). The parameters used for SESOIL are listed in Tables F.2.1 and F.2.2. As mentioned earlier, there are two groups of parameters. Remarks for each parameter are provided in these tables to clarify the source of the value and the justification for its selected value. Additional remarks for each variable parameter, including the values input into Crystal Ball, are provided in Table F.2.3. Finally, summary statistics for each variable parameter output by

Crystal Ball are provided in Table F.2.4. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.1 through F.2.18.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.1 and F.2.2.

    - **Soil Type:** The upper portion of the UCRS is loam, while the bottom portion of it is silty clay (DOE 1999). The soil type was considered to be silty loam for each area.

    - **Bulk Density:** The bulk density of the UCRS is 1.46 g/cm^3 (DOE 1999). The bulk density was set to this value for each area.

    - **Disconnectedness Index:** The disconnected index was set to a site-specific approximate value of 10 used in earlier work. The value was estimated by calibrating the deterministic model to an average recharge of 11.38 cm/yr.

    - **Porosity:** The porosity of the UCRS is 0.45 (DOE 1999). The porosity was set to this value for each area.

    - **Depth to Water Table:** The depth to the water table was estimated for each area considering site-specific data. The depths were estimated as 16.76 m (55 ft), and 18.29 m (60 ft) for SWMU 1 and C-720 areas, respectively.

    - **Freundlich Equation Exponent:** The Freundlich equation exponent typically ranges from 0.9 to 1.4; the default value of 1.0 is recommended if the actual value is not known (GSC 1996). The exponent was set to 1 for each area.

    - **Contaminant of Concern (COC):** The COC of interest was TCE.

    - **Source Area:** The source area was developed analyzing site-specific data for each area. Soil concentration for the area was analyzed layer-by-layer using SADA. A limitation of SESOIL required that all layers have the same area. Source areas and the average soil concentration in each layer were estimated, and the source area with the maximum contaminant mass was identified and set as the “uniform area.” Concentrations within each layer were then normalized against the “uniform area” (discussed later). The “uniform areas” used for SWMU 1 and the C-720 area were 324 m^2 and 1394 m^2, respectively.

    - **Molecular Weight:** The molecular weight was set to 131 g/gm-mol (EPA 1994).

    - **Solubility in Water:** The solubility in water was set to 1100 mg/L (EPA 1996).

    - **Diffusion in Air:** The diffusion in air was set to 0.08 cm^2/sec (EPA 1996).

    - **Henry’s Constant:** The Henry’s constant was set to 0.0103 atm-m^3/mol (EPA 1996).

    - **Soil Organic Carbon/Water Partition coefficient (K_{oc}):** The K_{oc} was set to 94 L/kg (EPA 1996).

2. **Variable Parameters:** These parameters are summarized in Tables F.2.1 through F.2.4.

- **Intrinsic Permeability:** Site-specific data were available for the vertical hydraulic conductivity of the UCRS. Therefore, the intrinsic permeability was estimated from vertical hydraulic conductivity using the following equation.

  $$K = k \frac{g}{\nu} \qquad (1)$$

  where K = vertical hydraulic conductivity of soil, k = intrinsic permeability of soil, ν = kinematic viscosity of water, and g = gravitational acceleration (Bear 1979). Taking ν = 0.01 cm^2/sec and g = 981 cm/sec^2 (Mills et al. 1985), and substituting in Equation 1 leads to

  $$k\left(cm^2\right) = \frac{K\left(cm/\sec\right)}{9.81\,x\,10^4\left(1/cm - \sec\right)} \qquad (2)$$

  The intrinsic permeability was estimated from the saturated vertical hydraulic conductivity using Equation 2.

  The site-specific vertical hydraulic conductivities measured earlier were assumed to be representative of that expected in the UCRS at each area. Summary statistics for the site-specific data are in Table F.2.3. A set of 13 results was available (DOE 1997a, DOE 1997b). These results ranged from 1.00E-08 cm/sec to 2.00E-04 cm/sec with a likeliest (mean) value of 1.64E-05 cm/sec. The coefficient of variation was estimated as 336%, and the skewness was estimated as 3.6. Next, the statistics were studied. The maximum value, when used in SESOIL produced an unreasonable recharge; therefore, a second estimate of maximum was sought through calibration. The maximum was re-estimated as 3.20E-05 through calibration to a recharge of 22 cm/yr (DOE 2000). Given that a range and a most likely value could be determined from the site-specific data, a triangular distribution was assumed. The vertical hydraulic conductivity was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for the resulting intrinsic permeabilities for each of the two source areas are in Figs. F.2.1 and F.2.2.

- **Organic Carbon Content:** Site-specific data were available for the organic carbon content of the UCRS. The site-specific organic carbon contents measured earlier were assumed to representative of that expected in the UCRS at each source area. Summary statistics for the site-specific data are in Table F.2.3. A set of 138 results was available. The coefficient of variation was estimated as 66%, and the skewness was estimated as 4.3. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for organic carbon content for each of the two source areas are in Figs. F.2.3 and F.2.4.

- **Soil Concentration:** Site-specific data were available for the TCE soil concentrations in each source area. Summary statistics for each layer are in Table F.2.3. For SWMU 1, a set of 135 results was available. The coefficient of variation for these results was estimated as 523%, and the skewness was estimated as 6.42. Given the coefficient of variation and skewness, a log-normal distribution was assumed. Using site-specific data, the correlation between Layers 1 and 2 soil concentrations was determined to be 0.92. (Please see Section 4.3 for additional discussion of correlations between layers.) Similar analyses led to choosing the log-normal distribution for Layer 1 at the C-720 area. The correlation coefficients between Layers 1 and 2 for the C-720 area were determined to be 0 and -0.50, respectively. Site-specific data were also available for the soil concentrations in Layer 2 through Layer 6. Summary statistics for each of these layers at each location are in Table F.2.3. For each layer at each location, a log-normal distribution was chosen, and correlations between layers were derived.

As mentioned earlier, a limitation of the SESOIL model required normalization of soil concentrations in each layer at each location to a "uniform area." To accomplish this, the layer with the maximum contaminant mass at each source was used as that source's "uniform area," and a simple ratio was used to normalize each layer's concentration to that of the "uniform area." The summary statistics for the value output by Crystal Ball are in Table F.2.4. Histograms for each layer at each location are in Figs. F.2.5 through F.2.16.

- **Degradation Half-Life/Degradation Rate:** Site-specific data were limited for the degradation half-life of TCE in the UCRS; therefore, a range of half-lives estimated for the RGA (3.2 to 11.3 years) were selected with uniform distribution for the UCRS. (Please see Attachment F.3 of Appendix F for additional information on the estimation of degradation half-life of TCE in the RGA at PGDP.) The degradation half-life was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms of the output values for degradation rate for each of the two source areas are in Figs. F.2.17 and F.2.18. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into SESOIL. Where, the degradation rate is derived from the degradation half-life using the following expression:

$$\lambda = \frac{\ln 2}{t_{1/2}} \tag{3}$$

where λ = degradation rate (day^{-1}), and $t_{1/2}$ = degradation half-life (days).

An additional scenario termed the "fixed degradation scenario" was also assessed in the probabilistic analysis. The degradation half-life was set equal to 26.6 years for these runs, while the remaining parameters listed above were allowed to vary.

5. AT123D PARAMETERS AND SOURCE TERM MODELING PARAMETERS

The AT123D software was used to simulate contaminant transport from the source areas through the RGA to the POEs. The parameters used for AT123D modeling are listed in Tables F.2.5, F.2.6, and F.2.7. Remarks for each parameter are provided in the table to clarify the source and justification of selected values. Additional remarks for each variable parameter are provided in Table F.2.8. Finally, the summary statistics for each variable parameter sampled output by Crystal Ball and used in the runs for AT123D and source term modeling are provided in Table F.2.9. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.19 through F.2.24.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.5, F.2.6, and F.2.7.

   - **Dispersivity:** The longitudinal dispersivity was set to 1.5 m for each area (DOE 1999). Similarly, the transverse (lateral) dispersivity and the vertical dispersivity were set to 1.5 m and 0.03 m, respectively, for the area.

   - **Bulk Density:** The bulk density of the RGA is 1670 kg/m^3 (DOE 1999). The bulk density was set to this value for each area.

   - **Density of Water:** The density of water was set to 1000 kg/m^3 (Mills et al. 1985).

   - **COC:** As mentioned earlier, the COC was TCE.

   - **Source Area:** The area used in AT123D modeling for each source was the "uniform area" developed for the source in SESOIL modeling.

   - **Diffusion in Water:** The diffusion in water was set to 3.28E-6 m^2/hr (EPA 1996).

   - **K_{oc}:** As mentioned earlier, the K_{oc} was set to 94 L/kg (EPA 1996).

   - **Distance to POEs:** The distance from the center of each source area to the POEs was estimated from plant maps. Each of the POEs was placed at the centerline of the estimated path of contaminant migration.

2. **Variable Parameter:** These parameters are summarized in Tables F.2.5 through F.2.9.

   - **Aquifer Depth (Thickness):** The aquifer depth was allowed to vary in order to account for changes in the thickness of RGA as a contaminant migrates from a source area to the Ohio River. Site-specific data were available from field measurements, and these data were assumed to be applicable to the RGA at each source area and along the estimated contaminant flow paths. A set of 24 results was available. The coefficient of variation was estimated as 31%, and the skewness was estimated as -0.61. Given the coefficient of variation and skewness, the distribution was assumed to be normal. The aquifer depth was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for aquifer depth is in Fig. F.2.19. (Note that each source area used the same set of parameters in AT123D modeling; therefore, only one histogram is presented for each of the AT123D variable parameters.)

   - Hydraulic Conductivity: Site specific data were available for the hydraulic conductivity of the RGA, and these data were assumed to be applicable to the RGA at each source area and along the contaminant flow paths. A set of 62 results was available. The data ranged from 1.00E-04 ft/day to 8.50E+05 ft/day with a likeliest value of 1.93E+04 ft/day. The coefficient of variation was estimated as 563%, and the skewness was estimated as 7.53. A value of 1500 ft/day was used in DOE 1999. During model set-up, the range was judged to be too variable given the site-specific soil condition, and a second estimate was sought from the PGDP groundwater flow model. This estimate was developed using an analysis based upon a plan area from the PGDP site-wide groundwater model and the path of contaminant migration from the source areas to the Ohio River (please see Fig.5.1 of the main report). Based upon this analysis, the minimum, maximum, and most likely values chosen were 75, 1500, and 967 ft/day, respectively. The coefficient of variation was estimated as 65%, and the skewness was estimated as -0.35. Subsequently, the selected most likely value was determined to be inconsistent with probable site conditions, and after consultation with site experts these value was changed to 350 ft/day (i.e., the geometric mean of the minimum and maximum in the plan area). The standard deviation was assumed equal to the likeliest value yielding a coefficient of variation of 100%. Given this coefficient of variation and the skewness from the earlier analyses (i.e., that related to site-specific data and plan area), a log-normal distribution was assumed. In addition, the hydraulic conductivity was assumed correlated to the hydraulic gradient and the porosity. The correlation coefficients selected by site experts were -0.50 and 0.20 for correlating the hydraulic conductivity to the hydraulic gradient and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic conductivity is in Fig. F.2.20.

Hydraulic Gradient: Site-specific data were available for the hydraulic gradient of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 12 results was available. The coefficient of variation was estimated as 111%, and the skewness was estimated as 1.95. Given the coefficient of variation and skewness, a log-normal distribution was assumed with minimum, maximum, and most likely values of 1.00E-04, 4.00E-03, and 1.01E-03 m/m, respectively. The standard deviation was set at 1.12E-03 m/m. Additionally, the hydraulic gradient was assumed correlated to the hydraulic conductivity and the porosity. The correlation coefficients were assumed as -0.50 and -0.20 for correlating the hydraulic gradient to the hydraulic conductivity and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic gradient is in Fig. F.2.21.

Effective Porosity: Site-specific data were available for the porosity of the RGA; therefore, the effective porosity was estimated from the porosity using a conversion value of 81% taken from DOE 1999. [In that report, an effective porosity of 0.30 and a porosity of 0.37 were reported (i.e., 0.30/0.37 = 0.81 or 81%).] The data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 28 results was available. The minimum, maximum, and most likely values selected for porosity were 27, 54, and 39%. The coefficient of variation was estimated as 15%, and the skewness was estimated as 0.43. Given the coefficient of variation and skewness, a normal distribution was assumed. Additionally, the porosity was assumed correlated to the hydraulic conductivity and the hydraulic gradient. The correlation coefficients were assumed as 0.20 and -0.20 for correlating the porosity to the hydraulic conductivity and to the hydraulic gradient, respectively. Summary statistics for the values output by Crystal Ball® and the resulting effective porosity values used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the effective porosity values is in Fig. F.2.22[1]. Note that only a histogram of effective porosity is presented because effective porosity and not porosity was the value input into AT123D.

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[1] Future groundwater modeling efforts at PGDP will utilize 35% as a practical upper-bound for effective porosity values.

- **Organic Carbon Content:** Site-specific data were available for the organic carbon content of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 38 results was available. The minimum, maximum, and most likely values selected were 3.0E-03, 2.53E-01, and 3.5E-02%, respectively. The coefficient of variation was estimated as 1.05%, and the skewness was estimated as 4.0. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for organic carbon content is in Fig. F.2.23.

- **Degradation Half-Life:** Recently, as part of response actions, the U.S. Department of Energy (DOE) has developed revised biodegradation rates that were incorporated into the SI modeling. Attachment F.3 to this appendix presents a detailed discussion of the derivation of the degradation rates. Additionally, the degradation half-life was observed to be correlated with groundwater flow which is a direct function of hydraulic conductivity and hydraulic gradient. However, for this analysis the degradation half-life was assumed 100% correlated to the hydraulic gradient. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for degradation rate is in Fig. F.2.24. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into AT123D. It should be noted here that although hydraulic gradient assumed a normal distribution, Crystal Ball output for degradation rate presented in Fig. F2.24 does not appear to be normally distributed. An additional scenario termed the "fixed degradation scenario" was also assessed in the probabilistic analysis. No degradation was assumed for these runs, while the remaining parameters listed above were allowed to vary.

6. CORRELATION MATRIX

As mentioned earlier, the soil concentration in each layer was assumed correlated to the adjacent layers for a given area. To estimate the correlation coefficient between two adjacent layers, sets of ordered pairs of concentrations were analyzed. Because data were sparse, ordered pairs were difficult to establish using the sampling date; therefore, the source developed using SADA was used for the estimation. For SADA data, the size and shape of the source areas in the adjacent layers differed; therefore, an ordered pair was formed only in the parts of the source where two layers overlapped.

The correlation values are presented in Table F.2.3.

7. SENSITIVITY ANALYSIS

Although there was not any sensitivity analysis performed under this task to select the parameters that were allowed to vary, previous groundwater modeling efforts at the PGDP have included sensitivity analyses of several of the parameters input into SESOIL and AT123D in order to understand some of the modeling uncertainties. The analyses are included in these documents:

- U-Landfill Design and Analysis (DOE 2002)
- K_d-Sensitivity Analysis (SAIC 2002)
- Northeast and Northwest Plume Groundwater Modeling (BJC 2003)
- Recharge- and Ohio River Stage-Sensitivity Analysis (DOE 2002)

Based on these analyses, the following parameters were determined to be the most sensitive parameters for fate and transport modeling using SESOIL and AT123D:

- Contaminant's concentration in the soil/source term,
- Contaminant's degradation half-life,
- Contaminant's distribution coefficient (K_d) (i.e., directly related to the organic carbon content of source soils for organic compounds)
- Percolation rate (controlled by source vertical permeability)
- Saturated hydraulic conductivity,
- Hydraulic gradient,
- Effective porosity, and
- Aquifer thickness

The contaminant concentration in the source term is one of the most sensitive parameters; increasing the source term concentration increases the predicted groundwater concentration at the POE by increasing contaminant flux and lengthening the time required for depletion of contaminant in the source. The percolation rate is also a very sensitive parameter; increasing the percolation rate results in increased contaminant flux to the RGA and, potentially, a greater peak concentration at the POE. An increased percolation rate, however, is related to faster depletion of contaminant in the source. The contaminant's distribution coefficient, K_d, is a very sensitive parameter for the SESOIL and AT123D models and may rank only behind contaminant concentration in terms of importance. Sensitivity analyses have shown that increasing the K_d of any layer included in the SESOIL model or of the RGA included in the AT123D model decreases contaminant concentrations at the POE because of retardation and attenuation due to sorption. Therefore, with higher K_d's the rate of source depletion is slowed, and the time required for source depletion is increased. Degradation half-life is also important if the time taken for source depletion or required for contaminant migration from the source to the POE is long relative to the contaminant's degradation half-life (i.e., 3 or more times half-life). This is the case because, under this condition, the rate of contaminant degradation in the source or as the contaminant migrates from the source to the POE results in markedly lower contaminant concentrations at the POE.

For AT123D modeling, the earlier sensitivity analyses have identified three additional input parameters. These parameters are hydraulic conductivity, hydraulic gradient, and effective porosity. In the AT123D model, hydraulic conductivity, hydraulic gradient, and effective porosity work together to control seepage velocity (i.e., seepage velocity equals hydraulic conductivity times hydraulic gradient divided by effective porosity), and an increase in seepage velocity increases the rate of contaminant migration to the POE. The values chosen for the Southwest Plume model indicates that the hydraulic gradient varies over a relatively narrow range in the RGA. Therefore, the impact of hydraulic gradient on seepage velocity is expected to be relatively smaller than that of hydraulic conductivity. Table 2.10

presents an overall summary of qualitative sensitivity of modeling results to input parameters for this analysis.

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KY 1997. *Analysis and Interpretation of Water Levels in Observations Wells at the Paducah Gaseous Diffusion Plant 1990-1997,* KY/EM-210, June 30.

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Mills, W. B., D. B. Porcella, M. J. Ungs, S.A. Gherini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Hadith 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants*, Parts II, EPA-600/6-85/002b, September, U. S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

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UT (University of Tennessee) 2002. Spatial Analysis and Decision Assistance (SADA), Version 2.3, User Guide, January. Accessible at http://www.tiem.utk.edu/~sada/.

Yeh, G. T. 1981. *AT123D: Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System*, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, Publication No. 1439.

Table F.2.1. Sil-specific parameters for SESOIL modeling (see Table F.46a)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Soil Type	-	Silty Loam	Silty Loam	DOE 1999
Bulk Density	g/cm^3	1.46	1.46	DOE 1999
Intrinsic Permeability	cm^2	Variable	Variable	Probabilistic method
Disconnectedness Index	-	10	10	Site-specific (to PGDP) approximate value used in earlier work
Porosity	-	0.45	0.45	DOE 1999
Depth to Water Table	m	16.76	18.29	Site-specific (to RGA) field data
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Freundlich Equation Exponent	-	1	1	Default

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/V4&D2, June.
DOE 2000. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1857&D1, July.

Table F.2.2. Chemical-specific parameters for SESOIL modeling (see Table F.46b)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Contaminant of Concern	-	Trichloroethene	Trichloroethene	
Source Area	m^2	324	1394	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 1	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 2	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 3	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 4	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 5	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 6	mg/kg	Variable	Variable	Probabilistic method
Molecular Weight	g/gmol	131	131	EPA 1994
Solubility in Water	mg/L	1100	1100	EPA 1996
Diffusion in Air	cm^2/s	0.08	0.08	EPA 1996
Henry's Constant	$atm.m^3/mol$	0.0103	0.0103	EPA 1996
Koc	L/kg	94	94	EPA 1996
Degradation Rate	day^{-1}	Variable	Variable	Probabilistic method

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/07-1777/V4&D2, June.
EPA 1994. Risk Reduction Engineering Laboratory (RREL) Treatability Database, ver. 5.0, Office of Research and Development, Cincinnati, OH.
EPA 1996. *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, DC.

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Vertical Hydraulic Conductivity[a]	Minimum	cm/sec	1.00E-08	1.00E-08	DOE 1997a, DOE 1997b
	Likeliest	cm/sec	1.64E-05	1.64E-05	DOE 1997a, DOE 1997b
	Maximum	cm/sec	2.00E-04	2.00E-04	[b]DOE 1997a, DOE 1997b
	Standard Deviation	cm/sec	5.52E-05	5.52E-05	DOE 1997a, DOE 1997b
	Count	#	13	13	DOE 1997a, DOE 1997b
	Coefficient of Variation	%	336.49	336.49	DOE 1997a, DOE 1997b
	Skew	-	3.60	3.60	DOE 1997a, DOE 1997b
	Maximum	cm/sec	3.20E-05	3.20E-05	[c,d]Recharge-specific (to RGA) calibration
	Distribution	-	Triangular	Triangular	See Section 4.0, Intrinsic Permeability
	Correlation Pair	-	None	None	None
	Correlation Coefficient	-	NA	NA	NA
Organic Carbon Content	Minimum	%	2.48E-02	2.48E-02	Site-specific (to PGDP) field data
	Likeliest	%	8.01E-02	8.01E-02	Site-specific (to PGDP) field data
	Maximum	%	4.55E-01	4.55E-01	Site-specific (to PGDP) field data
	Standard Deviation	%	5.27E-02	5.27E-02	Site-specific (to PGDP) field data
	Count	#	138	138	Site-specific (to PGDP) field data
	Coefficient of Variation	%	65.82	65.82	Site-specific (to PGDP) field data
	Skew	-	4.30	4.30	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	None	None	See Section 4.0, Organic Carbon Content
	Correlation Coefficient	-	NA	NA	NA
Soil Concentration - Layer 1	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	2.14E+00	1.56E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.70E+01	1.70E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.12E+01	5.12E+00	Site-specific (to PGDP) field data
	Count	#	135	11	Site-specific (to PGDP) field data
	Coefficient of Variation	%	522.90	328.48	Site-specific (to PGDP) field data
	Skew	-	6.42	3.32	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 2	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	1.59E+01	1.22E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	4.39E+02	1.90E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	7.87E+01	4.23E+00	Site-specific (to PGDP) field data
	Count	#	31	36	Site-specific (to PGDP) field data
	Coefficient of Variation	%	494.84	347.17	Site-specific (to PGDP) field data
	Skew	-	5.53	3.81	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 1 and Layer 2	Layer 1 with Layer 2	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	-5.00E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 3	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.60E+00	5.94E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.50E+01	6.80E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.82E+01	1.54E+01	Site-specific (to PGDP) field data
	Count	#	32	23	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.82	258.66	Site-specific (to PGDP) field data
	Skew	-	3.15	3.49	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 2 and Layer 3	Layer 2 with Layer 3	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	3.50E-01	5.90E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 4	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.12E+00	3.87E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	7.40E+01	1.80E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.46E+01	6.50E-01	Site-specific (to PGDP) field data
	Count	#	27	33	Site-specific (to PGDP) field data
	Coefficient of Variation	%	285.55	168.18	Site-specific (to PGDP) field data
	Skew	-	4.37	1.44	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 3 and Layer 4	Layer 3 with Layer 4	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	2.10E-01	1.60E-01	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 5	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.95E+00	2.00E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	6.60E+01	1.30E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.42E+01	3.69E-01	Site-specific (to PGDP) field data
	Count	#	33	30	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.99	184.61	Site-specific (to PGDP) field data
	Skew	-	3.24	2.04	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 4 with Layer 5	Layer 4 with Layer 5	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	4.00E-01	9.90E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 6	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.20E-01	1.17E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	3.40E+00	6.30E-01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.07E+00	2.04E-01	Site-specific (to PGDP) field data
	Count	#	12	16	Site-specific (to PGDP) field data
	Coefficient of Variation	%	148.61	174.34	Site-specific (to PGDP) field data
	Skew	-	1.71	1.61	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 5 with Layer 6	Layer 5 with Layer 6	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	5.00E-01	Site-specific (to TCE) SADA analysis
Degradation Half-life	Minimum	yr	3.20E+00	3.20E+00	See Attachment F.3
	Likeliest	yr	NA	NA	NA
	Maximum	yr	1.13E+01	1.13E+01	See Attachment F.3
	Standard Deviation	yr	NA	NA	NA
	Distribution	-	Uniform	Uniform	See Section 4.0, Degradation Half-Life
	Correlation Pair	-	None	None	See Section 4.0, Degradation Half-Life
	Correlation Coefficient	-	NA	NA	NA

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

[a] Field observation was available for vertical hydraulic conductivity. Therefore, intrinsic permeability was estimated from vertical hydraulic conductivity.

[b] The maximum from DOE 1997a and DOE 1997b was judged to be high and was re-estimated through calibration.

[c] The maximum was estimated through calibration to a recharge of 22 cm/yr (DOE 2000).

[d] The value selected for probabilistic method.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, *Environmental Degradation Rates*, Lewis Publishers, Inc. Chelsea, MI, 1991.

LMES (Lockheed Martin Energy Systems) 1997. *Evaluation of Natural Attenuation Processes for Trichloroethylene and Technetium-99 in the Northeast and Northwest Plumes at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-113.

DOE, 1997a. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/06-1628&D0, August.

DOE, 1997b. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky,* DOE/OR/07-1549&D1, February.

DOE 2000. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/07-1857&D1, July.

Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling (see Table F.47)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building
Vertical Hydraulic Conductivity[a]	Minimum	cm/sec	2.75E-06	2.75E-06
	Median	cm/sec	1.64E-05	1.64E-05
	Maximum	cm/sec	2.82E-05	2.83E-05
	Arithmetic Mean	cm/sec	1.60E-05	1.58E-05
	Standard Deviation	cm/sec	6.57E-06	6.73E-06
Intrinsic Permeability[a]	Minimum	cm^2	2.80E-11	2.80E-11
	Median	cm^2	1.67E-10	1.67E-10
	Maximum	cm^2	2.87E-10	2.89E-10
	Arithmetic Mean	cm^2	1.63E-10	1.61E-10
	Standard Deviation	cm^2	6.70E-11	6.86E-11
Organic Carbon Content[b]	Minimum	mg/kg	2.53E+02	2.67E+02
	Median	mg/kg	6.76E+02	6.86E+02
	Maximum	mg/kg	2.78E+03	3.47E+03
	Arithmetic Mean	mg/kg	7.90E+02	8.37E+02
	Standard Deviation	mg/kg	4.71E+02	5.14E+02
Organic Carbon Content (%)[b]	Minimum	%	2.53E-02	2.67E-02
	Median	%	6.76E-02	6.86E-02
	Maximum	%	2.78E-01	3.47E-01
	Arithmetic Mean	%	7.90E-02	8.37E-02
	Standard Deviation	%	4.71E-02	5.14E-02
Soil Concentration - Layer 1[c]	Minimum	mg/kg	2.86E-03	2.33E-03
	Median	mg/kg	5.73E-01	2.37E-01
	Maximum	mg/kg	3.58E+01	4.63E+00
	Arithmetic Mean	mg/kg	2.37E+00	6.46E-01
	Standard Deviation	mg/kg	5.15E+00	1.03E+00
Soil Concentration - Layer 2[c]	Minimum	mg/kg	6.03E-02	5.20E-03
	Median	mg/kg	3.64E+00	2.14E-01
	Maximum	mg/kg	1.88E+02	5.80E+00
	Arithmetic Mean	mg/kg	1.41E+01	5.95E-01
	Standard Deviation	mg/kg	3.09E+01	1.12E+00
Soil Concentration - Layer 3[c]	Minimum	mg/kg	1.28E-01	2.34E-02
	Median	mg/kg	5.80E+00	1.67E+00
	Maximum	mg/kg	1.02E+02	4.82E+01
	Arithmetic Mean	mg/kg	1.14E+01	5.08E+00
	Standard Deviation	mg/kg	1.63E+01	8.66E+00
Soil Concentration - Layer 4[c]	Minimum	mg/kg	1.28E-01	5.11E-03
	Median	mg/kg	2.78E+00	7.76E-02
	Maximum	mg/kg	1.15E+02	5.91E-01
	Arithmetic Mean	mg/kg	8.93E+00	1.24E-01
	Standard Deviation	mg/kg	1.62E+01	1.23E-01
Soil Concentration - Layer 5[c]	Minimum	mg/kg	1.26E-01	1.01E-03
	Median	mg/kg	4.39E+00	3.56E-02
	Maximum	mg/kg	7.50E+01	4.01E-01
	Arithmetic Mean	mg/kg	1.04E+01	6.09E-02
	Standard Deviation	mg/kg	1.44E+01	6.68E-02

Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling (see Table F.47) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building
Soil Concentration - Layer 6[c]	Minimum	mg/kg	5.30E-02	7.50E-04
	Median	mg/kg	1.04E+00	1.95E-02
	Maximum	mg/kg	6.65E+00	1.92E-01
	Arithmetic Mean	mg/kg	1.55E+00	3.31E-02
	Standard Deviation	mg/kg	1.53E+00	3.63E-02
Degradation Half-Life[d]	Minimum	yr	3.2	3.2
	Median	yr	4.9	4.9
	Maximum	yr	11.3	11.3
	Arithmetic Mean	yr	4.9	4.9
	Standard Deviation	yr	NA	NA
Degradation Rate[d]	Minimum	/hr	7.13E-06	7.21e-06
	Median	/hr	1.22E-05	1.13E-05
	Maximum	/hr	2.43E-05	2.43E-05
	Arithmetic Mean	/hr	1.32E-05	1.30E-05
	Standard Deviation	/hr	NA	NA

[a] Intrinsic permeability (cm^2) was estimated from the vertical hydraulic conductivity (cm/sec) using a conversion factor of 1.019E-5.

[b] Organic carbon content (%) was estimated from organic carbon content (mg/kg) using a conversion factor of 1E-4.

[c] Soil concentrations are normalized using the volume of the layer with the largest mass.

[d] Degradation rate was estimated from degradation half-life in units of days using the formula: rate = [(ln 2)/degradation half-life].

Table F.2.5. Hydrogeology-specific parameters for AT123D modeling (see Table F.49)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Aquifer Thickness	m	Variable	Variable	Probabilistic method
Hydraulic Conductivity	m/hr	Variable	Variable	Probabilistic method
Hydraulic Gradient	m/m	Variable	Variable	Probabilistic method
Effective Porosity	-	Variable	Variable	Probabilistic method
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Dispersivity - Longitudinal	m	15	15	DOE 1999
Dispersivity - Transverse	m	1.5	5	DOE 1999
Dispersivity - Vertical	m	0.03	5	DOE 1999
Bulk Density	kg/m^3	1670	1670	DOE 1999
Density of Water	kg/m^3	1000	1000	Mills et al. 1985

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/V4&D2, June.

Mills, W. B., D. B. Porcella, M. J. Ungs, S. A. Gherini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Hadith, 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Parts II*, EPA-600/6-85/002b, September, U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

Table F.2.6. Chemical-specific parameters for AT123D modeling (see Table F.49)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Contaminant of Concern	-	Trichloroethene	Trichloroethene	Selected for analysis
Source Area	m^2	324	1394	Site-specific (to TCE) SADA analysis
Diffusion in Water	m^2/hr	3.28E-06	3.28E-06	EPA 1996
Koc	L/kg	94	94	EPA 1996
Degradation Rate (half-life)[a]	hr^{-1} (year)	Variable	Variable	Attachment F.3

[a] Degradation rate was estimated from degradation half-life (see text).

EPA 1996. *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, D.C.

Table F.2.7. POE-specific parameters for AT123D modeling (see Table F.51)

Input Parameter	Unit	SWMU 1	C-720 Area	Remark
Distance to Plant Boundary	m (ft)	170 (558)	762 (2500)	See Fig. F.20
Distance to Property Boundary	m (ft)	915 (3000)	1460 (4789)	See Fig. F.20
Distance to Ohio River	m (ft)	7317 (24000)	7927 (26000)	See Fig. F.20

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48)

		SWMU 1 and C-720 Building				
Input Parameter	**Statistics**	**Crystal Ball**	**Unit**	**AT123D**	**Unit**	**Remark**
Aquifer Thickness	Minimum Value	10.00	ft	3.05	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Likeliest Value	38.71	ft	11.80	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Maximum Value	63.50	ft	19.36	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Standard deviation	11.84	ft	3.61	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Count	24	#	24	#	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Coefficient of Variation	30.59	%	30.59	%	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Skew	-0.61	-	-0.61	-	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Distribution	Normal	-	Normal	-	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Correlation pair	None	-	None	-	Assumed none
	Correlation coefficient	NA	-	NA	-	NA
Hydraulic Conductivity	Minimum Value	1.00E-04	ft/day	1.27E-06	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Likeliest Value	1.93E+04	ft/day	2.46E+02	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Maximum Value	8.50E+05	ft/day	1.08E+04	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Standard deviation	1.09E+05	ft/day	1.38E+03	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Count	62	#	62	#	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Coefficient of Variation	563.17	%	563.17	%	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Skew	7.53	-	7.53	-	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
Hydraulic Conductivity	Minimum Value	75.00	ft/day	0.95	m/hr	[a] PGDP Groundwater flow model
	Likeliest Value	966.85	ft/day	12.28	m/hr	[a] PGDP Groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	[a] PGDP Groundwater flow model
	Standard deviation	628.74	ft/day	7.99	m/hr	[a] PGDP Groundwater flow model
	Count	12166	#	12166	#	[a] PGDP Groundwater flow model
	Coefficient of Variation	65.03	%	65.03	%	[a] PGDP Groundwater flow model
	Skew	-0.35	-	-0.35	-	[a] PGDP Groundwater flow model
Hydraulic Conductivity	Minimum Value	75.00	ft/day	0.95	m/hr	[a,b] Minimum of the site-specific (to PGDP) groundwater flow model
	Likeliest Value	350.00	ft/day	4.45	m/hr	[a,b] Assumed approximate geomean of the minimum and maximum of the site-specific (to PGDP) groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	[a,b] Maximum of the site-specific (to PGDP) groundwater flow model
	Standard deviation	350.00	ft/day	4.45	m/hr	[a,b] Assumed equal to likeliest value
	Coefficient of Variation	100.00	%	100.00	%	[a,b] Assumed equal to likeliest value
	Distribution	Log normal	-	Log normal	-	BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Correlation pair	Hydraulic Conductivity and Porosity	-	Hydraulic Conductivity and Porosity	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA
Hydraulic Gradient	Minimum Value	1.00E-04	ft/ft	1.00E-04	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Likeliest Value	1.01E-03	ft/ft	1.01E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Maximum Value	4.00E-03	ft/ft	4.00E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Standard deviation	1.12E-03	ft/ft	1.12E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Count	12	#	12	#	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Coefficient of Variation	110.89	%	110.89	%	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Skew	1.95	-	1.95	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Distribution	Normal	-	Normal	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
Hydraulic Gradient	Correlation pair	Hydraulic Conductivity and Hydraulic Gradient	-	Hydraulic Conductivity and Hydraulic Gradient	-	Assumed

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
	Correlation coefficient	-0.50	-	-0.50	-	Assumed
Porosity ^{c}	Minimum Value	27.00	%	27.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Likeliest Value	39.11	%	39.11	%	DOE 1997a, DOE 1999a, DOE 1999c
	Maximum Value	54.00	%	54.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Standard deviation	5.98	%	5.98	%	DOE 1997a, DOE 1999a, DOE 1999c
	Count	28	#	28	#	DOE 1997a, DOE 1999a, DOE 1999c
	Coefficient of Variation	15.29	%	15.29	%	DOE 1997a, DOE 1999a, DOE 1999c
	Skew	0.43	-	0.43	-	DOE 1997a, DOE 1999a, DOE 1999c
	Distribution	Normal	-	Normal	-	DOE 1997a, DOE 1999a, DOE 1999c
	Correlation pair	Hydraulic Gradient and Porosity	-	Hydraulic Gradient and Porosity	-	Assumed
	Correlation coefficient	-0.20	-	-0.20	-	Assumed
Organic Carbon Content	Minimum Value	0.003	%	0.003	%	KY 1992a, DOE 1997a, BJC 2006
	Likeliest Value	0.035	%	0.035	%	KY 1992a, DOE 1997a, BJC 2006
	Maximum Value	0.253	%	0.253	%	KY 1992a, DOE 1997a, BJC 2006
	Standard deviation	0.037	%	0.037	%	KY 1992a, DOE 1997a, BJC 2006
	Count	38	#	38	#	KY 1992a, DOE 1997a, BJC 2006
	Coefficient of Variation	1.05	%	1.05	%	KY 1992a, DOE 1997a, BJC 2006
	Skew	4.00	-	4.00	-	KY 1992a, DOE 1997a, BJC 2006
	Distribution	Log normal	-	Log normal	-	KY 1992a, DOE 1997a, BJC 2006
	Correlation pair	None	-	None	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

		SWMU 1 and C-720 Building				
Input Parameter	**Statistics**	**Crystal Ball**	**Unit**	**AT123D**	**Unit**	**Remark**
Degradation Half-Life	Minimum Value	3.2	yr	NA	-	[d] See Attachment F.3
	Likeliest Value	NA	-	NA	-	NA
	Maximum Value	11.3	yr	NA	-	[d] See Attachment F.3
	Standard deviation	NA	-	NA	-	NA
	Count	NA	-	NA	-	NA
	Coefficient of Variation	NA	-	NA	-	NA
	Skew	NA	-	NA	-	NA
	Distribution	Uniform	-	NA	-	[d] See Attachment F.3
	Correlation pair	Hydraulic Gradient and Degradation Rate	-	NA	-	Assumed
	Correlation coefficient	-1.00	-	NA	-	[d] See Attachment F.3
Degradation Rate	Minimum Value	NA	-	7.01E-06	/hr	[d] See Attachment F.3
	Likeliest Value	NA	-	NA	-	NA
	Maximum Value	NA	-	2.45E-05	/hr	[d] See Attachment F.3
	Standard deviation	NA	-	NA	-	NA
	Count	NA	-	NA	-	NA
	Coefficient of Variation	NA	-	NA	-	NA
	Skew	NA	-	NA	-	NA
	Distribution	NA	-	Uniform	-	[d] See Attachment F.3
	Correlation pair	NA	-	Hydraulic Gradient and Degradation Rate	-	Assumed
	Correlation coefficient	NA	-	-1.00	-	[d] See Attachment F.3

[a] Multiple values were noted.

[b] The value selected for probabilistic method.

[c] Field observation was available for porosity. Therefore, effective porosity was estimated from porosity.

[d] Degradation rate was estimated from degradation half-life in units of hours using the formula: rate = [(ln 2)/degradation half-life].

BJC 2001a. C-746-U Solid Waste Landfill Groundwater Monitoring Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-205/R1, December.

BJC 2001b. Groundwater Monitoring Plan for the C-746-S Residential Landfill Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-268/R1, December.

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

		SWMU 1 and C-720 Building				
Input Parameter	**Statistics**	**Crystal Ball**	**Unit**	**AT123D**	**Unit**	**Remark**

BJC 2006.

DOE 1995. *Northeast Plume Preliminary Characterization Summary Report,* DOE/OR/07-1339/V2 & D2, July.

DOE 1997a. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky*, DOE/OR/07-1549&D1, February.

DOE 1997b. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/06-1628&D0, August.

DOE 1999a. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V1&D2, May.

DOE 1999b. R*emedial Investigation Report for Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/07-1777V1&D2, June.

DOE 1999c. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V2&D2, May.

DOE 2000a. *Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1845/D1, January.

DOE 2000b. *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky*, DOE/OR/07-1895/V2&D1, September.

DOE 2004. *Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-2180&D0, October.

KY 1992a. R*eport of the Paducah Gaseous Diffusion Plan Groundwater Investigation Phase III*, KY/E-150, November 25.

KY 1992b. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant*, KY/SUB/13B-97777C P-03/1991/1, April.

KY 1997. *Analysis and Interpretation of Water Levels in Observations Wells at the Paducah Gaseous Diffusion Plant 1990-1997,* KY/EM-210, June 30.

Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for Source Term development and AT123D modeling (see Table F.50)

Input Parameter	[c] Statistics	Unit	SWMU 1 and C-720 Building
Aquifer Depth	Minimum	m	3.38
	Median	m	11.30
	Maximum	m	18.50
	Arithmetic Mean	m	10.90
	[c] Standard Deviation	m	3.44
Hydraulic Conductivity	Minimum	m/hr	0.97
	Median	m/hr	3.54
	Maximum	m/hr	17.60
	Arithmetic Mean	m/hr	4.77
	[c] Standard Deviation	m/hr	3.70
Hydraulic Gradient	Minimum	m/m	1.63E-04
	Median	m/m	1.37E-03
	Maximum	m/m	3.98E-03
	Arithmetic Mean	m/m	1.49E-03
	[c] Standard Deviation	m/m	9.20E-04
Porosity	[a] Minimum	%	27.16
	Median	%	38.27
	Maximum	%	53.09
	Arithmetic Mean	%	39.51
	[c] Standard Deviation	%	6.17
Effective Porosity	[a] Minimum	-	0.22
	Median	-	0.31
	Maximum	-	0.43
	Arithmetic Mean	-	0.32
	[c] Standard Deviation	-	0.05
Organic Carbon Content	Minimum	%	0.003
	Median	%	0.024
	Maximum	%	0.228
	Arithmetic Mean	%	0.034
	[c] Standard Deviation	%	0.034
Degradation Half-Life	[b] Minimum	yr	3.2
	Median	yr	4.9
	Maximum	yr	11.3
	Arithmetic Mean	yr	4.9
	[c] Standard Deviation	yr	NA
Degradation Rate	[b] Minimum	/hr	7.20E-06
	Median	/hr	1.62E-05
	Maximum	/hr	2.45E-05
	Arithmetic Mean	/hr	1.61E-05
	[c] Standard Deviation	/hr	NA

Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for AT123D modeling (see Table F.50) (continued)

Input Parameter	[c] Statistics	Unit	SWMU 1 and C-720 Building
Groundwater Concentration in the RGA[c]	Minimum	μg/L	2.92
	Median	μg/L	362.7
	Maximum	μg/L	25311
	Arithmetic Mean	μg/L	2138.6
	[c] Standard Deviation	μg/L	4534.8
Total Soil Concentration Derived from Groundwater Concentrations[c]	Minimum	mg/kg	7.25E-04
	Median	mg/kg	9.73E-02
	Maximum	mg/kg	5.68E+00
	Arithmetic Mean	mg/kg	5.72E-01
	[c] Standard Deviation	mg/kg	1.18E+00

[a] Effective porosity was estimated from porosity (see text).

[b] Degradation rate was estimated from degradation half-life in units of hours using the formula: rate = [(ln 2)/degradation half-life].

[c] This parameter was only used for secondary source term modeling.

Table F.2.10. Qualitative sensitivity of modeling results to input parameters for the Southwest Plume SI Report

Input Parameter	Degree of sensitivity Low	Medium	High
Bulk density	√		
Effective porosity		√	
Horizontal hydraulic conductivity in the RGA		√	
Vertical hydraulic conductivity in the UCRS	√		
Percolation rate		√	
Horizontal hydraulic gradient in the RGA		√	
Aquifer thickness	√		
Longitudinal dispersivity	√		
Soil-water partition coefficient (K_d)			√
Fraction of organic carbon (%)			√
Biodegradation half-life			√
Molecular diffusion	√		
Source Area		√	
Source term in the UCRS			√

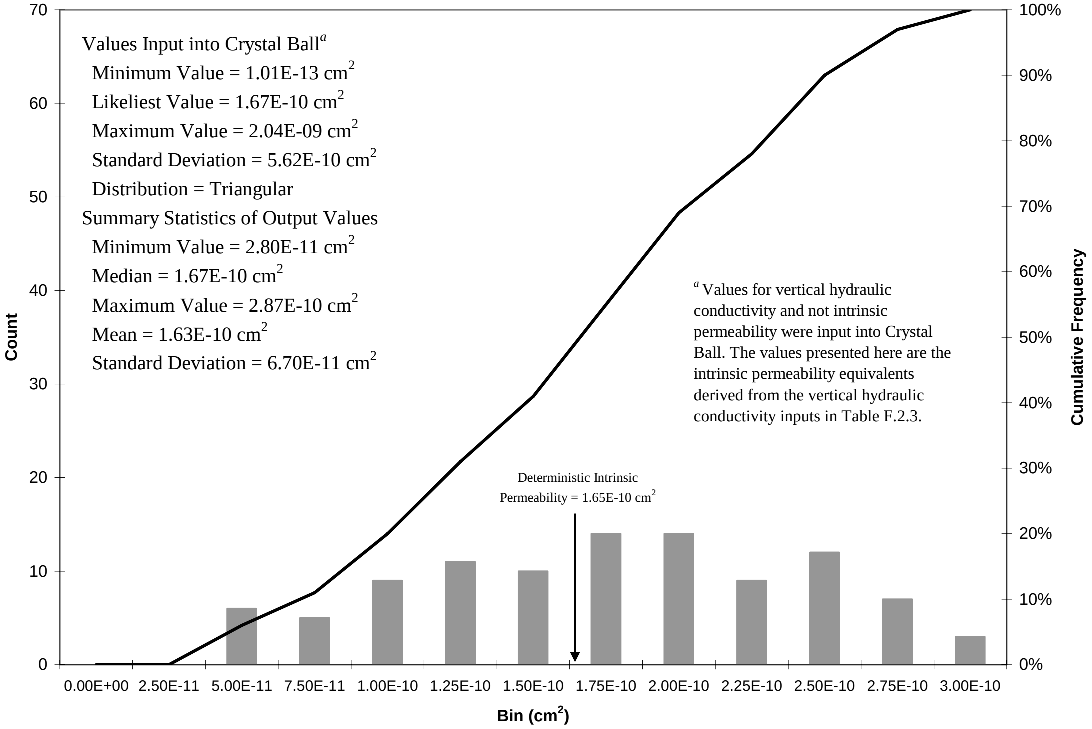
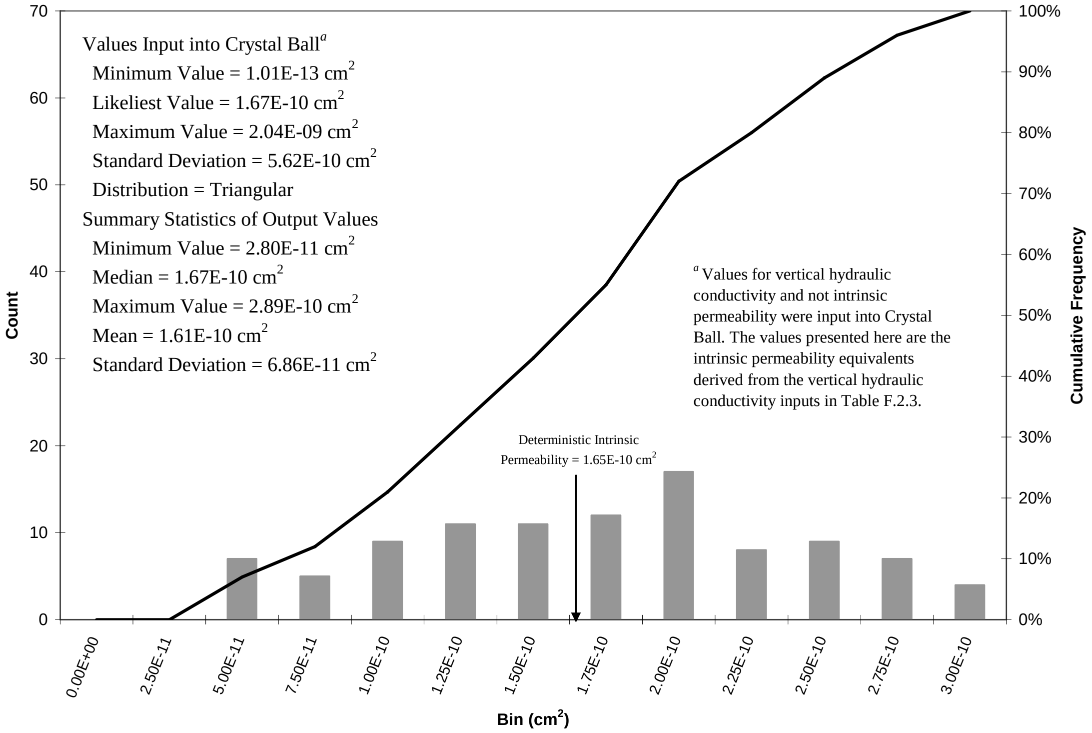


Fig. F.2.1. Histogram of Intrinsic Permeability SESOIL inputs for SWMU 1.

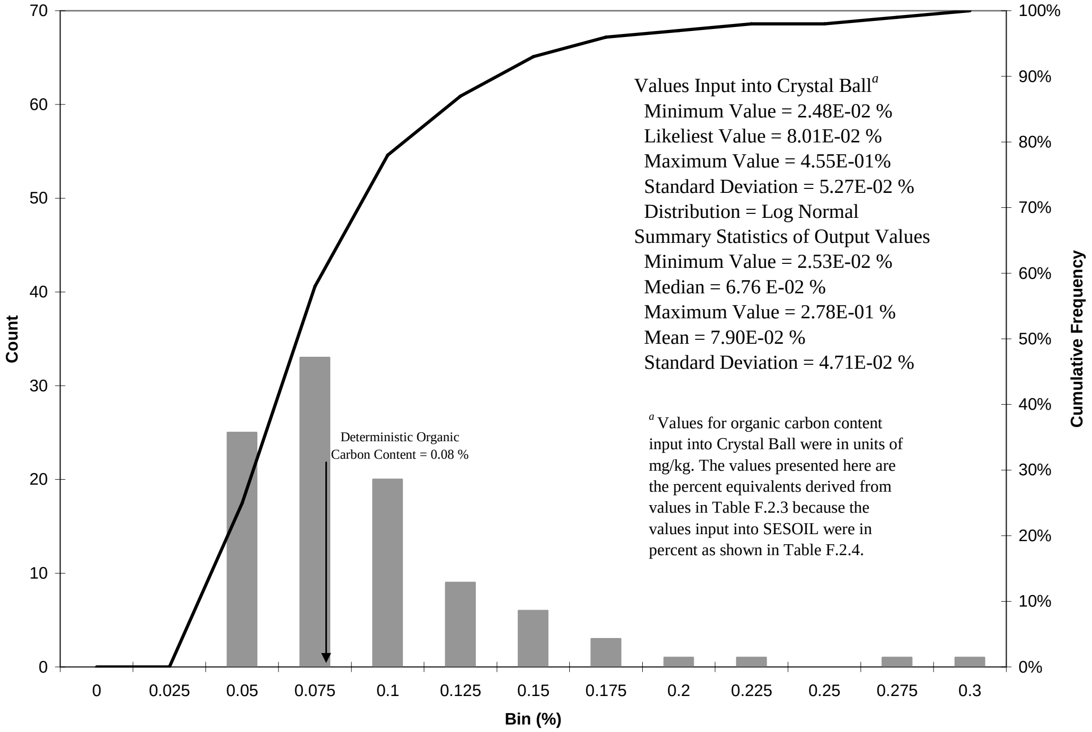


Values Input into Crystal Ball[a]
Minimum Value = 1.01E-13 cm^2
Likeliest Value = 1.67E-10 cm^2
Maximum Value = 2.04E-09 cm^2
Standard Deviation = 5.62E-10 cm^2
Distribution = Triangular
Summary Statistics of Output Values
Minimum Value = 2.80E-11 cm^2
Median = 1.67E-10 cm^2
Maximum Value = 2.89E-10 cm^2
Mean = 1.61E-10 cm^2
Standard Deviation = 6.86E-11 cm^2

Deterministic Intrinsic Permeability = 1.65E-10 cm^2

[a] Values for vertical hydraulic conductivity and not intrinsic permeability were input into Crystal Ball. The values presented here are the intrinsic permeability equivalents derived from the vertical hydraulic conductivity inputs in Table F.2.3.

Fig. F.2.2. Histogram of Intrinsic Permeability SESOIL inputs for the C-720 Area.

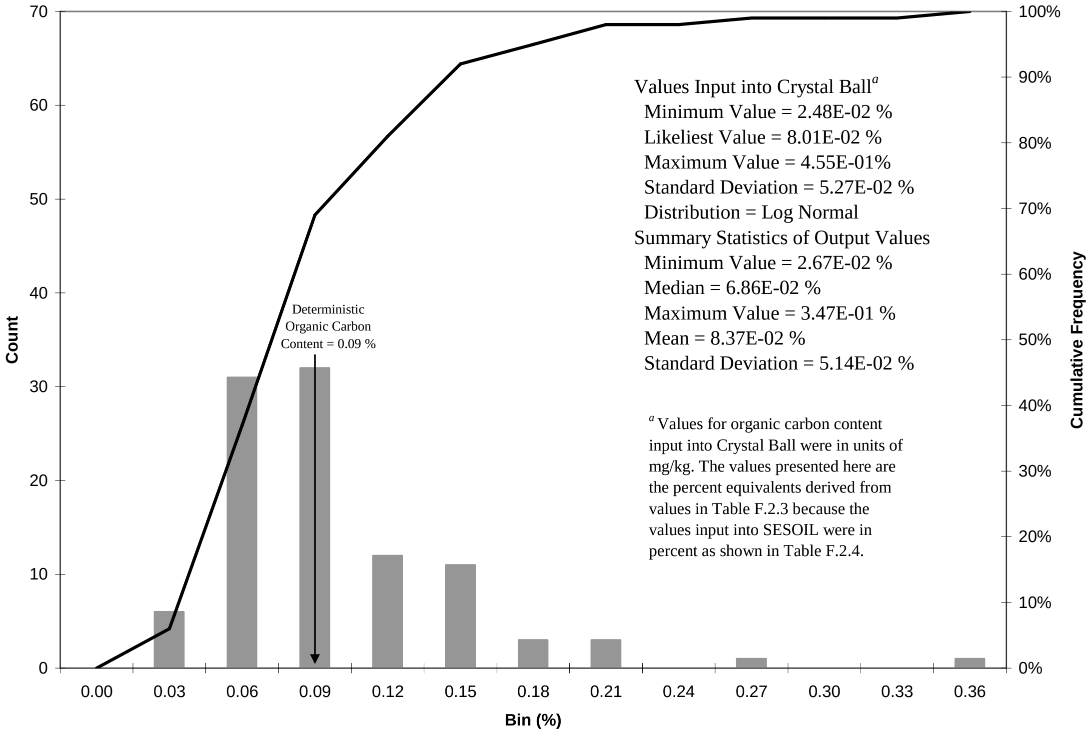


Values Input into Crystal Ball[a]
Minimum Value = 2.48E-02 %
Likeliest Value = 8.01E-02 %
Maximum Value = 4.55E-01%
Standard Deviation = 5.27E-02 %
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 2.53E-02 %
Median = 6.76 E-02 %
Maximum Value = 2.78E-01 %
Mean = 7.90E-02 %
Standard Deviation = 4.71E-02 %

Deterministic Organic Carbon Content = 0.08 %

[a] Values for organic carbon content input into Crystal Ball were in units of mg/kg. The values presented here are the percent equivalents derived from values in Table F.2.3 because the values input into SESOIL were in percent as shown in Table F.2.4.

Fig. F.2.3. Histogram of Organic Carbon Content SESOIL inputs for SWMU 1.

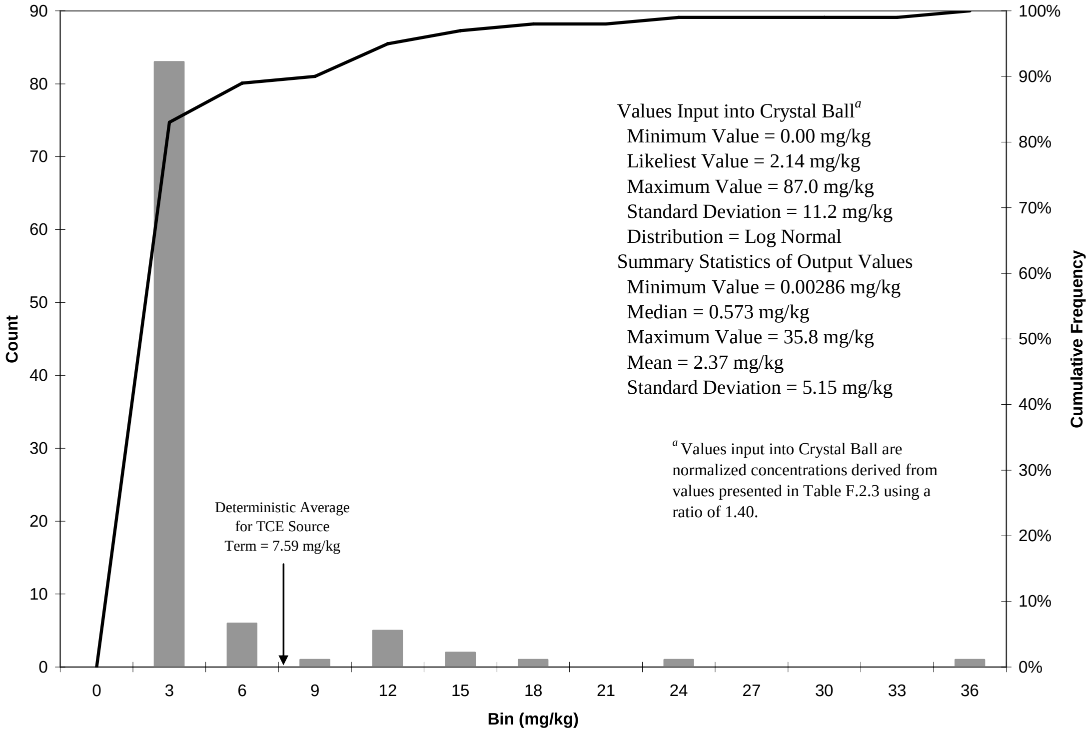


Deterministic Organic Carbon Content = 0.09 %

Values Input into Crystal Ball[a]
Minimum Value = 2.48E-02 %
Likeliest Value = 8.01E-02 %
Maximum Value = 4.55E-01%
Standard Deviation = 5.27E-02 %
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 2.67E-02 %
Median = 6.86E-02 %
Maximum Value = 3.47E-01 %
Mean = 8.37E-02 %
Standard Deviation = 5.14E-02 %

[a] Values for organic carbon content input into Crystal Ball were in units of mg/kg. The values presented here are the percent equivalents derived from values in Table F.2.3 because the values input into SESOIL were in percent as shown in Table F.2.4.

Fig. F.2.4. Histogram of Organic Carbon Content SESOIL inputs for the C-720 Area.

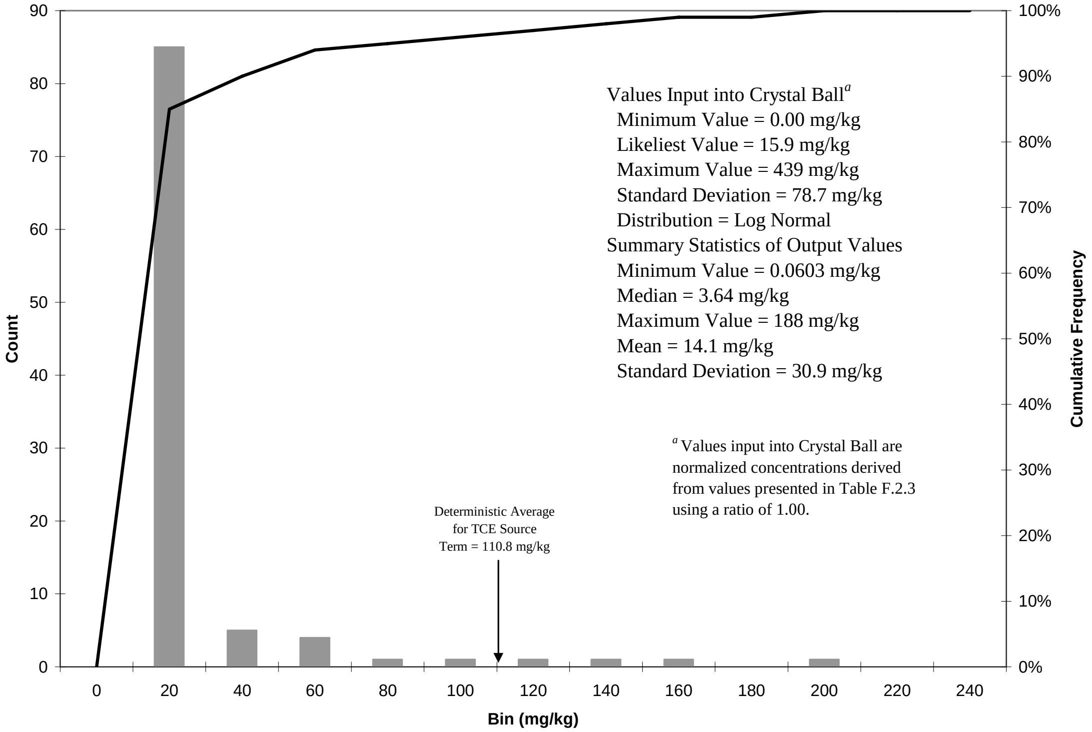


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 2.14 mg/kg
Maximum Value = 87.0 mg/kg
Standard Deviation = 11.2 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00286 mg/kg
Median = 0.573 mg/kg
Maximum Value = 35.8 mg/kg
Mean = 2.37 mg/kg
Standard Deviation = 5.15 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 1.40.

Deterministic Average for TCE Source Term = 7.59 mg/kg

Fig. F.2.5. Histogram of Layer 1 TCE concentrations at SWMU 1 used as SESOIL inputs.

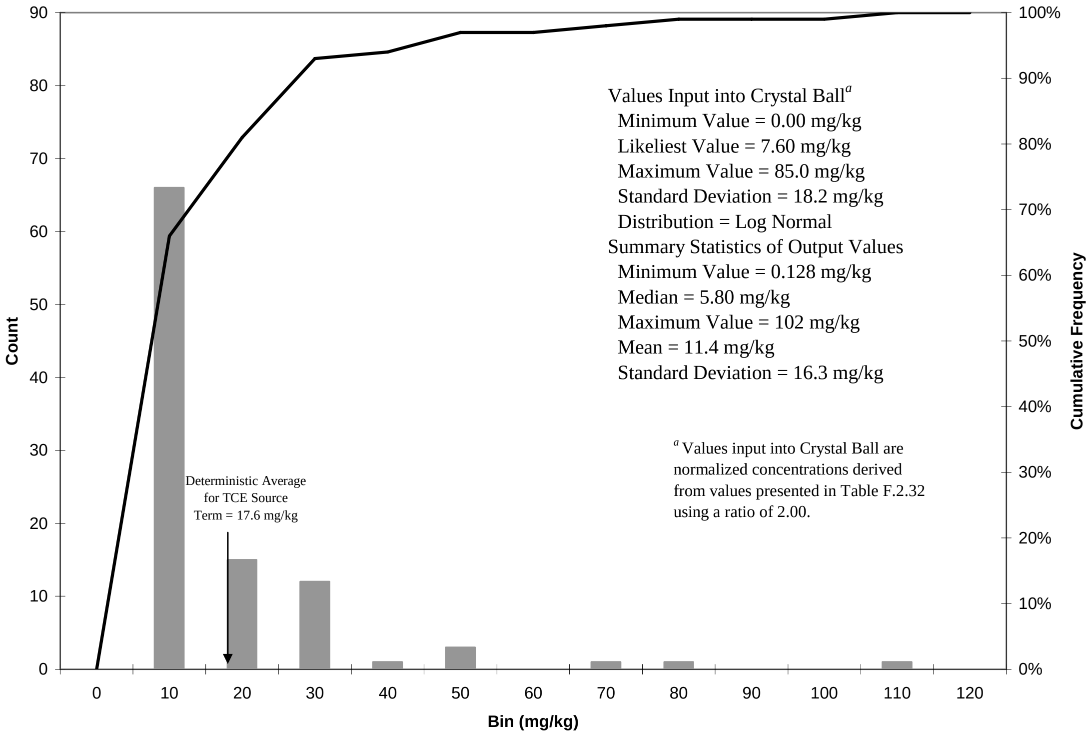


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 15.9 mg/kg
Maximum Value = 439 mg/kg
Standard Deviation = 78.7 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.0603 mg/kg
Median = 3.64 mg/kg
Maximum Value = 188 mg/kg
Mean = 14.1 mg/kg
Standard Deviation = 30.9 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 1.00.

Deterministic Average for TCE Source Term = 110.8 mg/kg

Fig. F.2.6. Histogram of Layer 2 TCE concentrations at SWMU 1 used as SESOIL inputs.

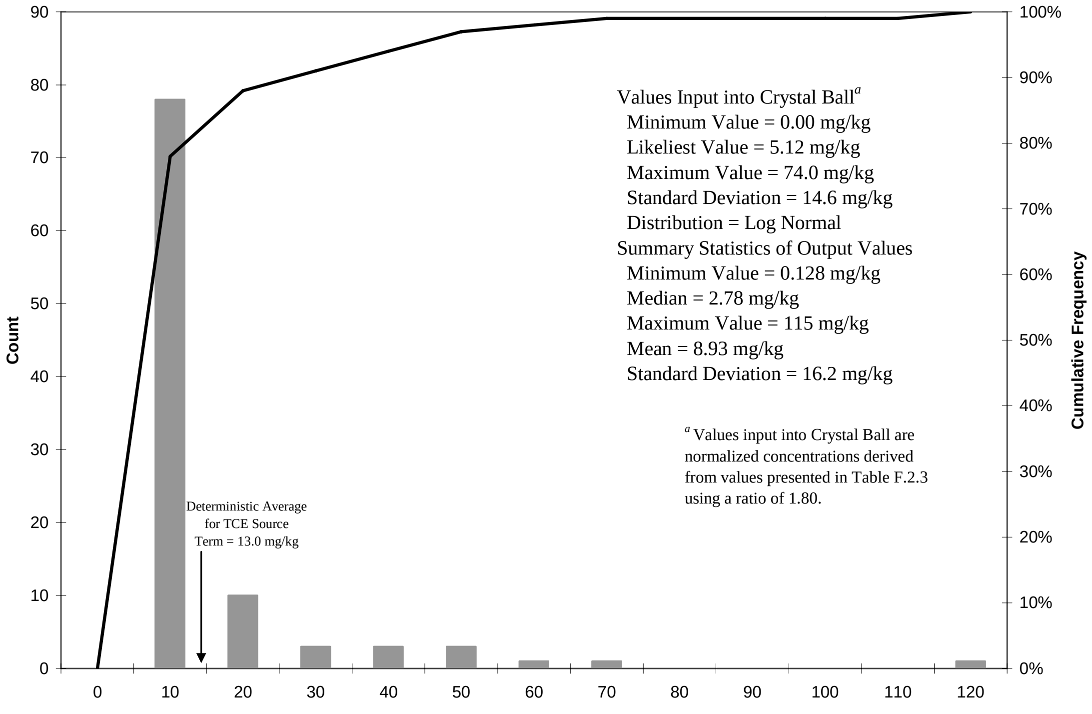


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 7.60 mg/kg
Maximum Value = 85.0 mg/kg
Standard Deviation = 18.2 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.128 mg/kg
Median = 5.80 mg/kg
Maximum Value = 102 mg/kg
Mean = 11.4 mg/kg
Standard Deviation = 16.3 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.32 using a ratio of 2.00.

Deterministic Average for TCE Source Term = 17.6 mg/kg

Fig. F.2.7. Histogram of Layer 3 TCE concentrations at SWMU 1 used as SESOIL inputs.



Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 5.12 mg/kg
Maximum Value = 74.0 mg/kg
Standard Deviation = 14.6 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.128 mg/kg
Median = 2.78 mg/kg
Maximum Value = 115 mg/kg
Mean = 8.93 mg/kg
Standard Deviation = 16.2 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 1.80.

Deterministic Average for TCE Source Term = 13.0 mg/kg

Fig. F.2.8. Histogram of Layer 4 TCE concentrations at SWMU 1 used as SESOIL inputs.

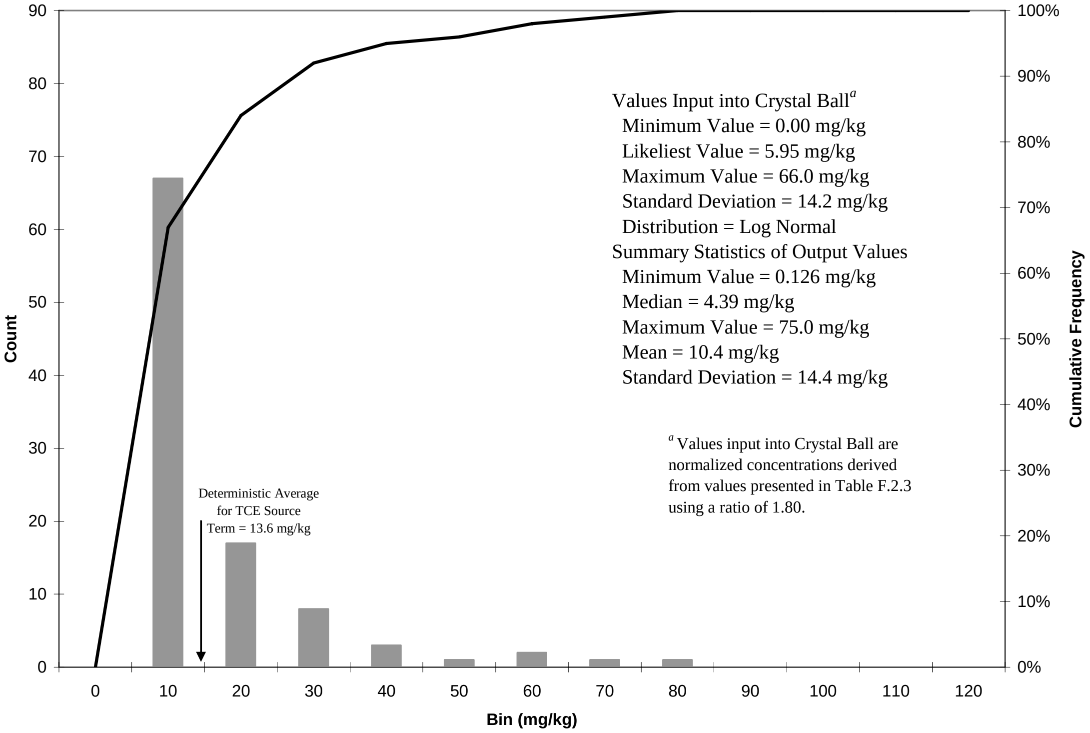


Fig. F.2.9. Histogram of Layer 5 TCE concentrations at SWMU 1 used as SESOIL inputs.

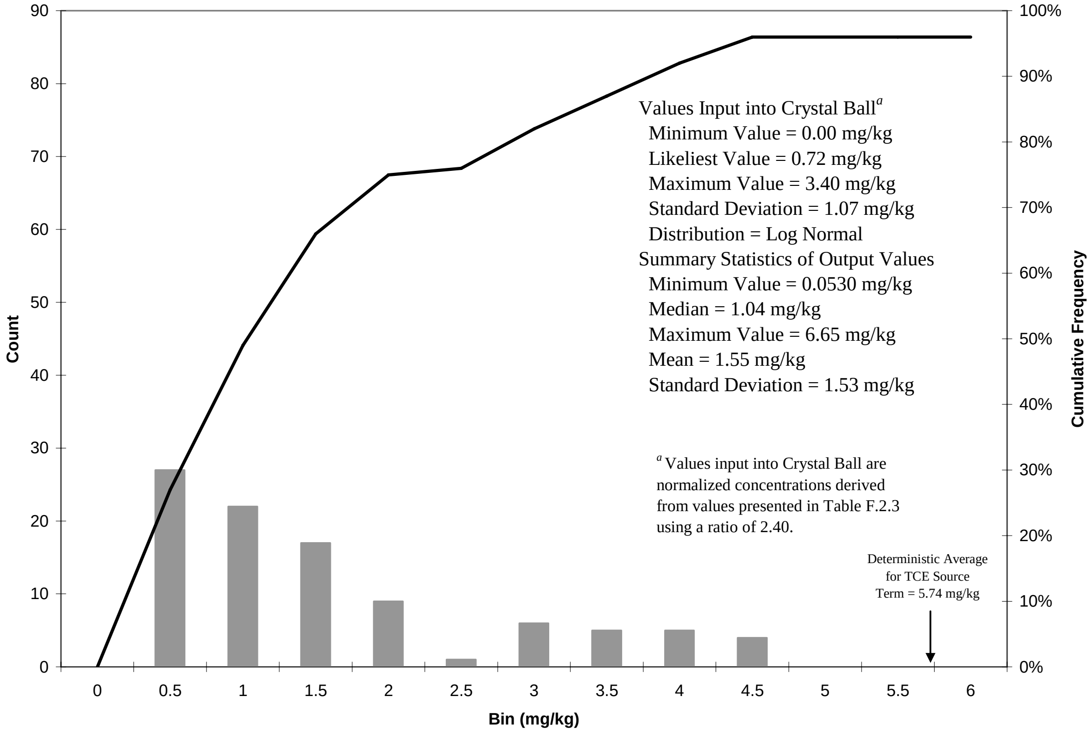
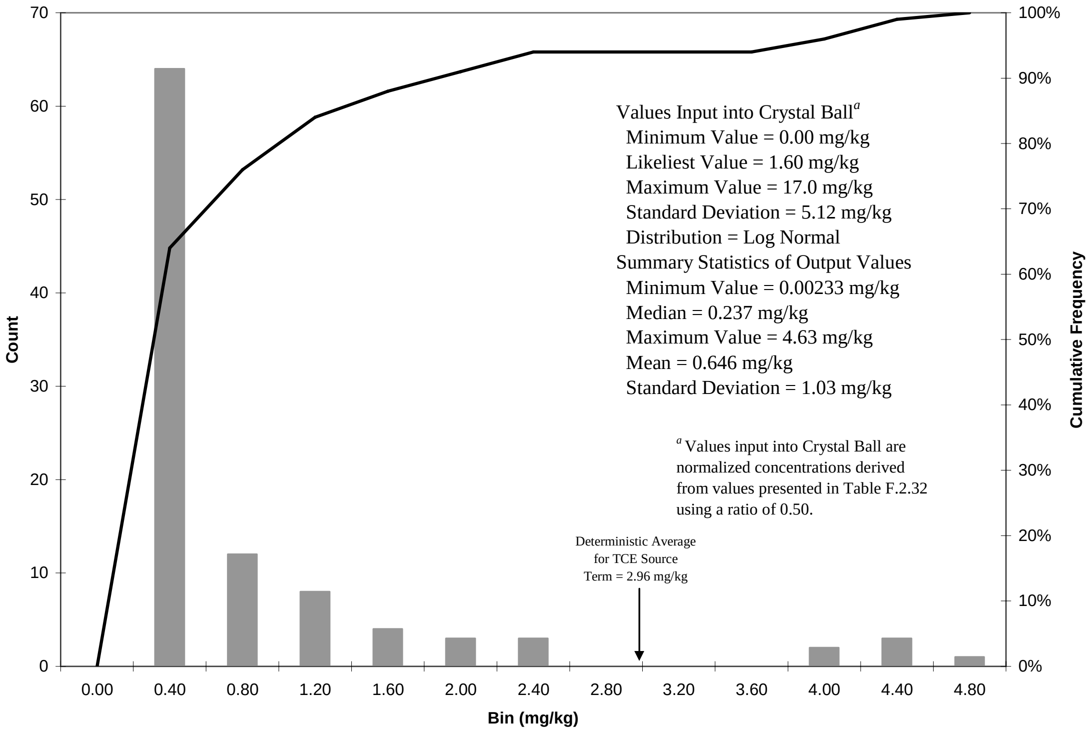


Fig. F.2.10. Histogram of Layer 6 TCE concentrations at SWMU 1 used as SESOIL inputs.

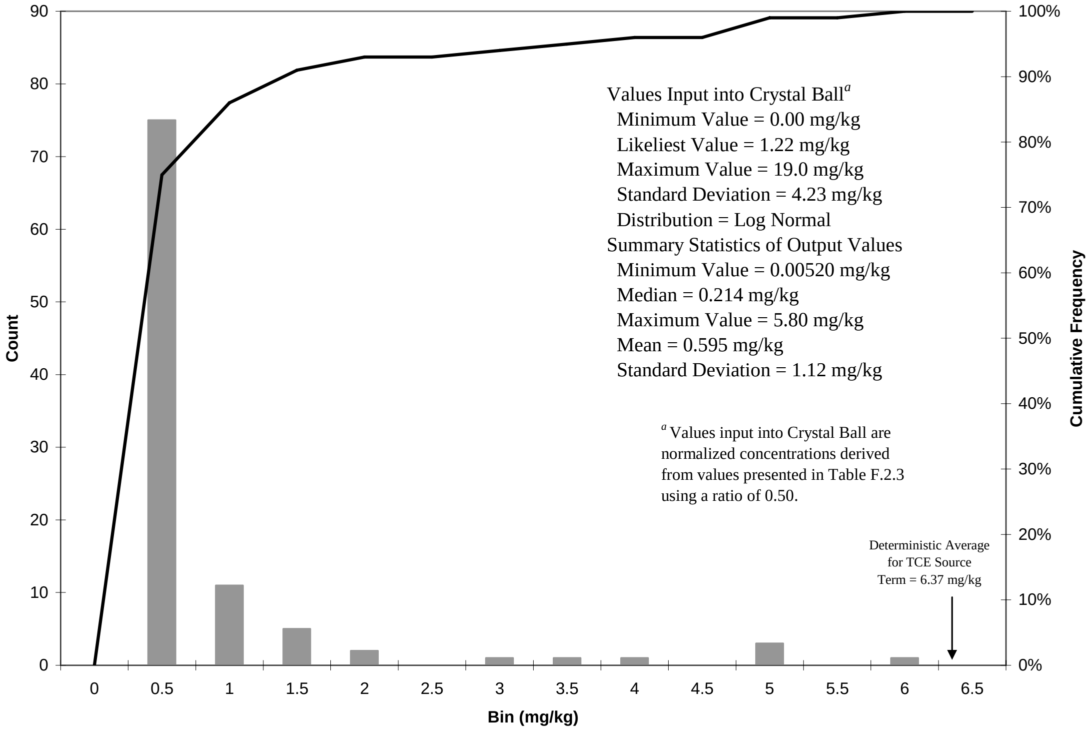


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 1.60 mg/kg
Maximum Value = 17.0 mg/kg
Standard Deviation = 5.12 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00233 mg/kg
Median = 0.237 mg/kg
Maximum Value = 4.63 mg/kg
Mean = 0.646 mg/kg
Standard Deviation = 1.03 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.32 using a ratio of 0.50.

Deterministic Average for TCE Source Term = 2.96 mg/kg

Fig. F.2.11. Histogram of Layer 1 TCE concentrations at C-720 Area used as SESOIL inputs.

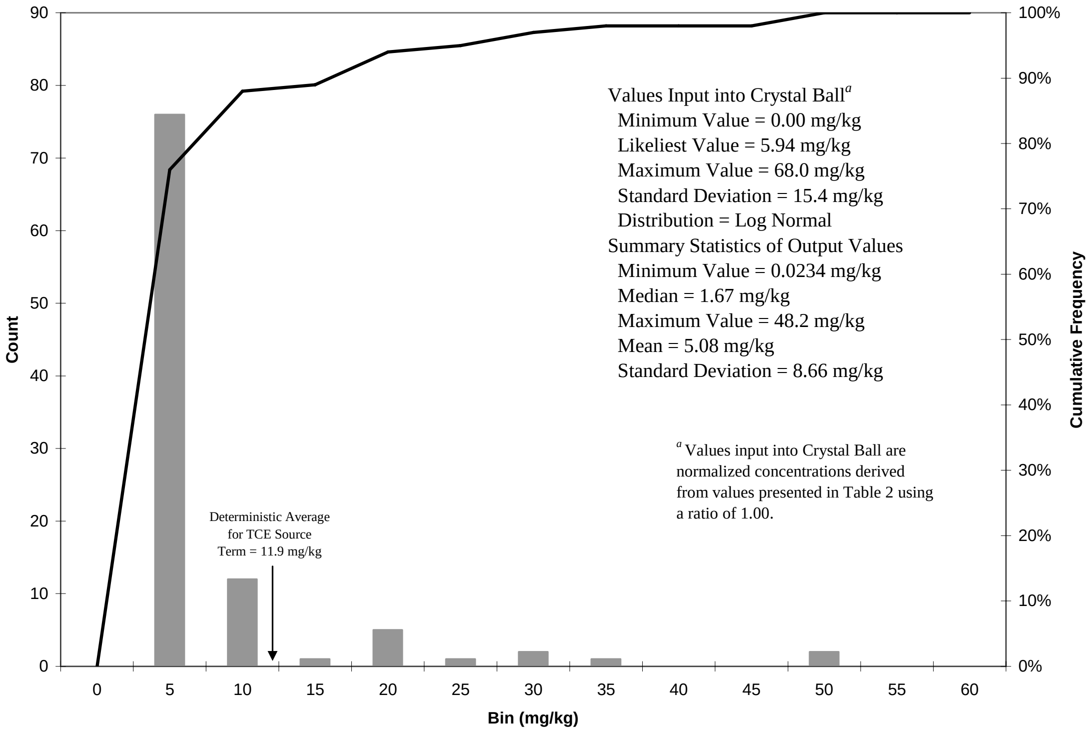


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 1.22 mg/kg
Maximum Value = 19.0 mg/kg
Standard Deviation = 4.23 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00520 mg/kg
Median = 0.214 mg/kg
Maximum Value = 5.80 mg/kg
Mean = 0.595 mg/kg
Standard Deviation = 1.12 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.50.

Deterministic Average for TCE Source Term = 6.37 mg/kg

Fig. F.2.12. Histogram of Layer 2 TCE concentrations at C-720 Area used as SESOIL inputs.

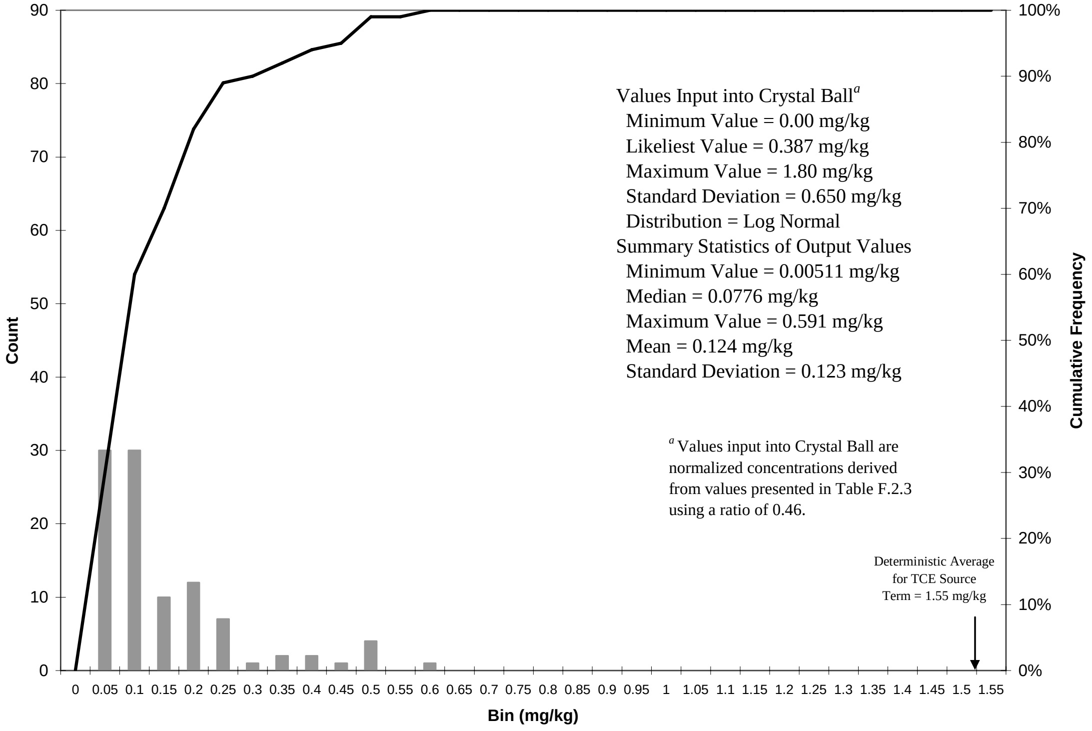


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 5.94 mg/kg
Maximum Value = 68.0 mg/kg
Standard Deviation = 15.4 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.0234 mg/kg
Median = 1.67 mg/kg
Maximum Value = 48.2 mg/kg
Mean = 5.08 mg/kg
Standard Deviation = 8.66 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table 2 using a ratio of 1.00.

Deterministic Average for TCE Source Term = 11.9 mg/kg

Fig. F.2.13. Histogram of Layer 3 TCE concentrations at C-720 Area used as SESOIL inputs.

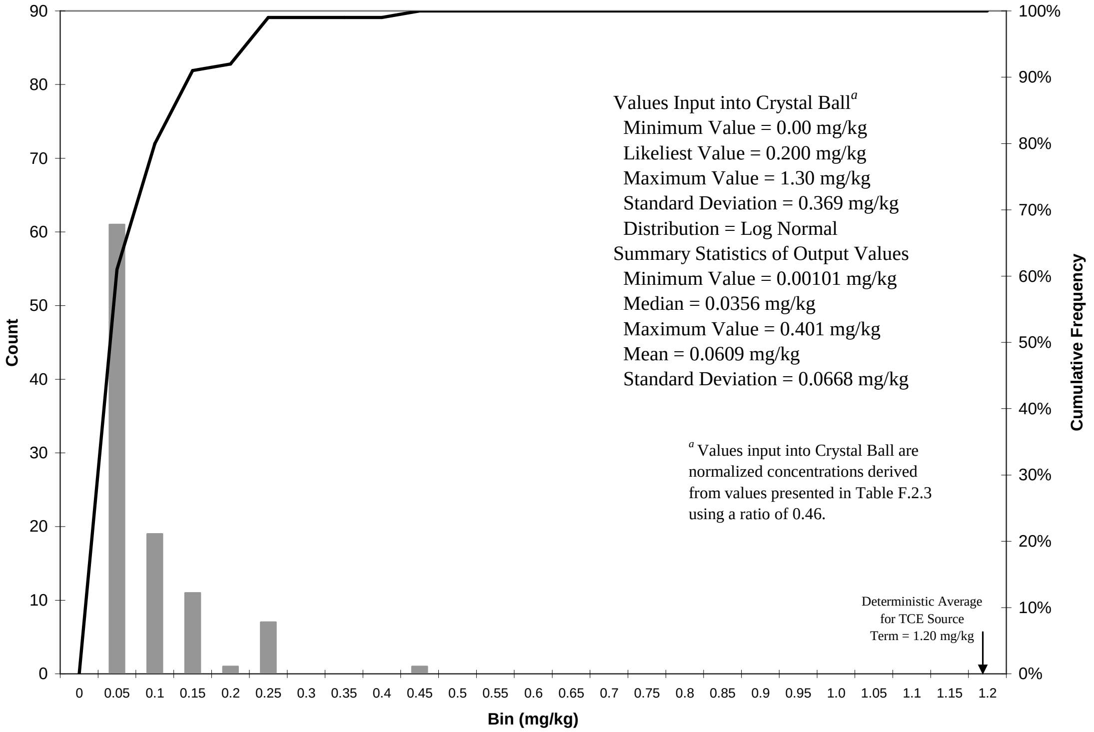


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.387 mg/kg
Maximum Value = 1.80 mg/kg
Standard Deviation = 0.650 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00511 mg/kg
Median = 0.0776 mg/kg
Maximum Value = 0.591 mg/kg
Mean = 0.124 mg/kg
Standard Deviation = 0.123 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 1.55 mg/kg

Fig. F.2.14. Histogram of Layer 4 TCE concentrations at C-720 Area used as SESOIL inputs.

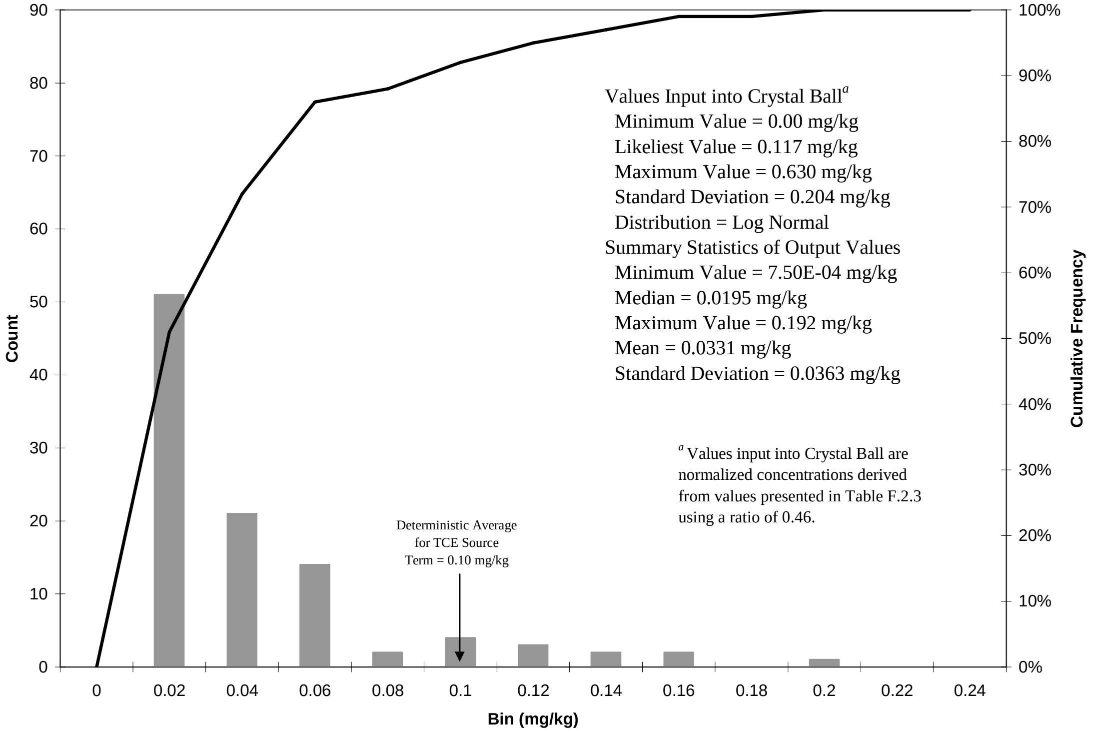


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.200 mg/kg
Maximum Value = 1.30 mg/kg
Standard Deviation = 0.369 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00101 mg/kg
Median = 0.0356 mg/kg
Maximum Value = 0.401 mg/kg
Mean = 0.0609 mg/kg
Standard Deviation = 0.0668 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 1.20 mg/kg

Fig. F.2.15. Histogram of Layer 5 TCE concentrations at C-720 Area used as SESOIL inputs.

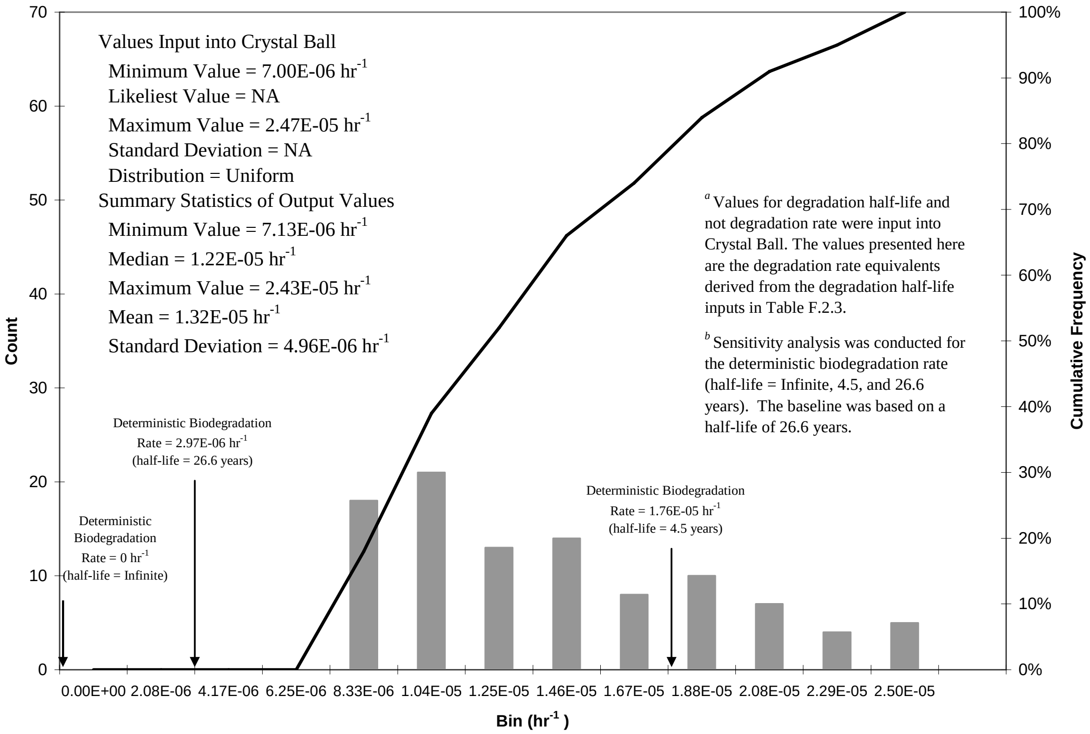


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.117 mg/kg
Maximum Value = 0.630 mg/kg
Standard Deviation = 0.204 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 7.50E-04 mg/kg
Median = 0.0195 mg/kg
Maximum Value = 0.192 mg/kg
Mean = 0.0331 mg/kg
Standard Deviation = 0.0363 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 0.10 mg/kg

Fig. F.2.16. Histogram of Layer 6 TCE concentrations at C-720 Area used as SESOIL inputs.



Values Input into Crystal Ball
Minimum Value = 7.00E-06 hr^{-1}
Likeliest Value = NA
Maximum Value = 2.47E-05 hr^{-1}
Standard Deviation = NA
Distribution = Uniform
Summary Statistics of Output Values
Minimum Value = 7.13E-06 hr^{-1}
Median = 1.22E-05 hr^{-1}
Maximum Value = 2.43E-05 hr^{-1}
Mean = 1.32E-05 hr^{-1}
Standard Deviation = 4.96E-06 hr^{-1}

Deterministic Biodegradation Rate = 0 hr^{-1} (half-life = Infinite)

Deterministic Biodegradation Rate = 2.97E-06 hr^{-1} (half-life = 26.6 years)

Deterministic Biodegradation Rate = 1.76E-05 hr^{-1} (half-life = 4.5 years)

[a] Values for degradation half-life and not degradation rate were input into Crystal Ball. The values presented here are the degradation rate equivalents derived from the degradation half-life inputs in Table F.2.3.

[b] Sensitivity analysis was conducted for the deterministic biodegradation rate (half-life = Infinite, 4.5, and 26.6 years). The baseline was based on a half-life of 26.6 years.

Fig. F.2.17. Histogram of Degradation Rate SESOIL inputs for SWMU 1.

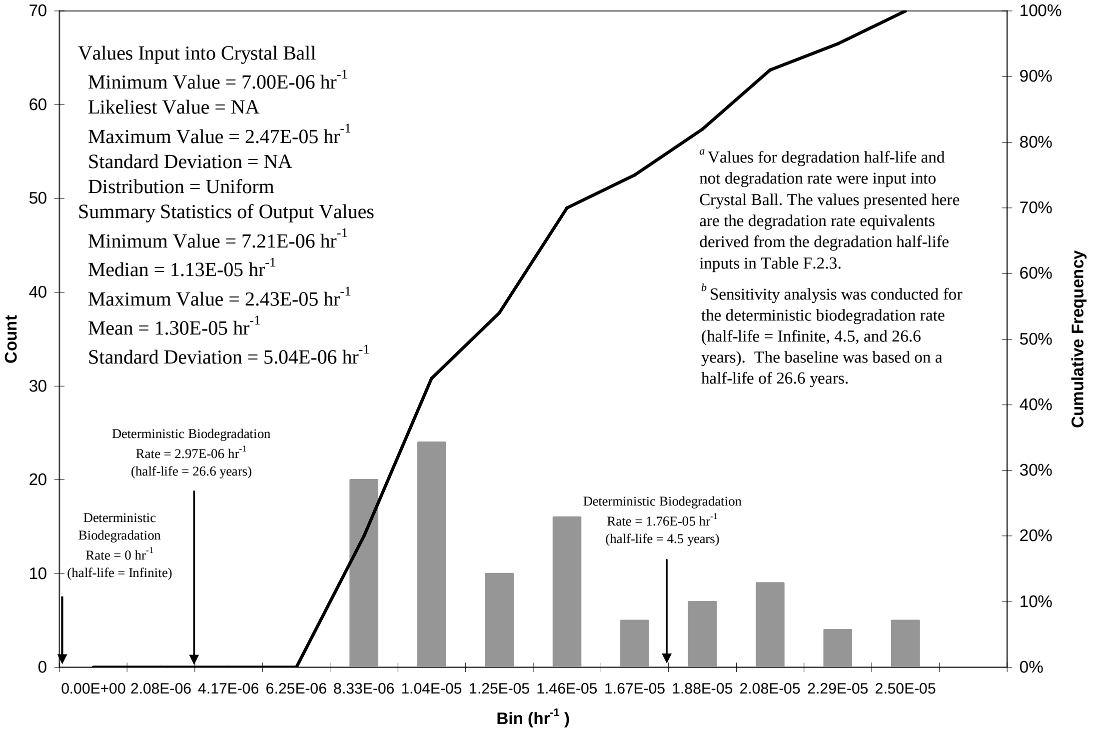


Fig. F.2.18. Histogram of Degradation Rate SESOIL inputs for C-720 Area.

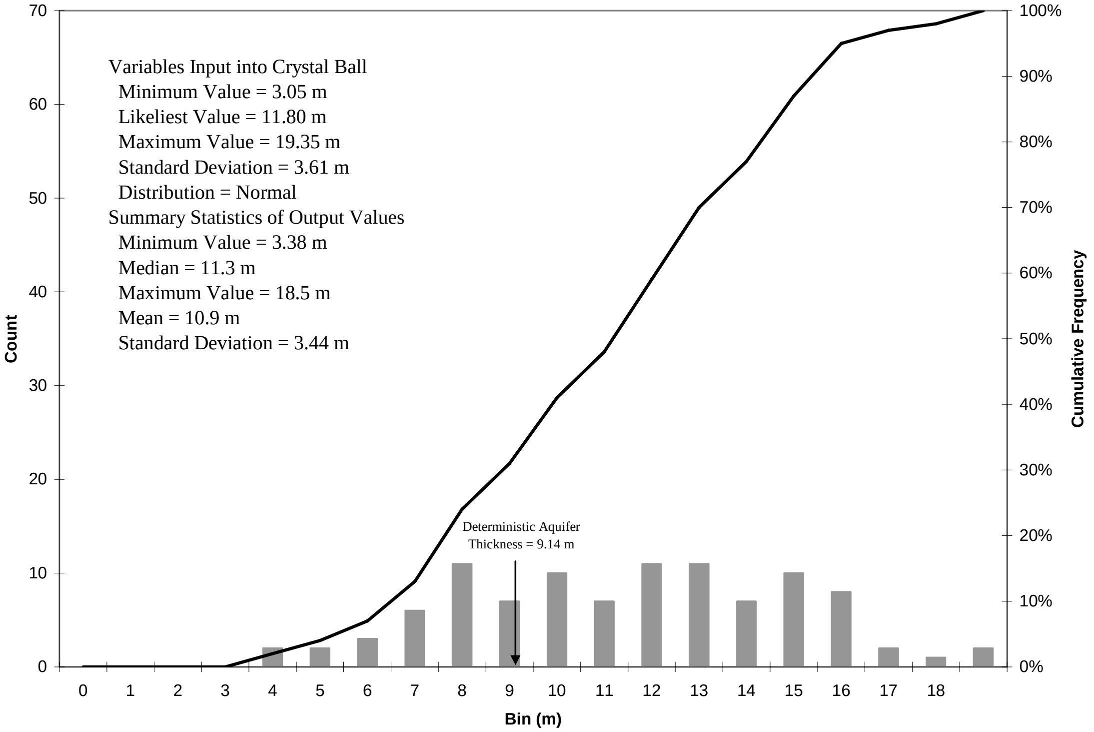
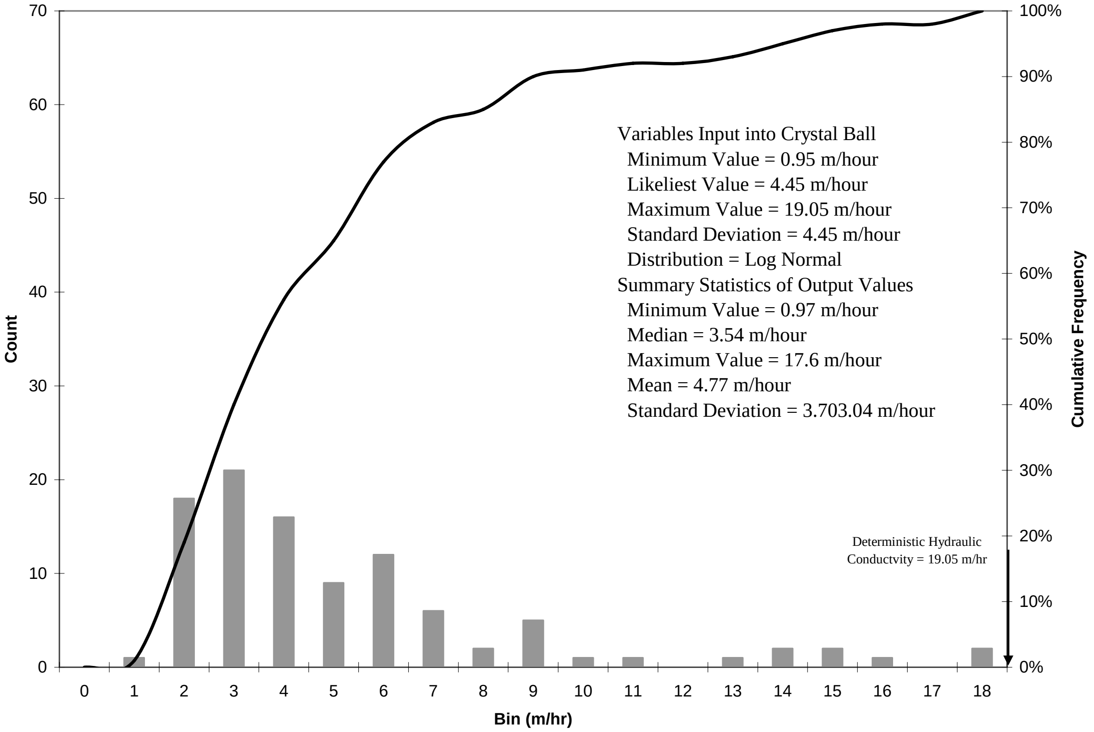


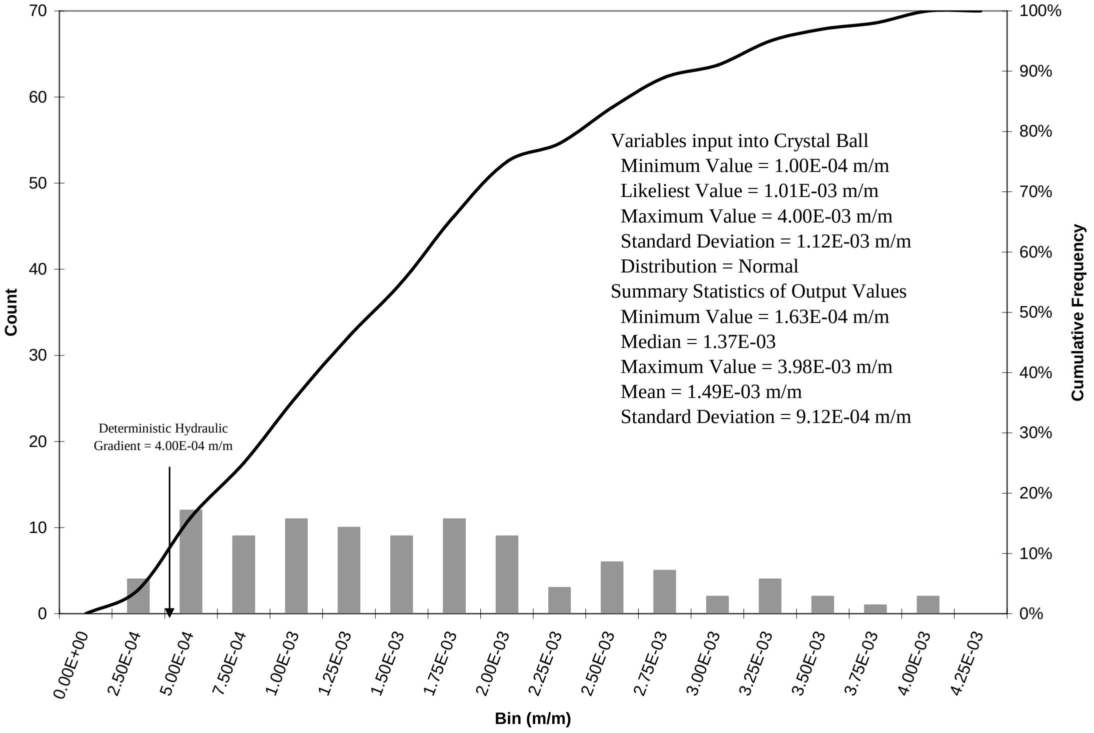
Fig. F.2.19. Histogram of Aquifer Thickness AT123D inputs for SWMU 1 and the C-720 Area.



Variables Input into Crystal Ball
Minimum Value = 0.95 m/hour
Likeliest Value = 4.45 m/hour
Maximum Value = 19.05 m/hour
Standard Deviation = 4.45 m/hour
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.97 m/hour
Median = 3.54 m/hour
Maximum Value = 17.6 m/hour
Mean = 4.77 m/hour
Standard Deviation = 3.703.04 m/hour

Deterministic Hydraulic
Conductvity = 19.05 m/hr

Fig. F.2.20. Histogram of Hydraulic Conductivity AT123D inputs for SWMU 1 and the C-720 Area.



Variables input into Crystal Ball
Minimum Value = 1.00E-04 m/m
Likeliest Value = 1.01E-03 m/m
Maximum Value = 4.00E-03 m/m
Standard Deviation = 1.12E-03 m/m
Distribution = Normal
Summary Statistics of Output Values
Minimum Value = 1.63E-04 m/m
Median = 1.37E-03
Maximum Value = 3.98E-03 m/m
Mean = 1.49E-03 m/m
Standard Deviation = 9.12E-04 m/m

Deterministic Hydraulic
Gradient = 4.00E-04 m/m

Fig. F.2.21. Histogram of Hydraulic Gradient AT123D inputs for SWMU 1 and the C-720 Area.

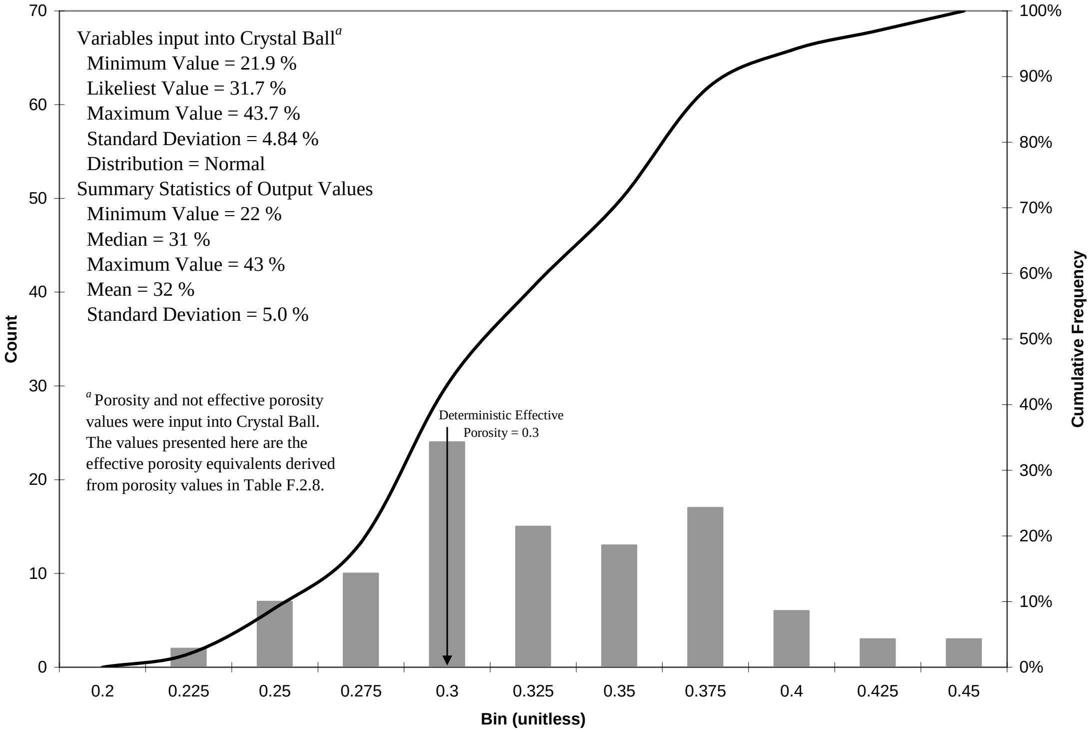


Fig. F.2.22. Histogram of Effective Porosity AT123D inputs for SWMU 1 and the C-720 Area.

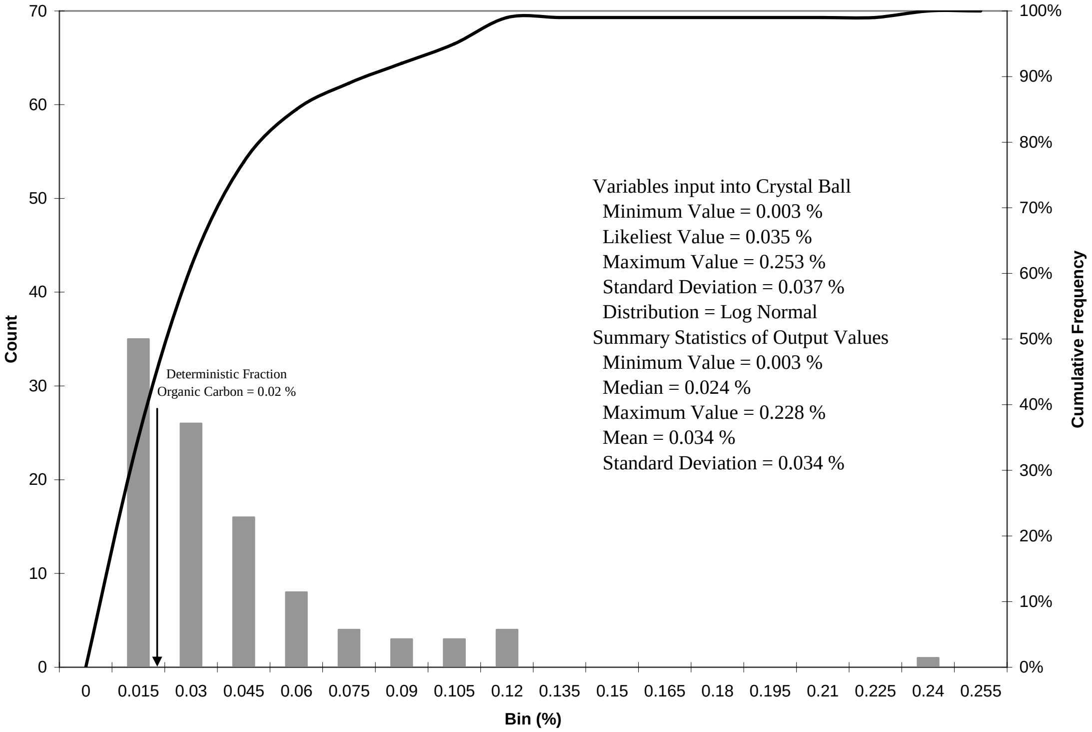


Fig. F.2.23. Histogram of Organic Carbon Content AT123D inputs for SWMU 1 and the C-720 Area.

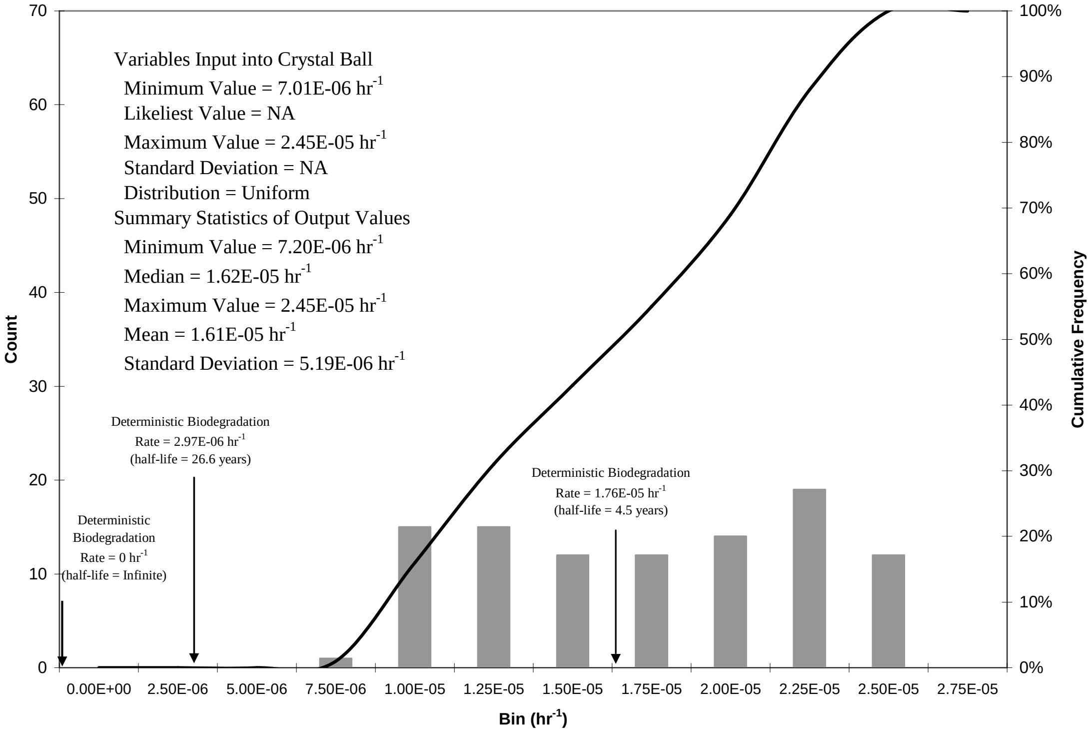


Fig. F.2.24. Histogram of Degradation Rate inputs for SWMU 1, and the C-720 Area.

E.6. LEAD-210 AT PGDP

Lead-210 is a radioactive form of lead, having an atomic weight of 210. It is one of the last elements created by the radioactive decay of the isotope uranium-238 (see Figure E.6). Lead-210 forms naturally in the sediments and rocks that contain uranium-238, as well as in the atmosphere, a by-product of radon gas. Within 10 days of its creation from radon, lead-210 falls out of the atmosphere. It accumulates on the surface of the earth where it is stored in soils, lake and ocean sediments, and glacial ice. The lead-210 eventually decays into a non-radioactive form of lead. Lead-210 has a half-life of 22.3 years and is a significant source of beta radiation (USGS 2012; EPA 2012).[1]

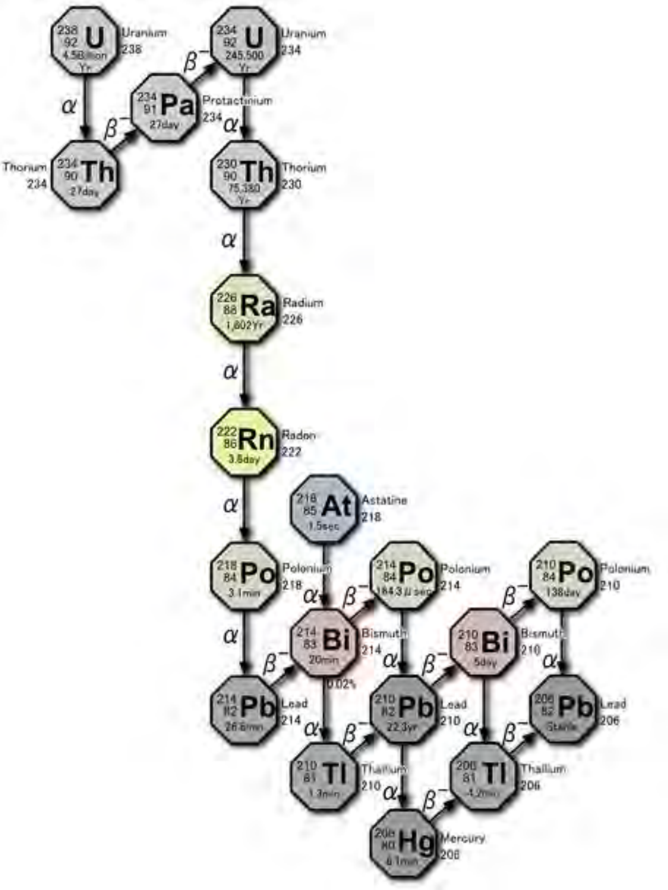


Figure E.6. Lead-210 Decay Chain

Lead-210 is not an easy analysis to perform and typically is not included in a regular gamma radiological scan; it has a peak at 46 KeV and requires a thin window detector and an efficiency curve using a standard with lead-210. Therefore, historical data was reviewed to ensure the analysis was necessary. Because lead-210 is found significantly down the decay chain for uranium-238 through radon-222, activities performed over the past 60 years at PGDP cannot have resulted in PGDP-sourced lead-210.

Available PGDP lead-210 data was plotted to estimate an approximate background value. This map is shown in Figure E.7. Because the majority of the available data is historical, data quality is not certain; however, it appears that the higher lead-210 activities within the PGDP boundaries are at background values.

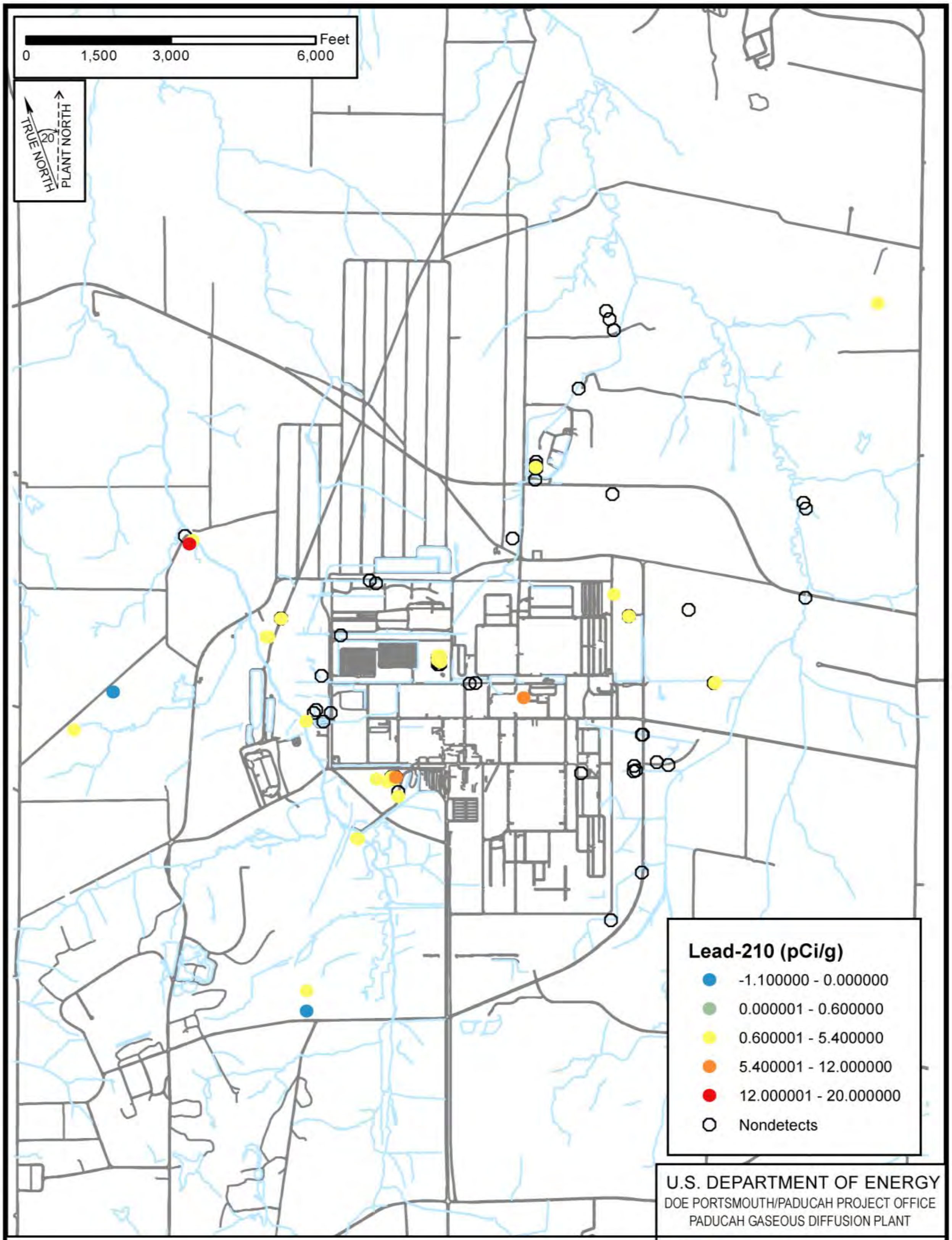


Figure E.7. Lead-210 Soil/Sediment Samples

LATA Environmental Services of Kentucky, LLC

Figure No. Lead-210_Soil.mxd
DATE 11-01-2012

Data indicate higher levels of lead-210 inside the PGDP boundary at SWMU 222, although radium-226 was not reported for the majority of these samples. The one sample that had radium-226 reported had a significant difference in activity between the radium-226 and its ingrowth radionuclides, lead-214 and bismuth-214. If radium-226 is truly at 11 pCi/g, as reported in that sample, and the analysis was conducted properly (ingrowth for 30 days in a sealed container), the lead-214 and bismuth-214 activity should have equaled the radium-226 activity. Under these analysis conditions the activity of lead-210 would not be in secular equilibrium with radium-226. The fact that the lead-210 is elevated in the samples suggests a possible separate source of lead-210 rather than ingrowth. Lead-210, which has a 22-year half-life, is included in the list of short-lived radionuclides associated with radium-226 for completeness, as this isotope and its short-lived decay products typically are present with radium-226.

After processing, radionuclides with half-lives of less than one year will reestablish equilibrium conditions with their longer-lived parent radionuclides within several years. For this reason, at processing sites what was once a single, long decay series (for example the series for uranium-238) may be present as several smaller decay series headed by the longer-lived decay products of the original series (that is, headed by uranium-238, uranium-234, thorium-230, radium-226, and lead-210 in the case of uranium-238). Each of these sub-series can be considered to represent a new, separate decay series. Understanding the physical and chemical processes associated with materials containing uranium, thorium, and radium is important when addressing associated radiological risks.

Detected lead-210 results available for PGDP were listed alongside radium-226 and uranium-238 results in Table E.4. Lead-210 would be expected to be in equilibrium (i.e., similar activity results) with uranium-238 for instances of natural uranium. Lead-210 would be expected to be in equilibrium with radium-226 for instances of enriched uranium. No split samples are available; however, a surrogate to a "split" could be simply looking at the uranium-238 to lead-210 ratio in samples, where available. For example, if lead-210 is a true contaminant, then it should exceed the uranium-238 level, when the uranium-238 is at background in at least some samples.

A further check of the available data was performed by filtering the activity results against minimum detectable activities and counting uncertainties. The only samples that passed both checks are shown in Table E.5. Recent Soils Operable Unit (OU) soils data passed both checks.

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
194-01,02	301043	9	LOCK	20.00	0.02			Yes					No	0.60		0.10		Yes
JP-0092	DOJ1-99-0092		PGDP	14.55	18.18	29.10	29.10	No	0.77	0.31	1.53	1.53	No	4386.00	4.20	89.00	1117.00	Yes
194-01,02	301048	20	LOCK	12.00	0.05			Yes					No	1.30		0.16		Yes
SWMU222-4	2010-53093[a]		KYRAD	10.60	2.05	1.03		Yes					No	27.80	1.62	1.12		Yes
SWMU222-4	2010-53093		KYRAD	10.60	2.05	1.03		Yes					No	27.80	0.03	2.33		Yes
SWMU222-5	2010-53094[b]		KYRAD	8.60	1.47	0.76		Yes					No	32.30	0.04	2.66		Yes
SWMU222-1	2010-53090[b]		KYRAD	8.44	1.71	0.87		Yes					No	23.70	0.13	2.10		Yes
194-01,02	301044	11.33	LOCK	8.00	0.03			Yes					No	0.61		0.11		Yes
SWMU222-2	2010-53091[b]		KYRAD	6.98	1.41	0.71		Yes					No	22.10	0.04	1.94		Yes
SWMU222-3	2010-53092[b]		KYRAD	6.81	1.14	0.61		Yes					No	16.70	0.03	1.51		Yes
SOU195-120A	2010-51253[a]	1	KYRAD	6.57	9.25	3.83		No	2.53	2.08	0.94		Yes	3.94	2.41	1.36		Yes
SOU195-014C	2010-51264[a]	10	KYRAD	6.01	5.28	2.16		Yes	1.44	1.27	0.57		Yes	2.25	0.93	0.84		Yes
194-01,02	301047	18.6	LOCK	5.40	0.00			Yes					No	0.90		0.13		Yes
SWMU222-1	2010-52457[b]		KYRAD	4.92	0.82	0.41		Yes					No	31.30	0.05	3.59		Yes
JP-0160	DOJ1-99-0160		PGDP	4.31	1.79	2.11	2.28	Yes	0.71	1.64	1.42	1.42	No	2.70	0.93	0.52	1.41	Yes
BCBOKYRAD01	2010-50535[a]		KYRAD	4.27	0.46	0.25		Yes	2.35	0.87	0.39		Yes	2.22	0.47	0.22		Yes
LBC2L020	LBCSOSU2S1-04	1	STLMO	4.20	2.00		1.70	Yes	0.80	0.21		0.25	Yes	3.90	1.50		1.40	Yes
RSO3	110013[c]		STLMO	3.90	1.90	1.90		Yes					No					No
JP-0152	DOJ1-99-0152		PGDP	3.76	5.96	7.52	7.52	No	0.84	0.12	1.69	1.69	No	208.00	0.04	3.30	42.00	Yes
H01,05,15	301025	0.7	LOCK	3.70	0.00			Yes					No	0.96		0.10		Yes
SOU195-014A	2010-51258[a]	10	KYRAD	3.56	5.07	2.13		No	1.40	1.10	0.50		Yes	1.54	0.90	0.79		Yes
RSO3	110012[c]		STLMO	3.50	1.40	1.20		Yes					No					No
BC5KYRAD01	2010-50537[a]		KYRAD	3.43	0.36	0.21		Yes	2.06	0.71	0.32		Yes	1.37	0.32	0.15		Yes
C12,18,19	301012[d]	2	LOCK	3.20	0.00			Yes					No	0.97		0.09		Yes
A10	PLDJNSA10-01SO	2.5	PGDP	3.10	5.90	6.20	6.20	No	0.16	0.07	0.01	0.08	Yes	6.60	0.05	0.35	0.89	Yes
LBC2L015	LBCSOSU2S1-03	1	STLMO	3.00	2.90		2.40	Yes	1.21	0.26		0.30	Yes	1.25	0.01		0.18	Yes
JP-0161	DOJ1-99-0161		PGDP	2.92	1.93	2.07	2.10	Yes	0.83	0.17	1.66	1.66	No	2.30	1.02	0.51	3.21	No
SOU200-004	2010-51270[a]	4	KYRAD	2.81	5.18	2.19		No	2.51	1.31	0.61		Yes	1.48	0.88	1.19		Yes
F04,02,29	301005	0.8	LOCK	2.80	0.00			Yes					No	0.82		0.08		Yes
SOU195-120C	2010-51252[a]	1	KYRAD	2.70	0.62	0.32		Yes	1.67	0.90	0.41		Yes	1.02	0.52	0.29		Yes
K008-AIP-RP	030301	0	STLMO	2.70	1.20	1.10		Yes					No	1.71	0.33	0.98		Yes
C07,08,09	301013[d]	0.9	LOCK	2.70	0.00			Yes					No	1.04		0.09		Yes
NST2S04	BJC2041SS	8	PGDP	2.65	2.40	2.50	2.60	Yes	2.43	0.33	4.85	4.85	No	4.11	1.24	0.66	2.11	Yes
SOU222-001	2010-51277[a]	0.5	KYRAD	2.57	0.59	0.76		Yes	11.10	1.30	0.71		Yes	19.62	0.76	0.65		Yes
BCBOKYRAD02	2010-50536[a]		KYRAD	2.51	0.71	0.33		Yes	7.18	1.17	0.56		Yes	10.26	0.87	0.46		Yes
F12,20,22	301004	1.5	LOCK	2.46	0.00			Yes					No	0.90		0.08		Yes
H04,06,09	301023	0.8	LOCK	2.45	0.00			Yes					No	0.84		0.09		Yes
JP-0019	DOJ1-99-0017		PGDP	2.44	16.16	4.87	10.54	No	1.06	0.29	2.11	2.11	No	2270.00	9.14	16.30	609.00	Yes
C12,18,19	301011[d]	0.8	LOCK	2.40	0.00			Yes					No	1.06		0.10		Yes
196-03,04	301038	6.67	LOCK	2.40	0.00			Yes					No	0.80		0.12		Yes
C01,10,24	301017[d]	0.7	LOCK	2.30	0.00			Yes					No	0.95		0.10		Yes
F05,07,17	301008	1.6	LOCK	2.20	0.00			Yes					No	0.86		0.09		Yes
C07,08,09	301015[d]	0.9	LOCK	2.09	0.00			Yes					No	1.00		0.10		Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID			Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
JP-0046	DOJ1-99-0046		PGDP	2.07	1.91	2.03	2.00	Yes	0.70	0.13	1.40	1.40	No	13.90	1.00	1.43	4.00	Yes
A2	PLDJNSA2D-01SO	8.5	PGDP	2.00	6.00	4.10	4.10	No	0.59	0.13	1.10	1.10	No	0.77	0.24	0.39	1.37	No
H04,06,09	301022	2.6	LOCK	1.90	0.00			Yes					No	1.01		0.10		Yes
F12,20,22	301001	0.8	LOCK	1.90	0.00			Yes					No	0.90		0.08		Yes
SOU195-014A	2010-51256[a]	4	KYRAD	1.89	5.01	2.14		No	1.55	1.16	0.52		Yes	1.12	0.93	1.18		No
F04,02,29	301006	1.5	LOCK	1.85	0.00			Yes					No	0.82		0.08		Yes
JP-0160	DOJ1-99-0177		PGDP	1.84	2.62	3.68	3.68	No	0.65	0.12	1.30	1.30	No	2.01	0.91	1.08	3.57	No
K008-AIP-RP	030303	0	STLMO	1.80	1.10	1.30		Yes	0.80	0.30	0.28		Yes	2.30	0.30	1.10		Yes
C02,03,20	301019[d]	0.7	LOCK	1.80	0.00			Yes					No	1.03		0.10		Yes
BC5KYRAD02	2010-50538[a]		KYRAD	1.74	0.90	0.42		Yes	2.01	1.56	0.70		Yes	0.69	0.93	0.55		Yes
194-05,06	301039	9	LOCK	1.72	0.00			Yes					No	0.79		0.12		Yes
194-03,04	301045[e]	16	LOCK	1.68	0.00			Yes					No	1.06		0.14		Yes
A2	PLDJNSA2-02SO	11.5	PGDP	1.60	6.60	3.30	4.40	No	1.10	0.18	2.20	2.20	No	1.69	0.86	1.03	3.04	No
F01,21,23	301009	0.8	LOCK	1.60	0.00			Yes					No	0.92		0.08		Yes
C02,03,20	301020[d]	3	LOCK	1.59	0.00			Yes					No	1.00		0.09		Yes
H01,05,15	301026	2.6	LOCK	1.57	0.00			Yes					No	0.87		0.08		Yes
C07,08,09	301014[d]	2.1	LOCK	1.56	0.00			Yes					No	0.94		0.08		Yes
JP-0157	DOJ1-99-0157		PGDP	1.56	4.07	3.11	3.11	No	0.90	0.16	1.80	1.80	No	108.00	1.80	2.95	29.10	Yes
JP-0113	DOJ1-99-0115		PGDP	1.54	1.60	1.68	1.69	No	0.49	0.12	0.97	0.97	No	6.02	0.88	1.33	3.23	Yes
C07,08,09	301016[d]	2.1	LOCK	1.51	0.00			Yes					No	0.91		0.08		Yes
H04,06,09	301021	0.8	LOCK	1.50	0.00			Yes					No	0.94		0.10		Yes
F12,20,22	301003	1.5	LOCK	1.50	0.00			Yes					No	0.92		0.09		Yes
K008-AIP-RP	030302	0	STLMO	1.49	1.20	0.82		Yes					No	0.76	0.26	0.56		Yes
BC14KYRAD	2010-50539[a]		KYRAD	1.49	0.68	0.32		Yes	1.94	1.52	0.67		Yes	1.64	0.70	0.40		Yes
JP-0075	DOJ1-99-0075		PGDP	1.48	4.62	2.97	2.97	No	1.24	0.16	2.48	2.48	No	14.80	1.54	2.05	6.04	Yes
194-03,04	301036[e]	8	LOCK	1.48	0.00			Yes					No	0.80		0.12		Yes
H02,10,18	301027	0.7	LOCK	1.44	0.00			Yes					No	1.00		0.11		Yes
F12,20,22	301002	0.8	LOCK	1.40	0.00			Yes					No	0.93		0.09		Yes
SOU195-014A	2010-51257[a]	7	KYRAD	1.38	0.70	0.32		Yes	2.12	1.07	0.49		Yes	1.11	0.58	0.38		Yes
JP-0090	DOJ1-99-0090		PGDP	1.37	2.21	2.74	2.74	No	0.77	0.14	1.55	1.55	No	22.00	0.02	0.75	3.30	Yes
OUTFALL10-1	WC02-242	4	PORTS	1.36	0.67	0.68	0.68	No	0.94	0.32	0.22	0.37	No	0.67	0.05	0.12	0.21	Yes
SOU195-014C	2010-51262[a]	4	KYRAD	1.31	0.79	0.36		Yes	2.30	1.59	0.71		Yes	0.49	0.97	0.46		Yes
JP-0062	DOJ1-99-0062		PGDP	1.31	2.95	2.61	2.61	No	0.71	0.13	1.41	1.41	No	4.01	1.17	1.62	3.02	Yes
F01,21,23	301010	1.6	LOCK	1.26	0.00			Yes					No	0.82		0.08		Yes
SWMU222-4	2010-52458[a]		KYRAD	1.25	0.48	0.22		Yes					No	1.52	0.44	0.29		Yes
JP-0163	DOJ1-99-0163		PGDP	1.22	2.94	2.45	2.45	No	0.97	0.23	1.93	1.93	No	3.23	1.36	0.78	1.76	Yes
NST2S02	BJC2021SS	3	PGDP	1.20	2.87	2.41	2.41	No	0.64	0.18	1.28	1.28	No	104.00	0.31	3.50	21.00	Yes
194-01,02	301040	6.75	LOCK	1.20	0.00			Yes					No	0.79		0.12		Yes
194-05,06	301050	17.5	LOCK	1.20	0.00			Yes					No	0.71		0.11		Yes
SOU195-014	2010-51255[a]	10	KYRAD	1.20	0.88	0.36		Yes	1.89	1.50	0.67		Yes	0.74	0.97	0.51		Yes
SOU195-014B	2010-51260[a]	7	KYRAD	1.17	0.64	0.30		Yes	2.25	0.91	0.43		Yes	0.79	0.56	0.35		Yes
194-05,06	301042	11.5	LOCK	1.17	0.00			Yes					No	0.72		0.11		Yes
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10		0.12		Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10				Yes
SOU195-006	2010-51265[a]	7	KYRAD	1.09	0.73	0.33		Yes	2.13	1.16	0.53		Yes	0.86	0.57	0.34		Yes
SOU195-025	2010-51250[a]	7	KYRAD	1.09	0.84	0.38		Yes	2.41	1.65	0.73		Yes	1.05	0.72	0.52		Yes
SOU195-014B	2010-51261[a]	10	KYRAD	1.08	0.96	0.43		Yes	1.46	1.45	0.64		Yes	0.77	0.69	0.44		Yes
SOU200-009	2010-51275[a]	4	KYRAD	1.08	5.15	2.23		No	1.87	1.32	0.60		Yes	1.08	0.93	0.88		Yes
H02,10,18	301028	3	LOCK	1.07	0.00			Yes					No	0.92		0.08		Yes
JP-0162	DOJ1-99-0162		PGDP	1.05	1.94	2.10	2.10	No	0.84	0.16	1.67	1.67	No	1.63	0.91	0.47	2.29	No
194-03,04	301041[e]	12	LOCK	1.04	0.00			Yes					No	0.81		0.12		Yes
SOU200-005	2010-51271[a]	4	KYRAD	1.04	0.89	0.40		Yes	2.15	1.57	0.70		Yes	1.64	0.99	0.64		Yes
SOU195-014C	2010-51263[a]	7	KYRAD	1.03	1.04	0.46		No	1.73	1.32	0.59		Yes	0.90	0.75	0.45		Yes
SOU195-025	2010-51251[a]	10	KYRAD	1.02	0.77	0.35		Yes	1.91	1.46	0.66		Yes	1.17	1.07	0.62		Yes
JP-0091	DOJ1-99-0091		PGDP	1.01	2.08	2.02	2.02	No	0.82	0.14	1.64	1.64	No	12.70	1.24	1.72	3.82	Yes
NST1S01	BJC1011SS	2.5	PGDP	1.01	3.31	2.02	2.02	No	0.65	0.19	1.29	1.29	No	65.90	1.87	2.87	18.00	Yes
SOU200-008	2010-51274[a]	4	KYRAD	1.01	0.70	0.32		Yes	1.88	1.18	0.53		Yes	1.01	0.56	0.32		Yes
H04,06,09	301024	2.6	LOCK	1.00	0.00			Yes					No	0.94		0.09		Yes
OUTFALL10-1	WC02-242D	4	PORTS	0.99	0.63	0.64	0.65	No	0.87	0.29	0.25	0.31	No	0.68	0.07	0.13	0.46	Yes
SOU195-014B	2010-51259[a]	4	KYRAD	0.99	0.92	0.41		Yes	1.62	1.32	0.59		Yes	0.93	0.99	0.56		Yes
JP-0018	DOJ1-99-0016		PGDP	0.96	4.68	1.92	2.81	No	0.64	0.14	1.28	1.28	No	188.00	0.05	2.30	32.00	Yes
OUTFALL10-2	WC02-243	4	PORTS	0.96	0.68	0.63	0.64	No	0.82	0.31	0.28	0.31	No	0.63	0.02	0.13	0.21	Yes
SOU200-006	2010-51272[a]	4	KYRAD	0.95	0.66	0.30		Yes	2.67	1.09	0.51		Yes	0.94	0.57	0.38		Yes
SOU200-001	2010-51267[a]	4	KYRAD	0.94	0.83	0.37		Yes	2.73	1.33	0.61		Yes	1.06	0.70	0.39		Yes
SOU200-010	2010-51276[a]	4	KYRAD	0.89	0.94	0.42		No	1.75	1.47	0.65		Yes	0.76	0.69	0.36		Yes
SOU195-006	2010-51266[a]	10	KYRAD	0.88	0.78	0.35		Yes	1.98	1.52	0.68		Yes	1.51	0.98	0.63		Yes
JP-0081	DOJ1-99-0081		PGDP	0.87	1.43	1.75	1.75	No	0.61	0.11	1.22	1.22	No	3.60	0.01	0.17	0.47	Yes
SOU200-003	2010-51269[a]	4	KYRAD	0.86	0.92	0.41		No	2.22	1.27	0.57		Yes	0.74	0.69	0.50		Yes
JP-0015	DOJ1-99-0013		PGDP	0.81	1.66	1.62	1.62	No	0.62	0.13	1.23	1.23	No	3.16	0.82	1.25	1.99	Yes
H03,07,13	301030	3	LOCK	0.80	0.00			Yes					No	0.83		0.08		Yes
NST1S03	BJC1031SS	12	PGDP	0.79	1.55	1.59	1.59	No	0.80	0.18	1.60	1.60	No	0.66	0.04	0.11	0.13	Yes
JP-0080	DOJ1-99-0080		PGDP	0.73	1.91	1.46	1.46	No	0.82	0.15	1.64	1.64	No	2.39	0.94	0.47	3.33	No
SOU195-014	2010-51254[a]	7	KYRAD	0.71	0.74	0.33		No	1.72	1.50	0.66		Yes	0.54	0.70	0.44		Yes
LBC2L005	LBCSOSU2S1-01	1	STLMO	0.70	2.20		1.30	No	1.40	0.15		0.30	Yes	3.12	16.80	9.24		No
SOU200-007	2010-51273[a]	4	KYRAD	0.69	0.78	0.35		No	2.12	1.68	0.75		Yes	1.16	0.90	0.41		Yes
JP-0110	DOJ1-99-0110		PGDP	0.67	8.67	1.34	5.33	No	0.81	0.19	1.61	1.61	No	626.00	4.72	8.10	168.00	Yes
SOU200-002	2010-51268[a]	4	KYRAD	0.65	0.62	0.28		Yes	2.10	0.94	0.44		Yes	1.08	0.56	0.33		Yes
JP-0057	DOJ1-99-0057		PGDP	0.65	1.60	1.30	1.30	No	0.28	0.09	0.56	0.56	No	7.97	0.78	1.14	4.06	Yes
JP-0097	DOJ1-99-0097		PGDP	0.62	1.70	1.25	1.25	No	0.76	0.13	1.52	1.52	No	2.58	0.77	1.04	3.71	No
JP-0066	DOJ1-99-0066		PGDP	0.60	2.87	1.21	1.85	No	0.85	0.14	1.70	1.70	No	4.81	1.22	1.63	3.47	Yes
JP-0082	DOJ1-99-0082		PGDP	0.60	2.74	1.20	1.67	No	1.29	0.18	2.58	2.58	No	20.00	0.02	0.75	3.30	Yes
194-03,04	301046[e]	21	LOCK	0.60	0.00			Yes					No	1.18		0.16		Yes
JP-0061	DOJ1-99-0061		PGDP	0.60	2.19	1.20	1.41	No	0.33	0.08	0.66	0.66	No	6.32	0.76	1.00	0.16	Yes
JP-0013	DOJ1-99-0011		PGDP	0.55	2.26	1.11	1.36	No	0.83	0.15	1.66	1.66	No	17.30	0.97	1.38	4.86	Yes
JP-0063	DOJ1-99-0063		PGDP	0.54	2.50	1.09	1.64	No	0.65	0.12	1.29	1.29	No	1.00	0.01	0.10	0.16	Yes
JP-0087	DOJ1-99-0088		PGDP	0.47	5.67	0.94	3.46	No	0.77	0.13	1.54	1.54	No	138.00	2.54	4.19	53.00	Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
A10	PLDJNSA10-02SO	8.5	PGDP	0.34	5.70	0.69	3.60	No	0.49	0.12	0.98	0.98	No	1.91	0.79	0.42	3.26	No
ISOCSOFFST	ISOCSBKGR08-01	0	PGDP	0.34	1.04	0.68	0.68	No					No	1.58	0.47	0.25	0.33	Yes
NST2S03	BJC2031SS	15	PGDP	0.31	2.30	0.61	1.39	No	0.99	0.19	1.98	1.98	No	19.80	0.08	0.79	3.00	Yes
JP-0112	DOJ1-99-0114		PGDP	0.27	1.38	0.54	0.85	No	0.67	0.11	1.34	1.34	No	7.50	0.01	0.37	1.10	Yes
JP-0060	DOJ1-99-0060		PGDP	0.22	2.13	0.44	1.40	No	0.13	0.04	0.16	0.26	No	8.24	0.85	1.26	3.40	Yes
C01,10,24	301018 [d]	2.8	LOCK	0.20	0.00			Yes					No	1.03		0.09		Yes
NST2S05	BJC2052SS	12.5	PGDP	0.17	1.28	0.35	0.78	No	0.52	0.14	1.03	1.03	No	1.21	0.20	0.32	1.70	No
JP-0100	DOJ1-99-0100		PGDP	0.09	1.44	0.18	0.89	No	0.72	0.12	1.44	1.44	No	1.48	0.67	0.39	2.08	No
NST1S02	BJC1021SS	2.5	PGDP	0.06	2.53	0.13	1.54	No	0.57	0.19	1.15	1.15	No	29.70	1.38	2.18	8.27	Yes
JP-0016	DOJ1-99-0014		PGDP	0.00	1.81	0.01	1.10	No	0.57	0.12	1.13	1.13	No	8.80	0.04	0.35	1.20	Yes
196-01,02	301037	7	LOCK	0.00[f]	0.00			No					No	0.82		0.12		Yes
JP-0164	DOJ1-99-0164		PGDP	-0.01	1.86	0.01	1.15	No	0.69	0.15	1.38	1.38	No	1.84	0.92	0.45	2.57	No
NST2S01	BJC2011SS	2	PGDP	-0.13	1.73	0.25	1.06	No	0.57	0.16	1.14	1.14	No	8.11	0.91	1.35	2.56	Yes
JP-0045	DOJ1-99-0045		PGDP	-0.29	2.68	0.58	1.76	No	0.58	0.12	1.15	1.15	No	6.00	0.01	0.23	0.77	Yes
JP-0016	DOJ1-99-0014DUP		PGDP	-0.29	1.76	0.59	1.08	No	0.52	0.12	1.05	1.05	No	11.00	0.02	0.37	1.40	Yes
JP-0087	DOJ1-99-0087		PGDP	-0.43	5.27	0.86	3.23	No	0.65	0.12	1.30	1.30	No	126.00	2.33	3.83	48.30	Yes
JP-0071	DOJ1-99-0071		PGDP	-0.75	5.45	1.50	3.40	No	2.78	0.26	5.56	5.56	No	19.00	1.98	2.46	7.68	Yes
BGS194-04	301049	24	LOCK	-0.80	0.01			No					No	0.76		0.12		Yes
JP-0085	DOJ1-99-0085		PGDP	-0.86 [f]	6.72	1.72	4.14	No	0.80	0.15	1.60	1.60	No	160.00	3.01	5.07	61.80	Yes
F05,07,17	301007	1	LOCK	-1.10 [f]	0.00			No					No	0.93		0.08		Yes
A10	PLDJNSA10-03SO	9	PGDP	-1.20	31.00	2.50	18.00	No	0.14	0.20	0.00	0.06	No	326.00	4.61	7.56	125.00	Yes
JP-0072	DOJ1-99-0072		PGDP	-1.31	9.10	2.62	5.58	No	6.88	0.41	13.75	13.75	No	87.00	0.24	2.80	21.00	Yes
JP-0111	DOJ1-99-0112		PGDP	-1.99	6.10	3.99	3.99	No	0.84	0.17	1.69	1.69	No	317.00	0.67	11.00	68.00	Yes
JP-0076	DOJ1-99-0076		PGDP	-2.04	6.16	4.07	4.07	No	2.19	0.23	4.38	4.38	No	69.00	2.28	3.26	26.70	Yes
NST2S05	BJC2051SS	12.5	PGDP	-2.12	12.77	4.25	7.90	No	5.15	1.39	10.30	10.30	No	11.10	1.90	3.14	4.33	Yes
JP-0077	DOJ1-99-0077		PGDP	-2.71	5.02	5.42	5.42	No	1.47	0.17	2.94	2.94	No	56.00	0.21	1.80	11.00	Yes
A2	PLDJNSA2-01SO	8.5	PGDP	-2.90	6.20	5.80	5.80	No	0.65	0.14	1.30	1.30	No	1.24	0.26	0.44	2.14	No
JP-0152	DOJ1-99-DUP1		PGDP	-2.91	6.47	5.83	5.83	No	0.87	0.13	1.73	1.73	No	393.00	0.69	12.00	120.00	Yes
JP-0111	DOJ1-99-0111		PGDP	-2.99	6.03	5.98	5.98	No	0.91	0.17	1.81	1.81	No	365.00	0.13	4.50	63.00	Yes
JP-0151	DOJ1-99-0151		PGDP	-4.78	8.89	9.57	9.57	No	0.54	0.13	1.07	1.07	No	365.00	3.25	5.42	140.00	Yes
JP-0150	DOJ1-99-0150		PGDP	-10.07	12.75	20.14	20.14	No	0.79	0.18	1.58	1.58	No	599.00	4.88	8.14	230.00	Yes
JP-0153	DOJ1-99-0153		PGDP	-19.47	14.31	38.93	38.93	No	0.32	0.17	0.64	0.64	No	1921.00	3.50	50.00	617.00	Yes

Yellow shading indicates sample analysis by the Kentucky Radiation Health Branch Laboratory.

Blue shading indicates a detected lead-210 result for samples other than those analyzed by the Kentucky Radiation Health Branch.

TPU = total propagated uncertainty

Lab Codes are the following: LOCK = Lockheed Engineering & Science Co., Las Vegas, NV; KYRAD = Kentucky Radiation Health Branch; PGDP = USEC-Paducah Gaseous Diffusion Plant; PORTS = USEC-Portsmouth Plant; STLMO = Severn Trent, Earth City, Missouri

[a] The uranium-238 results was reported by the lab as thorium-234/uranium-238.

[b] The maximum uranium-238 result was used for comparison.

[c] This sample is not plotted in Figure 2, the coordinates place the sample in Illinois. The available coordinates are likely incorrect.

[d] This sample is not plotted in Figure 2, no coordinates are available.

[e] This sample is not plotted in Figure 2, the coordinates place the sample in Ballard County, which is outside the scale of the map.

[f] This results is set as a nondetect because the reported result is less than the minimum detectable activity (MDA).

Table E.5. Results of Filtering

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	7/31/2006	152.1	KYRAD	2006-51812	SW	133.1	529.9		A-Composite	pCi/L	X	529.9		529.9
DNT	Lead-210	7/21/2004	139	KYRAD	2004-51807	SW	120.4	557.4		A-Composite	pCi/L	=	557.4		557.4
DNT	Lead-210	7/9/2003	86.13	KYRAD	2003-06373	SW	77.85	213.2		A-Composite	pCi/L	=	213.2		213.2
DNT	Lead-210	12/8/2006	141.6	KYRAD	2006-53149	SW	156.5	1469		A-Composite	pCi/L	X	1469		1469
DNT	Lead-210	7/18/2005	96.2	KYRAD	2005-51647	SW	176.1	661.4		A-Composite	pCi/L	X	661.4		661.4
DNT	Lead-210	5/26/2006	116	KYRAD	2006-51119	SW	126.8	1605		A-Composite	pCi/L	X	1605		1605
Gamma Spec	Lead-210	2/2/2007	159.2	KYRAD	2007-50161	SW	276.5	692.8	U	A-Composite	pCi/L	U	692.8		692.8
DNT	Lead-210	10/27/2005	105.5	KYRAD	2005-52609	SW	124.9	1707		A-Composite	pCi/L	X	1707		1707
Gamma Spec	Lead-210	6/4/2007	174.2	KYRAD	2007-51252	SW	107	1284		A-Composite	pCi/L	=	1284		1284
DNT	Lead-210	10/13/2004	99.77	KYRAD	2004-52643	SW	143.4	309.4		C-Composite	pCi/L	=	309.4		309.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	=	2593		2593
DNT	Lead-210	5/11/2005	144.7	KYRAD	2005-51034	SW	82.96	514		A-Composite	pCi/L	X	514		514
DNT	Lead-210	6/9/2004	147.5	KYRAD	2004-51367	SW	77.57	1714		A-Composite	pCi/L	=	1714		1714
Gamma Spec	Lead-210	4/3/2007	180.9	KYRAD	2007-50606	SW	97.97	1719	U	A-Composite	pCi/L	U	1719		1719
Gamma Spec	Lead-210	11/19/2007	168	KYRAD	2007-52795	SW	123.9	274.7	J	A-Composite	pCi/L	J	274.7		274.7
DNT	Lead-210	1/10/2005	138.2	KYRAD	2005-50023	SW	147.8	1210		C-Composite	pCi/L	X	1210		1210
Gamma Spec	Lead-210	2/22/2007	275.7	KYRAD	2007-50293	SW	160.8	2222	U	C-Composite	pCi/L	U	2222		2222
DNT	Lead-210	1/3/2006	299	KYRAD	2005-53157	SW	285.5	881.4		C-Composite	pCi/L	X	881.4		881.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	X	2593		2593
DNT	Lead-210	12/20/2004	173.3	KYRAD	2004-53235	SW	237	832.2		C-Composite	pCi/L	=	832.2		832.2
Gamma Spec	Lead-210	4/25/2007	128.9	KYRAD	2007-50839	SW	138.1	1185		C-Composite	pCi/L	=	1185		1185
DNT	Lead-210	12/14/2006	533.1	KYRAD	2006-53330	SW	283.4	3222	U	ATC746K	pCi/L	X	3222		3222
DNT	Lead-210	9/11/2006	149.7	KYRAD	2006-52207	SW	130.7	594		B-Composite	pCi/L	X	594		594
Gamma Spec	Lead-210	6/25/2007	154.2	KYRAD	2007-51454	SW	85.39	1936	U	B-Composite	pCi/L	U	1936		1936
DNT	Lead-210	9/22/2004	112.7	KYRAD	2004-52430	SW	121.2	368.1		B-Composite	pCi/L	=	368.1		368.1
DNT	Lead-210	10/13/2004	146.1	KYRAD	2004-52679	SW	126.1	664.9		D2-Composite2	pCi/L	=	664.9		664.9
DNT	Lead-210	12/24/2003	80.3	KYRAD	2003-08104	SW	79.66	233		D2-Composite2	pCi/L	=	233		233
DNT	Lead-210	3/2/2006	67	KYRAD	2006-50341	SW	43.39	102.5		B-Composite	pCi/L	X	102.5		102.5
Gamma Spec	Lead-210	4/3/2007	183.7	KYRAD	2007-50628	SW	95.3	2502	U	B-Composite	pCi/L	U	2502		2502
DNT	Lead-210	7/18/2005	129.3	KYRAD	2005-51670	SW	96.29	1306		B-Composite	pCi/L	X	1306		1306
DNT	Lead-210	1/10/2005	225.3	KYRAD	2005-50022	SW	113.8	3492		B-Composite	pCi/L	X	3492		3492
DNT	Lead-210	8/31/2004	106.9	KYRAD	2004-52253	SW	92.05	604.6		D-Composite	pCi/L	=	604.6		604.6
DNT	Lead-210	6/30/2004	138.7	KYRAD	2004-51697	SW	127.6	575.8		D2-Composite2	pCi/L	=	575.8		575.8
DNT	Lead-210	10/27/2005	115.4	KYRAD	2005-52720	SW	122.4	1419		F-Composite	pCi/L	X	1419		1419
Gamma Spec	Lead-210	11/29/2010	1.61	KYRAD	2010-53281	SW	0.894	974	U	C-613	pCi/L	U	974		974
DNT	Lead-210	11/17/2005	152.4	KYRAD	2005-52866	SW	106.8	1269		D-Composite	pCi/L	X	1269		1269
Gamma Spec	Lead-210	2/2/2007	126.9	KYRAD	2007-50240	SW	224.8	490.7	U	F-Composite	pCi/L	U	490.7		490.7
DNT	Lead-210	12/13/2006	532.5	KYRAD	2006-53325	SW	282.9	3226	U	BBCDG	pCi/L	X	3226		3226
DNT	Lead-210	10/27/2005	2017	KYRAD	2005-52676	SW	2740	9532		D1-Composite	pCi/L	X	9532		9532
DNT	Lead-210	9/14/2005	130.7	KYRAD	2005-52307	SW	55.96	169.4		D1-Composite	pCi/L	X	169.4		169.4
DNT	Lead-210	12/13/2006	5867	KYRAD	2006-53326	SW	3802	7905	U	BBCROSS	pCi/L	X	7905		7905
DNT	Lead-210	7/5/2006	315.2	KYRAD	2006-51734	SW	293.3	612.9	R	BBCUG	pCi/L	X	612.9		612.9
DNT	Lead-210	8/25/2005	592.4	KYRAD	2005-52201	SW	312.6	3755		BBCUG	pCi/L	X	3755		3755

Table E.5. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	12/8/2006	141.1	KYRAD	2006-53231	SW	155.1	1554		D1-Composite	pCi/L	X	1554		1554
Gamma Spec	Lead-210	6/4/2007	171.1	KYRAD	2007-51333	SW	99.26	406.2		D1-Composite	pCi/L	=	406.2		406.2
DNT	Lead-210	8/13/2004	135.7	KYRAD	2004-52111	SW	137.5	621.3		F-Composite	pCi/L	=	621.3		621.3
Gamma Spec	Lead-210	11/29/2010	51.1	KYRAD	2010-53280	SW	23.7	230	U	K001	pCi/L	U	230		230
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	X	482.9		482.9
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	=	482.9		482.9
DNT	Lead-210	7/16/2002	437.6	KYRAD	2002-06663	SW	256.7	27660		D2-Composite	pCi/L	=	27660		27660
DNT	Lead-210	9/14/2005	110.6	KYRAD	2005-52329	SW	55.95	146.3		D2-Composite	pCi/L	X	146.3		146.3
DNT	Lead-210	11/20/2006	267.2	KYRAD	2006-53106	SW	283.2	843		G-Composite	pCi/L	X	843		843
DNT	Lead-210	12/22/2006	230.8	KYRAD	2006-53421	SW	148.8	2500		G-Composite	pCi/L	X	2500		2500
DNT	Lead-210	8/31/2004	107.1	KYRAD	2004-52318	SW	90.23	526		G-Composite	pCi/L	=	526		526
DNT	Lead-210	7/31/2006	150.7	KYRAD	2006-51871	SW	132.9	446.9		D2-Composite	pCi/L	X	446.9		446.9
DNT	Lead-210	11/20/2006	113.4	KYRAD	2006-53074	SW	73.27	265.4		D2-Composite	pCi/L	X	265.4		265.4
DNT	Lead-210	7/21/2004	137.2	KYRAD	2004-51947	SW	144	342.6		G-Composite	pCi/L	=	342.6		342.6
DNT	Lead-210	5/26/2006	159.3	KYRAD	2006-51229	SW	79.65	2701		D2-Composite	pCi/L	X	2701		2701
DNT	Lead-210	8/25/2005	599	KYRAD	2005-52191	SW	424.1	1900		K010	pCi/L	X	1900		1900
DNT	Lead-210	6/1/2005	237.4	KYRAD	2005-51358	SW	260.6	1634		G-Composite	pCi/L	X	1634		1634
Gamma Spec	Lead-210	4/3/2007	182	KYRAD	2007-50729	SW	96.81	2054	U	G-Composite	pCi/L	U	2054		2054
DNT	Lead-210	12/14/2006	537.4	KYRAD	2006-53312	SW	285.4	3298	U	K011	pCi/L	X	3298		3298
DNT	Lead-210	6/16/2005	539.3	KYRAD	2005-51401	SW	366.8	865.9		K012	pCi/L	X	865.9		865.9
DNT	Lead-210	8/23/2005	589.5	KYRAD	2005-52186	SW	491.7	2210		L14	pCi/L	X	2210		2210
DNT	Lead-210	12/14/2006	539.1	KYRAD	2006-53316	SW	286.2	3332	U	K015	pCi/L	X	3332		3332
Gamma Spec	Lead-210	11/29/2010	685	KYRAD	2010-53280	SW	274	4070	U	L4	pCi/L	U	4070		4070
DNT	Lead-210	12/14/2006	7379	KYRAD	2006-53321	SW	4801	11210	U	LBC@McCaw	pCi/L	X	11210		11210
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	9.25275	KYRAD	2010-51253	SO	3.831	6.5693666	U	SOU195-120A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.738264	KYRAD	2010-51254	SO	0.327648	0.7087367	U	SOU195-014	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.87614	KYRAD	2010-51255	SO	0.357205	1.1963452		SOU195-014	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.00644	KYRAD	2010-51256	SO	2.14186	1.8868582	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.69731	KYRAD	2010-51257	SO	0.323468	1.3837602		SOU195-014A	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.07442	KYRAD	2010-51258	SO	2.12668	3.5576405	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.919572	KYRAD	2010-51259	SO	0.410998	0.9908741		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.643217	KYRAD	2010-51260	SO	0.297765	1.1705553		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.963233	KYRAD	2010-51261	SO	0.42696	1.0807067		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.786643	KYRAD	2010-51262	SO	0.364651	1.3145335		SOU195-014C	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	1.03762	KYRAD	2010-51263	SO	0.457097	1.0294589	U	SOU195-014C	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	5.28305	KYRAD	2010-51264	SO	2.15693	6.0068083	J	SOU195-014C	pCi/g	J			
Gamma Spec	Lead-210	5/12/2010	0.727831	KYRAD	2010-51265	SO	0.330025	1.0930592		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.779156	KYRAD	2010-51266	SO	0.351511	0.8835402		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.832552	KYRAD	2010-51267	SO	0.370699	0.9368339		SOU200-001	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.616779	KYRAD	2010-51268	SO	0.276128	0.6544536		SOU200-002	pCi/g	=			

Table E.5. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
Gamma Spec	Lead-210	5/5/2010	0.918867	KYRAD	2010-51269	SO	0.405092	0.8584913	U	SOU200-003	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.894012	KYRAD	2010-51271	SO	0.401519	1.0366496		SOU200-005	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.662666	KYRAD	2010-51272	SO	0.300982	0.9515829		SOU200-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.777267	KYRAD	2010-51273	SO	0.346092	0.6884684	U	SOU200-007	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.695554	KYRAD	2010-51274	SO	0.31533	1.0058769		SOU200-008	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	5.14907	KYRAD	2010-51275	SO	2.22839	1.0775268	U	SOU200-009	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.942465	KYRAD	2010-51276	SO	0.415427	0.8905683	U	SOU200-010	pCi/g	U			
Gamma Spec	Lead-210	4/27/2010	0.590492	KYRAD	2010-51277	SO	0.763757	2.571285		SOU222-001	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.816	KYRAD	2010-52457	SO	0.406	4.92		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.475	KYRAD	2010-52458	SO	0.221	1.25		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.71	KYRAD	2010-53090	SO	0.869	8.44		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.41	KYRAD	2010-53091	SO	0.709	6.98		SWMU222-2	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.14	KYRAD	2010-53092	SO	0.607	6.81		SWMU222-3	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	2.05	KYRAD	2010-53093	SO	1.03	10.6		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.47	KYRAD	2010-53094	SO	0.757	8.6		SWMU222-5	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			

DNT = Analytical methods was not transmitted.
Gamma Spec = Gamma Spec
KYRAD = Kentucky Radiation Health Branch Laboratory
SW = surface water
X = no 3rd party validation was performed
U = not detected above the MDA
R = result rejected
"=" = result accepted by 3rd party validation

Lead-210 is the daughter of polonium-214 that is a member of the uranium-238 decay chain. Lead-210 is reported at background levels of 1-2 pCi/g in at least one facility (http://www.lrb.usace.army.mil/Portals/45/docs/FUSRAP/DaytonIII/day3-si-2004-12.pdf, Table 2). Please see Tables E.4 and E.5 for the Kentucky Radiation Health Branch (RHB) lead-210 analysis. Only data with a sample specific minimum detectable concentration (MDC) of less than 1 pCi/g were included in the analysis. Based on the data provided by the RHB for lead-210, the background would be in the 1-2 pCi/g range for lead-210 at PGDP.

The no action levels [i.e., 1E-6 values calculated using Risk Assessment Information System (RAIS) and Paducah-specific parameters] are as follows:

- Resident—0.661 pCi/g,
- Industrial worker—7.62 pCi/g, and
- Outdoor worker—1.08 pCi/g.

Based on information provided by TestAmerica to LATA Environmental Services of Kentucky, LLC, the MDC obtained by liquid scintillation (LS) is approximately 5 pCi/g. TestAmerica indicates this is the target MDC by LS; however, this MDC can be lower, if necessary. TestAmerica's target MDC by gamma spectroscopy is the same, 5 pCi/g, but it could vary. TestAmerica indicates that "Lead-210 is a low energy radionuclide on the gamma spec and there could be interferences from other radionuclides and samples with sufficient activity. This could raise the MDA."

Soil analysis by the Kentucky RHB using gamma spectroscopy and a thin window high purity germanium (HPGe) detector, however, achieved an MDC of approximately 1 pCi/g for lead-210 (employing the 46 KeV line for lead-210). Using gamma spectroscopy with the appropriate thin window HPGe detector an MDC of 1 pCi/g is achievable without interference from other radionuclides. In fact, lead-210 is used in calibration standards for thin window HPGe detectors. Gamma spectroscopy, using these thin window HPGe detectors and incorporation of lead-210 into the calibration standard, provides a significant improvement in efficiency in the region less than 59 KeV. Because the analysis of lead-210 by gamma spectroscopy uses the 46 KeV line energy, thin window HPGe detectors are the preferred detectors for analysis of lead-210 by gamma spectroscopy. Achieving a 1 pCi/g MDC for soil analysis is fully supported by the Kentucky RHB data for lead-210 analysis. Because there is no requirement for sample dissolution and separation from other radionuclides, gamma spectroscopy using a thin window HPGe detector would be the preferred method for analysis of lead-210 in soil.

Because analysis of lead-210 by LS requires dissolution of the media in this case soil, it would be preferable to use gamma spectroscopy in order to eliminate concerns regarding complete dissolution of the sample.

With the equipment used by the United States Enrichment Corporation (USEC) laboratory, gamma spectroscopy analysis for lead-210 was not possible because the two primary energy lines are below the analytical laboratory normal energy calibration range. It would require the purchase of a new calibration mixture to include the Pb-210 lines at 46 KeV. The analytical laboratory only has one manual detector that can measure in the x-ray region, so output would be limited.

Lead-210 was included as part of the standard gamma scan for radiological analysis by TestAmerica during the Soils OU project. The MDC for lead-210 was approximately 30 pCi/g. This MDC is protective of a worker at a risk of 1E-5.

The ingrowth of lead-210 from uranium-238 is blocked at uranium-234. Due to the long ingrowth period from uranium-234 to lead-210, it is unlikely that, at the present time, ingrowth of lead-210 from the uranium used in the the uranium enrichment processes at PGDP contributes to presence of lead-210 as a potential contaminant/risk at PGDP.

Independent analysis of lead-210 is not necessary on a routine basis. The need for the analysis of radionuclides, such as lead-210, not related to natural uranium and recycled uranium enrichment by the gaseous diffusion process at PGDP should be assessed on project by project basis.

[1] EPA 2012. *Lead-210*, accessed from http://www.epa.gov/radiation/glossary/termjklm.html in 2012.

USGS 2012. *^{210}Pb (lead 210) Dating*, accessed from http://gec.cr.usgs.gov/archive/lacs/lead.htm in 2012.

E.7. PAH CONTAMINATION AND ESTABLISHMENT OF REMEDIAL GOALS

E.7.1 IDENTIFICATION OF THE PROBLEM

Due to the nature of polycyclic aromatic hydrocarbons (PAHs), as described in the Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs),[1] the presence of PAHs in Paducah Gaseous Diffusion Plant (PGDP) in some soils and sediments (e.g., along roads, including roadside ditches, and around buildings) may not be directly related to PGDP releases, but rather from other on- or off-site site activities, including airborne deposition of PAHs that result from the incomplete burning of oil, gas, wood, garbage, or other organic substances or deposition due to the use of rubber, asphalt, crude oil, coal tar, creosote, and roofing tar. The most common source of PAHs in the environment currently is deposition of automobile exhaust.[2] Thus, in evaluating risk/hazard at PGDP SWMUs/areas of concern (AOCs) under the FFA, there is a potential for PAHs not associated with PGDP releases to be identified as a risk driver, potentially leading to the development of disagreements on appropriate cleanup decisions.[3]

E.7.2 DISCUSSION

Varying approaches have been used to address the presence of PAHs as risk drivers by DOE. At the Oak Ridge Reservation, an early document proposed that DOE manage PAHs as if they were wholly associated with background;[4] however, currently at the Oak Ridge Reservation, PAHs are being addressed on a case-by-case basis and anthropogenic sources are considered.

At the Portsmouth Gaseous Diffusion Plant,[2] DOE proposed remediation of PAHs in areas where (1) the source has been determined to be contributed to by past plant operations or treatment, storage, and disposal (TSD) activities; and (2) concentrations are sufficiently high that the acceptable risk range of 1E-4 to 1E-6 is exceeded.[5] Additionally, Commonwealth of Kentucky guidance indicates that parking lots, paved areas, areas within 3 ft of a roadway, railroad tracks, railway areas, storm drains, or ditches presently or historically receiving industrial or urban runoff should not be sampled when determining background, in part due to the potential for PAHs to be present in these areas.[3,6] Kentucky Revised Statutes exclude emissions from the engine exhaust of a motor vehicle from the definition of a release;[7] therefore, remediation of the widespread low concentrations of PAHs, when linked to such sources (e.g., automobile exhaust and asphalt), should not be considered.

As part of the baseline human health risk assessment (BHHRA) process at PGDP, the potential risks posed by PAHs are included in the quantitative BHHRA. In evaluating methods to address unacceptable risk/hazard, the nature of the PAHs and the potential non-PGDP sources will be considered when identifying risk drivers requiring action and when analyzing alternatives to manage site risk. This evaluation will include consideration of the following:

- PAHs are a group of chemicals formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. PAHs are constituents of rubber, asphalt, coal, crude oil, coal tar, creosote, and roofing tar.

- Because of the many potential sources, PAH media concentrations in some areas (e.g., along roads and in roadside ditches) may increase over time in the absence of identifiable releases from PGDP processes. Alternatively, PAHs currently in the environment will degrade over time; however, the rate of degradation is unknown and depends upon the site conditions, including the medium in which PAHs are present and the location of the environmental medium.

Of the PAH chemicals considered to be carcinogenic, benzo(a)pyrene is believed to be the most potent. At PGDP, there were 334 detected benzo(a)pyrene results, out of 4,544 analyzed soil and sediment samples. Table E.6 summarizes these benzo(a)pyrene results and indicates that the highest concentrations of the PAH are in surface soils.

Table E.6. Maximum Benzo(a)pyrene Concentrations by Sample Depth

Sample Depth (ft)	Maximum Benzo(a)pyrene Concentration (mg/kg)
0-1	6,100
2-4	3.9
4-8	8.6
8-12	0.95
>12	0.98

Toxicity equivalence factors are used to calculate Total PAHs.[8] Factors utilize results from the carcinogen PAHs of benzo(a)pyrene; benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene. Table E.7 summarizes Total PAHs as they are found in surface (0–1 ft), subsurface (1–10 ft), and deep subsurface soils (> 10 ft) (as defined by the Paducah Risk Methods Document).[8]

Table E.7. Maximum Total PAHs by Depth

Sample Depth (ft)	Maximum Total PAH Concentration (mg/kg)
Surface (0–1)	8,750
Subsurface (1–10)	11.4
Deep Subsurface (> 10)	1.46

Figures E.8 through E.10 illustrate the location of these total PAHs by depth. Ranges of values are shown with respect to the no action level for the industrial worker (i.e., 1E-6) and action level for the industrial worker (i.e., 1E-4), 0.784 mg/kg and 78.4 mg/kg, respectively.

In conclusion, the Observations section of the BHHRA should address the uncertainties associated with the presence of PAHs, and the feasibility study (FS) should include discussions ensuring that remedial actions appropriately address the uncertainties associated with the presence of residual concentrations of PAHs.

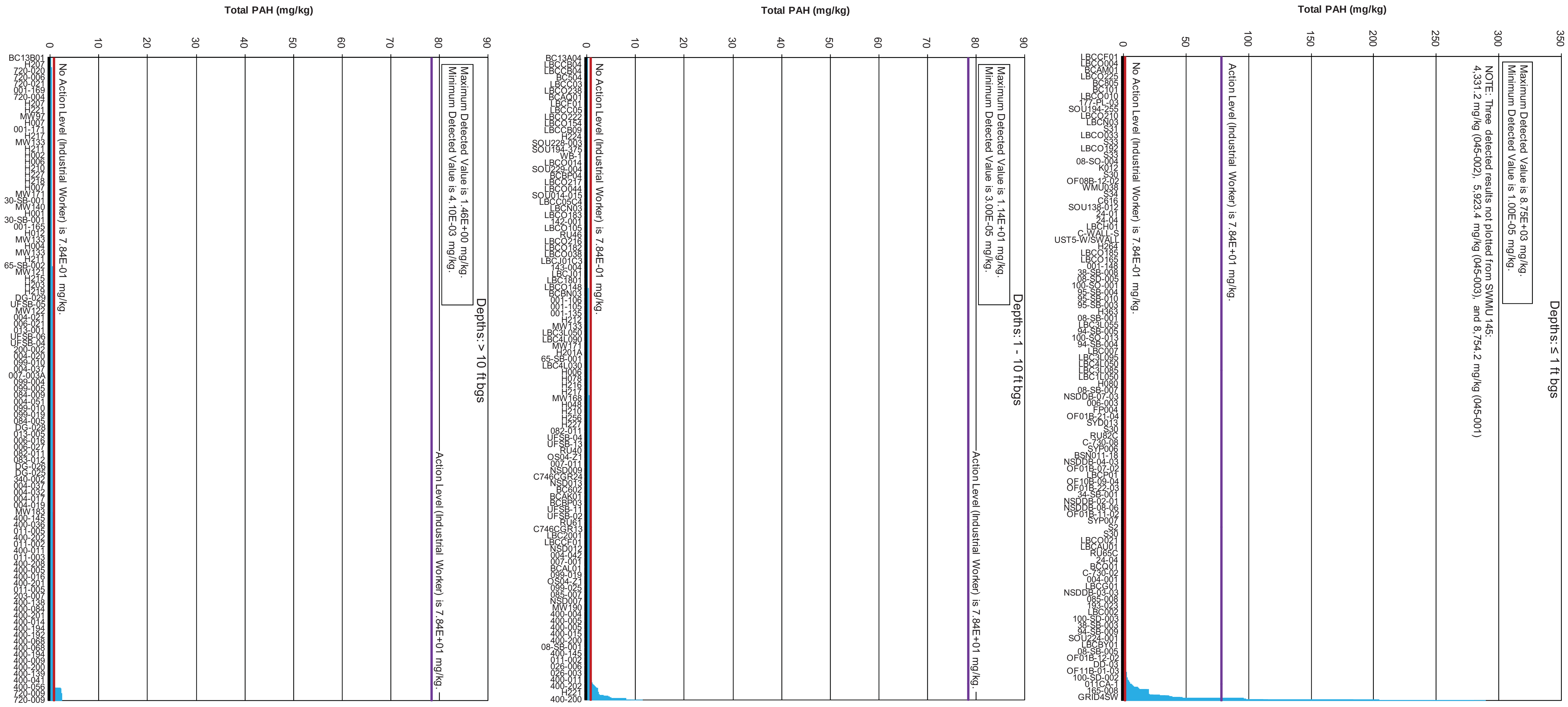


Figure E.8. Total PAH Concentrations by Depth

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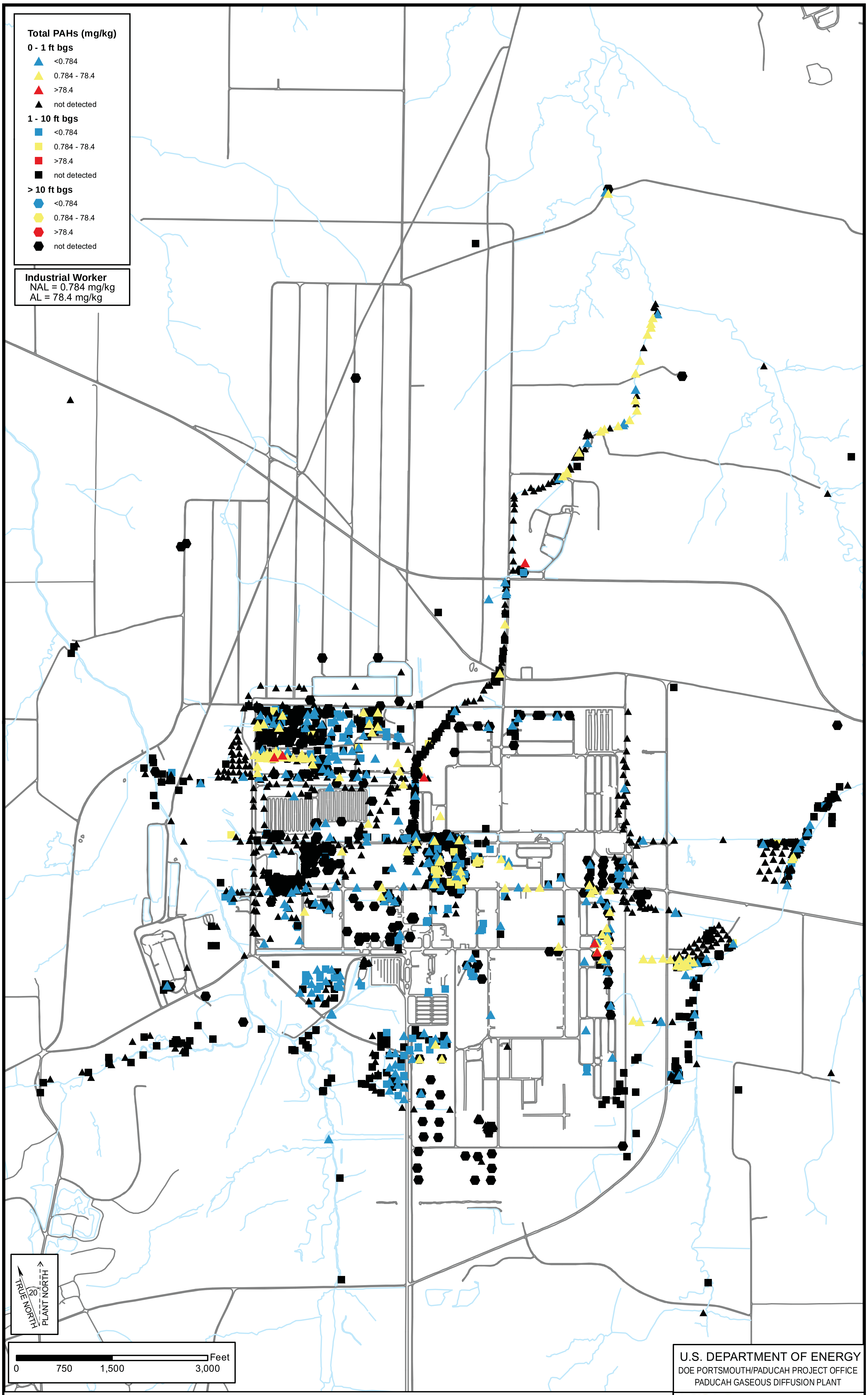

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Figure E.9. Total PAH Soil/Sediment Samples

Figure No. 2012_Total PAHs in Soil-SedimentR1.mxd
DATE 12-19-2012

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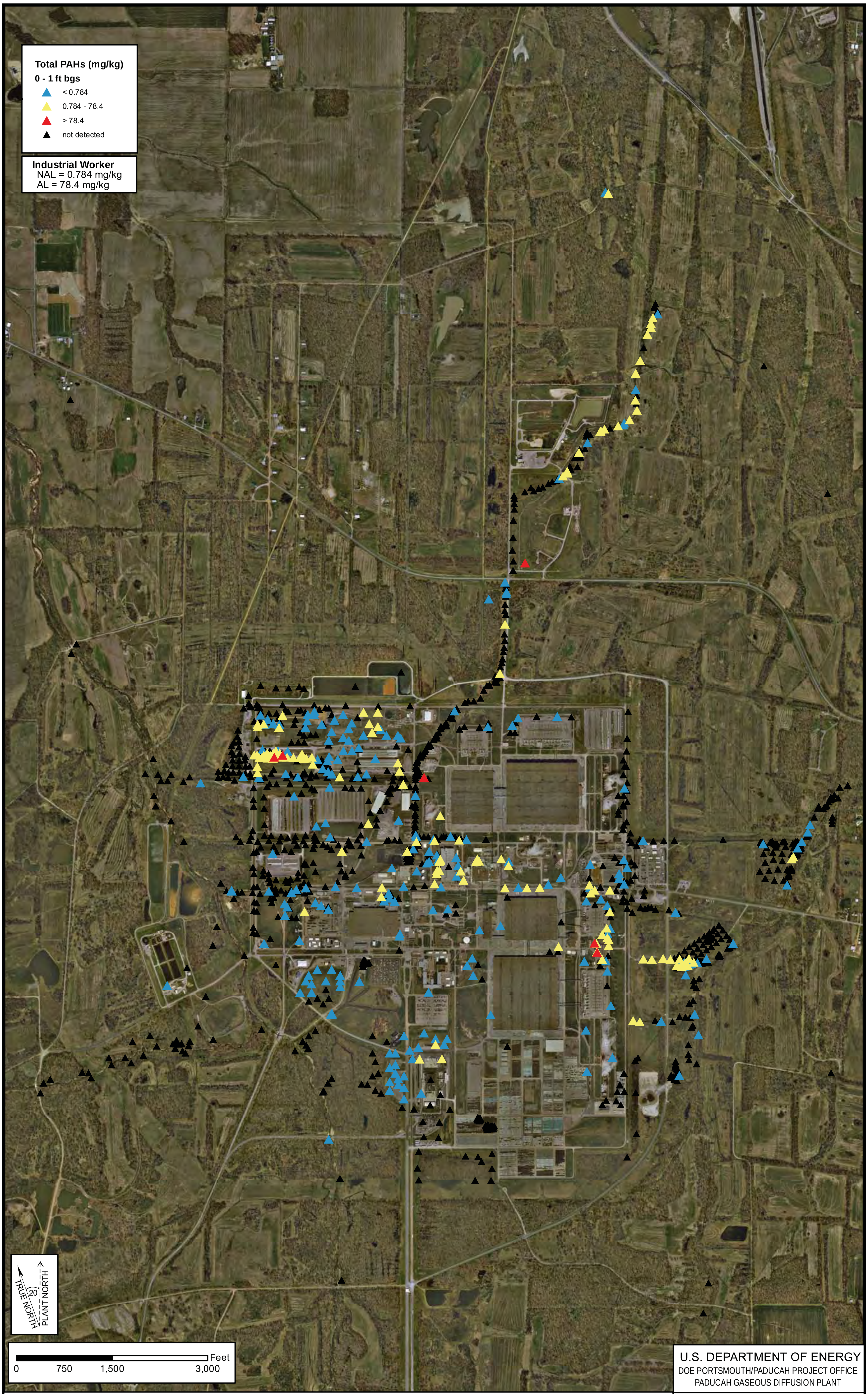

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Figure E.10. Total PAH Surface (0-1 ft bgs) Soil/Sediment Samples

Figure No. 2012_Total PAHs in Soil-Sediment_SurfaceR1.mxd
DATE 12-19-2012

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E.7.3 SUMMARY

In evaluating risk/hazard at PGDP, PAHs will be evaluated on a case-by-case basis to incorporate uncertainties concerning the presence of PAHs into the risk management process. This will include ***quantitative*** evaluation of the risk/hazard presented by PAHs in the BHHRA, consistent with the Paducah Risk Methods Document.[8] Subsequently, the BHHRA will discuss the uncertainties associated with the presence of PAHs, and these uncertainties will be combined with risk characterization in the Observations section. The FS will manage these uncertainties and incorporate regulatory requirements to ensure that potential exposure to residual PAHs in environmental media is addressed appropriately.

Because PAHs generally are not related to identifiable sources, sampling for PAHs at many SWMUs should be deferred to post-gaseous diffusion plant (GDP) activities; however, the need for sampling for PAHs would be appropriate during pre-GDP activities at SWMUs where PAHs release are potentially expected (e.g., SWMU 30, which contained an incinerator). The need for sampling for PAHs should be addressed during project scoping on a SWMU-specific basis.

[1] Agency for Toxic Substances and Disease Registry [ATSDR 1995] see http://www.atsdr.cdc.gov/toxprofiles/tp69.pdf).

[2] *Risk Management Considerations for Polycyclic Aromatic Hydrocarbon Contamination at the Portsmouth Gaseous Diffusion Plant,* POEF-ER-4616&D1, January 27, 1995.

[3] E-mail correspondence among FFA parties.

[4] *Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee; Volume 1, Results of Field Sampling Program,* DOE/OR/01-1175/V1.

[5] "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30) April 22, 1991.

[6] Kentucky Guidance for Ambient Background Assessment, January 8, 2004, Natural Resources and Environmental Protection Cabinet.

[7] Kentucky Revised Statute 224.01-400 (1) (b).

[8] *Risk Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0107&D2/R1, February 2011.

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E.8. DILUTION ATTENUATION FACTOR EVALUATION

An evaluation of the dilution attenuation factor (DAF), including a sensitivity analysis of how the screening results would vary in response to a change in the target DAF used in screening was conducted in the *Soils Operable Unit Remedial Investigation Report at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky,* DOE/LX/07-0358&D2/R1 (issued February 2013).

The attachment from DOE/LX/07-0358 containing this evaluation is reprinted in this section.

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C2. DILUTION ATTENUATION FACTOR EVALUATION

The maximum Upper Continental Recharge System (UCRS) soil concentrations that are protective of Regional Gravel Aquifer (RGA) groundwater quality are determined by combining the dilution attenuation factor (DAF) (unitless) calculations with contaminant-specific distribution coefficients (K_d) (units of volume/mass). The DAF is a measure of how much the UCRS concentration of a soil constituent is diluted or attenuated by the migration through the UCRS, coupled with the migration through the RGA.

The DAF was calculated by comparing the volume of contaminated groundwater passing vertically through a UCRS solid waste management unit (SWMU)/area of concern (AOC) with the volume of "clean" RGA groundwater flowing beneath the SWMU/AOC and mixing with the UCRS water. RGA groundwater flows are much higher relative to UCRS groundwater flows; thus, mixing the two waters will result in much lower RGA groundwater contaminant concentrations relative to the initial UCRS groundwater contaminant concentrations. The reduction in groundwater concentrations in the RGA is proportional to the ratio of the volume of "clean" RGA groundwater to contaminated UCRS groundwater. The DAF calculates the impact on the concentration from the relative rates of vertical migration of contaminated UCRS water and the horizontal rate of migration of "clean" RGA groundwater to yield a concentration of the blended diluted/attenuated water.

To complete the evaluation, the K_d of the constituent must be factored into the analysis. K_d represents the ratio of contamination adhered to soil particles relative to that dissolved in groundwater.

Starting with a target-acceptable RGA groundwater contaminant concentration below the source area [i.e., maximum contaminant levels (MCLs) or site-specific risk based concentrations, etc.], the maximum-acceptable UCRS groundwater contaminant concentration can be calculated. When this result is combined with the K_d, this calculation will yield the maximum-acceptable UCRS soil contaminant concentration that is protective of RGA groundwater quality at the target concentration.

Once calculated, the maximum UCRS soil contaminant concentrations were used as site-specific remedial guide soil screening levels to screen the site-specific soil contamination data to identify those constituents that may pose a threat to groundwater. Soil contaminants found at concentrations below the levels identified as protective were screened from further evaluation of impacts to groundwater. Sites having soil contamination above the identified protective levels then were subjected to additional evaluation to estimate the potential for impacts to groundwater. This evaluation is summarized elsewhere in Appendix C and included the following:

- Comparing the nature of the constituent against the constituents found to have had an impact on the RGA groundwater at Paducah Gaseous Diffusion Plant (PGDP) (see Attachment C1) to identify whether there is evidence of these soil concentrations having had an impact on the RGA groundwater;
- Evaluating the horizontal and vertical spatial distribution of soil constituent concentrations to identify hot spots that may need to be addressed;
- Evaluating the locations of the constituents and comparing them to the RGA groundwater impacts; and
- Performing numerical modeling using the spatial distribution of soil contamination as an input into the Seasonal Soil Compartment Model (SESOIL) and Analytical Transient 1-,2-,3- Dimensional (AT123D) modeling to predict downgradient RGA temporal groundwater concentrations.

This attachment discusses the derivation of the DAF and the finding that the deterministic DAF for these soils is calculated at 58. This attachment also provides a sensitivity analysis of the screening of Soils Operable Unit (OU) concentrations against values calculated using a DAF of 58 and a DAF of 20. The effects on the decision to model groundwater impacts from individual SWMU/AOC soil constituent combinations are also discussed.

C2.1. METHODOLOGY

The DAF calculation recognizes that vertical mixing of UCRS and RGA groundwater does not immediately occur throughout the entire RGA thickness and mixing primarily occurs in the upper portions of the RGA immediately below the source area, deemed the mixing depth. The DAF (unitless) for the Soils OU is calculated using the following equation:

$$DAF = 1 + \frac{Kid}{IL} \qquad \text{(EPA 1996)}$$

Where:

i = horizontal hydraulic gradient (m/m)
d = mixing zone depth (m)
I = infiltration rate (m/yr)
L = length of source area parallel to groundwater flow (m)
K = aquifer hydraulic conductivity (m/yr)

The equation for calculating the aquifer mixing zone depth, d:

$$d = \left(0.0112\, L^2\right)^{0.5} + d_a \left\{1 - e^{\left[\frac{(-L\, I)}{(K\, i\, d_a)}\right]}\right\}$$

Where:

d_a = aquifer thickness (m)

The first term in the equation predicts the depth of the mixing due to vertical dispersivity along the length of the groundwater flow path:

$$\left(0.0112\, L^2\right)^{0.5}$$

The second term in the equation estimates the depth of mixing due to the downward velocity of infiltrating water:

$$d_a \left\{ 1 - e^{\left[\frac{(-L\,I)}{(K\,i\,d_a)} \right]} \right\}$$

Most important is the presence of L (length of source area parallel to groundwater flow) in d (mixing zone depth) in the DAF equation. Incorporation of L in d, results in L being in both the numerator and denominator of the DAF equation. NOTE: These equations indicate that as long as hydraulic conductivity (K), hydraulic gradient (i) and the infiltration rate (I) remain constant, the DAF will be constant regardless of the size of the source area undergoing evaluation. While mathematically true, the DAF is ultimately based on plume center-line concentrations which remain the same regardless of source area size. What does differ is the plume footprint, smaller source areas will generate smaller plume widths and lengths relative to larger source areas; however, the plume center-line concentrations will be the calculated to be the same regardless of source area size.

C2.2. DAF CALCULATIONS

Assuming an L of 1 m and using the input parameters provided in Table C2.1, the DAF result is 58 for all Soils OU SWMUs/AOCs. With the exception of aquifer thickness, Table C2.1 values are exactly the same as those used for the Southwest Plume Site Investigation (DOE 2007) DAF evaluation. The aquifer thickness differs (9.14 m verses 10.54 m) slightly because the previous efforts did not include the Hydrogeologic Unit (HU) 4 stratigraphic thickness in the total RGA aquifer thickness despite the HU4 being considered part of the RGA flow system as evidenced by the unit being included in determining a representative RGA/HU4 hydraulic conductivity value.

Table C2.1. DAF Input Parameter Values

Parameter	Description	Value	Source
K	Horizontal Hydraulic Conductivity	0.45 cm/s; 1,286 ft/d This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence RGA K, 0.53 cm/s; thickness, 9.14 m K, 1,502 ft/d; thickness, 30 ft HU4 K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft	Southwest Plume Site-Investigation Report (DOE 2007)
I	Horizontal Hydraulic Gradient	4.00E-04 m/m, 4.00E-04 ft/ft	Southwest Plume Site-Investigation Report (DOE 2007)

Table C2.1. DAF Input Parameter Values (Continued)

Parameter	Description	Value	Source
I	Infiltration Rate	0.1054 m/yr, 4.1 inches/yr	SESOIL predicted net recharge rate to groundwater, Southwest Plume Remedial Investigation Report (DOE 2007)
d_a	Aquifer Thickness (HU4 +RGA)	10.54 m, 35 ft	Southwest Plume Site-Investigation Report (DOE 2007)

As noted previously, the DAF is independent of waste area size, but is dependent on K, i, and I. Given that the 50 Soils OU SWMUs/AOCs are widely distributed within the PGDP and the vicinity, it is expected that site-specific K, i, and I will vary somewhat.

An evaluation of RGA horizontal hydraulic gradients shows i is expected to range between 1.84×10^{-4} and 2.98×10^{-3} ft/ft and have average and median values of 7.81×10^{-4} and 4.4×10^{-4} ft/ft, respectively (DOE 2010). Because of the inclusion in the data set of some localized, relatively high horizontal hydraulic gradients associated with PGDP anthropogenic influences, the median horizontal hydraulic gradient is more representative than the average horizontal hydraulic gradient.

With respect to K variability, six RGA pumping tests have been conducted and have produced hydraulic conductivity estimates ranging between approximately 100 and 3,600 ft/day (CH2M HILL 1992; LMES 1996a; LMES 1996b; LMES 1997; Terran 1990; Terran 1992). The lowest measured RGA hydraulic conductivity is beneath PGDP. The highest measured value is between PGDP and the Ohio River. A previous evaluation assumed that RGA hydraulic conductivity ranged between 75 ft/d and 1,500 ft/d, with a likeliest value of 350 ft/d (DOE 2007). The evaluation was based on the 1997 PGDP groundwater flow model (DOE 1997), which has since undergone recalibration. The current calibrated PGDP RGA groundwater flow model (DOE 2010) contains K values that range over the values characterized by the RGA pumping tests.

Minimal HU4 K measurements have been collected so the value presented in Table C2.1 is assumed to be representative. In addition, the thicker (and thus higher weighted) and higher RGA K values dominate the arithmetic averaged calculations, thus fixing the HU4 K in the analysis will have minimal impact on the evaluation.

Thornthwaite analysis (Thornthwaite and Mather 1957), which is based on monthly precipitation and potential evaporation rates, was used to estimate I at PGDP (DOE 2010). The calculations estimate that I ranges from 2.64 to 7.64 inches/yr. In addition to I from precipitation, anthropogenic I from man-made sources could be as high as 48 inches/yr (DOE 2010). Note that the higher anthropogenic I values are believed to be associated with features such as the cooling towers, the C-616 Lagoons, and building drainage systems; thus, the anthropogenic I values are expected to have only limited impacts on the migration of constituents from the Soils OU SWMUs/AOCs. It is assumed that the calculated range associated with precipitation I is most appropriate for an evaluation of the Soils OU SWMUs/AOCs.

For this analysis, it was assumed that the HU4 and RGA thickness reported in Table C2.1 are "typical."

Table C2.2. Minimum and Maximum DAF Input Parameter Values

Parameter	Description	Minimum Value	Maximum Value
K	Horizontal Hydraulic Conductivity	0.03 cm/s, 85 ft/d This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence <u>RGA</u> K, 0.035 cm/s; thickness, 9.14 m K, 100 ft/d; thickness, 30 ft <u>HU4</u> K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft	1.09 cm/s; 3,087 ft/d This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence <u>RGA</u> K, 1.27 cm/s; thickness, 9.14 m K, 3,600 ft/d; thickness, 30 ft <u>HU4</u> K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft
i	Horizontal Hydraulic Gradient	1.84E-04 m/m, 1.84E-04 ft/ft	2.98E-03 m/m, 2.98E-04 ft/ft
I	Infiltration Rate	0.0679 m/yr, 2.64 inches/yr	0.1964 m/yr, 7.64 inches/yr
d_a	Aquifer Thickness (HU4 +RGA)	10.54 m, 35 ft	10.54 m, 35 ft

Based on expected minimum and maximum K, i, and I values (Table C2.2), DAF values for the Soils OU are expected to range between 5 and 139. If the maximum hydraulic conductivity value is limited to 1,500 ft/d, to reflect the lower hydraulic conductivity values found beneath the PGDP, then the maximum DAF is 68.

The previous calculations provide an indication of the potential DAF range based on sitewide input parameter variability; however, the evaluation does not characterize the DAF distribution between the potential minimum and maximum DAF values. To develop a better understanding of the potential DAF distribution, probabilistic evaluation was performed using the parameter value distributions listed in Table C2.3.

Table C2.3. Parameter Distributions

Parameter	Most Likely Value	Minimum Value	Maximum Value	Standard Deviation	Coefficient of Variation	Distribution Type
Hydraulic Conductivity, ft/d	350	75	1,500	350	100	Log Normal
Horizontal Hydraulic Gradient, ft/ft	1.01E-03	1.00E-04	4.00E-03	1.12E-03	1.11E+02	Normal
Infiltration, inches/yr	4.1	2.64	7.64	--	--	Uniform
Aquifer Thickness, ft	38.71	10	63.5	11.84	30.59	Normal

The parameter distributions, with the exception of I, were developed for probabilistic evaluation of soil cleanup RGs for SWMU 1 and the C-720 Building (DOE 2007; DOE 2011). For the soil RG probabilistic evaluation, I was held constant. For this probabilistic evaluation, I, as discussed previously, was assumed to range linearly between 2.64 inches/yr and 7.64 inches/yr.

Crystal Ball® (Decisioneering, Inc. 2000) was used to generate 10,000 individual K, horizontal i, I, and d_a values which were used as input to the DAF calculation. The evaluation predicted mean, median, minimum, and maximum DAF values of 52, 33, 3, and 366, respectively. Note that the probabilistic mean (52) DAF value is similar to the deterministic mean DAF value of 58. Additionally, the probabilistic minimum DAF (3) is similar to the minimum DAF (5) calculated using minimum parameter inputs (Table C2.2). The maximum probabilistic DAF (366), while larger than the deterministic maximum DAF (139), is within the same order of magnitude. Evaluation of the probabilistic DAF distribution (Figure C2.1) shows that lower DAF values occur more frequently than higher DAF values with the most frequently occurring DAF being between 11 and 20.

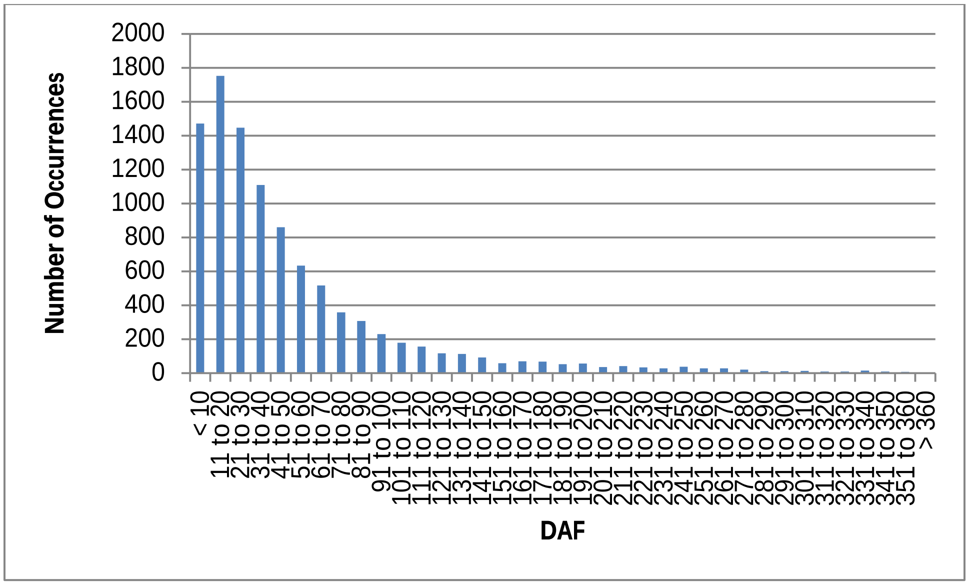

Figure C2.1. Probabilistic DAF Distribution

C2.3. SUMMARY

Deterministic evaluation of PGDP site conditions predicts a DAF of 58 for the Soils OU. Minimum and maximum deterministic predicted DAF values are 5 and 139, respectively. Probabilistic evaluation predicts average, median, minimum, and maximum DAF values of 52, 33, 3, and 366, respectively. Frequency evaluation shows that lower value DAF values are more common than higher DAF values, with the most frequently occurring DAF being between 11 and 20.

The DAF of 58 determined in this calculation was used to support screening of the Soils OU results to identify those SWMUs/AOCs where constituents might present an impact to groundwater. The results of this screening are summarized in Attachment C1 to Appendix C.

Section C2.4 presents a sensitivity analysis of this same screening using a DAF of 20. The DAF of 20 was used because it is a value that EPA uses as a default value for screening in their derivation of soil screening values and also because it is a lower value than the median value calculated for PGDP of 33. A value of 20 is recognized as a reasonable value for general soil conditions (including sandy soils); however, the UCRS at PGDP has much more silt and clay than the typical sandy soil condition; thus, a DAF greater than 20 (33 or 58) is expected to better estimate the actual potential for migration to groundwater at the PGDP. The DAF of 58 is similar to that calculated for the Southwest Plume and is considered typical of that found at PGDP where most locations have a majority of the URCS composed of silt and clay.

C2.4. SENSITIVITY ANALYSIS

The screening identified in Attachment C1 of Appendix C was carried out using a DAF of 58 to yield the results summarized in Tables C1.3 and C1.4. This screening identified 109 SWMU/AOC soil constituent combinations that exceeded the screening values based on the overall average concentration, as follows:

- Thirty exceeded for silver (9 exceeded average without maximum value exceedance);
- Twenty-three exceeded for Total polycyclic aromatic hydrocarbons (PAHs) or benz(a)anthracene [3 exceeded the average (calculated using half the detection limit) but the maximum detected value did not exceed the screening level];
- Twenty-three exceeded for molybdenum (18 exceeded average without maximum value exceedance);
- Two exceeded for nickel;
- Four exceeded for neptunium-237;
- Two exceeded for technetium-99;
- Eight exceeded for naphthalene;
- One exceeded for thorium-230;
- Two exceeded for cobalt;
- One exceeded for uranium-238;
- One exceeded for uranium;
- Two exceeded for vanadium;
- Three exceeded for Total polychlorinated biphenyl (PCBs);
- Two exceeded for pentachlorophenol (1 exceeded average without maximum value exceedance);
- Two exceeded for arsenic; and
- Three exceeded for volatile organic compounds (VOCs) (1 VOC each; all at SWMU 1).

Based upon the additional evaluation presented in Attachment C1 to Appendix C, 8 SWMU/AOC soil constituent combinations were subjected to fate and transport modeling as summarized in Appendix C.

This same screening approach was performed using values derived from a DAF of 20 in order to evaluate the sensitivity of this screening to the DAF. Screening against DAF 20 values identified 280

SWMU/AOC soil constituent combinations that exceeded the screening values based on the average concentrations, as follows, and shown in Table C2.4, sorted by analyte.

- Two exceeded soil screening levels/background for antimony
- Seven exceeded for arsenic
- Fifty-four exceeded for Total PAHs or benz(a)anthracene
- Two exceeded for cobalt
- Twenty-nine exceeded for mercury
- Thirty-three exceeded for molybdenum
- Eight exceeded for naphthalene
- Nine exceeded for neptunium-237
- Twenty-nine exceeded for nickel
- Two exceeded for pentachlorophenol
- Three exceeded for plutonium 239/240
- Thirty exceeded for selenium
- Thirty exceeded for silver
- Five exceeded for Tc-99
- Five exceeded for thallium
- Two exceeded for thorium-230
- Sixteen exceeded for Total PCBs
- Three exceeded for uranium
- Three exceeded for uranium-238
- Two exceeded for vanadium
- One exceeded for zinc
- Six exceeded for VOCs

Table C2.4. SWMU/AOC Soil Constituent Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
1	99	Antimony	mg/kg	5.47E+00	5.30E-01	**2.10E-01**	**5.42E+00**
2	196	Antimony	mg/kg	7.81E+00	1.21E+02	**2.10E-01**	**5.42E+00**
1	76	Arsenic	mg/kg	8.10E+00	1.31E+01	**7.90E+00**	**5.84E+00**
2	81	Arsenic	mg/kg	8.18E+00	1.37E+01	**7.90E+00**	**5.84E+00**
3	165	Arsenic	mg/kg	2.72E+01	1.30E+02	**7.90E+00**	**5.84E+00**
4	180	Arsenic	mg/kg	8.23E+00	1.38E+02	**7.90E+00**	**5.84E+00**
5	531	Arsenic	mg/kg	9.97E+00	4.68E+01	**7.90E+00**	**5.84E+00**
6	561	Arsenic	mg/kg	9.00E+00	3.96E+01	**7.90E+00**	**5.84E+00**
7	564	Arsenic	mg/kg	2.54E+01	4.30E+01	**7.90E+00**	**5.84E+00**
1	1	Benz(a)anthracene	mg/kg	3.02E-01	6.40E-02	**0.00E+00**	**8.64E-02**
2	19	Benz(a)anthracene	mg/kg	4.45E-01	3.70E+00	**0.00E+00**	**8.64E-02**
3	76	Benz(a)anthracene	mg/kg	9.40E-01	1.70E+00	**0.00E+00**	**8.64E-02**
4	81	Benz(a)anthracene	mg/kg	2.43E-01	6.50E-01	**0.00E+00**	**8.64E-02**
5	138	Benz(a)anthracene	mg/kg	5.24E-01	4.80E-02	**0.00E+00**	**8.64E-02**
6	153	Benz(a)anthracene	mg/kg	1.32E-01	5.80E-02	**0.00E+00**	**8.64E-02**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
7	156	Benz(a)anthracene	mg/kg	1.55E-01	6.60E-02	**0.00E+00**	**8.64E-02**
8	158	Benz(a)anthracene	mg/kg	3.67E-01	4.30E-01	**0.00E+00**	**8.64E-02**
9	163	Benz(a)anthracene	mg/kg	1.97E-01	1.60E-01	**0.00E+00**	**8.64E-02**
10	165	Benz(a)anthracene	mg/kg	3.36E-01	1.50E+00	**0.00E+00**	**8.64E-02**
11	169	Benz(a)anthracene	mg/kg	7.50E-01	1.30E+00	**0.00E+00**	**8.64E-02**
12	180	Benz(a)anthracene	mg/kg	1.84E-01	4.80E-02	**0.00E+00**	**8.64E-02**
13	194	Benz(a)anthracene	mg/kg	2.13E-01	8.90E-01	**0.00E+00**	**8.64E-02**
14	195	Benz(a)anthracene	mg/kg	2.05E-01	1.90E-01	**0.00E+00**	**8.64E-02**
15	196	Benz(a)anthracene	mg/kg	1.24E+00	6.90E+00	**0.00E+00**	**8.64E-02**
16	213	Benz(a)anthracene	mg/kg	1.10E-01	1.10E-01	**0.00E+00**	**8.64E-02**
17	215	Benz(a)anthracene	mg/kg	2.25E-01	8.00E-02	**0.00E+00**	**8.64E-02**
18	217	Benz(a)anthracene	mg/kg	2.08E-01	3.80E-01	**0.00E+00**	**8.64E-02**
19	221	Benz(a)anthracene	mg/kg	6.10E-01	6.10E-01	**0.00E+00**	**8.64E-02**
20	222	Benz(a)anthracene	mg/kg	1.20E-01	1.20E-01	**0.00E+00**	**8.64E-02**
21	227	Benz(a)anthracene	mg/kg	2.11E-01	1.18E-01	**0.00E+00**	**8.64E-02**
22	228	Benz(a)anthracene	mg/kg	1.18E-01	4.00E-02	**0.00E+00**	**8.64E-02**
23	488	Benz(a)anthracene	mg/kg	1.93E-01	1.90E-01	**0.00E+00**	**8.64E-02**
24	489	Benz(a)anthracene	mg/kg	1.36E-01	7.60E-02	**0.00E+00**	**8.64E-02**
25	518	Benz(a)anthracene	mg/kg	7.92E+00	1.10E+02	**0.00E+00**	**8.64E-02**
26	520	Benz(a)anthracene	mg/kg	2.25E-01	3.80E-01	**0.00E+00**	**8.64E-02**
27	531	Benz(a)anthracene	mg/kg	1.17E-01	3.90E-02	**0.00E+00**	**8.64E-02**
28	541	Benz(a)anthracene	mg/kg	6.29E-01	6.40E+00	**0.00E+00**	**8.64E-02**
29	561	Benz(a)anthracene	mg/kg	2.17E-01	1.90E+00	**0.00E+00**	**8.64E-02**
30	562	Benz(a)anthracene	mg/kg	2.55E-01	5.20E-01	**0.00E+00**	**8.64E-02**
1	1	*cis*-1,2-Dichloroethene	mg/kg	1.79E+01	2.40E+03	**0.00E+00**	**4.12E-01**
1	217	Cobalt	mg/kg	1.38E+01	1.90E+02	**1.30E+01**	**2.82E-01**
2	221	Cobalt	mg/kg	4.05E+01	1.44E+02	**1.30E+01**	**2.82E-01**
1	14	Mercury	mg/kg	4.87E+00	4.37E+01	**1.30E-01**	**2.08E+00**
2	76	Mercury	mg/kg	3.50E+00	7.45E+00	**1.30E-01**	**2.08E+00**
3	81	Mercury	mg/kg	4.27E+00	8.33E+00	**1.30E-01**	**2.08E+00**
4	99	Mercury	mg/kg	4.20E+00	9.53E+00	**1.30E-01**	**2.08E+00**
5	138	Mercury	mg/kg	4.89E+00	2.13E+01	**1.30E-01**	**2.08E+00**
6	153	Mercury	mg/kg	4.34E+00	1.99E-02	**1.30E-01**	**2.08E+00**
7	156	Mercury	mg/kg	4.70E+00	9.87E+00	**1.30E-01**	**2.08E+00**
8	158	Mercury	mg/kg	4.49E+00	1.05E+01	**1.30E-01**	**2.08E+00**
9	163	Mercury	mg/kg	4.33E+00	7.53E+00	**1.30E-01**	**2.08E+00**
10	169	Mercury	mg/kg	3.02E+00	7.87E+00	**1.30E-01**	**2.08E+00**
11	180	Mercury	mg/kg	4.69E+00	8.28E+00	**1.30E-01**	**2.08E+00**
12	194	Mercury	mg/kg	4.58E+00	8.94E+00	**1.30E-01**	**2.08E+00**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
13	195	Mercury	mg/kg	4.64E+00	8.43E+00	**1.30E-01**	**2.08E+00**
14	200	Mercury	mg/kg	4.62E+00	6.93E+00	**1.30E-01**	**2.08E+00**
15	212	Mercury	mg/kg	3.20E+00	6.94E+00	**1.30E-01**	**2.08E+00**
16	213	Mercury	mg/kg	4.75E+00	3.75E-02	**1.30E-01**	**2.08E+00**
17	214	Mercury	mg/kg	3.35E+00	4.16E-02	**1.30E-01**	**2.08E+00**
18	215	Mercury	mg/kg	4.35E+00	2.83E-02	**1.30E-01**	**2.08E+00**
19	216	Mercury	mg/kg	2.52E+00	3.49E-02	**1.30E-01**	**2.08E+00**
20	217	Mercury	mg/kg	3.60E+00	9.20E+00	**1.30E-01**	**2.08E+00**
21	219	Mercury	mg/kg	3.01E+00	2.59E-02	**1.30E-01**	**2.08E+00**
22	221	Mercury	mg/kg	4.80E+00	1.23E+01	**1.30E-01**	**2.08E+00**
23	222	Mercury	mg/kg	3.81E+00	2.77E-02	**1.30E-01**	**2.08E+00**
24	227	Mercury	mg/kg	3.83E+00	8.41E+00	**1.30E-01**	**2.08E+00**
25	228	Mercury	mg/kg	4.18E+00	9.37E+00	**1.30E-01**	**2.08E+00**
26	488	Mercury	mg/kg	3.90E+00	5.03E-02	**1.30E-01**	**2.08E+00**
27	489	Mercury	mg/kg	3.01E+00	3.39E-02	**1.30E-01**	**2.08E+00**
28	520	Mercury	mg/kg	4.25E+00	1.19E+01	**1.30E-01**	**2.08E+00**
29	531	Mercury	mg/kg	4.38E+00	3.65E-02	**1.30E-01**	**2.08E+00**
1	165	Methylene chloride	mg/kg	4.67E-02	6.80E-02	**0.00E+00**	**2.54E-02**
1	1	Molybdenum	mg/kg	4.31E+00	1.42E+01	**0.00E+00**	**2.10E+00**
2	14	Molybdenum	mg/kg	7.16E+00	2.87E+01	**0.00E+00**	**2.10E+00**
3	81	Molybdenum	mg/kg	6.70E+00	2.20E+00	**0.00E+00**	**2.10E+00**
4	99	Molybdenum	mg/kg	7.09E+00	1.60E+01	**0.00E+00**	**2.10E+00**
5	138	Molybdenum	mg/kg	6.90E+00	1.10E+00	**0.00E+00**	**2.10E+00**
6	153	Molybdenum	mg/kg	6.65E+00	1.20E+00	**0.00E+00**	**2.10E+00**
7	156	Molybdenum	mg/kg	6.73E+00	7.40E-01	**0.00E+00**	**2.10E+00**
8	158	Molybdenum	mg/kg	6.77E+00	1.20E+00	**0.00E+00**	**2.10E+00**
9	160	Molybdenum	mg/kg	5.54E+00	7.70E-01	**0.00E+00**	**2.10E+00**
10	163	Molybdenum	mg/kg	6.90E+00	1.60E+00	**0.00E+00**	**2.10E+00**
11	169	Molybdenum	mg/kg	6.59E+00	6.27E+00	**0.00E+00**	**2.10E+00**
12	180	Molybdenum	mg/kg	6.98E+00	1.40E+00	**0.00E+00**	**2.10E+00**
13	194	Molybdenum	mg/kg	6.94E+00	1.96E+01	**0.00E+00**	**2.10E+00**
14	195	Molybdenum	mg/kg	6.97E+00	5.60E+00	**0.00E+00**	**2.10E+00**
15	196	Molybdenum	mg/kg	4.14E+00	1.30E+00	**0.00E+00**	**2.10E+00**
16	200	Molybdenum	mg/kg	6.90E+00	7.30E-01	**0.00E+00**	**2.10E+00**
17	212	Molybdenum	mg/kg	6.06E+00	1.30E+00	**0.00E+00**	**2.10E+00**
18	213	Molybdenum	mg/kg	7.16E+00	6.10E-01	**0.00E+00**	**2.10E+00**
19	214	Molybdenum	mg/kg	5.15E+00	4.50E-01	**0.00E+00**	**2.10E+00**
20	215	Molybdenum	mg/kg	6.63E+00	1.00E+00	**0.00E+00**	**2.10E+00**
21	216	Molybdenum	mg/kg	4.11E+00	7.10E-01	**0.00E+00**	**2.10E+00**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
22	217	Molybdenum	mg/kg	6.88E+00	5.89E+00	**0.00E+00**	**2.10E+00**
23	219	Molybdenum	mg/kg	4.63E+00	3.40E-01	**0.00E+00**	**2.10E+00**
24	221	Molybdenum	mg/kg	6.83E+00	4.00E+00	**0.00E+00**	**2.10E+00**
25	222	Molybdenum	mg/kg	6.62E+00	1.20E+00	**0.00E+00**	**2.10E+00**
26	227	Molybdenum	mg/kg	6.51E+00	5.21E+00	**0.00E+00**	**2.10E+00**
27	228	Molybdenum	mg/kg	6.23E+00	1.20E+00	**0.00E+00**	**2.10E+00**
28	488	Molybdenum	mg/kg	5.92E+00	5.50E-01	**0.00E+00**	**2.10E+00**
29	489	Molybdenum	mg/kg	4.75E+00	7.40E-01	**0.00E+00**	**2.10E+00**
30	520	Molybdenum	mg/kg	6.99E+00	1.30E+00	**0.00E+00**	**2.10E+00**
31	531	Molybdenum	mg/kg	6.66E+00	1.10E+00	**0.00E+00**	**2.10E+00**
32	541	Molybdenum	mg/kg	2.42E+00	5.62E+00	**0.00E+00**	**2.10E+00**
33	564	Molybdenum	mg/kg	6.88E+00	7.84E+00	**0.00E+00**	**2.10E+00**
1	1	Naphthalene	mg/kg	1.25E+00	5.78E-04	**0.00E+00**	**1.16E-02**
2	19	Naphthalene	mg/kg	1.89E-01	1.10E+00	**0.00E+00**	**1.16E-02**
3	81	Naphthalene	mg/kg	2.21E-01	3.90E-01	**0.00E+00**	**1.16E-02**
4	165	Naphthalene	mg/kg	5.84E-01	4.70E+00	**0.00E+00**	**1.16E-02**
5	194	Naphthalene	mg/kg	1.98E-01	4.80E-02	**0.00E+00**	**1.16E-02**
6	196	Naphthalene	mg/kg	1.78E-01	1.10E+00	**0.00E+00**	**1.16E-02**
7	541	Naphthalene	mg/kg	2.71E-01	1.80E+00	**0.00E+00**	**1.16E-02**
8	561	Naphthalene	mg/kg	2.05E-01	5.50E-01	**0.00E+00**	**1.16E-02**
1	1	Neptunium-237	pCi/g	1.14E-01	6.63E-01	**0.00E+00**	**9.00E-02**
2	14	Neptunium-237	pCi/g	1.47E+00	1.60E+01	**0.00E+00**	**9.00E-02**
3	165	Neptunium-237	pCi/g	3.66E-01	5.60E-01	**0.00E+00**	**9.00E-02**
4	196	Neptunium-237	pCi/g	1.33E-01	3.11E-01	**0.00E+00**	**9.00E-02**
5	212	Neptunium-237	pCi/g	1.73E+00	4.00E+00	**0.00E+00**	**9.00E-02**
6	227	Neptunium-237	pCi/g	2.15E-01	2.53E+00	**0.00E+00**	**9.00E-02**
7	228	Neptunium-237	pCi/g	1.47E-01	8.00E-01	**0.00E+00**	**9.00E-02**
8	517	Neptunium-237	pCi/g	3.04E-01	1.07E+00	**0.00E+00**	**9.00E-02**
9	520	Neptunium-237	pCi/g	1.20E-01	1.10E+00	**0.00E+00**	**9.00E-02**
1	14	Nickel	mg/kg	2.44E+02	2.67E+03	**2.20E+01**	**2.72E+01**
2	19	Nickel	mg/kg	4.26E+01	4.38E+02	**2.20E+01**	**2.72E+01**
3	81	Nickel	mg/kg	3.31E+01	1.14E+02	**2.20E+01**	**2.72E+01**
4	99	Nickel	mg/kg	3.45E+01	9.05E+01	**2.20E+01**	**2.72E+01**
5	138	Nickel	mg/kg	3.56E+01	1.13E+02	**2.20E+01**	**2.72E+01**
6	153	Nickel	mg/kg	4.18E+01	9.92E+01	**2.20E+01**	**2.72E+01**
7	156	Nickel	mg/kg	3.13E+01	6.16E+01	**2.20E+01**	**2.72E+01**
8	158	Nickel	mg/kg	3.58E+01	1.32E+02	**2.20E+01**	**2.72E+01**
9	163	Nickel	mg/kg	3.70E+01	7.81E+01	**2.20E+01**	**2.72E+01**
10	169	Nickel	mg/kg	6.61E+01	8.04E+02	**2.20E+01**	**2.72E+01**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
11	180	Nickel	mg/kg	3.97E+01	1.08E+02	**2.20E+01**	**2.72E+01**
12	194	Nickel	mg/kg	3.55E+01	1.08E+02	**2.20E+01**	**2.72E+01**
13	195	Nickel	mg/kg	3.58E+01	1.02E+02	**2.20E+01**	**2.72E+01**
14	196	Nickel	mg/kg	3.91E+01	5.87E+02	**2.20E+01**	**2.72E+01**
15	200	Nickel	mg/kg	5.00E+01	2.60E+02	**2.20E+01**	**2.72E+01**
16	212	Nickel	mg/kg	2.91E+01	8.69E+01	**2.20E+01**	**2.72E+01**
17	213	Nickel	mg/kg	3.98E+01	9.10E+01	**2.20E+01**	**2.72E+01**
18	215	Nickel	mg/kg	3.26E+01	7.32E+01	**2.20E+01**	**2.72E+01**
19	217	Nickel	mg/kg	3.53E+01	1.31E+02	**2.20E+01**	**2.72E+01**
20	219	Nickel	mg/kg	3.08E+01	6.71E+01	**2.20E+01**	**2.72E+01**
21	221	Nickel	mg/kg	3.84E+01	1.39E+02	**2.20E+01**	**2.72E+01**
22	222	Nickel	mg/kg	3.66E+01	9.19E+01	**2.20E+01**	**2.72E+01**
23	227	Nickel	mg/kg	6.37E+01	6.53E+02	**2.20E+01**	**2.72E+01**
24	228	Nickel	mg/kg	3.58E+01	7.92E+01	**2.20E+01**	**2.72E+01**
25	489	Nickel	mg/kg	3.77E+01	7.88E+01	**2.20E+01**	**2.72E+01**
26	517	Nickel	mg/kg	5.65E+01	1.72E+02	**2.20E+01**	**2.72E+01**
27	520	Nickel	mg/kg	7.91E+01	8.10E+02	**2.20E+01**	**2.72E+01**
28	531	Nickel	mg/kg	5.37E+01	1.62E+02	**2.20E+01**	**2.72E+01**
1	14	PCB, Total	mg/kg	2.71E+00	1.00E+01	**0.00E+00**	**1.56E+00**
2	76	PCB, Total	mg/kg	1.57E+00	2.60E-01	**0.00E+00**	**1.56E+00**
3	81	PCB, Total	mg/kg	6.31E+00	3.70E+02	**0.00E+00**	**1.56E+00**
4	138	PCB, Total	mg/kg	1.93E+00	5.00E-01	**0.00E+00**	**1.56E+00**
5	153	PCB, Total	mg/kg	2.09E+00	6.00E-01	**0.00E+00**	**1.56E+00**
6	156	PCB, Total	mg/kg	2.33E+00	3.00E-01	**0.00E+00**	**1.56E+00**
7	169	PCB, Total	mg/kg	1.68E+00	1.00E+01	**0.00E+00**	**1.56E+00**
8	194	PCB, Total	mg/kg	2.29E+00	1.80E+01	**0.00E+00**	**1.56E+00**
9	195	PCB, Total	mg/kg	2.32E+00	7.40E-01	**0.00E+00**	**1.56E+00**
10	200	PCB, Total	mg/kg	2.35E+00	2.60E+00	**0.00E+00**	**1.56E+00**
11	213	PCB, Total	mg/kg	2.38E+00	7.30E-02	**0.00E+00**	**1.56E+00**
12	221	PCB, Total	mg/kg	2.23E+00	5.00E-01	**0.00E+00**	**1.56E+00**
13	227	PCB, Total	mg/kg	1.93E+00	1.26E+01	**0.00E+00**	**1.56E+00**
14	488	PCB, Total	mg/kg	2.81E+00	1.03E+01	**0.00E+00**	**1.56E+00**
15	492	PCB, Total	mg/kg	4.77E+00	4.41E+01	**0.00E+00**	**1.56E+00**
16	541	PCB, Total	mg/kg	1.39E+01	9.40E+01	**0.00E+00**	**1.56E+00**
1	1	Pentachlorophenol	mg/kg	9.33E-01	1.10E-01	**0.00E+00**	**2.02E-01**
2	165	Pentachlorophenol	mg/kg	1.10E+00	2.10E+00	**0.00E+00**	**2.02E-01**
1	1	Plutonium-239/240	pCi/g	2.20E+00	9.05E+00	**0.00E+00**	**1.56E+00**
2	165	Plutonium-239/240	pCi/g	2.93E+00	7.78E+00	**0.00E+00**	**1.56E+00**
3	212	Plutonium-239/240	pCi/g	3.32E+00	6.71E+00	**0.00E+00**	**1.56E+00**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
1	14	Selenium	mg/kg	9.30E+00	3.07E+01	**7.00E-01**	**5.20E+00**
2	76	Selenium	mg/kg	6.49E+00	1.50E+00	**7.00E-01**	**5.20E+00**
3	81	Selenium	mg/kg	8.48E+00	1.40E+00	**7.00E-01**	**5.20E+00**
4	99	Selenium	mg/kg	9.06E+00	1.30E+00	**7.00E-01**	**5.20E+00**
5	138	Selenium	mg/kg	8.54E+00	4.72E+00	**7.00E-01**	**5.20E+00**
6	153	Selenium	mg/kg	8.85E+00	1.70E+00	**7.00E-01**	**5.20E+00**
7	156	Selenium	mg/kg	9.04E+00	1.50E+00	**7.00E-01**	**5.20E+00**
8	158	Selenium	mg/kg	8.69E+00	4.15E+00	**7.00E-01**	**5.20E+00**
9	160	Selenium	mg/kg	7.44E+00	1.30E+00	**7.00E-01**	**5.20E+00**
10	163	Selenium	mg/kg	8.79E+00	2.00E+00	**7.00E-01**	**5.20E+00**
11	169	Selenium	mg/kg	6.14E+00	1.70E+00	**7.00E-01**	**5.20E+00**
12	180	Selenium	mg/kg	9.29E+00	3.82E+00	**7.00E-01**	**5.20E+00**
13	194	Selenium	mg/kg	9.15E+00	4.03E+00	**7.00E-01**	**5.20E+00**
14	195	Selenium	mg/kg	9.29E+00	3.06E+00	**7.00E-01**	**5.20E+00**
15	200	Selenium	mg/kg	8.99E+00	5.84E+00	**7.00E-01**	**5.20E+00**
16	212	Selenium	mg/kg	6.80E+00	1.60E+00	**7.00E-01**	**5.20E+00**
17	213	Selenium	mg/kg	9.54E+00	7.70E-01	**7.00E-01**	**5.20E+00**
18	214	Selenium	mg/kg	6.89E+00	6.70E-01	**7.00E-01**	**5.20E+00**
19	215	Selenium	mg/kg	8.81E+00	1.10E+00	**7.00E-01**	**5.20E+00**
20	216	Selenium	mg/kg	5.65E+00	1.30E+00	**7.00E-01**	**5.20E+00**
21	217	Selenium	mg/kg	7.63E+00	1.67E+00	**7.00E-01**	**5.20E+00**
22	219	Selenium	mg/kg	6.46E+00	1.20E+00	**7.00E-01**	**5.20E+00**
23	221	Selenium	mg/kg	9.26E+00	9.80E+00	**7.00E-01**	**5.20E+00**
24	222	Selenium	mg/kg	7.75E+00	1.40E+00	**7.00E-01**	**5.20E+00**
25	227	Selenium	mg/kg	8.27E+00	2.20E+00	**7.00E-01**	**5.20E+00**
26	228	Selenium	mg/kg	7.99E+00	3.97E+00	**7.00E-01**	**5.20E+00**
27	488	Selenium	mg/kg	8.09E+00	1.60E+00	**7.00E-01**	**5.20E+00**
28	489	Selenium	mg/kg	6.52E+00	1.40E+00	**7.00E-01**	**5.20E+00**
29	520	Selenium	mg/kg	8.24E+00	4.55E+00	**7.00E-01**	**5.20E+00**
30	531	Selenium	mg/kg	8.85E+00	1.10E+00	**7.00E-01**	**5.20E+00**
1	14	Silver	mg/kg	5.13E+00	2.22E+01	**2.70E+00**	**8.76E-01**
2	76	Silver	mg/kg	3.02E+00	6.30E-02	**2.70E+00**	**8.76E-01**
3	81	Silver	mg/kg	4.29E+00	2.70E+00	**2.70E+00**	**8.76E-01**
4	99	Silver	mg/kg	4.44E+00	1.03E+01	**2.70E+00**	**8.76E-01**
5	138	Silver	mg/kg	4.84E+00	1.65E+01	**2.70E+00**	**8.76E-01**
6	153	Silver	mg/kg	5.37E+00	1.32E+01	**2.70E+00**	**8.76E-01**
7	156	Silver	mg/kg	4.71E+00	1.19E+01	**2.70E+00**	**8.76E-01**
8	158	Silver	mg/kg	4.47E+00	1.47E+01	**2.70E+00**	**8.76E-01**
9	160	Silver	mg/kg	4.48E+00	1.13E+01	**2.70E+00**	**8.76E-01**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
10	163	Silver	mg/kg	4.53E+00	1.05E+01	**2.70E+00**	**8.76E-01**
11	165	Silver	mg/kg	1.14E+01	8.33E+01	**2.70E+00**	**8.76E-01**
12	169	Silver	mg/kg	3.09E+00	7.90E-02	**2.70E+00**	**8.76E-01**
13	180	Silver	mg/kg	4.90E+00	1.17E+01	**2.70E+00**	**8.76E-01**
14	194	Silver	mg/kg	4.97E+00	1.70E+01	**2.70E+00**	**8.76E-01**
15	195	Silver	mg/kg	4.77E+00	1.31E+01	**2.70E+00**	**8.76E-01**
16	200	Silver	mg/kg	4.63E+00	9.47E+00	**2.70E+00**	**8.76E-01**
17	212	Silver	mg/kg	4.24E+00	1.55E+01	**2.70E+00**	**8.76E-01**
18	213	Silver	mg/kg	6.12E+00	1.32E+01	**2.70E+00**	**8.76E-01**
19	214	Silver	mg/kg	3.34E+00	2.10E-02	**2.70E+00**	**8.76E-01**
20	215	Silver	mg/kg	4.55E+00	9.51E+00	**2.70E+00**	**8.76E-01**
21	217	Silver	mg/kg	4.14E+00	1.61E+01	**2.70E+00**	**8.76E-01**
22	219	Silver	mg/kg	3.02E+00	5.60E-02	**2.70E+00**	**8.76E-01**
23	221	Silver	mg/kg	4.58E+00	9.74E+00	**2.70E+00**	**8.76E-01**
24	222	Silver	mg/kg	3.84E+00	5.00E-02	**2.70E+00**	**8.76E-01**
25	227	Silver	mg/kg	4.09E+00	1.01E+01	**2.70E+00**	**8.76E-01**
26	228	Silver	mg/kg	4.58E+00	1.16E+01	**2.70E+00**	**8.76E-01**
27	488	Silver	mg/kg	3.91E+00	8.50E-02	**2.70E+00**	**8.76E-01**
28	489	Silver	mg/kg	3.01E+00	4.10E-02	**2.70E+00**	**8.76E-01**
29	520	Silver	mg/kg	4.54E+00	1.40E+01	**2.70E+00**	**8.76E-01**
30	531	Silver	mg/kg	4.38E+00	1.00E-01	**2.70E+00**	**8.76E-01**
1	14	Technetium-99	pCi/g	5.44E+01	4.06E+02	**2.80E+00**	**7.32E+00**
2	19	Technetium-99	pCi/g	1.01E+01	3.70E+01	**2.80E+00**	**7.32E+00**
3	165	Technetium-99	pCi/g	1.67E+01	6.00E+01	**2.80E+00**	**7.32E+00**
4	227	Technetium-99	pCi/g	1.65E+01	1.52E+02	**2.80E+00**	**7.32E+00**
5	517	Technetium-99	pCi/g	2.43E+01	8.32E+01	**2.80E+00**	**7.32E+00**
1	99	Thallium	mg/kg	5.03E+00	2.50E-01	**3.40E-01**	**2.84E+00**
2	163	Thallium	mg/kg	3.13E+00	3.50E-01	**3.40E-01**	**2.84E+00**
3	181	Thallium	mg/kg	3.06E+00	3.50E+00	**3.40E-01**	**2.84E+00**
4	227	Thallium	mg/kg	5.69E+00	5.10E-01	**3.40E-01**	**2.84E+00**
5	520	Thallium	mg/kg	4.66E+00	3.40E-01	**3.40E-01**	**2.84E+00**
1	1	Thorium-230	pCi/g	1.56E+01	6.50E+01	**1.40E+00**	**6.06E+00**
2	212	Thorium-230	pCi/g	6.64E+01	2.60E+02	**1.40E+00**	**6.06E+00**
1	14	Total PAH	mg/kg	1.04E-01	4.87E-01	**0.00E+00**	**8.64E-02**
2	19	Total PAH	mg/kg	5.94E-01	5.23E+00	**0.00E+00**	**8.64E-02**
3	76	Total PAH	mg/kg	1.01E+00	1.76E+00	**0.00E+00**	**8.64E-02**
4	81	Total PAH	mg/kg	2.39E-01	7.79E-01	**0.00E+00**	**8.64E-02**
5	138	Total PAH	mg/kg	4.45E-01	9.74E-02	**0.00E+00**	**8.64E-02**
6	158	Total PAH	mg/kg	3.31E-01	4.78E-01	**0.00E+00**	**8.64E-02**

Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
7	163	Total PAH	mg/kg	1.08E-01	2.85E-01	**0.00E+00**	**8.64E-02**
8	165	Total PAH	mg/kg	3.00E+00	1.87E+00	**0.00E+00**	**8.64E-02**
9	169	Total PAH	mg/kg	2.30E+00	4.59E+00	**0.00E+00**	**8.64E-02**
10	196	Total PAH	mg/kg	1.08E+00	9.04E+00	**0.00E+00**	**8.64E-02**
11	212	Total PAH	mg/kg	1.14E-01	0.00E+00	**0.00E+00**	**8.64E-02**
12	213	Total PAH	mg/kg	1.72E-01	1.72E-01	**0.00E+00**	**8.64E-02**
13	215	Total PAH	mg/kg	4.04E-01	5.00E-01	**0.00E+00**	**8.64E-02**
14	216	Total PAH	mg/kg	1.49E-01	1.49E-01	**0.00E+00**	**8.64E-02**
15	217	Total PAH	mg/kg	1.76E-01	7.37E-01	**0.00E+00**	**8.64E-02**
16	221	Total PAH	mg/kg	1.02E+00	1.02E+00	**0.00E+00**	**8.64E-02**
17	222	Total PAH	mg/kg	1.77E-01	1.77E-01	**0.00E+00**	**8.64E-02**
18	227	Total PAH	mg/kg	1.80E-01	3.38E-01	**0.00E+00**	**8.64E-02**
19	488	Total PAH	mg/kg	1.27E-01	2.50E-01	**0.00E+00**	**8.64E-02**
20	493	Total PAH	mg/kg	4.86E-01	5.00E-01	**0.00E+00**	**8.64E-02**
21	518	Total PAH	mg/kg	1.88E+00	1.27E+01	**0.00E+00**	**8.64E-02**
22	520	Total PAH	mg/kg	2.13E-01	5.52E-01	**0.00E+00**	**8.64E-02**
23	541	Total PAH	mg/kg	1.67E-01	7.63E+00	**0.00E+00**	**8.64E-02**
24	561	Total PAH	mg/kg	2.18E-01	2.63E+00	**0.00E+00**	**8.64E-02**
1	1	*trans*-1,2-Dichloroethene	mg/kg	8.69E-01	1.60E+01	**0.00E+00**	**5.88E-01**
1	1	Trichloroethene	mg/kg	1.79E+00	8.70E+01	**0.00E+00**	**3.56E-02**
2	165	Trichloroethene	mg/kg	3.56E-02	6.00E-03	**0.00E+00**	**3.56E-02**
1	81	Uranium	mg/kg	9.14E+02	6.50E+03	**4.60E+00**	**2.70E+02**
2	518	Uranium	mg/kg	3.05E+02	2.17E+02	**4.60E+00**	**2.70E+02**
3	541	Uranium	mg/kg	7.22E+02	2.02E+04	**4.60E+00**	**2.70E+02**
1	14	Uranium-238	pCi/g	9.74E+01	1.54E+03	**1.20E+00**	**9.09E+01**
2	492	Uranium-238	pCi/g	1.39E+02	3.83E+02	**1.20E+00**	**9.09E+01**
3	541	Uranium-238	pCi/g	2.83E+02	4.54E+03	**1.20E+00**	**9.09E+01**
1	221	Vanadium	mg/kg	4.57E+01	1.08E+02	**3.70E+01**	**1.41E+00**
2	564	Vanadium	mg/kg	6.87E+01	8.06E+01	**3.70E+01**	**1.41E+00**
1	1	Vinyl chloride	mg/kg	4.48E-01	4.80E+00	**0.00E+00**	**1.37E-02**
1	531	Zinc	mg/kg	7.78E+02	2.45E+03	**6.00E+01**	**3.90E+02**

A review of this table indicates that the principal impact of using a DAF of 20 is to increase the number of SWMU/AOC soil constituent combinations that fail the screening; however, there is no impact on the SWMU/AOC soil constituent combinations subjected to modeling because of the following:

- Where a SWMU/AOC soil constituent was going to be modeled because of screening against a DAF of 58, that same SWMU/AOC soil constituent will be modeled if screened against a DAF of 20 because it is the SWMU/AOC with the highest average concentration of that soil constituent. Thus, the additional SWMU/AOC soil constituent combinations will have impacts that are lower than those already subjected to modeling;

- Where a SWMU/AOC soil constituent was not going to be modeled because it is not found in groundwater, is not a groundwater COC, or where its concentration is controlled by other factors, it will not be modeled based on screening against either a DAF of 20 or DAF of 58; and
- All of those additional soil constituents that are not screened out using a DAF of 20, but are screened out using a DAF of 58, are also constituents that are not groundwater COCs, or the concentration is controlled by other factors, or the constituent is not found in groundwater.

This rationale is summarized in Table C2.5.

Based on this sensitivity analysis, no additional SWMU/AOC soil constituent combinations were subjected to modeling.

Table C2.5. Comparison of Soil Constituents Exceeding RG SSLs and Background Derived From DAF of 58 Versus Values Derived from DAF of 20

Soil Constituent (Modeled?)	DAF 58: # of SWMUs/AOCs with Soil Constituent Exceedance	DAF 20: # SWMUs/AOCs with Soil Constituent Exceedance	Comments on Impact of Screening Using DAF of 20 Values
Silver (No)	30	30	No impact on modeling. Silver not detected in RGA groundwater.
Total PAHs or benz(a)anthracene (No)	23	54	No impact on modeling. Not a groundwater COC.
Molybdenum (No)	23	33	No impact on modeling. Not major RGA issue; concentrations controlled by redox chemistry.
Nickel (Yes)	2	28	No impact on modeling. SWMU/AOC with highest average nickel concentration will be modeled.
Np-237 (No)	4	9	No impact on modeling. No above-MCL detections of Np-237 in RGA groundwater.
Tc-99 (Yes)	2	5	No impact on modeling. SWMU/AOC with highest average Tc-99 concentration will be modeled.
Naphthalene (No)	8	8	No impact on modeling. Not RGA COC.
Thorium-230 (No)	1	2	No impact on modeling. Not RGA COC.
Cobalt (No)	2	2	No impact on modeling. Not RGA COC.
U-238 (No)	1	3	No impact on modeling. No RGA impacts from Soils OU.
Uranium (Yes)	1	3	No impact on modeling. SWMU/AOC with highest avg. uranium concentration will be modeled.
Vanadium (No)	2	2	No impact on modeling. Not major RGA issue.
Arsenic (Yes)	2	7	No impact. SWMU/AOC with highest average arsenic concentration will be modeled.
VOCs (Yes/No)	3	6	No impact on modeling. Mostly in SWMU 1—modeled separately.
Antimony (No)	0	2	No impact. No RGA detects in 2,063 samples.
Chromium (Yes)	0	0	No impact. SWMU/AOC with highest concentration subjected to modeling.

Table C2.5. Comparison of Soil Constituents Exceeding RG SSLs and Background Derived From DAF of 58 Versus Values Derived from DAF of 20 (Continued)

Soil Constituent (Modeled?)	DAF 58: # of SWMUs/AOCs with Soil Constituent Exceedance	DAF 20: # SWMUs/AOCs with Soil Constituent Exceedance	Comments on Impact of Screening Using DAF of 20 Values
Manganese (No)	0	0	No impact on modeling. Concentrations controlled by redox chemistry.
Mercury (No)	0	29	No impact. Not a groundwater COC. RGA concentrations < MCL for all 2,265 samples.
PCB, Total (Yes)	3	16	No impact on modeling. SWMU/AOC with highest total PCB concentration will be modeled.
Pentachlorophenol (No)	2	2	No impact on modeling. Not RGA COC. No detects out of 436 RGA samples.
Plutonium-239/240 (No)	0	3	No impact. Not RGA COC. 1 detect out of 256 samples. Detect not near Soils OU SWMU/AOC.
Selenium (No)	0	30	No impact on modeling. Not RGA COC. No RGA results > MCL out of 2,426 samples.
Thallium (No)	0	5	No impact on modeling. Not RGA COC. 1 split detect (not near Soils OU SWMU/AOC) of 1,283 samples.
Zinc (No)	0	1	No impact on modeling. Not RGA COC. 2 exceed NAL (not near Soils OU SWMU/AOC) of 1,763.

VOCs = volatile organic compounds

C2.5. REFERENCES

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E.9. HUMAN HEALTH INFORMATION FOR THE PADUCAH VAPOR INTRUSION EVALUATION

Information provided in Table E.8 is taken from several sources. It should be noted that according to the Occupational Safety & Health Administration (OSHA) website (https://www.osha.gov/dsg/annotated-pels/ accessed in December 2014), "OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970, and have not been updated since that time. Since 1970, OSHA promulgated … new PELs for 16 agents, and standards without PELs for 13 carcinogens. Industrial experience, new developments in technology, and scientific data clearly indicate that in many instances these adopted limits are [also] not sufficiently protective of worker health. This has been demonstrated by the reduction in allowable exposure limits recommended by many technical, professional, industrial, and government organizations, both inside and outside the United States."

Additionally, the following information has been provided in this section:

- Information provided by EPA Region 4 for cis-1,2-DCE and trans-1,2-DCE screening levels.
- Information provided by EPA Region 4 regarding the basis of their use of the Agency for Toxic Substances and Disease Registry intermediate minimal risk levels.
- Excerpt of Agency for Toxic Substances and Disease Registry minimal risk levels updated March 2016.
- Excerpt of information from the Region 4 Scientific Support Section Vapor Intrusion Screening Tool.
- Information provided by Kentucky Risk Assessment Branch to support a project discussion on June 20, 2017.
- Archived Provisional Peer Reviewed Toxicity Values for *trans*-1,2-Dichloroethylene (withdrawn by EPA).

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Table E.8. Human Health Information for the Paducah Vapor Intrusion Evaluation

						OSWER Vapor Intrusion Calculator (EPA 2013)		Using RAIS' Calculator (10/15/2014)					
VOC	CAS Number	OSHA PEL* (ppm)	OSHA PEL* ($\mu g/m^3$)	ACGIH TLV* (ppm)	ACGIH TLV* ($\mu g/m^3$)	Residential ELCR = 1E-06 in $\mu g/m^3$	Residential HI = 1 in $\mu g/m^3$	Resident PRG: ELCR= 1E-06 in $\mu g/m^3$	Resident PRG: ELCR= 1E-04 in $\mu g/m^3$	Resident PRG: HI=1 in $\mu g/m^3$	Indoor Worker PRG: ELCR=1E-06 in $\mu g/m^3$	Indoor Worker PRG: ELCR=1E-04 in $\mu g/m^3$	Indoor Worker PRG: HI=1 in $\mu g/m^3$
1,2-Dichloroethene	540-59-0	200	7.93E+05	200	7.93E+05	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	156-59-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	NA	NA	NA	NA	NA	NA	NA	NA	62.6	NA	NA	263
Trichloroethene	79-01-6	100	5.37E+05	10	5.37E+04	0.48	2.1	0.478	47.8	2.09	2.99	299	8.76
Vinyl Chloride	75-01-4	1	2.56E+03	1	2.56E+03	0.17	100	0.168	16.8	104	2.79	279	438

Notes:

* 8-hour time-weighted average (TWA)
VOC = Volatile Organic Compound
CAS Number = Chemical Abstract Services Registry Number
OSHA PEL = Occupational Safety and Health Administration Permissible Exposure Limit
PPM = parts per million by volume
ACGIH TLV = American Council of Governmental Industrial Hygienists Threshold Limit Value
RAIS = Risk Assessment Information System (http://rais.ornl.gov/)
ELCR = Excess Lifetime Cancer Risk
HI = Hazard Index
OSWER = Office of Solid Waste and Emergency Response
EPA = U.S. Environmental Protection Agency
PRG = Preliminary Remedial Goal
For *cis*- and *trans*-1,2-dichloroethene, toxicity information (slope factors and reference doses/concentrations) are not available; therefore risk-based values are not available (NA) at this time.

NIOSH calculator (National Institute for Occupational Safety and Health) 10/15/2014 at http://www.cdc.gov/niosh/docs/2004-101/calc.html EPA's Draft 2013 OSWER guidance calculator at http://www.epa.gov/oswer/vaporintrusion/documents/VISL-Calculator.xlsm (Version 3.3.1)

EPA's Draft 2013 OSWER guidance calculator uses: ET= 24 hr/d; EF=350 d/yr; ED=26 yrs; AT(nc)=26 yrs; and AT(c)=70 yrs. Populations considered are the elderly, women of child bearing years, people suffering from a chronic illness, and disadvantaged populations. RAIS' Calculator uses: ET= 24 hr/d; EF=350 d/yr; ED=26 yrs; AT(nc)=26 yrs x 365 d/yr; and AT(c)=70 yrs x 365 d/yr for the residential scenario. RAIS' Calculator uses: ET= 8 hr/d; EF=250 d/yr; ED=25 yrs; AT(nc)=25 yrs x 365 d/yr; and AT(c)=70 yrs x 365 d/yr for the indoor worker scenario.

From on-line source: https://www.osha.gov/dsg/annotated-pels/ it states: "OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970, and have not been updated since that time. Since 1970, OSHA promulgated … new PELs for 16 agents, and standards without PELs for 13 carcinogens. Industrial experience, new developments in technology, and scientific data clearly indicate that in many instances these adopted limits are [also] not sufficiently protective of worker health. This has been demonstrated by the reduction in allowable exposure limits recommended by many technical, professional, industrial, and government organizations, both inside and outside the United States."

From https://www.osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html, American Council of Governmental and Industrial Hygienists (ACGIH) list of threshold limit values (as 8 hour time-weighted averages) of concentrations

-----Original Message-----
From: Koporec, Kevin
Sent: Thursday, June 15, 2017 10:04 AM
To: Bentkowski, Ben <Bentkowski.Ben@epa.gov>
Subject: VI/air screening levels

Here is the table of screening values Ben.
In case you want the DCE values handy before you can open the table, here's the SLs (ug/m3).

1,2-Dichloroethylene (both isomers):
residential indoor air SL = 800; subsurface soil vapor SL = 27,000.
Industrial indoor air SL = 3500; subsurface soil vapor SL = 120,000.

From: Koporec, Kevin <Koporec.Kevin@epa.gov>
Sent: Tuesday, June 20, 2017 1:46 PM
To: White, Jana; Bentkowski, Ben; Duncan, Tracey; Rich Bonczek; Corkran, Julie; 'Begley, Brian (EEC)'; Brewer, Gaye (EEC); Jeri.Higginbotham@ky.gov; Towarnicky, Joseph M; Overby, Teresa; Nourse, Bobette (PPPO/CONTR); Jung, Christopher H (EEC); Kim Knerr; Frederick, Tim
Subject: RE: C-400 VI Work Plan - Follow-up Technical Discussion
Attachments: 12DCE May2016.pdf

Re: DCE inhalation tox value.
Here is the basis for region 4's use of the ATSDR Intermediate MRL as an interim value for assessment of inhalation to 1,2-DCE. ATSDR is on the list of sources of Toxicity values on our (EPA Superfund risk assessment) hierarchy. I would note that we have recently requested an expedited assessment of this chemical by the EPA IRIS program.

Kevin Koporec
Toxicologist
USEPA Region 4

-----Original Appointment-----
From: White, Jana [mailto:Jana.White@FFSPaducah.Com]
Sent: Tuesday, June 20, 2017 1:23 PM
To: White, Jana; Koporec, Kevin; Bentkowski, Ben; Duncan, Tracey; Rich Bonczek; Corkran, Julie; 'Begley, Brian (EEC)'; Brewer, Gaye (EEC); Jeri.Higginbotham@ky.gov; Towarnicky, Joseph M; Overby, Teresa; Nourse, Bobette (PPPO/CONTR); Jung, Christopher H (EEC); Kim Knerr; Frederick, Tim
Subject: FW: C-400 VI Work Plan - Follow-up Technical Discussion
When: Tuesday, June 20, 2017 2:00 PM-3:00 PM (UTC-06:00) Central Time (US & Canada).
Where: DOE Large Conference Room Conference Call 1-800-454-9043 Participant Code: 4415861

-----Original Appointment-----
From: White, Jana [mailto:Jana.White@FFSPaducah.Com]
Sent: Friday, June 16, 2017 9:37 AM
To: White, Jana; Duncan, Tracey; Rich Bonczek; Corkran, Julie; Bentkowski, Ben; 'Begley, Brian (EEC)'; Brewer, Gaye (EEC); Jeri.Higginbotham@ky.gov; Towarnicky, Joseph M; Overby, Teresa; Nourse, Bobette (PPPO/CONTR); Jung, Christopher H (EEC); Kim Knerr; Frederick, Tim
Subject: C-400 VI Work Plan - Follow-up Technical Discussion
When: Tuesday, June 20, 2017 2:00 PM-3:00 PM (UTC-06:00) Central Time (US & Canada).
Where: DOE Large Conference Room Conference Call 1-800-454-9043 Participant Code: 4415861

The purpose of the meeting is to continue discussions on language for Condition 4; review remaining actions associated with Worksheet #15 of QAPP; and to discuss the schedule associated with C-400 VI.
The current deadline for the informal dispute is July 1st and the parties have agreed to meet prior to July 1st to continue resolution of the remaining technical issues.

If you have any questions, please let me know.
Thanks,
Jana

Superfund Technical Support Center
National Center for Environmental Assessment
U.S. Environmental Protection Agency
26 West Martin Luther King Drive, MS-AG41
Cincinnati, Ohio 45268

Phillip Kaiser/Hotline Director, Teresa Shannon/Administrator
Hotline 513-569-7300, FAX 513-569-7159, E-Mail: Superfund_STSC@epa.gov

May 25, 2016

Kevin Koporec
EPA Region 4

ASSISTANCE REQUESTED:	Inhalation toxicity value (RfC) for 1,2-dichloroethylene and its cis- and trans- isomers.
ENCLOSED INFORMATION:	Attachment 1: 1,2-DCE Frederick, Tim Response_Final.pdf

If you have any questions regarding this transmission, please contact the STSC at (513) 569-7300.

Attachments (1)

cc: STSC files

RESPONSE MESSAGE:

The STSC understands your urgent need for PPRTV assessments for 1,2-dichloroethylene and its cis- and trans- isomers. Our PTV document development queue is currently set through FY18, however NCEA/STSC representatives are currently working collaboratively on a standard operating procedure with OLEM to outline a formal chemical nomination process that might facilitate 'fast-tracking' specific PTV development requests for Regions. This process, while not currently enacted, may serve as the conduit for requests such as for 1,2-dichloroethylene and its cis- and trans- isomers. In the interim, the STSC suggests that you contact Michele Burgess (Burgess.Michele@epa.gov or 703-603-9003) of OLEM directly to discuss a path forward for PTV development for the chemicals of interest. Furthermore, please note that the ATSDR derived a Minimal Risk Level of 0.2 ppm in 1996 for acute-duration inhalation exposure and intermediate-duration inhalation exposure to trans-1,2-dichloroethylene that could be referred to when assessing the health risks associated with the inhalation of this chemical.

Agency for Toxic Substances and Disease Registry

MINIMAL RISK LEVELS (MRLs)

March 2016

Name	Route	Duration	MRL	Uncertainty Factors	Endpoint	Status	Cover Date	CAS Number
1,2-DICHLOROETHENE, CIS-	Oral	Acute	1 mg/kg/day	100	Hemato.	Final	08/96	156-59-2
		Int.	0.3 mg/kg/day	100	Hemato.			
1,2-DICHLOROETHENE, TRANS-	Inh.	Acute	0.2 ppm	1000	Hepatic	Final	08/96	156-60-5
		Int.	0.2 ppm	1000	Hepatic			
	Oral	Int.	0.2 mg/kg/day	100	Hepatic			

For Duration, Acute = 1 to 14 days, Intermediate = 15 to 364 days, and Chronic = 1 year or longer.

For general information on ATSDR Minimal Risk Levels, see www.atsdr.cdc.gov/MRLs.

For more information on a specific MRL, please refer to our Toxicological Profiles,
particularly Appendix A of Profiles released after 1995.
The Toxicological Profiles can be found online at www.atsdr.cdc.gov/ToxProfiles,
where you can also find a contact form. Or call 1-800-CDC-INFO.

Region 4 Scientific Support Section
Vapor Intrusion Screening Tool

Last updated 06/26/2017

Internal Use Only: Air Screening Table for Industrial Sites					**RSL**	**RSL**
	RSL(3)	**RSL(3)**	**RML(2)**	**RML(2)**	**Sub-slab(1)**	**Sub-slab(1)**
	ug/m^3	**ppbv**	**ug/m^3**	**ppbv**	**ug/m^3 c**	**ppbv c**
Acetone	14,000 n	5,900 n	420,000 n	180,000 n	4,500,000 n	1,900,000 n
Benzene	1.6 c	0.5 c	160 c	500 c	52 c	16 c
Carbon Tetrachloride	2 c	0.32 c	200 c	32 c	68 c	11 c
Chloroethane	4,400 n	1,700 n	130,000 n	50,000 n	1,500,000 n	57,000 n
Chloroform[a]	43 n	8.8 n	430 n	88 n	1400 n	300 n
1,1-Dichloroethane	7.7 c	1.9 c	770 c	190 c	260 c	64 c
1,2-Dichloroethane	0.47 c	0.12 c	47 c	12 c	16 c	4 c
1,1-Dichloroethylene	88 n	22 n	2600 n	670 n	29,000 n	7300 n
***cis* -1,2-Dichloroethylene[b]**	3500 n	880 n	10,000 n	2600 n	120,000 n	300,000 n
***trans* -1,2-Dichloroethylene[b]**	3500 n	880 n	10,000 n	2600 n	120,000 n	300,000 n
Ethylbenzene	4.9 c	1.1 c	490 c	110 c	160 c	37 c
Methylene Chloride	260 n	75 n	7800 n	2200 n	41,000 n	12,000 n
Naphthalene	0.36 c	0.07 c	36 c	7 c	12 c	2.3 c
1,1,1,2-Tetrachloroethane	1.7 c	0.25 c	170 c	25 c	55 c	8 c
1,1,2,2-Tetrachloroethane	0.21 c	0.03 c	21 c	3 c	7 c	1 c
Tetrachloroethylene (PCE)	18 n	2.7 n	540 n	80 n	1600 n	240 n
Toluene	2,200 n	580 n	66,000 n	17,500 n	730,000 n	190,000 n
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon)	2,200 n	290 n	390,000 n	51,000 n	4,400,000 n	57,000 n
1,1,1-Trichloroethane	2,200 n	400 n	66,000 n	12,000 n	730,000 n	130,000 n
1,1,2-Trichloroethane	0.088 n	0.016 n	SSV		26 n	5 n
Trichloroethylene (TCE)	0.88 n	0.16 n	8.8[d]/26[e] n	1.6[d]/4.8[e] n	100 n	19 n
1,2,3-Trimethylbenzene	26 n	5.3 n	66 n	13 n	730 n	150 n
1,2,4-Trimethylbenzene	26 n	5.3 n	93 n	19 n	1000 n	200 n
Vinyl Chloride	2.8 c	1.1 c	280 c	110 c	93 c	36 c
Xylene	44 n	10 n	1300 n	300 n	15,000 n	3500 n

(1) based on lower of HI=1 or 1x10e-6, except 1,2-Dichloroethylene & chloroform

(2) based on lower of HI=3 or 1x10e-4, except 1,2-Dichloroethylene & chloroform

(3) based on lower of HI=0.1 or 1x10e-6, except 1,2-Dichloroethylene, chloroform, & TCE

(a) RSL based on HI=0.1 & RML based on HI=1 because of chloroform being a threshold carcinogen (USEPA IRIS file)

(b) based on ATSDR MRL for trans-1,2-Dichloroethylene: http://www.atsdr.cdc.gov/mrls/pdfs/atsdr_mrls.pdf

(c) Values were calculated using the default sub-slab attenuation factor of 0.03

(d) based on HI=1 to be protective of sensitive sub-populations

(e) based on HI=3 to be protective of non-sensitive populations

SSV - Site Specific Value should be calculated

n = non carcinogen; c = carcinogen

*This table is not for rule making or specific guidance. It is a Region 4 screening tool only.

Region 4 Scientific Support Section
Vapor Intrusion Screening Tool

Last updated 06/24/2017

Internal Use Only: Air Screening Table for Residential Sites					**RSL**	**RSL**
	RSL(3)	**RSL(3)**	**RML(2)**	**RML(2)**	**Sub-slab(1)**	**Sub-slab(1)**
	ug/m^3	**ppbv**	**ug/m^3**	**ppbv**	**ug/m^3 [c]**	**ppbv [c]**
Acetone	3,200 n	1,350 n	96,000 n	40,400 n	1,100,000 n	463,000 n
Benzene	0.36 c	0.11 c	36 c	11 c	12 c	3.8 c
Carbon Tetrachloride	0.47 c	0.08 c	47 c	7.5 c	16 c	2.5 c
Chloroethane	1,000 n	380 n	30,000 n	11,000 n	350,000 n	133,000 n
Chloroform[a]	10 n	2 n	100 n	20 n	330 n	68 n
1,1-Dichloroethane	1.8 c	0.44 c	180 c	45 c	58 c	14 c
1,2-Dichloroethane	0.11 c	0.03 c	11 c	2.7 c	3.6 c	0.9 c
1,1-Dichloroethene	21 c	5.3 n	630 n	160 n	7000 c	1800 c
cis **-1,2-Dichloroethylene[b]**	800 n	200 n	2400 n	600 n	27,000 n	6,800 n
trans **-1,2-Dichloroethylene[b]**	800 n	200 n	2400 n	600 n	27,000 n	6,800 n
Ethylbenzene	1.1 c	0.25 c	110 c	25 c	37 c	8.5 c
Methylene Chloride	63 n	18 n	1,900 n	540 n	3400 n	980 n
Naphthalene	0.083 c	0.02 c	8.3 c	1.6 c	2.8 c	0.53 c
1,1,1,2-Tetrachloroethane	0.38 c	0.06 c	38 c	5.5 c	13 c	1.9 c
1,1,2,2-Tetrachloroethane	0.048 c	0.007 c	4.8 c	0.7 c	1.6 c	0.23 c
Tetrachloroethylene (PCE)	4.2 n	0.6 n	130 n	19 n	360 n	53 n
Toluene	520 n	140 n	16,000 n	4100 n	170,000 n	45,000 n
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon)	520 n	70 n	93,000 n	12,000 n	1,000,000 n	131,000 n
1,1,1-Trichloroethane	520 n	95 n	16,000 n	3000 n	170,000 n	31,000 n
1,1,2-Trichloroethane	0.021 n	0.004 n	SSV	0	6 n	1 n
Trichloroethylene (TCE)	0.21 n	0.04 n	2.1[d]/6.3[e] n	0.4[d]/1.2[e] n	16 n	3 n
1,2,3-Trimethylbenzene	6.3 n	1.3 n	16 n	100 n	170 n	35 n
1,2,4-Trimethylbenzene	6.3 n	1.3 n	22 n	150 n	240 n	49 n
Vinyl Chloride	0.17 c	0.07 c	17 c	6.7 c	6 c	2 c
Xylene	10 n	2.3 n	300 n	69 n	3500 n	800 n

(1) based on lower of HI=1 or 1x10e-6, except 1,2-Dichloroethylene, chloroform, & TCE

(2) based on lower of HI=3 or 1x10e-4, except 1,2-Dichloroethylene, chloroform, & TCE

(3) based on lower of HI=0.1 or 1x10e-6, except 1,2-Dichloroethylene, chloroform, & TCE

(a) RSL based on HI=0.1 & RML based on HI=1 because of chloroform being a threshold carcinogen (USEPA IRIS file)

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(d) based on HI=1 to be protective of sensitive sub-populations

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SSV - Site Specific Value should be calculated

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MEMORANDUM

DATE: June 17, 2014

SUBJECT: Removal of the *trans*-1,2-Dichloroethylene (CASRN 156-60-5) Provisional Peer-Reviewed Toxicity Value (PPRTV) assessment from the Electronic Library

FROM: Scott Wesselkamper
Director, Superfund Health Risk Technical Support Center (STSC)
EPA/ORD/NCEA

TO: Michele Burgess (OSWER/OSRTI)
Lynn Flowers (NCEA)
Teresa Shannon (NCEA)
The File

It was brought to the attention of the STSC that there is an inconsistency in the conclusions regarding the derivation of a reference concentration (RfC) for *trans*-1,2-Dichloroethylene (DCE) between the 2006 PPRTV assessment and the 2010 IRIS assessment (http://www.epa.gov/iris/toxreviews/0418tr.pdf) for this chemical. The 2006 PPRTV assessment derived a chronic p-RfC of 0.06 mg/m^3 based on pulmonary and liver effects observed in the principal study by Freundt et al. (1977). No subchronic p-RfC was derived. The 2010 IRIS assessment found Freundt et al. (1977), a study by the National Toxicology Program (NTP, 2002), and an unpublished study by DuPont (1998) to be insufficient to support derivation of an RfC value for *trans*-1,2-DCE. Thus, there appears to be a fundamental difference in how the principal study and critical effect(s) used to derive the chronic p-RfC in the 2006 PPRTV assessment were evaluated compared to what was more recently done by IRIS. It is important to note that there are some differences in the respective decision-making processes for developing PPRTV and IRIS assessments, specifically with the IRIS Program having a more extensive review process (e.g., agency and interagency review steps, a public comment period, etc.) than that utilized for developing PPRTV assessments.

Pertinent information from the 2010 IRIS Toxicological Review on *trans*-1,2-DCE that outlines why the Freundt et al. (1977) study was discounted and no RfC value was derived is excerpted and italicized below:

"The finding of lung effects in the Freundt et al. (1977) study is difficult to interpret as this study is the only report of lung pathology in animals exposed to trans-1,2-DCE, a small number of animals were examined, several of the controls also developed this effect, and the upper respiratory tract was not examined for pathology."

"For each of the exposure durations, there was no statistically significant difference between the controls and the exposed groups with respect to the incidence of liver effects (fat accumulation). In general, however, the incidence and severity of fat accumulation increased with increasing exposure duration. Although Freundt et al. (1977) reported histopathologic changes in the liver of rats, the DuPont (1998) study did not corroborate the Freundt et al. (1977) study findings. DuPont (1998) reported relatively small increases in relative and absolute liver weight (1–8%) and no gross or microscopic changes of the liver attributable to trans-1,2-DCE at an exposure concentration 20-fold higher than that

used in the Freundt et al. (1977) study. NTP (2002a) similarly found no histopathologic changes in the liver when trans-1,2-DCE was administered for 90 days by the oral route at dietary concentrations as high as 50,000 ppm. In light of the results of DuPont (1998) and NTP (2002a), it is difficult to explain the liver findings in the single-exposure concentration study by Freundt et al. (1977). Given the limitations of the Freundt et al. (1977) study (i.e., small sample size, use of only one exposure concentration, and observation of fatty accumulation in the liver lobules and Kupffer cells in control animals at some exposure durations) and lack of corroboration from other studies, the Freundt et al. (1977) study was not used as the basis for deriving an RfC for trans-1,2-DCE."

"In summary, the available inhalation data from DuPont (1998) and Freundt et al. (1977) were considered insufficient to support reference value derivation and, therefore, an RfC for trans-1,2-DCE was not derived."

Current practice by the PPRTV Program states that once an IRIS assessment becomes available for any given chemical, the PPRTV assessment for that chemical is removed from the PPRTV electronic library. Thus, based on this practice and the rationale outlined above, it is recommended that the conclusions presented in the IRIS assessment for *trans*-1,2-DCE be presently adhered to, and the *trans*-1,2-DCE PPRTV assessment has been removed from the electronic library. Any additional questions regarding *trans*-1,2-DCE should be directed to the IRIS Hotline at (202) 566-1676 or http://www.epa.gov/iris/contact_hotline.htm.

References:

Freundt, K.J., G.P. Liebaldt and E. Lieberwirth. 1977. Toxicity studies on trans-1,2-dichloroethylene. Toxicology. 7: 141-153.

NTP (2002). NTP technical report on the toxicity studies of trans-1,2-dichloroethylene (CAS No. 156-60-5) administered in microcapsules in feed to F344/N rats and B6C3F1 mice. Public Health Service, U.S. Department of Health and Human Services; NTP TR 55. Available from the National Institute of Environmental Health Sciences, Research Triangle Park, NC and online at http://ntp.niehs.nih.gov/ntp/htdocs/ST_rpts/tox055.pdf

10-31-2002

Provisional Peer Reviewed Toxicity Values for

trans-1,2-Dichloroethylene
(CASRN 156-60-5)

Derivation of a Chronic Inhalation RfC

Superfund Health Risk Technical Support Center
National Center for Environmental Assessment
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

Acronyms and Abbreviations

bw	body weight
cc	cubic centimeters
CD	Caesarean Delivered
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CNS	central nervous system
cu.m	cubic meter
DWEL	Drinking Water Equivalent Level
FEL	frank-effect level
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
g	grams
GI	gastrointestinal
HEC	human equivalent concentration
Hgb	hemoglobin
i.m.	intramuscular
i.p.	intraperitoneal
i.v.	intravenous
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
kg	kilogram
L	liter
LEL	lowest-effect level
LOAEL	lowest-observed-adverse-effect level
LOAEL(ADJ)	LOAEL adjusted to continuous exposure duration
LOAEL(HEC)	LOAEL adjusted for dosimetric differences across species to a human
m	meter
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MF	modifying factor
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MRL	minimal risk level
MTD	maximum tolerated dose
MTL	median threshold limit

NAAQS	National Ambient Air Quality Standards
NOAEL	no-observed-adverse-effect level
NOAEL(ADJ)	NOAEL adjusted to continuous exposure duration
NOAEL(HEC)	NOAEL adjusted for dosimetric differences across species to a human
NOEL	no-observed-effect level
OSF	oral slope factor
p-IUR	**provisional inhalation unit risk**
p-OSF	**provisional oral slope factor**
p-RfC	**provisional inhalation reference concentration**
p-RfD	**provisional oral reference dose**
PBPK	physiologically based pharmacokinetic
ppb	parts per billion
ppm	parts per million
PPRTV	**Provisional Peer Reviewed Toxicity Value**
RBC	red blood cell(s)
RCRA	Resource Conservation and Recovery Act
RDDR	Regional deposited dose ratio (for the indicated lung region)
REL	relative exposure level
RfC	inhalation reference concentration
RfD	oral reference dose
RGDR	Regional gas dose ratio (for the indicated lung region)
s.c.	subcutaneous
SCE	sister chromatid exchange
SDWA	Safe Drinking Water Act
sq.cm.	square centimeters
TSCA	Toxic Substances Control Act
UF	uncertainty factor
µg	microgram
µmol	micromoles
VOC	volatile organic compound

10-31-2002

PROVISIONAL PEER REVIEWED TOXICITY VALUES FOR *trans*-1,2-DICHLOROETHYLENE
Derivation of a Chronic Inhalation RfC

Background

On December 5, 2003, the U.S. Environmental Protection Agency's (EPA's) Office of Superfund Remediation and Technology Innovation (OSRTI) revised its hierarchy of human health toxicity values for Superfund risk assessments, establishing the following three tiers as the new hierarchy:

1. EPA's Integrated Risk Information System (IRIS).

2. Provisional Peer-Reviewed Toxicity Values (PPRTV) used in EPA's Superfund Program.

3. Other (peer-reviewed) toxicity values, including:

    - Minimal Risk Levels produced by the Agency for Toxic Substances and Disease Registry (ATSDR),
    - California Environmental Protection Agency (CalEPA) values, and
    - EPA Health Effects Assessment Summary Table (HEAST) values.

A PPRTV is defined as a toxicity value derived for use in the Superfund Program when such a value is not available in EPA's Integrated Risk Information System (IRIS). PPRTVs are developed according to a Standard Operating Procedure (SOP) and are derived after a review of the relevant scientific literature using the same methods, sources of data, and Agency guidance for value derivation generally used by the EPA IRIS Program. All provisional toxicity values receive internal review by two EPA scientists and external peer review by three independently selected scientific experts. PPRTVs differ from IRIS values in that PPRTVs do not receive the multi-program consensus review provided for IRIS values. This is because IRIS values are generally intended to be used in all EPA programs, while PPRTVs are developed specifically for the Superfund Program.

Because science and available information evolve, PPRTVs are initially derived with a three-year life-cycle. However, EPA Regions or the EPA Headquarters Superfund Program sometimes request that a frequently used PPRTV be reassessed. Once an IRIS value for a specific chemical becomes available for Agency review, the analogous PPRTV for that same chemical is retired. It should also be noted that some PPRTV manuscripts conclude that a PPRTV cannot be derived based on inadequate data.

Disclaimers

Users of this document should first check to see if any IRIS values exist for the chemical of concern before proceeding to use a PPRTV. If no IRIS value is available, staff in the regional Superfund and RCRA program offices are advised to carefully review the information provided in this document to ensure that the PPRTVs used are appropriate for the types of exposures and circumstances at the Superfund site or RCRA facility in question. PPRTVs are periodically updated; therefore, users should ensure that the values contained in the PPRTV are current at the time of use.

It is important to remember that a provisional value alone tells very little about the adverse effects of a chemical or the quality of evidence on which the value is based. Therefore, users are strongly encouraged to read the entire PPRTV manuscript and understand the strengths and limitations of the derived provisional values. PPRTVs are developed by the EPA Office of Research and Development's National Center for Environmental Assessment, Superfund Health Risk Technical Support Center for OSRTI. Other EPA programs or external parties who may choose of their own initiative to use these PPRTVs are advised that Superfund resources will not generally be used to respond to challenges of PPRTVs used in a context outside of the Superfund Program.

Questions Regarding PPRTVs

Questions regarding the contents of the PPRTVs and their appropriate use (e.g., on chemicals not covered, or whether chemicals have pending IRIS toxicity values) may be directed to the EPA Office of Research and Development's National Center for Environmental Assessment, Superfund Health Risk Technical Support Center (513-569-7300), or OSRTI.

INTRODUCTION

An RfC for *trans*-1,2-dichloroethylene is not available on IRIS (U.S. EPA, 2002) or in the HEAST (U.S. EPA, 1997). The CARA list (U.S. EPA, 1991, 1994a) includes a Health Effects Assessment (HEA) for *trans*-1,2-dichloroethylene (U.S. EPA, 1984) and a Health and Environmental Effects Profile (HEEP) on dichloroethylenes (U.S. EPA, 1986) that reported no data regarding inhalation toxicity in humans and inconsistent results in two subchronic inhalation assays in animals. ATSDR (1996) established an intermediate inhalation MRL of 0.2 ppm (0.8 mg/m^3) based on a LOAEL of 200 ppm (790 mg/m^3) in a 16-week subchronic inhalation study in rats by Freundt et al. (1977) to protect against hepatic effects. ACGIH (1991, 2001) assigned a TLV-TWA of 200 ppm (790 mg/m^3) for all isomers of 1,2-dichloroethylene based on a no-effect level of 1000 ppm following exposure to mixed isomers in a study by Torkelson (ACGIH, 1991). However, the value was under review, since liver effects had been reported in rats repeatedly exposed to 200 ppm of the *trans* isomer (Freundt et al., 1977). The NIOSH (1981, 2001) REL-TWA and OSHA (1999, 2000) PEL for isomers of 1,2-dichloroethylene were both established at

200 ppm (790 mg/m^3) to protect against irritation of the eyes and respiratory system and depression of the central nervous system. Neither IARC (2001) nor the WHO (2001) have written a toxicological review document on *trans*-1,2-dichloroethylene. A toxicity review on unsaturated halogenated hydrocarbons (Lemen, 2001) and the NTP (2001a,b) management status report and health and safety report for *trans*-1,2-dichloroethylene were consulted for relevant information. Literature searches were conducted from 1994 to June 2001 for studies relevant to the derivation of a provisional RfC for *trans*-1,2-dichloroethylene. The databases searched were: TOXLINE, MEDLINE, CANCERLIT, TOXLIT/BIOSIS, RTECS, HSDB, GENETOX, CCRIS, TSCATS, EMIC/EMICBACK, and DART/ETICBACK.

REVIEW OF THE PERTINENT LITERATURE

Human Studies

Acute exposures to high concentrations (>1000 ppm) of *trans*-1,2-dichloroethylene have been reported to cause eye irritation, nausea, vertigo, and narcosis in humans (ACGIH, 1991; OSHA, 1999). Due to its narcotic effects, *trans*-1,2-dichloroethylene has been used as an anesthetic in humans (ACGIH, 1991). One human fatality, presumably from depression of the central nervous system, was reported following exposure to an unknown quantity of 1,2-dichloroethylene vapor (isomer composition unreported) in an enclosed area (ATSDR, 1996). No data regarding chronic or subchronic inhalation toxicity of *trans*-1,2-dichloroethylene in humans were found in the available review documents (U.S. EPA, 1984, 1986; Lemen, 2001) or in the literature search.

Animal Studies

1,2-Dichloroethylene has been used as an anesthetic in animals (ACGIH, 1991; Lemen, 2001). Inhalation toxicity studies of *trans*-1,2-dichloroethylene in animals include a subchronic rat study by Freundt et al. (1977) and a developmental rat study by Hurtt et al. (1993). No chronic duration animal study was located in the literature search.

Other Studies

Freundt et al. (1977) exposed groups of six female Wistar rats by inhalation to 0 or 200 ppm (0 or 794 mg/m^3) of *trans*-1,2-dichloroethylene for 8 hours/day for 1 day only and for 8 hours/day, 5 days/week for prolonged durations of 1, 2, 8 and 16 weeks. Additional studies were done at higher concentrations (1000 and 3000 ppm) for 8 hours/day for a single day. All concentrations were given as mean values with a variability of ±3% (S.E.M.) based on monitoring the chambers using gas chromatography.

Subsequent to single and repeated exposures at 200 ppm, the rats were examined for gross pathology and histological pathology of selected organs (brain, sciatic nerve, lung, heart, liver, kidney, spleen, brain, and muscle). No signs of narcosis were observed during exposure, and no mortality was reported. Histopathological effects were observed only in the liver(fatty accumulation in liver lobule and Kupffer cells) and lungs (capillary hyperemia and alveolar septum distension).

Repeated exposures of 200 ppm for 1 and 2 weeks produced only slight histopathological changes for liver and lungs in contrast to the studies of 8 and 16 weeks where slight to severe changes were noted. Therefore, these latter studies of longer duration will only be addressed in this report.

In the group exposed for 8 weeks, fatty degeneration was observed in the liver lobule of 3/6 treated rats (versus 0/6 controls) and in the Kupffer cells of 3/6 treated rats (versus 1/6 controls). In the group exposed for 16 weeks, fatty degeneration both in the liver lobule and in Kupffer cells was observed in 5/6 treated rats and 2/6 controls. The observed liver lesions were graded as slight changes, except for Kupffer cell fat accumulation in the 8-week exposure group (all 3 treated and 1 control rats showing the lesion) and liver lobule fat accumulation in the 16-week exposure group (3 of the 5 treated rats with the lesion), which were graded as severe changes. Lung lesions were all graded as slight changes. In the 8-week exposure group, pulmonary capillary hyperemia and distension of the alveolar septum were observed in 6/6 treated rats (3 with severe pneumonic infiltration) and 0/6 controls. Identical findings were reported in the16-week exposure group. This study identified a free standing LOAEL of 200 ppm (794 mg/m^3) for hepatic and pulmonary lesions in rats subchronically exposed to *trans*-1,2-dichloroethylene.

These findings are supported by shorter-term experiments described in the same paper. Freundt et al. (1977) observed the same hepatic and pulmonary effects (hepatic fatty infiltration, pulmonary capillary hyperemia, and alveolar septal distension) in rats exposed to 200 ppm for as short as 8 hours. With the exception of one rat in a single exposure for 8 hours only), the incidence and/or severity was lower . Eight-hour exposure to higher concentrations produced no additional effects, except that histopathology of the cardiac muscle was observed in rats given a single 8-hour exposure to 3000 ppm. Additional studies showed that pulmonary lesions similar to those observed by inhalation exposure were also produced by intraperitoneal exposure. Based on this finding and the absence of histological evidence (transudates or exudates) for irritation of the bronchial epithelium, the investigators suggested that irritation can be discounted as the causal agent for the observed lesions and that the pulmonary lesions may be, at least in part, systemic in origin.

An overview of all the brief and prolonged studies demonstrates that both dose (200, 1000 and 3000 ppm for 8 hours) and time (200 ppm for 8 hours, 1, 2, 8 and 16 weeks) do appear to make a difference in the severity of fat accumulation in the liver lobule and of cardiotoxicity.

A developmental study by Hurtt et al. (1993) showed that the developing organism is not a sensitive target for *trans*-1,2-dichloroethylene. Hurtt et al. (1993) exposed groups of 24 presumed pregnant female CRL:CD BR rats by inhalation to concentrations of 0, 2000, 6000, or 12,000 ppm (0, 7940, 23,820, or 47,640 mg/m^3) of *trans*-1,2-dichloroethylene (99.64% purity) for 6 hours/day on gestational days (GD) 7-16. Rats were observed daily (twice daily on exposure days) for clinical signs. During exposure, the response of the dams to a sound stimulus (rapping on the side of the exposure chamber) was recorded; because of the design of the chamber, not all animals in each group could be observed. Maternal body weight was recorded on GD 1, 7-17, and 22; feed consumption was measured on alternate days from GD 1-19 and on GD 22. Dams were sacrificed on GD 22 and examined for gross pathology; the weights of liver, gravid uterus and empty uterus were recorded. Other endpoints included the number of uterine resorptions (revealed by ammonium sulfide staining in apparently ‘nonpregnant’ dams), fetal mortality, weight and sex of live fetuses, and the number of stunted live fetuses. All fetuses were examined for external malformations and variations, and subsequently analyzed for either skeletal or visceral changes. Two control females were found to be not pregnant and were excluded from most analyses.

No maternal mortality was observed (Hurtt et al., 1993). Significantly reduced body weight gain was observed at 6000 ppm on GD 11-13 and at 12,000 ppm on GD 7-17 (actual loss of weight on GD 7-9). Significantly reduced feed consumption occurred at 2000 ppm on GD 13-15, and at both higher doses during the exposure period. Body weight and food consumption reverted to normal values during the post-exposure period. Ocular irritation (lacrimation and stained periocular hair) was observed in all exposed groups. Narcotizing effects of treatment and alopecia were observed at 6000 and 12,000 ppm, and lethargy and salivation at 12,000 ppm. Of these clinical signs, only alopecia was observed in exposed rats in the post-exposure period. No other compound-related effects were observed in dams. Significant trends and increases in the mean number of total and early resorptions per litter were found in dams exposed to 6000 or 12,000 ppm. However, the researchers considered this finding to be not biologically significant, but rather an artifact of the unusually low resorption rate in the concurrent control group; rates in exposed groups were within the limits of historical control data from the same laboratory during the previous 2 years. The pregnancy rate, corpora lutea, fetuses per litter, and number of stunted fetuses were unaffected by treatment. At 12,000 ppm, mean fetal weight was significantly reduced and there was a small, statistically nonsignificant increase in the incidence of hydrocephalus. Otherwise, treatment had no significant effect on the incidence of fetal malformations or variations. In this study, fetal effects were found only at high concentrations producing overt maternal toxicity, indicating that the developing organism is not a sensitive target of *trans*-1,2-dichloroethylene toxicity.

In a briefly-described range-finding experiment for the developmental study, Hurtt et al. (1993) exposed groups of pregnant female Crl:CD BR rats by inhalation to 0, 6000, 9000, or 12,000 ppm (0, 23,820, 35,730, or 47,640 mg/m^3) of *trans*-1,2-dichloroethylene for 6 hours/day on gestational days 7-16. Narcosis [central nervous system (CNS) depression] was observed in all test groups during exposure and was evident as incoordination immediately following exposure. Maternal body weight gain and food consumption were decreased at the two highest exposure levels, and fetal body weight was decreased at the highest level.

DERIVATION OF A PROVISIONAL RfC FOR *trans*-1,2-DICHLOROETHYLENE

No pertinent data were located regarding the chronic or subchronic inhalation toxicity of *trans*-1,2-dichloroethylene in humans. No chronic inhalation toxicity study in animals was located in the literature search. The 16-week subchronic rat inhalation toxicity study by Freundt et al. (1977) was cited on IRIS (U.S. EPA, 2002) in support of the oral RfD, but was not used to derive a p-RfC. The U.S. EPA (1986) concluded that there was an unresolvable conflict between the adverse level of 200 ppm for the *trans* isomer in the Freundt study and results of an unpublished study on the mixed isomers by Torkelson that was submitted in 1965 to the ACGIH (1991). As reported in secondary sources (Torkelson and Rowe, 1981; ACGIH, 1991), no adverse effects were observed in rats, guinea pigs, rabbits, or dogs exposed by inhalation to the equivalent of 200 or 400 ppm of *trans*-1,2-dichloroethylene (500 or 1000 ppm of 1,2-dichloroethylene containing 40% *trans* isomer) for 7 hours/day, 5 days/week for 6 months. However, as indicated in a report of this study submitted to the EPA in 1994 (Dow, 1962), statistically significant increases in organ weights relative to body weight were observed in the liver of female rats and the kidney of male rats at both exposure levels, and in kidney of female rats at the high exposure level; in addition, average relative liver weight was also increased in a small group of male and female rabbits. The reported organ weight changes observed for the mixed isomers in the Dow (1962) study would appear to provide support for the *trans*-isomer-related hepatic toxicity reported by Freundt et al. (1977). However, absolute organ weights and histopathology results were not reported for the Dow (1962) study.

The critical study of Freundt et al. (1977) reported adverse effects in the liver (fatty degeneration) and lung (pulmonary capillary hyperemia and distension of the alveolar septum) in female Wistar rats exposed to atmospheres containing 200 ppm (794 mg/m^3) of *trans*-1,2-dichloroethylene 8 hours/day, 5 days/week for 16 weeks. As mentioned above, the pulmonary effects were considered to be not only local, but systemic, since they occurred in rats exposed by other routes and were not accompanied by signs of irritation in the lungs (Freundt et al., 1977). Although these same lesions were also observed in rats exposed to the same free standing LOAEL of 200 ppm for only 8 hours, a p-RfC based on this LOAEL is expected to be protective for systemic effects from chronic exposure. The minimal nature of the effects in the 8-hour study suggests that the LOAEL of 200 ppm is very close to the threshold for acute effects. Exposure to 200 ppm for longer durations (up to 16 weeks) or higher concentrations (up to 3000 ppm) for acute durations produced increases in incidence and/or severity of the lesions, but no differences in the types of lesions observed or target organs (with the exception of cardiac histopathology after 3000 ppm for 8 hours). This suggests that the concentration- and duration-response curves for *trans*-1,2-dichloroethylene are shallow, and therefore, that the LOAEL of 200 ppm is a reasonable basis for a chronic p-RfC (i.e., uncertainty factors applied during derivation of the p-RfC are likely to encompass the chronic NOAEL).

The developmental study of Hurtt et al. (1993) was conducted at much higher concentrations (2000-12000 ppm) than the Freundt et al. (1977) study. At these levels, *trans*-1,2-dichloroethylene produced overt clinical signs of toxicity in the dams. Fetal effects were observed, but only at levels that also produced overt maternal toxicity. Therefore, a p-RfC based on the LOAEL of 200 ppm (794 mg/m^3) is expected to provide adequate protection of the fetus in case of maternal exposure.

To calculate the provisional RfC, the LOAEL of 200 ppm (794 mg/m^3) in rats (Freundt et al., 1977) is first adjusted for intermittent exposure, as follows (U.S. EPA, 1994b):

$$\begin{aligned}\text{LOAEL}_{\text{ADJ}} &= (\text{LOAEL}_{\text{RAT}})\ (\text{hours}/24\ \text{hours})\ (\text{days}/7\ \text{days}) \\ &= (794\ mg/m^3)\ (8/24)\ (5/7) \\ &= 189\ mg/m^3\end{aligned}$$

For purposes of calculating the p-RfC, *trans*-1,2-dichloroethylene was treated as a category 3 gas. Lesions in the lung, as well as the liver, were considered extrarespiratory effects for this derivation, because the evidence (discussed above) suggests that the lung lesions were, at least partly, systemic in origin. The human equivalent concentration (HEC) for extrarespiratory effects produced by a category 3 gas is calculated by multiplying the duration-adjusted LOAEL by the ratio of blood:gas partition coefficients ($H_{b/g}$) in animals and humans (U.S. EPA, 1994b). Since the value of $H_{b/g}$ for *trans*-1,2-dichloroethylene in rats (9.58; Gargas et al., 1989) is larger than $H_{b/g}$ in humans (6.04), a default value of 1 is used for the ratio of partition coefficients, and the $\text{LOAEL}_{\text{HEC}}$ becomes 189 mg/m^3:

$$\text{LOAEL}_{\text{HEC}} = (\text{LOAEL}_{\text{ADJ}}) \times [(H_{b/g})_{\text{RAT}} / (H_{b/g})_{\text{HUMAN}}],$$

$$\text{If} \quad (H_{b/g})_{\text{RAT}} > (H_{b/g})_{\text{HUMAN}}, \text{ then } (H_{b/g})_{\text{RAT}} / (H_{b/g})_{\text{HUMAN}} = 1$$

$$\text{Since} \quad 9.58 > 6.04,$$

$$= 189\ mg/m^3 \times [1] = 189\ mg/m^3$$

A composite uncertainty factor of 3000 was used, reflecting the following areas of uncertainty: use of a LOAEL, use of a less than chronic study, extrapolation from rats to humans using the dosimetric adjustments, protection of sensitive individuals, and database deficiencies (including lack of a multigeneration reproduction study). The modifying factor was set to 1. The provisional RfC for *trans*-1,2-dichloroethylene was derived as follows:

$$\begin{aligned}\text{p-RfC} &= \text{LOAEL}_{\text{HEC}} \div (\text{UF} \times \text{MF}) \\ &= 189\ mg/m^3 \div (3000 \times 1) \\ &= 0.06 \text{ or } 6E\text{-}2\ mg/m^3\end{aligned}$$

Although based on the same critical study, the provisional RfC for *trans*-1,2-dichloroethylene (6E-2 mg/m^3) is 13-fold lower than the intermediate inhalation MRL (8E-1 mg/m^3) calculated by ATSDR (1996). This difference stems from lack of duration adjustment and an alternative application of uncertainty factors in the ATSDR (1996) assessment.

STATEMENT OF CONFIDENCE

Confidence in the critical study is low because, although methods and results were adequately designed, conducted and reported, certain inadequacies remain, namely, small sample size, use of a single sex, the use of a single exposure level, the relatively short exposure duration, and the lack of analysis of body and organs weights, nasal histology, clinical chemistry, and hematology. Confidence in the database is low because of the lack of data for exposures longer than 16 weeks, or for species other than rat, and the lack of a multigeneration reproduction study. Low confidence in the p-RfC results.

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E.10. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP

This chapter presents meeting minutes from the Paducah Risk Assessment Working Group. Notes from the 2000 meetings and 2007 meetings are presented, along with minutes from the quarterly meetings beginning in June 2012. Future revisions of this document will present meeting minutes held to date.

The meeting minutes are included for historical information only.

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PADUCAH RISK ASSESSMENT WORKING GROUP MEETING MINUTES

2000 MEETINGS

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Human Health Risk Working Group for Paducah Gaseous Diffusion Plant
Meeting Minutes/ Summary for May 2-3, 2000 Meeting

I. Develop Human Health Thresholds Per Land Use

   a. Receptors
   b. Routes
   c. Exposure Parameters
   d. Equations

II. Risk / Hazard Level

   a. Action: Risk > 1.0E-04; HI > 3.0 (Risk greater than 1.0E-04 or HI greater than 3.0)
   b. No Action: Risk ≤ 1.0E-06; HI ≤ 0.1 (Risk less than or equal to 1.0E-06 or HI less than or equal to 0.1)
   c. Further Evaluation:
      Risk ≤ 1.0E-04 and > 1.0E-06 (Risk less than or equal to 1.0E-04 and greater than 1.0E-06);
      HI ≤ 3 and > 0.1 (HI less than or equal to 3 and greater than 0.1).

III. Current / Future Scenario

   a. Industrial Worker – Current (surface soils only)
   b. Industrial Worker – Excavation
   c. Recreational User – Lives Nearby
   d. Resident

IV. Exposure Routes (Screening Thresholds)

   a. Industrial Worker (Current)
      i. Soil / Sediment
         1. Dermal Contact (Table 33)
         2. Incidental Ingestion (Table 29)
            a. Note that area of contact defaults to 1.
         3. Inhalation (Table 31)
         4. External Exposure (Table 34)
      ii. Surface Water
         1. Dermal Contact (Table 36)
            a. Note uncertainty associated with high exposure assumptions.
      iii. Groundwater – Not Applicable. Groundwater is screened based on residential scenario.
   b. Industrial Worker (Excavation)
      i. Soil / Sediment
         1. Dermal Contact (Table 39)
         2. Incidental Ingestion (Table 37)
            a. AC term doesn't apply except for small sites

            3. Inhalation (Table 38)
            4. External Exposure (Table 40)
        ii. Surface Water
            1. Dermal Contact (Table 36)
                a. Note uncertainty associated with high exposure assumptions.
        iii. Groundwater – Not Applicable. Groundwater is screened based on residential scenario.

c. Recreational User – Lives Nearby (HI calculated for residential child only)
    i. Soil/Sediment
        1. Incidental Ingestion (Table 15)
        2. Dermal Contact (Table 16)
        3. External Exposure (Table 18)
        4. Inhalation (Table 17)
    ii. Surface Water
        1. Incidental Ingestion - Swimming (Table 19)
        2. Dermal Contact – Wading (Table 20 - Wading & Table 21 Swimming)
    iii. Groundwater – Based on Residential scenario

d. Resident – (*HI calculated for resident child only)
    i. Surface Water / Sediment Covered by "Recreational User – Lives Nearby"
    ** Separate Table (as needed) for Biota Ingestion:
        Fish
        Game (rabbit, deer, quail and turkey)
    ii. Soil
        1. Incidental Ingestion (Table 5)
        2. Inhalation (Table 7)
        3. Dermal Contact (Table 6)
        4. External Exposure (Table 8)
    iii. Groundwater
        1. Ingestion (Table 1)
        2. Dermal Contact - showering (Table 4)
        3. Inhalation - showering and household use (Table 2 & 3)

V. Action Items
a. Inhalation – Rich took lead on:
    i. Developing Paducah specific PEF for sites < 0.5 acres
    ii. Locating guidance for VF

Guidance suggested for calculating the PEF and VF was the "Soil Screening Guidance: User's Guide (Pub. 9355.4-23, July 1996). The specific equations are #5 for PEF and #8 for VF.

b. Industrial Worker - Surface Water Dermal Contact
    i. Identify uncertainty in exposure factors

c. Biota – Fish and Game
   - i. Not considered for screening. PGDP Risk Work Group decided not to calculate biota values in preparation of the May 31 Core Team meeting, because these would not be considered for action and no action screening.

VI. Resolved Action Items / Issues

a. Dermal Contact - Determine what dermal absorption factor should be used: EPA vs. KY assumptions
   - i. Solution: Use EPA values for 1.0E-04 threshold
     Use KY values for 1.0E-06 threshold

b. Current Industrial Worker – determine more realistic exposure assumptions
   - i. Solution: Use mean exposure assumptions for the Action threshold (1.0E-04) and use default values for the No Action threshold (1.0E-06).

c. Groundwater
   - i. For purposes of Action: 1.0E-04 RBC
   - ii. For purposes of No Action: 1.0E-06 RBC
   - iii. List MCLs for comparison
   - iv. Do a fate and transport leaching based on 1.0E-04 /1.0E-06
     Lateral Evaluation not part of initial screen

d. Industrial Worker (Excavation)
   - i. Change Ingestion, Inhalation and Dermal contact exposure duration (ED)
     1. ED = 1 for 10^{-4} threshold
     2. ED = 25 years for 10^{-6} threshold

e. For resident receptor, screening values to sediment remain the same as soil. Determine range $10^{-6} \rightarrow 10^{-4}$

f. For surface water:
   - i. Wading – Dermal Contact
   - ii. Swimming – Incidental ingestion and dermal contact

g. Use HI = 3 for screening tables. Core Team to decide between HI = 3 or HI = 10

h. For Lead:
   - i. Residential Values
     1. 400 mg/kg — 30 ug/L *
     2. 50 mg/kg — 15 ug/L
   - ii. Industrial Values
     1. 1250 mg/kg — 30 ug/L
        50 mg/kg — 15 ug/L

* 30 ug/L represents the EPA Emergency Response Removal Action Level.

VII. Deliverables

a. Screening Tables
   - i. Receptors
     1. Media Risk $10^{-6} \rightarrow 10^{-4}$
     2. HI = 0.1 → HI = 3
     3. MCLs for groundwater

b. Use Priority Contaminant List (Example only)

        i. Add radionuclides including Th, Pu, U and Am
    c. Appendix
        i. Exposure Assumptions/Equations
        ii. Toxicity Values
    d. Uncertainty Discussions
    e. Because HEAST tables are no longer being updated on a regular basis, the order of preference for EPA toxicity values is as follows: (1) IRIS, (2) NCEA, and (3) HEAST.

* During the review of the draft meeting notes, the KYDEP raised the issue of route-to-route extrapolation when there were no toxicity values available for a given route of exposure. Following a discussion with John Purdy (KYDEP) and Glenn Adams (USEPA), a decision was reached to use the extrapolated values identified in the Region 9 PRG tables when available. With the exception of the Region 9 values, no additional extrapolations are needed for preparation of the screening tables for the May 31 Core Team meeting. The use of route-to-route extrapolations will be discussed at the next PGDP Risk Work Group meeting.

    f. Paducah RCBA decision Framework (See attached file from: Risk Based Corrective Action PS 104-9A)
        i. Tier 1 – Residential Screen
        ii. Tier 2 – Recreational or Industrial depending on Land Use

VIII. Schedule

May 8, 2000 – Meeting summary/minutes due to PGDP Risk Work Group
May 10, 2000 – Comments on meeting minutes due via email
May 22, 2000 – Deliverables due to PGDP Risk Group
May 25, 2000 – Conference call to review deliverables
May 31, 2000 – Action/No Action screening levels presented to PGDP Core Group

Agenda
PGDP Risk Work Group Conference Call
May 25, 2000 1:00 – 3:00 (EST)
Call In Number: (202)287-5293

I. Receptors and Exposure Parameters

a. Receptor Description/Media Exposure Assumptions

- Receptor description per land use
- Additions/deletions to media considered for each receptor

b. Exposure Factors for Receptors

- <u>Current Industrial Worker</u> - central tendancy values not available for action threshold; default values used for both 10^{-4} and 10^{-6} threshold.
- <u>Industrial Worker (Excavation)</u> - exposure duration of 1 yr (10^{-4} threshold) and 25 yrs. (10^{-6} threshold)
- <u>Current Industrial Worker, Resident, Recreational User</u> – default values used for both 10^{-4} and 10^{-6} threshold

(KY and EPA dermal absorption values applied to all receptors)

II. PGDP Priority Contaminants and MCL List

a. Additions/Deletions to List

III. Analyte Specific Values for Priority Contaminants

a. Agreement with toxicity information

b. Use of route-to-route extrapolations

IV. Action and No Action Levels for Each Receptor

a. Determine which HI to use for action and no action threshold for each media (i.e., child for noncancer effects for no action)

b. Surface water – use wading or swimming threshold values

V. Risk-Based Corrective Action Decision Process and Use of Action Levels

VI. Deliverables for May 31 Core Team Presentation

VII. Action Items

a. Prior to Core Team Meeting on May 31 – June 1

b. Future Risk Work Group meetings

PGDP Risk Work Group Conference Call Summary Minutes
May 25, 2000 1:00 - 2:30 (EST)

I. Discussion on Receptors and Exposure Parameters

a. Receptor Description/Media Exposure Assumptions
  - The recreational user is considered to be a resident of the area, but this category also allows for recreational users who are occasional visitors.
  - No additions or deletions were made to media considered for each receptor

b. Exposure Factors for Receptors
  - <u>Current Industrial Worker</u> - Glenn Adams will provide central tendency values (Region 6 document) for current industrial worker.
  - <u>Industrial Worker (Excavation)</u> - Confirmed that exposure duration of 1 year is to be used for 10^{-4} threshold (useful for sites that present excessive risks) and 25 years for 10^{-6} threshold.
  - <u>Difference between Current Industrial Worker and Excavation Worker</u> – The industrial worker is considered a long-term employee whose main exposure route is inhalation, however he is only exposed to surface soil. The excavation worker is not considered a long –term employee and is exposed to surface as well as sub-surface soils through activities such as maintenance (digging ditches) or gardening.

II. PGDP Priority Contaminants and MCL List

a. No additions to list

b. It was suggested that for presentation at the core team meeting only the total dioxin/furan, PAHs, and PCBs number be shown (all would be used for screening).

III. Analyte Specific Values for Priority Contaminants

a. Agreement with toxicity information

b. Use of route-to-route extrapolations to be discussed at next work group meeting.

c. PEF factor will be reevaluated based on Soil Screening Guidance.

IV. Action and No Action Levels for Each Receptor

a. On-site recommendation
  - Action - Use industrial worker values
  - No Action - Use child resident values

b. Off-site recommendation
  - Action – child recreator values
  - No Action – child recreator values

c. Surface water (wading/swimming) – The core team will decide on SWMU by SWMU basis which route is applicable.

V. Risk-Based Corrective Action Decision Process and Use of Action Levels

a. Tier 1 Screen
  - Use cancer # and HI #
  - Recommend cumulative risk evaluation

VI. Deliverables for May 31 Core Team Presentation

a. Assumptions for each receptor
b. Exposure parameters
c. Final numbers (two lists)
    - Original list prepared by Rich
    - List with recommended scenarios and exposure parameters
d. Cumulative Risk should be brought up to the core team

VII. Action Items

a. Prior to Core Team Meeting on May 31 – June 1
    - Recalculate Excavation worker Default values
b. Cumulative Risk has to be addressed
c. Glenn Adams will find central tendency values for current industrial worker (Region 6 document/criteria)

Attended:
John Volpe
Steve Hampson
Glenn Adams
Dena Brett
Rich Bonczek
John Purdy
Jon Richards
Larry Taylor
Marissa Colburn

Absent:
Tuss Taylor
Jeff Crane
John Morgan

ISSUES FROM PAST COMMENTS
Status as of 9/7/2000

ISSUE	SOURCE	RESOLUTION
Data required to completely delimit the nature and extent of contamination • Horizontal contaminant boundaries (Nondetects) • Horizontal contaminant boundaries (Hot spots) • Vertical contaminant boundaries (0’ - >1’ as surface soil)	• KDEP Comment #1 on WAG 27 D2 • KDEP Comment #8 on WAG 6 D2 • KDEP General Comment #3 and #11 on SWMU 7&30 D1 • KDEP Specific Comments in WAG 28 D1	• Use 0 to 1’ bgs only for surface soil. • For radionuclides, use 2×’s machine background when selecting data within horizontal extent. • Will need to use professional judgement when determining extent of “hot spots”. • SWMU boundaries (which are generally based on process history at the PGDP) serve as the starting point for extent determination but may be altered using sampling data and/or professional judgement – don’t include data from clean areas in the calculations. • Drop “AC” from risk exposure equations and move “AC” to uncertainty section.
Use of modeling to predict future concentrations at points of compliance • Selection of COPCs • Use of modeling • Point of compliance • Point of exposure • Calibration of screening level transport models • Use of historical data	• KDEP Comments #3, #5, #6 on WAG 27 D2 • KDEP Comment #10 on WAG 27 D1 • KDEP General Comment #2 on WAG 6 D1 • KDEP Specific Comment #2 on WAG 6 D2 • EPA General Comment #3 on SWMU 2 DSIR D1 • KDEP Specific Comment #102 on SWMU 2 DSIR D1 • KDEP General Comment #4 on SWMU 7&30 D1	• Use residential SSLs (DAF=1) for COPC selection. • Use modeling matrix to direct level of effort. • Point of compliance is not a risk assessment concern – need to model to four points of exposure (at unit, at fence, at property boundary, and at Little Bayou Creek/Ohio River). (Note that Little Bayou Creek/Ohio River may not be appropriate for some units.) • When the project is such that a site’s data set is “augmented” (i.e., historical data is assumed to be valid), then all data should be used in the modeling effort. • When using an “augmented” data set, be sure to address uncertainty. • Screening level models are not calibrated. The reasons for not calibrating and its importance to decision-making needs to be discussed in the risk assessment.

ISSUE	SOURCE	RESOLUTION

Cumulative risk
• Exposure over space
  • Summing risk estimates
• Exposure over time
• Exposure over activities
  • Game for residents
  • Summing risks
	• KDEP Comment #4 on WAG 27 D2
	• KDEP Comment #5 on WAG 27 D1 comments on responses
	• KDEP General Comment #4 on WAG 27 D1
	• KDEP Specific Comment #48 on WAG 6 D1
	• KDEP General Comments #2, #8, and #11 on SWMU 7&30 D1
	• EPA Specific Comment #5 on the WAG 28 D1
		• Summing over space is not an issue if the exposure equations use an AC=1.
		• Summing over activities – need to show individual values and their summation as appropriate in the uncertainty section of the assessment. Recognize and discuss “Intake” and “EFD” problems involved in simple summations.
		• For recreational – only consider soil exposure when area’s expected future use is recreational. Doing this allows summing the recreational and residential scenario’s results without the “double counting” concerns.

Calculation of cleanup goals for NFA sites	• KDEP cover letter for WAG 23 Residual Risk Report	• When calculating residual risks for a group of units, there is no need to include calculations for units previously agreed to be NFA based upon an approved risk assessment (or alternative calculation such as a screening assessment performed under the authority of the Core Team). However, the documentation should include the NFA site’s risk results by reference. • When calculating residual risks, the land use and analyte list must meet the requirements established in the final ROD. If there is no final ROD to work from, then the approach to be used for the residual risk calculation (e.g., scenarios to consider, sampling results to include) is to be discussed by the RAWG.
Definition of *de minimis* risk and use of EPA risk range	• KDEP General Comment #1 on WAG 23 Residual Risk Report • EPA General Comment #1 on WAG 27 D1	In all risk assessments, the calculated risk values should be compared to both the *de minimis* risk level and the EPA risk range. The reference for the EPA risk range (i.e., “EPA’s generally acceptable risk range for site-related exposures in 1 × 10^{-4} to 1 × 10^{-6}”) is *A Guide to Preparing Superfund Proposed Plans, Records of Decisions, and Other Remedy Selection Documents* (EPA-540-R-98-031, July 1999).

ISSUE	**SOURCE**	**RESOLUTION**
Exposure equation revision • Use of concept of exposure unit • Use of site-specific values • Dermal absorption % • Excavation worker	• KDEP Specific Comment #1a on WAG 23 Residual Risk Report • KDEP Specific Comment #50 and 51 on WAG 27 D1 • KDEP Specific Comment #54 on WAG 6 D1 • EPA Specific Comment #9 on WAG 28 D1	*Not addressed to date.*
Use of COCs in residual risk reports	• KDEP Specific Comment #1a on WAG 23 Residual Risk Report •	See previous discussion.
Extrapolation of toxicity values in baseline risk assessments	• KDEP Comment #12 on WAG 27 D1 comments on responses • KDEP Comment #51 on WAG 6 D1 •	• Risk assessments are to use provisional and withdrawn toxicity values. See later discussion as well. • Use the toxicity data base developed for calculation of the screening values in risk assessments.
COPC selection • Background screen • Use of RDA calculation • Nonnumeric factors (rad issues) • Risk targets for RBCs for screening	• KDEP General Comment #6 on WAG 27 D1 • KDEP Specific Comment #45 on WAG 6 D1 • KDEP Specific Comment #45 on WAG 27 D1 • EPA General Comment #2 on WAG 6 D1 • EPA Specific Comment #5 on WAG 6 D1 • KDEP General Comment #2 on WAG 6 D2 • KDEP Specific Comment #3 on WAG 6 D2 •	• Move the RDA screen to the uncertainty discussion except can drop the analytes listed in EPA Region IV guidance (e.g., calcium, phosphorus, potassium, magnesium, and chlorine). • Move the background screen to the uncertainty section. This will allow the consideration of background values from other sources as part of the uncertainty discussion. The use of background values from other sources is important for analytes for which PGDP does not have a background value (e.g., ^{210}Pb at WAG 6). • For the toxicity screen performed as part of COPC selection, use 1×10^{-6} as the cancer target for both radionuclides and chemicals. Use 0.1 as the hazard target. • Quantitatively examine the effect of removing analytes on the basis of the toxicity screen in the uncertainty section.
COPC concentration calculation for radionuclides	• KDEP Specific Comment #42 on WAG 27 D1	When calculating representative exposure concentrations for radionuclides, use the value reported in the data set. That is, negative results are to be included in calculations just like positive values.

ISSUE	SOURCE	RESOLUTION
Cleanup goal calculations • Background • Radionuclide decay • Chemical degradation • Regulatory values for radionuclides	• KDEP Specific Comment #44 on WAG 27 D1 • EPA Specific Comment #11 on SWMU 2 DSIR D1 (contains list of “’91 PROP” values	• Much of this has been addressed earlier as part of the North-South Diversion Ditch cleanup goal calculations, and those resolutions will not be repeated here. • When listing regulatory values for radionuclides, do not use the values listed as “91 PROP” in the SWMU 2 DSIR comment set. Those values are dated and newer values should be used. • Decay should be considered when developing cleanup goals for radionuclides. However, unless PGDP develops a substantial body of supporting information, chemical degradation should not be included.
How to assess UCRS groundwater • Drinking issue • Contact issue	• KDEP Specific Comment #46 on WAG 27 D1 • KDEP General Comment #6 on WAG 6 D2 • KDEP (DWM) Specific Comment #7 on SWMU 7&30 D1	• UCRS drinking water does not need to be assessed in the main body of the risk assessment. However, the “risk” posed to someone hypothetically using this water should be discussed quantitatively in the uncertainty section. • Similarly, treat contact with UCRS water under an excavation scenario as an uncertainty. This can be a qualitative discussion.

ISSUE	SOURCE	RESOLUTION
Conceptual site model • Radionuclides in groundwater and surface water • Livestock at small units • Exposure at ponds at small units • Scope of investigation – surface releases from subsurface sites • Soil exposure by residents versus recreators • Routes for the off-site rural resident in source investigations	• KDEP Specific Comment #53, 54, and 56 on WAG 27 D1 • KDEP Specific Comment #49 and #50 on WAG 6 D1 • KDEP (DWM) Specific Comment #8 on SWMU 7&30 D1 • EPA General Comment #1 on WAG 28 D1 • KDEP Specific Comment #44 and #46 on WAG 28 D1	• Risk for external exposure to radionuclides in water does not need to quantified. The reason for not quantifying this route of exposure needs to be stated in the risk assessment. • Do not need to assess either livestock or ponds (man-made) at small units within the industrialized area of the PGDP. These pathways will need to be included in the assessment of larger units located inside the industrialized area and in the assessment of all areas located outside the industrialized area. • When reporting risks from units at which no surface soil samples were collected, need to state the following: “The potential risk from exposure to surface soil was not quantified in this risk assessment and is, therefore, unknown. The risk from exposure to this medium was not quantified because the investigation of this medium falls outside the scope of the current investigation.” (Note that this will also apply when considering risk from groundwater use when data is not available due to the scope of the investigation.) • When assessing risk to offsite users of groundwater contaminated by migration from materials originating from a source unit, include rural residential household exposure pathways only. Do not include either the gardening or livestock pathways.
Correction of EPA Region IV TEFs	• KDEP Specific Comment #50 on WAG 6 D1	Need to get the correct values and use in future assessments.

ISSUE	**SOURCE**	**RESOLUTION**
Evaluation of Total PAHs, Dioxins/Furans, and PCBs Cancer (All) Noncancer (PAHs and PCBs)	• KDEP General Comment #6 on SWMU 7&30 D1	• When calculating Total PAHs and Total PCBs, apply the TEFs to detected values only and sum. (All TEFs for PCBs are assumed to be 1 at this time. This may change in the future.) • When calculating Total Dioxin, apply TEFs to both detected values and to one-half the SQL for dioxins/furans not detected and then sum. • Total PAHs and Total PCBs only applies to cancer calculations. When performing hazard calculations use individual PAH compounds and individual Aroclors.
Use of withdrawn toxicity values (beryllium issue)	• KDEP General Comment #3 on WAG 6 D2	In general, provisional and withdrawn toxicity values are to be used. An exception is when the withdrawn number is replaced or when the value is withdrawn for a reason that makes the old value clearly suspect. The latter exception will require discussion in the risk assessment and will probably be best addressed as an uncertainty.
RAGS Part D formatting	• NEW ISSUE	RAGS Part D formatting will be implemented at least in part. The extent of use will need to be proposed in the draft Methods Document.
Calculation of groundwater concentrations (averages)	• KDEP Specific Comment #45 on SWMU 2 DSIR D1	Because of the uncertainty in the averaging approach, there is no need to include this in the main body of the risk assessment. However, may want to address this as an uncertainty.
Background issues • Soil (Letter vs report) • Groundwater • Sediment • Surface water (RCB has values?)	• KDEP Specific Comment #52 on SWMU 2 DSIR D1 • KDEP Comment #6 on WAG 9&11 SER D1 • EPA Specific Comment #3 on SWMU 7 & 30 D1 • KDEP Specific Comment #15 on SWMU 7&30 D1 • KDEP (DWM) Specific Comment #6 on SWMU 7&30 D1	*Not addressed to date.*
Risk assessment for lead	• KDEP General #5 on SWMU 7&30 D1	*Not addressed to date.*

ISSUE	**SOURCE**	**RESOLUTION**
Uncertainties to address quantitatively in BRAs • Infrequent detects • Infrequent analysis • Laboratory contaminants • Use of background screen • Use of toxicity screen • Total vs filtered water • Biota pathways • RME vs average exposure parameters • Summing groundwater and soil risks • Dermal absorption • Default vs site-specific exposure parameters • Extrapolation of toxicity values • Withdrawn and provisional values	• KDEP General #6 on WAG 28 D1	*Not addressed to date.*
Probabilistic risk assessment	• CONTINUING ISSUE	*Not addressed to date.*
Complete toxicity profiles in BRA	• EPA Specific Comment #10 on WAG 28 D1	*Not addressed to date.*

Notes from HHRAWG Meeting #2

August 1, 2000; 10 am to 4:30 pm
Central Laboratory Facility, Frankfort, Kentucky

Members in Attendence:

Name	Organization	Phone	E-mail Address
Rich Bonczek (Chair)	SAIC	(865)481-4679	Richard.R.Bonczek@saic.com
Steve Hampson	KY RCB	(502)564-8390	SKHamp1@pop.uky.edu
Larry Taylor	KY DWM	(502)564-6120	larryc.taylor@mail.state.ky.us
John Pudry	KY DWM	(502)564-6120	John.Purdy@mail.state.ky.us
Al Westerman	KY DWM	(502)564-6120	Albert.Westerman@mail.state.ky.us
John Morgan	BJ LLC	(270)441-5069	morganjw@bechteljacobs.org
John Volpe	KY RCB	(502)564-7818 x3692	John.Volpe@mail.state.ky.us
Glen Adams	EPA	(404) 562-8667	adams.glenn@epa.gov

Members Absent:

Name	Organization	Phone	E-mail Address
Gary Bodenstein	DOE	(270) 441-6831	bodensteingw@oro.doe.gov
Jeff Crane	EPA	(404) 562-8546	crane.jeff@epa.gov
Jon Richards	EPA	(404) 562-8648	richards.jon@epa.gov
Tuss Taylor	KY DWM	(502) 564-6716	tuss.taylor@mail.state.ky.us

Notes and Agreements:

Topic #1: Revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1506&D1):

The document considered at this meeting was the draft document numbered DOE/OR/07-1506&D1/R0 released for consideration at the HHRAWG Meeting #1 held on May 2 & 3, 2000. The following are specific revisions discussed.

1. Revise document to be consistent with screening/scoping activities being followed by the Core Team.
2. Revise table formats to be consistent with RAGS Part D. This will allow tables to be taken directly into forthcoming decision documents (e.g., FS/PRAP/ROD).
3. Include RBCs for PGDP priority contaminants in the appendices of the revised document. Post these RBCs and relevant supporting material on the internet as time allows.
4. Include soil and groundwater background values for PGDP in the appendices of the revised document.
5. Include list of RDAs in the appendices of the revised document after updating values (See link for new table. http://www.nal.usda.gov/fnic/dga/rda.pdf). Also, drop “RDA screen” from screening steps used to develop the list of COPCs in the baseline risk assessment – include as uncertainty only.
6. Add a RAGS Part D formatted table of exposure parameters to the revised RBC appendix. Note that this table does not replace the exposure tables found in the current Appendix 4 of the document.
7. Add a RAGS Part D formatted table of toxicity values for the PGDP priority contaminants to the revised RBC appendix. Include effects in this table along with values.
8. Add a RAGS Part D formatted table of chemical-specific values for the PGDP priority contaminants to the revised RBC appendix. Include references for all values.
9. Leave Appendix 2 – Deriving RBCs – in the document but add a discussion on the derivation of RBCs for radionuclides and on the derivation of soil/sediment RBCs for protection of groundwater, surface water, and biota.
10. Leave Appendix 3 – Baseline Risk Assessment Outline – in the document but add direction of use of RAGS Part D formatting. (Note: Additional comments on the outline may be forthcoming.)
11. Leave Appendix 4 – Exposure Equations – in the document.
12. Leave Appendix 5 – Flow Charts for Use of Risk Information in PA/SIs – in the document but modify to be consistent with the Core Team screening/scoping process.

Topic #2: Schedule for revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1506&D1):

The draft schedule is as follows:

August 28, 2000 – Revised document delivered electronically to group members for review.
September 7 and 8, 2000 – On-line review of document by group members.
September 30, 2000 – Revised document delivered to regulatory agencies for formal review.

Topic #3: Clean-up Goal Development:

(Note: The discussion was generic for the most part; however, some specific issues for the North-South Diversion Ditch clean-up goals were addressed.)

Issue #1: Selection of COCs:

If a baseline risk assessment is available, then use the guidance in the current Methods Document to select COCs. This guidance (taken from the aforementioned document) is as follows:

> In identifying use scenarios, pathways, contaminants, and media of concern, specific rules will be followed. These rules were agreed to by DOE, EPA, and Kentucky during meetings held in February 1996 (DOE 1996d) and during follow-up discussions (EPA 1996c, KYDEP 1996d). The rule for each item of concern is discussed below.
>
> - Identification of use scenarios of concern. To determine use scenarios of concern, risk characterization results for total systemic toxicity (HI_{total}) and total risk ($ELCR_{total}$) will be compared to benchmarks of 1.0 and 1×10^{-6}, respectively. Use scenarios with HI_{total} or $ELCR_{total}$ exceeding either of these benchmarks will be deemed use scenarios of concern.
>
> - Identification of pathways of concern. To determine pathways of concern, risk characterization results for pathway hazard (HI_p) and risk ($ELCR_p$) over all chemicals *within a use scenarios of concern* will be compared to benchmarks of 0.1 and 1×10^{-6}, respectively. Pathways within a use scenario of concern exceeding either of these benchmarks will be deemed pathways of concern for the use scenario of concern.
>
> - Identification of contaminants of concern. To determine contaminants of concern, risk characterization results for chemical hazard (HQ_i) and risk ($ELCR_i$) over all pathways *within a use scenario of concern* will be compared to benchmarks of 0.1 and 1×10^{-6}, respectively. Chemicals of potential concern within a use scenario of concern exceeding either of these benchmarks will be deemed contaminants of concern for the use scenario of concern.
>
> - Identification of media of concern. To determine media of concern, the pathways of concern are reviewed, and those media in these pathways are deemed to be media of concern. This is equivalent to screening the total risk and hazard posed by chemicals of potential concern in the various media against benchmarks of 0.1 and 1×10^{-6}.

If a baseline risk assessment is not available (as in the case of potential early action projects such as the North-South Diversion Ditch), then COCs will be those contaminants that have a maximum detected concentration greater than the residential use "No Action" RBCs.

Issue #2: Modification of the Initial List of COCs:

The initial list of COCs should then be refined to address issues such as the future land use of the area the project is addressing and data quality issues (PARCC). The steps taken to refine the list of COCs should be discussed in detail.

Issue #3: Cleanup Goal Calculations – Time Considerations:

When deriving cleanup goals, the decay of radionuclides and the degradation of chemicals can be considered. However, any modification of the clean-up goals for decay and/or degradation needs to be discussed in detail.

Issue #4: Cleanup Goal Calculations – Space Considerations:

Migration: The cleanup goals derived for any project should consider the potential for migration of contaminants from source material to receiving media (i.e., groundwater, sediment, and surface water). For radionuclides, the cleanup goals for protection of receiving media can be quantified using RESRAD. For chemicals, the cleanup goals for protection of receiving media can be quantified using various models. See notes on modeling matrix discussion for additional information.

Meeting the Goal: The committee recognizes that the concept of the exposure unit is applicable when determining if a cleanup goal is met. However, the areal extent of the exposure unit to be used in these calculations is to be no greater than 25' by 50'. The depth of this unit should be consistent with the site in question, but a depth greater than 1' is not to be used for all areas with surface contamination.

Within the exposure unit, the cleanup goal for chemicals will be deemed to be met if verification sampling determines that the average residual COC contamination is less than the cleanup goal and that the result for no single sample is greater than two times the cleanup goal.

Within the exposure unit, the cleanup goal for radionuclides will be deemed to be met if verification sampling determines that no single sample exceeds the cleanup goal. While this seems to be a more stringent requirement than that for chemicals, this approach is consistent with the manner in which cleanup goals for radionuclides will be calculated and the ALARA approach to cleanup.

Values: Cleanup goals will be derived for all COCs using the methods for RBC calculation described in Appendix 2 of the Methods Document. For chemicals, the risk targets to be used are an ELCR of 1×10^{-6} and a HI of 0.1. Note that the cleanup goals should be derived for the appropriate future use and disposition of the site. That is, not all areas need to be cleaned to residential standards; however, areas not cleaned to residential standards will not be "free release" sites. That is, those areas not cleaned to residential standards will need to include use restrictions as part of the remedy for the site. For example, for the North-South Diversion Ditch outside the industrialized area of the PGDP (i.e., "outside the fence"), the appropriate future use scenario is recreational if residential development of the property is restricted as part of the remedy. Also, given the physical nature of the site, the appropriate frequency and duration of exposure for the recreator (chemical cleanup goals only) are 140 days per year for ages 1 to 13 (i.e., 12 years) and 14 days/year for ages 15 to 41 (i.e., 28 years).

Topic #4: Modeling Considerations:

The discussion of modeling was directed by consideration of the "Modeling Matrix" developed/discussed at the PGDP Modeling Group meeting held on July 27, 2000. This matrix is an attachment to these notes. The revised matrix is also attached.

Issues of note concerning the modeling matrix were:

- The use of a tiered approach to ensure that the appropriate level of effort is put into modeling given its uncertainties.
- Changing the default SSL DAF for groundwater from 20 to 1.
- The use of a "RESRAD TRANS" model to examine the lateral transport of radionuclides in groundwater – once this model becomes generally available.
- The use of risk targets of ELCR = 1×10^{-6} and HI = 0.1 for RBCs in groundwater and surface water.
- The inclusion of biota modeling.
- The recognition that the North-South Diversion Ditch project is caught between groundwater modeling Tiers 1 and 3 – Tier 1 because COCs for groundwater protection have not been delineated and Tier 3 because site-specific information should be used to develop the final cleanup goals for protection of groundwater.
- The recognition that only monitoring the receiving media (i.e., groundwater, surface water, and biota) can ensure that the cleanup goals for source materials has been met.

Action Items:

1. Steve Hampson to provide a copy of the Rocky Flats RESRAD writeup for use in development of a similar writeup for the PGDP. (OPEN ON 8/13/00).
2. John Morgan to provide a new PGDP remedial action figure consistent with the current Core Team approach for presentation in the revised Methods Document. (OPEN ON 8/13/00).
3. Rich Bonczek to set-up time and place of next meeting after consideration of group members' schedules. (OPEN ON 8/13/00).

Notes from HHRAWG Meeting #3

August 21, 2000; 9 am to 4:30 pm
Central Laboratory Facility, Frankfort, Kentucky

Members in Attendance:

Name	Organization	Phone	E-mail Address
Rich Bonczek (Chair)	SAIC	(865)481-4679	Richard.R.Bonczek@saic.com
Steve Hampson	KY RCB	(502)564-8390	SKHamp1@pop.uky.edu
Larry Taylor	KY DWM	(502)564-6120	larryc.taylor@mail.state.ky.us
John Pudry	KY DWM	(502)564-6120	John.Purdy@mail.state.ky.us
Al Westerman	KY DWM	(502)564-6120	Albert.Westerman@mail.state.ky.us
John Volpe	KY RCB	(502)564-7818 x3692	John.Volpe@mail.state.ky.us
Glen Adams	EPA	(404) 562-8667	adams.glenn@epa.gov
Jon Richards	EPA	(404) 562-8648	richards.jon@epa.gov

Note that Glenn Adams and Jon Richards were present for short periods of time only. Therefore, they are not aware of all items contained in these draft notes.

Members Absent:

Name	Organization	Phone	E-mail Address
Gary Bodenstein	DOE	(270) 441-6831	bodensteingw@oro.doe.gov
Jeff Crane	EPA	(404) 562-8546	crane.jeff@epa.gov
Tuss Taylor	KY DWM	(502) 564-6716	tuss.taylor@mail.state.ky.us
John Morgan	BJ LLC	(270)441-5069	morganjw@bechteljacobs.org

Notes and Agreements:

Topic #1: Clean-up goal calculation for the North-South Diversion Ditch:

Much of this discussion was project specific; however, some materials are applicable to clean-up goal calculations in general. This material is reported here.

When developing lists of COCs for the PGDP, need to be careful about including radium and radon. These are not expected to be in environmental media due to plant operations because of the "block" at ^{234}U. However, it would not be appropriate to drop these without reason. Therefore, need to include in initial list of COCs.

When developing lists of COCs, start with residential no action values. To refine the list, use site-specific no action values (e.g., those for industrial or recreational use).

Because moving from default exposure rates is difficult to justify, the no action values will serve as *de minimus* levels.

For groundwater clean-up goals, use both the MCLs and 1×10^{-6} RBCs (residential use). These values are also the ones that we will start with when back-calculations are done to produce values for soil.

Background concentrations can be used to refine the list of COCs and can be used as an alternative set of clean-up goals. However, a comparison of risk-based goals or ARAR-based goals and background is appropriate.

When calculating clean-up goals, only degradation of radionuclides should be considered. Degradation of chemicals is not to be considered at present because information is insufficient. Note, it is appropriate to qualitatively consider the geochemistry of the environment when developing clean-up goals. The maintenance of the current geochemistry at a site should be considered once clean-up goals are determined because a change in geochemistry may make COCs less or more mobile.

It is appropriate to calculate dose-based clean-up goals in addition to risk-based values. When these are calculated, RESRAD is to be used. Note that back-calculating from risk-based goals is not sufficient and that 15 mrem is the target dose.

When calculating groundwater protection clean-up goals, need to consider the following points of exposure:
- at the unit
- at the fence line
- at the property boundary
- at Little Bayou Creek

When calculating clean-up goals for excavation actions, need to include direct contact clean-up goals based on 1×10^{-4} and 3. These clean-up goals are appropriate if contaminated soils are to be left in place and are under a maintained cover equivalent to one foot of clean soil.

If a direct contact cleanup goal based upon 1×10^{-4} or 3 are exceeded, then additional excavation may be appropriate depending upon the depth of contamination. The decision for additional excavation is a site-specific design criterion that requires further discussion.

Topic #2: BHHRA Methods Document Production:

Due to time constraints (primarily cleanup goal calculation issues), the Methods Document production is behind schedule. It will not be sent for RAWG review on8/28 as planned. Additionally, the 9/7 & 8 review meeting will be changed into a planning meeting. A revised schedule for Methods Document production is not available at this time.

Topic #3: Review of Routes of Exposure to Consider in PGDP Risk Assessments:

The routes listed in the current version of the document adequately cover those that can reasonably expected to be important at the PGDP. No change is required.

Topic #4: Review of Baseline Risk Assessment Methods for Investigations – Issues from Comments:

This discussion was directed by reference to the table entitled "Issues from Past Comments." This table, with resolutions added, is presented on the following pages.

Action Items:

1. John Morgan to provide a new PGDP remedial action figure consistent with Core Team approach for presentation in the revised Methods Document. (OPEN on 8/30/00 – carryover from 8/1/00 Notes)
2. Rich Bonczek to set time and place of next meeting. (OPEN on 8/30/00 – however, tentatively scheduled for 9/6/00 at SAIC offices in Oak Ridge, TN)

Human Health Risk Assessment Working Group Issues
Paducah Gaseous Diffusion Plant
(Status as of 8/28/2000 is in *italics*)

1) Risk-based clean-up goal development
    a) General approach (*Pretty much complete?*)
    b) North/South Diversion Ditch (*Ongoing*)
2) Soil screening levels for protection of groundwater
    a) Radionuclides (*Complete*)
    b) Chemicals (*Complete*)
3) Methods document revisions
    a) General outline of document (*Complete*)
    b) Screening methods/tables (*Complete*)
    c) Baseline risk assessment methods for investigations
        i) Derivation of off-site COPC concentrations/modeling (*Complete*)
        ii) Conceptual site models/Routes of exposure (*Complete*)
        iii) RAGS Part D reporting (*Complete*)
        iv) Other issues (To be compiled from comment packages on risk assessments completed since the completion of the original methods document) (*Ongoing*)
    d) Risk assessment methods for decision documents – focus on impact of new stream-lined approach
        i) Clean-up goals and residual risk calculations (*Ongoing*)
        ii) Risk management in feasibility study reports (*Not addressed to date*)
        iii) Reporting in Proposed Plans (*Not addressed to date*)
        iv) Reporting in RODs (*Not addressed to date*)
        v) Reporting in 5-year reviews (*Not addressed to date*)

Notes from RAWG

August 30, 2001 2:30 to 4:45 pm
Teleconference

Members in Attendance:

Name	Organization	Phone	E-mail Address
Human Health			
Rich Bonczek (Chair)	SAIC	(865) 481-4679	Richard.R.Bonczek@saic.com
Gary Bodenstein	DOE	(270) 441-6831	bodensteingw@oro.doe.gov
John Morgan	BJ LLC	(270) 441-5069	morganjw@bechteljacobs.org
Steve Hampson	KY RCB	(502) 564-8390	SKHamp1@pop.uky.edu
John Volpe	KY RCB	(502) 564-7818 x3692	John.Volpe@mail.state.ky.us
John Purdy	KY DES	(502) 564-6120	John.Purdy@mail.state.ky.us
Larry Taylor	KY DES	(502) 564-6120	larryc.taylor@mail.state.ky.us
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Jon Richards	EPA	(404) 562-8648	richards.jon@epa.gov
Ecological			
Tom Burns (Chair)	SAIC	(865)481-8772	burnst@saic.com
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Jim Lane	KDFWR	(502)564-7109 x366	jim.lane@mail.state.ky.us
Al Westerman	KDEP	(502)564-6120	albert.westerman@mail.state.ky.us

Members Absent:

Name	Organization	Phone	E-mail Address
Human Health			
Alan Grant	KY DES	(502) 564-6120	alan.grant@mail.state.ky.us
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Ecological			
Alan Grant	KDEP	(502)564-6120	alan.grant@mail.state.ky.us
Jon Maybriar	KDEP/DWM	(502)564-6716	jon.maybriar@mail.state.ky.us
Lynn Wellman	USEPA Region 4	(404)562-8647	wellman.lynn@epa.gov

Others in Attendance:

Name	Organization	Phone	Organization
Marissa Steketee	PPC	Don Dunning	DOE
Cheryl Niebrou	Parallax	Harvey Rice	DOE
Lee Nix	Parallax	Gary Benfield	Parrallax
Lila ??	US FWS		
Tony Hatton	KDEP		

Notes and Agreements:

Topic #1: Status of Methods Document:

Comment Response Package for comments received on the D1 Human Health and Ecological Risk Methods Documents was sent by DOE to respective regulatory agency management. Letter was dated August 23rd.

DOE is awaiting letters approving responses before beginning document revision. Regulatory agencies agreed to provide letters by September 15th. DOE agreed to provide revised documents by October 30th if September 15th date for letters is achieved.

Topic #2: Development of Recommendations to Core Team on U-Landfill Performance Evaluation/Risk Evaluation:

Scope of Work Review and Revision:

Title of document was agreed to. This title is *Risk and Performance Evaluation of C-746-C Landfill*.

Purpose and scope were reviewed and agreed to.

Schedule was discussed and agreed to. Changes were made to meeting and briefing schedule. The revised schedule to be recommended to the Core Team is as follows:

RAWG Preliminary Planning Meeting: August 30, 2001
RAWG Preliminary Planning Meeting: Week of September 10, 2001
Core Team Scoping: September 19, 2001
Preliminary Results Briefing for Core Team: mid-November 2001
Preliminary Results Briefing for CAB: mid-November 2001
D0 Report Delivery (courtesy copies to regulatory agencies): December 17, 2001
D0 Review Period Ends: December 30, 2001
Draft Final Results Briefing for Core Team: mid-February 2002
D1 Report Delivery: February 13, 2002
D1 Review Period Ends: March 14, 2002
D2 Report Delivery: April 15, 2002
D2 Approval Date: May 1, 2002

EPA noted that more than 1 day may be needed for Core Team scoping. The RAWG agreed that the Core Team will need to be flexible concerning scoping meetings.

In addition, the RAWG agreed to recommend that the Core Team forms a Project Team for this project and that this Project Team hold weekly meetings.

The RAWG also agreed to recommend that the proposed Fact Sheets for this project follow the same development and delivery schedule as the report.

Assumptions and Modifying Factors were reviewed and revised. Agreements and changes were as follows:

The RAWG agreed that the regulatory agencies should receive courtesy copies of the D0 report for their review. Therefore, the numbers of hard- and electronic-copy D0 reports required under the SOW were increased 15 to 20 and 10 to 15, respectively.

The RAWG agreed that the report could follow the outline used in Appendix E of the CERCLA Disposal Options RI/FS. However, the RAWG did make some minor modifications to the outline and recommended that the SOW be modified so that it recognized that the Core Team may modify this outline during project scoping. The modified outline is attached.

The RAWG agreed that, for chemicals, the methods in Appendix E of the CERCLA Disposal Options RI/FS would be appropriate with the additions of the examination of both contaminant release and transport under the short-term and quantitation of all scenarios. However, the RAWG agreed that utilizing the most sensitive receptor was appropriate for developing the initial list of what the RAWG agreed to call CERCLA Risk-based Disposal Criteria.

The RAWG tentatively agreed that, for radionuclides, the methods in DOE Order 5400.5 should be followed. Therefore, the text regarding the assessment of radionuclides was modified. DOE is to send a copy of this Order to Tony Hatton, Al Westerman, John Purdy, Larry Taylor, and Jeff Crane. (Action completed on August 30, 2001.)

The RAWG tentatively agreed that the reference to the Oak Ridge “EMWMF RI/FS” should be deleted from the SOW.

The RAWG agreed that both “as built” as well as design criteria should be reflected in transport modeling. (See below for additional discussion of this topic.)

The RAWG agreed that the report should contain appendices more closely examining the NSDD and Scrap Yard waste streams. The RAWG agreed that text should be added to the SOW recognizing that the Core Team may ask for the production of additional appendices examining other waste streams.

The RAWG agreed that the waste inventory developed for CERCLA Disposal Options RI/FS should be used for the main body of the U-Landfill RE/PE report. DOE noted that the report may need to consider additional chemicals because that waste inventory does not consider contaminants that may be present in non-CERCLA waste.

The RAWG agreed that it would be appropriate to examine both partial release and catastrophic release scenarios.

The RAWG discussed and tentatively agreed that solid wastes currently in the landfill would not be included in this evaluation. However, the RAWG also agreed that the design of current cells must be used in modeling if CERCLA waste is to be placed in any of those cells.

Next Meeting – Because the RAWG did not complete the agenda, all agreed that a second meeting should be scheduled for the week of September 10. A summary table containing recommendations to the Core Team is to be provided to the RAWG for review prior to this meeting.

Action Items:

1) DOE (Rich Bonczek) to produce meeting summary including modified SOW and proposed report outline and distribute to RAWG. (Completed on September 4, 2001.)

2) DOE (Rich Bonczek) to send electronic copies of DOE Order 5400.5 to Tony Hatton, Al Westerman, Larry Taylor, John Purdy, and Jeff Crane. (Completed on August 30, 2001.)

3) EPA (Jeff Crane) and KY (Tony Hatton) to provide letters approving Methods Documents comment response summaries by September 15, 2001. (Action open.)

4) DOE to produce and release revised Methods Documents by October 30, 2001. This date is dependent upon receiving letters approving the comment response summaries by September 15, 2001. (Action open.)

5) DOE (Rich Bonczek) to produce and provide to the RAWG a summary table containing recommendations to the Core Team prior to the next meeting. (Action open.)

Notes from HHRAWG Meeting #4

September 6, 2000; 10:00 am to 5:30 pm
SAIC Offices, Oak Ridge, Tennessee

Members in Attendance:

Name	Organization	Phone	E-mail Address
Rich Bonczek (Chair)	SAIC	(865) 481-4679	Richard.R.Bonczek@saic.com
Alan Grant	KY DES	(502) 564-6120	alan.grant@mail.state.ky.us
Steve Hampson	KY RCB	(502) 564-8390	SKHamp1@pop.uky.edu
John Morgan	BJ LLC	(270) 441-5069	morganjw@bechteljacobs.org
Larry Taylor	KY DES	(502) 564-6120	larryc.taylor@mail.state.ky.us
Al Westerman	KY DES	(502) 564-6120	Albert.Westerman@mail.state.ky.us
Glen Adams	EPA	(404) 562-8667	adams.glenn@epa.gov
Jon Richards	EPA	(404) 562-8648	richards.jon@epa.gov

Members Absent:

Name	Organization	Phone	E-mail Address
Gary Bodenstein	DOE	(270) 441-6831	bodensteingw@oro.doe.gov
Jeff Crane	EPA	(404) 562-8546	crane.jeff@epa.gov
John Purdy	KY DES	(502) 564-6120	John.Purdy@mail.state.ky.us
Tuss Taylor	KY DWM	(502) 564-6716	tuss.taylor@mail.state.ky.us
John Volpe	KY RCB	(502) 564-7818 x3692	John.Volpe@mail.state.ky.us

Notes and Agreements:

Topic #1: Correction to Minutes from August 21, 2000 Meeting (RAWG #3):

Effect of cover upon direct contact cleanup goal use:

- Change 1 foot of clean cover to 2 feet of clean cover to cut exposure route.
- Need to consider use of concept of hypothetical direct contact with Principal Threat Source Material.
  - This can be alternatively defined as (1) material presenting a direct contact risk or hazard greater than or equal to 1×10^{-3} or 10, respectively (EPA) or (2) material presenting a direct contact risk or hazard greater than or equal to 1×10^{-4} or 10, respectively (KY DES). Note that a cumulative risk calculation should be used.
  - Glenn Adams is to provide RAWG members the guidance document describing the use of the concept of Principle Threat Source Material.
  - The use of the concept of Principal Threat Source Material is an issue that needs to be considered by the Core Team.

Revised schedule for Methods Document production:

- Draft was due for review on 8/28/2000. This date was missed due to need for RAWG to consider other issues. Primary among these issues was the calculation of North-South Diversion Ditch cleanup goals.
- New schedule is as follows:
  - Draft due for RAWG review – 9/29/2000 (electronic delivery)
  - Online comment resolution meeting at SAIC in Oak Ridge – 10/23 & 24/2000
  - Release of draft final for formal regulatory agency review – 11/20/2000
- Schedule for ecological risk methods document also needs to be updated.
- The Core Team will be advised of this change on 9/12/2000.

Use of the concept of the Exposure Unit:
All group members agreed that this concept needs to be used both during characterization of a site and verification of cleanup, but the actual method implementation is difficult to express. Agreements include:

- The exposure unit that is applicable to characterization of a site may differ from that which is applicable to verification of cleanup at the same site.

- For characterization: (1) The maximum exposure unit to be used for fields is 100’ by 100’. A smaller exposure unit may be appropriate at some sites, and the need for sampling to determine extent of contamination must be included. (2) The exposure unit applicable to characterization is a site-specific decision. Density of sampling should be justified using site-specific information.
- For verification: In general this is a site-specific design decision; however, for radionuclides, the group agree that MARSSIM will need to be used to verify radionuclide cleanup. Therefore, the group also agreed that a similar approach may be useful for chemicals. The MARSSIM-like approach for chemicals will need to be demonstrated before a final decision can be made. (Apply to North-South Diversion Ditch?)

Topic #2: Issues from Core Team North-South Diversion Ditch phone call of August 30, 2000:

The excavation worker and screening:
The group agreed that values based on the industrial worker and not the excavation worker should be used for all screening and for identification of Principal Threat Source material.

Cleanup goals based upon dose calculations:
All parties agreed that the RESRAD computer program will be used to perform the dose calculations. The calculations will need to be iterative and occur in three steps.

- Step 1 – Calculate cleanup goals for each radionuclide on the PGDP plant-wide list ignoring cumulative contributions.
- Step 2 – Calculate cleanup goals for all radionuclides on the PGDP plant-wide list considering cumulative contributions.
- Step 3 – Calculate cleanup goals for site-specific radionuclides. Site-specific radionuclides to be determined by sampling.

The plant-wide radionuclide list is composed of ^{238}U, ^{235}U, ^{234}U, ^{99}Tc, ^{137}Cs, $^{239/240}$Pu, ^{241}Am, ^{237}Np, and ^{230} Th. Need to check Rocky Flats document to refine as needed.

Topic #3: Review of Baseline Risk Assessment Methods for Investigations – Issues from Comments:

This discussion was directed by reference to the table entitled “Issues from Past Comments.” This table, with resolutions added, is presented on the following pages.

Action Items:

1. John Morgan to provide a new PGDP remedial action figure consistent with Core Team approach for presentation in the revised Methods Document. (OPEN on 9/7/00 – carryover from 8/1/00 Notes)
2. Glenn Adams to provide RAWG with copies (electronically) of Principal Treat Source document. (OPEN on 9/7/00)
3. Rich Bonczek to contact Tom Burns to develop schedule for ecological risk methods document. (Completed on 9/7/00) (The ecological risk methods document will be released under the same schedule as the human health methods document except the online review meeting will occur at a time and place to be determined.)
4. Rich Bonczek to set-up next meeting of the RAWG. (OPEN on 9/7/00)
5. Rich Bonczek to send updated regulatory value list to group members. (Completed on 9/7/00)
6. Glenn Adams to check the dioxin TEFs that are on the web to ensure that the correct values are posted. (OPEN on 9/7/00)

Human Health Risk Assessment Working Group Issues
Paducah Gaseous Diffusion Plant
(Status as of 9/7/2000 is in *italics*)

1) Risk-based clean-up goal development
    a) General approach (C*omplete*)
    b) North/South Diversion Ditch (*Ongoing*)
2) Soil screening levels for protection of groundwater
    a) Radionuclides (*Complete*)
    b) Chemicals (*Complete*)
3) Methods document revisions
    a) General outline of document (*Complete*)
    b) Screening methods/tables (*Complete*)
    c) Baseline risk assessment methods for investigations
        i) Derivation of off-site COPC concentrations/modeling (*Complete*)
        ii) Conceptual site models/Routes of exposure (*Complete*)
        iii) RAGS Part D reporting (*Complete*)
        iv) Other issues (To be compiled from comment packages on risk assessments completed since the completion of the original methods document) (*Ongoing*)
    d) Risk assessment methods for decision documents – focus on impact of new stream-lined approach
        i) Clean-up goals and residual risk calculations (*Complete*)
        ii) Risk management in feasibility study reports (*Ongoing*)
        iii) Reporting in Proposed Plans (*Ongoing*)
        iv) Reporting in RODs (*Ongoing*)
        v) Reporting in 5-year reviews (*Not addressed to date*)

Notes from HHRAWG Meeting #5

September 19, 2000; 12:00 noon to 4:00 pm
Teleconference

Members in Attendance:

Name	Organization	Phone	E-mail Address
Rich Bonczek (Chair)	SAIC	(865) 481-4679	Richard.R.Bonczek@saic.com
Alan Grant	KY DES	(502) 564-6120	alan.grant@mail.state.ky.us
Steve Hampson	KY RCB	(502) 564-8390	SKHamp1@pop.uky.edu
Larry Taylor	KY DES	(502) 564-6120	larryc.taylor@mail.state.ky.us
Al Westerman	KY DES	(502) 564-6120	Albert.Westerman@mail.state.ky.us
Glen Adams	EPA	(404) 562-8667	adams.glenn@epa.gov
Jon Richards	EPA	(404) 562-8648	richards.jon@epa.gov

Members Absent:

Name	Organization	Phone	E-mail Address
Gary Bodenstein	DOE	(270) 441-6831	bodensteingw@oro.doe.gov
Jeff Crane	EPA	(404) 562-8546	crane.jeff@epa.gov
John Morgan	BJ LLC	(270) 441-5069	morganjw@bechteljacobs.org
John Purdy	KY DES	(502) 564-6120	John.Purdy@mail.state.ky.us
Tuss Taylor	KY DWM	(502) 564-6716	tuss.taylor@mail.state.ky.us
John Volpe	KY RCB	(502) 564-7818 x3692	John.Volpe@mail.state.ky.us

Notes and Agreements:

Topic #1: Additions and Correction to Minutes from September 6, 2000 Meeting (RAWG #4):

Principal Threat Source Material (PTSM):

- This needs to be the first screening step. If have PTSM, then further screening is not needed to determine action.
- Rules for declaration of PTSM:
  - If contaminant concentration exceeds action level (target risk = 1×10^{-4}), then perform additional analysis to determine if cumulative risk is greater than 1×10^{-3}. If so, then declare presence of PTSM.
  - If contaminant concentration exceeds the action level (target hazard = 3), then perform additional analysis to determine if cumulative hazard is greater than 10. If so, then declare presence of PTSM.
- Methods for additional analysis:
  - For on-site areas use the industrial no action levels (i.e., target risk = 1×10^{-6} and target hazard = 0.1) when calculating cumulative risk.
  - For off-site areas use the residential no action levels (i.e., target risk = 1×10^{-6} and target hazard = 0.1) when calculating cumulative risk.

TEFs on website:

- These values were checked. The correct values are in the guidance document found on the EPA Region 4 website.

Topic #2: Issues from Past Comments:

Several additions and changes were made to previous resolutions. These changes are presented in red font on the attached table. After reviewing the past resolutions, the remaining issues were addressed. The resolutions for these issues are also presented in the attached table.

Topic #3: Risk Evaluations in Decision Documents:

The discussion of this issue was very brief due to time restrictions. The main resolution was to follow the reporting outlines contained in the EPA guidance document entitled *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Documents* (EPA/540-R-98-031).

An additional point was how to focus the risk summary in the FS towards the "primary COCs." It was suggested and agreed that this discussion should be in the FS only if the discussion is not in the baseline risk assessment. The method to be followed was not detailed, but all agreed that the discussion should focus upon the uncertainties identified in the risk assessment. To facilitate the discussion of the development of the method to be followed, Glenn Adams is going to send a SRS protocol for group consideration. A proposal developed by Rich Bonczek will appear in the Methods Document. The group will modify this method during document review.

Topic #4: Important Dates:

September 29, 2000 – Revised Risk Methods Document sent for RAWG review.
October 23 and 24, 2000 – RAWG on-line review of revised Methods Document.
November 20, 2000 – Revised Methods Document sent for regulatory review.

Action Items:

1. John Morgan to provide a new PGDP remedial action figure consistent with Core Team approach for presentation in the revised Methods Document. (OPEN on 9/26/00 – carryover from 8/1/00 Notes)
2. Glenn Adams to send SRS COC protocol to group members (closed on 9/26/00 – copy attached.)

Human Health Risk Assessment Working Group Issues
Paducah Gaseous Diffusion Plant
(Status as of 9/20/2000 is in *italics*)

1) Risk-based clean-up goal development
    a) General approach (C*omplete*)
    b) North/South Diversion Ditch (*Complete*)
2) Soil screening levels for protection of groundwater
    a) Radionuclides (*Complete*)
    b) Chemicals (*Complete*)
3) Methods document revisions
    a) General outline of document (*Complete*)
    b) Screening methods/tables (*Complete*)
    c) Baseline risk assessment methods for investigations
        i) Derivation of off-site COPC concentrations/modeling (*Complete*)
        ii) Conceptual site models/Routes of exposure (*Complete*)
        iii) RAGS Part D reporting (*Complete*)
        iv) Other issues (To be compiled from comment packages on risk assessments completed since the completion of the original methods document) (*Complete*)
    d) Risk assessment methods for decision documents – focus on impact of new stream-lined approach
        i) Clean-up goals and residual risk calculations (*Complete*)
        ii) Risk management in feasibility study reports (*Complete*)
        iii) Reporting in Proposed Plans (*Complete*)
        iv) Reporting in RODs (*Complete*)
        v) Reporting in 5-year reviews (*To be taken from DOE Guidance*)

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PADUCAH RISK ASSESSMENT WORKING GROUP
MEETING MINUTES
2007 MEETINGS

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Update of the Risk Methods Documents
Volume I Human Health Risk Assessment

Background-

The PGDP Risk Methods Documents (RMD) Volume I (Human Health) was last revised in December 2001. Since that time, the National Academy of Sciences and governmental organizations identified a number of significant recommendations to improve the human health and ecological risk assessment processes. Additionally, the regulatory agencies's and DOE's comments on risk assessments and risk evaluations completed since 2001 are not reflected in the RMD. This fact sheet summarizes the status and presents an overview of some proposed revisions to the Human Health RMD; however, the actual changes made to the Human Health RMD will be based on the outcomes of meetings of the Risk Assessment Working Group (RAWG)[1]. The goals for the proposed revision are:

- Simplify information presented in the Human Health RMD,
- Integrate guidance from all agencies to streamline forthcoming risk assessments and risk evaluations, and
- Develop a web-based document that is easily accessible and linked to supporting information.

Status

Federal agencies, states and scientific organizations have strengthened the risk assessment process in the past several years, and improvement efforts are ongoing. The risk assessment community has begun to embrace new methodologies, such as predicting the body's reaction to a contaminant and conducting a graded approach to uncertainty analysis. Listed below are examples of recommendations from these groups.

- Improve the quantity and quality of the data upon which risk assessments are based, and identify additional data needs on the potential adverse effects from exposure to contaminants
- Fully assess the health risk from exposures, it is recommended that when a risk assessment relies on default options/parameters that the associated documentation more clearly indicate that it relies on default options/parameters, how they are/were chosen, and the sensitivity of the assessment to changes in these default options/parameters
- Improve the accuracy of risk assessments through the use of better evaluation methods and models and incorporation of newer, more powerful tools, when appropriate
- Address the inevitable uncertainties associated with gaps in scientific knowledge and general unknowns about model and data accuracy - explicitly specify the methods by which sources of uncertainty are analyzed and characterized and, when possible, discuss the uncertainties both descriptively (qualitatively) and numerically (quantitatively)
- Analyze variability in levels of exposures to contaminants, as well as differences in individual reactions to exposure - analysis of effects should occur when possible exposure to a mixture of contaminants through a variety of exposure routes is indicated (e.g., dermal contact with skin and breathing air)

The proposed schedule for completing both the human health and ecological documents will be discussed at the June 13, 2007 meeting. The discussion will include future meeting times, document review cycles, and comment resolution and incorporation.

Overview of Potential Revisions

The following is a list of some items proposed for revision in the RMD.

- Update toxicity values
- Update chemical-specific values for significant COPCs
- Incorporate *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*
- Modify risk equations/parameters, as needed
- Update action and no action levels

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[1] The Risk Assessment Working Group (RAWG) was formed in May 2000. Participants at that time included representatives from the Commonwealth of Kentucky, U.S. Environmental Protection Agency, the U.S. Department of Energy, U.S. Fish and Wildlife Service, and contractor support.

- Incorporate *Risk Assessment Guidance for Superfund Volume 3 Part A: Process for Conducting Probabilistic Risk Assessment,* and *The Role of Screening-Level Risk Assessments*
- Incorporate EPA Guidance for Data Quality Assessment (DQA)
- Include recommendations in Framework for Metals Risk Assessment, EPA 2007
- Update background values for soil and groundwater, as appropriate and include state's background values reported in Kentucky's Voluntary Environmental Remediation Program guidance materials
- Include methods for use of the Paducah Data Warehouse
- Update significant COPCs list
- Include new appendices on probabilistic parameters
- Update modeling matrix to clarify use of probabilistic modeling
- Revise list of regulatory limits (e.g., lead)
- Expand on methods for feasibility studies, proposed remedial action plans, and records of decision to limit presentations for those documents and better recognize EPA's PRAP/ROD guidance
- Include recommendations in Child-Specific Exposure Factors Handbook, September 2006 External Review Draft EPA/600/R/06/096A

Path Forward
The following are some activities expected to be completed in the next few weeks. After the second meeting of the RAWG, the revisions to the human health RMD should be finalized, and preparation of the revised draft RMD will begin.

- Conduct June 13, 2007meeting [schedule follow-up meeting(s)]
    a. Agree on critical elements of the document revision
    b. Capture innovative concepts and potential issues
- Complete scoping meeting(s)
    a. Assimilate outcomes of discussions
    b. Prepare a document outline
    c. Document critical changes
- Prepare a description of the web based RMD, risk calculator, and associated content
- Distribute materials to the RAWG for review prior to scoping meeting(s)

Note that similar meetings leading to revision of PGDP Risk Methods Documents (RMD) Volume II (Ecological) are also planned. The revision of the Ecological RMD is currently planned to begin in mid summer 2007.

Agenda for Meeting #1
Update of the Risk Methods Documents
Volume I Human Health

PPPO Offices; Lexington, KY
June 13, 2007
8:00 – 12:00 EST

8:00 – 8:15	**Introductions**
8:15 – 8:45	**Purpose and Scope of the Risk Assessment Working Group**
8:45 – 10:00	**Discussion of Potential Changes to the Human Health Risk Methods Document**
10:00 – 10:15	**Break**
10:15 – 11:00	**Revisions to the Modeling Matrix**
11:00- 11:30	**Guidance for FS, PRAP, RODs**
11:30 – 12:00	**Path Forward/Revision Schedule/Next Meeting**

Risk Method Document Update Kickoff Meeting
June 13, 2007
DOE PPPO Offices, Lexington, Kentucky
Meeting Minutes

Attendees:

By Phone:

Jon Richards	EPA	richards.jon@epamail.epa.gov	
Myrna Redfield	PRS	mxn@prs-llc.net	270-441-5113
David Thorne	Portage	dthorne@portageenv.com	

In Lexington:

Tracey Brindley	PRS	tb1@prs-llc.net	270-441-5167
Rich Bonczek	DOE	Rich.Bonczek@lex.doe.gov	859-219-4051
Nick Stanisich	Portage	nstanisich@portageenv.com	406-683-2836
Dave Dollins	DOE	dave.dollins@lex.doe.gov	270-441-6819
Steve Golian	DOE-HQ	steven.golian@em.doe.gov	301-903-7791
John Morgan	PRS	j31@prs-llc.net	270-441-5069
Ed Winter	KDEP	Edward.winner@ky.gov	502-564-2061
David Williams	EPA	Williams.david@epa.gov	404-562-8554
Tim Frederick	EPA	Frederick.tim@epa.gov	404-562-8598
John Volpe	CHFS	john.volpe@bellsouth.net	502-330-0222
Steve Hampson	UK	steve.hampson@ky.gov	859-533-0633

Future Meetings:

June 26 (Lexington 12:30 – 4:30) ***- changed to June 27 after the meeting***
July 20 (Lexington 11:00 – 3:00)
August 15 (Paducah 9:00 – 4:00)

Introduction:

Rich Bonczek provide an introduction of the purpose of this meeting. He briefed the group on the history of the previous Risk Methods document development (Human Health and Ecological Volumes). The contents of the previous document were reviewed and the participants in the last development were noted.

Additional focus for this document is to standardize modeling inputs.

A discussion about the previous document approved (or lack of formal approval) was held. David Williams had heard that EPA had never approved the document. Rich Bonczek spoke about emails that were received from KDEP and EPA; however, noted that no formal transmittal of approvals via letters ever occurred.

One goal expressed by the team is that this updated document reach consensus and have a formal approval process.

A discussion was held to determine if this scope is a re-do of the entire document or just update sections and information as necessary. The team decided this is an update. The document does need to setup no action numbers and needs a basis for the screening values. The document should describe how to use the screening numbers for all pathways.

The Risk Assessment methods should be updated. A section on sample methodology should be included. There was concern about being too prescriptive and as long as the approach is outlined for sampling strategies and DQO development, this should be useful. DQP processes are not always followed. The team should look at EPA's process and look at Handford's or other DOE sites processes.

The framework for sample planning and data evaluation should be included. The document should consider the usefulness of additional methods, such as probabilistic risk assessment (PRA). KDEP raised a concern that probabilistic risk assessment is hard to follow and people are not comfortable with it due to lack of reproducibility. The public is not as familiar with the process. PRA should be used sparingly. It may make sense if it is limited in use and is explained very well.

One major goal of the updated Risk Methods document is to reduce uncertainty and it must be digestible by the public.

DQO should be discussed and how it should be implemented at Paducah. The previous document gives you limited choices. Primary problem is always lack of data.

The document must include input parameters for modeling for all modeling found in the matrix.

What types of things should be taken out of the document?

The document should be updated more often and on-line and easily updated (perhaps quarterly but must include an administrative approval process). May want to collect changes and update prior to starting any new risk assessments.

The document should not be a "how to" for risk management.

Do not re-do background values, leave provisional if necessary.

The document should not have a discussion on schedule or budget for projects.

Do we need to include a site-wide conceptual model (sources of contamination, methods of transport, receiving populations). EPA preferred to have this as a stand-along document. Perhaps an appendix be included that is updated. This might be done during the BGOU first. Land use maps may be included for future use conceptual model.

The Risk Assessment Working Group (RAWG) will be re-instituted for this update process. Member identified are:

Rich Bonczek	DOE
Ed Winner	KDEP, EPPC
Tim Frederick	EPA
David Williams	EPA
John Volpe	CHFS
Nick Stanisich	PRS

Nick Stanisich briefed the team on the prepared PowerPoint presentation.

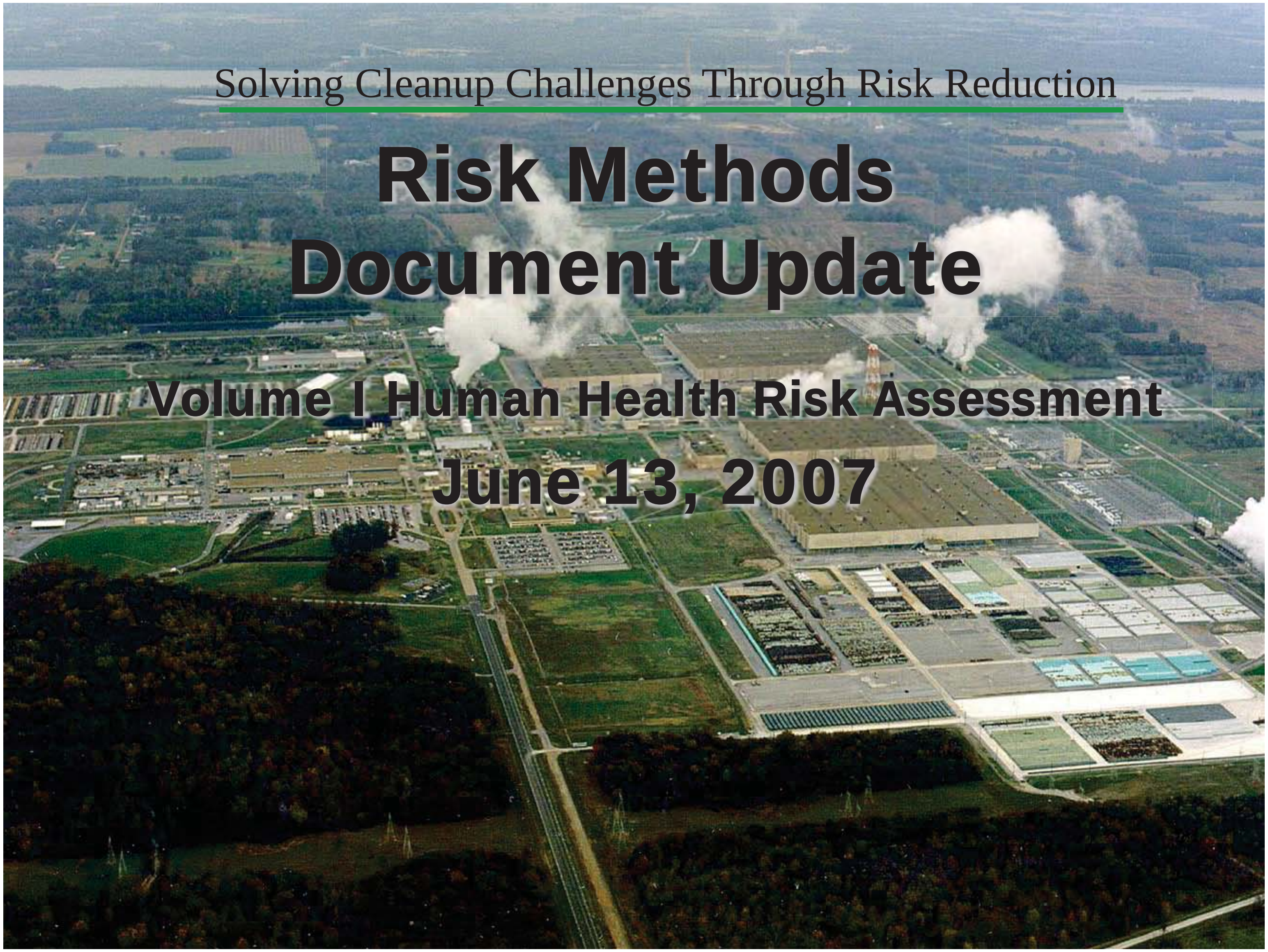
Comments during presentation:
Vapor intrusion needs to be added to the list
DOE does not want to develop toxicity values for PGDP

Action Item – Team needs to discuss dose document guidance. Volpe and Stanisich to prepare list

Action Item – Ed Winner will send out VERP information to the team.

Action Item – Stanisich will develop a draft team charter for review.

Action Item – Rich Bonczek will send the DQA guidance to Steve Golian.



Solving Cleanup Challenges Through Risk Reduction

Risk Methods Document Update

Volume I Human Health Risk Assessment

June 13, 2007

Planning

- Dialogue, information exchange planned to create important resource document
- Break-out sessions on specific issues may be necessary

Why Update Risk Methods Documents?

- Federal agencies, states and scientific organizations have strengthened risk assessment process in the past decade
- Ongoing improvements
- New methodologies, e.g.:
  - To predict body's reaction to contaminant exposure
  - Conduct graded approach to uncertainty analysis

Risk Assessment Working Group

- Originally formed in May 2000
- Developed initial set of No Action and Action Levels
- Composed of personnel from:
  - Commonwealth of Kentucky
  - EPA
  - DOE
  - U.S. Fish and Wildlife
  - Contractor Support

Summary of Recommendations
(government agencies, states, independent organizations)

- Improve data quantity and quality
- Identify additional data needs on the potential adverse effects from exposure to contaminants
- Risk assessments should more clearly indicate when default options are used and how those are chosen
  - Lack of data to fully assess health risk from exposures
  - Common for assessment to use defaults
- Improve assessment accuracy
  - Better evaluation methods
  - Better models
  - Use newer, more powerful tools when appropriate.
- Address uncertainties associated with gaps in scientific knowledge and unknowns about model and data accuracy
  - Specify methods by which these sources of uncertainty are analyzed and characterized
  - When possible, discuss uncertainties both qualitatively and quantitatively
- Variability in levels of exposures to contaminants should be analyzed

Overview of Potential Revisions

- Update toxicity values
- Incorporate *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*
- Modify risk equations/parameters, as appropriate; update related action and no action levels
- Incorporate *Risk Assessment Guidance for Superfund Volume 3 Part A: Process for Conducting Probabilistic Risk Assessment*, and *The Role of Screening-Level Risk Assessments*
- Update usability discussion to incorporate EPA Guidance for Data Quality Assessment (DQA)
- Include conclusions in framework for Metals Risk Assessment, EPA 2007

Additional Revisions to be Considered

- Include PGDP End State Vision report as a reference
- Update chemical-specific values for significant COPCs
- Update background values for soil and groundwater, as appropriate
- Include background values from Kentucky's Voluntary Environmental Remediation Program (VERP) guidance materials
- Update regulatory values for significant COPCs (i.e. MCLs)
- Include methods for use of the Paducah Data Warehouse
- Update No Action and Action Screening Values
- Update significant COPCs and chemical-specific values
- Include new appendices on probabilistic parameters to use for transport modeling and risk calculations
- Update modeling matrix to clarify use of probabilistic modeling
- Revise lead regulatory limits
- Modify document, as appropriate, in response to meetings with regulatory agencies
- Expand methods for feasibility studies, proposed remedial action plans, and records of decision to limit presentations for those documents and better recognize EPA’s PRAP/ROD guidance

Toxicity Value Hierarchy
Update Toxicity Values

- Tier 1- EPA's IRIS
- Tier 2- EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs)
- Tier 3- Other Toxicity Values
  - California Environmental Protection Agency (Cal EPA) toxicity values are peer reviewed and address both cancer and non-cancer effects
  - The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure
  - HEAST toxicity values are Tier 3 values (NOTE: Neither IRIS or the PPRTV database contains radionuclide slope factors)

Information From
Supplemental Guidance, Dermal Risk Assessment

Supplemental Guidance for Dermal Risk Assessment
(Summary of Part E of RAGs)

- For the dermal-water pathway, only those chemicals which contribute to more than 10% of the dose from the oral (drinking water) pathway should be considered
- Limited availability of dermal absorption values for dermal-soil pathway is expected to result in a limited number of inorganic contaminants being considered in a quantitative risk assessment
- Since the Kp (permeability constant) parameter has been identified as one of the major parameters contributing to uncertainty in dermal exposures to contaminants in water, it is important that risk assessments be consistent when estimating this parameter
- The suggested default soil adherence factor (AF) for RME adult residential activities is 0.07 mg/cm^2. The suggested default AF value for a RME child resident is 0.2 mg/cm^2. The suggested default AF value for a commercial/ industrial adult worker is 0.2 mg/cm^2.

Dermal Exposure Values

Suggested Dermal Exposure Values for Central Tendency and RME Residential and Industrial Scenarios – Soil Contact Part E Guidance

Exposure Parameters		**Central Tendency**		**RME Scenario**	
		Residential	**Industrial**	**Residential**	**Industrial**
Concentration- C_{soil} (mg/kg)		site-specific values			
Event frequency (events/day)		1	1	1	1
Exposure frequency (days/yr)		site-specific	219	350	250
Exposure duration (yr)		9	9	30	25
Skin surface area (cm^2)	Adult	5,700	3,300	5,700	3,300
	Child	2,800	NA	2,800	NA
Soil adherence factor (mg/cm^2)	Adult	0.01	0.02	0.07	0.2
	Child	0.04	NA	0.2	NA
Dermal absorption fraction		chemical-specific values			

- Recreational and excavation worker scenarios would be site-specific

Absorption Fraction from Soil
Part E Guidance

RECOMMENDED DERMAL ABSORPTION FRACTION FROM SOIL

Compound	Dermal Absorption Fraction (ABS_d)[1]	Reference
Arsenic	0.03	Wester, et al. (1993a)
Cadmium	0.001	Wester, et al. (1992a) U.S. EPA (1992a)
Chlordane	0.04	Wester, et al. (1992b)
2,4-Dichlorophenoxyacetic acid	0.05	Wester, et al. (1996)
DDT	0.03	Wester, et al. (1990)
TCDD and other dioxins -if soil organic content is >10%	0.03 0.001	U.S. EPA (1992a)
Lindane	0.04	Duff and Kissel (1996)
Benzo(a)pyrene and other PAHs	0.13	Wester, et al. (1990)
Aroclors 1254/1242 and other PCBs	0.14	Wester, et al.(1993b)
Pentachlorophenol	0.25	Wester, et al. (1993c)
Semivolatile organic compounds	0.1	—

The values presented are experimental mean values.

Dermal Absorption Factors
(suggested changes)

- Guidance provides default dermal absorption fraction for semivolatile organic compounds (SVOCs) of 10% as a screening method for the majority of SVOCs without dermal absorption fractions
- No default dermal absorption values for volatile organic compounds
  - Rationale: In the considered soil exposure scenarios, volatile organic compounds would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in the combined exposure pathway analysis
- No default dermal absorption values presented for inorganic classes of compounds
  - For inorganics, compound speciation is critical to dermal absorption
  - Too little data to extrapolate a reasonable default value.

Dermal Exposure Summary
(discussion points)

- Guidance does not recommend exposure parameters for contact with contaminated sediment
  - Due to the high degree of variability in sediment adherence and duration of sediment contact with the skin. However, information included in the guidance would allow a risk assessor to assess sediment exposure on a site-specific basis.
- Guidance does not specifically address dermal toxicity, either acute or chronic
  - Dermal dose derived with the methodology provides an estimate of the contribution of the dermal pathway to the systemic dose
  - Exclusion of dermal toxicity should be considered an uncertainty.
- Current studies suggest dermal exposure may be expected to contribute no more than 10% to the total body burden of those chemicals present in the vapor phase
  - Therefore, guidance does not include a method for assessing dermal absorption of chemicals in the vapor phase, with the assumption that inhalation will be the major exposure route for vapors
- Methodology described in the guidance does not cover the exposure associated with dermal contact with contaminated surfaces

Dermal Exposure Summary (discussion points)

- Dermal risk guidance uses a mathematical model to predict absorption and risk from exposures to water
  - Contaminants with sufficient data to predict dermal absorption with acceptable confidence are said to be within the model's effective predictive domain (EPD)
  - Greater uncertainty for contaminants outside the EPD
  - This uncertainty means the model should not be used to quantify risk to contaminants in water outside the EPD; data to be treated as an uncertainty in the risk assessment.
- Derivation of dermal slope factors is recommended for a few chemicals, all of which are metals and include antimony and chromium

Revision of Action or No Action Levels

- Action and no action levels will be updated for environmental media
- Soil screening guidance equations will be used in the calculations
- Example parameters to be reviewed
  - PEF for inhalation pathway
  - Review site specific exposure frequency default parameters
  - Dermal pathway ABS, AF, EF and SA defaults in the RMD

Probabilistic Risk Assessment

- Rigorous analysis (PRA) is used only when risk mangers require additional information to make a decision
- PRA can be an important set of statistical tools for analyzing uncertainty and variability is risk assessments if adequate supporting data is available.
- Risk assessors, should carefully consider whether the toxicity value is representative of the population of concern.

Recommendations for a Tiered Approach to PRA

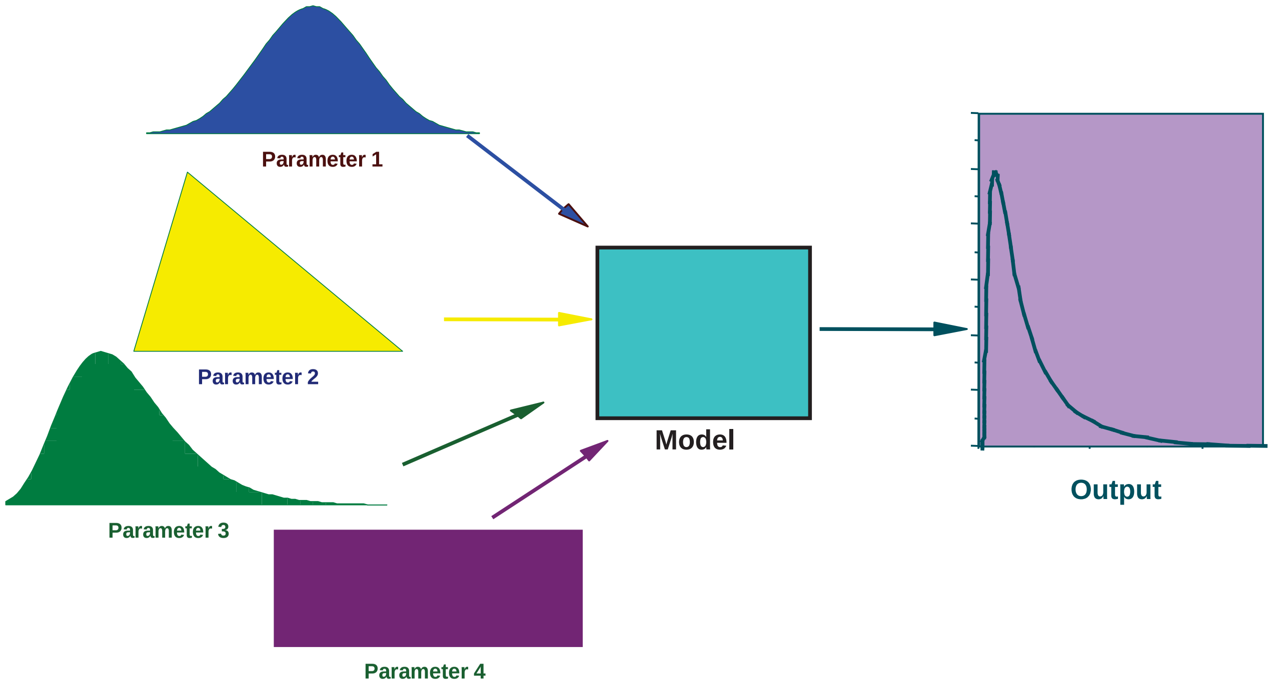
- In human health risk assessments, the toxicity term is expressed as a point estimate.
- The EPA guidance recommends using a tiered approach when considering PRA to help with risk management decisions.
- A tiered approach provides balance between the benefits of conducting a complex analysis, and the time, resources, and challenges for risk communication. PRA may require additional resources compared with the point estimate approach and may not be warranted if it is unlikely to provide information that will affect the risk management decision.
- Point estimate risk assessment should be conducted as a first step after completing the remedial investigation (RI) planning, site scoping, problem formulation, data collection, and the development of a site conceptual model
- Sensitivity analysis should be conducted in analysis to guide decisions regarding data collection and the analysis needed to characterize variability and/or uncertainty in risk.
- In PRA, a recommended starting point for risk management decisions regarding the RME is the 95th percentile of the risk distribution
- Variability and uncertainty need to be considered

Monte Carlo Analysis (A Common PRA Approach)

- Goal is to characterize, quantitatively, the uncertainty and variability in estimates of exposure or risk
- Monte Carlo risk modeling encompasses a range of techniques to mathematically describe the impact of risk and uncertainty on a problem
- Each uncertain or variable parameter within the model is represented by a probability distribution
- The shape and size of these distributions defines the range of values that the parameters may take and their relative probabilities

Monte Carlo Methods

- Values are chosen at random from each distribution to run the model, resulting in a distribution of the outputs



Update Methods for Data Quality Assessment

- DQA is built on a fundamental premise: data *quality* is meaningful only when it relates to the *intended use* of the data

- By using DQA, a reviewer can answer four important questions:
  - Can a decision (or estimate) be made with the desired level of certainty, given the quality of the data?
  - How well did the sampling design perform?
  - If the same sampling design strategy is used again for a similar study, would the data be expected to support the same intended use with the desired level of certainty?
  - Is it likely that sufficient samples were taken to enable the reviewer to see an effect if it was really present?

Basics of DQA
(a recommended approach)

- **Review the project's objectives and sampling design**
  - Review objectives to assure they are still applicable
  - Review sampling design and data collection documentation for consistency with the project objectives observing any potential discrepancies
- ***Conduct a preliminary data review***
  - Review QA reports (when possible) for the validation of data, calculate basic statistics, and generate plots of the data
  - Use this information to learn about the structure of the data and identify patterns, relationships, or potential anomalies
- ***Select the statistical method***
  - Select appropriate procedures for summarizing and analyzing data, based on the review of the performance and acceptance criteria associated with the projects objectives
  - Identify key underlying assumptions associated with the statistical test
- ***Verify the assumptions of the statistical method***
  - Evaluate whether underlying assumptions hold, or whether departures are acceptable, given the actual data and other information about the study
- ***Draw conclusions from the data***
  - Perform the calculations pertinent to the statistical test
  - Document conclusions to be drawn as a result of these calculations

Recommendations for Revisions to Calculation of the End Point Concentration

- The H statistic should not be prescriptive
- Data should be reviewed and plotted to determine distribution
- Statistical analysis of the concentration distribution should be performed for better understanding of the data
- PRO-UCL should be used only after a statisticians review of the data as described in the previous sides

Discussion of Incorporation of “Framework Metals in Risk Assessment”

- Rural Resident scenarios for example, apply bio transfer factors (BTF) for organic and inorganic compounds for food pathways. These factors have been developed for organic substances that do not apply to metals.
- The BTFs do not distinguish between metal elements, metal compounds, or particulate size
- Environmental chemistry is a primary factor influencing metal speciation and subsequent transport, uptake, and toxicity

June 2007 Updates

- Mercuric Sulfide GIABS updated to 0.07 based on **RAGS Part E** Exhibit 4-1. Also the oral RfD has been modified to 0.0003 mg/kg-day to reflect the intent of, SRC SF 01-016a/09-25-02 "Risk Assessment Issue Paper for: Evaluation of the Provisional RfD for Mercuric Sulfide (CASRN 1344-48-5), that states the IRIS value for mercuric chloride should be protective of mercuric sulfide. Footnotes and references have been updated.

May 2006 Updates

- The toxicity values for chloral and chloral hydrate were reported to be combined on the RAIS and they have been separated. A footnote was added to p-Chlorobenzoic acid giving screening RfDs.

April 2006 Updates

- Oral reference doses were added for 4-Amino-2,6-Dinitrotoluene and 2-Amino-4,6-Dinitrotoluene. The toxicity values were taken from the EPA Region 9 PRG table as listed under the contaminant Aminodinitrotoluene with a reference of NCEA.

February 2006 Updates

- A new IRIS report for Phosgene CAS 75-44-5 has been released. A new chronic inhalation RfC has been released.

January 2006 Updates

- A new IRIS report for n-Hexane CAS 110-54-3 has been released. A new chronic inhalation RfC has been released. Toxicity metadata have been updated.
- The RAIS has adopted the California EPA slope factors for **Tetrachloroethylene**. The oral paper can be found **here** and the inhalation paper can be found **here**.

September 2005 Updates

- A new IRIS report for Toluene CAS 108-88-3 has been released. A new chronic oral RfD and inhalation RfC have been released.
- Oral toxicity values were added for Ethyl chloride from NCEA as reported in the US EPA Region 9 PRG table.
- Slope Factor values were added for Methyl tertbutyl ether (MTBE) from California EPA as reported in the US EPA Region 9 PRG table.
- An oral chronic RfD was added for 4-Nitrophenol from NCEA as reported in the US EPA Region 6 PRG table.

July 2005 Updates

- An Oral RfD was added for Barium from IRIS.

June 2005 Updates

- An Oral RfD was added for Iron from the EPA Regional tables.

March 2005 Updates

- A new IRIS oral reference dose of 7E-04 was released for Perchlorate and Perchlorate Salts (CAS 7790-98-9). The salts include Ammonium perchlorate (CAS 7790-98-9), Lithium perchlorate (CAS 7791-03-9), Potassium perchlorate (CAS 7778-74-7) and Sodium perchlorate (CAS 7601-89-0).

October 2004 Updates

- The RAIS has updated the subchronic oral RfD for arsenic. The previous value (5.0E-03) was withdrawn. The new value of 3.0E-04 comes from HEAST which has taken the chronic value from IRIS.

September 2004 Updates

- The RAIS ABS values have been updated for those analytes found in "Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final July 2004" **Exhibit 3-4**.

August 2004 Updates

- The toxicity summary for Boron and Compounds has been revised, and a Toxicological Review for **Boron and Compounds** has been added to the IRIS Web site. The following toxicity values are to be used for Boron and Compounds:

- The Chronic Oral Reference Dose is now 2.0E-01 (mg/kg-day) and associated metadata have been updated.
- The Dermal Reference Dose of 1.8E-01 (mg/kg-day) was calculated from the oral RfD.

July 2004 Updates

The toxicity summary for 1,2-Dibromoethane has been revised, and a Toxicological Review for **1,2-Dibromoethane** has been added to the IRIS Web site. The following toxicity values are to be used for 1,2-Dibromoethane:

- The new Chronic Inhalation Reference Concentration (RfC) of 9.0E-03 (mg/m^3) has been added. The associated toxicity metadata have also been updated.
- The Chronic Inhalation Reference Dose of 2.57E-03 (mg/kg-day) was calculated from the RfC.
- The Chronic Oral Reference Dose is now 9.0E-03 (mg/kg-day) and associated metadata have been updated.
- The Dermal Reference Dose of 7.2E-03 (mg/kg-day) was calculated from the oral RfD.
- The Oral Slope Factor is now 2.00E+00 (mg/kg-day)$^{-1}$ and associated metadata has been added.
- The Dermal Slope Factor is now 2.50E+00 (mg/kg-day)$^{-1}$ and was calculated from the oral slope factor.
- The Oral Unit Risk is now 6.00E-02 (mg/L)$^{-1}$ and associated metadata has been added.
- The Inhalation Unit risk is now 6.0E-01 (mg/m^3)$^{-1}$ associated metadata has been added.
- The Inhalation Slope Factor is now 2.10E-01 (mg/kg-day)$^{-1}$ and was calculated from the

inhalation unit risk.

December 2003 Updates

The Oral Subchronic Reference Dose for Chromium III was changed from 1.0E+00 to 1.5E+00 mg/kg-d . According to HEAST, the chronic value was adopted as the subchronic value. The chronic value is listed on IRIS as 1.5E+00 mg/kg-d. The previous subchronic oral RfD of 1.0E+00 was an artifact of the original HEAST database. The associated dermal subchronic value is also updated.

September 2003 Updates

- The toxicity summary for Methyl ethyl ketone (MEK) has been revised, and a Toxicological Review for **MEK** has been added to the IRIS Web site. The following toxicity values are to be used for MEK:
  - The Chronic Inhalation Reference Concentration (RfC) is now 5.00E+00 mg/m^3) based on the critical effect of developmental toxicity (skeletal variations).
  - The associated toxicity metadata have also been updated.
  - The Chronic Inhalation Reference Dose is now 1.43E+00 (mg/kg-day).
- The toxicity summary for Cyclohexane has been revised, and a new Toxicological Review for **Cyclohexane** has been added to the IRIS Web site. The following toxicity values are to be used for Cyclohexane:
  - The Chronic Inhalation Reference Concentration is now 6.00E+00 (mg/m^3) based on the critical effect of reduced pup weights in the F1 and F2 generations.
  - The Chronic Inhalation Reference Dose of 1.71E+00 (mg/kg-day) was calculated from the RfC.
  - The associated toxicity metadata have also been updated.
- The toxicity summary for Dichloroacetic acid has been revised, and a Toxicological Review for **Dichloroacetic acid** has been added to the IRIS Web site. The following toxicity values are to be used for Dichloroacetic acid:
  - The Chronic Oral Reference Dose (RfD) is now 4.00E-03 mg/kg-day) based on the critical effect of lesions observed in the testes, cerebrum, cerebellum, and liver.
  - The associated toxicity metadata have also been updated.
  - The Dermal Reference Dose is now 2.00E-03 (mg/kg-day).
  - The drinking water unit risk of 1.4E-03 (mg/L)$^{-1}$was added based on hepatoadenoma and hepatocarcinoma in mice.
  - The oral slope factor of 5.00E-02 (mg/kg-day)$^{-1}$was added based on hepatoadenoma and hepatocarcinoma in mice.
  - The associated toxicity metadata have also been updated.
  - The Dermal Slope Factor is now 1.00E-01 (mg/kg-day)$^{-1}$.

August 2003 Updates

- The toxicity summary for Acetone has been revised, and a new Toxicological Review for **Acetone** has been added to the IRIS Web site. The following toxicity values are to be used for Acetone:
  - The Chronic Oral Reference Dose is now 9.0E-01 (mg/kg-day) based on the critical effect of nephropathy.
  - The Dermal Reference Dose is now 7.47E-01 (mg/kg-day).
  - The associated toxicity metadata have also been updated.
- The toxicity summary for Hydrogen sulfide has been revised, and a Toxicological Review for **Hydrogen sulfide** has been added to the IRIS Web site. The following toxicity values

are to be used for Hydrogen sulfide:

  - The Chronic Inhalation Reference Concentration (RfC) is now 2.0E-03 (mg/m^3) based on the critical effect of nasal lesions of the olfactory mucosa.
  - The Chronic Oral Reference Dose of 3.0E-03 (mg/kg-day) was withdrawn. This value remains on the RAIS and has been footnoted. When a new value is available from IRIS, it will replace the withdrawn value.

July 2003 Updates

- The Ethylbenzene cancer toxicity values have been withdrawn by NCEA. This chemical is now being reassessed for IRIS which automatically flags further use of any provisional cancer or non-cancer assessments. However, the RAIS has retained these values and added appropriate footnotes.
- Toxicity values have been added for Copper. HEAST presents a drinking water standard of 1.3 mg/L for Copper. The RAIS has converted this value into a chronic and subchronic RfD for oral and dermal exposure. The following toxicity values are to be used for Copper:
  - The Chronic Oral Reference Dose (RfD) of 4.00E-02 (mg/kg-day) was added.
  - The Subchronic Oral Reference Dose (RfD) of 4.00E-02 (mg/kg-day) was added.
  - The Chronic Dermal Reference Dose (RfD) of 1.20E-02 (mg/kg-day) was added.
  - The Subchronic Dermal Reference Dose (RfD) of 1.20E-02 (mg/kg-day) was added.

June 2003 Updates

- The toxicity summary for Acrolein has been revised, and a new Toxicological Review for **Acrolein** has been added to the IRIS Web site. The following toxicity values are to be used for Acrolein:
  - The Chronic Inhalation Reference Concentration (RfC) of 2.0E-05 (mg/m^3) has not changed but the associated toxicity metadata has been updated.
  - The Chronic Oral Reference Dose is now 5.0E-04 (mg/kg-day) based on critical effects of decreased survival.
  - The Dermal Reference Dose is now 4.0E-04 (mg/kg-day).
- The toxicity summary for Methyl isobutyl ketone (MIBK) has been revised, and a Toxicological Review for **MIBK** has been added to the IRIS Web site. The following toxicity values are to be used for MIBK:
  - The Chronic Inhalation Reference Concentration (RfC) of 3.0E+00 (mg/m^3) has been added. The associated toxicity metadata have also been added as follows: critical effects of reduced fetal body weight.
  - The Chronic Inhalation Reference Dose of 8.57E-01 (mg/kg-day) was calculated from the RfC.

May 2003 Updates

The toxicity summary for Trichloroethylene (TCE) has been revised. The following toxicity values are to be used for TCE:

- The Chronic Inhalation Reference Concentration (RfC) of 4.0E-02 (mg/m^3) has been added. The associated toxicity metadata have also been added as follows: critical effects in the central nervous system, liver, and endocrine system.
- The Chronic Inhalation Reference Dose of 1.14E-02 (mg/kg-day) was calculated from the RfC.
- The Chronic Oral Reference Dose is now 3.0E-04 (mg/kg-day) based on critical effects in

the liver, kidney, and developing fetus.

- The Dermal Reference Dose is now 4.5E-05 (mg/kg-day).
- The Oral Slope Factor is now 4.00E-01 $(mg/kg\text{-}day)^{-1}$. No metadata is presented in the report.
- The Inhalation Slope Factor is now 4.00E-01 $(mg/kg\text{-}day)^{-1}$. No metadata is presented in the report.
- The Dermal Slope Factor is now 2.67E+00 $(mg/kg\text{-}day)^{-1}$.

April 2003 Updates

- The toxicity summary for Benzene has been revised, and a new Toxicological Review for **Benzene** has been added to the IRIS Web site. The following changes have been made on the toxicity databases and toxicity profiles:

- The Chronic Inhalation Reference Concentration (RfC) of 3.0E-02 (mg/m^3) has been added. The associated toxicity metadata have also been added as follows: UF = 300; MF = 1; critical effect = decreased lymphocyte count; inhalation study confidence= medium; study reference = Rothman et. al., 1996; species = human; basis = BMCL.
- The Chronic Inhalation Reference Dose of 8.57E-03 (mg/kg-day) was calculated from the RfC.
- The Chronic Oral Reference Dose of 4.0E-03 (mg/kg-day) has been added. The associated toxicity metadata have also been added as follows: UF = 300; MF = 1; critical effect = decreased lymphocyte count; inhalation study confidence= medium; study reference = Rothman et. al., 1996; species = human; basis = BMCL.
- The Chronic Dermal Reference Dose of 3.88E-03 (mg/kg-day) was calculated from the Chronic Oral RfD.

March 2003 Updates

- The toxicity summary for Xylenes has been revised, and a new Toxicological Review for **Xylenes** has been added to the IRIS Web site. The following changes have been made on the toxicity database:
    - The Chronic Inhalation Reference Concentration (RfC) of 1.0E-01 (mg/m^3) has been added. The associated toxicity metadata have also been added as follows: UF = 300; MF = 1; critical effect = impaired motor coordination (decreased rotarod performance); inhalation study confidence= medium; study reference = Korsak et. al., 1994; species = male rats; basis = NOAEL (HEC).
    - The Chronic Inhalation Reference Dose of 2.86E-02 (mg/kg-day) was calculated from the RfC.
    - The Chronic Oral Reference Dose is now 2.0E-01 (mg/kg-day).
    - The Dermal Reference Dose is now 1.84E-01 (mg/kg-day).
- **Diesel engine exhaust** was added as a new Chemical on the IRIS website. The following additions have been made:
    - The Chronic Inhalation Reference Concentration (RfC) of 5.0E-03 (mg/m^3) was added. The associated toxicity metadata have also been updated as follows: UF = 30; MF = 1; critical effect = pulmonary inflammation and histopathology; inhalation study confidence = medium; study reference = Ishinishi 1988; species = rat; basis = NOAEL (HEC).
    - The Chronic Inhalation Reference Dose (RfD) of 1.43E-03 (mg/kg-day) was calculated from the RfC.

November 2002 Updates

- The summary for 1,3-Butadiene has been revised, and a new Toxicological Review for **1,3-Butadiene** has been added to the IRIS Web site. The following changes have been made on the toxicity database:
    - The Chronic Inhalation Reference Concentration (RfC) of 2E-03 (mg/m^3) has been added. The associated toxicity metadata have also been added as follows: UF = 1000; MF = 1; critical effect = ovarian atrophy; confidence = medium; study reference = NTP 1993; species = mouse; target organ = ovaries; basis = BMCL.
    - The Inhalation Unit Risk is now 3.0E-02 (mg/m^3)$^{-1}$. The associated toxicity metadata have also been added as follows: inhalation study reference = US EPA 2002 and Health Canada 1998; study species = human; target organ = lymphatic and hematopoietic tissue; tumor = leukemia.
    - The Inhalation slope factor is now 1.05E-01(mg/kg-day)$^{-1}$.
    - The EPA Cancer Classification was changed from B2, probable human carcinogen to "carcinogenic to humans by inhalation".
- The summary for Phenol has been revised, and a new Toxicological Review for **Phenol** has been added to the IRIS Web site. The following changes have been made on the toxicity database:
    - The Chronic Oral Reference Dose (RfD) of 6.0E-01 (mg/kg-day) was changed to 3.0E-01 (mg/kg-day). The associated toxicity metadata have also been updated as follows: UF = 300; MF = 1; critical effect = decreased maternal weight gain; confidence = medium/high; study reference = Argus Research Laboratories 1997; species = rat; target organ = none; basis = BMDL.
    - The Chronic Dermal Reference Dose (RfD) of 5.4E-01 (mg/kg-day) was changed to 2.7E-01 (mg/kg-day).
- The inhalation unit risk value for asbestos was changed on the RAIS to be 2.3E-04 (fiber/L)$^{-1}$. Also the inhalation slope factor was changed to 8.05E-07 (fiber/kg-day)$^{-1}$. These changes are a result of converting the IRIS units to RAIS standard units.

October 2002 Updates

- 1,1-Dichlorethylene toxicity values were updated based on a new IRIS toxicological release at http://www.epa.gov/IRIS/toxreviews/0039-tr.pdf. The non-cancer Reference Dose (RfD) was changed from 0.009 mg/kg-day to 0.05 mg/kg-day.

May 2002 Updates

There are new Inhalation Unit Risk (URi) values on the RAIS for 2,3,7,8-TCDD and associated chemicals based on adjustment with a Toxicity Equivalent Factor (TEF). This change was necessary to correct an error in the standard unit conversions from HEAST format to RAIS format. The standard units for inhalation unit risk in HEAST are (ug/m^3)$^{-1}$, however the HEAST URi for 2,3,7,8-TCDD was presented in the nonstandard units of (pg/m^3)$^{-1}$. Below are the new toxicity values for URi, presented in (mg/m^3)$^{-1}$ for the RAIS:

- 2,3,7,8-TCDD, TEF=1.0; new URi = 3.30E+04
- 2,3,7,8-PeCDD, TEF=0.5; new URi = 1.65E+04
- 2,3,7,8-HxCdd, TEF=0.1; new URi = 3.30E+03
- 2,3,7,8-HpCdd, TEF=0.01; new URi = 3.30E+02
- OCDD, TEF=0.001; new URi = 3.30E+01
- 2,3,7,8-TCDF, TEF=0.1; new URi = 3.30E+03

- 1,2,3,7,8-PeCDF, TEF=0.5; new URi = 1.65E+04
- 2,3,4,7,8-PeCDF, TEF=0.05; new URi = 1.65E+03
- 2,3,7,8-HxCDF, TEF=0.1; new URi = 3.30E+03
- 2,3,7,8-HpCDF, TEF=0.01; new URi = 3.30E+02
- OCDF, TEF=0.001. new URi = 3.30E+01

October 2001 Updates

The summary for Quinoline has been revised, and a new Toxicological Review for **Quinoline** has been added to the IRIS Web site. The following changes have been made on the toxicity database:

- The Oral Slope Factor is now 3.0 (mg/kg-day)$^{-1}$.
- The Dermal Slope Factor is now 6.0 (mg/kg-day)$^{-1}$.
- The Oral Unit Risk is now 9.0E-02 (mg/L)$^{-1}$.
- The EPA Cancer Classification is now B2, probable human carcinogen.

July 2001 Updates

- The summary for Chloromethane has been revised, and a new Toxicological Review for Chloromethane has been added to the IRIS Web site. The following changes have been made on the toxicity database:
    - Inhalation Chronic RfC = 9.0E-02 (mg/kg-day)
    - Inhalation Chronic RfD = 2.57E-02 (mg/kg-day)
    - EPA Weight of Evidence Class = D
- The summary for Hexachlorocyclopentadiene (HCCPD) has been revised, and a new Toxicological Review for Hexachlorocyclopentadiene (HCCPD) has been added to the IRIS Web site. The following changes have been made on the toxicity database:
    - Oral Chronic RfD = 6.0E-03 (mg/kg-day)
    - Dermal Chronic RfD = 3.0E-03 (mg/kg-day)
    - Inhalation Chronic RfC = 2.0E-04 (mg/kg-day)
    - Inhalation Chronic RfD = 5.7E-05 (mg/kg-day)
    - EPA Weight of Evidence Class = E

June 2001 Updates

Bromate (CAS 15541-45-4) has been added to IRIS. Therefore, the toxicity database has been updated with the following information:

- Oral Chronic RfD = 4.0E-03 (mg/kg-day)
- Dermal Chronic RfD = 8.0E-04 (mg/kg-day)
- Oral Slope Factor = 7.0E-01 (mg/kd-day)$^{-1}$
- Oral Unit Risk = 2.0E-02 (mg/L)$^{-1}$
- Dermal Slope Factor = 3.5E+00 (mg/kd-day)$^{-1}$
- GI Absorption Factor = 0.2
- Dermal Absorption Factor = 0.001
- EPA Cancer Class = B2

May 2001 Updates

- For 47 chemicals, the inhalation slope factor was changed from a HEAST value to a conversion from the IRIS unit risk value, which is more current. A footnote was also added to indicate this conversion. This change occurred for the following chemicals: Acrylamide; Acrylonitrile; Aldrin; Aramite; Azobenzene; Benzene; Beryllium; Bis(2-chloroethyl)ether; Bis(chloromethyl)ether; Bromoform; Butadiene, 1,3-; Carbon Tetrachloride; Chlordane; Chloroform; Chromium VI (chromic acid mists and particulates); Coke Oven Emissions; DDT; Dibromoethane, 1,2-; Dichloroethylene, 1,1-; Dichloropropene, 1,3-; Dieldrin; Diphenylhydrazine, 1,2-; Epichlorohydrin; Formaldehyde; Heptachlor; Heptachlor Epoxide; Hexachlorobenzene; Hexachlorobutadiene; Hexachlorocyclohexane, Alpha-; Hexachlorocyclohexane, Beta-; Hexachlorocyclohexane, Technical; Hexachloroethane; Hydrazine; Hydrazine Sulfate; Nickel Refinery Dust; Nickel Subsulfide; Nitrosodiethylamine, N-; Nitrosodimethylamine, N-; Nitroso-di-N-butylamine, N-; Nitrosopyrrolidine, N-; Propylene Oxide; Tetrachloroethane, 1,1,2,2-; Toxaphene; Trichloroethane, 1,1,2; Trichlorophenol, 2,4,6; and Vinyl Chloride.

February 2001 Updates

- Updated the Oral RfD for Uranium (Soluble Salts). The new value is 6.0E-4 mg/kg/day and the new Dermal RfD is 5.1E-4 mg/kg/day. Source: **Federal Register,** Thursday December 7, 2000. Part II, Environmental Protection Agency. 40 CFR Parts 9, 141, and 142 - National Primary Drinking Water Regulations; Radionuclides; Final Rule. p 76713.

January 2001 Updates

- There has been a new release of toxicity values for radionuclides as presented in **Federal Guidance Report No. 13**. Essentially, every slope factor has changed. In addition, oral values are tabulated separately for ingestion of tap water, dietary intakes (food), and incidental soil ingestion. Please consult the User's Guide section on radionuclide carcinogenicity for the derivation of radionuclide slope factors and guidance on their use. Also please note that the output of the **Preliminary Remediation Goal** and **Human Health Exposure Modeling** sections will reflect these changes in toxicity values.

October 2000 Updates

- Chloral toxicity has been updated on IRIS. The chemical name is now "Chloral Hydrate" and the new Oral Chronic RfD is 1E-1.
- Chlorine Dioxide toxicity has been updated on IRIS. The new Oral Chronic RfD is 3E-2.
- Chlorite (Sodium Salt) toxicity has been updated on IRIS. The new Oral Chronic RfD is 3E-2.

August 2000 Updates

- The IRIS summary for Vinyl Chloride has been revised, and a new Toxicological Review for Vinyl Chloride has been added to the IRIS Web site. The following changes to Vinyl Chloride have been made on the RAIS:
  - The oral RfD is now 3E-3 mg/kg/day.
  - The dermal RfD has been added to reflect the addition of the oral RfD.
  - The inhalation RfC is now 1E-1 mg/m^3.
  - The inhalation RfD had been added to reflect the addition of the inhalation RfC.
  - The oral slope factor has been changed to 1.4 (mg/kg/day)$^{-1}$.
  - The dermal slope factor has been changed to reflect the change in the oral slope factor.
  - The oral unit risk has been changed to 4.2E-2 (mg/L)$^{-1}$.

    - The inhalation unit risk has been changed to 8.8E-3 $(mg/m^3)^{-1}$.
    - The inhalation slope factor has been changed to reflect the change in the inhalation unit risk.

June 2000 Updates

- The IRIS summary for 1,3-Dichloropropene has been revised, and a new Toxicological Review for 1,3-Dichloropropene has been added to the IRIS Web site. The following changes to 1,3-Dichloropropene have been made on the RAIS:
    - The oral RfD has been changed to 3E-2 mg/kg/day.
    - The dermal RfD has been changed to reflect the change in the oral RfD.
    - The oral slope factor has been changed to 1E-1 $(mg/kg/day)^{-1}$.
    - The dermal slope factor has been changed to reflect the change in the oral slope factor.
    - The oral unit risk has been changed to 3E-3 $(mg/L)^{-1}$.
    - The inhalation unit risk has been changed to 4E-3 $(mg/m^3)^{-1}$.
    - The inhalation slope factor has been changed to reflect the change in the inhalation unit risk.

April 2000 Updates

- The following chemicals have been added to the RAIS with **provisional** toxicity values - CAS numbers are in parentheses:
    - Dibenzofuran (000132-64-9)
    - Dichlorobenzophenone, 4,4'- (000090-98-2)
    - Methyl Mercaptan (000074-93-1)
    - Thiocyanate (000463-56-9)
    - Trimethylbenzene, 1,2,4- (000095-63-6)
    - Trimethylbenzene, 1,3,5- (000108-67-8)
- The following chemicals have new **provisional** toxicity values:
    - Antimony
        - Subchronic RfC=4E-4
        - Subchronic RfD=2E-4
    - Cadmium
        - Subchronic RfC=9E-4
    - Carbon Tetrachloride
        - Subchronic RfC=2E-2
    - Chlorine
        - Chronic RfC=2E-4
    - Dimethyl Hydrazine, 1,1-
        - Inhalation UR=4.9E0
        - Oral SF=3E0
    - Ethylbenzene
        - Inhalation UR=1.1E-3
        - Subchronic RfC=1E0
        - Subchronic RfD=1.1E-1
    - Hexachlorobenzene
        - Subchronic RfD=1E-4
    - Methyl Hydrazine
        - Inhalation UR=4.9E0
        - Oral SF=3E0
    - Toluene

        - Subchronic RfC=9.23E-1
    - Trichloroethane, 1,1,1-
        - Chronic RfC=2.2E0
        - Subchronic RfC=2.2E+1

February 2000 Updates

- The IRIS summary for benzene has been revised with a new oral carcinogenicity assessment. The oral unit risk is now 1.6E-3 $(mg/L)^{-1}$ and the oral slope factor is now 5.5E-2 $(mg/kg/day)^{-1}$.
- Footnote "h" of **Toxicity Footnotes** has been revised to read "Value expressed as fibers/L".
- The following chemicals have been assigned CAS numbers:
    - Polybrominated Biphenyls -- 059536-65-1
    - Benzene, Ethylmethyl -- 025550-14-5
    - Benzene, Methylpropenyl -- 000768-00-3
- The inhalation slope factor for Diethylstilbesterol was withdrawn from HEAST and is now referenced with a 'w'. The withdrawn date is July 1997.
- The oral reference dose for Methyl Methacrylate is now referenced as coming from IRIS.

Last updated on Monday, June 25th, 2007
URL: http://rais.ornl.gov/homepage/whatnew.shtml

Meeting notes for the PGDP Risk Assessment Working Group

June 27, 2007

- The toxicity value hierarchy was agreed to by the participants.

Toxicity values:

1. IRIS
2. EPA PPRTVs
3. Tier 3 sources;
   CalEPA
   ATSDR
   HEAST (for radionuclides)

- The participants agreed that that the risk screening concentrations as established by the no action limits would be the primary screening tool. The no action limits would use the latest toxicity information and the latest physical and chemical parameters. The concentrations would be compared against the 2002 Region 9 PRGs to ensure consistency with the Commonwealth of Kentucky code. A complete version (URL link provided) of the 2002 PRGs has been supplied by Commonwealth of Kentucky personnel.
- It was agreed that the existing risk methods documents would be the standard to be used unless the RAWG agreed on changes.
- Exposure parameters for tables D-1 to D-14 were reviewed by the participants. A 24 yr exposure duration for an adult was agreed to. The body weight of a child was changed to 15 kg. The inhalation rate of 0.833 m^3/hour was discussed but unchanged. The fraction volatilized in Table D-3 was changed to 0.5 (unit less) based on State guidance.
- The Beef ingestion rate on Table D-10 was to be checked for consistency with other values.
- Physical constants for chemicals should match the RAIS database. A secondary source of such values would be the Region 9 physical chemical factors table.
- Current methods for calculation of risk and hazard, of all contaminants will be performed as per the existing methods document. Calculation of contaminants below background should not be listed separately or in an appendix.
- The RAWG did reach consensus that ProUCL could be included as one of the tools for analyzing data, and that the maximum detected value would continue to be considered as the EPC if the recommended UCL exceeded the maximum detected concentration,
- Ed Winner verified via e-mail that 24 years could be used instead of 34 for the rural resident exposure duration.

Meeting Notes from 7/20/07 RAWG meeting On Revision of the Risk Methods Document

Summary of Discussions/Agreements

Dioxins: the TEFs used for dioxins and furans will be updated to the 2005 WHO TEFs. For the summing of results for toxicity comparison in a sample in which one dioxin/furan is detected, one half of the detection limit will continue to be used as the value to represent each non-detected dioxin/furan.

PAHs/PCBs: Currently these are summed for comparison to the class toxicity value by summing only the detected concentrations. There will be additional discussion next meeting on the handling of non-detects for summing PAHs and PCBs, after EPA and Kentucky DEP representatives check for any additional guidance from their agencies. The next meeting will consider how guidance on specific classes (PAHs and PCBs) as well as guidance on data issues such as frequency of detection can be used to establish a revised method for assessing these high toxicity compounds.

TCE: The RAWG discussed the available oral cancer slope factors for TCE. The values considered were the range in the EPA draft TCE reassessment (0.02 to 0.4 mg/kg/d-1), the value recommended by Kentucky DEP based on their review (0.32 mg/kg/d-1), and the withdrawn value (0.011 mg/kg/d-1). Two screening values are proposed for inclusion in the screening document: the 0.32 value for Kentucky, which is near the upper end of the range recommended in the EPA reassessment, and the withdrawn value of 0.011 mg/kg/d-1. The EPA representative suggested using the Cal EPA inhalation slope factor, but no decision was made on the value for this exposure route. The discussion concluded with the KDEP value of 0.32 mg/kg/d-1 being considered for the inhalation slope factor as well.

Modeling methodology: There was a brief discussion of the role of probabilistic modeling. Kentucky DEP believes probabilistic modeling was useful for addressing uncertainties in the risk assessment, but may not be appropriate for the risk assessment itself because of the difficulty in presenting these probabilistic risk assessments to the public. Kentucky DEP indicated a desire to limit the application of probabilistic risk assessment with concurrence/scoping by the Agencies required prior to conducting probabilistic risk assessments at PGDP. Kentucky DEP prefers use of Crystal Ball over SAS in the modeling because of the cost of appropriating the software to verify the calculations. Overall, Kentucky DEP prefers that the risk methods document include a limited suite of models that will be used, so that their staff can be familiar with the uses and limitations of the models they will see used in the risk assessments from the facility. The model for intake of contaminants through ingestion of biota was discussed. It was agreed that the current model should be compared to uptake equations presented on the RAIS website to see if biota modeling equations have been updated from the version in the appendix of the current risk method document. The biota model should also be reviewed to address criteria for collecting biota tissue concentrations in lieu of using the equations used in the model. For vapor modeling, the Johnson and Ettinger model will be moved up so that it is used in Tier I of the modeling. There will be a separate workshop for the modeling group and David Thorne to finalize the technical approach to the modeling on August 7th.

Model for VOC inhalation from water: The RAWG reviewed the differences between the EPA model (Andelman volatilization factor) and the current Kentucky DEP model (Schaum). Both models are widely used and accepted. It was decided to determine the inhalation dose over a day from the two methods at a couple of groundwater concentrations to compare the methods at the next meeting. The Kentucky DEP representative will confer with their representative to verify if the model as presented in KRAGS is what's currently used by their agency.

UCL calculation: The RAWG discussed how to calculate UCLs for exposure point concentrations for risk assessments. The consensus was to continue the 3 tiered approach: sites with 5 or fewer samples will use the maximum detected concentration and sites with 10 or more samples will use an appropriate UCL calculated using EPA's ProUCL 4.0. Sites with 6-9 samples will be handled using an approach to assess whether the dataset is adequate for UCL calculation. The approach for 6-9 samples will be discussed at the next meeting.

Approach to Comparison to Background: There was a discussion of how to conduct the comparison to background to eliminate analytes at concentrations for the presentation of quantitative risks in the main body of future risk assessments. Rather, a proposal was made to screen analytes / compounds below background out of the initial presentation of risks, including them in the uncertainty section of the document. Currently, they are presented in reverse. EPA concurred with this proposal. Kentucky DEP will review with their risk assessment group to determine if this will satisfy their requirements and will resolve at the next meeting. The comparison options for background discussed were: 1) to compare mean and maximum values as described in KRAGS section 2.1.5 or 2) to compare the site and background datasets using a two sample t test (such as the one on ProUCL).

Action Items

1. Send PTSM guidance to Tim Frederick (Rich Bonczek)
2. Provide recommendation for how to treat data at sites with 6-9 samples (Jill Lundell)
3. Review handout "Summary of Statistical Approach for Paducah Data" (All)
4. Send copy of Schaum model paper to Kirby (Ed Winner)
5. Determine if the Schaum model as presented in KRAGs is the current approach used by Kentucky DEP risk assessors (Ed Winner)
6. Check for new agency guidance on including non-detects in PAH and PCB calculations (Tim Frederick and Ed Winner)
7. Revise chart of COPCs to COCs from recent docs to consider for addition to significant COPC list (Gary McManus)

8. Revise modeling recommendation for August 7th meeting (Dave Thorne)
9. Send Kentucky review of TCE to Tim Frederick (Kirby Olson)
10. Review equations on RAIS to see if food uptake models have changed (Kirby Olson)
11. Estimate TCE inhalation dose from EPA and Kentucky RAGS methods to determine effect of showering input in Kentucky DEP method (Kirby Olson, Ed Winner)
12. Develop list of parameters that should be considered for revision and proposed new values to distribute prior to meeting (Kirby Olson)
13. Review background comparison / background risk presentation and determine if current proposal to present background risks as uncertainty is acceptable (Ed Winner)
14. Deliver updated recommendations as write-up well in advance of next meeting so all participants have sufficient time to review (PRS).

<u>Draft Agenda for next meeting</u>

- Discuss Background Screening proposal, Kentucky DEP approval / reservations
- Discuss EPA data screening criteria (e.g. frequency of detection, etc.) and how the revised document can incorporate these criteria for evaluation of high toxicity compounds (Dioxins, PAHs, PCBs).
- Discuss Data Quality / Data Evaluation (carry over from previous meeting)
- Discuss recommendation for data use for sites with 6-9 samples.
- Identify approach/model for inhalation exposure to VOCs in water
- Review of proposed versus existing values for those parameters which may be revised
  - Direct exposure parameters
  - Food ingestion parameters

Risk Methods Document Update
Proposed Paducah Models
And Methodology

David Thorne

E_M Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

Modeling at PGDP Site

Introduction

- Model matrix will consider four end points:
  - Groundwater
  - Surface Water
  - Biota
  - Vapor

Modeling at PGDP Site

Groundwater Models

- Models range in complexity from relatively simplistic one-dimensional screening-level models to sophisticated three-dimensional numerical models.
- Approach includes
  - Deterministic Modeling
  - Probabilistic Modeling

Groundwater Modeling at PGDP Site

Current Groundwater Models

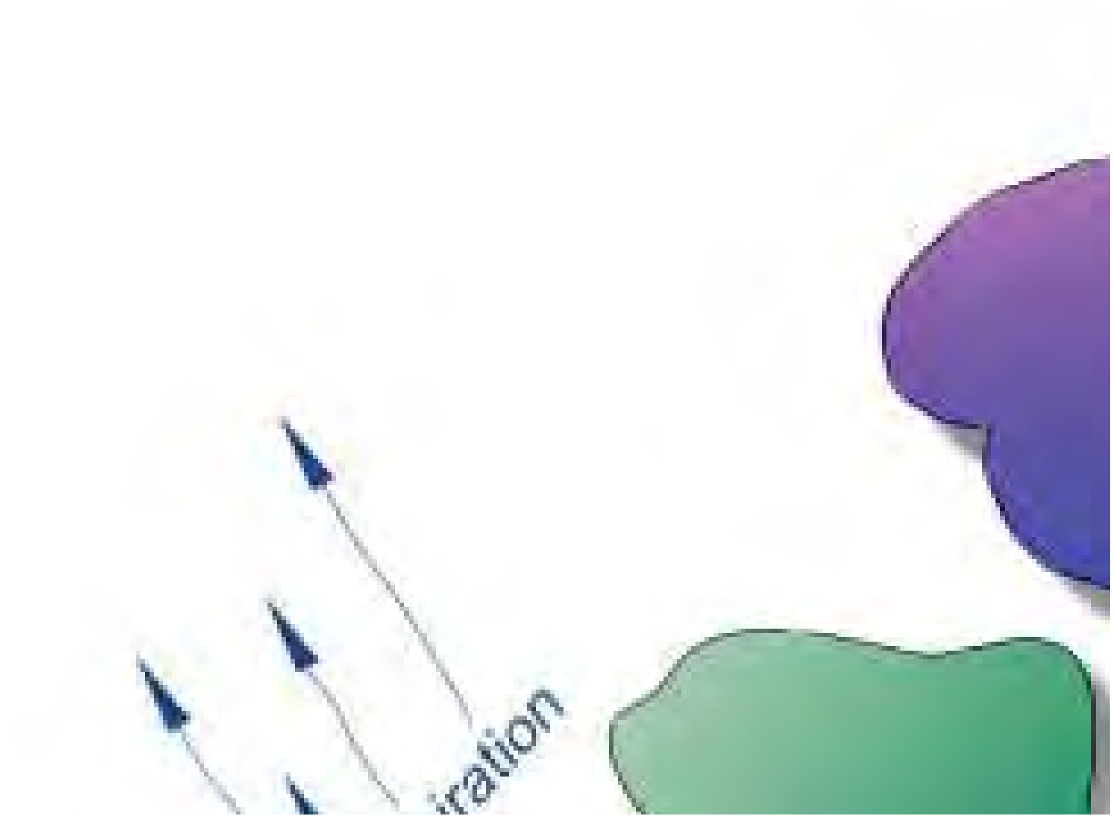
- Analytical Models
  - MEPAS: RI/FS, screening level
  - AT123D: RI/FS, screening level
  - SESOIL: RI/FS, screening level
  - DUST: Performance Assessment (PA), screening level
  - RESRAD: RI/FS, PA, screening level
- Numerical Models
  - MODFLOW: RI/FS, other
  - MODFLOWT: RI/FS, sensitivity analysis
  - MODPATH: Particle tracks, distance to exposure points
  - PHREEQC: K_d estimation
  - SADA: Source characterization
  - HELP: Infiltration estimates

Groundwater Modeling at PGDP Site

Current PGDP Modeling Matrix

Tier	Model	Point of Exposure	Notes
Tier 1 Used for Scoping	SSLs and/or RESRAD	At Source Unit	To be used for initial scoping.
Tier 2 Used for Scoping	SESOIL and/or RESRAD	At Source Unit	Includes source delimitation. Used for follow-up activities.
Tier 3 Used for Decision Documents	SESOIL and RESRAD with AT123D	At Source Unit and Downgradient Points	Uses source delimitation. Used to set initial cleanup goals.
Tier 4 Used for Decision and Design Documents	Source Modeling and MODFLOW T	At Source Unit and Downgradient Points	Used to refine cleanup goals and set monitoring goals

Groundwater Modeling at PGDP Site



Modeling Matrix Proposed Changes

- **All models in the matrix are being updated to the newest available versions**
- **SEVIEW GUI is being used in place of RISKPRO to run SESOIL and AT123D**
- **MODFLOWT will be replaced with MT3D/RT3D**
  - MODFLOWT used originally due to grid spacing and instability
  - Updated Site Wide MODFLOW model being developed
  - MT3D/RT3D were developed more recently than MODFLOWT

Groundwater Modeling at PGDP Site

Probabilistic Groundwater Modeling

- Parameter distributions from Southwest Plume will be used for future probabilistic analyses
- Crystal Ball linked to Excel is used to sample distributions and provide data for input files
- SEVIEW will need to be modified for probabilistic modeling

Current Surface Water Models

Surface Water Modeling at PGDP Site

- **SWMM**
  - – Used in the surface water investigation report
  - – Surface water model consisting of pipes, conduits, ponds, etc.

Current Surface Water Modeling Matrix

Tier	Model	Point of Exposure	Notes
Tier 1 Used for Scoping	SSLs and/or RESRAD	At Source Unit	To be used for initial scoping.
Tier 2 Used for Scoping	MUSLE	At Source Unit	Includes source delimitation. Used for follow-up activities.
Tier 3 Used for Decision Documents	SWMM	At Source Unit and Downgradient Points	Uses source delimitation. Used to set initial cleanup goals.
Tier 4 Used for Decision and Design Documents	Enhanced SWMM	Downgradient Points	Used to refine cleanup goals and set monitoring goals

Surface Water Modeling at PGDP Site

Modeling Matrix Proposed Changes

- SWMM was used for modeling on site to the outfalls
- Water Quality Analysis Simulation Program (WASP) will be used for transport modeling of surface water contaminants off-site.
- WASP can be linked to SWMM

Biota Modeling at PGDP Site

Current Biota Modeling Matrix

Tier	Model	Point of Exposure	Notes
Tier 1	NONE	NONE	HHRAWG determined screening levels not appropriate.
Tier 2 Used for Baseline Risk Assessments	Those contained in current Methods Document	At Source Unit	Includes source delimitation.
Tier 3 Used for Decision Documents	Those contained in current Methods Document	At Source Unit and Downgradient Points	Uses source delimitation. Used to set initial cleanup goals.
Tier 4 Used for Decision and Design Documents	Those contained in current Methods Document	At Source Unit and Downgradient Points	Used to refine cleanup goals and set monitoring goals

Biota Modeling at PGDP Site

- No changes proposed for biota modeling matrix

Vapor Transport Modeling

- Johnson and Ettinger Model used to evaluate vapor transport to a basement

Agenda for August 14th RAWG Meeting

1. Discuss Background Screening proposal, Kentucky DEP approval / reservations
2. Discuss EPA data screening criteria (e.g. frequency of detection, etc.) and how the revised document can incorporate these criteria for evaluation of high toxicity compounds (Dioxins, PAHs, PCBs).
3. Discuss Data Quality / Data Evaluation (carry over from previous meeting)
4. Discussion of COCs from recent risk assessments
5. Discuss recommendation for data use for sites with 6-9 samples.
6. Comparison of equations for COPC concentration in food to RAIS website
7. Identify approach/model for inhalation exposure to VOCs in water
8. Review of proposed versus existing values for those parameters which may be revised
    - Direct exposure parameters
    - Food ingestion parameters

Data Evaluation Methods (agenda item # 3)

For purposes of revising the *Risk Methods Document*, data evaluation will incorporate the aspects of data quality / data usability (measurement quality objectives) with an evaluation of planned data uses for each project (data quality objectives) to make a determination concerning the suitability of historical / current project data for use in risk assessment. Use of this systematic approach, which is consistent with EPA guidance, will ensure that risk assessments employ data of known quality and the appropriate quantities and types of data are acquired. The key aspects of the data evaluation process are:

- Data Verification
- Data Validation
- Data Quality Assessment
- Data Screening / Statistical Analyses

The following figure and text summarizes the elements of the data evaluation process and describes how the Risk Methods Document will be revised.

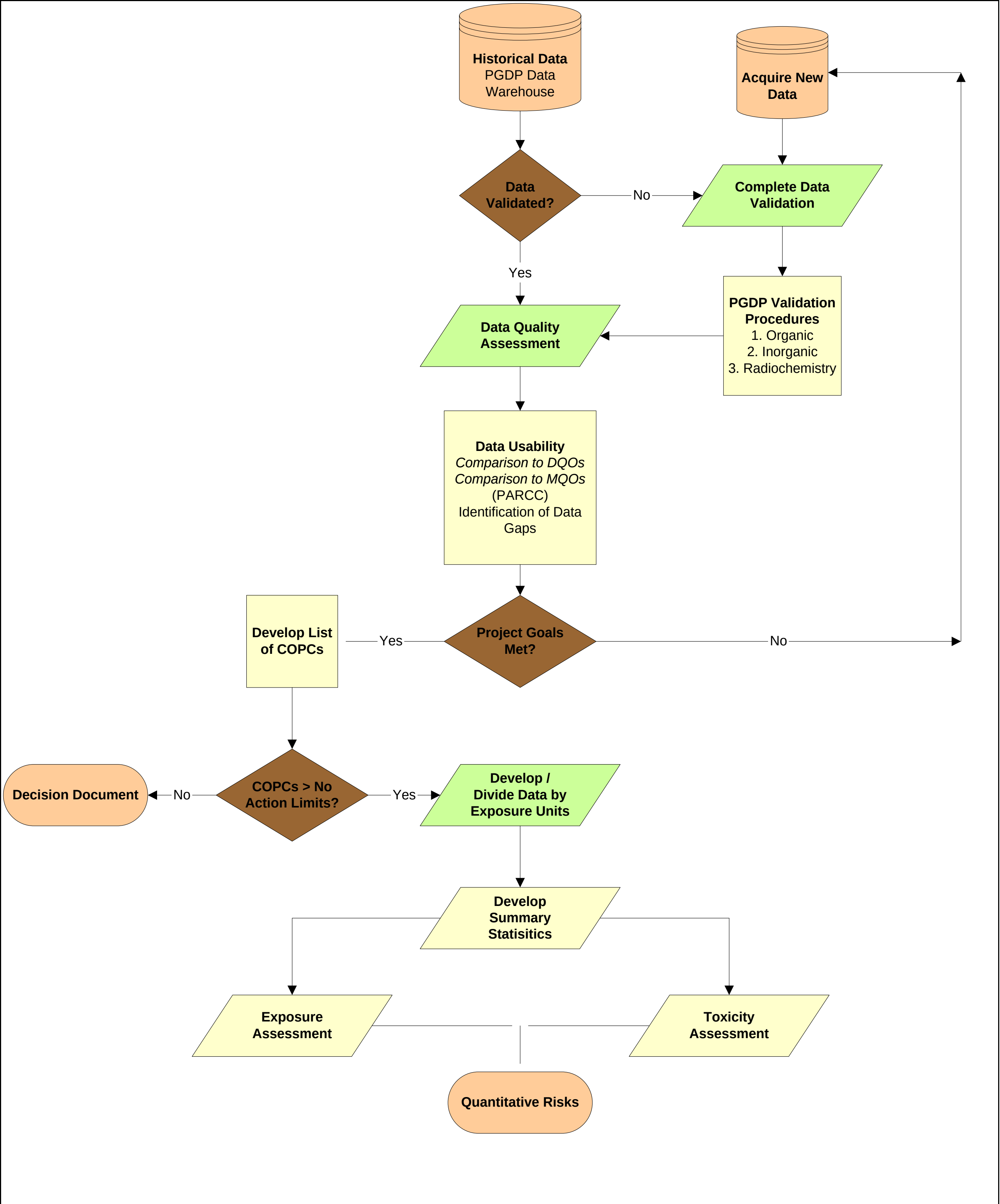


Fig. 2.2 Data Quality / Data Usability - PGDP Risk Methods Document (Proposed Revisions)

Data Verification

Data verification is first step in the data evaluation process (EPA = Contract Compliance Screening). It involves a review of the planned sampling and analysis activities versus the actual sampling and analysis information acquired, to ensure all samples and all corresponding analysis requests have been properly executed during analysis. It involves a review of the PEMS output for each sample (sample identification number, corresponding location, analysis request, and reported results), field notes, and the laboratory deliverable to ensure that each of the planned parameters have been sampled for and reported.

Verification also requires a cursory review of analytical results to ensure there are no gross reporting errors, results are provided in the proper units, and each sample has a corresponding result for the requested parameter(s). At PGDP, data verification is governed by several site-wide procedures. These include:

- PRS-ENM-1001, *Transmitting Environmental Data to the Paducah, Oak Ridge Environmental Information System OREIS*
- PRS-ENM-1002, *Submitting, Reviewing, and Dispositioning Changes to the Environmental Databases (OREIS and PEMS)*
- PRS-DOC-1009, *Records Management, Administrative Records and Document Control*
- PRS-ENM-5003, *Quality Assured Data*
- PRS-ENM-5004, *Sample Tracking Laboratory Coordination and Sample Handling Guidance*

All PGDP environmental data acquired from a contract laboratory is required to undergo verification / contract compliance screening prior to it use in risk assessment. PRS-ENM-5003 governs the review activities relative to data verification. The remaining procedures govern related aspects of data acquisition, transfer, and management. These procedures will be prescribed in revisions to the *Risk Methods Document* as a means of properly completing data verification. They represent the most up to date procedures employed at PGDP as of July 2007.

Data Validation

Data validation is a process where all aspects of laboratory analyses are reviewed and reconstructed to determine if the quality of reported results has satisfied the requirements of the analytical method and pre-determined quality requirements prescribed by standardized validation procedures. Data validation involves the review of all quality related aspects of individual data points and a determination as to the quality of that data point as defined by the analytical method. Validation is not intended to incorporate the aspects of a laboratory audit or long term laboratory proficiency. These aspects of the quality program are governed by external DOE-CAP audits, internal audits, and periodic quality assurance proficiency checks. Key aspects of the data validation review process include:

- Sample Custody
- Sample Holding Times and Preservation
- Instrument / Method Calibration
- Periodic Calibration Verification
- Blank Analyses
- Matrix Spike Analyses
- Duplicate Analyses
- Laboratory Control Sample Analyses
- Internal Standard Performance
- Surrogate Performance
- Tracer Performance
- Calculation Accuracy

There are a number of other quality elements that accompany each data point which are reconstructed during the data validation process and undergo scrutiny. Each quality element has a specific purpose, some designed to evaluate the accuracy of an analytical run, while others measure the cleanliness of the sampling and analytical sequence. When quality elements fail to meet prescribed requirements during analysis, they are generally indicative of difficulties encountered during sample analysis.

Sources of these difficulties may range from complexities within the sample matrix, to systematic or random error introduced during sampling or analysis. Data validation monitors these issues through a review of both laboratory reports and supporting raw data, as a means of measuring error, evaluating their impact on sample data, and assigning basic usability and/or usability restrictions on individual data points for use in future decision making.

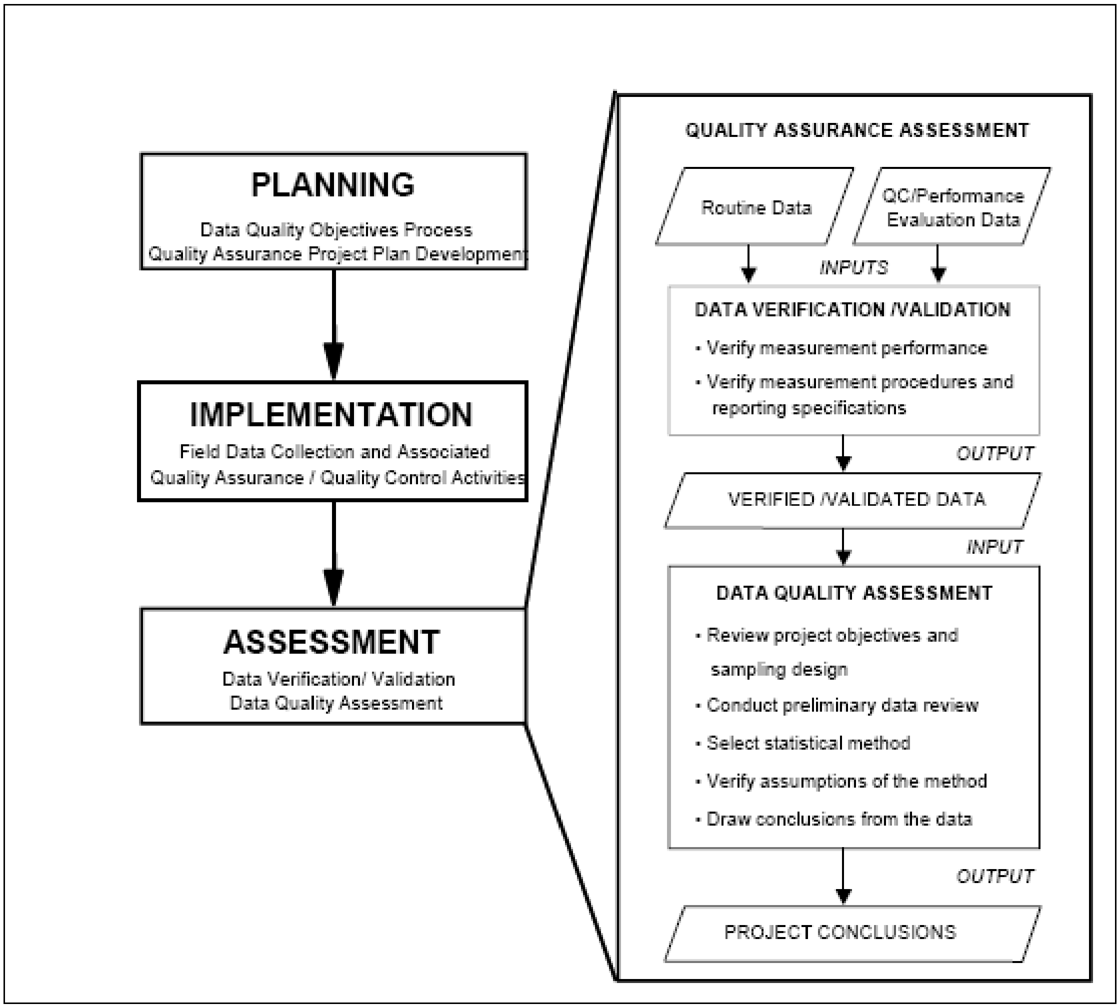
For *Risk Methods Document* revisions, PGDP site-wide data validation procedures will be specified and prescribed for all analysis types during project planning, to ensure continuity of data quality and the validation process from project to project. Site-wide procedures to be employed include:

- PRS-ENM-5107, *Inorganic Data Verification and Validation*
- PRS-ENM-0026, *Wet Chemistry Data Verification and Validation*
- PRS-ENM-5102, *Radiochemical Data Verification and Validation*
- PRS-ENM-5105, *Volatile and Semivolatile Data Verification and Validation*
- PRS-ENM-0811, *Pesticide and PCB Data Verification and Validation*

Discussion Point: Presently, 10% of project data at PGDP used in risk assessment undergoes data validation. This level of validation lags the industry for data used in decision making, risk assessment, and similar data uses. In general, the industry validates 100% of all data used in risk assessment. This practice helps to ensure data that only data of known quality are used to support risk management decisions. The practice varies nationwide, with some facilities performing Level IV data validation (PGDP = Level C) while others perform Level IV on a percentage of the results and complete Level III (Level D) validation for the remainder. In both cases the industry performs a higher degree of combined verification / validation on data used to support risk assessment. This issue should be resolved prior to the completion of revisions to the *Risk Methods Document.*

Data Quality Assessment

Data quality assessment (DQA) combines the conclusions of data verification, data validation, and pre-defined data quality objectives to determine if the historical / current data will adequately support the intended data uses (DQOs). To do so, DQA examines the data set to ensure that the MQOs have been met, a sufficient quantity of data has been acquired, the data is representative of the population investigated, and if significant data gaps remain. Overall, DQA seeks to determine if the investigation has satisfied the objectives of the planned activity and therefore can support decision making. The following figure from the *EPA Data Quality Assessment Guidance* is provided to illustrate how DQA fits into the data evaluation process.



For *Risk Methods Document* revisions, each data set planned for use in risk assessment will undergo data quality assessment. The revised document will specify *Data Quality Assessment: A Reviewer's Guide* (EPA 2006c) and *Data Quality Assessment: Statistical Methods for Practitioners* (EPA 2006d) as the basis for performing DQA on project data. The updated *Risk Methods Document* will contain an outline for performing DQA, key aspects of the DQA process, and required elements of the DQA that must be included to support risk assessment.

<u>Discussion of COCs from Recent Risk Assessments (agenda item #4)</u>

The first set of tables in Appendix A contains screening levels for significant COPCs. Recent risk assessments were reviewed to determine if chemicals not already designated as significant COPCs were COCs in those risk assessments. The table below presents those chemicals highlighted in yellow. These chemicals will be discussed at the meeting to determine if they warrant addition to the significant COPC tables.

Comparison of COPCs and COCs from Recent RAs to COPC's in Risk Method Document

COPC's	Significant COPCs From RMD	COC's from SWOU SAP	COC's from SWOU Report	COC's from SW Plume Report	COC's from WAG 27 Report	COC's from WAG 3 Report
INORGANIC CHEMICALS						
Alumium	x	NA	x	x	x	x
Antimony (metallic)	x	NA	x	x	x	
Arsenic, Inorganic	x	NA	x	x	x	x
Barium		NA	x	x	x	x
Beryllium and compounds	x	NA	x	x	x	x
Boron						x
Cadmium (Diet)	x	NA	x		x	x
Chromium (III) (Insoluble Salts)	x	NA	x		x	x
Chromium (Total)	x	NA		x		
Chromium VI (particulates)	x	NA				
Cobalt		NA		x	x	
Copper	x	NA	x		x	
Iron	x	NA	x	x	x	x
Lead And Compounds	x	NA	x			
Manganese	x	NA	x	x	x	x
Mercury, Inorganic Salts	x	NA	x			x
Molybdenum	x	NA	x			
Nickel Soluble Salts	x	NA	x	x	x	x
Selenium	x	NA	x			
Silicon		NA				
Silver	x	NA	x			
Thallium Chloride	x	NA				
Uranium (Soluble Salts)	x	NA	x	x	x	x
Vanadium, Metallic	x	NA	x	x	x	x
Zinc (Metallic)	x	NA	x		x	x

COPC's	Significant COPCs From RMD	COC's from SWOU SAP	COC's from SWOU Report	COC's from SW Plume Report	COC's from WAG 27 Report	COC's from WAG 3 Report
ORGANIC CHEMICALS						
Acenaphthene	x	NA				
Acenaphthylene	x	NA				
Acetone		NA			x	
Acrylonitrile	x	NA				
Anthracene	x	NA				
Aroclor 1016	x	NA				
Aroclor 1221	x	NA				
Aroclor 1232	x	NA				
Aroclor 1242	x	NA				
Aroclor 1248	x	NA				
Aroclor 1254	x	NA				
Aroclor 1260	x	NA				
Benz[a]anthracene	x	NA	x			
Benzene	x	NA				
Benzo[a]pyrene	x	NA	x			
Benzo[b]fluoranthene	x	NA	x			
Benzo[k]fluoranthene	x	NA	x			
Benzo[g,h,i]perylene		NA				
Bis(2-chloroethyl)-ether				x	x	
Bis(2-ethylhexlyl)phthalate					x	
Bromodichloromethane		NA				
Carbazole			x			
Bromomethane		NA				
Carbon Tetrachloride	x	NA		x	x	
Chloroform	x	NA		x	x	x
Chloromethane		NA				x
Chrysene	x	NA	x			
Dibenz[a,h]anthracene	x	NA	x			
Dibromochloromethane		NA				
Dichloroethane, 1,2-		NA				
Dichloroethylene, 1,1-	x	NA		x		x
Dichloroethylene, 1,2- (Mixed Isomers)	x	NA			x	
Dichloroethylene, 1,2-cis-	x	NA		x	x	x
Dichloroethylene, 1,2-trans-	x	NA				
Dieldrin				x	x	

COPC's	Significant COPCs From RMD	COC's from SWOU SAP	COC's from SWOU Report	COC's from SW Plume Report	COC's from WAG 27 Report	COC's from WAG 3 Report
Dioxins/Furans (Total)	x	NA	x	x		
Ethylbenzene	x	NA				x
Fluoranthene	x	NA	x			
Fluorene	x	NA				
hexachlorobenzene				x	x	
HpCDD, 2,3,7,8-	x	NA				
HpCDF, 2,3,7,8-	x	NA		x	x	
HxCDD, 2,3,7,8-	x	NA				
HxCDF, 2,3,7,8-	x	NA				
Indeno[1,2,3-cd]pyrene	x	NA	x			
Methylene chloride		NA			x	
2-Nitroanaline				x	x	
Nitrobenzene			x			
N-Nitros-di-n-propylamine			x	x	x	
Naphthalene	x	NA				
OCDD	x	NA				
OCDF	x	NA				
PeCDD, 2,3,7,8-	x	NA				
PeCDF, 1,2,3,7,8-	x	NA				
PeCDF, 2,3,4,7,8-	x	NA				
Phenanthrene	x	NA				
Polychlorinated Biphenyls (Total) (high risk)	x	NA	x	x	x	x
Polychlorinated Biphenyls (Total) (lowest risk)	x	NA				
Polynuclear Aromatic Hydrocarbons (Total)	x	NA		x	x	x
Propanol, 2-		NA				
Pyrene	x	NA	x			
TCDD, 2,3,7,8-	x	NA				
TCDF, 2,3,7,8-	x	NA				
Tetrachloroethylene	x	NA			x	
Trichloroethylene	x	NA		x	x	x
Vinyl Chloride	x	NA		x	x	x
Xylene, Mixture	x	NA				
Xylene, m-	x	NA				
Xylene, o-	x	NA				
Xylene, p-	x	NA				

COPC's	**Significant COPCs From RMD**	**COC's from SWOU SAP**	**COC's from SWOU Report**	**COC's from SW Plume Report**	**COC's from WAG 27 Report**	**COC's from WAG 3 Report**
RADIONUCLIDES						
Am-241	**x**	**NA**	**x**	**x**	**x**	
Co-60	**x**	**NA**	**x**	**x**	**x**	
Cs-137+D	**x**	**NA**	**x**	**x**	**x**	
Np-237+D	**x**	**NA**	**x**	**x**	**x**	
Pu-238	**x**	**NA**				
Pu-239	**x**	**NA**	**x**		**x**	
Pu-240	**x**	**NA**	**x**		**x**	
Ra-226+D	**x**	**NA**				**x**
Rn-222+D	**x**	**NA**			**x**	
Sr-90+D	**x**	**NA**				
Tc-99	**x**	**NA**	**x**	**x**	**x**	**x**
Th-228+D	**x**	**NA**	**x**			
Th-230	**x**	**NA**	**x**		**x**	
Th-232	**x**	**NA**	**x**			
U-234	**x**	**NA**	**x**			**x**
U-235+D	**x**	**NA**	**x**	**x**	**x**	
U-238+D	**x**	**NA**	**x**	**x**	**x**	**x**

Evaluation of Sites with 6-9 Samples (agenda item #5)

1. If the population is relatively homogeneous, such as rinsate or manually well mixed soil, compute a UCL on the data.
2. If the population is very small and a large percentage (~25%) was sampled compute a UCL on the data.
3. If the population is heterogeneous, such as soils, then a five-number summary, normal-quantile plot (to look at spread) will be examined and the maximum detected value, if it is not an outlier, will be the reporting limit. If the maximum detected value is an outlier, then the outlier will be remedied if possible (such as recording error). If the outlier is not a result of a recording error or some similar error, the second largest detected value will be used as the reporting limit.
4. If situations in the data indicate that an approach other than the above mentioned is appropriate, a more appropriate method may be developed for a particular site.

Comparison of Equations for COPC Concentration in Food to RAIS website (agenda item #6)

Tables D-41 to D-50 present the equations used to calculate the concentration or activity in food items based on the concentration in soil and water. All the equations presented in these tables match the corresponding equations presented on the RAIS website as of July 2007. There are equations for more types of food items in the RM document (because RAIS does not present equations for most game animals), but these equations use adaptations of the RAIS equations for domestic animals. Many of the default values for parameters in the RM document also match the default values for the same parameters given on the RAIS website. The exceptions are values such as amount of soil ingested by deer, as well as quantity of soil and pasture consumed by beef and dairy cattle. The values for those parameters are based on values more specific to the facility.

VOC Inhalation Dose Using Schaum and EPA models (agenda item #7)

This comparison is still under development due to the difficulties in obtaining the model, but will be ready for the August 14th meeting.

Exposure Parameters for PGDP (agenda item #8)

1. General issues with parameters

KRAGS 2005 doesn't include discussion of the sediment pathway; sediment exposure values currently in RM are cited as coming from previous version of KRAGS. Alternate sources should be cited or developed for the values for sediment exposure.

Excavation worker exposure parameters match defaults for KRAGS outdoor worker, including 185 days/year EF. This scenario can be made more PGDP-specific. For example, in some operable units where work is ongoing, dates on work releases can be used to calculate exposure frequencies.

KRAGS recommends on page A-8 using equations from RAGS Part E to calculate dermal component of showering exposure. This differs from the equations used in the current RM document for dermal exposure during showering. The discussion of dermal exposures following the table examines this issue more in-depth.

2. Specific parameter values for discussion and possible revision

The table below lists the parameters from the Appendix D tables to consider for potential revision. Parameters are listed in this table either because new potential sources for these values have become available since the risk methods document was written, or because the source of the original value is no longer available.

Exposure Parameter	Current PGDP RM value	2005 KRAGS value	Proposed value	Source for Proposed value
Child (1-7) water ingestion, L/day	1	1.7*	1	95th percentile for age range 1-6 in 2003 child-specific EFH
ED-rural resident, years	34	34	24	EPA
vegetable ingestion rate (child 1-7), kg/d	0.130	none	0.29	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.09	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study

Exposure Parameter	Current PGDP RM value	2005 KRAGS value	Proposed value	Source for Proposed value
vegetable ingestion rate (adult), kg/d	0.1995	none	0.72	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.26	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
beef ingestion rate (child 1-7), kg/d	0.040	none	0.07	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.01	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
Beef ingestion rate (adult), kg/d	0.075	none	0.19	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.05	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
milk ingestion rate (child 1-7), kg/d	0.435	none	0.90	95th percentile estimate for total dairy for consumers only from 2003 CSFII Food Intake Study
			0.33	50th percentile estimate for total dairy for consumers only from 2003 CSFII Food Intake Study

Exposure Parameter	Current PGDP RM value	2005 KRAGS value	Proposed value	Source for Proposed value
milk ingestion rate (adult), kg/d	0.266	none	1.25	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.36	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
poultry ingestion rate (child 1-7), kg/d	0.0377	none	0.07	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.01	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
poultry ingestion rate (adult), kg/d	0.0615	none	0.17	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.02	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
pork ingestion rate (child 1-7), kg/d	0.0248	none	0.03	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.0022	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study

Exposure Parameter	Current PGDP RM value	2005 KRAGS value	Proposed value	Source for Proposed value
pork ingestion rate (adult), kg/d	0.0437	none	0.08	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.0061	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
egg ingestion rate (child 1-7), kg/d	0.0173	none	0.06	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.0022	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
egg ingestion rate (adult), kg/d	0.0252	none	0.11	95th percentile estimate for consumers only from 2003 CSFII Food Intake Study
			0.0045	50th percentile estimate for consumers only from 2003 CSFII Food Intake Study
fish ingestion rate (child 1-7)	0.059 kg/meal	None	0.106 kg/day	EPA 2002 estimated per capita fish consumption in the US report. Value is 95th percentile for uncooked fish for consumers only for children for ages 1-7.

Exposure Parameter	Current PGDP RM value	2005 KRAGS value	Proposed value	Source for Proposed value
Fish ingestion frequency (all ages)	64 meals/year	None	60 meals/year	Fiore et al 1989 study 95% percentile for sport-caught fish meals as reported in EPA EFH
Inhalation rate (child 1-7) (m3/day)	20	20	10	EFH and 2002 child-specific EFH
Exposure Frequency (recreational rural adult)	104	104	TBD	Proposed value TBD based on USEC security logs
Exposure Frequency (recreational child/teen)	140	140	TBD	Proposed value TBD based on USEC security logs
Inhalation rate during showering	0.6 m3/hr	0.833 m3/day	TBD	Will be determined during model comparison
Time of shower, hr	0.1	0.2	0.2	KRAGS
Time after shower, hr	0.1	none	None	KRAGS
Surface area of child while showering, cm2	0.72	0.65	0.65	KRAGS
Fraction volatilized (whole house exposure)	0.75	0.5	0.5	KRAGS
Exposure time (whole house exposure), hr	16	24**	24	KRAGS
Dermal Absorption Factor	0.25 VOCs 0.1 SVOCs 0.05 Inorganics 0.03 dioxins 0.06 PCBs 0.01 cadmium 0.25 carbon disulfide	0.25 VOCs 0.1 SVOCs 0.05 Inorganics	0 VOCs 0.1 SVOCs 0 inorganics 0.03***dioxin 0.14 PCBs 0.001 cadmium 0.13 PAHs 0.03 arsenic 0.04 chlordane 0.05 2,4-D 0.03 DDT 0.04 lindane 0.25 pentochlorophenol	EPA RAGS Part E final 2004

Exposure Parameter	**Current PGDP RM value**	**2005 KRAGS value**	**Proposed value**	**Source for Proposed value**
Surface area of rural child resident for dermal contact with soil	0.373 m2 (=3730 cm2)	2800 cm2/day	2800 cm2/day	KRAGS
Surface area of rural adult resident for dermal contact with soil	0.350 m2 (=3500 cm2)	5700 cm2/day	5700 cm2/day	KRAGS
Gamma shielding factor	0.2	None	0.4?	John Volpe
Dermal surface area (swimming) teen	1.350	1.31	1.31	KRAGS
Dermal surface area (swimming) child	0.720	0.650	0.650	KRAGS
PEF	3.21E+10	9.3E+08 residential 6.2E+08 industrial	9.3E+08 residential 6.2E+08 industrial	Recommend KRAGS values (based on 96 SSL technical background doc, unless current value is PGDP-specific (appears to be Little Rock, AK value)
Dermal surface area (industrial/excavation)	0.43 m2 (=4300 cm2)	3300 cm2 industrial 4700 cm2 outdoor	3300 or 4700	Recommendation depends on whether indoor or outdoor worker
Exposure time for sediment (industrial)	2.6	None	2.6	Need to document basis of sediment exposure factors

* KRAGS presents 2 values for this parameter within the age of 1-7 for this parameter; this value is a weighted average across 1-7

**Not specified in KRAGS, assumed based on 20 m3/d inhalation rate specified for this pathway

***abs =0.001 if soil organic content>10%

Summary of the Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)

Hazard Identification

- For the dermal-water pathway, only those chemicals which contribute to more than 10% of the dose from the oral (drinking water) pathway should be considered important enough to carry through the risk assessment. The other chemicals should be screened from the quantitative risk assessment. Screening of dermal–water pathway for recreational use may be problematic because there is not a water ingestion pathway in the recreational scenario.

- For the dermal-soil pathway, the limited availability of dermal absorption values is expected to result in a limited number of inorganic contaminants being considered in a quantitative risk assessment. An important decision for the risk assessor is whether the default value of 10% dermal absorption from soil, for all organic compounds without specific absorption values, should be applied to a quantitative risk assessment.

Exposure Assessment

- Since the K_p (permeability coefficient) parameter has been identified as one of the major parameters contributing to uncertainty in the assessment of dermal exposures to contaminants in aqueous media, it is important that risk assessments be consistent when estimating this parameter. Since the variability between the predicted and measured K_p values is no greater than the variability in inter-laboratory replicated measurements, this guidance recommends the use of predicted K_p values. However, there are some chemicals that fall outside the Effective Prediction Domain for determining K_p, particularly those with a high molecular weight and high K_{ow} values. To address these chemicals, a fraction absorbed (FA) term should be applied.

- The guidance presents recommended default exposure values for all variables for the dermal-water and dermal-soil pathways. These include the residential scenario for water exposure and residential and industrial for soil exposure.

- For dermal-water exposures, the entire skin surface area is assumed to be available for exposure when bathing and swimming occurs. A wading scenario may result in less surface area exposed. For dermal-soil exposures, clothing is expected to limit the extent of exposed surface area. For the adult resident, the total default surface area should include the head, hands, forearms and lower legs. For a residential child the default surface area should include the head, hands, forearms, lower legs and feet. For an adult commercial/industrial worker, the total default surface area should include the head, hands and forearms.

- During typical exposure scenarios, more soil is dermally contacted than is ingested. The default soil adherence factor (AF) for RME adult residential activities ($0.07\ mg/cm^2$) should be based on the central tendency value for a high-end soil contact activity (e.g., a gardener). The default AF value for a RME child resident ($0.2\ mg/cm^2$) should be based on both the high end estimate for an average soil contact activity (i.e., children playing in dry soil) and the central tendency AF estimates for a high-end soil contact-intensive activity (i.e., children playing in wet soil). The default AF value for a commercial/ industrial adult worker (0.2 mg/cm^2) should be based on the central tendency estimate for a high-end soil contact activity (i.e., utility worker).

- The contribution of dermal absorption of chemicals from soils to the systemic dose generally is estimated to be more significant than direct ingestion for those chemicals which have a soil absorption fraction exceeding about 10%.

- Excavation worker exposure values can be derived from the guidance appendices. The recreational scenarios would need to be developed. They are many types of activities described in the guidance which could be used or modified for recreational exposures such as archeologists, reed gatherers, soccer players and rugby players.

Dermal Absorbed Dose – Water Contact

$$DAD = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT} \tag{3.1}$$

where:

Parameter		Definition (units)	Default Value
DAD	=	Dermally Absorbed Dose (mg/kg-day)	–
DA_{event}	=	Absorbed dose per event (mg/cm^2-event)	Chemical-specific, see Eq. 3.2, 3.3 and 3.4
SA	=	Skin surface area availablefor contact (cm^2)	See Exhibit 3-2
EV	=	Event frequency (events/day)	See Exhibit 3-2
EF	=	Exposure frequency (days/year)	See Exhibit 3-2
ED	=	Exposure duration (years)	See Exhibit 3-2
BW	=	Body weight (kg)	70 kg (adult) 15 kg (child)
AT	=	Averaging time (days)	noncarcinogenic effects AT = ED x 365 d/yr carcinogenic effects AT = 70 yr x 365 d/yr

EXHIBIT 3-2

RECOMMENDED DERMAL EXPOSURE VALUES FOR CENTRAL TENDENCY AND RME RESIDENTIAL SCENARIOS – WATER CONTACT

Exposure Parameters	**Central Tendency Scenario**				**RME Scenario**			
	Showering/ Bathing		**Swimming**		**Showering/ Bathing**		**Swimming**	
Concentration- C_w (mg/cm^3)	Site-specific		Site-specific		Site-specific		Site-specific	
Event frequency- EV (events/day)	1		Site-specific		1		Site-specific	
Exposure frequency- EF (days/yr)	350		Site-specific		350		Site-specific	
Event duration- t_{event} (hr/event)	**Adult[1]**	**Child[2]**	**Adult**	**Child**	**Adult[1]**	**Child[2]**	**Adult**	**Child**
	0.25	0.33	Site-specific		0.58	1.0	Site-specific	
Exposure duration- ED (yr)	9	6	9	6	30	6	30	6
Skin surface area- SA (cm^2)	18,000	6,600	18,000	6,600	18,000	6,600	18,000	6,600
Dermal permeability coefficient-K_p (cm/hr)	Chemical-specific values Exhibits B-3 and B-4							

[1] Adult showering scenario used as the basis for the chemical screening for the dermal pathway, as shown in Appendix B, Exhibits B-3 and B-4. Event duration for adult exposure is based on showering data from the EFH (U.S. EPA, 1997a).

[2] Event duration for child exposure is based on bathing data from the EFH (U.S. EPA, 1997a).

- Dermal-soil absorption values for ten compounds are provided in this guidance. Screening absorption values are provided for semi-volatile organic compounds as a class. No screening values are provided for inorganic compounds, due to the lack of sufficient data on which to base an appropriate default screening level for inorganics other than arsenic and cadmium. For the dermal-soil pathway, the limited availability of dermal absorption values is expected to result in a limited number of inorganic contaminants being considered in a quantitative risk assessment

RECOMMENDED DERMAL EXPOSURE VALUES FOR CENTRAL TENDENCY AND RME RESIDENTIAL AND INDUSTRIAL SCENARIOS - SOIL CONTACT

Exposure Parameters		**Central Tendency**		**RME Scenario**	
		Residential	**Industrial**	**Residential**	**Industrial**
Concentration- C_{soil} (mg/kg)		site-specific values			
Event frequency (events/day)		1	1	1	1
Exposure frequency (days/yr)		site-specific	219	350	250
Exposure duration (yr)		9	9	30	25
Skin surface area (cm^2)	Adult	5,700	3,300	5,700	3,300
	Child	2,800	NA	2,800	NA
Soil adherence factor (mg/cm^2)	Adult	0.01	0.02	0.07	0.2
	Child	0.04	NA	0.2	NA
Dermal absorption fraction		chemical-specific values			

RECOMMENDED DERMAL ABSORPTION FRACTION FROM SOIL

Compound	Dermal Absorption Fraction (ABS_d)[1]	Reference
Arsenic	0.03	Wester, et al. (1993a)
Cadmium	0.001	Wester, et al. (1992a) U.S. EPA (1992a)
Chlordane	0.04	Wester, et al. (1992b)
2,4-Dichlorophenoxyacetic acid	0.05	Wester, et al. (1996)
DDT	0.03	Wester, et al. (1990)
TCDD and other dioxins -if soil organic content is >10%	0.03 0.001	U.S. EPA (1992a)
Lindane	0.04	Duff and Kissel (1996)
Benzo(a)pyrene and other PAHs	0.13	Wester, et al. (1990)
Aroclors 1254/1242 and other PCBs	0.14	Wester, et al.(1993b)
Pentachlorophenol	0.25	Wester, et al. (1993c)
Semivolatile organic compounds	0.1	—

[1] The values presented are experimental mean values.

Toxicity Assessment

Before estimating risk from dermal exposures, the toxicity factor should be adjusted so that it is based on an absorbed dose. Usually, adjustments of the toxicity factor are only necessary when the GI absorption of a chemical from a medium similar to the one employed in the critical study is significantly less than 100% (i.e., 50%). When gastrointestinal absorption of a chemical in the critical study is poor (e.g., 1%), the absorbed dose is much smaller than the administered dose; thus, toxicity factors based on absorbed dose should be adjusted to account for the difference in the absorbed dose relative to the administered dose.

In effect, the magnitude of toxicity factor adjustment is inversely proportional to the absorption fraction in the critical study. That is, when absorption efficiency in the critical study is high, the absorbed dose approaches the administered dose resulting in little difference in a toxicity factor derived from either the absorbed or administered dose. The recommended GI absorption values (ABS_{GI}) for those compounds with chemical-specific dermal absorption factors from soil are presented in the guidance. For those organic chemicals that do not appear on the table, the recommendation is to assume a 100% ABS_{GI} value, based on review of literature, indicating that organic chemicals are generally well absorbed (>50%) across the GI tract. Metals are commonly the contaminants where a toxicity factor adjustment is recommended. The metals include antimony, chromium (III) and (VI), cadmium, manganese, nickel, silver and vanadium.

EXPOSURES NOT INCLUDED IN DERMAL GUIDANCE

- The guidance does not explicitly recommend exposure parameters for contact with contaminated sediment. This exclusion is due to the high degree of variability in sediment adherence and duration of sediment contact with the skin. However, information is included in the guidance document that would allow a risk assessor to assess sediment exposure on a site-specific basis. The guidance does not address recreational scenarios.

- The guidance does not specifically address dermal toxicity, either acute or chronic. The dermal dose derived with this methodology provides an estimate of the contribution of the dermal pathway to the systemic dose. The exclusion of dermal toxicity should be considered an uncertainty issue that could underestimate the total risk.

- Current studies suggest that dermal exposure may be expected to contribute no more than 10% to the total body burden of those chemicals present in the vapor phase. Therefore, the guidance does not include a method for assessing dermal absorption of chemicals in the vapor phase, with the assumption that inhalation will be the major exposure route for vapors.

Derivation of Reference Dose Based on Absorbed Dose

$$RfD_{ABS} = RfD_O \times ABS_{GI} \qquad (4.3)$$

where:

Parameter		Definition (units)	Default Value
RfD_{ABS}	=	Absorbed reference dose (mg/kg-day)	Chemical-specific, see Exhibit 4-1
RfD_O	=	Reference dose oral (mg/kg-day)	Chemical-specific
ABS_{GI}	=	Fraction of contaminant absorbed in gastrointestinal tract (dimensionless) in the critical toxicity study	Chemical-specific, see Exhibit 4-1 and Appendix B

- The dermal risk guidance uses a mathematical model to predict absorption and risk from exposures to water. Contaminants for which there are sufficient data to predict dermal absorption with acceptable confidence are said to be within the model's effective predictive domain (EPD). Although the methodology can be used to predict dermal exposures and risk to contaminants in water outside the EPD, there appears to be greater uncertainty for these contaminants. The guidance does not recommend that the model be used to quantify exposure and risk to contaminants in water that are outside the EPD in the "body" of the risk assessment. Rather, it is recommended that such information be presented in the discussion of uncertainty in the risk assessment.

Derivation of Cancer Slope Factor Based on Absorbed Dose

$$SF_{ABS} = \frac{SF_O}{ABS_{GI}} \qquad (4.2)$$

where:

Parameter		Definition (units)	Default Value
SF_{ABS}	=	Absorbed slope factor	Chemical-specific, See Exhibit 4-1
SF_O	=	Oral slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
ABS_{GI}	=	Fraction of contaminant absorbed in gastrointestinal tract (dimensionless) in the critical toxicity study	Chemical-specific, see Exhibit 4-1 and Appendix B

Meeting Notes from 8/14/07 RAWG meeting
On Revision of the Risk Methods Document

Summary of Discussions/Agreements

Comparison to Background

Two issues related to background were discussed at the August meeting. The first issue is whether to include analytes detected only below their background values in the first set of quantitative risk and hazard calculations (those analytes would still appear in an appendix to provide an estimate of risk from total concentrations of all analytes). EPA agrees with the principle of excluding the analytes below background from the risk assessment presented in the main body of the document; KDEP is considering this issue in their meetings this month. The second issue related to background is the selection of values to represent background for inorganic chemicals. EPA screens site concentrations against 2 times the average background concentration to determine which analytes are likely to represent site-related contaminants. KDEP is considering whether this approach would be inclusive enough to agree to its substitution for their current method of comparison to background values for screening of site-related contamination. There was agreement that site data is too limited to support comparison of the distributions of site contaminants with the distribution of the background values.

Discussion of PAH/PCB/Dioxin Class Evaluations

The approach to handling non-detects of some analytes within these classes for samples from sites in which analytes within these classes were detected in other samples was discussed. For dioxins/furans, the approach will remain the same as in the current document. For samples where all PCBs or PAHs are non-detects, the revised document would recommend using the value for the minimum detection limit of the PAHs with TEFs or the PCBs with TEFs.

Data Evaluation Issues

The group reviewed the draft revised data evaluation section in the handout. The RAWG agreed that some of this information should appear in the document (including both the proposed figures). However, they felt that the data evaluation section should be revised to reduce the discussion of data validation to referencing the PGDP site-wide data validation procedures. The topic of the appropriate percent validation for analytical results was deemed more appropriate for a different forum than the risk methods document.

Addition/Deletion of COCs from Recent Risk Assessment to the Significant COPCs List

The compilation of new COCs identified in risk screenings and assessments completed in 2002 and later was reviewed to determine whether analytes should be added to the significant COPCs list in Table 2.1. That table is the basis of the selection of analytes presented in the "short list" tables of no action levels and action levels in Appendix A. Four metals (aluminum, barium, boron, and cobalt) were added to the table. Five organic chemicals (carbazole, dieldrin, hexachlorobenzene, 2-nitroaniline, and N-Nitroso-di-n-propylamine) were also added to the significant COPCs list. No radionuclides were added, but strontium-90 was removed because it is not routinely analyzed for at PGDP sites.

Calculation of Exposure Point Concentrations (EPCs) for Data Sets of Various Sizes

The current risk methods document provides guidance for calculating an exposure point concentration for three class sizes of data sets. Based on consideration of new statistical guidance from EPA (including the new version of ProUCL) and the review of the approach by the statistician, the RAWG decided to move to two size classes for developing EPCs for screening. Sites with 9 or fewer samples taken will use the maximum concentration as the EPC. Sites with 10 or more samples will calculate a 95% UCL of the mean (ProUCL 4.0 can be used for these calculations) to serve as the EPC.

Comparison of COPC Concentration in and Dose from Food Items to Equations on the RAIS Website

The equations in Tables D-41 to D-50 were reviewed and found to be consistent with the current approach used on the RAIS website for these pathways. The RAWG therefore did not recommend any changes to these equations nor to the parameters in them. However, the bag limits for game will be verified to see that they are still current as part of the updates to Appendix D.

VOC Inhalation Dose Using Schaum and EPA models

Calculation of the inhalation dose at the TCE MCL concentration and a high concentration (100 mg/l) was done with both the KDEP Schaum model and using the EPA Andelman volatilization factor (VF). The calculations indicated that the Schaum model recommended by KDEP generates a lower estimate of the inhalation dose from TCE that the EPA adjustment to the ingestion dose using the Andelman VF. EPA is reviewing the Schaum model to determine if they feel is appropriate for use in place of the Andelman VF they use for generation of screening levels.

Selection of New Exposure Parameter Values for Equations in Appendix D

Some general issues with selection of parameter values were addressed by the RAWG. The current version of KRAGS does not directly address exposure to sediment. Sediment exposure pathways are considered in the development of PGDP action and no action levels. The RAWG determined the new version of the risk methods document should include an explanation of how sediment exposure factors were developed from the KRAGs soil exposure parameters. There was also consensus that KRAGS exposure frequencies for recreational and outdoor worker exposures would continue to be used for development of screening levels instead of site-specific exposure frequencies so that screening levels would continue to represent baseline exposures.

There was a discussion of the method for assessing dermal exposure and the values used for dermal absorption. EPA favors use of the values presented in EPOA RAGS Part E. KDEP currently has a separate set of default exposure parameters, but is reviewing the two approaches as part of their revisions to the KDEP risk guidance.

The proposed values for a number of specific exposure parameters were discussed. The RAWG resolved what changes to make to some of the parameters listed in the handout. However, both KDEP and EPA are reviewing the proposed human food ingestion parameters derived from the new food consumption survey. There was consensus that values for "consumers only" were appropriate for developing screening levels for these pathways, but both agencies want to internally discuss further whether 50th percentile estimates or 95th percentile estimates are more appropriate for these food ingestion parameter values.

Additional Items

Some other revisions to the document were briefly discussed at the need of the meeting. Appendix B will be revised to include a brief discussion of the exposure scenario for each receptor. Part 2 of Appendix C will be deleted as the "binning process" is no longer used in screening evaluations of sites. An additional phone conference will be held to determine if a new appendix addressing probabilistic risk assessment (PRA) should be added and, if so, what material it should contain.

PADUCAH RISK ASSESSMENT WORKING GROUP
MEETING MINUTES
QUARTERLY MEETINGS
BEGINNING 2012

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Risk Assessment Working Group
Quarterly Meeting Minutes—June 13, 2012—Revised August 2012

1. **No Action Level (NAL)/Action Level (AL) tables:**

   a. **Discuss use of PORTS calculator for Paducah instead of NAL/AL tables in the Risk Methods Document (RMD) or use of EPA's Regional Screening Levels (RSLs).**
   After discussion, it was agreed to revise NALs and ALs and post them by September 30, 2012, and to include an "as of" date. These values will use updated toxicity values.
   Targets for hazard: NAL is 0.1; AL is 3.
   Targets for ELCR: AL is 10E-4; NAL is 10E-6 with statement regarding cumulative risk.
   Issues arising during NAL calculations will be brought up and addressed by email.
   NOTE: These revised NALs/ALs will NOT affect current projects (specifically the Soils OU RI, with a few noted exceptions to be written up in the risk assessment sections of the Soils OU RI Report).
   An e-mail was sent July 24, 2012, proposing use of RAIS for calculating NALs using site-specific exposure parameters to the extent possible. RAIS is consistent with RSL values.
   No responses to the e-mail were received.

   In a comment to the minutes, KY expressed a reluctance to use the PORTS calculator in determining NALs for Paducah.

   For dose, ranges are 1 mrem/yr, 4 mrem/yr (for water only), 15 mrem/yr, and 25 mrem/yr. 100 mrem/yr will be added to relate to the DOE order and KY public dose limits. It should be noted that 1 mrem/yr and 15 mrem/yr are not DOE or KY standards, and none of these radiation dose rates are EPA's standards, including the 15 mrem/yr.

   b. **Revise lead action levels**
   Currently, 400 mg/kg is listed as the action level for the resident. The industrial worker action level also is listed as 400 mg/kg—this number will be changed to 800 mg/kg. A reference will be provided prior to change. The MCL is 15 ug/L, this will remain unchanged in the RMD.

   c. **Tox factors and dermal; but also MCLs for Rad, SSLs**
   An "as of" date will be used and sent by email for review and concurrence. The RSL table will be used for toxicity values and original references (although the original references may be revisited if it proves problematic). The actual hierarchy of the source of the toxicity values will remain as in the current RMD (consistent with EPA guidance.) This hierarchy is on page 3-33 of the 2011 RMD.

   Use GI ABS value for calculating dermal absorption from oral values.
   Add section to RMD/Risk Assessments that recognizes the uncertainty of using RAGS Part E for metals and volatiles for dermal. This text will be sent for review by the RAWG prior to the next meeting and approval of the revised NALs/ALs

   RESRAD to be used to determine risk or dose-based values and SSLs based on dosimetry—presenting the results based on the current dosimetry, and also consistent with the factors designated in the standards.

For example, the current EPA MCLs for Tc-99, etc. will continue to be recognized even though we agree that the dosimetry is outdated (i.e., 1959 vs current dosimetry calculations). (That is, we will present both the 900 pCi/L and the 4 mrem/yr-based value.)

d. **SSLs for noncancer are usually based on an HI of 1, not 0.1 for the groundwater pathway.**
The SSL table in the RMD (Table A.7a) will now only include those from EPA-based values (remove values calculated for NALs). The first preference for calculation will be the MCL value, if an MCL is not available, the risk-based value will be used, as shown in the EPA RSL table (note: values in the RSL table are for a DAF of 1). RMD will include values for DAFs of 1, 20, and 58.

2. **Setting cleanup goals for the various soil horizons**

Background: the FS for BGOU SWMUs, IW RGO based on 0-1 ft bgs; OW RGO (for subsurface) based on 1-16 ft bgs.

For BGOU SWMUs IW cleanup set at 10^{-5} and OW set at 10^{-4} (for subsurface) (though KY may not agree with this value).

Cleanup scenarios need to be explained over all horizons, not just the surface layer.

The key is that the scenarios need to be explained. Additional information will be provided in the BGOU FS.

3. **Risk result presentation**

Discussion of possible formats that may help the agency review. It was decided that the presentation was okay, as is.

4. **Gamma walkovers**

A discussion was held as to the process that should be used on how to incorporate/consider gamma walkover survey results in the assessment. It was decided that gamma walkover survey results can be used in determining boundaries for determining exposure point concentrations (EPCs), but not in calculating EPCs.

Further, discussion was held regarding how we handle gamma walkover survey results that cast doubt on analytical values and what upfront QC can be done. Results of gamma walkover surveys should be included in the data representativeness evaluation prior to calculating risk. A specific evaluation for inconsistencies between gamma survey results and analytical results will be added to the uncertainty section (list of uncertainties) in RMD.

Nature and extent determinations need to be connected to the risk evaluation. "Is data sufficient to determine what you have…"

A sample text write-up will be sent to the group for comment.

5. **Principal Threat Waste Determination: Establish Additional Criteria**

a. **The RMD needs further direction with respect to PTW on the outcome for currently required calculations resulting in an ELCR, HI, or dose greater than the benchmarks.**
Additional comments regarding Meeting Notes with respect to PTW were made and will be addressed with the revised PTW text box for the RMD.

b. **Current dose benchmark of 25 mrem/yr is not the same scale of magnitude above the acceptable level, as is the ELCR benchmark. Propose setting the benchmark for PTW. Radiation dosimetry should be based on ICRP 60 and ICRP 72. All dosimetry should be consistent with DOE Order 458.1. DCFs should be the consistent with 458.1.**

See #1 for additional dose benchmarks added.
A revised textbox (from RMD) will be circulated to the Risk Assessment Working Group (RAWG) for review and concurrence in July, prior to presenting to managers. The entire textbox may be dropped instead of revising.

6. **Background Values**
Currently used values may need to be revisited to develop recommendation on future activities.
All background values, but especially groundwater are listed as provisional. Many background values are set at detection limits values. There are no plans for changes here. Background values should be finalized and will be placed on the next quarter's agenda.

Background values over all media are considered to be a range. The basic background screen is against Paducah-specific values; for COPC identification Paducah-specific values are used.

Additional criteria for comparison, such as the KY state background values (listed in Appendix E of the RMD) and fallout values, can be used to refine COC selection. These chemicals do remain as COPCs. As discussed, caution should be used when comparing sample results at PGDP with nationwide fallout averages that are an order of magnitude in range. It may not be very defensible to make that comparison (especially concerning results that indicate a very heterogeneous distribution of the contaminant) and there are likely better ways of evaluating the importance of elevated (but still low) activity concentrations of radionuclides attributable to fallout.

7. **Lessons Learned from Recent Projects**
   a. **Begin development of lessons learned for the Modeling Matrix from the recent CERCLA Cell and SW Plume modeling efforts.**
   b. **Begin development of lessons learned for Remedial Goal (RG) calculations from the internal ditches and SW Plume projects.**
   No specific issues were discussed.

8. **PAHs: Establish Direction for Handling PAH Contamination in Establishing Remedial Goals (RGs).**
Background: for the SWOU Onsite RA, PAHs were not used in cleanup determination based on their sporadic nature.
It was proposed to include criteria in the next RMD revision to exclude PAH contamination from RG calculations, though KY has commented on meeting notes that they are not in favor of this. This text, if adopted, could be included in the SMP regarding ubiquitous PAH contamination in the CSOU.
One KAR states that PAHs near roadways are not subject to cleanup (find citation)
Draft text for presentation to risk managers will be sent for review/concurrence to RAWG.

9. **Recreational User Equations**
The proposed new equation is below on the following page. A replacement page will be sent for the RMD.

10. **Dermal Risk for Metals**

See Minutes Item #1.

RMD Appendix D footnotes will be revised to "Chemical-specific absorption factors available are listed in Table B.5 [38]."

Table B.5 of the RMD will be updated from the RSL table; KY ABS values will remain in the table in order to compare as an uncertainty. It was noted that the uncertainty discussion needs to be as transparent as possible.

11. **Revisit SSLs**
    See Minutes Item #1d.

12. **Difference(in calculations for exposure to Rads) between what is currently used in the (1) PORTS Risk Calculator and is used by the (2) Oak Ridge Risk Analysis Information System (RAIS); *lambda and t* are used.**
    Example equations from RAIS documentation are shown on pages 5 and 6.

    PORTS and RAIS equations correct for decay and time of release. Equations in the RMD are simpler. Paducah radionuclides of interest (specifically uranium and technetium) do not decay very fast; therefore, while the preliminary remediation goal (PRG) would be lower than if the decay rate were used, the simpler equation will be used for Paducah. If the PORTS calculator is used for Paducah in the future, their equation will need to be changed.

    NOTE: These equations were not changed for the NALs to be reviewed for the September 2012 meeting. RAIS equations were used as is with no changes, unless otherwise noted.

    This calculation needs further discussion with respect to decay correction.

13. **Example RGO Discussion (provided through Soils OU team)**
    The example text will be discussed/commented upon by e-mail. Additional information (like from Appendix D) needs to be sent.

Table D.15. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Sediment by a Recreational User[a]

Equations:

$$\textbf{Chemical Intake}\,[\textbf{mg/(kg}\times\textbf{day]} = \frac{C_{sed} \times CF \times EF \times ED \times IR \times FI}{BW \times AT}$$

$$\textbf{Radionuclide Intake}\,(\textbf{pCi}) = A_{sed} \times CF_{rad} \times EF \times ED \times IR \times FI$$

Parameter	Units	Value used	References[b]
Concentration in sediment = **C**$_{\textbf{sed}}$	mg/kg	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Activity in soil = **A**$_{\textbf{sed}}$	pCi/g	Chemical-specific	-----
Conversion factor = **CF**$_{\textbf{rad}}$	g/mg	10^{-3}	-----
Exposure frequency = **EF**	day/yr	104 (adult) 140 (child and teen)	[14]
Exposure duration = **ED**	year	12 (adult) 12 (teen) 6 (child)	[14]
Ingestion rate = **IR**	mg/day	100 (adult) 100 (teen) 200 (child)	[14]
Fraction ingested = **FI**	unitless	1	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation after [1].

[b] References follow Table D.50.

Residential Soil from RAIS

The residential soil land use equations, presented here, contain the following exposure routes:

incidental ingestion of soil,

$$PRG_{res\text{-}soil\text{-}rad\text{-}ing}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\left(1-e^{-\lambda t_{res}}\right)\times SF_o\left(\frac{risk}{pCi}\right)\times IFS_{adj}\left(\frac{120\ mg}{day}\right)\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r(30\ years)\times\left(\frac{g}{1000\ mg}\right)}$$

where

$$IFS_{adj}\left(\frac{120\ mg}{day}\right)=\frac{\left(IRS_c\left(\frac{200\ mg}{day}\right)\times ED_c(6\ years)+IRS_a\left(\frac{100\ mg}{day}\right)\times ED_r-ED_c(24\ years)\right)}{ED_r(30\ years)}$$

inhalation of particulates emitted from soil,

$$PRG_{res\text{-}soil\text{-}rad\text{-}inh}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\begin{gathered}\left(1-e^{-\lambda t_{res}}\right)\times SF_i\left(\frac{risk}{pCi}\right)\times IFA_{adj}\left(\frac{18\ m^3}{day}\right)\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r(30\ years)\times\frac{1}{PEF\left(\frac{m^3}{kg}\right)}\times\\ \left[ET_{ro}\left(\frac{0.073\ hour}{hour}\right)+\left(ET_{ri}\left(\frac{0.683\ hour}{hour}\right)\times DF_i(0.4)\right)\right]\times\left(\frac{1000\ g}{kg}\right)\end{gathered}}$$

where

$$IFA_{adj}\left(\frac{18\ m^3}{day}\right)=\frac{IRA_c\left(\frac{10\ m^3}{day}\right)\times ED_c(6\ years)+IRA_a\left(\frac{20\ m^3}{day}\right)\times ED_r-ED_c(24\ years)}{ED_r(30\ years)}$$

external exposure to ionizing radiation and

$$PRG_{res\text{-}soil\text{-}rad\text{-}ext}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\begin{gathered}\left(1-e^{-\lambda t_{res}}\right)\times SF_x\left(\frac{risk/year}{pCi/g}\right)\times ACF(0.9)\times\left[ET_{ro}+\left(ET_{ri}\times GSF(0.4)\right)\right]\times\\ EF_r\left(\frac{350\ days}{year}\right)\times\left(\frac{1\ year}{365\ days}\right)\times ED_r(30\ years)\end{gathered}}$$

Total.

$$PRG_{res\text{-}soil\text{-}rad\text{-}tot}(pCi/g)=\frac{1}{\frac{1}{PRG_{res\text{-}soil\text{-}rad\text{-}ing}}+\frac{1}{PRG_{res\text{-}soil\text{-}rad\text{-}inh}}+\frac{1}{PRG_{res\text{-}soil\text{-}rad\text{-}ext}}}$$

RADIONUCLIDE SOIL SCREENING LEVELS FOR RESIDENTS from PORTS calculator

Soil Ingestion

$$SL_{r-ing}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda t_r})\times SF_s\times IFS_{r-adj}\times EF_r\times ED_r\times\frac{g}{1000mg}}$$

$$IFS_{r-adj}\left(\frac{mg}{day}\right)=\frac{ED_{r-c}\times IRS_{r-c}+ED_{r-a}\times IRS_{r-a}}{ED_{r-a}}$$

Inhalation

$$SL_{r-inh}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda tr})\times SF_i\times IFA_{r-adj}\times EF_r\times ED_r\times\frac{1}{PEF}\times\frac{1000g}{kg}\times ET_r\times\frac{1day}{24hours}}$$

$$IFA_{r-adj}\left(\frac{m^3}{day}\right)=\frac{ED_{r-c}\times IRA_{r-c}+ED_{r-a}\times IRA_{r-a}}{ED_{r-a}}$$

External

$$SL_{r-ext}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda tr})\times SF_{ext-sv_i}\times ACF\times EF_r\times\frac{1year}{365days}\times ED_r\times[ET_{r-o}+(ET_{r-i}\times GSF_i)]}$$

Risk Assessment Working Group
Proposed Agenda—September 2012

1. **Additional changes to June 2012 Meeting Minutes.**
   Changes made and finalized.
2. **Discuss FY 13 RAWG Work Plan and Quarterly Meeting Schedule.**
   December 5, 2012—8:30-11:00 central (9:30-12:00 eastern)
   March 6, 2013—8:30-11:00 central (9:30-12:00 eastern)
   June 5, 2013—8:30-11:00 central (9:30-12:00 eastern)
   September 11, 2013—8:30-11:00 central (9:30-12:00 eastern)
   RMD is site-specific guidance for risk assessment. LATA to provide page changes for review/approval. (Include in plan for proceeding – see Item 7)
3. **Revisions to the Risk Methods Document text:**

   a. Suggest deletion of the following text from page 3-21:"The total dioxin concentration will be compared to the EPA residential cleanup level of 1 ppb toxicity equivalents (TEQs) for residential and 5 to 20 ppb TEQs for industrial scenarios (EPA 1998c), in addition to comparison to the PRGs in Appendix A."
   These levels are no longer recommended.
   EPA recommends the use of the RSL values. These are screening levels, not necessarily cleanup levels.

   b. Remove Cobalt-60 from PGDP COPC List.
   No indication Co-60 is site contaminant. Still including Co-60 in risk assessments? Would still be included in dataset, but dropped from COPC list because the Co-60 results would not be representative. This explanation would need to be included in the risk assessment write-up. IF cobalt-60 shows up in new sample data, values would be included in risk assessment [Follow up: how is gross gamma screen performed? How do we ensure we don't miss other rads (e.g., Sr-90)? Double-check with Sample Management to ensure Co-60 is in gamma library for labs—this would need to remain in the lab SOW].
   -Won't be in PRG tables.
   -Won't be in Site QAPP (footnote that Co-60 remain in lab's gamma library).

4. **Discussion to incorporate RAGS Part F.**
   RAGS Part F is the inhalation unit risk guidance.
   RMD text would be updated to refer to RAGS Part F.
   The equations in Appendix D would be updated, with reference to RAGS Part F.
   Changes to other tables?

5. **Discussion regarding PAHs text. See attached file.**
   Coal-fire facility at PGDP is likely a source for PAHs that need to be remediated.
   Comments on PAH paper expected by Wednesday, October 31. Look at doing a sitewide PAH study (using data already available, noting data within 2(?) ft of roadway and outside influence of coal plant). The purpose is to understand the concentration distribution at the site.
   Risk from PAHs could also be addressed as an uncertainty.

Follow-up: map of existing PAH samples (separated surface and subsurface), is it possible to use these samples for a sitewide study?

6. **Discussion regarding revised PTW language. Revised text box language for the Risk Methods Document is not available at this time. Discussion will be in general.**
RMD will reference EPA guidance (1991, fact sheets) and text box will be removed. "High risks lead to early actions." Principal threats discussed in RMD (esp. ROD section) will refer to EPA guidance. Also should be discussed in FS section. Figure 1.1 will reference guidance (1991).

7. **Discussion regarding revised NALs/ALs and Table B.5.**
Jerri's e-mail (text is below)– Corrections will be sent.

In addition to our previous discussions via e-mail, here are some errors/clarifications that need to be discussed tomorrow.

Chromium (total)	KY ABS	5E-02	Change to 2.5E-02 (CrVI) or 1.3E-02 (CrIII)
Manganese (diet)	KY ABS	4E-02	Change to 5E-02 (default); current value is GI ABS non-dietary exposure
Vanadium	KY ABS	2.6E-02	Change to 5E-02 (default)
1,1-Dichloroethylene	VF Res	1.02E+03	Change to 1.2E+03
1,1-Dichloroethylene	VF Ind	6.84E+02	Change to 1.2E+03
Naphthalene	KY ABS	2.5E-02	Change to 1.3E-1 (EPA ABS)

Acenaphthylene	What is surrogate source of ABS and Permeability Constant?
Phenanthrene	What is surrogate source of ABS and Permeability Constant?
PCB (high risk)	What is surrogate source of Permeability Constant?
PCB (low risk)	What is surrogate source of Permeability Constant?
PCB (lowest risk)	What is surrogate source of Permeability Constant?

Add columns for reference to ABS and permeability constant.
Ensure parameters input into RAIS calculator are transparent.
Use RSL/RAIS calculator, working through issues.
Each media to be sent separately with documentation of any issues and parameters input so that values can be reproduced.

Recommendation for any tables to be removed from RMD Appendices—(Table B.4?) TableB.5 would likely stay for documentation purposes.

First week of October: plan for proceeding, including review cycle (30 day review—keeping holidays in mind).

Risk Assessment Working Group
Agenda—December 5, 2012
and Meeting Minutes

Present:

Jerri Martin	**Tim Fredrick**	**Rich Bonczek**
Nathan Garner	**Turpin Ballard**	**Bobette Nourse**
Gaye Brewer	**Jon Richards**	**John Volpe**
Todd Mullins		**Joe Towarnicky**
		LeAnne Garner

1. **Review of the September 2012 Meeting Minutes.**
   Meeting minutes are acceptable, but need to add PAH discussion to this agenda.

2. **Discussion of Revisions sent to date.**

   a. Soil/Sediment NALs and associated write-ups
   Action level for HI = 3. Range of values for HI, based on RGO tables were 0.1, 1, and 3.
   *A footnote explaining why the action level for HI is 3 needs to be added (Might refer to Figure 1.1). Also add to introduction notes in Appendix A.
   RAIS screens were helpful.
   *Check with RAIS why the adherence factor and surface area are not input parameters available for adjustment in the calculator for the industrial worker scenario.

   b. Groundwater NALs and associated write-ups
   Action level for HI = 3. Range of values for HI, based on RGO tables were 0.1, 1, and 3. A footnote explaining why the action level for HI is 3 needs to be added (Might refer to Figure 1.1).

   c. Gamma Screens (removing Co-60 as a Paducah COPC and discussion of Pb-210)

   Current recommendation, after comments received: "Currently, contracted laboratories only report what is requested in the laboratory SOW, which typically is the PGDP COPC list.
   For <u>future</u> SOWs that are applicable (i.e., have gamma analyses), it will be requested that if cobalt-60 appears in the gamma screen above the MDA, it will be noted.
   This also will be documented in the appropriate QAPP.
   For the USEC lab, the presence of cobalt-60 will appear as a laboratory comment. For offsite labs, the presence of cobalt-60 will be reported in their case narratives; this information will then be manually input into the database systems (most likely in lab comments).
   While lead-210 is another radionuclide that has been detected in some samples onsite (notably SWMU 222), it is not expected to be a sitewide contaminant. Lead-210 may be requested as a special analysis on specific projects. On these projects, the MDC should be set at 1 pCi/g or less for lead-210 (46 KeV peak) using a thin window HPGe detector. Additionally, the counting uncertainty should be less than 50% for lead-210."

   Additional information regarding lead-210 is included in Attachment 1.

   ***What is the risk for MDC of lead-210 with no special detector?**

Residential default at 10^{-6} is 0.7 pCi/g. Industrial worker at 10^{-6} is 4 pCi/g.
***Check to see if labs would need to recalibrate equipment to see lead-210.**

d. Revisions to Risk Methods Document

— Main text

1. Discussion regarding RGO text in Section 4.1. Excerpts from guidance documents are included for reference on Pages 6 and 7.
   Text will be added to Section 4.1.4 Include information here regarding RGO and PRG revision guidance. Some discussion was in the 2001 RMD, but this was deleted during revision because the language was not accurate.
   Any revision of PRGs needs to be clear as to the reason for revision. Revising PRGs after the FS is final is not likely. The general expectation is that cleanup goals in the ROD would be the revised PRGs in the FS.
   Jerri will send state guidance if there is any.
   *Revised text will be sent out to RAWG.
2. KY Risk Assessment Branch Comments (see Pages 8-10).
   Include in Section 3.3.4.3. "(2a) General discussion of options to determine the ten or more samples." Write-up on how to handle soils data. Include example determination of EPC from grid values (from Soils OU). Revised text to be sent as scheduled. Adding this discussion for EPC calculations for soils is consistent with the groundwater EPC discussion found later in Section 3.3.4.3.
   Include rationale for choosing KDEP-specific values for dermal absorption as a footnote or text box to Section 3.3.5.2.
   Add 8b and 11b equations for inhalation pathways, since they are different using RAGS Part F guidance. Send revisions to RAWG as scheduled.

— Appendix A

1. Revised Table A.14 was sent for review.
   See comments from Jon Richards from CERCLA Cell. EPA prefers Table A.14 list 900 pCi/L as the MCL for Tc-99 and footnote the uncertainty. Other comments (especially for uranium isotopes) can be e-mailed.

— Appendix B

1. KY Risk Assessment Branch Comments (see Pages 8-10).
   Need to correct non-cancer AT (days x years), as appropriate. This is a table (presentation) error and not a AL/NAL calculation error.
   Jerri has sent a list of surrogate chemicals as follows.

Acenaphthylene → Acenaphthene

Benzo(g,h,i)perylene → Pyrene or Fluoranthene

Phenanthrene → Acenaphthene or Fluoranthene

Send revision to Appendix B as scheduled.

2.

— Appendix D

Highlight in introduction to Appendix D that the parameters shown in equations may not be the same as those used in PRG calculations and why. Revisions to be sent to RAWG as scheduled.

Also see Items 3 and 7.

Follow-up on radionuclides calculations from June meeting minutes.

Discussion regarding the addition of decay correction (i.e., lambda and t) to the equations in the Paducah Risk Methods Document.

The following is taken from the June meeting minutes:
"Difference (in calculations for exposure to Rads) between what is currently used in the (1) PORTS Risk Calculator and is used by the (2) Oak Ridge Risk Analysis Information System (RAIS); *lambda and t* are used.
Example equations from RAIS documentation are shown on Pages 11 and 12.
PORTS and RAIS equations correct for decay and time of release. Equations in the RMD are simpler. Paducah radionuclides of interest (specifically uranium and technetium) do not decay very fast; therefore, while the preliminary remediation goal (PRG) would be lower than if the decay rate were used, the simpler equation will be used for Paducah. If the PORTS calculator is used for Paducah in the future, their equation will need to be changed.
NOTE: These equations were not changed for the NALs to be reviewed for the September 2012 meeting. RAIS equations were used as is with no changes, unless otherwise noted.
This calculation needs further discussion with respect to decay correction."

Revision to Appendix D should include lambda and t. Note that PRG calculations include use of lambda and t. Revised Appendix D to be sent to RAWG as scheduled.

3. **Provisional Groundwater Background**
Values have been used as a screening tool even though they are still provisional. Should these be called final?
Many values in Table A.13 are not truly background, they are detection limits. If analyzed today, these may be lower. This is not a problem for most metals [note Arsenic background value is listed as 0.005 mg/L (a detection limit), but the MCL for Arsenic is 0.01 mg/L]. For chromium, results may need additional evaluation.
*Calculation for background value for Nickel needs to be checked.
*In Table A.13, highlight the background values based on detection limits that are greater than the MCL or, if no MCL, the residential GW NAL.
*Since the background values were originally included in Groundwater OU FS and they were never approved, leave values as "provisional."

4. **An issue to consider is how to screen XRF and isotope-specific rad detector results against background. The background we have are really not appropriate to use with results from these field techniques.**
Difference in fixed-base and field-base results should be noted in RMD as an uncertainty—XRF results are likely higher than fixed-base results. If it is agreed that the XRF data is of sufficient quality to determine risk, the uncertainty should not drive decision.
Add this as a bullet to Section 3.3.1. Also add to page 3-16 (discussion of XRF).

5. **For SSLs derived from RESRAD, consider verification that the DCFs and dose calculation are consistent with requirements in DOE Order 458.1. Thus must make sure ICRP 60 and ICRP 72 were used.**

SSL are derived using a spreadsheet from RESRAD inputs. Need to make sure the dose-based PRGs are correct. Tables in Appendix A will be evaluated with an update and/or revised tables to the RAWG as scheduled. See #7, below.

6. **Review exposure times for residents; currently we are using 24 hours/day.**

Table D.8 in the Risk Methods Document lists the equation and reasonable maximum exposure assumptions for external exposure to ionizing radiation from soil.
The exposure frequency (EF) is 350/365 day/day.
The gamma exposure time (ET) factor is 24/24 hr/hr.

A question was raised during review of the proposed Paducah Soil/Sediment No Action Levels as to why outdoor and indoor exposure times encoded by RAIS (0.073 hr/hr and 0.683 hr/hr, respectively) for the rad PRGs did not equal 1 hr/hr. The exposure time for the resident outside (ETro) and exposure time for the resident inside (ETri) assumed by RAIS allows for time spent away from home. The default scenario for the resident is 18 hr/day, 350 days/yr.

Should the Paducah default scenario remain as it is or should the equation and exposure assumptions be revised to account for indoor and outdoor time (i.e., gamma shielding applied for indoor time and not for outdoor time) and should the time be 18 hr/day instead of 24?

Exposure time in this instance only applies to external gamma exposure. These exposure times should be changed to be consistent, so that the default scenario is 18 hr/day, 350 days/yr. Changes will be reflected in Appendix D and Table B.4. Additionally, revisions to dose PRGs/SSLs will be necessary (see #6 above).

7. **Reporting soil sample results on a dry weight basis.**

LATA has noted that the industry accepted practice is for laboratories to report soil samples on a dry weight corrected basis. Because of the increase in soil projects going to the field, we believed that this was a good time to discuss a change with the USEC Analytical Lab.
The topic was discussed at length with the USEC lab recently and also input was enlisted from DOECAP auditors who were on sight at the time. As a result of those conversations, we believe we have a pathforward on this process; LATA has asked them to analyze one aliquot for moisture and enter that result in LIMS. Then, as other analyses are completed (metals, volatiles, etc) are completed, the LIMS system will perform a dry weight correction utilizing the one moisture result that was entered in the system. This way, all analyses for the sample are adjusted utilizing the same correction factor. Therefore, the resulting values reported by the lab will be based on a dry weight basis.

These changes may take a little while, so they may not be able to make the corrections within LIMS to start the process immediately, but we directed them to conduct (and report) moisture analysis on our next upcoming project (SWMU 4). This data can be presented on either an “as received” basis or dry weight corrected basis.

The key for this will be how to use historical data.

*Uncertainties will need to be captured in project-specific documents. Also include in RMD as a potential uncertainty in Section 3.3.7.1 and also Step 2 on page 3-16. Revision to be sent as scheduled.
*Send update to RAWG with method the lab is using to determine moisture.
Drying samples is part of CLP

As an update, the method shown below was sent to the group on 12/17/2012, as the method the USEC lab will be using to determine moisture:

> ASTM D2974-07a, Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

EPA supplied the following information:
Usually, each method would include the % moisture, but if the sample is reasonably homogenous, then one analysis applied to all aliquots should work. In the methods, VOAs do not require drying as it is a closed-system and the vial is loaded directly to the machine with any interaction being performed via the septum seal. Drying would create loss of contaminants. For extractables (SemiVOA, Pest, PCB, etc), the sample does have any standing water decanted off and then is mixed with sodium sulfate or Hydromatrix, so it doesn't go into the extraction all soupy exactly. For Metals, there isn't really a discussion or rationale and usually we don't even decant, though that optionally be done. There are definitely arguments out there that we should be doing better homogenization and particle size partitioning for Metals and drying would be a part of that. (Hg might not be amenable to drying without contaminant loss.) Overall, I think it comes down to trying to bring the sample into the process as close to its natural state in the environment as possible. A high moisture sample is often problematic, though, and we do ask the field to try to minimize the moisture content to the extent possible when collecting. Some references are SW-846 3500 (generic extraction methodology) at http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm. In the CLP SOWs, most relevant discussion is in Exhibit D, Section 10 of each method where the sample prep is discussed. See SOM01.2 and ISM01.3 at www.epa.gov/superfund/program/clp.

8. Add PAH discussion to agenda.

The intent of the PAH paper was to send a recommendation to the FFA managers for how we propose to handle PAHs in risk assessments and why. A map of existing PAH samples is due to the RAWG January 4. Comments from EPA on paper may be available mid January.

Next meeting: March 6. Between now and then individual meetings may need to take place in order to facilitate revisions to RMD.

***Schedule for Revisions will be sent following this meeting.**

Revisions to Risk Methods Document

Excerpts from Guidance Documents Regarding RGO Text

In RAGS Volume 1 Part B it is stated:

From Section 2.3 Future Land Use

"When waste will be managed onsite, land-use assumptions and risk-based PRG development become more complicated because the assumptions for the site itself may be different from the land use in the surrounding area. For example, if waste is managed onsite in a residential area, the risk-based PRGs for the ground water beneath the site (or at the edge of the waste management unit) may be based on residential exposures, but the risk-based PRGs for the site soils may be based on an industrial land use with some management or institutional controls."

From Section 2.8 Modification of Preliminary Remediation Goals

"Upon completion of the baseline risk assessment (or as soon as data are available), it is important to review the future land use, exposure assumptions, and the media and chemicals of potential concern originally identified at scoping, and determine whether PRGs need to be modified. Modification may involve adding or subtracting chemicals of concern, media, and pathways or revising individual chemical-specific goals."

RAGS Volume 1 Part B also includes the following in a text box:

NCP PREAMBLE: EXPOSURE, TECHNICAL, AND UNCERTAINTY FACTORS (55 Federal Register 8717, March 8, 1990)

"Preliminary remediation goals ... may be revised ... based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and crossmedia impacts of alternatives. Factors related to uncertainty may include: the reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria .... "

Revisions to Risk Methods Document
Excerpts from Guidance Documents Regarding RGO Text
Continued

Finally, OSWER DIRECTIVE 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" states:

In USE OF BASELINE RISK ASSESSMENT TO MODIFY PRELIMINARY REMEDIATION GOALS

"Remediation goals developed under CERCLA section 121 are generally medium-specific chemical concentrations that will pose no unacceptable threat to human health and the environment. Preliminary remediation goals are developed early in the RI/FS process based on ARARs and other readily available information, such as concentrations associated with 10(-6) cancer risk or a hazard quotient equal to one for noncarcinogens calculated from EPA toxicity information. These preliminary goals may be modified based on results of the baseline risk assessment, which clarifies exposure pathways and may identify situations where cumulative risk of multiple contaminants or multiple exposure pathways at the site indicate the need for more or less stringent cleanup levels than those initially developed as preliminary remediation goals. In addition to being modified based on the baseline risk assessment, preliminary remediation goals and the corresponding cleanup levels may also be modified based on the given waste management strategy selected at the time of remedy selection that is based on the balancing of the nine criteria used for remedy selection (55 Fed. Reg. at 8717 and 8718)."

Comments to Risk Methods Document

Received from KY Risk Assessment Branch

Main Text

3.3.4.3 Quantification of Exposure

- Discussion of how the grid values will be determined should be included, similar to the following:

  Grid values were determined following guidance in the work plan. Basically, the maximum detected result from within the grid applies to the grid. If not detected, the minimum detection limit applies to the grid.

  If a grid had no result (detect or non-detect) for the COPC, an average of the results for the grids with results was used.

NO RESULT	RESULT = 9	NO RESULT	RESULT = 2
RESULT = 7	NO RESULT	RESULT = 3	NO RESULT
RESULT = 3	NO RESULT	RESULT = 5	RESULT = 5

  For grids with "NO RESULT," the average of the grids with results was used.
  (9+2+7+3+3+5+5)/7= 4.857143

  The UCL95 would be calculated from the following:

4.857143	9	4.857143	2
7	4.857143	3	4.857143
3	4.857143	5	5

3.3.5.2 Sources of toxicity information

- Discussion of the "KDEP-specific values for dermal absorption" should be included, such as the following:

In RAGS E 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows:

Beryllium	0.007 = 0.7%
Chromium III	0.013 = 1.3%
Chromium VI	0.025 = 2.5%
Manganese	0.04 = 4%
Nickel	0.04 = 4%
Silver	0.04 = 4%
Vanadium	0.026 = 2.6%

This is in addition to the chemical-specific dermal absorption fractions listed in Exhibit 3-4, including:

Arsenic	0.03 = 3%
Cadmium	0.001=0.1%

Equation 8, Page 64

- The RfD_i is not interchangeable with the RfC.

  RfD_i (mg/kg-day) = RfC (mg/m^3) x 20 m^3/day ÷ 70 kg

Equation 11, page 64

- The SF_i is not interchangeable with the inhalation unit risk (IUR)

  SF_i (kg-day/mg) = IUR ($m^3/\mu g$) x (20 $m^3/\text{day})^{-1}$ x 70 kg x 10^3 μg/mg

Appendix B

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs

- General Parameters – Averaging time – noncancer (AT-N)

  It appears that instead of multiplying the number of years times the number of days in the year, the number of years is multiplied by 70 instead of 365…this must be corrected.

- Inhalation RGA Groundwater (Table D.2, D.27)

  It appears that instead of multiplying the number of years times the number of days in the year times the number of hours in the day, the number of years times the number of hours in the day is multiplied by 70 instead of 365…this must be corrected.

Table B.5 Toxicity Values and Information Used in PRG Derivation

- Acenaphthylene → use acenaphthene toxicity values (e.g., oral reference dose, absorbed dose)

- Acrylonitrile → absorbed dose slope factor (5.4E-01) should be added to the table

- Carbazole → absorbed dose slope factor (2.0E-02) should be added to the table

- U-235+D → the external exposure slope factor listed is for U-235, not U-235+D; the SFe Reference lists FGR12*, but there is no explanation of the "*"

Notes on Table B.5

- Note 15 should include information (or location of such) given above in the comment for the main text Section 3.3.5.2 (copied below)

  In RAGS E 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows:

Beryllium	0.007 = 0.7%
Chromium III	0.013 = 1.3%
Chromium VI	0.025 = 2.5%
Manganese	0.04 = 4%
Nickel	0.04 = 4%
Silver	0.04 = 4%
Vanadium	0.026 = 2.6%

  This is in addition to the chemical-specific dermal absorption fractions listed in Exhibit 3-4, including:

Arsenic	0.03 = 3%
Cadmium	0.001=0.1%

Radionuclides Calculations

Residential Soil from RAIS

The residential soil land use equations, presented here, contain the following exposure routes:

incidental ingestion of soil,

$$PRG_{res\text{-}sol\text{-}rad\text{-}ing}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\left(1\text{-}e^{-\lambda t_{res}}\right)\times SF_{s}\left(\frac{risk}{pCi}\right)\times IFS_{adj}\left(\frac{120\ mg}{day}\right)\times EF_{r}\left(\frac{350\ days}{year}\right)\times ED_{r}(30\ years)\times\left(\frac{g}{1000\ mg}\right)}$$

where

$$IFS_{adj}\left(\frac{120\ mg}{day}\right)=\frac{\left(IRS_{c}\left(\frac{200\ mg}{day}\right)\times ED_{c}(6\ years)+IRS_{a}\left(\frac{100\ mg}{day}\right)\times ED_{r}\text{-}ED_{c}(24\ years)\right)}{ED_{r}(30\ years)}$$

inhalation of particulates emitted from soil,

$$PRG_{res\text{-}sol\text{-}rad\text{-}inh}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\begin{array}{c}\left(1\text{-}e^{-\lambda t_{res}}\right)\times SF_{i}\left(\frac{risk}{pCi}\right)\times IFA_{adj}\left(\frac{18\ m^{3}}{day}\right)\times EF_{r}\left(\frac{350\ days}{year}\right)\times ED_{r}(30\ years)\times\frac{1}{PEF\left(\frac{m^{3}}{kg}\right)}\times\\ \left[ET_{ro}\left(\frac{0.073\ hour}{hour}\right)+\left(ET_{ri}\left(\frac{0.683\ hour}{hour}\right)\times DF_{i}(0.4)\right)\right]\times\left(\frac{1000\ g}{kg}\right)\end{array}}$$

where

$$IFA_{adj}\left(\frac{18\ m^{3}}{day}\right)=\frac{IRA_{c}\left(\frac{10\ m^{3}}{day}\right)\times ED_{c}(6\ years)+IRA_{a}\left(\frac{20\ m^{3}}{day}\right)\times ED_{r}\text{-}ED_{c}(24\ years)}{ED_{r}(30\ years)}$$

external exposure to ionizing radiation and

$$PRG_{res\text{-}sol\text{-}rad\text{-}ext}(pCi/g)=\frac{TR\times t_{res}\times\lambda}{\begin{array}{c}\left(1\text{-}e^{-\lambda t_{res}}\right)\times SF_{x}\left(\frac{risk/year}{pCi/g}\right)\times ACF(0.9)\times\left[ET_{ro}+\left(ET_{ri}\times GSF(0.4)\right)\right]\times\\ EF_{r}\left(\frac{350\ days}{year}\right)\times\left(\frac{1\ year}{365\ days}\right)\times ED_{r}(30\ years)\end{array}}$$

Total.

$$PRG_{res\text{-}sol\text{-}rad\text{-}tot}(pCi/g)=\frac{1}{\frac{1}{PRG_{res\text{-}sol\text{-}rad\text{-}ing}}+\frac{1}{PRG_{res\text{-}sol\text{-}rad\text{-}inh}}+\frac{1}{PRG_{res\text{-}sol\text{-}rad\text{-}ext}}}$$

Radionuclides Calculations
Continued

RADIONUCLIDE SOIL SCREENING LEVELS FOR RESIDENTS from PORTS calculator

Soil Ingestion

$$SL_{r-ing}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda t_r})\times SF_s\times IFS_{r-adj}\times EF_r\times ED_r\times\frac{g}{1000mg}}$$

$$IFS_{r-adj}\left(\frac{mg}{day}\right)=\frac{ED_{r-c}\times IRS_{r-c}+ED_{r-a}\times IRS_{r-a}}{ED_{r-a}}$$

Inhalation

$$SL_{r-inh}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda tr})\times SF_i\times IFA_{r-adj}\times EF_r\times ED_r\times\frac{1}{PEF}\times\frac{1000g}{kg}\times ET_r\times\frac{1day}{24hours}}$$

$$IFA_{r-adj}\left(\frac{m^3}{day}\right)=\frac{ED_{r-c}\times IRA_{r-c}+ED_{r-a}\times IRA_{r-a}}{ED_{r-a}}$$

External

$$SL_{r-ext}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\times\lambda}{(1-e^{-\lambda tr})\times SF_{ext-sv_i}\times ACF\times EF_r\times\frac{1year}{365days}\times ED_r\times[ET_{r-o}+(ET_{r-i}\times GSF_i)]}$$

ATTACHMENT 1
LEAD-210 at PGDP
Sent by e-mail 11/14/2012

Lead-210 at PGDP

Lead-210 is a radioactive form of lead, having an atomic weight of 210. It is one of the last elements created by the radioactive decay of the isotope uranium-238 (see Figure 1). Lead-210 forms naturally in the sediments and rocks that contain uranium-238, as well as in the atmosphere, a by-product of radon gas. Within 10 days of its creation from radon, lead-210 falls out of the atmosphere. It accumulates on the surface of the earth where it is stored in soils, lake and ocean sediments, and glacial ice. The lead-210 eventually decays into a non-radioactive form of lead. Lead-210 has a half-life of 22.3 years and is a significant source of beta radiation (USGS 2012, EPA 2012).

Lead-210 is not an easy analysis to perform and typically is not included in a regular gamma radiological scan; it has a peak at 46 KeV and requires a thin window detector and an efficiency curve using a standard with lead-210. Therefore, historical data was reviewed to ensure the analysis was necessary. Since lead-210 is found significantly down the decay chain for uranium-238 through radon-222, activities performed over the past 60 years at PGDP cannot have resulted in PGDP-sourced lead-210.

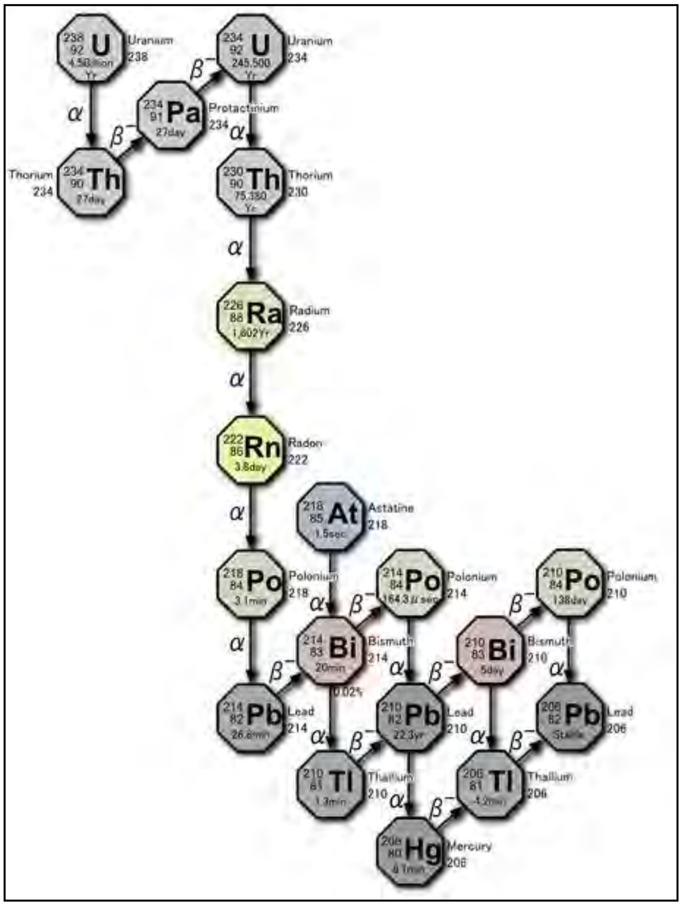

Figure 1. Lead-210 Decay Chain

Available PGDP lead-210 data was plotted to estimate an approximate background value. This map is shown in Figure 2. Since the majority of the available data is historical, data quality is not certain. However, is appears that the higher lead-210 activities within the PGDP boundaries are at background values.

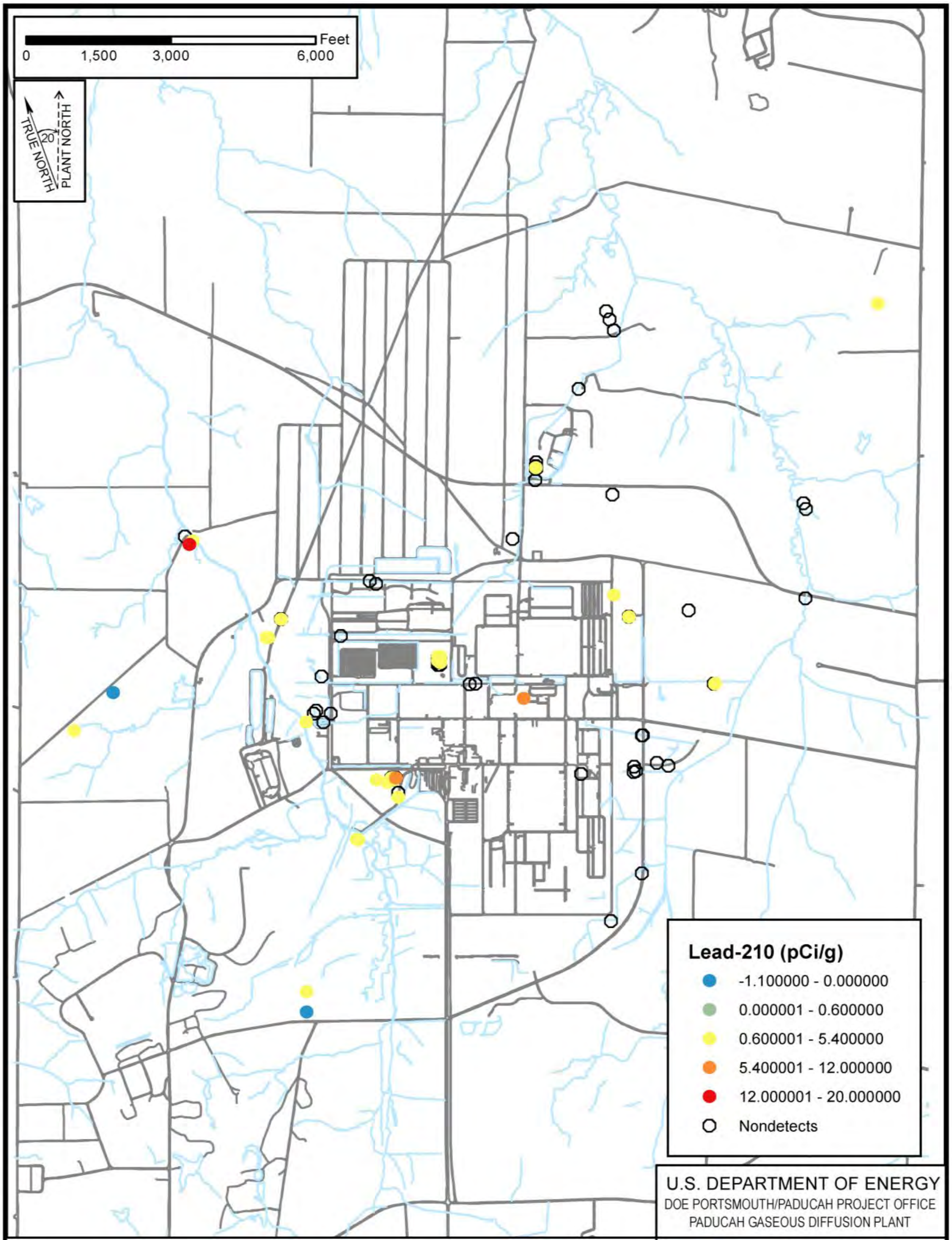

Figure 2. Lead-210 Soil/Sediment Samples

LATA Environmental Services of Kentucky, LLC

Figure No. Lead-210_Soil.mxd
DATE 11-01-2012

Data indicate higher levels of lead-210 inside the PGDP boundary at SWMU 222, although radium-226 was not reported for the majority of these samples. The one sample that had radium-226 reported had a significant difference in activity between the radium-226 and its ingrowth radionuclides lead-214 and bismuth-214. If radium-226 is truly at 11 pCi/g as reported in that sample, and the analysis was conducted properly (ingrowth for 30 days in a sealed container), the lead-214 and bismuth-214 activity should have equaled the radium-226 activity. Under these analysis conditions the activity of Pb-210 would not be in secular equilibrium with radium-226. The fact that the lead-210 is elevated in the samples suggests a possible separate source of lead-210 rather than ingrowth. Lead-210, which has a 22-year half life, is included in the list of short-lived radionuclides associated with radium-226 for completeness, as this isotope and its short-lived decay products are typically present with radium-226.

After processing, radionuclides with half-lives less than one year will reestablish equilibrium conditions with their longer-lived parent radionuclides within several years. For this reason, at processing sites what was once a single, long decay series (for example the series for uranium-238) may be present as several smaller decay series headed by the longer-lived decay products of the original series (that is, headed by uranium-238, uranium-234, thorium-230, radium-226, and lead-210 in the case of uranium-238). Each of these sub-series can be considered to represent a new, separate decay series. Understanding the physical and chemical processes associated with materials containing uranium, thorium, and radium is important when addressing associated radiological risks.

Detected lead-210 results available for PGDP were listed alongside radium-226 and uranium-238 results in Table 1. Lead-210 would be expected to be in equilibrium (i.e., similar activity results) with uranium-238 for instances of natural uranium. Lead-210 would be expected to be in equilibrium with radium-226 for instances of enriched uranium. No split samples are available; however, a surrogate to a "split" could be simply looking at the uranium-238 to lead-210 ratio in samples, where available. For example, if lead-210 is a true contaminant, then it should exceed the uranium-238 level, when the uranium-238 is at background in at least some samples.

A further check of the available data was performed by filtering the activity results against minimum detectable activities and counting uncertainties. The only samples that passed both checks are shown in Table 2. Recent Soils OU soils data passed both checks.

Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
194-01,02	301043	9	LOCK	20.00	0.02			Yes					No	0.60		0.10		Yes
JP-0092	DOJ1-99-0092		PGDP	14.55	18.18	29.10	29.10	No	0.77	0.31	1.53	1.53	No	4386.00	4.20	89.00	1117.00	Yes
194-01,02	301048	20	LOCK	12.00	0.05			Yes					No	1.30		0.16		Yes
SWMU222-4	2010-53093[a]		KYRAD	10.60	2.05	1.03		Yes					No	27.80	1.62	1.12		Yes
SWMU222-4	2010-53093		KYRAD	10.60	2.05	1.03		Yes					No	27.80	0.03	2.33		Yes
SWMU222-5	2010-53094[b]		KYRAD	8.60	1.47	0.76		Yes					No	32.30	0.04	2.66		Yes
SWMU222-1	2010-53090[b]		KYRAD	8.44	1.71	0.87		Yes					No	23.70	0.13	2.10		Yes
194-01,02	301044	11.33	LOCK	8.00	0.03			Yes					No	0.61		0.11		Yes
SWMU222-2	2010-53091[b]		KYRAD	6.98	1.41	0.71		Yes					No	22.10	0.04	1.94		Yes
SWMU222-3	2010-53092[b]		KYRAD	6.81	1.14	0.61		Yes					No	16.70	0.03	1.51		Yes
SOU195-120A	2010-51253[a]	1	KYRAD	6.57	9.25	3.83		No	2.53	2.08	0.94		Yes	3.94	2.41	1.36		Yes
SOU195-014C	2010-51264[a]	10	KYRAD	6.01	5.28	2.16		Yes	1.44	1.27	0.57		Yes	2.25	0.93	0.84		Yes
194-01,02	301047	18.6	LOCK	5.40	0.00			Yes					No	0.90		0.13		Yes
SWMU222-1	2010-52457[b]		KYRAD	4.92	0.82	0.41		Yes					No	31.30	0.05	3.59		Yes
JP-0160	DOJ1-99-0160		PGDP	4.31	1.79	2.11	2.28	Yes	0.71	1.64	1.42	1.42	No	2.70	0.93	0.52	1.41	Yes
BCBOKYRAD01	2010-50535[a]		KYRAD	4.27	0.46	0.25		Yes	2.35	0.87	0.39		Yes	2.22	0.47	0.22		Yes
LBC2L020	LBCSOSU2S1-04	1	STLMO	4.20	2.00		1.70	Yes	0.80	0.21		0.25	Yes	3.90	1.50		1.40	Yes
RSO3	110013[c]		STLMO	3.90	1.90	1.90		Yes					No					No
JP-0152	DOJ1-99-0152		PGDP	3.76	5.96	7.52	7.52	No	0.84	0.12	1.69	1.69	No	208.00	0.04	3.30	42.00	Yes
H01,05,15	301025	0.7	LOCK	3.70	0.00			Yes					No	0.96		0.10		Yes
SOU195-014A	2010-51258[a]	10	KYRAD	3.56	5.07	2.13		No	1.40	1.10	0.50		Yes	1.54	0.90	0.79		Yes
RSO3	110012[c]		STLMO	3.50	1.40	1.20		Yes					No					No
BC5KYRAD01	2010-50537[a]		KYRAD	3.43	0.36	0.21		Yes	2.06	0.71	0.32		Yes	1.37	0.32	0.15		Yes
C12,18,19	301012[d]	2	LOCK	3.20	0.00			Yes					No	0.97		0.09		Yes
A10	PLDJNSA10-01SO	2.5	PGDP	3.10	5.90	6.20	6.20	No	0.16	0.07	0.01	0.08	Yes	6.60	0.05	0.35	0.89	Yes
LBC2L015	LBCSOSU2S1-03	1	STLMO	3.00	2.90		2.40	Yes	1.21	0.26		0.30	Yes	1.25	0.01		0.18	Yes
JP-0161	DOJ1-99-0161		PGDP	2.92	1.93	2.07	2.10	Yes	0.83	0.17	1.66	1.66	No	2.30	1.02	0.51	3.21	No
SOU200-004	2010-51270[a]	4	KYRAD	2.81	5.18	2.19		No	2.51	1.31	0.61		Yes	1.48	0.88	1.19		Yes
F04,02,29	301005	0.8	LOCK	2.80	0.00			Yes					No	0.82		0.08		Yes
SOU195-120C	2010-51252[a]	1	KYRAD	2.70	0.62	0.32		Yes	1.67	0.90	0.41		Yes	1.02	0.52	0.29		Yes
K008-AIP-RP	030301	0	STLMO	2.70	1.20	1.10		Yes					No	1.71	0.33	0.98		Yes
C07,08,09	301013[d]	0.9	LOCK	2.70	0.00			Yes					No	1.04		0.09		Yes
NST2S04	BJC2041SS	8	PGDP	2.65	2.40	2.50	2.60	Yes	2.43	0.33	4.85	4.85	No	4.11	1.24	0.66	2.11	Yes
SOU222-001	2010-51277[a]	0.5	KYRAD	2.57	0.59	0.76		Yes	11.10	1.30	0.71		Yes	19.62	0.76	0.65		Yes
BCBOKYRAD02	2010-50536[a]		KYRAD	2.51	0.71	0.33		Yes	7.18	1.17	0.56		Yes	10.26	0.87	0.46		Yes
F12,20,22	301004	1.5	LOCK	2.46	0.00			Yes					No	0.90		0.08		Yes
H04,06,09	301023	0.8	LOCK	2.45	0.00			Yes					No	0.84		0.09		Yes
JP-0019	DOJ1-99-0017		PGDP	2.44	16.16	4.87	10.54	No	1.06	0.29	2.11	2.11	No	2270.00	9.14	16.30	609.00	Yes
C12,18,19	301011[d]	0.8	LOCK	2.40	0.00			Yes					No	1.06		0.10		Yes
196-03,04	301038	6.67	LOCK	2.40	0.00			Yes					No	0.80		0.12		Yes
C01,10,24	301017[d]	0.7	LOCK	2.30	0.00			Yes					No	0.95		0.10		Yes
F05,07,17	301008	1.6	LOCK	2.20	0.00			Yes					No	0.86		0.09		Yes
C07,08,09	301015[d]	0.9	LOCK	2.09	0.00			Yes					No	1.00		0.10		Yes

Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
JP-0046	DOJ1-99-0046		PGDP	2.07	1.91	2.03	2.00	Yes	0.70	0.13	1.40	1.40	No	13.90	1.00	1.43	4.00	Yes
A2	PLDJNSA2D-01SO	8.5	PGDP	2.00	6.00	4.10	4.10	No	0.59	0.13	1.10	1.10	No	0.77	0.24	0.39	1.37	No
H04,06,09	301022	2.6	LOCK	1.90	0.00			Yes					No	1.01		0.10		Yes
F12,20,22	301001	0.8	LOCK	1.90	0.00			Yes					No	0.90		0.08		Yes
SOU195-014A	2010-51256[a]	4	KYRAD	1.89	5.01	2.14		No	1.55	1.16	0.52		Yes	1.12	0.93	1.18		No
F04,02,29	301006	1.5	LOCK	1.85	0.00			Yes					No	0.82		0.08		Yes
JP-0160	DOJ1-99-0177		PGDP	1.84	2.62	3.68	3.68	No	0.65	0.12	1.30	1.30	No	2.01	0.91	1.08	3.57	No
K008-AIP-RP	030303	0	STLMO	1.80	1.10	1.30		Yes	0.80	0.30	0.28		Yes	2.30	0.30	1.10		Yes
C02,03,20	301019[d]	0.7	LOCK	1.80	0.00			Yes					No	1.03		0.10		Yes
BC5KYRAD02	2010-50538[a]		KYRAD	1.74	0.90	0.42		Yes	2.01	1.56	0.70		Yes	0.69	0.93	0.55		Yes
194-05,06	301039	9	LOCK	1.72	0.00			Yes					No	0.79		0.12		Yes
194-03,04	301045[e]	16	LOCK	1.68	0.00			Yes					No	1.06		0.14		Yes
A2	PLDJNSA2-02SO	11.5	PGDP	1.60	6.60	3.30	4.40	No	1.10	0.18	2.20	2.20	No	1.69	0.86	1.03	3.04	No
F01,21,23	301009	0.8	LOCK	1.60	0.00			Yes					No	0.92		0.08		Yes
C02,03,20	301020[d]	3	LOCK	1.59	0.00			Yes					No	1.00		0.09		Yes
H01,05,15	301026	2.6	LOCK	1.57	0.00			Yes					No	0.87		0.08		Yes
C07,08,09	301014[d]	2.1	LOCK	1.56	0.00			Yes					No	0.94		0.08		Yes
JP-0157	DOJ1-99-0157		PGDP	1.56	4.07	3.11	3.11	No	0.90	0.16	1.80	1.80	No	108.00	1.80	2.95	29.10	Yes
JP-0113	DOJ1-99-0115		PGDP	1.54	1.60	1.68	1.69	No	0.49	0.12	0.97	0.97	No	6.02	0.88	1.33	3.23	Yes
C07,08,09	301016[d]	2.1	LOCK	1.51	0.00			Yes					No	0.91		0.08		Yes
H04,06,09	301021	0.8	LOCK	1.50	0.00			Yes					No	0.94		0.10		Yes
F12,20,22	301003	1.5	LOCK	1.50	0.00			Yes					No	0.92		0.09		Yes
K008-AIP-RP	030302	0	STLMO	1.49	1.20	0.82		Yes					No	0.76	0.26	0.56		Yes
BC14KYRAD	2010-50539[a]		KYRAD	1.49	0.68	0.32		Yes	1.94	1.52	0.67		Yes	1.64	0.70	0.40		Yes
JP-0075	DOJ1-99-0075		PGDP	1.48	4.62	2.97	2.97	No	1.24	0.16	2.48	2.48	No	14.80	1.54	2.05	6.04	Yes
194-03,04	301036[e]	8	LOCK	1.48	0.00			Yes					No	0.80		0.12		Yes
H02,10,18	301027	0.7	LOCK	1.44	0.00			Yes					No	1.00		0.11		Yes
F12,20,22	301002	0.8	LOCK	1.40	0.00			Yes					No	0.93		0.09		Yes
SOU195-014A	2010-51257[a]	7	KYRAD	1.38	0.70	0.32		Yes	2.12	1.07	0.49		Yes	1.11	0.58	0.38		Yes
JP-0090	DOJ1-99-0090		PGDP	1.37	2.21	2.74	2.74	No	0.77	0.14	1.55	1.55	No	22.00	0.02	0.75	3.30	Yes
OUTFALL10-1	WC02-242	4	PORTS	1.36	0.67	0.68	0.68	No	0.94	0.32	0.22	0.37	No	0.67	0.05	0.12	0.21	Yes
SOU195-014C	2010-51262[a]	4	KYRAD	1.31	0.79	0.36		Yes	2.30	1.59	0.71		Yes	0.49	0.97	0.46		Yes
JP-0062	DOJ1-99-0062		PGDP	1.31	2.95	2.61	2.61	No	0.71	0.13	1.41	1.41	No	4.01	1.17	1.62	3.02	Yes
F01,21,23	301010	1.6	LOCK	1.26	0.00			Yes					No	0.82		0.08		Yes
SWMU222-4	2010-52458[a]		KYRAD	1.25	0.48	0.22		Yes					No	1.52	0.44	0.29		Yes
JP-0163	DOJ1-99-0163		PGDP	1.22	2.94	2.45	2.45	No	0.97	0.23	1.93	1.93	No	3.23	1.36	0.78	1.76	Yes
NST2S02	BJC2021SS	3	PGDP	1.20	2.87	2.41	2.41	No	0.64	0.18	1.28	1.28	No	104.00	0.31	3.50	21.00	Yes
194-01,02	301040	6.75	LOCK	1.20	0.00			Yes					No	0.79		0.12		Yes
194-05,06	301050	17.5	LOCK	1.20	0.00			Yes					No	0.71		0.11		Yes
SOU195-014	2010-51255[a]	10	KYRAD	1.20	0.88	0.36		Yes	1.89	1.50	0.67		Yes	0.74	0.97	0.51		Yes
SOU195-014B	2010-51260[a]	7	KYRAD	1.17	0.64	0.30		Yes	2.25	0.91	0.43		Yes	0.79	0.56	0.35		Yes
194-05,06	301042	11.5	LOCK	1.17	0.00			Yes					No	0.72		0.11		Yes
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10		0.12		Yes

Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10				Yes
SOU195-006	2010-51265[a]	7	KYRAD	1.09	0.73	0.33		Yes	2.13	1.16	0.53		Yes	0.86	0.57	0.34		Yes
SOU195-025	2010-51250[a]	7	KYRAD	1.09	0.84	0.38		Yes	2.41	1.65	0.73		Yes	1.05	0.72	0.52		Yes
SOU195-014B	2010-51261[a]	10	KYRAD	1.08	0.96	0.43		Yes	1.46	1.45	0.64		Yes	0.77	0.69	0.44		Yes
SOU200-009	2010-51275[a]	4	KYRAD	1.08	5.15	2.23		No	1.87	1.32	0.60		Yes	1.08	0.93	0.88		Yes
H02,10,18	301028	3	LOCK	1.07	0.00			Yes					No	0.92		0.08		Yes
JP-0162	DOJ1-99-0162		PGDP	1.05	1.94	2.10	2.10	No	0.84	0.16	1.67	1.67	No	1.63	0.91	0.47	2.29	No
194-03,04	301041[e]	12	LOCK	1.04	0.00			Yes					No	0.81		0.12		Yes
SOU200-005	2010-51271[a]	4	KYRAD	1.04	0.89	0.40		Yes	2.15	1.57	0.70		Yes	1.64	0.99	0.64		Yes
SOU195-014C	2010-51263[a]	7	KYRAD	1.03	1.04	0.46		No	1.73	1.32	0.59		Yes	0.90	0.75	0.45		Yes
SOU195-025	2010-51251[a]	10	KYRAD	1.02	0.77	0.35		Yes	1.91	1.46	0.66		Yes	1.17	1.07	0.62		Yes
JP-0091	DOJ1-99-0091		PGDP	1.01	2.08	2.02	2.02	No	0.82	0.14	1.64	1.64	No	12.70	1.24	1.72	3.82	Yes
NST1S01	BJC1011SS	2.5	PGDP	1.01	3.31	2.02	2.02	No	0.65	0.19	1.29	1.29	No	65.90	1.87	2.87	18.00	Yes
SOU200-008	2010-51274[a]	4	KYRAD	1.01	0.70	0.32		Yes	1.88	1.18	0.53		Yes	1.01	0.56	0.32		Yes
H04,06,09	301024	2.6	LOCK	1.00	0.00			Yes					No	0.94		0.09		Yes
OUTFALL10-1	WC02-242D	4	PORTS	0.99	0.63	0.64	0.65	No	0.87	0.29	0.25	0.31	No	0.68	0.07	0.13	0.46	Yes
SOU195-014B	2010-51259[a]	4	KYRAD	0.99	0.92	0.41		Yes	1.62	1.32	0.59		Yes	0.93	0.99	0.56		Yes
JP-0018	DOJ1-99-0016		PGDP	0.96	4.68	1.92	2.81	No	0.64	0.14	1.28	1.28	No	188.00	0.05	2.30	32.00	Yes
OUTFALL10-2	WC02-243	4	PORTS	0.96	0.68	0.63	0.64	No	0.82	0.31	0.28	0.31	No	0.63	0.02	0.13	0.21	Yes
SOU200-006	2010-51272[a]	4	KYRAD	0.95	0.66	0.30		Yes	2.67	1.09	0.51		Yes	0.94	0.57	0.38		Yes
SOU200-001	2010-51267[a]	4	KYRAD	0.94	0.83	0.37		Yes	2.73	1.33	0.61		Yes	1.06	0.70	0.39		Yes
SOU200-010	2010-51276[a]	4	KYRAD	0.89	0.94	0.42		No	1.75	1.47	0.65		Yes	0.76	0.69	0.36		Yes
SOU195-006	2010-51266[a]	10	KYRAD	0.88	0.78	0.35		Yes	1.98	1.52	0.68		Yes	1.51	0.98	0.63		Yes
JP-0081	DOJ1-99-0081		PGDP	0.87	1.43	1.75	1.75	No	0.61	0.11	1.22	1.22	No	3.60	0.01	0.17	0.47	Yes
SOU200-003	2010-51269[a]	4	KYRAD	0.86	0.92	0.41		No	2.22	1.27	0.57		Yes	0.74	0.69	0.50		Yes
JP-0015	DOJ1-99-0013		PGDP	0.81	1.66	1.62	1.62	No	0.62	0.13	1.23	1.23	No	3.16	0.82	1.25	1.99	Yes
H03,07,13	301030	3	LOCK	0.80	0.00			Yes					No	0.83		0.08		Yes
NST1S03	BJC1031SS	12	PGDP	0.79	1.55	1.59	1.59	No	0.80	0.18	1.60	1.60	No	0.66	0.04	0.11	0.13	Yes
JP-0080	DOJ1-99-0080		PGDP	0.73	1.91	1.46	1.46	No	0.82	0.15	1.64	1.64	No	2.39	0.94	0.47	3.33	No
SOU195-014	2010-51254[a]	7	KYRAD	0.71	0.74	0.33		No	1.72	1.50	0.66		Yes	0.54	0.70	0.44		Yes
LBC2L005	LBCSOSU2S1-01	1	STLMO	0.70	2.20		1.30	No	1.40	0.15		0.30	Yes	3.12	16.80	9.24		No
SOU200-007	2010-51273[a]	4	KYRAD	0.69	0.78	0.35		No	2.12	1.68	0.75		Yes	1.16	0.90	0.41		Yes
JP-0110	DOJ1-99-0110		PGDP	0.67	8.67	1.34	5.33	No	0.81	0.19	1.61	1.61	No	626.00	4.72	8.10	168.00	Yes
SOU200-002	2010-51268[a]	4	KYRAD	0.65	0.62	0.28		Yes	2.10	0.94	0.44		Yes	1.08	0.56	0.33		Yes
JP-0057	DOJ1-99-0057		PGDP	0.65	1.60	1.30	1.30	No	0.28	0.09	0.56	0.56	No	7.97	0.78	1.14	4.06	Yes
JP-0097	DOJ1-99-0097		PGDP	0.62	1.70	1.25	1.25	No	0.76	0.13	1.52	1.52	No	2.58	0.77	1.04	3.71	No
JP-0066	DOJ1-99-0066		PGDP	0.60	2.87	1.21	1.85	No	0.85	0.14	1.70	1.70	No	4.81	1.22	1.63	3.47	Yes
JP-0082	DOJ1-99-0082		PGDP	0.60	2.74	1.20	1.67	No	1.29	0.18	2.58	2.58	No	20.00	0.02	0.75	3.30	Yes
194-03,04	301046[e]	21	LOCK	0.60	0.00			Yes					No	1.18		0.16		Yes
JP-0061	DOJ1-99-0061		PGDP	0.60	2.19	1.20	1.41	No	0.33	0.08	0.66	0.66	No	6.32	0.76	1.00	0.16	Yes
JP-0013	DOJ1-99-0011		PGDP	0.55	2.26	1.11	1.36	No	0.83	0.15	1.66	1.66	No	17.30	0.97	1.38	4.86	Yes
JP-0063	DOJ1-99-0063		PGDP	0.54	2.50	1.09	1.64	No	0.65	0.12	1.29	1.29	No	1.00	0.01	0.10	0.16	Yes
JP-0087	DOJ1-99-0088		PGDP	0.47	5.67	0.94	3.46	No	0.77	0.13	1.54	1.54	No	138.00	2.54	4.19	53.00	Yes

Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
A10	PLDJNSA10-02SO	8.5	PGDP	0.34	5.70	0.69	3.60	No	0.49	0.12	0.98	0.98	No	1.91	0.79	0.42	3.26	No
ISOCSOFFST	ISOCSBKGR08-01	0	PGDP	0.34	1.04	0.68	0.68	No					No	1.58	0.47	0.25	0.33	Yes
NST2S03	BJC2031SS	15	PGDP	0.31	2.30	0.61	1.39	No	0.99	0.19	1.98	1.98	No	19.80	0.08	0.79	3.00	Yes
JP-0112	DOJ1-99-0114		PGDP	0.27	1.38	0.54	0.85	No	0.67	0.11	1.34	1.34	No	7.50	0.01	0.37	1.10	Yes
JP-0060	DOJ1-99-0060		PGDP	0.22	2.13	0.44	1.40	No	0.13	0.04	0.16	0.26	No	8.24	0.85	1.26	3.40	Yes
C01,10,24	301018 [d]	2.8	LOCK	0.20	0.00			Yes					No	1.03		0.09		Yes
NST2S05	BJC2052SS	12.5	PGDP	0.17	1.28	0.35	0.78	No	0.52	0.14	1.03	1.03	No	1.21	0.20	0.32	1.70	No
JP-0100	DOJ1-99-0100		PGDP	0.09	1.44	0.18	0.89	No	0.72	0.12	1.44	1.44	No	1.48	0.67	0.39	2.08	No
NST1S02	BJC1021SS	2.5	PGDP	0.06	2.53	0.13	1.54	No	0.57	0.19	1.15	1.15	No	29.70	1.38	2.18	8.27	Yes
JP-0016	DOJ1-99-0014		PGDP	0.00	1.81	0.01	1.10	No	0.57	0.12	1.13	1.13	No	8.80	0.04	0.35	1.20	Yes
196-01,02	301037	7	LOCK	0.00[f]	0.00			No					No	0.82		0.12		Yes
JP-0164	DOJ1-99-0164		PGDP	-0.01	1.86	0.01	1.15	No	0.69	0.15	1.38	1.38	No	1.84	0.92	0.45	2.57	No
NST2S01	BJC2011SS	2	PGDP	-0.13	1.73	0.25	1.06	No	0.57	0.16	1.14	1.14	No	8.11	0.91	1.35	2.56	Yes
JP-0045	DOJ1-99-0045		PGDP	-0.29	2.68	0.58	1.76	No	0.58	0.12	1.15	1.15	No	6.00	0.01	0.23	0.77	Yes
JP-0016	DOJ1-99-0014DUP		PGDP	-0.29	1.76	0.59	1.08	No	0.52	0.12	1.05	1.05	No	11.00	0.02	0.37	1.40	Yes
JP-0087	DOJ1-99-0087		PGDP	-0.43	5.27	0.86	3.23	No	0.65	0.12	1.30	1.30	No	126.00	2.33	3.83	48.30	Yes
JP-0071	DOJ1-99-0071		PGDP	-0.75	5.45	1.50	3.40	No	2.78	0.26	5.56	5.56	No	19.00	1.98	2.46	7.68	Yes
BGS194-04	301049	24	LOCK	-0.80	0.01			No					No	0.76		0.12		Yes
JP-0085	DOJ1-99-0085		PGDP	-0.86 [f]	6.72	1.72	4.14	No	0.80	0.15	1.60	1.60	No	160.00	3.01	5.07	61.80	Yes
F05,07,17	301007	1	LOCK	-1.10 [f]	0.00			No					No	0.93		0.08		Yes
A10	PLDJNSA10-03SO	9	PGDP	-1.20	31.00	2.50	18.00	No	0.14	0.20	0.00	0.06	No	326.00	4.61	7.56	125.00	Yes
JP-0072	DOJ1-99-0072		PGDP	-1.31	9.10	2.62	5.58	No	6.88	0.41	13.75	13.75	No	87.00	0.24	2.80	21.00	Yes
JP-0111	DOJ1-99-0112		PGDP	-1.99	6.10	3.99	3.99	No	0.84	0.17	1.69	1.69	No	317.00	0.67	11.00	68.00	Yes
JP-0076	DOJ1-99-0076		PGDP	-2.04	6.16	4.07	4.07	No	2.19	0.23	4.38	4.38	No	69.00	2.28	3.26	26.70	Yes
NST2S05	BJC2051SS	12.5	PGDP	-2.12	12.77	4.25	7.90	No	5.15	1.39	10.30	10.30	No	11.10	1.90	3.14	4.33	Yes
JP-0077	DOJ1-99-0077		PGDP	-2.71	5.02	5.42	5.42	No	1.47	0.17	2.94	2.94	No	56.00	0.21	1.80	11.00	Yes
A2	PLDJNSA2-01SO	8.5	PGDP	-2.90	6.20	5.80	5.80	No	0.65	0.14	1.30	1.30	No	1.24	0.26	0.44	2.14	No
JP-0152	DOJ1-99-DUP1		PGDP	-2.91	6.47	5.83	5.83	No	0.87	0.13	1.73	1.73	No	393.00	0.69	12.00	120.00	Yes
JP-0111	DOJ1-99-0111		PGDP	-2.99	6.03	5.98	5.98	No	0.91	0.17	1.81	1.81	No	365.00	0.13	4.50	63.00	Yes
JP-0151	DOJ1-99-0151		PGDP	-4.78	8.89	9.57	9.57	No	0.54	0.13	1.07	1.07	No	365.00	3.25	5.42	140.00	Yes
JP-0150	DOJ1-99-0150		PGDP	-10.07	12.75	20.14	20.14	No	0.79	0.18	1.58	1.58	No	599.00	4.88	8.14	230.00	Yes
JP-0153	DOJ1-99-0153		PGDP	-19.47	14.31	38.93	38.93	No	0.32	0.17	0.64	0.64	No	1921.00	3.50	50.00	617.00	Yes

Yellow shading indicates sample analysis by the Kentucky Radiation Health Branch Laboratory.

Blue shading indicates a detected lead-210 result for samples other than those analyzed by the Kentucky Radiation Health Branch.

Lab Codes are the following: LOCK = Lockheed Engineering & Science Co., Las Vegas, NV; KYRAD = Kentucky Radiation Health Branch; PGDP = USEC-Paducah Gaseous Diffusion Plant; PORTS = USEC-Portsmouth Plant; STLMO = Severn Trent, Earth City Missouri

[a] The uranium-238 results was reported by the lab as thorium-234/uranium-238.

[b] The maximum uranium-238 result was used for comparison.

[c] This sample is not plotted in Figure 2, the coordinates place the sample in Illinois. The available coordinates are likely incorrect.

[d] This sample is not plotted in Figure 2, no coordinates are available.

[e] This sample is not plotted in Figure 2, the coordinates place the sample in Ballard County, which is outside the scale of the map.

[f] This results is set as a nondetect because the reported result is less than the MDA.

Table 2. Results of Filtering

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	7/31/2006	152.1	KYRAD	2006-51812	SW	133.1	529.9		A-Composite	pCi/L	X	529.9		529.9
DNT	Lead-210	7/21/2004	139	KYRAD	2004-51807	SW	120.4	557.4		A-Composite	pCi/L	=	557.4		557.4
DNT	Lead-210	7/9/2003	86.13	KYRAD	2003-06373	SW	77.85	213.2		A-Composite	pCi/L	=	213.2		213.2
DNT	Lead-210	12/8/2006	141.6	KYRAD	2006-53149	SW	156.5	1469		A-Composite	pCi/L	X	1469		1469
DNT	Lead-210	7/18/2005	96.2	KYRAD	2005-51647	SW	176.1	661.4		A-Composite	pCi/L	X	661.4		661.4
DNT	Lead-210	5/26/2006	116	KYRAD	2006-51119	SW	126.8	1605		A-Composite	pCi/L	X	1605		1605
Gamma Spec	Lead-210	2/2/2007	159.2	KYRAD	2007-50161	SW	276.5	692.8	U	A-Composite	pCi/L	U	692.8		692.8
DNT	Lead-210	10/27/2005	105.5	KYRAD	2005-52609	SW	124.9	1707		A-Composite	pCi/L	X	1707		1707
Gamma Spec	Lead-210	6/4/2007	174.2	KYRAD	2007-51252	SW	107	1284		A-Composite	pCi/L	=	1284		1284
DNT	Lead-210	10/13/2004	99.77	KYRAD	2004-52643	SW	143.4	309.4		C-Composite	pCi/L	=	309.4		309.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	=	2593		2593
DNT	Lead-210	5/11/2005	144.7	KYRAD	2005-51034	SW	82.96	514		A-Composite	pCi/L	X	514		514
DNT	Lead-210	6/9/2004	147.5	KYRAD	2004-51367	SW	77.57	1714		A-Composite	pCi/L	=	1714		1714
Gamma Spec	Lead-210	4/3/2007	180.9	KYRAD	2007-50606	SW	97.97	1719	U	A-Composite	pCi/L	U	1719		1719
Gamma Spec	Lead-210	11/19/2007	168	KYRAD	2007-52795	SW	123.9	274.7	J	A-Composite	pCi/L	J	274.7		274.7
DNT	Lead-210	1/10/2005	138.2	KYRAD	2005-50023	SW	147.8	1210		C-Composite	pCi/L	X	1210		1210
Gamma Spec	Lead-210	2/22/2007	275.7	KYRAD	2007-50293	SW	160.8	2222	U	C-Composite	pCi/L	U	2222		2222
DNT	Lead-210	1/3/2006	299	KYRAD	2005-53157	SW	285.5	881.4		C-Composite	pCi/L	X	881.4		881.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	X	2593		2593
DNT	Lead-210	12/20/2004	173.3	KYRAD	2004-53235	SW	237	832.2		C-Composite	pCi/L	=	832.2		832.2
Gamma Spec	Lead-210	4/25/2007	128.9	KYRAD	2007-50839	SW	138.1	1185		C-Composite	pCi/L	=	1185		1185
DNT	Lead-210	12/14/2006	533.1	KYRAD	2006-53330	SW	283.4	3222	U	ATC746K	pCi/L	X	3222		3222
DNT	Lead-210	9/11/2006	149.7	KYRAD	2006-52207	SW	130.7	594		B-Composite	pCi/L	X	594		594
Gamma Spec	Lead-210	6/25/2007	154.2	KYRAD	2007-51454	SW	85.39	1936	U	B-Composite	pCi/L	U	1936		1936
DNT	Lead-210	9/22/2004	112.7	KYRAD	2004-52430	SW	121.2	368.1		B-Composite	pCi/L	=	368.1		368.1
DNT	Lead-210	10/13/2004	146.1	KYRAD	2004-52679	SW	126.1	664.9		D2-Composite2	pCi/L	=	664.9		664.9
DNT	Lead-210	12/24/2003	80.3	KYRAD	2003-08104	SW	79.66	233		D2-Composite2	pCi/L	=	233		233
DNT	Lead-210	3/2/2006	67	KYRAD	2006-50341	SW	43.39	102.5		B-Composite	pCi/L	X	102.5		102.5
Gamma Spec	Lead-210	4/3/2007	183.7	KYRAD	2007-50628	SW	95.3	2502	U	B-Composite	pCi/L	U	2502		2502
DNT	Lead-210	7/18/2005	129.3	KYRAD	2005-51670	SW	96.29	1306		B-Composite	pCi/L	X	1306		1306
DNT	Lead-210	1/10/2005	225.3	KYRAD	2005-50022	SW	113.8	3492		B-Composite	pCi/L	X	3492		3492
DNT	Lead-210	8/31/2004	106.9	KYRAD	2004-52253	SW	92.05	604.6		D-Composite	pCi/L	=	604.6		604.6
DNT	Lead-210	6/30/2004	138.7	KYRAD	2004-51697	SW	127.6	575.8		D2-Composite2	pCi/L	=	575.8		575.8
DNT	Lead-210	10/27/2005	115.4	KYRAD	2005-52720	SW	122.4	1419		F-Composite	pCi/L	X	1419		1419
Gamma Spec	Lead-210	11/29/2010	1.61	KYRAD	2010-53281	SW	0.894	974	U	C-613	pCi/L	U	974		974
DNT	Lead-210	11/17/2005	152.4	KYRAD	2005-52866	SW	106.8	1269		D-Composite	pCi/L	X	1269		1269
Gamma Spec	Lead-210	2/2/2007	126.9	KYRAD	2007-50240	SW	224.8	490.7	U	F-Composite	pCi/L	U	490.7		490.7
DNT	Lead-210	12/13/2006	532.5	KYRAD	2006-53325	SW	282.9	3226	U	BBCDG	pCi/L	X	3226		3226
DNT	Lead-210	10/27/2005	2017	KYRAD	2005-52676	SW	2740	9532		D1-Composite	pCi/L	X	9532		9532
DNT	Lead-210	9/14/2005	130.7	KYRAD	2005-52307	SW	55.96	169.4		D1-Composite	pCi/L	X	169.4		169.4
DNT	Lead-210	12/13/2006	5867	KYRAD	2006-53326	SW	3802	7905	U	BBCROSS	pCi/L	X	7905		7905
DNT	Lead-210	7/5/2006	315.2	KYRAD	2006-51734	SW	293.3	612.9	R	BBCUG	pCi/L	X	612.9		612.9
DNT	Lead-210	8/25/2005	592.4	KYRAD	2005-52201	SW	312.6	3755		BBCUG	pCi/L	X	3755		3755

Table 2. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	12/8/2006	141.1	KYRAD	2006-53231	SW	155.1	1554		D1-Composite	pCi/L	X	1554		1554
Gamma Spec	Lead-210	6/4/2007	171.1	KYRAD	2007-51333	SW	99.26	406.2		D1-Composite	pCi/L	=	406.2		406.2
DNT	Lead-210	8/13/2004	135.7	KYRAD	2004-52111	SW	137.5	621.3		F-Composite	pCi/L	=	621.3		621.3
Gamma Spec	Lead-210	11/29/2010	51.1	KYRAD	2010-53280	SW	23.7	230	U	K001	pCi/L	U	230		230
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	X	482.9		482.9
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	=	482.9		482.9
DNT	Lead-210	7/16/2002	437.6	KYRAD	2002-06663	SW	256.7	27660		D2-Composite	pCi/L	=	27660		27660
DNT	Lead-210	9/14/2005	110.6	KYRAD	2005-52329	SW	55.95	146.3		D2-Composite	pCi/L	X	146.3		146.3
DNT	Lead-210	11/20/2006	267.2	KYRAD	2006-53106	SW	283.2	843		G-Composite	pCi/L	X	843		843
DNT	Lead-210	12/22/2006	230.8	KYRAD	2006-53421	SW	148.8	2500		G-Composite	pCi/L	X	2500		2500
DNT	Lead-210	8/31/2004	107.1	KYRAD	2004-52318	SW	90.23	526		G-Composite	pCi/L	=	526		526
DNT	Lead-210	7/31/2006	150.7	KYRAD	2006-51871	SW	132.9	446.9		D2-Composite	pCi/L	X	446.9		446.9
DNT	Lead-210	11/20/2006	113.4	KYRAD	2006-53074	SW	73.27	265.4		D2-Composite	pCi/L	X	265.4		265.4
DNT	Lead-210	7/21/2004	137.2	KYRAD	2004-51947	SW	144	342.6		G-Composite	pCi/L	=	342.6		342.6
DNT	Lead-210	5/26/2006	159.3	KYRAD	2006-51229	SW	79.65	2701		D2-Composite	pCi/L	X	2701		2701
DNT	Lead-210	8/25/2005	599	KYRAD	2005-52191	SW	424.1	1900		K010	pCi/L	X	1900		1900
DNT	Lead-210	6/1/2005	237.4	KYRAD	2005-51358	SW	260.6	1634		G-Composite	pCi/L	X	1634		1634
Gamma Spec	Lead-210	4/3/2007	182	KYRAD	2007-50729	SW	96.81	2054	U	G-Composite	pCi/L	U	2054		2054
DNT	Lead-210	12/14/2006	537.4	KYRAD	2006-53312	SW	285.4	3298	U	K011	pCi/L	X	3298		3298
DNT	Lead-210	6/16/2005	539.3	KYRAD	2005-51401	SW	366.8	865.9		K012	pCi/L	X	865.9		865.9
DNT	Lead-210	8/23/2005	589.5	KYRAD	2005-52186	SW	491.7	2210		L14	pCi/L	X	2210		2210
DNT	Lead-210	12/14/2006	539.1	KYRAD	2006-53316	SW	286.2	3332	U	K015	pCi/L	X	3332		3332
Gamma Spec	Lead-210	11/29/2010	685	KYRAD	2010-53280	SW	274	4070	U	L4	pCi/L	U	4070		4070
DNT	Lead-210	12/14/2006	7379	KYRAD	2006-53321	SW	4801	11210	U	LBC@McCaw	pCi/L	X	11210		11210
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	9.25275	KYRAD	2010-51253	SO	3.831	6.5693666	U	SOU195-120A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.738264	KYRAD	2010-51254	SO	0.327648	0.7087367	U	SOU195-014	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.87614	KYRAD	2010-51255	SO	0.357205	1.1963452		SOU195-014	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.00644	KYRAD	2010-51256	SO	2.14186	1.8868582	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.69731	KYRAD	2010-51257	SO	0.323468	1.3837602		SOU195-014A	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.07442	KYRAD	2010-51258	SO	2.12668	3.5576405	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.919572	KYRAD	2010-51259	SO	0.410998	0.9908741		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.643217	KYRAD	2010-51260	SO	0.297765	1.1705553		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.963233	KYRAD	2010-51261	SO	0.42696	1.0807067		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.786643	KYRAD	2010-51262	SO	0.364651	1.3145335		SOU195-014C	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	1.03762	KYRAD	2010-51263	SO	0.457097	1.0294589	U	SOU195-014C	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	5.28305	KYRAD	2010-51264	SO	2.15693	6.0068083	J	SOU195-014C	pCi/g	J			
Gamma Spec	Lead-210	5/12/2010	0.727831	KYRAD	2010-51265	SO	0.330025	1.0930592		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.779156	KYRAD	2010-51266	SO	0.351511	0.8835402		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.832552	KYRAD	2010-51267	SO	0.370699	0.9368339		SOU200-001	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.616779	KYRAD	2010-51268	SO	0.276128	0.6544536		SOU200-002	pCi/g	=			

Table 2. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
Gamma Spec	Lead-210	5/5/2010	0.918867	KYRAD	2010-51269	SO	0.405092	0.8584913	U	SOU200-003	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.894012	KYRAD	2010-51271	SO	0.401519	1.0366496		SOU200-005	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.662666	KYRAD	2010-51272	SO	0.300982	0.9515829		SOU200-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.777267	KYRAD	2010-51273	SO	0.346092	0.6884684	U	SOU200-007	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.695554	KYRAD	2010-51274	SO	0.31533	1.0058769		SOU200-008	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	5.14907	KYRAD	2010-51275	SO	2.22839	1.0775268	U	SOU200-009	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.942465	KYRAD	2010-51276	SO	0.415427	0.8905683	U	SOU200-010	pCi/g	U			
Gamma Spec	Lead-210	4/27/2010	0.590492	KYRAD	2010-51277	SO	0.763757	2.571285		SOU222-001	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.816	KYRAD	2010-52457	SO	0.406	4.92		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.475	KYRAD	2010-52458	SO	0.221	1.25		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.71	KYRAD	2010-53090	SO	0.869	8.44		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.41	KYRAD	2010-53091	SO	0.709	6.98		SWMU222-2	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.14	KYRAD	2010-53092	SO	0.607	6.81		SWMU222-3	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	2.05	KYRAD	2010-53093	SO	1.03	10.6		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.47	KYRAD	2010-53094	SO	0.757	8.6		SWMU222-5	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			

DNT = Analytical methods was not transmitted.
Gamma Spec = Gamma Spec
KYRAD = Kentucky Radiation Health Branch Laboratory
SW = surface water
X = no 3rd party validation was performed
U = not detected above the MDA
R = result rejected
"=" = result accepted by 3rd party validation

Paducah Risk Assessment Working Group
February 6, 2013
Minutes for Risk Methods Document Revisions

Present:

Jerri Martin	**Tim Frederick**	**Rich Bonczek**
Gaye Brewer		**Bobette Nourse**
Todd Mullins		**LeAnne Garner**
Stephanie Brock		**John Volpe**
Nathan Garner		
Mike Guffey		

1. **PAH Recommendation paper.** The paper received comments from EPA and the state. A revised paper should be sent (included in schedule at the end of these meeting notes). Once agreement is reached among the group, the paper will be presented to the FFA managers. If agreed to by the FFA managers, the paper can be appended to Risk Methods Document, Appendix E, upon decision of the RAWG.

2. **Ensure text that follows** is consistent with the rest of the document and with what we intend: **"**The dermal absorption of 5% for inorganic chemicals (or revised dermal absorption to reflect intestinal absorption) may be replaced with a lower value from EPA dermal guidance. These revised calculations may be considered in the development of revised PRGs and remediation levels to be used in the preparation of remedy selection documents. These types of decisions would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.**"**

3. **Whether to include the statement currently in the main text—"**Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the dataset.**"**

   Text has been revised and footnoted as follows (red indicates added text):

   Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the project dataset, provided the MDC is an acceptable level for the project.[6]

   [6] These types of decisions (acceptable MDCs) would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.

4. **Whether to add a note to the main text regarding negative values for radionuclide results.** Include footnote to text regarding radionuclides on page 3-18, if text can be agreed to. DOE/LATA Kentucky will e-mail to group for comments, but the starting point will adopt text from Soils OU RI, which is as follows: "Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count."

   Text for comments is as follows: "Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count seen by the same detector."

5. **NOTE with respect to correcting incidental ingestion of sediment by a recreational user:** the recreational user and the resident should not be considered additive because the ingestion rates are independent.

6. **Appendix D with respect to updating equations to be consistent with RAGs Part F:** Ensure units cancel correctly in inhalation equations (e.g., D.17). Averaging Time units have been revised for inhalation equations from "hours × yr × day/yr" to "hours/day × yr × day/yr." No changes to values. This also will affect Table B.5. Current Table B.5 lists units for Averaging Time as "hours × days" (which is "hours × yr × day/yr" with the yr canceled out). This will be revised to "hours," where both yr and days cancel out.

7. **Lead-210:** Need cost estimate for analyzing lead-210 at whatever level is possible (i.e., 10^{-5}) and at 10^{-6} levels. "Other COPCs should be identified during project scoping" added to Table 2.1. Look further into potential Lead-210 sources at PGDP and define use of the term "AL" in the response. Additionally, see markup below (red indicates added text, strikethrough font indicates text to be removed):

   However,

   ~~(1) There is no known PGDP source for lead-210 at Paducah; and~~

   ~~(2)~~ In regard to GDP process, the ingrowth of lead-210 from uranium-238 is blocked at uranium-234. Due to the long ingrowth period from uranium-234 to lead-210, it is unlikely that at the present time the GDP processes at PGDP contribute to presence of lead-210 as a potential contaminant/risk at PGDP.

NOTE: Additional comments resulted from this item indicating the Lead-210 paper is not complete.

8. **Updates to RAIS that affect NALs and ALs in Appendix A.** Updates of these screening values will be locked in with annual update cycle. The 2012 updates were made in October. Subsequent updates will reflect the November updates (consistent with RSL revisions). Risk assessors must ensure toxicity values used in risk assessments are up-to-date.

Remaining Schedule:

DATE	RESPONSIBLE	DESCRIPTION
February 6, 2013	meeting	Interim meeting re: Final Page Changes for main text, Appendix B and Appendix D
February 18, 2013	DOE/LATA Kentucky	Revised PAH paper.
February 20, 2013	DOE/LATA Kentucky	Appendix A remaining tables.
February 26, 2013	DOE/LATA Kentucky	Revised Nickel Groundwater Background values.
March 6, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) Update on lead-210 information
March 8, 2013	RAWG	Final comments due to DOE/LATA Kentucky for all draft page changes to RMD

DATE	RESPONSIBLE	DESCRIPTION
April 8, 2013	DOE/LATA	Final Revised Risk Methods Document - D2/R2/V1 sent to RAWG for final review
April 22, 2013	RAWG	RAWG approval of D2/R2/V1 document
April 29, 2013	DOE/LATA	Initiate DOE review of D2/R2/V1 document
May 13, 2013	DOE/LATA	DOE comments due
May 20, 2013	DOE/LATA	Transmit D2/R2/V1 document changes due to DOE comments to RAWG
June 5, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) RAWG to discuss and approve revisions to D2/R2/V1 document due to DOE comments
June 17, 2013	DOE/LATA Kentucky	Final D2/R2/V1 document to DOE for concurrence
June 30, 2013	DOE/LATA Kentucky	Transmit D2/R2/V1 document to FFA Managers (EPA/KY) for approval
September 11, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) Consider face-to-face meeting (probably in Kentucky)

Paducah Risk Assessment Working Group
March 6, 2013
Minutes for Quarterly Meeting

Present:

Jerri Martin	**Tim Frederick**	**Rich Bonczek**
Gaye Brewer	**Jon Richards**	**Bobette Nourse**
Nathan Garner		**Joe Towarnicky**
Todd Mullins		**LeAnne Garner**

1. **Additional changes to December 2012 Meeting Minutes or February 2013 Meeting Minutes.**
   a. Comments received from Stephanie Brock and Nathan Garner for February meeting minutes, incorporated. SEE NOTE.
   -Struck through text in Lead-210 paper "~~(1) There is no known PGDP source for lead-210 at Paducah; and~~"
   -Need to add additional information regarding recreational user and residential user not being additive. This information will be included in the revised RMD, if not already in there. The recreational user is assumed to be a local resident.
   b. Considered final. SEE NOTE.

   NOTE: The comment to strike through the text "There is no know PGDP source for lead-210 at Paducah" resulted in additional comments from others. The February 2013 Meeting Minutes have been changed to reflect additional comments resulted and that the Lead-210 paper is not complete.

2. **Updates to Appendix A.**
   Sent by e-mail to RAWG for review on 2/22. All draft comments due March 8, 2013.

3. **Discussion regarding PAHs text. Revised file sent February 18.**
   a. Comments received from Todd Mullins incorporated. Use of "coal" removed.

   "Due to the nature of polycyclic aromatic hydrocarbons (PAHs), as described in the *Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)*,1 the presence of PAHs in Paducah Gaseous Diffusion Plant (PGDP) in some soils and sediments (e.g., along roads, including roadside ditches and around buildings) is not directly related to PGDP releases, but rather from other on- or off-site site activities, including airborne deposition of PAHs that result from the incomplete burning of ~~coal,~~ oil, gas, wood, garbage, or other organic substances or deposition due to the use of rubber, asphalt, ~~coal,~~ crude oil, coal tar, creosote, and roofing tar."

   b. Comments received from Tim Frederick: revise text to "At the Oak Ridge Reservation, an early document proposed that DOE manage PAHs as if they were wholly associated with background.4 However, currently at the Oak Ridge Reservation, PAHs are being addressed on a case-by-case basis and anthropogenic sources are considered."
   Tim will look for a reference. If none is found, personal communication with RPM may be used.

c. Need to look for additional reference to “The most common source of PAHs in the environment currently is deposition of automobile exhaust.2” Change “The most” to “A”.
d. Also note Tim’s editorial comments.

Once Tim’s comments addressed, send for final approval.

4. Update on Lead-210 paper.
-Need cost estimate for analyzing lead-210: working.
-Look further into potential Lead-210 sources at PGDP: working. “There is no known PGDP source for lead-210 at Paducah” was removed from paper. Still need list of potential sources (e.g., equipment from other sites). Need anecdotal references. SEE NOTE to Item 1.
-Define use of the term “AL”: Analytical Laboratory

5. Remaining schedule for Risk Methods Document Revision:

March 8, 2013	RAWG	Final comments due to DOE/LATA for all draft page changes to RMD
April 8, 2013	DOE/LATA	Final Revised Risk Methods Document—D2/R2/V1 sent to RAWG for final review
April 22, 2013	RAWG	RAWG approval of D2/R2/V1 document
April 29, 2013	DOE/LATA	Initiate DOE review of D2/R2/V1 document
May 13, 2013	DOE/LATA	DOE comments due
May 20, 2013	DOE/LATA	Transmit D2/R2/V1 document changes due to DOE comments to RAWG

Need to let Jana White know that updates are coming so that she can let FFA Managers know.

6. Discussion regarding including RAWG Meeting Minutes in Appendix E
Draft consolidation of final meeting minutes to be sent for comment and additional discussion of whether they will all be incorporated. Most recent minutes (i.e, 2012 and 2013) will be included.

7. Discussion of Ni background for groundwater
Change was made in Appendix A to correct value. Old calculations are not able to be revised. The revised background value will be footnoted in the Risk Methods Document with the text, “Nickel background value varies from previous Risk Methods Documents due to an error in calculation.”
Add groundwater background to future agendas. Need to look at differences in analytical methods. There may be data currently in the database that already have lower detection level. Bobette Nourse will provide update at next meeting.

8. Next Meeting: June 5, 2013. 9:30-12:00 EST. Following that, the next meeting is September 11, 2013.

From: Garner, Leanne K (YLN)
Sent: Friday, August 02, 2013 2:48 PM
To: Rich Bonczek; 'Bobette Nourse'; John Volpe; 'Brewer, Gaye (EEC)'; 'Higginbotham, Jeri (EEC)'; 'Martin, Jerri (EEC)'; Todd Mullins; Stephanie Brock; 'Garner, Nathan (CHS-PH)'; Guffey, Mike (EEC) (Mike.Guffey@ky.gov); Towarnicky Joseph; Redfield, Myrna E (MXN); 'Frederick.Tim@epamail.epa.gov'; 'Richards.Jon@epamail.epa.gov'; White, Jana L (FMT); 'Tufts, Jennifer (Tufts.Jennifer@epa.gov)'
Subject: Paducah Risk Assessment Working Group Meeting Minutes - Comments on Risk Methods Document
Attachments: Proposed Text Revisions (outdoor worker-gardener).docx

Paducah Risk Assessment Working Group
July 31, 2013
Minutes for Risk Methods Document Comment Meeting

Present:
Jerri Martin
Gaye Brewer
Nathan Garner
Mike Guffey
Tim Frederick
Jon Richards
Rich Bonczek
Bobette Nourse
John Volpe
Joe Towarnicky
LeAnne Garner

1. **Outdoor Worker/Gardener**

Comments on attached material are requested. If no changes to current materials (attached), then materials can be put into final Risk Methods Document (RMD) update. If not, plan to include in next year's update
The following additional summary information is to be included in Appendix A.

- Outside industrialized area—surface only and surface/subsurface soils, default exposure parameters (or as agreed to by project) (e.g., wildlife management area worker or farmer).
- Inside industrialized area—surface only soils, default exposure parameters (or as agreed to by project) (e.g., unprotected worker).
- Inside industrialized area—surface/subsurface soils, default exposure parameters with the exception of shorter exposure duration/exposure frequency consistent with civil engineering estimates, as agreed to by project (e.g., excavation worker).

Kentucky expressed some concern about the excavation worker/outdoor worker/gardener issue in regard to possibly being overly definitive. Additional comments on the issue might be forthcoming.

2. **FY 2013 RMD Approval**

No issues have been identified to date.
Approval with comments is acceptable (comments can include the understanding that the revised text regarding outdoor worker/gardener sent by e-mail will be added to the next revision).
Reminder will be sent in 2 weeks!

3. **Upcoming Schedule**

- To align the RMD with the Environmental Monitoring Plan and Programmatic QAPP schedules, need approval of the FY 13 RMD update by the FFA Managers by the end of August 2013.
- For next year, quarterly meetings will be planned; do not expect significant text changes to Human Health RMD, like this year. Hope to have FFA Managers' approval of RMD by July 2014.

Footnote on page 3-27:

[7] ~~Although a~~A single set of exposure equations and parameters are ~~used~~provided for the outdoor worker/gardener scenario~~, the gardener scenario~~ in Appendix D. The exposure parameters provided in Appendix D should ~~only be considered~~ be used without changes when assessing risk from exposure to ~~be a reasonable scenario for areas~~surface soils in locations outside the ~~limited~~industrialized area at the Paducah site. ~~Additionally~~When assessing risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, however, all exposure parameters~~ for ~~, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker/gardener ~~scenario, except exposure duration (ED), can~~to surface and subsurface soil in locations outside the industrialized area should be ~~used for~~established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented. Similarly, when assessing risk from exposure to either surface soil or subsurface soil or both in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. ~~When used~~As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker ~~scenario,~~to surface soil or subsurface soil or both in locations inside the ~~ED~~industrialized area should be ~~reduced to 1 and 5 years (based on~~established considering guidance ~~from~~in the Exposure Factors Handbook~~).~~ (EPA 1997b), or similar sources, and be documented.

Text on page B-3:

B.1.2.1 Receptors

Table B.1 provides a matrix ~~of~~ showing the medium-receptor combinations for which PRGs were derived. As shown there, over all media, the receptors for which no action and action direct contact risk-based PRGs were derived are the industrial worker, the resident, the recreational user, and the outdoor worker/gardener. ~~The outdoor worker/gardener scenario replaces the "excavation worker" in the 2001 version of this document. The outdoor worker/gardener uses the same exposure parameters as the former excavation worker; the receptor name was changed to better reflect that the exposure parameters are designed to assess a long-term plant worker conducting outdoor maintenance activities. The 25-year exposure duration for the outdoor worker/gardener can be modified to a value between one and five years to generate site-specific values for exposures during excavation.~~ These receptors were chosen because they represent the most likely current and future receptors for most areas and units at the Paducah Gaseous Diffusion Plant (PGDP). Also, it is believed that the PRGs derived for these receptors yield a range of values that is most useful for determining the clean-up priority for the various areas and units at PGDP. (Note that outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, a better approach would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.)

Footnote to Table B.1. on page B-4:

3. Determining which soil and sediment screening value is appropriate is a location-specific decision. For all ~~areas~~locations inside the industrialized area~~s~~ at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For ~~areas~~locations inside the industrialized area~~s~~ at PGDP where contact with surface soil and subsurface soil is of concern (~~i.e~~e.g., soil from the surface down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate~~. Site-specific values should be developed~~ for ~~sites at which~~ a construction/excavation worker. ~~is expected (see~~(A better approach, however, would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section ~~1.2.1.).~~ 3.3.4.3.) For ~~areas,~~locations outside the industrialized area~~, use of~~ where surface soil contamination is of concern, screening using the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most "conservative~~."~~ (in terms of protecting human health)." Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. ~~Also, note that the recreator and resident values are actually only applicable to surface soil.~~Finally, the outdoor worker/gardener values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening considers both surface and subsurface soil in locations outside the industrialized area, however, development of scenario-specific PRGs for the outdoor worker based on site-specific conditions is a better approach. See discussion in Section 3.3.4.3.)

Risk Assessment Working Group
Meeting Minutes—September 2013

Present:
Jerri Martin
Mike Guffey
Nathan Garner
Tim Frederick
Jon Richards
Rich Bonczek
Bobette Nourse
LeAnne Garner

1. Call for Issues from RAWG Members

No additional issues.

2. Discussion of FY 2014 Schedule

Revisions made as follows:

Quarterly Meeting (September)	9/18/2013
Submit Work Plan (this schedule)	9/25/2013
Approve Work Plan (this schedule)	10/23/2013
Submit Appendix A (PRGs) to RAWG for Review	11/13/2013
Submit Suggested Deletions/Changes from Appendix E	12/4/2013
Comments Due for Appendix A	12/4/2013
Quarterly Meeting (December)	12/11/2013
Submit Revised Appendix B, D, and Main Text to RAWG for Review	12/11/2013
Submit Revised Appendix E	1/15/2013
RAWG Approve Appendix A	2/12/2014
Comments Due for Appendix B, D, and Main Text	2/12/2014
Comments Due for Appendix E	2/26/2014
Quarterly Meeting (March)	3/5/2014
RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Quarterly Meeting (June)	6/4/2014
Comments Due for Entire Revised RMD	5/16/2014
Submit RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Approval of the revised Risk Methods Document (at least Appendix A) is needed by end of June (approximately) to support Programmatic QAPP revision.

3. **Proposed Revisions to the 2013 Risk Methods Document for the 2014 Version re: Outdoor Worker. Text attached (from e-mail sent 6/27/2013).**

Kentucky Division of Waste Management Comment:

The Division has discussed inconsistent language regarding the outdoor worker/gardener contained in the document (page 3-27 vs. page B-3 and B-4) with DOE and their contractors. Per our discussion, this issue will be placed on the next Risk Working Group meeting agenda.

Double-check that page 3-27 vs. page B-3 and B-4 **are the only locations in the RMD where there is inconsistent language regarding the outdoor worker/gardener.**

Comments on language included will be included with RAWG member comments to the meeting minutes.

4. **Status of Lead-210 Paper**

Comments on language included will be included with RAWG member comments to the meeting minutes.

Text attached (reworked from previous version)

Kentucky Cabinet for Health Services—Radiation Health Branch Comment:

This document does not yet contain a consistent and defensible method for handling contaminants not on the sitewide COPC list, but which may be present in a unit based upon new data and/or are found at unexpected levels during sampling efforts (e.g., Pb-210 contamination at SWMU 222). It would be in the best interest of all parties to develop such a method and integrate it into the document.

Write-up/flow chart of how the potential for additional COPCs are identified consistently during project scoping; possibly add to Section 2. The write-up/flow chart will be sent to RAWG for comments on October 15. Comments will be due with main text/Appendix B comments.

5. **Background Groundwater**

- Nickel value was updated for the 2013 RMD.
- No additional activity planned for FY 2014; plan to use existing values for now.
- Review addressing new values in FY 2015.

6. **Update WKWMA/Wildlife and Hunting Information in Appendix E**

Update Agricultural Extension Information in Appendix E

Provide RAWG a plan for update at December meeting. Work plan schedule revised to accommodate.

7. Revisit Qualitative Assessment of High Sample Quantitation Limits (Section 3.3.3.2, Step 3)

The subject matter expert raising the issue was not on the call, so discussion was postponed until the December quarterly meeting.

8. Revisit Use of Negative XRF Results

Currently these results are included for statistical calculations.

The RAWG will explore other options for use. RAWG will follow-up at December meeting. Any input should be given to LeAnne. See KRCEE paper regarding AOC 492 and the first soil piles report for background information. The EPA representative stated he was against using proxy values.

9. Deletion of Groundwater Exposure in Industrial Worker Scenario (Tables D.26 and D.27 in the Risk Methods Document)

Table D.26, "Reasonable Maximum Exposure Assumptions for Ingestion of Water by an Industrial Worker"

Table D.27, "Reasonable Maximum Exposure Assumptions for Inhalation of VOCs in Water while Showering by an Industrial Worker"

Table D.28, "Reasonable Maximum Exposure Assumptions for Dermal Contact with Water while Showering by an Industrial Worker"

Equations should be left in place for now, but they most likely will not be the driver for remedial action. Results could affect future land use control discussions.

Need to develop a footnote to these equations regarding their use. This will be submitted for review as part of the Risk Methods Document, Appendix D revision.

10. Round Table Issues/Comments

EPA is looking at making updates to the default exposure parameter handbook in February 2014. PRGs may be affected; will need to look at our site-specific parameters to see if we want to make changes.

On the December agenda, consider if there is anything that needs to be addressed in the Eco Risk Methods document. Invitee list will be checked to ensure Jeri Higginbotham is invited.

Proposed Text Revisions (Outdoor Worker-Gardener)

Footnote on page 3-27:

[7] A single set of exposure equations and parameters are provided for the outdoor worker/gardener scenario in Appendix D. The exposure parameters provided in Appendix D should be used without changes when assessing risk from exposure to surface soils in locations outside the industrialized area at the Paducah site. When assessing risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, however, all exposure parameters, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker/gardener to surface and subsurface soil in locations outside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented. Similarly, when assessing risk from exposure to either surface soil or subsurface soil or both in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker to surface soil or subsurface soil or both in locations inside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented.

Text on page B-3:

B.1.2.1 Receptors

Table B.1 provides a matrix showing the medium-receptor combinations for which PRGs were derived. As shown there, overall media, the receptors for which no action and action direct contact risk-based PRGs were derived, are the industrial worker, the resident, the recreational user, and the outdoor worker/gardener. These receptors were chosen because they represent the most likely current and future receptors for most areas and units at the Paducah Gaseous Diffusion Plant (PGDP). Also, it is believed that the PRGs derived for these receptors yield a range of values that are most useful for determining the cleanup priority for the various areas and units at PGDP. (Note: Outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, a better approach would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.)

Footnote to Table B.1. on page B-4:

3. Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (e.g., soil from the surface down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate for a construction/excavation worker. (A better approach, however, would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.) For locations outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most "conservative (in terms of protecting human health)." Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Finally, the outdoor worker/gardener values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening considers both surface and subsurface soil in locations outside the industrialized area, however, development of scenario-specific PRGs for the outdoor worker based on site-specific conditions is a better approach. See discussion in Section 3.3.4.3.)

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Additional Information to RAWG Regarding Lead-210
(Revised September 2013)

In response to discussion during the December 2012 Risk Assessment Working Group, we researched the potential for reporting analytical results of lead-210 and the potential value of this information. The two action items for the Risk Assessment Working Group below were taken from that discussion.

- What is the risk for lead-210 at the minimum detectable concentration (MDC) with no special detector?

- Check to see if labs would need to recalibrate equipment to analyze lead-210 by gamma spectroscopy.

Lead-210 is the daughter of polonium-214 that is a member of the uranium-238 decay chain. Lead-210 is reported at background levels of 1–2 pCi/g in at least one facility (see Web site http://www.lrb.usace.army.mil/Portals/45/docs/FUSRAP/DaytonIII/day3-si-2004-12.pdf, Table 2). See attached spreadsheets for the Radiation Health Branch (RHB) lead-210 analysis. Only data with a sample-specific MDC of less than 1 pCi/g were included in the analysis. Based on the data provided by the RHB for lead-210, the background would be in the 1–2 pCi/g range for lead-210 at PGDP.

The no action levels (i.e., 10^{-6} values calculated using RAIS and Paducah-specific parameters) are as follows:

- Resident, 0.66 pCi/g;
- Industrial worker, 7.62 pCi/g; and
- Outdoor worker, 1.08 pCi/g.

Based on information provided by TestAmerica to LATA Environmental Services of Kentucky, the MDC obtained by liquid scintillation counting (LSC) is approximately 5 pCi/g. TestAmerica indicates this is the target MDC by LSC; however, this MDC can be lower, if necessary. TestAmerica's target MDC by gamma spectroscopy is the same, 5 pCi/g, but it could vary. TestAmerica indicates that "Lead-210 is a low energy radionuclide on the gamma spec and there could be interferences from other radionuclides and samples with sufficient activity. This could raise the MDA."

However, soil analysis by the Kentucky RHB using gamma spectroscopy and a thin window HPGe detector achieved a MDC of approximately 1 pCi/g for lead-210 (employing the 46 KeV line for lead-210). Using gamma spectroscopy with the appropriate thin window HPGe detector, an MDC of 1 pCi/g is achievable without interference from other radionuclides. In fact, lead-210 is used in calibration standards for thin window HPGe detectors. Gamma spectroscopy, using these thin window HPGe detectors and incorporation of lead-210 into the calibration standard, provides a significant improvement in efficiency in the region less than 59 KeV. Since the analysis of lead-210 by gamma spectroscopy uses the 46 KeV line energy, thin window HPGe detectors are the preferred detectors for analysis of lead-210 by gamma spectroscopy. Achieving a 1 pCi/g MDC for soil analysis is fully supported by the Kentucky RHB data for lead-210 analysis. Since there is no requirement for sample dissolution and separation from other radionuclides, gamma spectroscopy using a thin window HPGe detector would be the preferred method for analysis of lead-210 in soil.

Since analysis of lead-210 by LSC requires dissolution of the media in this case soil, it would be preferable to use gamma spectroscopy in order to eliminate concerns regarding complete dissolution of the sample.

With the current equipment used by the USEC laboratory, gamma spectroscopy analysis for lead-210 is not possible because the primary energy line is below the analytical laboratory normal energy calibration range. It would require the purchase of a new calibration mixture to include the lead-210 line at 46 KeV. The analytical laboratory has only one manual detector that can measure in the X-ray region, so output would be limited.

Lead-210 was included as part of the standard gamma scan for radiological analysis by TestAmerica during the Soils OU project. The MDC for lead-210 was approximately 30 pCi/g. This MDC is protective of a worker at a risk of 10^{-5}.

The ingrowth of lead-210 from uranium-238 is blocked at uranium-234. Due to the long ingrowth period from uranium-234 to lead-210, it is unlikely that, at the present time, the uranium enrichment processes at PGDP contribute to the presence of lead-210 as a potential contaminant/risk at PGDP; therefore, analysis of lead-210 is not necessary on a routine basis. The need for the analysis of radionuclides, such as lead-210, not related to natural uranium and recycled uranium enrichment by the gaseous diffusion process at PGDP should be assessed on a project-by-project basis.

Risk Assessment Working Group
Meeting Minutes—December 2013

Present:

✓ Gaye Brewer
✓ Nathan Garner
✓ Mike Guffey
✓ Jeri Higginbotham
✓ Jerri Martin
✓Todd Mullins
✓ Tim Frederick
✓ Rich Bonczek
✓ Martin Clauberg
✓ LeAnne Garner
✓ Bobette Nourse
✓ Joe Towarnicky

1. Call for Issues from RAWG Members

No additional issues were raised from Risk Assessment Working Group (RAWG) members.

2. Remainder of Fiscal Year (FY) 2014 Schedule

One revision made to submittal date for Appendix E. The revised date is shown in the table.

Submit Suggested Deletions/Changes from Appendix E	12/4/2013
Comments Due for Appendix A	12/4/2013
Quarterly Meeting (December)	12/11/2013
Submit Revised Appendix B, D, and Main Text to RAWG for Review	12/11/2013
Submit Revised Appendix E	1/29/2014
RAWG Approve Appendix A	2/12/2014
Comments Due for Appendix B, D, and Main Text	2/12/2014
Comments Due for Appendix E	2/26/2014
Quarterly Meeting (March)	3/5/2014
RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Quarterly Meeting (June)	6/4/2014
Comments Due for Entire Revised RMD	5/16/2014
Submit RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

An e-mail confirmation was requested from each RAWG member whether additional comments on Appendix A are expected.

3. Discussion of Outdoor Worker/Gardener Text (update) and Other Comments Received

KDWM requested the Risk Methods Document (RMD) be double-checked that page 3-27 vs. pages B-3 and B-4 are the only locations in the RMD where there is inconsistent language regarding the outdoor worker/gardener. One additional location for change was sent in October 15 e-mail to the RAWG.

The following was presented as a suggested response to comments that were received for the proposed text changes:

B.1.2.1 Receptors

"Note: Outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, ~~a better approach would be to derive~~ scenario-specific PRGs for the construction/excavation worker based on site-specific conditions should be derived, as appropriate."

Throughout the footnote on page 3-27, "risk," was replaced with "potential risk."

Additional editorial changes were made to provide clarity.

4. Status of Lead-210 Paper

No comments on language provided in previous meeting were made. The paper will be added to Appendix E. Comments can be made on Appendix E when it is submitted.

The write-up/flowchart of how the potential for additional chemicals of potential concern (COPCs) are identified consistently during project scoping was sent to RAWG for comment on October 15. Comments will be due with main text comments.

5. Risk Methods Document Appendix E Update

A proposal was made that Appendix E be put on compact disc (CD) or a separate volume; the group agreed.

The plan for updating Appendix E is as follows:

E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND CONCENTRATIONS: Leaving in 2014 RMD with no changes.

E.2. SITE-SPECIFIC EXPOSURE INFORMATION: Updating for the 2014 RMD with more current information, as follows.

- Letter and survey form used during the Phase I Site Investigation (CH2M Hill 1991) to determine groundwater use near PGDP:

  Clarify the purpose for having the survey forms in this document (i.e., to address the question of how groundwater would be used if municipal water were not provided for developing the exposure scenarios in the RMD).

- Summary of the interview with Mr. Kenny E. Perry, Agricultural Extension Agent, Ballard County, Kentucky, regarding agricultural practices in Ballard County held in February 1994:

  Update in 2014 RMD with revised interview/information for Ballard County.

- Summary of the interview with Mr. Douglas A. Wilson, Agricultural Extension Agent, McCracken County, Kentucky, regarding agricultural practices in McCracken County held in February 1994:

Update in 2014 RMD with revised interview/information for McCracken County.

- Letter dated February 24, 1994, from Mr. Douglas A. Wilson, Agriculture Extension Agent, McCracken County, Kentucky, to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, regarding area of crop land in McCracken County:

  Update in 2014 RMD with revised information for McCracken County.

- Questionnaire dated October 26, 1995, sent to Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife Resources (KDFWR), by FMSM Engineers, Inc., regarding recreational use of Little and Big Bayou Creeks near PGDP:

  Update in 2014 RMD with revised information from KDFWR.

- Facsimile dated November 8, 1995, sent to Mr. Stephen Scott, FMSM Engineers, Inc., containing responses from Mr. Charles Logsdon, KDFWR, to the aforementioned questionnaire:

  Update in 2014 RMD with revised information from KDFWR.

- Letter dated April 5, 1994, from KDFWR to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, containing annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, Kentucky:

  Update in 2014 RMD with revised information from KDFWR (most information should be available from KDFWR Web site).

- Reports entitled “Planning Issues for Superfund Site Remediation” and “Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study” from *Hazardous Materials Control* regarding use of exposure units in risk calculations and remedial decisions:

  Leave in 2014 RMD. Attempt to find better quality copy.

E.3. KENTUCKY REGULATORY GUIDANCE: Leaving in 2014 RMD, especially if putting Appendix E on CD.

E.4. FLOWCHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION: Leaving in 2014 RMD, especially if putting Appendix E on CD. LATA Kentucky is checking into whether adding this flowchart to the RMD was a commitment for the Environmental Indicators (EI) project. A cover letter may be added indicating that. The main text also has flowcharts for scoping that could be used for other projects. Mike Guffey will check whether the existing flowcharts in the main text are adequate and sufficient for the uncertainty management of burial ground nature and extent identification.

E.5. DATA QUALITY OBJECTIVE MATERIALS: Removing material from 2014 RMD, but adding introductory information and Web link to Hanford information to the main text where DQOs are discussed.

E.6. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS: Leaving in 2014 RMD, especially if putting Appendix E on CD.

E.7. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP: Leaving in 2014 RMD. This section will continue to be updated.

E.8. LEAD-210 AT PGDP: Leaving in 2014 RMD. Replace "placeholder" with information agreed to by RAWG; any comments to be made as part of this submittal.

E.9. PAH CONTAMINATION AND ESTABLISHMENT OF REMEDIAL GOALS: Leaving in 2014 RMD. Replace "placeholder" with information agreed to by RAWG; any comments to be made as part of this submittal.

6. Revisit Qualitative Assessment of High SQLs (Section 3.3.3.2, Step 3)

No changes were proposed to Human Health assessment as a result of using high sample quantitation limits (SQLs). Exposure point concentrations (EPCs) are calculated using ProUCL.

The issue may need to be addressed in an update to the Paducah Ecological RMD, because the Ecological RMD still uses one-half the detection limit to calculate EPC, while the ProUCL is used for EPCs for the human health evaluations.

It was noted that there is a new version of ProUCL (i.e., Version 5).

7. Revisit Use of Negative XRF Results

Following-up from previous quarterly meeting, use of negative X-ray fluoroscopy (XRF) results was discussed. No changes were proposed to their use. It is not anticipated that negative XRF results should occur in the future, due to changes in instrumentation; this issue affects only historical data (specifically soil piles data, such as chromium). The group believes that data should not be thrown out. The group needs to ensure this issue is documented as an uncertainty, if it applies to a project. EPA recently had XRF project at another site; Tim Frederick will share information at next RAWG quarterly meeting. Joe Towarnicky will review findings from XRF results in relation to laboratory results that were documented in the Soils Operable Unit Remedial Investigation on an element-by-element basis so that we know how to use XRF data (e.g., can XRF be used for selenium); these findings will be added to Appendix E.

8. Anything that needs to be addressed in the Eco Risk Methods document?

Brett Thomas needs to be added to meeting distribution. The Paducah Ecological RMD needs to be revised in FY 2015. See above regarding EPC calculation. Jeri Higginbotham will send additional changes for the Paducah Ecological RMD to LeAnne. These suggestions will be included in the next RAWG quarterly meeting agenda (to be held on March 5, 2014).

Risk Assessment Working Group
Meeting Minutes—March 2014

Present:
✓**Gaye Brewer**
✓**Stephanie Brock**
✓**Nathan Garner**
✓**Mike Guffey**
✓**Jeri Higginbotham**
✓**Jerri Martin**
✓**Todd Mullins**
✓**Tim Frederick**
✓**Jon Richards**
✓**Brett Thomas**
✓**Rich Bonczek**
✓**Martin Clauberg**
✓**LeAnne Garner**
✓**Bobette Nourse**
✓**Joe Towarnicky**

1. Call for Issues from RAWG Members

An electronic link for most recent Ecological Risk Methods Document (RMD) was sent to the Risk Assessment Working Group (RAWG). Any additional comments on the document will be sent in to the group. An explanation was provided that clarified that any changes to the current, approved Ecological RMD would be part of next year's work plan that will be developed in September and approved in October 2014.

2. Remainder of Fiscal Year 2014 Schedule

A proposal was made to postpone incorporation of recreational user lifetime excess lifetime cancer risk (ELCR) no action levels (NALs) and action levels (ALs) and excavation worker site-specific scenario until the next revision of the RMD.

The excavation worker site-specific scenario information would be adopted into the RMD from the Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS). The BGOU FS will use the "2 men and a backhoe" concept. The concept of how the individual units fit in with the whole site needs to be considered.

It was highlighted that the entire revised Human Health (HH) RMD will be sent for review on April 16 and that comments will be due May 16. This schedule needs to be met in order to incorporate HH RMD changes (including revised NALs) into the year's revision of the programmatic Quality Assurance Project Plan.

RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Comments Due for Entire Revised RMD	5/16/2014
Quarterly Meeting (June)	6/4/2014
Submit RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

3. Summary of RAWG review and comments received.

All portions of the 2014 RMD with revisions have been sent. Due dates for comments for all sections have passed. Below is a summary of the comments received.

Main Text:

- Vapor intrusion analysis/scenario needs to be added to text—
  Add the guidance "2008 Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment, EPA 542-R-08-001."
  A newer reference is expected soon from the U.S. Environmental Protection Agency (EPA). The current RMD should use the 2008 guidance, for now, and it will be replaced in the next version of the RMD.

- To keep in mind, default exposure parameters will be updated soon (likely in June 2014) for EPA's Regional Screening Levels. The Paducah RMD will, in turn, need to incorporate these changes in the next revision of the RMD.

- References to data quality assessment/data quality objectives and other items in Appendix E need revision. References will need to be made to EPA and U.S. Department of Energy (DOE) guidance instead of the Hanford example previously used.

- Based on discussion in the February 7, 2014, meeting, revise use of "outdoor worker/gardener" to "outdoor worker" and "excavation" to "site-specific."
  The word "gardener" will not be used. Additionally, the scenarios should be for the future outdoor and excavation workers. A follow-up e-mail will be sent to the group with details about how the term "site-specific" is to be used (i.e., with respect to "site-specific" and "unit-specific").

- Based on discussion in the February 7, 2014, meeting, revise previously agreed footnote for

  (1) "Outdoor worker" and associated soil depth to be evaluated.
  (2) "Excavation worker" and associated soil depth to be evaluated.
  (3) Site-specific excavation worker with respect to soil depth and the application of varying exposure durations (EDs) ("two men and a backhoe").

  This year's RMD will say the excavation worker will use site-specific parameters [e.g., depths, EDs, and exposure frequencies (EFs)]. All subsequent RMD revisions will adopt the agencies-approved BGOU SWMUs 2, 3, 7, and 30 FS project approach.
  A follow-up e-mail will be sent to the group with details about how the site-specific term is to be used.

Appendix A:

Recreational Scenario ELCR Preliminary Remediation Goals (PRGs) (i.e., NALs and ALs) need to be developed for a lifetime exposure. Subsequent RMD revisions will address this addition.

Appendix B:

- Table B.5. Toxicity Values and Information Used in PRG Derivation: Mercury, Inorganic Salts. Inhalation reference concentration 3.00E-05 was deleted, but no replacement value was given. The RSL table lists 3.0E-04 for RfC, and the key is marked "S" indicating that the User Guide, Section 5 should be seen, but there is nothing in the User Guide, Section 5 on mercury.
  As a follow-up, "Mercuric Sulfide" and "Mercury, Inorganic Salts" were removed from the table and "Mercuric Chloride" was renamed "Mercuric Chloride (and other Mercury salts)." EPA plans to correct the reference on their table.

- Based on discussion in the February 7, 2014, meeting, revise previously agreed text note and footnotes for outdoor worker/gardener for
  (1) "Outdoor worker" and associated soil depth to be evaluated.
  (2) "Excavation worker" and associated soil depth to be evaluated.
  (3) Site-specific excavation worker with respect to soil depth and the application of varying EDs ("two men and a backhoe").
  (See notes on main text, above, where this comment is discussed.)

- Based on discussion in the February 7, 2014, meeting, revise use of "outdoor worker/gardener" to "outdoor worker" and "excavation" to "site-specific." (See notes on main text, above, where this comment is discussed.)

Appendix D:
Add information for the excavation worker to the outdoor worker equations.
(See notes on main text, above, where this comment is discussed.)

Appendix E:

- **Section E.4: Flowchart for Uncertainty Management for Unknown Areas of Contamination**
  While the decision to proceed with a remedial investigation (RI) (including a baseline risk assessment), FS, proposed remedial action plan, etc., without source term data must be dealt with by risk and uncertainty managers; the RMD addresses risk assessment (communication) at these various stages. When the parties agree to proceed with remedy selection without source term data (i.e. without defined nature and extent), care should be taken not to present risk in accordance with protocol [e.g., no contaminants of concern (COCs)] developed under the assumption that nature and extent are defined. Any presentations of risk at the various stages must be strongly qualified and coupled with a firm bias (presumption?) for action. COC selection must be governed by conservatism.
  When projects have limited data, the baseline risk assessment needs to qualify information regarding the source term.
  See if text above can fit into the FS section of the main text referencing Risk Assessment Guidance for Superfund (RAGS). If possible, language from RAGS or other risk assessment guidance (e.g., DOE guidance on uncertainty) will be used as an addition to the main text.
  See if Site Management Plan has similar language.
  An opinion was expressed by DOE that the text above goes to risk management and not risk assessment. The HH RMD and its references include guidance on the need to address uncertainties in the risk characterization in the baseline human health risk assessment. How those uncertainties are addressed by the risk managers is a follow-up concern.

4. Revisit use of negative XRF results

Joe Towarnicky reviewed findings from X-ray fluorescence (XRF) results in relation to laboratory results that were documented in the Soils Operable Unit RI on an element-by-element basis so that we know how to use XRF data (e.g., can XRF be used for selenium); these findings will be added to Appendix E. Joe's findings are attached.

The group should send any comments they have to LeAnne. This information will be included in this Risk Methods Document, Appendix E.

5. **Excavation Worker Scenario (chronic versus subchronic toxicity values)**

Chronic toxicity values are more conservative, in terms of protecting human health, and not many subchronic values are available. The RAWG prefers to stay with chronic values.
Ensure the RMD states that we use chronic values as a layer of protectiveness even if subchronic values are available. The BGOU FS should not add a footnote to explain that subchronic values were not used.

6. **Topics that need to be addressed in the Eco Risk Methods document (Review of Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Volume 2. Ecological. DOE/LX/07-0107&D2/V2)**

Jeri Higginbotham had the following suggestions:

a. On page 2-9, Sample et al is cited with an incorrect date of 1998. The date is listed correctly (1997) in the reference section on page 4-2. Please correct.
b. On page 2-11, change "using one-half the reported detection limit for all results reported as nondetected concentrations." Methodology now available in Pro-UCL or an equivalent statistical package is preferable. An exception to this is when a sample contains a small fraction of non-detects (i.e., no more than 10-15%), simple substitution of half the reporting limit is generally adequate (USEPA 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, EPA 530/R-09-007).
c. On page 2-12, the sentence, "Toxicity profiles for COPCs should include a discussion of published data on the relative toxicity of various groups of organisms" should be changed to, "Toxicity profiles for COPCs should include a discussion of published data on the relative toxicity to various groups of organisms".
d. On page 2-19, there are 4 bullets, but the sentence preceding the bullets indicates there should be three. The second bullet may be more clearly treated as an if-then statement subsequent to the bulleted information.
e. On page A-9 in Table A.2, the no further action (NFA) screening values for sulfur, thiocyanates, benzene, ethylbenzene, toluene, and xylene are listed as 500, 1, 0.01, 0.03, 0.01, and 0.1, respectively. The source for all six values is listed as EPA Region 4. The screening values listed by EPA Region 4 are 2, 2, 0.05, 0.05, 0.05, and 0.05 respectively, as can be seen at http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf.
f. On page A-10 in Table A.2, the NFA screening values for carbon tetrachloride, 1,2-dichloroethane, 1,2-dichloropropane, chlorobenzene, chloroform, dichlorobenzene, dichloromethane, hexachlorobenzene, pentachlorobenzene, tetrachloroethylene, and aldrin are listed as 0.4, 0.02, 0.1, 0.1, 0.02, 0.1, 0.4, 0.05, 0.05, 0.002, and 0.0006 respectively. The source for all is listed as EPA Region 4. The screening values listed by EPA Region 4 are 1.0, 0.4, 700, 0.05, 0.001, 0.01, 2, 0.0025, 0.0025, 0.01, and 0.0025 respectively, as can be seen at http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf.
g. On page A-11 in Table A.2, the NFA screening values are 0.0002 for atrazine, 0.009 for BHC-beta, 0.00003 for carbaryl, 0.00002 for carbofuran, 0.0049 for dieldrin, 0.00004 for endrin, 0.002 for maneb, 0.000007 for acrylonitrile, 0.05 for catechol, 960 for ethylene glycol, and 0.3 for styrene. The source for all is listed as EPA Region 4. The screening values listed by EPA Region 4 are 0.00005, 0.001, 0.5, 0.2, 0.0005, 0.001, 3.5, 1000, 20, 97, and 0.1 respectively, as can be seen at http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf.
h. On page A-11 in Table A.2, cresols has a b superscript, but there is no corresponding b footnote. Please add the b footnote.

i. In Table A.6, on page A-17, change the selenium NFA Screening Value Type from “Kentucky State ‘warm water’” to “Region 4 Freshwater ESV.”
j. On page A-19, change the Polychlorinated biphenyls Screening Value from “0.0014” to “0.014”.

LeAnne will prepare a schedule for the Ecological RMD revision before the June 2014, quarterly meeting to include incorporation of the above-referenced revisions. The group should consider whether the Ecological RMD needs to include the revised guidance for the later steps of the ecological risk assessment methodology.

7. Validation needed for closure activities [CERCLA 120(h)]

Typical validation (i.e., 3rd party validation) currently is 10%. What is appropriate for closure activities? RAWG will develop a recommendation during the next quarterly meeting. Also, DOE agreed to ask the PGDP Site Manager about scheduling a CERCLA 120() training.

8. Derivation of Risk-based Surface Water Effluent Limits

Based upon the most recent resource use information developed for the revised Appendix E, in consideration of surface water, the recreational user wading, swimming, and fishing and outdoor worker exposure scenarios apply to Bayou and Little Bayou Creek. Of these, fishing is likely implausible for Little Bayou Creek due to the lack of catchable fish. Subsistence fishing is unlikely for Bayou Creek because the fishery is too small to allow subsistence catches without considering that many of the fish caught would be from the Ohio River. Wading and swimming are plausible but only swimming allows for derivation of a risk-based value for radionuclides (dose is from incidental ingestion of water). The RAWG needs to consider this and other information and develop a recommendation on how best to develop risk-based effluent limits.
Just because a scenario is not plausible, we don’t need to do away with rad effluent limits.
RAWG will develop a recommendation during the next quarterly meeting.
Some inputs to consider are the following:

- How were NPDES limits developed? Are their scenarios reasonable to use at this site?
- Are there similar ways to calculate rad limits?
- Can we extrapolate 1E-04, 1E-05, and 1E-06 values for the Risk Methods Document?
- Does Oak Ridge have an ALARA implementation procedure that we could use here?
- What scenarios do we need to use to set limits?
- What are the risk-based inputs?

9. Status of RAWG SWMUs 2, 3, 7 and 30 FS Remedial Action Objective Revision Recommendation

The revision that was recommended by the RAWG during special-called meetings January 31 and February 7, has been incorporated into the draft document. This recommendation may be put into the comment resolution summary that includes the tables (comparing the outdoor worker and excavation worker numbers) presented during those meetings in January and February.

10. Poll RAWG Members/Open Discussion

It was highlighted that the next meeting will be on June 4. No additional discussion occurred.

DRAFT Discussion Concerning Use of XRF Data with Negative Values

Issue:

X-ray fluorescence (XRF) analyses for a few constituents (chromium, lead, and uranium) at the Paducah Gaseous Diffusion Plant (PGDP) historically have reported negative (less than zero) concentration values [See attached excerpt from Soils Operable Unit (OU) Remedial Investigation (RI) Report Comment Response Summary]. Because an element concentration cannot be less than zero, there is concern over how best to use the raw XRF data. In the Soils OU RI, the negative values were used in the calculation of the means and standard deviations.

Background:

- XRF data have been used at PGDP to supplement laboratory analyses of soil samples to define better the nature and extent of the presence of elements. Some of the reported results have been less than zero.

- ***The less-than-zero values for chromium, lead, and uranium all were from XRF analyses conducted in 2007.***

- The less-than-zero values had no detection limits reported in the database; however, 2010 XRF data report XRF detection limits of 85 mg/kg (chromium), 13 mg/kg (lead), and 20 mg/kg (uranium). The detection limit for lead (13 mg/kg) is less than the background concentration of lead at PGDP (per Table A.12 of the Risk Methods Document).

- The data set includes 590 less-than-zero chromium (~4794 total results), 27 lead (~4917 total results), and 129 uranium (~4,700 total results) results.

- The Soil Piles Investigation, Appendix B (Section 9.6) summarizes the data management for that project using Kaplan-Meier, the EPA recommended method of handling nondetects (Singh 2006) and compares that to using the raw values (including negative values) as reported from the XRF method.

- The Soil Piles Investigation compared the use of the raw data to the use of the Kaplan-Meier approach and found that for elements with most values above the detection limits, the means and standard deviations are comparable; however, for elements with few (or no) detects, the two methods yielded different results. For example, the chromium mean value for the concentration was negative (from the XRF data set with no detectable chromium results). As a result, the conclusions section of Section B.9.6 stated: "Thus, it is not recommended substituting the raw values in place of undetected values for computation of summary statistics and UCLs" (for those elements with few detected values).

Discussion:

Module 2 – Basic XRF Concepts XRF Web Seminar discusses the application of XRF analysis (http://www.clu-in.org/conf/tio/xrf_080408/prez/XRF_02pdf.pdf). The page reproduced (below) from this module discusses how negative values can be reported when there is none of the element present. Counting statistics will report values that cluster around zero, with half the results being positive and half the results being negative.

A second page (reproduced below) describes recommendations for use of data reported at concentrations below the detection limit. Some instruments do not report these data. Some manufacturers advise against using these data. These values can be valuable information if careful about its use…particularly true if one is trying to calculate average values over a set of measurements.

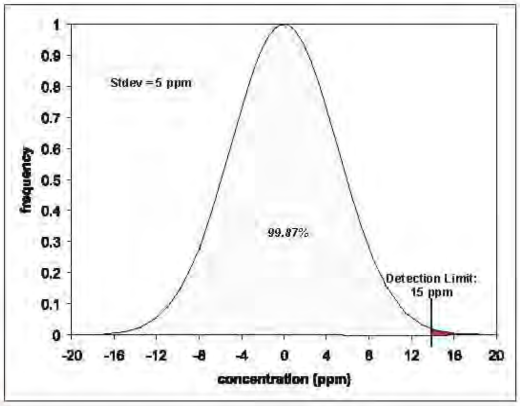
The XRF measurements represent concentrations near the surface of the sample, while laboratory results are volumetric in nature. Thus, one can expect some differences between the XRF and the lab results, except in those cases where the concentrations of elements are homogeneously dispersed in the soil.

Impacts on Soils OU RI Results:

1. The more recent XRF results did not have any negative results reported; thus, this may not be an issue going forward except when trying to use older historical results.
2. The less-than-zero results only occur when the true value is near zero.
3. The detection limit for the recent results is a more positive value than the average less-than-zero value. Thus, the use of negative values somewhat balances the positive bias introduced when using a detection limit (e.g., 85 mg/kg) as the nondetected value.
4. The 1,049 ***lab*** results (including one nondetect) had an average chromium concentration of 32 mg/kg.
5. The 4,794 lab and XRF results (including the 2,362 XRF nondetect results of which 590 were less-than-zero values) had an average concentration of 50 mg/kg. It appears that even when the negative values are used, the XRF results tend to yield a somewhat false positive result for chromium.
6. If remedial actions are taken for chromium, the use of XRF in confirmation sampling may need to be limited.

The 3 Standard Deviation Concept

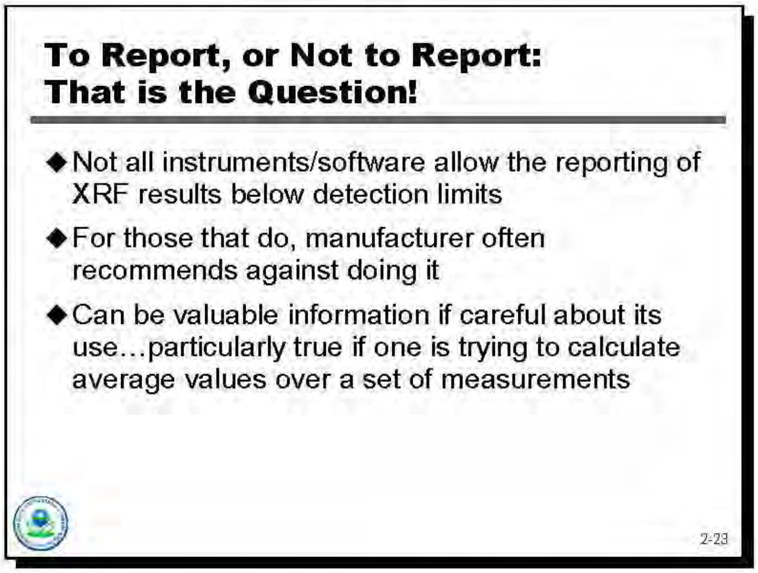
Frequency of XRF Responses When Element Not Present



2-17

Notes

- The graphic above illustrates the frequency of XRF responses when the element is not present. Assume that a sample does not have an element present (or that it is present at trace levels). If one were to take a measurement of the sample with the XRF, the XRF would record a concentration present for that element just because of the random nature of x-ray counting statistics. If one did a large number of repeat measurements, one could generate a distribution or frequency plot of those "random" concentrations such as is shown here, with a measurable standard deviation. Notice that the frequency distribution is centered around zero, indicating that this instrument is providing an unbiased estimate of the concentration for the element of interest. Notice too that half the time the instrument would report positive values, and half the time it would report negative values…an important fact that will be discussed later. If one moves three standard deviations up from zero and calls that the detection limit (consistent with SW846 Method 6200), then almost 100% of the concentration values generated when the element is not present would be less than the detection limit. In other words, if the instrument records a result greater than this detection limit, then it is very likely that in fact the element is present.



To Report, or Not to Report: That is the Question!

- Not all instruments/software allow the reporting of XRF results below detection limits
- For those that do, manufacturer often recommends against doing it
- Can be valuable information if careful about its use…particularly true if one is trying to calculate average values over a set of measurements

Notes

- **Not all instruments/software allow the reporting of XRF results below detections limits:** Some instruments and associated software do not allow the reporting of measurement results that are below detection limits.
- **For those that do, manufacturer ofter recommends against doing it:** For those instruments that do allow reporting of results below detection limits, the manufacturer usually advises against it. Within the chemistry analytical world, the approach has been to not report values less than detection limits. Within the radionuclide analytical world, the approach has been to report values less than detection limits. The XRF is an analytical technique that has its roots in the radionuclide world (e.g., gamma and alpha spectroscopy), but has applications to the chemical world (e.g., elemental metals).
- **Can be valuable information if careful about its use . . . particularly true if one is trying to calculate average values over a set of measurements:** Values below detection limits can be useful when calculating average values over a set of measurements. If the instrument's calibration is unbiased for low levels of the element of interest, using measured values below the instrument's detection limits can yield more accurate assessments of average concentrations that flagging readings as non-detects and substituting some arbitrary value such as the detection limit, or half the detection limit, in average value calculations. Great care and full disclosure are necessary when using values below detection limits.

Risk Assessment Working Group

Meeting Minutes—June 2014

Present:

✓Stephanie Brock
✓Nathan Garner
✓Mike Guffey
✓Jerri Martin
✓Tim Frederick
✓Jon Richards
✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse

1. Call for Issues from RAWG Members

None.

2. Remainder of FY 2014 Schedule (revised)

Quarterly Meeting (June)	6/4/2014
Submit Risk Methods Document (RMD) to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	7/16/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/30/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Develop next FY's schedule by next quarterly meeting.

3. Summary of RAWG Review and Comments Received

Below is a summary of the comments received on the 2014 RMD. Minor editorial changes are not listed.

Main Text:

(1) Page 1-1, new footnote: for clarity, added "(for example, area of concern, remediation area, and/or SWMU)" following "location." (See also Item 4 of these minutes.)

(2) Figure 2.2, added definition of site-specific from page 1-1.

(3) Figure 3.1, new footnote: revise to "Because future use of groundwater at the PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided here for informational purposes only." Conforming changes to be made in Appendix D (Tables D.26, D.27, and D.28).

(4) Page 3-12, update Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" (EPA 1991d) to OSWER Directive 9200.1-120 2014 (see also Item 9 of these minutes).

(5) Page 3-13, add reference to meeting minutes in Appendix E.

(6) Page 3-13, add reference to "Determining Groundwater Exposure Point Concentrations, Supplemental Guidance" (2014)—http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9283-1-42-GWEPC-2014.pdf (see also Item 10 of this agenda).

(7) Page 3-46, the revised text, "As part of the uncertainty analysis for the risk assessment, risk may be recalculated with default exposure factors replaced using exposure parameters consistent with the SWMU/area of concern (AOC)" should be revised back to "consistent with site-specific values" instead of "consistent with the SWMU/area of concern (AOC)."

Appendix A:

(1) Page A-3, "unit-specific" revised back to "site-specific," based on a comment that we do not want to add a new term. This is to be applied globally. Site-specific is defined on page 1-1.

(2) Table A.7a, footnotes e and f, this is a deviation from the earlier AL/NAL tables where acenaphthene is used for both acenaphthylene and phenanthrene. This variance needs to be addressed.

Plan to leave as is for 2014 RMD, but address the surrogates in 2015 RMD (see also Item 9 of these minutes).

(3) Table A.13, revisit footnote, "Values contained in this table have not been approved for all uses by the PGDP Risk Assessment Working Group; therefore, the values presented here are provisional values and subject to change. Issues to be resolved in forthcoming meetings include the data set from which these values were derived and the statistical methods used to analyze the data set."

Issue for nickel was resolved previously. Changes to the footnote are to the second sentence, now revised to read, "The issues to be resolved are the data set from which these values were derived and the statistical methods used to analyze the data set."

Radionuclide MDAs are from 1990s; this information needs to be reevaluated. These issues will need to be resolved prior to restart of the Dissolved-Phase Plume Project.

(4) Table A.14, add the following text to the Tc-99 footnote, "See Table A.9 for Tc-99 groundwater concentrations resulting in a 4 mrem/yr dose based upon more recent dosimetry."

Appendix D:

(1) Table D.19, remove "Notes: Chemical concentration in surface water (mg/L) times intake factor [L/(kg X day)] yields default RME dose for associated endpoint.

Radionuclide activity in surface water (pCi/L) times intake factor (L) yields default RME dose."

This information is a leftover from when the intake factors equations were included in these tables.

(2) These should be updated with new default exposure values (2014 OSWER Directive) (see also Item 9 of these minutes.) This will be included in the 2015 RMD.

(3) Conforming changes from main text.

Appendix E:

(1) Section E.2.5: Received comment to state more explicitly that the information in this section is summarized and updated; actual interview information is in attachments.

(2) Section E.2.6: Received comment from Tim Kreher to include 2013 numbers in annual harvest because 2013 included additional area near PGDP in turkey hunting, therefore numbers significantly increased.

4. Use of "Site-Specific" in RMD

The "site-specific" term in the main text of the 2014 RMD will remain unchanged except for the following context (in these instances, site-specific was deleted):

"For excavation activities performed by the outdoor worker, data collected from 0 to 10 ft bgs will be used to estimate the EPC, unless ~~site-specific~~ information indicates that results from samples collected at deeper depths (i.e., 0–16 ft bgs in areas where infrastructure is found) should be included in the derivation of the EPC."

"As part of the uncertainty analysis for the risk assessment, risk may be recalculated using exposure parameters consistent with the SWMU/AOC. The decision to recalculate risks using these alternative exposure parameters ~~site-specific values~~ would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development."

A footnote explaining site-specific has been added upon first use, as follows: "The term site-specific is indicative of the location for which a risk analysis is performed. The boundaries of the location (for example, area of concern, remediation area, and/or SWMU) should be defined during establishment of data quality objectives (DQOs) (see Chapter 3)."

Use of "site-specific" in the 2014 RMD is acceptable. Add use of term "site-specific" to next quarter's agenda as an open topic.

5. Use of Outdoor Worker and Excavation Worker in 2015 RMD

A comment was made to the previous RAWG meeting minutes on the text, "The excavation worker site-specific scenario information would be adopted into the RMD from the Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS)."

Todd Mullins commented as follows: "I'm still not sure that I'm entirely comfortable with incorporating this scenario into the RMD. Using it to adjust RGs when a prior baseline risk assessment has mandated that an FS evaluation of alternatives is required is one thing. Using it to potentially determine whether an action is required is something else entirely. The assumptions being made under the site-specific excavation worker scenario appear too arbitrary and unit specific to be integrated into a baseline risk assessment."

Need discussion at the FFA manager's level regarding appropriateness of the evaluation used for BGOU cleanup levels applied across the board in the RMD. LeAnne will ask Jana to add this to the FFA manager's topics. This topic will be discussed next quarter. Additionally, some risk management guidance may need to be incorporated into the 2015 RMD.

6. Ecological RMD Proposed Schedule

The group should consider whether the Ecological RMD (*Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. Volume 2. Ecological. DOE/LX/07-0107&D2/V2) needs to include the revised guidance for the later steps of the ecological risk assessment methodology.

Proposed initial revision submitted to RAWG for review	10/6/2014
Comments due on initial revision	11/24/2014
Quarterly Meeting (December) (discuss comments)	12/3/2014
Submit Final Ecological RMD (DOE/LX/07-0107&D2/R1/V2) to FFA managers for approval	1/9/2015
FFA managers approve final Ecological RMD (DOE/LX/07-0107&D2/R1/V2)	2/9/2015

7. Validation Needed for Closure Activities [CERCLA § 120(h)]

RAWG will have input regarding closure activities. Typical validation at Paducah (i.e., 3rd party independent data validation) that is done on a project basis and is between 5–20%; it is not a recommendation on a programmatic basis.

LATA Kentucky is preparing a paper regarding validation that will be provided to the RAWG soon for informational purposes only. This subject will be discussed further after receipt of the paper.

Rich Bonczek is planning CERCLA § 120(h) training.

8. Derivation of Risk-based Surface Water Effluent Limits

The RAWG recommendation on risk-based effluent limits will be discussed further at a subsequent quarterly meeting.

9. Additional Proposed Revisions to 2015 RMD

— **Relook at significant COPCs for PGDP (Table 2.1 of the 2014 RMD).**
— **Revised EPA recommended exposure parameters (see attached comparison).**

The following is the definition of “Area Correction Factor” in the Risk Assessment Information System (RAIS):

> The RAGS/HHEM Part B model assumes that an individual is exposed to a source geometry that is effectively an infinite slab. The concept of an infinite slab means that the thickness of the contaminated zone and its aerial extent are so large that it behaves as if it were infinite in its physical dimensions. In practice, soil contaminated to a depth greater than about 15 cm and with an aerial extent greater than about 1,000 m^2 will create a radiation field comparable to that of an infinite slab. (U.S. EPA. 2000a)

> To accommodate the fact that in most residential settings the assumption of an infinite slab source will result in overly conservative SSLs, an adjustment for source area is considered to be an important modification to the RAGS/HHEM Part B model. Thus, an area correction factor, ACF, has been added to the calculation of SSLs (EPA 2000a).

The "Dilution Factor" is referenced to EPA 2000a (page 2-20) and EPA 2000b (page 2-13):

> EPA 2000a. Soil Screening Guidance for Radionuclides: User's Guide. Office of Emergency and Remedial Response and Office of Radiation and Indoor Air. Washington, DC. OSWER No. 9355.4-16A.
>
> EPA 2000b. Soil Screening Guidance for Radionuclides: Technical Background Document. Office of Emergency and Remedial Response and Office of Radiation and Indoor Air. Washington, DC. OSWER No. 9355.4-16

— **Updated NALs and ALs based on updated toxicity values and potentially updated exposure values (Tables A.1 through A.6).**

The 2015 RMD should add a table of surrogates. Exposure values will be a combination of KY values and EPA updated values.

Whether NALs and ALs for the excavation worker are added is a topic for next quarter's meeting.

— **Risk-Based SSLs for the protection of RGA groundwater (Table A.7a).**

DAFs of 1 and 20 currently are used in Table A.7a. For the 2015 RMD, a DAF of 57 may be added to the table.

— **Dose-based soil/sediment screening levels (Table A.8).**

Use of new dosimetry will be discussed at the next meeting for Tables A.8, A.9, A.10, and A.11.

— **Dose-Based Groundwater Screening Levels (Table A.9).**

— **Dose-Based Surface Water Screening Levels (Table A.10).**

— **Dose-Based Soil Screening Levels for the Protection of RGA Groundwater (Table A.11).**

— **Expand Residual Risk Assessment Discussion.**

This topic would be for the risk remaining after a cleanup activity is completed. This discussion would be a good place for risk management options and CERCLA § 120(h) inputs.

10. Use of Groundwater EPC EPA Directive

Guidance is thought to be used at Paducah currently—need to ensure there are no other implications in the directive that should be included—add reference to 2015 RMD.

11. Poll RAWG Members/Open Discussion

The excavation worker revision in the BGOU SWMUs 2, 3, 7, and 30 FS was in response to EPA comments. A common understanding is needed in the exposure parameters used.

Comparison of Industrial Worker Soil/Sediment No Action Levels
Using Current 2014 Risk Methods Document Default Exposure Parameters and EPA's 2014 Recommended Default Exposure Parameters

Chemical	Units	2014 RMD Default Carcinogenic NAL TR=1.0E-6	2014 RMD Default Noncarcinogenic NAL HI=0.1	Revised Carcinogenic NAL TR=1.0E-6	Revised Noncarcinogenic NAL HI=0.1	Difference ELCR NAL	Difference HI NAL
Arsenic, Inorganic	mg/kg	3.81E+00	6.09E+01	4.36E+00	6.95E+01	13%	13%
Uranium (Soluble Salts)	mg/kg		5.98E+02		6.81E+02		13%
Polychlorinated Biphenyls, Total	mg/kg	2.86E+00		3.27E+00		13%	
Trichloroethylene	mg/kg	6.73E+00	2.04E+00	6.77E+00	2.05E+00	1%	1%
Vinyl Chloride	mg/kg	2.11E+00	4.20E+01	2.18E+00	4.23E+01	3%	1%
Tc-99	pCi/g	2.02E+03		2.02E+03		0%	
U-238+D	pCi/g	7.48E+00		7.48E+00		0%	

Comparison of Input Parameters:

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Body weight	70 kg	70 kg	80 kg
Exposure duration	25 years	25 years	25 years
Exposure frequency	250 days	250 days	250 days
Exposure time	8 hours	8 hours	8 hours
Soil ingestion rate	50 mg/day	50 mg/day	50 mg/day
Lifetime	70 years	70 years	70 years

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Area correction factor	0.9[a]	n/a	n/a
Dilution factor	0.4[a]	n/a	n/a
Indoor exposure time	0.33 hr/hr[b]	n/a	n/a
Outdoor exposure time	0 hr/hr[a]	n/a	n/a
Gamma shielding factor	0.2[c]	n/a	n/a
Inhalation rate	20 m^3/day[d]	n/a	n/a

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

[a] The value is not included in either the RMD or in the EPA recommended values. Default value in RAIS is used for calculating the no action level (NAL).

[b] 0.33 hr/hr is calculated using the 8-hour exposure time and a 24-hour day (i.e., 8/24).

[c] Gamma shielding factor is not included in the EPA recommended values; however, the default value in RAIS is 0.4. The 2014 RMD value for the gamma shielding factor is 0.2.

[d] The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS 60 m^3/day. The 2014 RMD value is 20 m^3/day (calculated from 2.5 m^3/hr x 8 hr/day).

Comparison of Resident Groundwater No Action Levels
Using Current 2014 Risk Methods Document Default Exposure Parameters and EPA's 2014 Recommended Default Exposure Parameters

Chemical	Units	2014 RMD Carcinogenic NAL TR=1.0E-6	2014 RMD Noncarcinogenic NAL HI=0.1	Revised Carcinogenic NAL TR=1.0E-6	Revised Noncarcinogenic NAL HI=0.1	Difference ELCR NAL	Difference HI NAL
Arsenic, Inorganic	mg/L	3.78E-05	3.13E-04	5.17E-05	5.99E-04	31%	63%
Uranium (Soluble Salts)	mg/L	-	3.13E-03	-	5.99E-03		63%
Polychlorinated Biphenyls, Total	mg/L	1.42E-04	-	1.95E-04	-	31%	
Trichloroethylene	mg/L	4.07E-04[a]	2.27E-04	4.93E-04	2.82E-04	19%	22%
Vinyl Chloride	mg/L	1.11E-05	2.67E-03	1.88E-05	4.44E-03	52%	50%
Tc-99	pCi/L	1.82E+01	-	1.90E+01	-	4%	
U-238+D	pCi/L	5.75E-01	-	6.00E-01	-	4%	

[a] This value will not be the 2014 NAL when the RMD is published. This value reflects the February 2014 change made to RAIS; the NALs for the 2014 RMD were completed in November 2013 and will be 1.95E-04 for TCE.

Comparison of Input Parameters:

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Body weight	Child—15 kg Adult—70 kg	Child—15 kg Adult—70 kg	Child—15 kg Adult—80 kg
Exposure duration	Child—6 yr Adult—24 yr	Child—6 yr Adult—24 yr	Child—6 years Adult—20 years
Exposure frequency	350 days	350 days	350 days
Exposure time	24 hours/day	24 hours/day	24 hours/day
Exposure time (shower)	0.2 hours/event	Child-1 hr Adult-0.58 hr	Child-0.54 hr Adult-0.71 hr
Events/Day	1 event/day	1 event/day	1 event/day

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Water ingestion rate	Child—1.5 L/day Adult—2.0 L/day	Child—1.0 L/day Adult—2.0 L/day	Child—0.78 L/day Adult—2.5 L/day
Lifetime	70 yr	70 yr	70 yr
Surface area	Child—6,500 cm^2 Adult—18,150 cm^2	Child—6,600 cm^2 Adult—18,000 cm^2	Child—6,378 cm^2 Adult—20,900 cm^2
Exposure duration (resident)	30 yr	30 yr	26 yr
Inhalation rate (adult)	20 m^3/day*	N/A	N/A
Inhalation rate (child)	20 m^3/day*	N/A	N/A

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

*The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS 20 m^3/day. The 2014 RMD value also is 20 m^3/day (calculated from 0.833 m^3/hr x 24 hr/day).

June 4 Quarterly Meeting Item for Discussion:

The soil ingestion rate, exposure frequency, adherence factor, and surface area currently used in the RMD are based on Kentucky Risk Assessment Guidance (Appendix E). If these exposure parameters are left as is, only the body weight potentially would change.

Comparison of Outdoor Worker Exposure Parameters

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Adherence Factor	1 mg/cm^2	0.2 mg/cm^2	0.12 mg/cm^2
Body weight	70 kg	70 kg	80 kg
Exposure duration	25 years	25 years	25 years
Exposure frequency	185 days	225 days	225 days
Exposure time	8 hours	8 hours	8 hours
Soil ingestion rate	480 mg/day	100 mg/day	100 mg/day
Lifetime	70 years	70 years	70 years
Surface area	4700 cm^2/day	3300 cm^2/day	3470 cm^2/day
Indoor exposure time	0 hr/hr	N/A	N/A
Outdoor exposure time	0.33 hr/hr[a]	N/A	N/A
Gamma shielding factor	0.2[b]	N/A	N/A
Inhalation rate	20 m^3/day[c]	N/A	N/A

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

[a] 0.33 hr/hr is calculated using the 8-hour exposure time and a 24-hour day (i.e., 8/24).

[b] Gamma shielding factor is not included in the EPA recommended values; however, the default value in RAIS is 0.4. The 2014 RMD value for the gamma shielding factor is 0.2.

[c] The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS 60 m^3/day. The 2014 RMD value is 20 m^3/day (calculated from 2.5 m^3/hr x 8 hr/day).

Risk Assessment Working Group
Meeting Minutes—September 2014

✓Gaye Brewer
✓Stephanie Brock
✓Nathan Garner
✓Mike Guffey
✓Jeri Higginbotham
✓Jerri Martin
✓Todd Mullins

✓Tim Frederick
✓Jon Richards
✓Brett Thomas

✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse

1. Call for Issues from Risk Assessment Working Group (RAWG) Members.

None.

2. 2014 Risk Methods Document (RMD).

— **Status of Approval**
E-mails have been received from U.S. Environmental Protection Agency (EPA) and Kentucky Department for Environmental Protection (KDEP). The 2014 RMD is considered complete.

— **Summarization and Discussion of Comments Received**
Replacement pages were sent, changing the revision number to R4; removed footnote defining site-specific from page 1-1 and Figure 2.2. An electronic copy is available at the following Web address:
http://www.latakentucky.com/PublicDocuments/Risk%20Methods%20Document%20D2R4V1,%202014-09/

3. Draft Revised FY 2015 Schedule/Work Plan.

Submit Work Plan (this schedule)	8/25/2014
Quarterly Meeting (September)	9/23/2014
Proposed initial revision of Ecological (Eco) RMD submitted to RAWG for review	*10/6/2014*
Approve Work Plan (this schedule)	10/8/2014
Comments due on initial revision of Eco RMD	*11/24/2014*
Submit HH Appendix A [Preliminary Remediation Goals (PRGs)] to RAWG for Review	12/1/2014
Quarterly Meeting (December) — Discuss Eco RMD comments	12/3/2014
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2014
Comments due for HH Appendix A	1/5/2014
Submit Final Eco RMD **(DOE/LX/07-0107&D2/R1/V2)** ***to FFA managers for approval***	*1/9/2015*
FFA managers approve final Eco RMD **(DOE/LX/07-0107&D2/R1/V2)**	*2/9/2015*
RAWG approve HH Appendix A	2/12/2015
Comments due for HH Main Text and HH Appendices B-E	2/12/2015
Quarterly Meeting (March)	3/4/2015
RAWG approve HH Main Text and HH Appendices B-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2015
FFA Managers approve HH RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2015
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)
Italics indicate Eco RMD schedule, as agreed upon during June 2014 Quarterly Meeting.

4. Modified Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 PRGs for the Excavation Worker.

The use of the “two men and a backhoe” approach (i.e., the unit-specific assumption) to calculate PRGs vs. using truly “site-specific” exposure assumptions was discussed.

Since EPA recommends a range of 1-5 years for excavation, KDEP would prefer to use 5 years as the exposure duration to develop PRGs for the excavation worker (surface and subsurface exposure) instead of using a unit-specific duration. Exposure frequency would be 185 days per year. All other parameters would be the same as for the outdoor worker in the 2014 RMD.

For small units, the “two men and a backhoe” approach still will appear in uncertainty section in baseline risk assessments, among other uncertainties that are discussed.

Chronic toxicity values (not subchronic) will be used. For No Action Levels (NALs) in the 2015 RMD, see Item 6.

5. Use of the Terms “outdoor worker,” “excavation worker,” and “site-specific” in 2015 RMD.

The term “outdoor worker” will be defined as the person exposed to surface soil (0–1 ft) inside the plant and surface and subsurface soil (0–10 ft or 0–16 ft, as appropriate) outside the plant. The term “excavation worker” will be defined as the person exposed to 0–10 ft or 0–16 ft, as appropriate of soil for 5 years for 185 days/year.

A citation of what “site-specific” refers to is found in EPA RAGS Part B, which states, “...risk-based PRGs generally are modified based on site-specific data gathered during the remedial investigation/feasibility study (RI/FS)....” Whenever you develop a RI/FS, you develop site-specific parameters. This definition will not be included in 2015 RMD. (The footnote removed on page 1-1 for the 2014 version will not be reserved in future versions of the RMD. Footnotes will be renumbered, as appropriate.) In the future, the term “site-specific” will be defined, as needed, during project scoping.

The end note 3 in Table B.1 (and Table B.2) of the RMD should be the following: (Note: The text below is reflective of that discussed in the September 2014 Quarterly Meeting. Comments have been made to these minutes suggesting revisions to this text. These changes will be discussed in the December 2014 Quarterly Meeting and will be reflected in the revised Risk Methods Document text due to be sent for comments on December 11, 2014.)

Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (~~e.g~~i.e., soil from the surface down to 16 ft bgs), use of the ~~outdoor~~ excavation worker values is appropriate ~~for a construction/excavation worker~~. ~~(Scenario-specific PRGs for the construction/excavation worker based on site-specific conditions should be derived, as appropriate. See discussion in Section 3.3.4.3.)~~ For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most “conservative” (in terms of protecting human health).~~”~~ Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Finally, the outdoor worker values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening needs to consider~~s~~ shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, ~~however, development of scenario-specific~~excavation worker

PRGs ~~for the outdoor worker based on site-specific conditions is a better approach. See discussion in Section 3.3.4.3~~should be used.)~~.~~

The text of the RMD, including footnote 9 (pages 3-26 and 3-27), also should be revised to be consistent with the table footnote above. The revised text is provided in Attachment 1 to these minutes for comment by the RAWG.

6. Additional Proposed Revisions to 2015 RMD:

— **Discussion of Soil Vapor Intrusion.**
Currently, the RMD states that the soil vapor intrusion model should be run. EPA Region 4 is finalizing new guidance; this will be revisited as soon as the guidance is final.

— **Relook at Significant Chemicals of Potential Concern for Paducah (Table 2.1 of the 2014 RMD).**
This relook will be completed using more recent risk assessments. Chemicals/radionuclides are expected to be added, but none are expected to be removed. Additional chemicals/radionuclides that are not listed as COPCs in Table 2.1 of the 2014 RMD but may be of interest in some future projects (e.g., Freon at SWMU 4) may be included so that their NALs/Action Levels (ALs) will be included in the appendices. These additional chemicals/radionuclides would be footnoted.

— **Site-Specific Exposure Parameters (Table B.4 of the 2014 RMD).**
For the 2015 RMD, current site-specific exposure parameters should be revised to EPA's new recommended default parameters with the following exceptions:

- Ingestion rate for the outdoor (and excavation) workers should remain at 480 mg/day.
- Adherence factors need to use 1.0 mg/cm^2.
- Exposure frequencies for the outdoor (and excavation) workers should be 185 days/year.

A redline-strikeout version of the parameter table (i.e., Table B.4) is shown as Attachment 2 to these minutes for review and comment.

— **NALs and ALs (Tables A.1 through A.6).**
For the 2015 RMD, values will be revised based on updated toxicity values and updated exposure values. Toxicity values will be as of November 2014. It will be ensured that RAIS is updated before calculator is used.

— **Add NALs and ALs for Excavation Worker? (If so, how to set exposure frequency and exposure duration to account for site-specific conditions?)**
NALs and ALs will be added for the excavation worker using 5 year/185 day exposure period. This will be a new column in Table A.1 Soil/Sediment Action Levels for Significant COPCs at PGDP and Table A.4 Soil/Sediment No Action Levels for Significant COPCs at PGDP.

— **Update Risk-Based Soil Screening Levels (SSLs) for the Protection of Regional Gravel Aquifer Groundwater (Table A.7a).**
For the 2015 RMD, a dilution attenuation factor of 57 will be added to Table A.7a. The equations from other document (i.e., SWMU 1 Feasibility Study) and parameters will be included in Appendix E. A citation for the reference will be added to the table.

— **Update Dose-based Screening Levels (Tables A.8 through A.11).**
New dosimetry values were agreed to be used for Tables A.8, A.9, A.10, and A.11 for their 2015 RMD update.

— **Expand Residual Risk Assessment Discussion.**
This topic would be for the risk remaining after a cleanup activity is completed. This discussion would be a good place for risk management options and CERCLA § 120(h) inputs.

A revision of Section 4.2.3 was agreed to be drafted. A review schedule was agreed to be sent. That proposed schedule has been added below for comment.

Section 4.2.3 will be sent to the RAWG on 11/24/2014 for initial review. The section will be discussed in the December 2014 RAWG meeting. Revisions will be made, if necessary and sent with the revisions to the HH main text that is due out to the RAWG on 12/11/2014.

— **Add EPA Directive, Determining Groundwater Exposure Point Concentrations, Supplemental Guidance to References.**
The guidance will be referenced and noted that the RMD will be consistent with the guidance. The use of the guidance will be revisited at the December 2014 RAWG meeting. The document can be found at the following Web site: http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9283-1-42-GWEPC-2014.pdf

7. Additional EPA Risk Assessment Guidance to Potentially Include.

— Probabilistic Risk Assessment
The following guidance documents will be added to the reference list in Section 3.3.4.6, Probabilistic Risk Assessment of the RMD:

- EPA Risk Assessment Forum Probabilistic Risk Assessment White Paper PDF (EPA/100/R-14/004, July 2014) http://www.epa.gov/raf/prawhitepaper/pdf/raf-pra-white-paper-final.pdf

EPA Risk Assessment Forum Probabilistic Risk Assessment FAQs (EPA/100/R-14/003, July 2014) http://www.epa.gov/raf/prawhitepaper/pdf/raf-pra-faq-final.pdf

— Radiation Risk Assessment at CERCLA Sites
This fact sheet (OSWER Directive 9200.4-40) provides an overview of current EPA guidance for risk assessment and related topics for radioactively contaminated CERCLA sites. This fact sheet supersedes an earlier one from December 1999 and is available at the following link: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/Rad%20Risk%20QA%20with%20transmit%20memo_June_13_2014.pdf .

Dose calculations in Appendix A tables and associated text (including page 2-9) of the 2015 RMD will be changed from 15 mrem to 12 mrem.

8. PEGASIS Demonstration.

A link to the site is as follows: http://padgis.latakentucky.com/padgis/
User instructions are available from a link on the site.
Demonstration was postponed until the December 2014 RAWG meeting.

9. Status of Programmatic Quality Assurance Project Plan (pQAPP) revision.

- **Schedule (Relationship of pQAPP Project Action Limits and RMD NALs).**
  A meeting with FFA managers regarding updating the worksheets is planned for early October 2014.
- **Summary of Revisions.**
  Revisions will be discussed in the December 2014 RAWG meeting, including a cross walk table of RMD with pQAPP.

10. Poll RAWG Members/Open Discussion.

No other topics were discussed.

Discussion Topics on Hold:

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014 – further discussion on this topic depends on completing presentations to Paducah Site Lead). Training tentatively is being planned for January 2015.

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014 – further discussion on this topic depends on resolution of Northeast Plume Dispute). This topic may be deferred.

Attachment 1

The following text from pages 3-26 and 3-27 are provided for comment by the RAWG. They have been revised to be consistent with end note 3 in Table B.1 (and Table B.2) of the RMD described in Item 5 of the meeting minutes.

With the revised text from pages 3-26 and 3-27, footnote 9 is proposed for deletion.

In determining the UCL when the medium is soil, data will be segregated into depth intervals relevant to receptors. For all scenarios except the outdoor worker in locations outside the industrialized area and the excavation worker inside the industrialized area, data from samples collected from 0 to 1 ft bgs will be used to estimate the EPC.[9] For ~~excavation~~ outdoor maintenance type activities performed by the outdoor worker in locations outside the industrialized area and the excavation worker inside the industrialized area, data collected from 0 to 10 ft bgs will be used to estimate the EPC, unless information indicates that results from samples collected at deeper depths (i.e., 0–16 ft bgs in areas where infrastructure is found) should be included in the derivation of the EPC.

[9] ~~A single set of exposure equations and parameters is provided for the outdoor worker scenario in Appendix D. The exposure parameters provided in Appendix D should be used without changes when assessing potential risk from exposure to surface soils in locations outside the industrialized area at the Paducah site. When assessing potential risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, all exposure parameters, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker to surface and subsurface soil in locations outside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b) or similar sources (e.g., site-specific information) and should be documented. Similarly, when assessing potential risk from exposure either to surface soil or subsurface soil in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker to surface soil or subsurface soil or both in locations inside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b) or similar sources and should be documented.~~

Attachment 2

A preliminary Table B.4 from the Draft 2015 Risk Methods Document is shown below for review and comment.

Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
General Parameters Used in All Intake Models (unless otherwise noted)									
Exposure frequency (EF)	days/year	250	185	185	350	350	104	140	140
Exposure duration (ED)	Years	25	25	5	20	6	10	10	6
Body weight (BW)	Kg	80	80	80	80	15	80	43	15
Averaging time - cancer (AT-C)	Days	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365
Averaging time - noncancer (AT-N)	Days	365 × 25	365 × 25	365 × 5	365 × 20	365 × 6	365 × 10	365 × 10	365 × 6
Ingestion of Water (Tables D.1, D.26)									
Drinking water ingestion rate (IR)	L/day	NA	NA	NA	2.5	0.78	NA	NA	NA
Inhalation RGA Groundwater (Table D.2, D.27)									
Indoor inhalation rate	m^3/hour	0.833	NA	NA	0.833	0.833	NA	NA	NA
Exposure time in the shower (ET$_{shower}$)	hours/day	0.71	NA	NA	0.71	0.71	NA	NA	NA
Time of shower (t1)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA
Time after shower (t2)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA
Fraction volatilized while showering (f$_{shower}$)	unitless	0.75	NA	NA	0.75	0.75	NA	NA	NA
Water flow rate (Fw)	L/h	890	NA	NA	890	890	NA	NA	NA
Bathroom volume (Va)	m^3	11	NA	NA	11	11	NA	NA	NA
Averaging time - cancer (AT-C)	hours	24×70×365	NA	NA	24×70×365	24×70×365	NA	NA	NA
Averaging time - noncancer (AT-N)	hours	24×365×25	NA	NA	24×365×20	24×365×6	NA	NA	NA
Exposure time household use (ET$_{house}$)	hours/day	NA	NA	NA	24	24	NA	NA	NA
Exchange rate (ER)	changes/day	NA	NA	NA	10	10	NA	NA	NA
Mixing coefficient (MC)	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA
Fraction volatilized household use (f$_{house}$)	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA
Water flow rate (WHF)	L/day	NA	NA	NA	890	890	NA	NA	NA
House volume (HV)	m^3	NA	NA	NA	450	450	NA	NA	NA
Dermal Contact with RGA Groundwater (showering) (Tables D.4, D.28)									
Body surface area exposed (SA)	m^2	2.09	NA	NA	2.09	0.6378	NA	NA	NA
Event time (t$_{event}$)	hour/event	0.71	NA	NA	0.71	0.71	NA	NA	NA
Event frequency (EV)	events/day	1	NA	NA	1	1	NA	NA	NA
Incidental Ingestion of Soil/Sediment (Tables D.5, D.15, D.29, D.30, D.37)									
Incidental ingestion rate (IR)	mg/day	50	480	480	100	200	100	100	200
Fraction ingested		1	1	1	1	1	1	1	1
Dermal Contact with Soil/Sediment (Tables D.6, D.16, D.33, D.39)									
Body surface area exposed (SA)	m^2/day	0.347	0.347	0.347	0.6032	0.269	0.57	0.75	0.28
Soil-to-skin adherence factor (AF)	mg/cm^2 –day	1	1	1	1	1	1	1	1

Comment [LG1]: See Item 6 of Meeting Minutes

Comment [LG2]: See Item 6 of Meeting Minutes

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Comment [LG5]: See Item 6 of Meeting Minutes

Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
Inhalation of Vapors and Particulates Emitted from Soil/Sediment (Tables D.7, D.17, D.31, D.32, D.38)									
Total inhalation rate (IR)	m^3/hour	2.5	2.5	2.5	0.833	0.833	2.5	2.5	2.5
Exposure time (ET) (soil)	hours/day	8	8	8	24	24	5	5	5
Exposure time (ET) (sediment)	hours/day	2.6	NA	NA	NA	NA	NA	NA	NA
Particulate emission factor (PEF)	m^3/kg	6.20E+08	6.20E+08	6.20E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08
External Exposure to Ionizing Radiation from Soil/Sediment (Tables D.8, D.18, D.34, D. 35, D.40)									
Exposure frequency (EF)	day/day	250/365	185/365	185/365	350/365	350/365	104/365	140/365	140/365
Gamma shielding factor (Se)	unitless	0.2	0.2	0.2	0.2	0.2	0	0	0
Gamma exposure time factor (Te)	hr/hr	8/24	8/24	8/24	18/24	18/24	5/24	5/24	5/24
Consumption of Home-grown Vegetables (Table D.9)									
Diet fraction (FI)	unitless	NA	NA	NA	0.4	0.4	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.72	0.29	NA	NA	NA
Consumption of Beef (Table D.10)									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.19	0.07	NA	NA	NA
Consumption of Milk (Table D.11)									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	1.25	0.9	NA	NA	NA
Consumption of Poultry (Table D.12)									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.17	0.07	NA	NA	NA
Consumption of Pork (Table D.13)									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.08	0.03	NA	NA	NA
Consumption of Eggs (Table D.14)									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.11	0.06	NA	NA	NA
Incidental Ingestion of Surface Water (swimming) (Table D.19)									
Ingestion rate (IR)	L/hr	NA	NA	NA	NA	NA	0.05	0.05	0.05
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6
Exposure frequency (EF)	day/year	NA	NA	NA	NA	NA	45	45	45
Dermal Contact with Surface Water (wading) (Table D.20)									
Body surface area exposed (SA)	m^2	NA	NA	NA	NA	NA	1.06	0.75	0.33
Exposure frequency (EF)	day/year	NA	NA	NA	NA	NA	52	140	140
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6

Comment [LG6]: See Item 6 of Meeting Minutes

Comment [LG7]: See Item 6 of Meeting Minutes

Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
Dermal Contact with Surface Water (swimming) (Table D.21)									
Body surface area exposed (SA)	m^2	NA	NA	NA	NA	NA	2.09	1.31	0.6378
Exposure frequency (EF)	days/year	NA	NA	NA	NA	NA	45	45	45
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6
Event (EV)	event/day	NA	NA	NA	NA	NA	1	1	1
Dermal Contact with Surface Water (Table D.36)									
Body surface area exposed (SA)	m^2	0.347	0.347	0.347	NA	NA	NA	NA	NA
Exposure frequency (EF)	days/year	250	20	20	NA	NA	NA	NA	NA
Exposure time (ET)	hr/day	2.6	8	8	NA	NA	NA	NA	NA
Consumption of Fish (Table D.22)									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.029	0.029	0.029
Exposure Frequency (EF)	days/year	NA	NA	NA	NA	NA	365	365	365
Consumption of Venison (Table D.23)									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.032	0.032	0.007
Consumption of Rabbit (Table D.24)									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.0165	0.0082	0.0033
Consumption of Quail (Table D.25)									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.0047	0.0024	0.00094

Information compiled September 2014.
NA = not applicable

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Risk Assessment Working Group
Meeting Minutes—December 2014

✓Gaye Brewer
✓Stephanie Brock
✓Nathan Garner
✓Mike Guffey
✓Jeri Higginbotham
✓Jerri Martin
✓Todd Mullins
✓Tim Frederick
✓Jon Richards
✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bruce Meadows
✓Bobette Nourse
✓Joe Towarnicky

1. PEGASIS Demonstration (Bruce Meadows)

Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) was designed to provide dynamic mapping and environmental monitoring data display for the U.S. Department of Energy (DOE)–PPPO.
A link to the site is as follows: http://padgis.latakentucky.com/padgis/
User instructions are available from a link on the site.

2. Call for Issues from Risk Assessment Working Group (RAWG) Members

Issues included request for discussion regarding vapor intrusion sampling. This information was added to Item 9 of these minutes.

3. Ecological (Eco) Risk Methods Document (RMD)

Comments have been received from Jeri Higginbotham (see Attachment 1). Specifically, Comments 3 and 10 were discussed. EPA Region 5 will be added to the hierarchy of sources for no further action values (see Comment 3). Jeri Higginbotham and Bobette Nourse will follow up regarding undocumented model inputs (see Comment 10).

4. Upcoming Fiscal Year 2015 Schedule/Work Plan

Revisions were made to the work plan resulting in the following remaining fiscal year 2015 schedule:

Submit Revised Human Health (HH) Main Text and HH Appendices B-E to RAWG for Review	12/11/2014
Comments due for HH Appendix A	1/5/2015
Comments due on initial revision of Eco RMD	*1/9/2015*
Submit Final Eco RMD **(DOE/LX/07-0107&D2/R1/V2)** ***to FFA managers for approval***	*2/9/2015*
RAWG approve HH Appendix A	2/12/2015
Comments due for HH Main Text and HH Appendices B-E	2/12/2015
Quarterly Meeting (March)	3/4/2015
FFA managers approve final Eco RMD **(DOE/LX/07-0107&D2/R1/V2)**	*3/9/2015*
RAWG approve HH Main Text and HH Appendices B-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2015
FFA Managers approve HH RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2015
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be via Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern).
Italics indicate Eco RMD schedule.

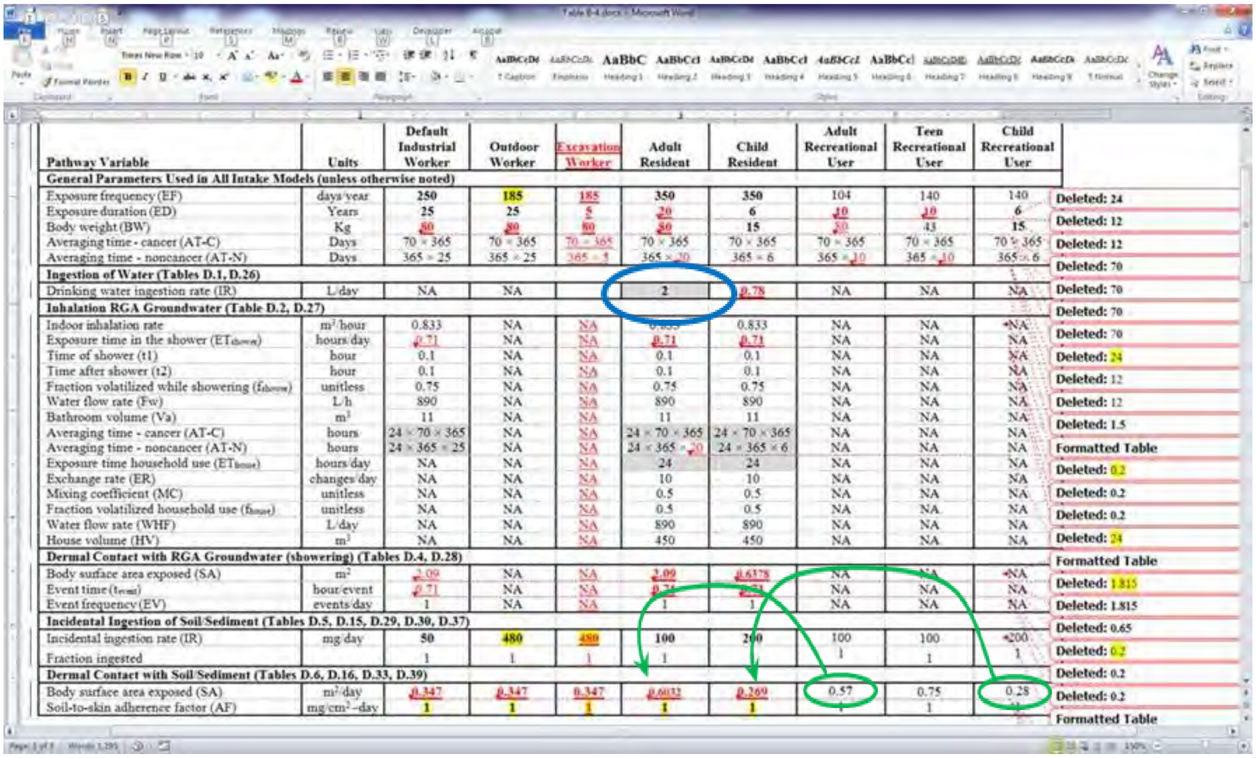
5. Comments/Discussion of Revised Table 2.1 Site Chemicals of Potential Concern (COPCs) (see Attachment 2)

Two COPCs specifically were discussed: bis(2-ethylhexyl)phthalate and thorium-234. Additional information regarding bis(2-ethylhexyl)phthalate was sent to the group following the meeting (see Footnote 10). Thorium-234 was agreed to remain off of the site COPC list (see Footnote 27).

6. HH RMD Appendix A [Preliminary Remediation Goals (PRGs)] Out for Review (12/2/2014)

Revisions will be made to the Appendix as discussed in the following bullets. A revised Appendix A will be sent to the group.

— Revision to adult resident drinking water ingestion rate [from 2 liters/day to 2.5 liters/day as suggested by the new U.S. Environmental Protection Agency (EPA) guidance]. (See below circled in blue.)
Note that DOE-HQ and the Nuclear Regulatory Commission (NRC) have not adopted the change to 2.5 liters/day water ingestion rate for the dose-based calculations.



Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
General Parameters Used in All Intake Models (unless otherwise noted)									
Exposure frequency (EF)	days/year	**250**	**185**	185	**350**	**350**	104	140	140
Exposure duration (ED)	Years	**25**	**25**	5	20	**6**	10	10	**6**
Body weight (BW)	Kg	80	80	80	80	**15**	80	43	**15**
Averaging time - cancer (AT-C)	Days	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365
Averaging time - noncancer (AT-N)	Days	365 × 25	365 × 25	365 × 5	365 × 20	365 × 6	365 × 10	365 × 10	365 × 6
Ingestion of Water (Tables D.1, D.26)									
Drinking water ingestion rate (IR)	L/day	NA	NA		**2**	0.78	NA	NA	NA
Inhalation RGA Groundwater (Table D.2, D.27)									
Indoor inhalation rate	m^3/hour	0.833	NA	NA	0.833	0.833	NA	NA	NA
Exposure time in the shower (ET_{shower})	hours/day	0.71	NA	NA	0.71	0.71	NA	NA	NA
Time of shower (t1)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA
Time after shower (t2)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA
Fraction volatilized while showering (f_{shower})	unitless	0.75	NA	NA	0.75	0.75	NA	NA	NA
Water flow rate (Fw)	L/h	890	NA	NA	890	890	NA	NA	NA
Bathroom volume (Va)	m^3	11	NA	NA	11	11	NA	NA	NA
Averaging time - cancer (AT-C)	hours	24 × 70 × 365	NA	NA	24 × 70 × 365	24 × 70 × 365	NA	NA	NA
Averaging time - noncancer (AT-N)	hours	24 × 365 × 25	NA	NA	24 × 365 × 20	24 × 365 × 6	NA	NA	NA
Exposure time household use (ET_{house})	hours/day	NA	NA	NA	24	24	NA	NA	NA
Exchange rate (ER)	changes/day	NA	NA	NA	10	10	NA	NA	NA
Mixing coefficient (MC)	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA
Fraction volatilized household use (f_{house})	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA
Water flow rate (WHF)	L/day	NA	NA	NA	890	890	NA	NA	NA
House volume (HV)	m^3	NA	NA	NA	450	450	NA	NA	NA
Dermal Contact with RGA Groundwater (showering) (Tables D.4, D.28)									
Body surface area exposed (SA)	m^2	2.09	NA	NA	2.09	0.6378	NA	NA	NA
Event time (t_{event})	hour/event	0.71	NA	NA	0.71	0.71	NA	NA	NA
Event frequency (EV)	events/day	1	NA	NA	1	1	NA	NA	NA
Incidental Ingestion of Soil/Sediment (Tables D.5, D.15, D.29, D.30, D.37)									
Incidental ingestion rate (IR)	mg/day	**50**	**480**	480	**100**	**200**	100	100	200
Fraction ingested		1	1	1	1	1	1	1	1
Dermal Contact with Soil/Sediment (Tables D.6, D.16, D.33, D.39)									
Body surface area exposed (SA)	m^2/day	0.347	0.347	0.347	0.6032	0.269	0.57	0.75	0.28
Soil-to-skin adherence factor (AF)	mg/cm^2–day	**1**	**1**	**1**	**1**	**1**	1	1	1

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— Revision to adult and child recreational user body surface area exposed (to 0.6032 m^2/day and 0.269 m^2/day, respectively). (See above circled in green.)
Exposure is for head, hands, forearms, lower legs, and feet. This exposure is applicable to both the resident and the recreational user.

— Radionuclide PRGs calculator.
Two options are available for calculating radionuclide PRGs. Their Web addresses follow.
http://rais.ornl.gov/cgi-bin/prg/PRG_search?select=rad
http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search

The group agreed to use the RAIS calculator, with an area correction factor of 0.9, as has been used previously.

— Besides soil screening levels (SSLs) based on a dilution attenuation factors (DAFs) of 1 and 20, a DAF of 58 is added to the SSL tables based on information from the Soils OU Remedial Investigation Report. (The Southwest Plume Focused Feasibility Study used a DAF of 59.) Derivation of this DAF that was included in the Soils OU Remedial Investigation Report will be included in Appendix E of the HH RMD.

— Dose-Based SSLs for Protection of Regional Gravel Aquifer Groundwater for Site-Related Radionuclides at the Paducah Gaseous Diffusion Plant (PGDP) are calculated using the equations presented for the 2015 HH RMD. For the 2011– 2014 HH RMDs, these values were generated by the Residual Radioactivity (RESRAD) model.

7. Use of the Terms "outdoor worker," "excavation worker," and "site-specific" in 2015 HH RMD

The end note 3 in Table B.1 (and Table B.2) of the HH RMD was discussed. The suggested revision reads as follows:

Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker risk-based screening values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker risk-based screening values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (i.e., soil from the surface down to 10 or 16 ft bgs, as appropriate), use of the excavation worker risk-based screening values is appropriate. For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident risk-based screening values is appropriate. As with the surface water values, the child resident risk-based screening values are the most "conservative" (in terms of protecting human health). Generally, the recreator risk-based screening values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident risk-based screening values are more appropriate for grassy fields. Finally, the outdoor worker risk-based screening values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. ~~(~~If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, excavation worker PRGs ~~should~~ can be used.~~)~~

8. Expand Residual Risk Assessment Discussion

Section 4.2.3 was sent to the RAWG on 11/24/2014 for initial review. The section was resent following the meeting, with comments due on this section only by 1/15/2015.

9. Vapor Intrusion

New guidance from EPA is still in draft.
The table, "Human Health Information for the Paducah Vapor Intrusion Evaluation," was sent to the group following the meeting. The table also will be added to Appendix E, with an explanation.

Discussion was held regarding adding minimum sampling requirements (e.g. when to sample, minimum samples, what kind of sampling) to the Human Health document.
Discussion included, with respect to sampling: sub-slab sampling should be required (not groundwater or soil). Guidance is available from ITRC and draft guidance from EPA.
Vapor intrusion pathway could be significant and should be addressed in the project DQOs.
A proposal for addition to the main text of the HH RMD will be sent to the group for comment.

10. Summary of revisions to Programmatic Quality Assurance Project Plan (QAPP)

The draft is being reviewed by DOE. Document scheduled to be complete in January; a meeting will be held with regulators after that.

11. Poll RAWG Members/Open Discussion

Discussion topics on hold were discussed.

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014–further discussion on this topic depends on completing presentations to Paducah Site Lead).
Additional information is included in the Programmatic QAPP.

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014–further discussion on this topic depends on resolution of Northeast Plume Dispute).
This topic still is on hold.

Attachment 1
Ecological Risk Methods Document Comments

Comments received from Kentucky:

1. **2.4.1 Study Design--Exposure and Effects Measurements Toxicity Tests. (page 2-19)**
   The last two sentences of the first paragraph on this page are**, "**Screening toxicity tests do not produce definitive benchmark concentrations associated with specific levels of adverse effects. Screening toxicity tests are considered to be chronic tests (EPA 2000b; EPA 2002; ASTM 1998), and test durations are believed to be sufficiently long for adverse effects on sensitive life stages to be observed at concentrations exceeding ecological screening values (ESVs)." Is the word "screening" necessary or appropriate here?

2. **Table 1. Model Parameters for Calculating Preliminary Hazard Quotients for PGDP ERAs (Page 2-9) and Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (page B-4)**
   The soil/sediment ingestion rate is listed as 10.2 and 10 for the American robin and marsh wren respectively in Table 1. Both are listed as 10.4 in Table B.1. Please clarify the discrepancy.

3. **APPENDIX A: PGDP NO FURTHER ACTION LEVELS (page A-4)**
   Sediment NFA levels are stated to be from the following hierarchy of sources:

   (1) "EPA Region 4 values and"

   (2) "Values selected from among KDEP screening values and ORNL sediment screening values based on professional judgment"

   I note in Table A.4. (PGDP Sediment NFA Screening Values) that many of the levels are from Region 5. Please clarify the discrepancy.

4. **Table A.4. PGDP Sediment NFA Screening Values (page A-11)**
   The NFA screening levels for cobalt and 1,1-dichloroethane in sediment has as their source KDEP. KDEP used the Region 5 levels. Please change the source to EPA Region 5 for both.

5. **Table A.4. PGDP Sediment NFA Screening Values (pages A-11 and A-12)**
   The NFA screening levels for benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and toxaphene in sediment has as their source KDEP. KDEP used the levels from a 1996 EPA Region 4 document (United States Environmental Protection Agency (USEPA). 1996 (October). Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Screening Values). This particular document seems to have been superceded. Please change the levels to those used by EPA Region 5, 10400 uk/kg for benzo(b)fluoranthene, 240 uk/kg for benzo(k)fluoranthene, 200 uk/kg for indeno(1,2,3-cd)pyrene, and 0.077 ug/kg for toxaphene.

6. **Table A.6. PGDP Surface Water NFA Screening Values (page A-13)**
   The source for the selenium screening value is listed as NRWQC. However the footnote (e) indicates that the EPA Region 4 value was chosen. Please clarify.

7. **Table A.8. NOAEL-based TRVs for PGDP Wildlife Receptors (page A-17)**
   Both the mammalian and bird TRV listed for 4,4'-DDT are TRVs for 4,4'-DDT and its metabolites, 4,4'-DDD and 4,4'-DDE. It does not appear that there should be a separate entry for each compound in the table. Rather, there should be one entry for 4,4'-DDT,4,4'-DDD. and 4,4'-DDE.

8. **Table A.8. NOAEL-based TRVs for PGDP Wildlife Receptors (page A-18)**
   Table A.8 has the bird TRV for xylene listed as not available. The LANL Ecorisk database lists 107 as the bird TRV. Please use the LANL value.

9. **APPENDIX B: EXPOSURE PARAMETERS FOR PGDP MODEL ECOLOGICAL RECEPTORS**
   Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (pages B-3 to B-6)

   For a number of parameters in this table, two sources are given. The second source is often EPA 1993. If the parameter value was obtained from EPA 1993 and not the original research paper, then please insert the word "in" between the two.

10. **Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (pages B-3 to B-6)**
    Table A.8 contains a footnote explaining the source, EPA Region 4. However, Table B.1 has no such footnote explaining the source, EPA Region 4. Please add a footnote explaining this source. Also, the source, Kentucky Department of Fish and Wildlife Resources, is listed as a personal communication but the name of the individual is not given. Please add the name of the individual.

11. **Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (pages B-3 to B-6)**
    One of the FIR parameter sources for the American robin is Hazelton *et al*., 1984. This source is not listed in the footnotes. Please add this source to the footnotes.

12. **Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (pages B-3 to B-6)**
    There are four sources listed in the footnotes which are not cited in the table. They are:

    - Anthony, E. L. P. and T. H. Kunz 1977. "Feeding Strategies of the Little Brown Bat, *Myotis lucifugus*, in Southern New Hampshire," *Ecology* **58**: 775–786;
    - Burt, W. H. and R. P. Grossenheider 1980. *A Field Guide to the Mammals of North America North of Mexico*, Houghton Mifflin Co., Boston, MA;
    - Sample, B. E., D. M. Opresko, and G. W. Suter II 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*, ES/ER/TM-86/R3; and
    - Skorupa, J. P. and R. L. Hothem 1985. "Consumption of Commercially Grown Grapes by American Robins (*Turdus migratorius*): A Field Evaluation of Laboratory Estimates," *J. Field Ornithol.* **56**: 369–378.

    Please clarify.

13. **Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (page B-5)**
    No sources are provided for the smallmouth bass parameters. Please provide sources for the smallmouth bass parameters.

Attachment 2
COPC Updates to Table 2.1 of the Risk Methods Document

COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
Inorganic Chemicals					
Aluminum	X	X	X	X	X
Antimony	X	X	X	X	X
Arsenic	X	X	X	X	X
Barium	X	X	X	X	
Beryllium	X	X	X	X	
Boron	X		X		
Cadmium	X	X	X	X	X
Chromium III (or total)	X	X	X	X	X
Chromium VI	X				
Cobalt	X	X		X	X
Copper	X	X	X	X	X
Fluoride[2]	O	X	X		
Iron	X	X	X	X	X
Lead	X		X		
~~Lithium~~[3]		X	X		
Manganese	X	X	X	X	X
Mercury	X	X	X		X
Molybdenum	X	X	X		
Nickel	X	X	X	X	X
~~Nitrate (as N)~~[4]			X		
~~Nitrate + Nitrite (as N)~~[5]			X		
Selenium	X			X	
Silver	X	X	X		
~~Strontium~~[6]			X		
Thallium	X				X
Uranium	X	X	X	X	X
Vanadium	X	X		X	X
Zinc	X	X		X	X
Organic Chemicals					
Acenaphthene	X				
Acenaphthylene	X				
~~Acetone~~[7]		X	X		
Acrylonitrile	X		X		
~~Aldrin~~[8]		X			
Anthracene	X				
Benzene	X	X	X		
~~Bis(2-chloroethyl)ether~~[9]		X			
Bis(2-ethylhexyl)phthalate[10]	O	X	X		X
Bromodichloromethane[11]	O	X	X		
~~Bromomethane~~[12]			X		
~~2-Butanone~~[13]			X		
Carbazole	X		X		X
Carbon tetrachloride	X	X	X		
~~Chlorobenzene~~[14]			X		
Chloroform	X	X	X		
~~Chloromethane~~[15]			X		

COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
Organic Chemicals (Cont)					
~~**Dibromochloromethane**~~[16]			X		
1,1-Dichloroethene	X	X	X	X	
1,2-Dichloroethane[17]	O	X	X		
1,2-Dichloroethene (mixed)	X	X	X		
trans-1,2-Dichloroethene	X	X	X		
cis-1,2-Dichloroethene	X	X	X	X	X
Dieldrin	X	X			
~~**2,4-Dimethylphenol**~~[18]			X		
Ethylbenzene	X		X		
Fluoranthene	X				
Fluorene	X				
Hexachlorobenzene	X	X			
~~**4-Methyl-2-pentanone**~~[19]			X		
~~**Methylene Chloride**~~[20]			X		
Naphthalene	X		X	X	X
2-Nitroaniline	X	X			
N-Nitroso-di-n-propylamine	X	X			
Pentachlorophenol[21]	O	X			
Phenanthrene	X		X		
Pyrene	X	X			
Tetrachloroethene	X	X	X		
1,1,1-Trichloroethane[22]	O		X		
1,1,2-Trichloroethane[23]	O	X	X		
Trichloroethene	X	X	X	X	X
Total Dioxins/Furans	X			X	
2,3,7,8-HpCDD	X				
2,3,7,8-HpCDF	X				
2,3,7,8-HxCDD	X				
2,3,7,8-HxCDF	X				
OCDD	X				
OCDF	X				
2,3,7,8-PeCDD	X				
1,2,3,7,8-PeCDF	X				
2,3,4,7,8-PeCDF	X				
2,3,7,8-TCDD	X				
2,3,7,8-TCDF	X				
Total PAHs	X			X	X
Benz(a)anthracene	X	X[1]		X	
Benzo(a)pyrene	X	X		X	
Benzo(b)fluoranthene	X	X[1]		X	
Benzo(k)fluoranthene	X				
Chrysene	X	X			
Dibenz(a,h)anthracene	X	X		X	
Indeno(1,2,3-cd)pyrene	X	X		X	
Total PCBs	X	X	X	X	X
Aroclor 1016	X	X			
Aroclor 1221	X				
Aroclor 1232	X				
Aroclor 1242	X				

COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
Organic Chemicals (Cont)					
Aroclor 1248	X				
Aroclor 1254	X	X	X	X	
Aroclor 1260	X	X		X	
~~Toxaphene~~[24]		X			
Vinyl chloride	X	X	X	X	
Xylenes (Mixture)	X		X		
p-Xylene	X				
m-Xylene	X				
o-Xylene	X				
Radionuclides					
Americium-241	X		X		X
Cesium-137+D	X	X[1]	X		X
Neptunium-237+D	X	X	X	X	X
Plutonium-238	X				
Plutonium-239	X		X	X	X
Plutonium-240	X				
~~Radium-226+D~~[25]			X	X	
~~Radon-222~~[26]		X	X		
Technetium-99	X	X	X	X	X
Thorium-230	X				X
~~Thorium-234~~[27]		X			
Uranium-234	X	X	X	X	X
Uranium-235+D	X		X	X	X
Uranium-238+D	X	X	X	X	X
Other constituents to add to Appendix A					
Dichlorodifluoromethane (Freon-12)					
1,1-Dichloroethane					
Toluene					
1,1,2-Trichlorotrifluoroethane (Freon-113)					

The initial list of "Significant COPCs for PGDP" is shown above in black, regular font, and includes COCs from SWMU 2 (1996a), WAGs 1&7 (1996b), WAG 6 (1999a), WAG 27 (1999b), SWOU SAP (2005), and SWOU SI (2008). Additional, potential "Significant COPCs for PGDP" are shown in red, bold font in updates to Table 2.1 and include COCs from the references listed below.

- DOE 2000. *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1846/V4&D2, August.

- DOE 2001. *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (Table 1.9) DOE/OR/07-1857&D2, August.

- DOE 2010. *Remedial Investigation Report for the Burial Grounds Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0030&D2/R1, February.

- DOE 2013. *Soils Operable Unit Remedial Investigation Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0358&D2/R1, February.

[1] DOE 2000 also lists benzo(a)fluoranthene, benzo(b)anthracene, and cesium, but these are assumed to be typos, since these chemicals were not analyzed by the project.

[2] Fluoride will be added to the list of significant COPCs at PGDP. Fluoride was listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA (although the GWOU FS states that, based upon the minimal contribution to total HI, fluoride was not considered further as a COC in the FS). Additionally, fluoride is a component of known contamination at the site (e.g., magnesium fluoride and hydrogen fluoride).

[3] Lithium was listed as a COC in the WAG 28 RI and GWOU FS, but will not be listed in the "Significant COPCs for PGDP." The WAG 28 RI states the following:

> Analyses of two inorganic analytes, lithium and total strontium (i.e., not radioisotopes of strontium), were supplied during the WAG 28 RI. These metals were not identified as COPCs and are not part of the Contract Laboratory Program Target Analyte List (TAL) proposed in the WAG 28 work plan (DOE 1998b). However, the analyses were supplied when the laboratory scope of work specified SW-846 methods. In a similar manner, boron was included in the reported analytical results for the historical data. Screening of lithium and strontium is problematic because no site-specific background data are available for these constituents. Additionally, no other concentration [such as EPA Soil Screening Levels (SSLs)] was available for screening purposes. Therefore, all detections of these metals would survive the screening process intended to exclude naturally occurring constituents. More importantly, concentrations for both metals fall within the range for occurrences in natural soils as reported by the USGS (1984) for surface soils in the contiguous United States. For these reasons, these metals have not been included in the discussion of nature and extent of contamination. A review of those analytical results is included in Appendix C. For completeness, however, these analytes have been incorporated in the risk evaluation in Vol 4.

[4] Nitrate (as N) will not be considered as a Significant COPC at PGDP. Although nitrate is a significant contributor to risk in the GWOU FS baseline risk assessment, nitrates are produced by natural biological and physical oxidations and therefore are ubiquitous in the environment. Most of the excess nitrates in the environment originate from inorganic chemicals manufactured for agriculture.

[5] Nitrate + Nitrite (as N) will not be considered as a Significant COPC at PGDP. See Nitrate (as N) for explanation.

[6] Strontium was listed as a COC in the GWOU FS, but will not be listed in the "Significant COPCs for PGDP." See Lithium for explanation.

[7] Acetone will not be considered a Significant COPC at PGDP because it is a common laboratory contaminant. Acetone was determined to be a COC in the WAG 28 BRA and the GWOU FS BRA. The WAG 28 BRA did not include a screen to delete COPCs if they also were detected in blank samples. Based upon the minimal contribution to total HI, acetone was not considered further as a COC in the GWOU FS. Additionally, acetone was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time.

[8] Aldrin will not be considered a significant COPC at PGDP because, despite its being included as a COC in the WAG 28 BRA, Aldrin is not listed as having a detected concentration in OREIS at SWMU 99 (where it is a COC in WAG 28). It is assumed that WAG 28 did not recognize the "U" qualifier because the data summary lists Aldrin with 2/2 detections (additional research regarding data use was not performed for this exercise). Only 4 surface water samples show detections in environmental samples (additionally, 15 waste samples are listed as detections).

[9] Bis(2-chloroethyl) ether will not be considered a significant COPC at PGDP because, despite its being included as a COC in the Northwest Plume BRA and the WAG 28 BRA, bis(2-chloroethyl) ether is not listed as having a detected concentration in OREIS for any environmental samples [8 detections of bis(2-

chloroethyl) ether are listed for waste samples]. Additionally, bis(2-chloroethyl) ether was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time.

[10] Bis(2-ethylhexyl)phthalate was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time. It since has been included as a COC in the Soils OU RI. During the December 2014 RAWG meeting, it was discussed that bis(2-ethylhexyl)phthalate is considered a common laboratory contaminant because of its ubiquitous use as a plasticizer. Whether to add bis(2-ethylhexyl)phthalate as a COPC for the site is under consideration.

[11] Bromodichloromethane will be added to the list of significant COPCs at PGDP because it was included as a COC in the WAG 28 BRA. The GWOU FS BRA found that the frequency of detection for bromodichloromethane in unfiltered samples is minimal (0.4%). Based upon the minimal contribution to total HI and total ELCR and the minimal frequency of detection, bromodichloromethane was not considered further as a COC in the GWOU FS.

[12] Although bromomethane was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the minimal frequency of detection, bromomethane was not considered further as a COC in the FS. Bromomethane has not been added to the list of significant COPCs at PGDP.

[13] Although 2-butanone was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI, 2-butanone was not considered further as a COC in the FS. 2-Butanone has not been added to the list of significant COPCs at PGDP.

[14] Chlorobenzene has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, the text of the document states that based upon the minimal contribution to total HI and the minimal frequency of detection, chlorobenzene was not considered further as a COC in the FS.

[15] Although chloromethane was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the small frequency of detection, it was not considered further as a COC in the FS. Chloromethane has not been added to the list of significant COPCs at PGDP.

[16] Dibromochloromethane has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the small frequency of detection, dibromochloromethane was not considered further as a COC in the FS.

[17] 1,2-Dichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA. Although the GWOU FS does not consider 1,2-dichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

[18] Although 2,4-dimethylphenol was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI, 2,4-dimethylphenol was not considered further as a COC in the FS. 2,4-Dimethylphenol has not been added to the list of significant COPCs at PGDP.

[19] 4-Methyl-2-pentanone has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, no additional information is provided in the FS.

[20] Although methylene chloride was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total ELCR, methylene chloride is not considered further as a COC in the FS. Methylene chloride has not been added to the list of significant COPCs at PGDP.

[21] Pentachlorophenol will be added to the list of significant COPCs at PGDP because it is listed as a COC in the WAG 28 RI BRA. Pentachlorophenol was commonly used as a wood preservative and in manufacturing pesticides. Pentachlorophenol was reported to have been used on the cooling towers at PGDP [*Report for Environmental Audit Supporting Transition of the Gaseous Diffusion Plants to the United States Enrichment Corporation* (DOE/OR/1087&V5, June 1993)].

[22] 1,1,1-Trichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in the GWOU FS BRA. Although the GWOU FS does not consider 1,1,1-trichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

[23] 1,1,2-Trichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA. Although the GWOU FS does not consider 1,1,1-trichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

[24] Toxaphene will not be considered a significant COPC at PGDP because, despite its being included as a COC in the WAG 28 BRA, toxaphene is not listed as having a detected concentration in OREIS at SWMU 99 (where it is a COC in WAG 28). It is assumed that WAG 28 did not recognize the “U” qualifier because the data summary lists toxaphene with 2/2 detections (additional research regarding data use was not performed for this exercise). Only 9 liquid sludge samples show detections in environmental samples.

[25] Radium-226+D previously was included as a significant COPC at PGDP (DOE 2001), but it was removed from the list as part of document revision between the issuance of the September 2007 HHRMD and the January 2009 HHRMD. It was included as a COC in the BGOU RI; but because no source term for the isotope is known for PGDP, radium-226 will not be added to the list of significant COPCs at PGDP.

[26] Radon-222 previously was included as a significant COPC at PGDP (DOE 2001), but it was removed from the list as part of document revision between the issuance of the September 2007 HHRMD and the January 2009 HHRMD. Additional information is provided in *Paducah Groundwater Contamination, Detailed History and Summary of Future Actions* (KY/H-41/Rev. 1,December 1988), as follows:

> Since Thorium-230 has a half-life of approximately 80,000 years, the production of Radon-222 is extremely slow. Uranium from plant operations cannot contribute to any significant formation of Radon-222 because all the Thorium was removed in the refining, and feed preparation processes.
>
> Published reports by EPA for samples from public supply wells in this area show similar Radon-222 concentrations to those detected in the PGDP vicinity wells. EPA data for LaCenter and Metropolis …offer further corroboration that Radon-222 in the plant aquifer is unrelated to plant operations.

[27] Thorium-234 previously was not included as a significant COPC at PGDP (DOE 2001). It was included as a COC in the WAG 28 RI; but because the isotope is a daughter product of uranium-238 with a long half-life, thorium-234 will not be added to the list of significant COPCs at PGDP. Additional information

discussed in the December 2014 RAWG meeting was that the half-life of thorium-234 is 24.1 days. While thorium-234 may be present, its risk is captured with uranium-238.

Risk Assessment Working Group
Meeting Minutes—March 2015

✓Gaye Brewer
✓Stephanie Brock
✓Nathan Garner
✓Jeri Higginbotham
✓Todd Mullins
✓Tim Frederick
✓Jon Richards
✓Julie Corkran
✓Jennifer Tufts
✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse
✓Joe Towarnicky

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

2. Ecological (Eco) Risk Methods Document (RMD)

A separate meeting will be held to address comments and to ensure the document progresses and schedule does not slip further.

3. Upcoming Fiscal Year 2015 Revised Schedule/Work Plan

Quarterly Meeting (March)	3/11/2015
Eco Meeting (tentative)	4/2/2015
*** ***Submit Final Eco RMD*** **(DOE/LX/07-0107&D2/R1/V2)** ***to FFA managers for approval***	*5/7/2015*
*** ***FFA managers approve final Eco RMD*** **(DOE/LX/07-0107&D2/R1/V2)**	*6/8/2015*
RAWG approve HH Main Text and HH Appendices A-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2015
FFA Managers approve HH RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2015
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)
Italics indicate Eco RMD schedule.

4. Summary of February 3, 2015, Meeting Regarding Dermal Absorption (ABS) Values

The resolution from the February 3, 2015, meeting is found in the Attachment to these minutes (Note: the e-mail formerly sent as “minutes” now is titled “resolution,” since e-mails following the actual meeting revised the path forward). Todd agreed to follow up with Jerri to ensure the resolution is captured correctly.

From the meeting and follow-up, the following are understood going forward:

a. NALs/ALs will be calculated using EPA ABS values.
b. The uncertainty section in baseline human health risk assessments will include a comparison of risks and hazard indices from metals determined using EPA ABS values and KY ABS values.
c. The uncertainty section will include comparison of risks and hazard indices from COPCs that had been dropped by using NALs calculated with EPA ABS that would not have been dropped if KY ABS values had been used.

Additional information discussed in the February 3, meeting was a description of NALs and ALs as follows:

- NALs (i.e., the lesser of ELCR=10-6 and HI=0.1) are used to tell us “where there might be a problem.”

- ALs (i.e., the lesser of ELCR=10-4 and HI=3) are used to tell us “where there is definitely a problem.”

5. Status of HH Appendix A [Preliminary Remediation Goals (PRGs)] Review

Comments received have been included in a separate comment response summary (CRS).

6. Status of HH Appendices B-E and Main Text Review

Comments received and responses discussed in the meeting have been included in a separate CRS.

7. Use of EPA RSLs as the basis for project action levels in upcoming potential vapor intrusion work

See page 6 of the guide for equations used in the Vapor Intrusion Screening Level (VISL) Calculator

Calculator and user guide available at the following:
http://www.epa.gov/oswer/vaporintrusion/guidance.html

The following equations would appear in the 2016 RMD, Appendix D.

EPA Regional Screening Levels (RSLs) would be used for screening, **if** RAWG members agree to the use of RSL exposure parameters. No site-specific values for air would be included in Appendix A of the RMD. Explanation regarding use of differing exposure parameters would need to be documented.
OR the Ambient Air PRGs table (following) could be included in Appendix E of the 2016 RMD.

The site-specific ambient air equations would be included in Appendix D of the 2016 RMD.

Any comments on the equations or preference for use of RSLs should be sent to LeAnne and will be addressed during the June 2015 quarterly meeting.

Ambient Air PRGs (using RAIS 03/05/2015), VISL Values (using VISL Version 3.3.1 & May 2014 RSLs), and Paducah Site-specific Levels

Analyte	Noncarcinogen or Carcinogen based values	Units	RAIS Resident	RAIS Outdoor Worker (225 d/yr for 25 yrs)	PAD Site-specific Outdoor Worker (185 d/yr for 25 yrs)*	RAIS Composite Worker (250 d/yr for 25 yrs)	RAIS Construction Worker (20 d/yr for 1 yr)	VISL Value** (Resident)
Benzene	C	μg/m^3	0.36	1.75	2.12	1.57	491	0.36
cis-1.2-DCE		μg/m^3						
trans-1,2-DCE	NC	μg/m^3	62.6	292	355	263	3290	
Ethylbenzene	C	μg/m^3	1.12	5.45	6.63	4.91	1530	1.1
Toluene	NC	μg/m^3	5210	24300	29600	21900	274000	5200
TCE	C	μg/m^3	0.478	3.32	4.04	2.99	935	0.48
Vinyl Chloride	C	μg/m^3	0.168	3.10	3.77	2.79	871	0.17
Xylenes	NC	μg/m^3	104	487	592	438	5480	100

Note: The RAIS PRGs, PAD PRGs, and VISLs are the lesser of the ELCR at 1E-06 and the HI at 1.0, for comparison purposes only with the VISL calculator.

Gray shading implies that no values are available.

*Exposure parameters from the 2014 Paducah RMD.

VISL Target Indoor Air Concentrations (Residential**), Version 3.3.1, RSLs from May 2014 were used in determining VISL Values.

8. Poll RAWG Members/Open Discussion

Radon information for modeling pulled together for Waste Disposal Alternatives project will be included in 2016 RMD (Appendix E, similar to probabilistic modeling).

CERCLA 120(h) training session is being planned. 2016 RMD will need to include limits and information with respect to property transfer. More information will follow training.

Discussion Topics on Hold:

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014–further discussion on this topic depends on completing presentations to Paducah Site Lead).

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014–further discussion on this topic depends on resolution of Northeast Plume Dispute).

ATTACHMENT

NOTE: The following text (with the exception of the title) is taken directly from an e-mail sent to the Risk Assessment Working Group on February 6, 2015.

Based on e-mail comments, the meeting minutes are revised below and are now considered a resolution.

Risk Assessment Working Group Meeting Resolution—February 2015

✓Gaye Brewer
✓Nathan Garner
✓Mike Guffey
✓Jerri Martin
✓Todd Mullins

Tim Frederick (comments provided by e-mail)

✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Joe Towarnicky

The dermal absorption values (ABS) to use in development of no action levels (NALs) and action levels (ALs).

The ABS to use in the main body of a baseline human health risk assessment (BHHRA) and the ABS to use in the uncertainty calculations.

The following was discussed as a history regarding the use of ABS values:

- 2006: In development of the Risk Methods Document, KY ABS values were used to calculate NALs, and EPA ABS values were used to calculate ALs. Baseline risks were calculated using KY ABS and then recalculated using EPA ABS.

- 2013: The Risk Methods Document used EPA ABS for both NALs, ALs, and baseline risks, with KY ABS used in uncertainty section. The 2013 version led to a misunderstanding on what was used.

Going forward, the 2015 Risk Methods Document will continue to use EPA ABS (Table B.5 of Risk Methods Document) for inorganics with published values in RAGs Part E for baseline risk and NAL/AL calculations; KY ABS will be used in uncertainty calculations. Additionally, the uncertainty section will include a comparison of NALs using EPA ABS values and KY ABS values. If a chemical is eliminated from consideration as a contaminant of concern based on dermal assumptions, it should be clearly communicated in the risk assessment.

The draft 2015 Risk Methods Document needs to be revised to be clear with the points discussed above. Sections 4 and 5 of the draft document should include this understanding.
(Since the text already is with the Risk Assessment Working Group for comment, please provide comments where you feel necessary. Additionally, places for revision will be noted in the upcoming Quarterly meeting.)

It was noted during the meeting that the “outdoor worker” can assume exposure to subsurface soils outside the fence. The “excavation worker” also could be used outside the fence.

Risk Assessment Working Group
Meeting Minutes—June 2015

✓Gaye Brewer	✓Jon Richards	✓Rich Bonczek
✓Mike Guffey		✓LeAnne Garner
✓Jeri Higginbotham		✓Bobette Nourse
✓Jerri Martin		

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

2. Remaining Fiscal Year 2015 Schedule/Work Plan

The remaining fiscal year (FY) 2015 schedule has been updated for dates.

Submit Final Ecological (Eco) Risk Methods Document (RMD) **(DOE/LX/07-0107&D2/R1/V2)** ***to FFA managers for approval***	***5/28/2015***
Quarterly Meeting (June)	**6/17/2015**
Submit Human Health (HH) RMD to FFA Managers (DOE/LX/07-0107&D2/R5/V1)	**6/26/2015**
FFA managers approve final Eco RMD **(DOE/LX/07-0107&D2/R1/V2)**	***6/22/2015***
FFA Managers approve HH RMD (DOE/LX/07-0107&D2/R5/V1)	7/17/2015
Quarterly Meeting (September)	**9/16/2015**

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)
Italics indicate Eco RMD schedule.

3. Ecological Risk Methods Document

Kentucky comments were received. Jon Richards was checking with Brett Thomas on the status of EPA's review. Depending on EPA's comments, replacement pages may be sent for the Eco RMD.

4. Human Health Risk Methods Document

RAWG comments to the 2015 HH RMD were discussed. The entire list is found in the Attachment. No significant comments were received during DOE internal review.

5. Use of EPA RSLs as the basis for project action levels in upcoming potential vapor intrusion work

Based on Jeri Higginbotham's comments, June 2015 meeting minutes are considered final as revised. Revisions to the table discussed in that meeting for Appendix E were sent to RAWG on 4/20/2015 and are included in the 2015 HH RMD.

Additionally, the 2016 revision of the HH RMD will include the vapor intrusion screening level (VISL) calculator and guidance to scoping and baseline sections. Other items to be updated in the 2016 HH RMD include air concentrations and equations.

6. RAWG Schedule/Work Plan for FY 2016

Suggested draft plan: This plan, including all dates, will be discussed by the RAWG at the September 2015 Quarterly Meeting.

Submit Work Plan (this schedule)	6/17/2015
Quarterly Meeting (September)	9/16/2015
Approve Work Plan (this schedule) by e-mail	10/30/2015
Submit HH Appendix A (Preliminary Remediation Goals) to RAWG for Review	11/12/2015
Quarterly Meeting (December)	12/2/2015
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2015
Comments Due for HH Appendix A	1/5/2016
RAWG Approve HH Appendix A	2/12/2016
Comments Due for HH Main Text and HH Appendices B-E	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Approve HH Main Text and HH Appendices B-E	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/1/2016
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2016
FFA Managers Approve HH RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2016
Quarterly Meeting (September)	9/7/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Note that an update for the Eco RMD is not planned for FY 2016, unless Region 4 has new guidance. Any topics that need to be included as part of the FY16 Work Plan, especially in regard to updating in the Eco RMD and/or the HH RMD, should be e-mailed to LeAnne for discussion at the September 2015 Quarterly Meeting.

7. Update on CERCLA 120(h)

Previously topic on hold: "Validation needed for closure activities [CERCLA 120(h)] (added 6/2014 – further discussion on this topic depends on completing presentations to Paducah Site Lead)."

- Additional information regarding training.
- Additional information regarding "validation needed for closure activities." and "RMD will need to include limits and information with respect to property transfer."
- Additional information regarding roles of the Paducah Site Lead, the FFA Managers, and the RAWG.

From March 2014 Meeting Minutes:

Validation needed for closure activities [CERCLA 120(h)]

Typical validation (i.e., 3rd party validation) currently is 10%. What is appropriate for closure activities? RAWG will develop a recommendation during the next quarterly meeting. Also, DOE agreed to ask the PGDP Site Manager about scheduling a CERCLA 120(h) training.

From June 2014 Meeting Minutes:

> **Validation Needed for Closure Activities [CERCLA § 120(h)]**
>
> RAWG will have input regarding closure activities. Typical validation at Paducah (i.e., 3rd party independent data validation) that is done on a project basis and is between 5–20%; it is not a recommendation on a programmatic basis.
>
> LATA Kentucky is preparing a paper regarding validation that will be provided to the RAWG soon for informational purposes only. This subject will be discussed further after receipt of the paper.
>
> Rich Bonczek is planning CERCLA § 120(h) training.

From March 2015 Meeting Minutes:

> CERCLA 120(h) training session is being planned. 2016 RMD will need to include limits and information with respect to property transfer. More information will follow training.

DOE does plan to transfer property prior to shutdown similar to what was done at K-25. DOE plans a training session during which Leslie Cusick describes experiences with property transfer in Oak Ridge. DOE PPPO is aware that the Paducah FFA lays out specific actions that must be followed as part of property transfer. The RAWG discussion is not in regard to these required actions.

An environmental assessment (EA) on property transfer at Paducah is forthcoming. Parcels currently in mind for transfer would be clean transfers.

8. Poll RAWG Members/Open Discussion

The on-hold topic, “Derivation of Risk-based Surface Water Effluent Limits,” (added 6/2014 – because further discussion on this topic depends on resolution of Northeast Plume Dispute) may require a separate working group.

Attachment
Comments to the *DRAFT* 2015 Risk Methods Document by the Risk Assessment Working Group

#	Commenter	Location	Comment	Resolution
		Main Text		
1	DOE (Bobette)	General	Somewhere in the Main text of this document; perhaps in the uncertainty section or in data evaluation methods = Section 3.3.3. Please include the generic PARCCS discussion (in a text box or as a subsection) that was part of the recent 2015 Paducah Sitewide SER document.	To be added to the list to discuss for next revision.
2	DOE (Rich)	Section 3.3.1.1, page 3-13, 1st bullet	I think these are superseded by "Region 4 Human Health Supplemental Guidance" January 2014, available at http://www.epa.gov/region04/superfund/programs/riskassess/riskassess.html.	Revised.
3	DOE (Rich)	Section 4.1.2.1, 1st full para, "impacts of continuation the"	This needs to be either "impacts of continuation of the" to be consistent with the series.	Revised.
4	DOE (Rich)	Section 4.1.4, 2nd para, "FS follow"	To be consistent with the tone of the paragraph, this should probably be "FS will follow."	Revised.
5	DOE (Bobette)	Section 4.1.4.2, last sentence	Consider replacing "so" with "such."	Revised.
6	DOE (Rich)	Section 4.2.2, page 4-9, 1st line	This sounds as if we are taking risk information and not a table format from the guidance. Consider, "In most cases, the tabular format in EPA 1999b will be used to present risk assessment/evaluation results in the ROD;"	Revised.
7	DOE (Rich)	Section 4.2.3, page 4-9, 1st para, "in addition"	For readability, this should probably be "Thirdly" (YUCK!) or "Finally."	Revised.
8	DOE (Rich)	Section 4.2.3, page 4-9, 1st para, "The methods…"	Recommend new paragraph here. This is a new subject (i.e., details of the residual risk assessment).	Revised.

9	DOE (Bobette)	Section 4.2.3, where change was made	Suggest replacing “from sources” to: “from a source (or multiple sources)”.	Revised.
10	DOE (Rich)	Section 4.2.3, page 4-9, 1st para, last sent “will”	I found this sentence confusing. Consider if “should” is better here.	Revised.
11	DOE (Rich)	Section 5	If appropriate, add new EPA Region 4 reference and delete old EPA Region 4 reference.	Revised.
		Appendix A		
12	DOE (Rich)	Page A-4 #8	Consider adding a comma here for readability and clarification because the ED/EF apply to both locations (i.e., “area, for”).	Added.
13	DOE (Rich)	Table A.1 (and others)	If we can fit it in, I think the very important note concerning the significant COPCs should be included as a note here. That is, add “Values in this table are for significant COPCs for PGDP. Values for other chemicals can be obtained using the Risk Assessment Information System (RAIS) online calculator, as modified using PGDP-specific inputs.” as a note to all the AL/NAL tables.	Added.
14	DOE (Bobette)	Table A.4	Please explain why there are values in purple, and red, and blue in a footnote or at least in the CRS package to this review. Thank you!	Red indicated the initial changes; blue indicated changes based on the ABS values for metals; and purple indicated changes for the industrial/indoor worker. No footnotes are necessary: all values will be shown in black.
15	DOE (Rich)	Table A.8 footnote, “Screening levels are based on dose conversion factors from ICRP 72 and base external ICRP 60.”	This needs to be rephrased. Something seems to be missing.	Revised.
16	DOE (Bobette)	Table A.9	For this Child Resident, the mrem/yr was dropped from 15 to 12. Hence, why are these values larger then the 2014 RMD? Is it because of the increase in ingestion rate of water from the new EPA EFs Guidance?	Suggest adding the following to the footnotes for Table A.9: Screening levels are based on dose

			For clarity, please explain in the text with a footnote.	conversion factors from ICRP 72 and base external ICRP 60. (See Table B.3.) Screening Value = [Σ1/(Pathway-Specific Action Levels)]-1 Pathway includes ingestion. (See Table B.4 for exposure parameters.) Footnotes for Tables A.8 through A.10 have been made consistent.
17	DOE (Bobette)	Table A.11	For clarity, at the end of this sentence. please add: "; because....." After the "because", please briefly explain why the three DAF values are reported.	Text revised to, "Values in this table were calculated using the best available information in November 2014, following the methods shown in Table A.7b and the values presented in Table A.9 for the Adult Resident. SSL 1 indicates the soil screening level calculated for a DAF of 1. SSL 20 indicates the soil screening level calculated for a DAF of 20. SSL 58 indicates the soil screening level calculated for a DAF of 58."
18	DOE (Bobette)	Table A.14	The CAS# for Fluoride is 16984488 and it is accidently missing here.	Table has been revised.
		Appendix D		
19	DOE (Bobette)	General	Add reference to RAIS for BAFs used in equations.	Page D-3 states, "Chemical-specific values, except for those listed in Appendix B are not reflected in this Risk Methods Document. See the RAIS website for additional information (http://rais.ornl.gov/)."
20	DOE (Bobette)	Table D.42	I still think we should add-back the BAFs values table, in Appendix B, that use to be in Appendix B. If we don't add it in now, we should add a reference to the last time it was in the RMD: i.e., in 2001- Appendix D: Part 2 Chemical-specific Values. - OR a reference to where values can be found (e.g., RAIS, RESRAD, etc.) Given the concerns with fish/water at Paducah, we should definitely include the updated BAFs table in the next revision of this document!	I disagree, but I will add it to the list to discuss for the next revision.
		Appendix E		
21	DOE	Table E.8	Please add the Version # for the VISL calculator, since it is soon to be	Added (Version 3.3.1)

	(Bobette)		updated by the EPA.	
22	DOE (Bobette)	Table E.8	Please add cis- and trans-1,2-dichloroethylene to this table. EPA is soon revising the toxicity values for at least one of these isomers. Also there are values for the 1st six columns and NA can be put in the other columns for now. That would make this table more complete for the next go-around with the 2016 RMD.	HI for resident and indoor worker added for trans-1,2-DCE. All other values added as “NA.”
23	DOE (Bobette)	Table E.8 (Notes)	This should say, “For cis- and trans-1,2-dichloroethylene, toxicity.....”	Revised.

Risk Assessment Working Group
Meeting Minutes—September 16, 2015

Brian Begley
Gaye Brewer
Nathan Garner
Jerri Martin
Tim Fredrick
Jon Richards
Rich Bonczek
Martin Clauberg
LeAnne Garner
Bobette Nourse

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

LeAnne Garner will check on toll free or other options for meetings.

2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

Quarterly Meeting (September)	9/16/2015
Approve Work Plan (this schedule)	9/16/2015*
Suggested revisions/corrections to Human Health (HH) Risk Methods Document (RMD) text should be sent to LeAnne	11/2/2015
Submit HH Appendix A (i.e., PRGs) to RAWG for Review	11/12/2015
Comments Due for HH Appendix A	1/5/2016
Quarterly Meeting (December)	12/2/2015
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2015
RAWG Approve HH Appendix A	2/12/2016
Comments Due for HH Main Text and HH Appendices B-E	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Approve HH Main Text and HH Appendices B-E	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2016
FFA Managers Approve HH RMD (DOE/LX/07-0107&D2/R3/V1)	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

*Approval is needed before October 31, 2015.

Note that an update for the Ecological RMD is not planned for FY 2016.
Having the review times spread out is helpful, so schedule will remain as it is. Updates were made to the quarterly meeting dates and to non-workday dates. These changes are reflected in the schedule above. Approval of this schedule, along with RMD changes contained in these minutes, is the RAWG FY 2016 Work Plan.

3. Revise RAWG Charter

The original charter developed in 2007 with proposed updates is found in Attachment 1.
Revisions were made to the membership during the meeting and are reflected in the attachment.

4. Revise Exposure Parameters

The following comment was received to the 2015 RMD from KY to update the following exposure parameters to be consistent with EPA guidance:

- **Dermal Contact with RGA Groundwater (showering)**
  - Child Resident: 0.71 hour/event should be changed to 0.54 hour/event (this needs to be changed in Table D.3 as well)

- **Dermal Contact with Soil/Sediment**
  - Default Industrial Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day
  - Outdoor Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day
  - Excavation Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day
  - Child Resident: 0.269 m^2/day should be changed to 0.2373 m^2/day (this needs to be changed in Table D.5 as well)
  - Child Recreational user: 0.269 m^2/day should be changed to 0.2373 m^2/day (this needs to be changed in Table D.15 as well)

- **Dermal Contact with Surface Water**
  - Default Industrial Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day (this needs to be changed in Table D.32 as well)
  - Outdoor Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day (this needs to be changed in Table D.35 as well)
  - Excavation Worker: 0.347 m^2/day should be changed to 0.3527 m^2/day (this needs to be changed in Table D.35 as well)

The revisions above will be made in the upcoming RMD. Differences were due to two different versions on EPA's Web site. The Web site is being fixed so that only one version is available.

5. Integrated Exposure Uptake and Biokinetic (IEUBK) Model Lead Values

Regarding the following text in Appendix B of the HH RMD: "The PGDP median value for lead in surface soil from DOE 1995 (17.5 mg/kg) and the value for lead in RGA groundwater from Appendix A, Table A.13 (0.129 mg/L) should be used in place of the model default value," the question below was asked.

Why are the background concentrations in surface soil from Table A.12 (36 mg/kg) not being used?

Additional information was provided from Rich Bonczek: "The median was selected by the RAWG for the 2009 update because they felt the model needs to consider the most likely lead concentration encountered and not the upper end of the background range (i.e., 95% UTL), which would be rarely encountered."

In the meeting, it was pointed out that for the IEUBK model, median values are appropriate.

Additionally, Table B.6 values in the RMD may have been mislabeled. Updates may be made in the revised RMD, if necessary. LeAnne will check to determine whether a table was dropped or if there was a disconnect between a VF parameter table and the IEUBK model input table.

6. Revised Regulatory Values for the 2016 HH RMD

- EPA's Updated Ambient Water Quality Criteria for the Protection of Human Health [Federal Register Vol. 80, No. 124 (June 29, 2015)]. This value affects Table A.12 of the RMD; it should be footnoted that promulgation for Kentucky of this value will be in 2018.

- Are metals included in the recent EPA updates for AWQC (e.g., “Final 2015 Updated National Recommended Human Health Criteria”)? Tim Frederick to check and provide update at the December 2015 quarterly meeting. EPA values will be included in the RMD and referenced, as appropriate.

7. Additional Values/Revisions to Include in 2016 HH RMD

These will be discussed in the December meeting:

- Bioaccumulation factor (BAF) values will be added for Table 2.1 “Significant Chemicals of Potential Concern at PGDP” with primary references.
- Update Section 3.3.4.2 list of exposure pathways.
- Revise use of term “dose” to distinguish between radiation dose (i.e., rem) and absorbed/ administered dose (i.e., chemical and radionuclide intake).
- Revise “constituents of concern” so that terminology is consistent.
- Revise Figure 2.1, if necessary, for logic flow.
- Revise Figure 2.3, to show continuation of “Go to” boxes.
- Add note to Equation 1 (Section 2.1) that relationship is not applicable to non-linear based PRGs (e.g., Vapor Intrusion PRGs).
- Reorganize equations in Appendix D to consolidate receptors and reference Table B.4 for exposure parameters.
- Add errata section (e.g., adult body weight listed in Table D.4 of 2015 HH RMD).
- Suggested revisions/corrections to HH RMD text should be sent to LeAnne by November 2, 2015 (if FY 2016 schedule is unchanged).

Note that vapor intrusion screening levels (VISLs) were used for Paducah’s five-year review for CERCLA actions. The RMD needs to document that VISLs are the starting point for screening. There currently is a place holder for vapor intrusion in the RMD (Section 3.3.4.4). Input from the Portsmouth RMD can be included in Paducah’s RMD. Additional updates will be provided in the December 2015 quarterly meeting.

8. Derivation of Risk-based Surface Water Effluent Limits – Status of discussions to resolve EPA Condition #3 on BGOU SWMUs 2, 3, 7, and 30 FS

Part of EPA Condition #3 of the BGOU 2, 3, 7, and 30 RI/FS stated the following:

> “The entries in ARARs Table F.2 for Effluent limits for radionuclides in wastewaters references the NRC regulation and DOE Order that are based upon annual dose limits (50 mrem and 100 mrem, respectively) that can (without adequate partitioning between all sources at the PGDP and application of ALARA that uses treatment) result in levels of radionuclides that EPA does not consider protective of human health and the environment. DOE must either delete these entries or alternatively add the following NOTE: to the requirements columns that states: “NOTE: Actual effluent limits for any radionuclide discharged into surface water will be established in accordance with ARARs, TBC and/or risk methodologies and listed in the ROD. Such limits must be within EPA’s generally accepted risk range under CERCLA and derived in a manner consistent with the designated use classifications of the receiving surface water body. These limits may be technology based and/or based upon ambient water quality equivalent levels derived using EPA and KY standard methodology used for calculating ambient water quality criteria.” In addition, Section 2.4.1.9.2 and Section F.4.5 Waste

> Water Treatment must be revised to include language consistent with this condition and the explanatory NOTE language. EPA recognizes that resolution of the formal dispute for the Northeast Plume ESD related to Tc-99 discharges and/or the resolution of the Stop Work Order issued by EPA on accumulated radioactively contaminated water in the Bldg. C-410 basement may be relevant to how the FFA parties decide to address effluent limits for radionuclides in wastewater discharged into surface waters."

DOE is calculating values for potential limits. Assumptions are incorporated into the calculations, including those for a mixing zone. Currently, calculation will use Outfalls K001 and K002 in mixing zone calculations because they are the northernmost outfalls on each side of the plant.

Additional meetings on a project-specific basis are being planned. There will be a follow-up to this item at the December 2015 quarterly meeting.

9. Status of CERCLA 120(h) Informational Briefing in Regard to Property Transfer Requests and Activities.

Rich Bonczek gave an update as follows:
A programmatic meeting will be held next week with Paducah and Portsmouth (DOE and contractors). Lesley Cusick (Remediation Services, Inc.) is providing training. Rich hopes to have training for the Paducah Site including KY and have presentations from EPA with respect to CERCLA 120(h) and its implementation in Oak Ridge. The training may be provided during November 2015, hopefully in Lexington.

DOE is hoping to transfer unimpacted properties that do not affect DOE's mission. The definition of unimpacted is in the statute.

10. Poll RAWG Members/Open Discussion

The Paducah RMD is a helpful tool.

Attachment 1
Risk Assessment Working Group Charter
(Developed in 2007, Revised in 2015)

1. **Working Group's Official Designation (Title):** Paducah Gaseous Diffusion Plant (PGDP) Risk Assessment Working Group (RAWG)

2. **The RAWG will be composed of members from the following agencies**

   a. Commonwealth of Kentucky, Cabinet for Health and Family Service, Department for Public Health, Radiation Health Branch (KY RHB)

   b. Commonwealth of Kentucky, Energy and Environment~~al & Public Protection ~~Cabinet (KEEC), Department for Environmental Protection (KDEP)

   c. U.S. Environmental Protection Agency (EPA) Region 4~~ Federal Facilities Branch~~, Superfund Division

   d. U.S. Department of Energy (DOE) Portsmouth/Paducah Project Office (PPPO)

   ~~e. U.S. Fish and Wildlife Service (Ecological Risk)~~

   ~~f.~~e. ~~Paducah Remediation Services.~~DOE Prime Contractor

3. **Workgroup Objectives:** The ~~Risk Assessment Work Group (~~RAWG~~)~~ was established as a working group to promote the efficient application of the human health and ecological risk assessment and risk evaluation processes at ~~the ~~PDGP. ~~In the near term, t~~This will be accomplished through ~~the ~~an annual revision of Risk Methods Documents for the assessment and evaluation of Human Health (Volume I) and, as needed revision of Ecological Risk Assessment (Volume II). ~~Over the longer term, t~~The RAWG will share information and help ensure the preparation of consistent and defensible risk assessments and risk evaluations prepared for ~~the ~~PDGP.

The Risk Methods Document states the following:

> The RAWG is a multiagency, multidisciplinary group tasked with meeting the following goals:
>
> - Produce tools that can be used to prioritize remedial activities at the PGDP.
> - Develop methods to complete risk evaluations for the PGDP.
> - Make the results of the risk assessments and evaluations at the PGDP more useful to risk managers.
> - Enhance risk communication between the producers of risk assessments and risk evaluations and the users of this information (e.g., risk managers).

4. **Official(s) to Whom the Committee Reports:** The RAWG will submit the final reports to the Federal Facilit~~ies~~y Agreement ~~designated officials~~Managers from EPA Region 4, ~~the Department of Energy~~DOE, ~~the U.S. Fish and Wildlife Service, ~~and ~~the Commonwealth of Kentucky~~KDEP for acknowledgement or approval, as appropriate.

5. When revising the Risk Methods Documents, the RAWG will perform the following tasks~~In the near term the RAWG will develop revisions to the Risk Method documents.~~

~~This will include completion of the following tasks~~:

- Propose policies, procedures, tools, methodologies, and guidance for implementing sound risk assessments and evaluations.
- Develop and recommend initiatives, methodologies, and strategies that will support the use of sound risk assessment and evaluations tools and processes.
- Share lessons learned~~,~~ and experiences and develop recommendations for the most efficient and cost-effective approaches.
- Promote the integration of both ecological and human health risk assessments and evaluations throughout the environmental management process.
- Clearly delineate risk assessment issues from risk management concerns.
- Reach consensus in methods for measuring and describing cancer risks or risks of other chronic health effects from exposure to hazardous substances considering such alternative approaches as the lifetime risk of cancer or other effects.
- Identify methods to reflect uncertainties in measurement and estimation techniques, including the existence of synergistic or antagonistic effects among hazardous substances.

Risk Assessment Working Group
Meeting Minutes—December 2, 2015

✓Brian Begley
✓Gaye Brewer
✓Stephanie Brock
✓Nathan Garner
✓Mike Guffey
✓Jeri Higginbotham
✓Jerri Martin
✓Julie Corkran
✓Tim Fredrick
✓Jon Richards
✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse
✓Joe Towarnicky

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

Quarterly Meeting (December)	12/2/2015
Submit Revised Human Health (HH) Main Text and HH Appendix D to RAWG for Review*	12/11/2015
Comments Due for HH Appendix A and B	1/5/2016
RAWG Concur with HH Appendix A and B	2/12/2016
Comments Due for HH Main Text and HH Appendix D*	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Concur with HH Main Text and HH Appendix D*	4/11/2016
Submit Entire Revised HH Risk Methods Document (RMD) to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
Submit HH RMD to Federal Facility Agreement (FFA) Managers (DOE/LX/07-0107&D2/R7/V1)	6/13/2016
FFA Managers Acknowledge Receipt of HH RMD	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

*This is changed slightly from the original. Appendix B was sent with Appendix A. Appendix C does not contain changes, and the only change to Appendix E (currently) is the addition of working group meeting minutes that already have been reviewed. [Note: Also see Item 3, information regarding use of nondetect (ND) results also may be added; but if it is added, it will be reviewed separately.]

3. Discussion of Revisions to the 2016 HH RMD

- **Use of Nondetects in 95% UCL of the arithmetic mean (UCL95) Calculation** *(taken from comments to the Soils Operable Unit (OU) Remedial Investigation (RI) 2 Report)*
  "It appears that no distinction was made between detected and nondetected values when calculating an [exposure point concentration (EPC)] for each EU. According to the ProUCL Version 5.0.00 User Guide (USEPA, 2013), '[a]ll ND observations in ProUCL are identified by the value '0' of the indicator variable used in ProUCL to distinguish between detected (=1) and nondetected (=0) observations. It is the users' responsibility to supply correct numerical values for NDs (should be entered as the reported detection limit or RL values) and not as qualifiers (e.g., J, U, B, UJ, ...) for ND observations in the data set.' Although this may be due to the way some of the grid values were derived (e.g., as an average of the grid values present), it results in considerable uncertainty."

  Currently, the HH RMD does not specifically state what to do with NDs.

Below are a few excerpts from the text, for reference.

Page 3-18:

> Chemicals. The sample quantitation limits for each analyte and sample will be examined to determine if these limits were below the concentration at which the analyte may pose an unacceptable risk or hazard to human health. If the maximum sample quantitation limit for an analyte (over all samples within a medium) is greater than the concentration that may pose an unacceptable risk or hazard to human health, and the analyte is not detected in any sample, then the data for that analyte will be deemed suspect. Data from these analytes will not be used quantitatively in the risk assessment, but the potential risk or hazard from exposure to media potentially containing these analytes will be examined qualitatively. In developing the qualitative assessment for these data, the maximum quantitation limit for the analyte (in all samples from a medium) will be compared to the appropriate no action residential PRG if historical or process information indicates that the analyte potentially could be present. One-half the maximum quantitation limit for the analyte (in all samples from a medium) will be used in this comparison if historical or process information indicates that the analyte is not expected to be present.

Page 3-19:

> **Step 4: Evaluation of data qualifiers and codes.** …Specifically, if chemical data are qualified 'B,' and the value is less than that defined by the '5 and 10X's Rule,' then the data will be assumed to be a nondetect and the reported value will be used to derive the EPC.

Pages 3-19 and 3-20:

> **Step 5: Elimination of analytes not detected.** Generally, any chemical not detected in at least one sample from a medium will be deleted from the data set. Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the project dataset, provided the MDC is an acceptable level for the project. If a chemical analyte is suspected of being present at very low concentrations (i.e., below the quantitation limit) due to cross-media contamination or is suspected of being present based on historical or process information, the analyte may remain in the data set even though the analyte was not detected. In this case, the concentrations used to determine the representative or EPC for the analyte will be the sample quantitation limits for the analyte in the medium. For classes of analytes such as polycyclic aromatic hydrocarbons (PAHs), PCBs, and dioxins/furans, if one compound is detected at a concentration greater than a screening value and is identified as a COPC, then others in that class will be assumed to be present as well. The method used to analyze these classes of compounds is presented later in this section.

Text box page 3-26:

> If the SWMU/exposure unit combination had less than 10 grids, the maximum grid result was used as the EPC. If the SWMU/exposure unit combination had 10 or more grids, the grid values were used to determine the EPC. Grid values were determined following guidance in the work plan. Basically, the maximum detected result from within the grid applies to the grid. If not detected, the minimum detection limit applies to the grid.

Footnote Page 4-6 recognizes that uncertainty in detection needs to be addressed:

> 9 "Preliminary remediation goals...may be revised...based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts of alternatives. Factors related to uncertainty may include: the

> reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria....” [taken from the National Contingency Plan Preamble: Exposure, Technical, and Uncertainty Factors (55 Fed. Reg. 8717, March 8, 1990)]. Also, see RAGS Volume 1, Part B, Section 2.3 and 2.8 (EPA 1993a) and OSWER Directive 9355.0-30, “Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions” (EPA 1990a).

Discussion during the meeting was the following:

— An example for polychlorinated biphenyls (PCBs) is as follows: Although the maximum detected value for SWMU 13 is 1.25 mg/kg, but the EPC is 10.76 mg/kg. The result is that risk values appear higher than they actually are.

— Datasets may need to be subdivided into contaminated and noncontaminated areas in the case where there are numerous NDs and few detects of significant concentration.

— Page 2-11 of the Ecological RMD states the following:

> For all activities conducted as part of Step 3a of PGDP ERAs, mean and 95% UCL concentrations for detected substances are calculated using ProUCL.[2] Site concentration data for PGDP sites are those data present in Paducah OREIS. All relevant concentration data for a site should be gathered and entered into Paducah OREIS before conducting Step 3a. Site concentration data used in ERAs and other ecological risk activities must be qualified as valid. An important consideration is the relationship between detection limits and benchmarks. Also, the appropriateness of using statistical manipulation of data must be considered in relation to the number of samples.
>
> [2] If results from ten or more samples are available, then the most recent version of EPA’s ProUCL software will be used to determine the 95% UCL concentration. The value selected as the 95% UCL concentration will be the value recommended by ProUCL, noted as the “Suggested UCL to Use.” EPA’s ProUCL software (available at www.epa.gov/osp/hstl/tsc/software.htm) incorporates a number of different distributional tests that may be used to perform the distributional tests and calculates the most appropriate 95% UCL (EPA 2013). An exception to use of ProUCL is when a sample contains a small fraction of nondetects (i.e., no more than 10–15%), simple substitution of half the reporting limit is generally adequate (EPA 2009).

— There are two issues: how to deal with non-detects and the determination of the EPC using ProUCL with the NDs being used as if they were detected values.

— There is not a good way to handle NDs within the dataset. In the 1990s, a proxy value of half the SQL was used for NDs. Several software solutions tried to account for NDs by handling it in different ways. After the earlier software, ProUCL was designed; but still there is not a good way to handle NDs. Use of “1s” and “0s” is believed to be new, beginning with ProUCL Version 4.

— For Soils OU RI 2, ProUCL Version 5 was used and all grid values were assumed to be detects. If there are not enough “1s,” ProUCL in general will not return a value.

— Additional information regarding the statistics may be added to Appendix E. Martin, Bobette, and LeAnne will work on the issue; if added to the 2016 RMD, Appendix E, the draft text will be presented at the next quarterly meeting.

- **Use of UCL95 if Greater than Maximum Detect** *(taken from comments to the Soils OU RI 2 Report)*
  "…'[i]n some instances, ProUCL (Version 5.0) will calculate the UCL95 as greater than the maximum value. In these cases, the UCL95 was used at [sic] the EPC.' We do not recommend using a 95% UCL value that is greater than the maximum detected concentration."

  Below are a few excerpts from the text, for reference.

  Pages 3-26 and 3-27:

  > (2) If results from ten or more samples are available, then the most recent version of EPA's ProUCL software version of EPA's ProUCL software will be used to determine the EPC. The value selected as the EPC will be the value recommended by ProUCL, noted as the "Potential UCL to Use." EPA's ProUCL software[7] incorporates a number of different distributional tests that may be used to perform the distributional tests and calculates the most appropriate EPC (EPA 2013).

  Page 3-27:

  > In determining the UCL when the medium is groundwater….If the 95% UCL is greater than the maximum detected concentration, EPA guidance recommends that the EPC default to the maximum detected concentration for that contaminant.

  Discussion during the meeting included the following:

  — The maximum is a value representative of the sample from the population. As such, it is incorrect to compare the UCL95 on the mean to the max of the sample to select the EPC. Language from the current ProUCL manual is included at the end of these minutes.

  — Ensure that the 2016 HH RMD states that this condition (i.e., use of an EPC greater than the maximum detected value) is identified as an uncertainty in risk assessments. Use of an EPC greater than the maximum detected values errs on the side of caution. Further, ground-truthing in setting up cleanup levels is expected.

  — Excerpt from page 3-27 is in reference to samples collected from within the same groundwater well. Tim looked into the latest EPA guidance, *Determining Groundwater Exposure Point Concentrations*, OSWER Directive 9283.1-42, February 2014. The guidance does still recommend defaulting to the max detect for groundwater) rather than the UCL for determination of the EPC. Additional discussion of the issue will take place during the March 2016 Quarterly Meeting.

  — PCB test kits with higher detection limits may need to be further evaluated. For the role of the RMD, there needs to be a consistent method of dealing with that data.

- **Inclusion of USGS Background Values for Lithium and Molybdenum** *(taken from comments to the Soils OU RI 2 Report)*
  "In 2013, the U.S. Geological Survey published, 'Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801' Smith et al., 2013). Data tables can be accessed at http://pubs.usgs.gov/ds/801/downloads/."

The question was asked if we can add background values for these elements. The HH RMD states non-site-specific background values can be used if site-specific values are not available (see p. 3-20, “Analytes retained as COPCs, however, may be considered with the full range of background as part of the uncertainty analysis.”) Add USGS reference to list of references in RMD, but not to table of values.

- **Use of ROPC/COPC in RAGs** *(input from Tim Frederick)*
  from https://trainex.org/moreinfo/Radiation_Risk_Assessment_2015.pdf.
  The 2016 HH RMD will define COPCs as inclusive of chemicals and radionuclides in one or more places.

- **Revisions Mentioned Last Quarter**

– Bioaccumulation factors (BAFs) for Fish have been added to Appendix B. Other BAFs will not be included in Risk Methods Document, since they are not used for annual preliminary remediation goal (PRG) development and will need verification prior to use. Appendix D will list of references providing BAFs with the equation. These likely will include the Risk Assessment Information System and RESRAD technical document.

  Changes to BAF as a result of project-specific information will be included in future HH RMD revisions.

– Section 3.3.4.2 exposure pathways have been updated.

– Use of term “dose” has been revised to distinguish between radiation dose (i.e., rem or mrem) and absorbed/ administered dose (i.e., chemical and radionuclide intake).

– “Constituents of concern” has been revised so that terminology is consistent.

– Figures 2.1 and 2.3 have been revised slightly.

– Note has been added to Equation 1 (Section 2.1) that relationship is not applicable to non-linear based PRGs (e.g., Vapor Intrusion PRGs).

– Information has been included in Section 3.3.4.4 (previously a placeholder) for vapor intrusion. *Suggested text to add is the following:*

> Analysis of the exposure pathway for vapor intrusion due to volatile organic compound (VOC)-contaminated soils and groundwater will be evaluated on a project-specific basis, as needed. This potential exposure pathway is often considered in order to support possible future industrial missions within the PGDP industrialized area. Redevelopment with the potential for inhabited structures to be located in areas where VOC-contaminated groundwater and soil exists or has existed is considered a reasonable future use.
>
> VISLs are risk-based screening levels used to identify sites or buildings likely to pose a health concern through the vapor intrusion pathway. The EPA VISL calculator is located on the Web site http://www2.epa.gov/sites/production/files/2015-09/visl-calculator_v_343_0.xlsm. Please refer to Table E.8 in Appendix E for vapor intrusion risk information. At sites where subsurface concentrations of vapor-forming chemicals fall below VISLs, no further action or study is warranted (EPA 2015). Conversely, exceeding a VISL generally suggests that further evaluation of the vapor intrusion pathway or a response action is appropriate.

EPA 2015. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, OSWER 9200.2-154, Office of Solid Waste and Emergency Response, Washington, DC, June.

Revisions to the text were recommended during the meeting and are reflected as redline in the text above. It was noted that the text still has not been through internal reviews, so the suggested text will be similar to, but may not be exactly, what appears in the HH RMD.

- Equations have been reorganized in Appendix D to consolidate receptors and reference Table B.4 for exposure parameters.

- No errata section has been added, since document is revised annually.

4. Questions/Comments on Appendix A or Appendix B?
Sent to RAWG for review on 11/12/2015; comments due 1/5/2016.

5. Derivation of Risk-based Surface Water Effluent Limits
Status of discussions to resolve EPA Condition #3 on BGOU SWMUs 2, 3, 7, and 30 FS and condition on Waste Disposal Alternative regarding effluent.

A white paper was submitted to FFA Managers in early November 2015. Further activity is pending.

6. Status of CERCLA 120(h) Informational Briefing in Regard to Property Transfer Requests and Activities. *(input from Rich Bonczek)*
Paducah-Area Community Reuse Organization has requested disposition of property from DOE. DOE has begun briefing their management regarding implementation of transfer under 10 CFR 770 at Oak Ridge. The following activities are ongoing,

- Training sessions for contractors and DOE staff at both Paducah and Portsmouth.

- Training session for legal at Portsmouth/Paducah Project Office (PPPO).

- Development of a protocol and, subsequently, a procedure for clean parcel transfer.

- Meetings with DOE-Oak Ridge Operations (and others) regarding PPPO plans and lessons learned.

The only items/areas expected to be transferred in the near term are those that are “clean and unimpacted.”

Informational briefing for KY and EPA originally hoped to be presented in November 2015 is delayed to February or March 2016.

“Clean parcel transfer” is addressed in CERCLA Section 120(h)(4). See the following for additional information: http://www2.epa.gov/fedfac/guidance-epa-concurrence-identification-uncontaminated-parcels-under-cercla-section-120-h4

The activities of the RAWG are anticipated to intersect with the risk evaluation component of the clean parcel land release. RAWG involvement in the process will likely only commence once a path forward is established by the FFA Managers. DOE is offering the informational briefing to the RAWG to inform the technical SMEs of the overall CERCLA 120(h) process.

7. Poll RAWG Members/Open Discussion

Exposure factors are in Table B.4 (included in Appendix B), comments due 1/5/2016.
Meeting minutes for this meeting can be expected by the RAWG by 12/9/2015.

From Item 3, Bullet 2, below is an excerpt from the current ProUCL manual *ProUCL Version 5.0.00 User Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*, EPA/600/R-07/041, September 2013.

1.10.2 Use of Maximum Detected Value to Estimate EPC Terms

Some practitioners tend to use the maximum detected value as an estimate of the EPC term. This is especially true when the sample size is small such as < 5 or when a UCL95 exceeds the maximum detected values (EPA, 1992a). Specifically, the EPA (1992a) document suggests the use of the maximum detected value as a default value to estimate the EPC term when a 95% UCL (e.g., the H-UCL) exceeds the maximum value. ProUCL computes 95% UCLs of mean using several methods based upon normal, gamma, lognormal, and non-discernible distributions. In the past (e.g., EPA 1992), a lognormal distribution was used as the default distribution to model positively skewed environmental data sets; and only two methods were used to estimate the EPC term based upon: 1) normal distribution and Student's t-statistic, and 2) lognormal distribution and Land's H-statistic (1971, 1975). The use of the H-statistic often yields unstable and impractically large UCL95 of the mean (Singh, Singh, and Engelhardt, 1997; Singh, Singh, and Iaci, 2002). For skewed data sets of smaller sizes (e.g., < 30, < 50,...), H-UCL often exceeds the maximum detected value. Since the use of a lognormal distribution has been quite common (e.g., suggested as a default model in a risk assessment guidance for Superfund [RAGS] document [EPA, 1992a]), the exceedance of the maximum value by an H-UCL95 is frequent for many skewed data sets of smaller sizes (e.g., < 30, < 50). These occurrences result in the possibility of using the maximum detected value as an estimate of the EPC term.

It should be pointed out that in some cases, the maximum observed value actually might represent an impacted location. Obviously, it is not desirable to use a potential outlier representing an impacted location to estimate the EPC term for an AOC. The EPC term represents the average exposure contracted by an individual over an EA during a long period of time; therefore, the EPC term should be estimated by using an average value (such as an appropriate 95% UCL of the mean) and not by the maximum observed concentration. One needs to compute an average exposure and not the maximum exposure. Singh and Singh (2003) studied the performance of the max test (using the maximum observed value as an estimate of the EPC term) via Monte Carlo simulation experiments. They noted that for skewed data sets of small sizes (e.g., < 10-20), even the max test does not provide the specified 95% coverage to the population mean, and for larger data sets it overestimates the EPC term, which may lead to unnecessary further remediation.

Today, several methods, some of which are described in EPA (2002a), are available in the various versions of ProUCL (e.g., ProUCL 3.00.02 [EPA 2004], ProUCL 4.0 [EPA 2007], ProUCL 4.00.05[EPA 2009, 2010]) to estimate the EPC terms. For data sets with NDs, ProUCL 5.0 has some new UCL (and other limits) computation methods which were not available in earlier versions of ProUCL. It is unlikely that the UCLs based upon those methods will exceed the maximum detected value, unless some outliers are present in the data set.

Risk Assessment Working Group
Meeting Minutes—February 24, 2016

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1. Call for Issues from Risk Assessment Working Group (RAWG) Members

Lead values: The U.S. Environmental Protection Agency's (EPA's) regional screening level (RSL)/cleanup level is 400 mg/kg that was derived using the Integrated Exposure Uptake and Biokinetic (IEUBK) model for lead using the Center for Disease Control's (CDC's) recommendation of 10 µg/dL lead in blood. The new recommendation for lead in blood is 5 µg/dL. A new interim policy is expected. The new policy most likely will show a new RSL/cleanup level for lead at a reduction of approximately 50% (i.e., ~ 200 mg/kg). The new interim policy may be coming from Office of Land and Emergency Management (OLEM) (formerly the Office of Solid Waste and Emergency Response) this quarter. Revised values will be included in the Human Health (HH) Risk Methods Document (RMD) when available.

2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

RAWG Concur with HH Appendix A and B	2/12/2016
Comments Due for HH Main Text and HH Appendix D	2/12/2016
Quarterly Meeting (March)	2/24/2016
RAWG Concur with HH Main Text and HH Appendix D	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
Submit HH RMD to Federal Facility Agreement (FFA) Managers (DOE/LX/07-0107&D2/R7/V1)	6/13/2016
FFA Managers Acknowledge Receipt of HH RMD	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

3. Concurrence of HH RMD Appendices A and B (Due 2/12/2016)

- Kentucky has no further comments.
- EPA responded that they had no comments and that their concurrence was not required.

4. Discussion of Comments Received to the 2016 HH RMD Main Text and Appendix D (Due 2/12/2016)

- Term "radiological activity concentration" revised to "activity concentration" in Appendix D and throughout the rest of the document in order to go with the standard terminology.

- Kentucky, EPA, and U.S. Department of Energy (DOE) have no other comments at this time.

5. Follow-up on EPA Guidance Regarding Groundwater Exposure Point Concentration (EPC)

The text in the draft 2016 HH RMD states the following: "If the 95% [upper confidence limit (UCL)] is greater than the maximum detected concentration, EPA guidance recommends that the EPC default to the maximum detected concentration for that contaminant."

Ensure whether the 95% UCL being greater than the maximum detected concentration is included in the list of uncertainties. [LeAnne followed up with this; and it was added to the list of uncertainties for this draft (page 3-44 of the main text), based on the December 2, 2015, RAWG Meeting Minutes.]

Text in draft 2016 HH RMD has been revised to include the following in Section 3.3.4.3 (page 3-27): "The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed in the uncertainty section of the risk assessment."

6. Discussion on Polychlorinated Biphenyl (PCB) Test Kits/Higher Detection Limits

From the December 2015 quarterly meeting, discussion was held with respect to UCL95 values being greater than the maximum detect. The meeting minutes state, "PCB test kits with higher detection limits may need to be further evaluated. For the role of the RMD, there needs to be a consistent method of dealing with that data."

Follow-up on topic from the December 2015 meeting: "Additional information regarding the statistics may be added to Appendix E. Martin, Bobette, and LeAnne will work on the issue; if added to the 2016 RMD, Appendix E, the draft text will be presented at the next quarterly meeting."

Recommended text for the main text of the RMD is found in the attachment. No text is recommended for Appendix E.

Additionally with respect to PCB test kits with higher detection limits, the project teams will need to address the uncertainty if EPCs are inconsistent with maximum detected results, which may include getting additional sampling/analytical data. Detection limits of the PCB test kits [and similarly uranium for the X-ray fluorescence (XRF)] must be below levels consistent with expected cleanup levels; whether the kits' detection limits are adequate should be addressed by the project teams during scoping. [LeAnne followed up on this. Section 3.3.3.2 of the main text (page 3-17) contains information regarding XRF and PCB test kit data. Additional information (from above) will be added for comment to the version scheduled for review beginning 4/18/2016.] Additionally, these requirements will be evaluated for inclusion in the Programmatic Quality Assurance Project Plan (QAPP).

7. Ecological RMD: Future Addition of Reference

January's "TechDirect" listed the information below. This information could be applied to Paducah's Ecological RMD because it provides justification for the soil and sediment sampling depth for ecological risk assessment. Reference says 0–1 ft bgs sampling for soils and 0–6 inch sampling for sediment should be targeted [EPA 2015. *Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments (Final Report)*. U.S. Environmental Protection Agency, Ecological Risk Assessment Support Center, Cincinnati, OH, EPA/600/R-15/176].

Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments. Ecological risk assessors frequently are faced with the challenge of defining the biologically active zone, or biotic zone, in soils and sediments during the design and interpretation of soil and sediment sampling programs. With respect to terrestrial assessments, this study uses a meta-analysis approach to quantify the zone of highest biological activity for soil-dwelling ecological receptors commonly utilized in ecological risk assessments. For decisions related to ecological assessment or remediation in aquatic scenarios, we develop practical default values for the depth of the biotic zone (i.e., biologically relevant sampling depth) in various habitats based on the 80th percentile of abundance or biomass depth distributions. In areas populated by a high density of deep dwelling organisms, such as those listed in this paper, the biotic zone may be somewhat deeper than our recommended values. View or download at http://cfpub.epa.gov/ncea/erasc/recordisplay.cfm?deid=310058.

This information is being considered applicable to the Ecological RMD (i.e., informally included) now, and will be included formally in the Ecological RMD during its next revision.

8. Ecological RMD: Metadata Required for Sampling

Several metadata are required for sampling to better interpret ecological impacts from metals analyses. For example, for project scoping meetings and the next Ecological RMD update will address these metadata. Metadata include soil pH for aluminum screening and water hardness for metals screening in water.

These requirements will be incorporated into Programmatic QAPP revisions, project-specific QAPPs, and eventually into the Ecological RMD when it is updated.

LeAnne has checked the Surface Water Operable Unit (off-site) Work Plan to ensure these parameters are captured. The work plan is available in the EIC at the following link: http://paducaheic.com/Search.aspx?accession=env 1.A-00222, and states the following:

> All bioaccumulation tests will be analyzed for metals, radionuclides, PAHs, geotechnical (10% of surface samples), and PCBs. Geotechnical parameters include Total Organic Carbon (TOC), grain size, bulk density, % solids, pH, and moisture content.
>
> Surface water samples will be analyzed for metals, radionuclides, and physical parameters (e.g., pH, hardness, dissolved oxygen, conductivity, temperature, and turbidity).

9. Ecological RMD: Use of ProUCL

In the next revision of the Ecological RMD (page 2-11, footnote 2), additional text from Item 6 could be added for consistency. Jeri Higginbotham is double-checking whether this is appropriate.

10. Derivation of Risk-based Surface Water Effluent Limits

Status of discussions to resolve EPA Condition #3 on Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS) and condition on Waste Disposal Alternative regarding effluent.

BGOU SWMUs 2, 3, 7, and 30 FS and Waste Disposal Alternative Remedial Investigation/FS are in formal dispute right now. Derivation of the surface water effluent limits is pending that outcome.

11. Status of CERCLA 120(h) Informational Briefing in Regards to Property Transfer Requests and Activities.

Informational briefing for KY and EPA originally hoped to be presented in November 2015 has been delayed to April or May 2016. The briefing is expected to include lessons learned from previous transfers. A programmatic procedure for determining clean parcel transfer is being developed by DOE.

12. Poll RAWG Members/Open Discussion

Programmatic QAPP is expected this week. A briefing will be scheduled with Kentucky and EPA on what has been changed (in March or April 2016).

ATTACHMENT

Recommended text (shown in red) (Agenda Item 6)

(2) If results from ten or more samples are available, then the most recent version of EPA's ProUCL software will be used to determine the EPC. The value selected as the EPC will be the value recommended by ProUCL, noted as the "Potential UCL to Use." EPA's ProUCL software[7] incorporates a number of different distributional tests that may be used to calculate the most appropriate EPC (EPA 2013a). In the current version of ProUCL, the software has computation methods for handling data sets with nondetect values. Unless other determinations are made during project scoping, nondetect values should be handled according to the recommendations in the ProUCL User Guide (EPA 2013a). Additional information regarding the statistics and computation methods used in ProUCL can be found in the User Guide and in the ProUCL Technical Guide (EPA 2013b). Additionally, it is unlikely that the UCLs based upon those methods will exceed the maximum detected value, unless some outliers are present in the data set. The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed in the uncertainty section of the risk assessment.

Options to determine the ten or more samples may include use of grid values. It is recommended that a geostatistical approach utilizing Spatial Analysis and Decision Assistance (SADA) or similar software be used to estimate values for empty grids. SADA is available at http://www.tiem.utk.edu/~sada/index.shtml. Alternately, an average value may be used. An example is shown in the text box [from Soils Operable Unit RI Report (DOE 2012)]. These options should be discussed and agreed to in the planning phases of projects.

References:

EPA 2013a. *ProUCL Version 5.0.00 User Guide.* EPA/600/R-07/041, Office of Research and Development Site Characterization and Monitoring Technical Support Center, Atlanta, GA, September, model available at www.epa.gov/land-research/proucl-software.

EPA 2013b. *ProUCL Version 5.0.00 Technical Guide.* EPA/600/R-07/041, Office of Research and Development Site Characterization and Monitoring Technical Support Center, Atlanta, GA, September, model available at www.epa.gov/land-research/proucl-software.

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[7] Software is available at www.epa.gov/land-research/proucl-software ~~www.epa.gov/osp/hstl/tsc/software.htm~~.

Risk Assessment Working Group
Meeting Minutes—June 15, 2016

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1. Call for Issues from Risk Assessment Working Group (RAWG) Members

None.

2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

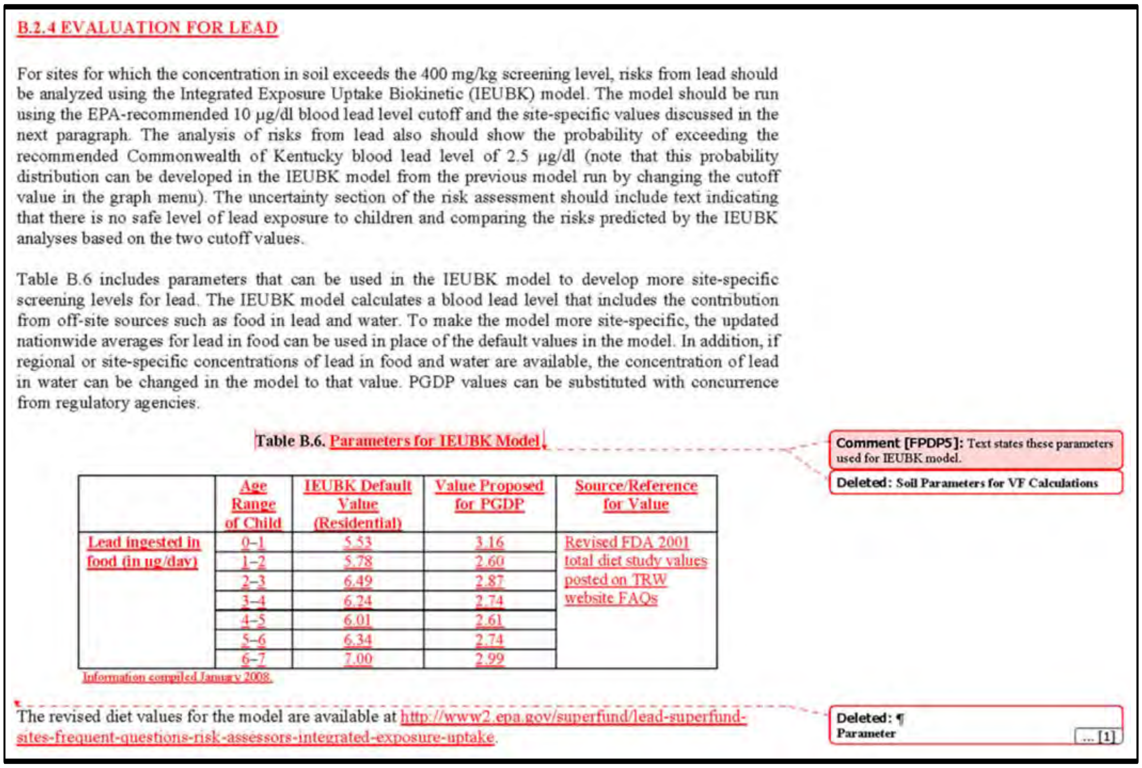
Quarterly Meeting (June)	6/15/2016
Submit Human Health (HH) Risk Methods Document (RMD) to Federal Facility Agreement (FFA) Managers (DOE/LX/07-0107&D2/R7/V1)	6/21/2016
FFA Managers Acknowledge Receipt of HH RMD and provide additional comments, if necessary	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)
Note that dates for Quarterly Meeting and Submit HH RMD to FFA Managers were revised.

3. Discussion of Comments Received to the 2016 HH RMD

– Regarding Section B.2.4 Evaluation for Lead:

Screen shot of redline RMD sent 4/18/2016 for review:



B.2.4 EVALUATION FOR LEAD

For sites for which the concentration in soil exceeds the 400 mg/kg screening level, risks from lead should be analyzed using the Integrated Exposure Uptake Biokinetic (IEUBK) model. The model should be run using the EPA-recommended 10 µg/dl blood lead level cutoff and the site-specific values discussed in the next paragraph. The analysis of risks from lead also should show the probability of exceeding the recommended Commonwealth of Kentucky blood lead level of 2.5 µg/dl (note that this probability distribution can be developed in the IEUBK model from the previous model run by changing the cutoff value in the graph menu). The uncertainty section of the risk assessment should include text indicating that there is no safe level of lead exposure to children and comparing the risks predicted by the IEUBK analyses based on the two cutoff values.

Table B.6 includes parameters that can be used in the IEUBK model to develop more site-specific screening levels for lead. The IEUBK model calculates a blood lead level that includes the contribution from off-site sources such as food in lead and water. To make the model more site-specific, the updated nationwide averages for lead in food can be used in place of the default values in the model. In addition, if regional or site-specific concentrations of lead in food and water are available, the concentration of lead in water can be changed in the model to that value. PGDP values can be substituted with concurrence from regulatory agencies.

Table B.6. Parameters for IEUBK Model

	Age Range of Child	IEUBK Default Value (Residential)	Value Proposed for PGDP	Source/Reference for Value
Lead ingested in food (in µg/day)	0–1	5.53	3.16	Revised FDA 2001 total diet study values posted on TRW website FAQs
	1–2	5.78	2.60	
	2–3	6.49	2.87	
	3–4	6.24	2.74	
	4–5	6.01	2.61	
	5–6	6.34	2.74	
	6–7	7.00	2.99	

Information compiled January 2008.

The revised diet values for the model are available at http://www2.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-integrated-exposure-uptake.

Comment [FPDP5]: Text states these parameters used for IEUBK model.

Deleted: Soil Parameters for VF Calculations

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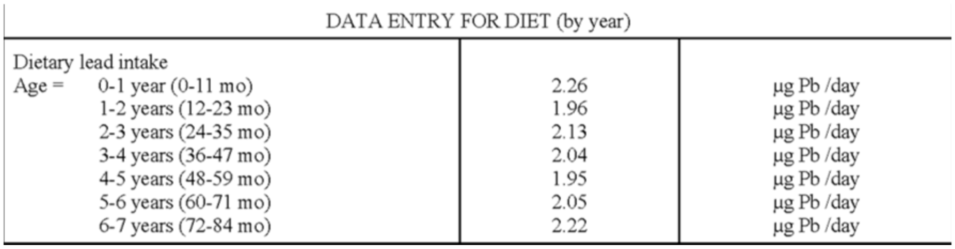
Parameter ... [1]

- World Health Organization already has changed, and U.S. Environmental Protection Agency (EPA) is expected to change, the recommended blood lead level "cutoff" to 5 µg/dL [see also *Risk Assessment Working Group Meeting Minutes—February 24, 2016*]; Kentucky Department for Environmental Protection (KDEP) still recommends 2.5 µg/dL.

- The Integrated Exposure Uptake Biokinetic (IEUBK) model was last updated in 2010 (and the User's Guide in 2007), well after the 2001 U.S. Food and Drug Administration (FDA) reference was produced, but the original values from the 1994 model appear to be listed as the "default" values.

- The link provided below the table does not include the revised diet values (they can be found in the 2007 User's Guide in Table 2-1), and are as follows:



DATA ENTRY FOR DIET (by year)		
Dietary lead intake		
Age = 0-1 year (0-11 mo)	2.26	µg Pb /day
1-2 years (12-23 mo)	1.96	µg Pb /day
2-3 years (24-35 mo)	2.13	µg Pb /day
3-4 years (36-47 mo)	2.04	µg Pb /day
4-5 years (48-59 mo)	1.95	µg Pb /day
5-6 years (60-71 mo)	2.05	µg Pb /day
6-7 years (72-84 mo)	2.22	µg Pb /day

RESPONSE: The link provided below the table will be updated to the 2007 User's Guide, Table 2-1. Additional changes to Table B.6 will be made in the 2017 RMD and with input from the anticipated revised EPA guidance. (See also Item 4 of these meeting minutes.)

– Regarding Table B.4

Screen shot of redline RMD sent 4/18/2016 for review:

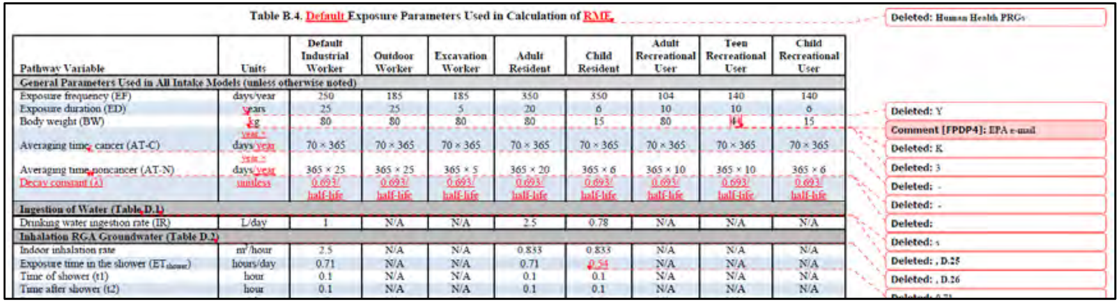


Table B.4. Default Exposure Parameters Used in Calculation of RME

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
General Parameters Used in All Intake Models (unless otherwise noted)									
Exposure frequency (EF)	days/year	250	185	185	350	350	104	140	140
Exposure duration (ED)	years	25	25	5	20	6	10	10	6
Body weight (BW)	kg	80	80	80	80	15	80	[illegible]	15
Averaging time, cancer (AT-C)	year × days/year	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365
Averaging time, noncancer (AT-N)	year × days/year	365 × 25	365 × 25	365 × 5	365 × 20	365 × 6	365 × 10	365 × 10	365 × 6
Decay constant (λ)	unitless	0.693/ half-life	0.693/ half-life	0.693/ half-life	0.693/ half-life	0.693/ half-life	0.693/ half-life	0.693/ half-life	0.693/ half-life
Ingestion of Water (Table D.1)									
Drinking water ingestion rate (IR)	L/day	1	N/A	N/A	2.5	0.78	N/A	N/A	N/A
Inhalation RGA Groundwater (Table D.2)									
Indoor inhalation rate	m^3/hour	2.5	N/A	N/A	0.833	0.833	N/A	N/A	N/A
Exposure time in the shower (ET_{shower})	hours/day	0.71	N/A	N/A	0.71	0.54	N/A	N/A	N/A
Time of shower (t1)	hour	0.1	N/A	N/A	0.1	0.1	N/A	N/A	N/A
Time after shower (t2)	hour	0.1	N/A	N/A	0.1	0.1	N/A	N/A	N/A

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- The parameters "Time of shower" (0.1 hour) and "Time after shower" (0.1 hour) appear to be in error. These are not consistent with the Exposure time in the shower of 0.71 hours/day (adult resident) and 0.54 hours/day (child resident), but rather correspond to the older (KRAG recommended value) of 0.2 hours/day as the Exposure time in the shower.

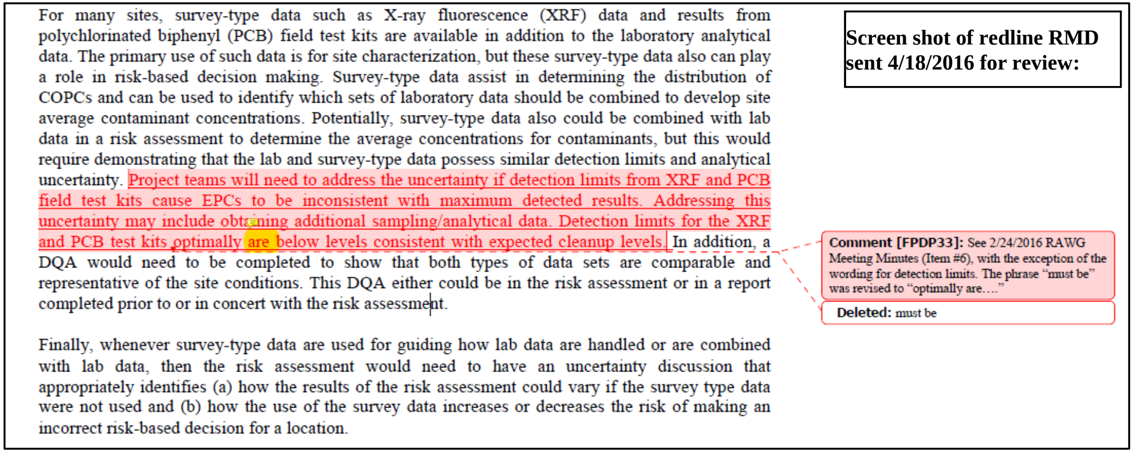
  — Adding the "Time of shower" and "Time after shower" should result in the Exposure time in the shower of 0.71 hours/day (adult resident) and 0.54 hours/day (child resident).

  — Using the EFH, it appears that the "Time of shower" is ~60% of the total time, and "Time after shower" is ~40% of the total time.

RESPONSE: Time of shower and Time after shower for the adult and child will be revised to that listed below. [Note: These exposure parameters for groundwater usage have not been used in recent BHHRAs (e.g., Soils OU RI 2, which evaluated soils only) or in the Risk Assessment Information System (RAIS) Preliminary Remediation Goal (PRG) input.]

Pathway Variable	Units	Adult Resident	Child Resident
Exposure time in the shower (ET_{shower})	hours/day	0.71	0.54
Time of shower (t1)	hour	0.43	0.32
Time after shower (t2)	hour	0.28	0.22

– Regarding Section 3.3.3.2. Procedures to screen or evaluate data to determine COPCs:



Screen shot of redline RMD sent 4/18/2016 for review:

For many sites, survey-type data such as X-ray fluorescence (XRF) data and results from polychlorinated biphenyl (PCB) field test kits are available in addition to the laboratory analytical data. The primary use of such data is for site characterization, but these survey-type data also can play a role in risk-based decision making. Survey-type data assist in determining the distribution of COPCs and can be used to identify which sets of laboratory data should be combined to develop site average contaminant concentrations. Potentially, survey-type data also could be combined with lab data in a risk assessment to determine the average concentrations for contaminants, but this would require demonstrating that the lab and survey-type data possess similar detection limits and analytical uncertainty. Project teams will need to address the uncertainty if detection limits from XRF and PCB field test kits cause EPCs to be inconsistent with maximum detected results. Addressing this uncertainty may include obtaining additional sampling/analytical data. Detection limits for the XRF and PCB test kits optimally are below levels consistent with expected cleanup levels. In addition, a DQA would need to be completed to show that both types of data sets are comparable and representative of the site conditions. This DQA either could be in the risk assessment or in a report completed prior to or in concert with the risk assessment.

Finally, whenever survey-type data are used for guiding how lab data are handled or are combined with lab data, then the risk assessment would need to have an uncertainty discussion that appropriately identifies (a) how the results of the risk assessment could vary if the survey type data were not used and (b) how the use of the survey data increases or decreases the risk of making an incorrect risk-based decision for a location.

Comment [FPDP33]: See 2/24/2016 RAWG Meeting Minutes (Item #6), with the exception of the wording for detection limits. The phrase "must be" was revised to "optimally are…."

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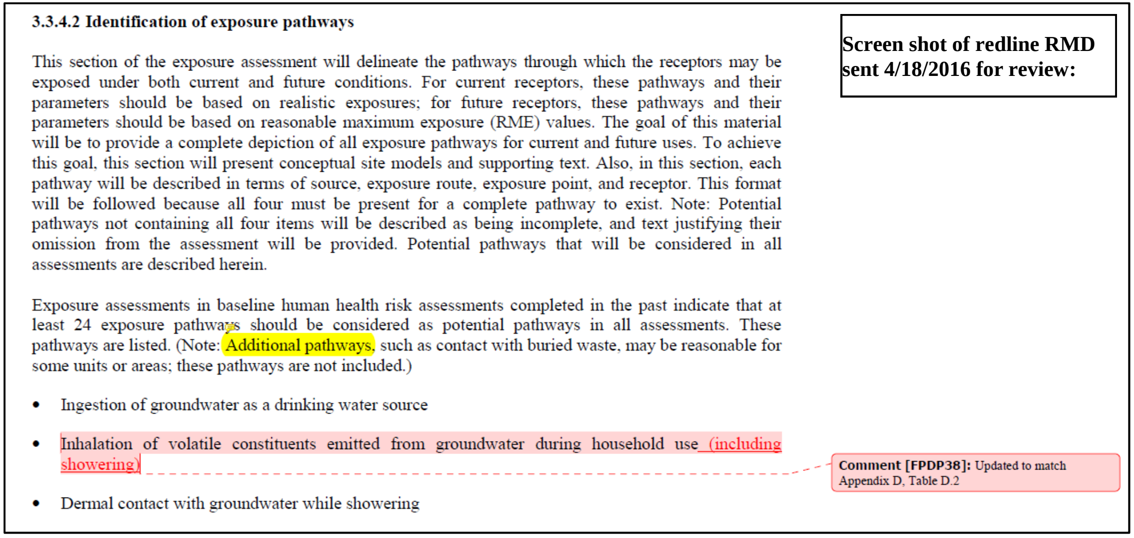
- Consider if "should be" is better here.

RESPONSE: Revise "are" to "should be."

– Regarding Section 3.3.4.2, "Identification of exposure pathways":



Screen shot of redline RMD sent 4/18/2016 for review:

3.3.4.2 Identification of exposure pathways

This section of the exposure assessment will delineate the pathways through which the receptors may be exposed under both current and future conditions. For current receptors, these pathways and their parameters should be based on realistic exposures; for future receptors, these pathways and their parameters should be based on reasonable maximum exposure (RME) values. The goal of this material will be to provide a complete depiction of all exposure pathways for current and future uses. To achieve this goal, this section will present conceptual site models and supporting text. Also, in this section, each pathway will be described in terms of source, exposure route, exposure point, and receptor. This format will be followed because all four must be present for a complete pathway to exist. Note: Potential pathways not containing all four items will be described as being incomplete, and text justifying their omission from the assessment will be provided. Potential pathways that will be considered in all assessments are described herein.

Exposure assessments in baseline human health risk assessments completed in the past indicate that at least 24 exposure pathways should be considered as potential pathways in all assessments. These pathways are listed. (Note: Additional pathways, such as contact with buried waste, may be reasonable for some units or areas; these pathways are not included.)

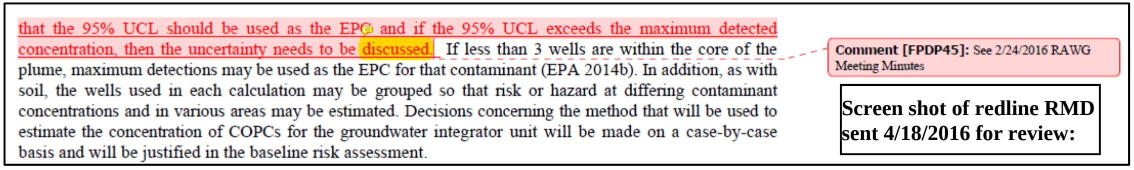
- Ingestion of groundwater as a drinking water source
- Inhalation of volatile constituents emitted from groundwater during household use (including showering)
- Dermal contact with groundwater while showering

Comment [FPDP38]: Updated to match Appendix D, Table D.2

- The pathways listed here really do not include inhalation of volatiles emitted from groundwater and that move into a building via the EPA VI model. The RMD needs a bullet here to capture this. Note that the topic emissions from soils is included later on.

RESPONSE: Note will be revised as follows: “Note: Additional pathways, such as contact with buried waste and modeled vapor intrusion, may be reasonable for some units or areas; these pathways are not included.)”

– Regarding Section 3.3.4.3 (page 3-27):



that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed. If less than 3 wells are within the core of the plume, maximum detections may be used as the EPC for that contaminant (EPA 2014b). In addition, as with soil, the wells used in each calculation may be grouped so that risk or hazard at differing contaminant concentrations and in various areas may be estimated. Decisions concerning the method that will be used to estimate the concentration of COPCs for the groundwater integrator unit will be made on a case-by-case basis and will be justified in the baseline risk assessment.

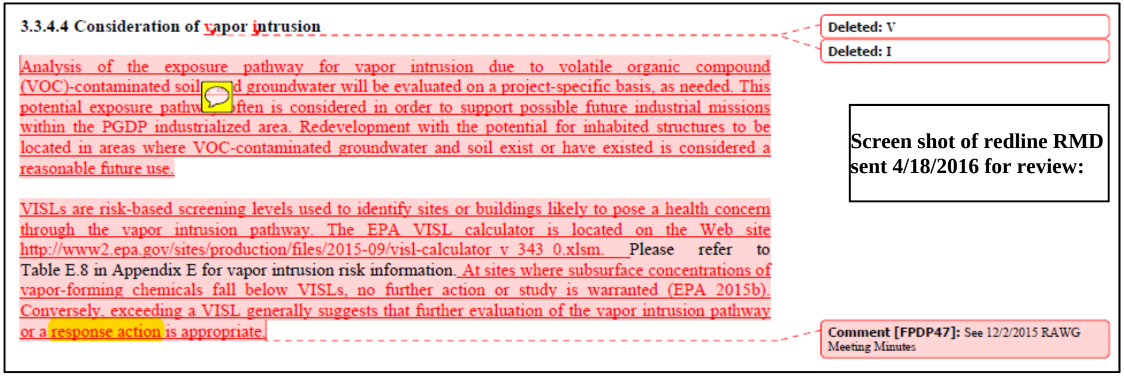
Comment [FPDP45]: See 2/24/2016 RAWG Meeting Minutes

Screen shot of redline RMD sent 4/18/2016 for review:

- Suggest revising this to: “addressed in the uncertainty section of the risk assessment/evaluation.”

RESPONSE: Revise to “…to be discussed in the uncertainty section of the risk assessment,” which is consistent with the RAWG Meeting Minutes.

– Regarding Section 3.3.4.4 “Consideration of vapor intrusion”:



3.3.4.4 Consideration of vapor intrusion

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Analysis of the exposure pathway for vapor intrusion due to volatile organic compound (VOC)-contaminated soil [illegible]d groundwater will be evaluated on a project-specific basis, as needed. This potential exposure pathw[illegible]ften is considered in order to support possible future industrial missions within the PGDP industrialized area. Redevelopment with the potential for inhabited structures to be located in areas where VOC-contaminated groundwater and soil exist or have existed is considered a reasonable future use.

VISLs are risk-based screening levels used to identify sites or buildings likely to pose a health concern through the vapor intrusion pathway. The EPA VISL calculator is located on the Web site http://www2.epa.gov/sites/production/files/2015-09/visl-calculator_v_343_0.xlsm. Please refer to Table E.8 in Appendix E for vapor intrusion risk information. At sites where subsurface concentrations of vapor-forming chemicals fall below VISLs, no further action or study is warranted (EPA 2015b). Conversely, exceeding a VISL generally suggests that further evaluation of the vapor intrusion pathway or a response action is appropriate.

Screen shot of redline RMD sent 4/18/2016 for review:

Comment [FPDP47]: See 12/2/2015 RAWG Meeting Minutes

- Consider also adding text at the end of this paragraph (or in a new paragraph) for outside the industrialized area (because, e.g. we did VI analyses for the Water Policy Area, recently).
- VISL are not triggers for a response.

RESPONSE: The 1st paragraph will be revised to include, “Additionally, area outside the industrialized area (e.g., the Water Policy Area) may be considered.”

The 2nd paragraph will be revised to the following: “Conversely, exceeding a VISL generally suggests that further evaluation of the vapor intrusion pathway is appropriate, including consideration of an early response action.”

This will be reviewed by DOE after approval from the RAWG.

– Regarding Table B.8:

Screen shot of redline RMD sent 4/18/2016 for review:

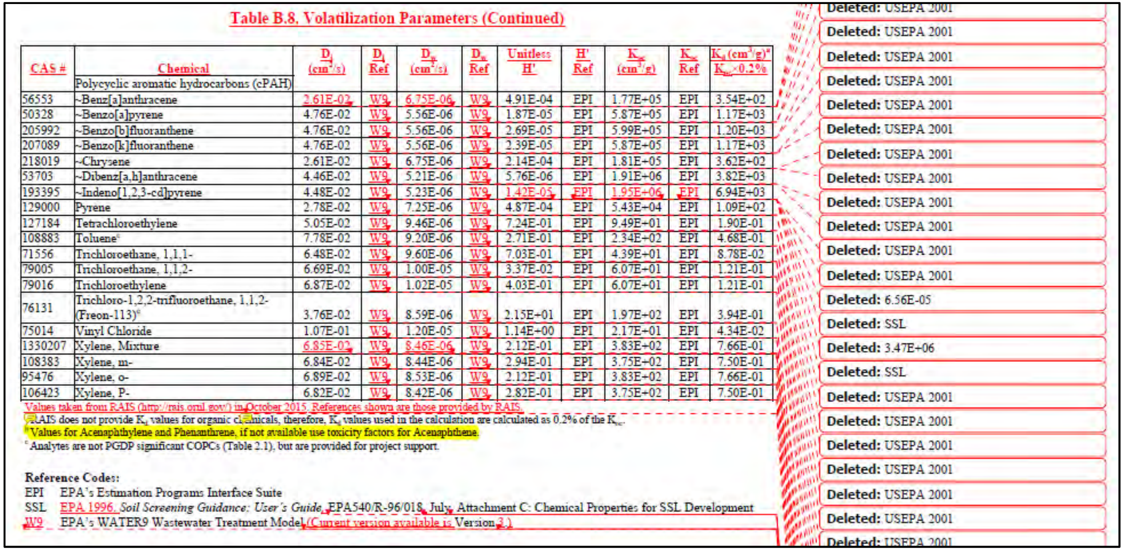

Table B.8. Volatilization Parameters (Continued)

CAS #	Chemical	D_i (cm²/s)	D_i Ref	D_w (cm²/s)	D_w Ref	Unitless H'	H' Ref	K_{oc} (cm³/g)	K_{oc} Ref	K_d (cm³/g)[a] K_{oc}×0.2%
	Polycyclic aromatic hydrocarbons (cPAH)									
56553	~Benz[a]anthracene	2.61E-02	W9	6.75E-06	W9	4.91E-04	EPI	1.77E+05	EPI	3.54E+02
50328	~Benzo[a]pyrene	4.76E-02	W9	5.56E-06	W9	1.87E-05	EPI	5.87E+05	EPI	1.17E+03
205992	~Benzo[b]fluoranthene	4.76E-02	W9	5.56E-06	W9	2.69E-05	EPI	5.99E+05	EPI	1.20E+03
207089	~Benzo[k]fluoranthene	4.76E-02	W9	5.56E-06	W9	2.39E-05	EPI	5.87E+05	EPI	1.17E+03
218019	~Chrysene	2.61E-02	W9	6.75E-06	W9	2.14E-04	EPI	1.81E+05	EPI	3.62E+02
53703	~Dibenz[a,h]anthracene	4.46E-02	W9	5.21E-06	W9	5.76E-06	EPI	1.91E+06	EPI	3.82E+03
193395	~Indeno[1,2,3-cd]pyrene	4.48E-02	W9	5.23E-06	W9	1.42E-05	EPI	1.95E+06	EPI	6.94E+03
129000	Pyrene	2.78E-02	W9	7.25E-06	W9	4.87E-04	EPI	5.43E+04	EPI	1.09E+02
127184	Tetrachloroethylene	5.05E-02	W9	9.46E-06	W9	7.24E-01	EPI	9.49E+01	EPI	1.90E-01
108883	Toluene[c]	7.78E-02	W9	9.20E-06	W9	2.71E-01	EPI	2.34E+02	EPI	4.68E-01
71556	Trichloroethane, 1,1,1-	6.48E-02	W9	9.60E-06	W9	7.03E-01	EPI	4.39E+01	EPI	8.78E-02
79005	Trichloroethane, 1,1,2-	6.69E-02	W9	1.00E-05	W9	3.37E-02	EPI	6.07E+01	EPI	1.21E-01
79016	Trichloroethylene	6.87E-02	W9	1.02E-05	W9	4.03E-01	EPI	6.07E+01	EPI	1.21E-01
76131	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[c]	3.76E-02	W9	8.59E-06	W9	2.15E+01	EPI	1.97E+02	EPI	3.94E-01
75014	Vinyl Chloride	1.07E-01	W9	1.20E-05	W9	1.14E+00	EPI	2.17E+01	EPI	4.34E-02
1330207	Xylene, Mixture	6.85E-02	W9	8.46E-06	W9	2.12E-01	EPI	3.83E+02	EPI	7.66E-01
108383	Xylene, m-	6.84E-02	W9	8.44E-06	W9	2.94E-01	EPI	3.75E+02	EPI	7.50E-01
95476	Xylene, o-	6.89E-02	W9	8.53E-06	W9	2.12E-01	EPI	3.83E+02	EPI	7.66E-01
106423	Xylene, P-	6.82E-02	W9	8.42E-06	W9	2.82E-01	EPI	3.75E+02	EPI	7.50E-01

Values taken from RAIS (http://rais.ornl.gov/) in October 2015. References shown are those provided by RAIS.

[a] RAIS does not provide K_d values for organic chemicals, therefore, K_d values used in the calculation are calculated as 0.2% of the K_{oc}.

[b] Values for Acenaphthylene and Phenanthrene, if not available use toxicity factors for Acenaphthene.

[c] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.

Reference Codes:

EPI	EPA's Estimation Programs Interface Suite
SSL	EPA 1996. *Soil Screening Guidance: User's Guide*, EPA540/R-96/018, July, Attachment C: Chemical Properties for SSL Development
W9	EPA's WATER9 Wastewater Treatment Model (Current version available is Version 3.)

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Deleted: SSL
Deleted: 3.47E+06
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- Please verify that note "b" is called out in Table B.8. If not, please delete here or add to the table.

RESPONSE: Footnote b will be deleted, because it is extraneous.

4. **Status of EPA's Policy for Lead in Blood**
   EPA is working on updating screening values and IEUBK values; currently EPA is making sure model works with updated values.

   The 2016 RMD will be footnoted to check EPA's lead screening values to ensure the NALs and ALs still are current. The NAL water value is the MCL; it is not being changed in the near term.

5. **Derivation of Risk-based Surface Water Effluent Limits**
   BGOU SWMUs 2, 3, 7, and 30 FS and Waste Disposal Alternative Remedial Investigation/FS are in formal dispute right now. Derivation of the surface water effluent limits is pending that outcome.

6. **Status of CERCLA 120(h) Informational Briefing in Regards to Property Transfer Requests and Activities.**
   Portsmouth is continuing their process—Environmental Baseline Survey is completed. Informational briefing is through most of DOE's reviews. KY briefing/workshop possibly will be scheduled for August or September 2016.

7. FY 2017 Schedule/Work Plan

Approve Work Plan (this schedule)	9/14/2016*
Suggested revisions/corrections to HH RMD text should be sent to LeAnne	11/2/2016
Submit HH Appendix A (i.e., PRGs) to RAWG for Review	11/14/2016
Quarterly Meeting (December)	12/7/2016
Submit Revised HH Main Text and HH Appendix B and D to RAWG for Review	12/12/2016
Comments Due for HH Appendix A	1/13/2017
RAWG Concur with HH Appendix A	2/13/2017
Comments Due for HH Main Text and HH Appendix B and D	2/13/2017
Quarterly Meeting (March)	3/8/2017
RAWG Concur with HH Main Text and HH Appendix B and D	4/10/2017
Submit Entire Revised HH RMD to RAWG for Review	4/17/2017
Comments Due for Entire Revised HH RMD	5/15/2017
Quarterly Meeting (June)	6/7/2017
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R8/V1)	6/20/2017
FFA Managers Acknowledge Receipt of HH RMD	7/17/2017
Quarterly Meeting (September)	9/13/2017

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

*Approval is needed before October 31, 2016.

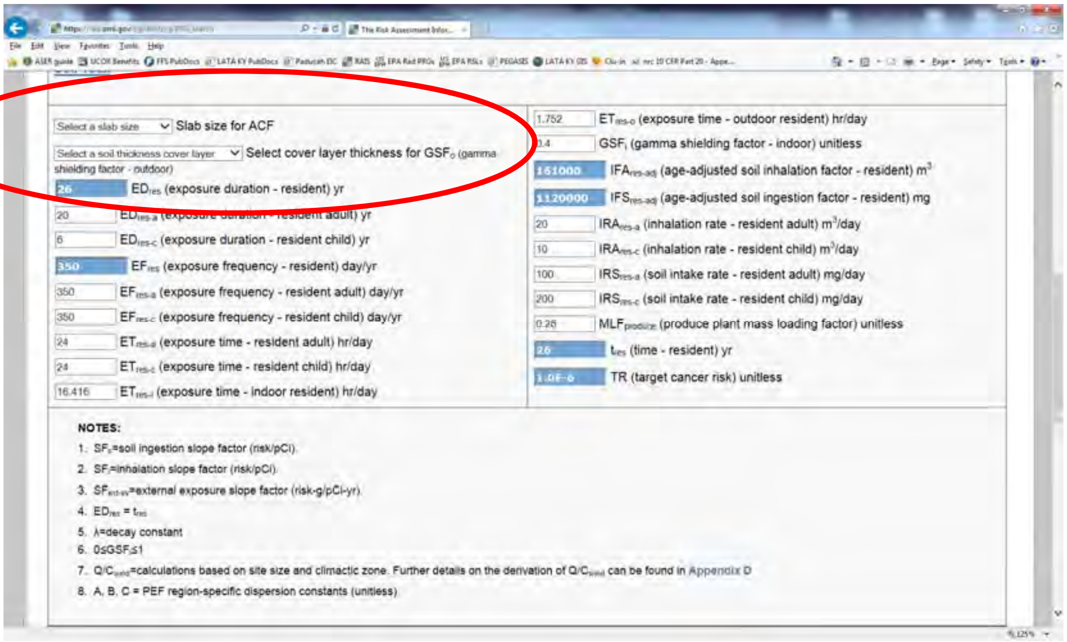
8. Revised ProUCL Is Available

Newest revision will be used in the 2017 RMD.

9. RAIS Radionuclide PRG Calculator (to be discussed at the September 2016 meeting)

The RAIS radionuclide PRG calculator has been revised to be more like EPA's calculator. There are some inputs that will need to be included for the 2017 revision. The RAWG will review these new default values and convene in September 2016 to make a final decision for the 2017 RMD.

A screen shot for residential exposure to soils is provided below (with new input circled in red).



Select a slab size Slab size for ACF

Select a soil thickness cover layer Select cover layer thickness for GSF_o (gamma shielding factor - outdoor)

26 ED_{res} (exposure duration - resident) yr

20 $ED_{res\text{-}a}$ (exposure duration - resident adult) yr

6 $ED_{res\text{-}c}$ (exposure duration - resident child) yr

350 EF_{res} (exposure frequency - resident) day/yr

350 $EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr

350 $EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr

24 $ET_{res\text{-}a}$ (exposure time - resident adult) hr/day

24 $ET_{res\text{-}c}$ (exposure time - resident child) hr/day

16.416 $ET_{res\text{-}i}$ (exposure time - indoor resident) hr/day

1.752 $ET_{res\text{-}o}$ (exposure time - outdoor resident) hr/day

0.4 GSF_i (gamma shielding factor - indoor) unitless

161000 $IFA_{res\text{-}adj}$ (age-adjusted soil inhalation factor - resident) m^3

1120000 $IFS_{res\text{-}adj}$ (age-adjusted soil ingestion factor - resident) mg

20 $IRA_{res\text{-}a}$ (inhalation rate - resident adult) m^3/day

10 $IRA_{res\text{-}c}$ (inhalation rate - resident child) m^3/day

100 $IRS_{res\text{-}a}$ (soil intake rate - resident adult) mg/day

200 $IRS_{res\text{-}c}$ (soil intake rate - resident child) mg/day

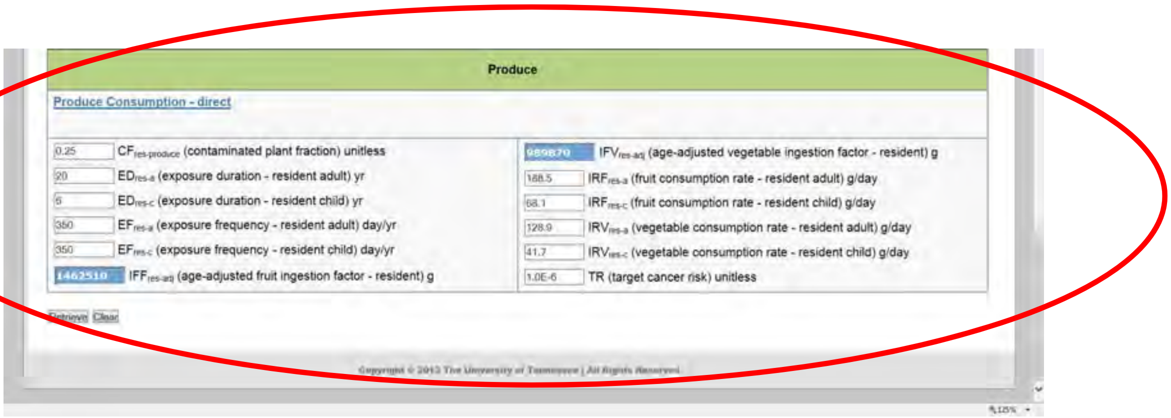
0.26 $MLF_{produce}$ (produce plant mass loading factor) unitless

26 t_{res} (time - resident) yr

1.0E-6 TR (target cancer risk) unitless

NOTES:

1. SF_s=soil ingestion slope factor (risk/pCi).
2. SF_i=inhalation slope factor (risk/pCi).
3. $SF_{ext\text{-}sv}$=external exposure slope factor (risk-g/pCi-yr).
4. $ED_{res} = t_{res}$
5. λ=decay constant
6. $0 \leq GSF_i \leq 1$
7. Q/C_{wind}=calculations based on site size and climactic zone. Further details on the derivation of Q/C_{wind} can be found in Appendix D
8. A, B, C = PEF region-specific dispersion constants (unitless)

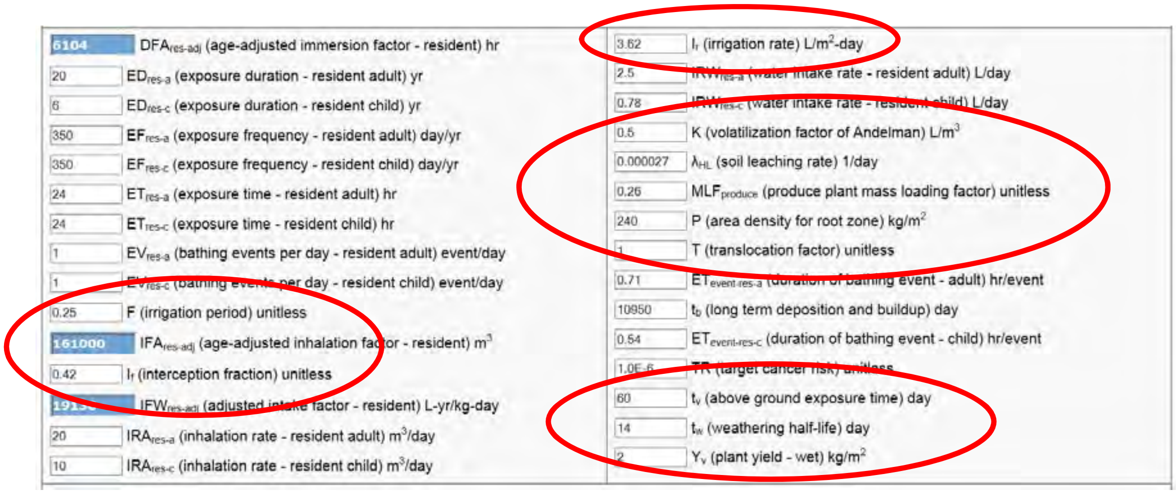


Produce

Produce Consumption - direct

0.25 $CF_{res\text{-}produce}$ (contaminated plant fraction) unitless
20 $ED_{res\text{-}a}$ (exposure duration - resident adult) yr
6 $ED_{res\text{-}c}$ (exposure duration - resident child) yr
350 $EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr
350 $EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr
1462510 $IFF_{res\text{-}adj}$ (age-adjusted fruit ingestion factor - resident) g
989870 $IFV_{res\text{-}adj}$ (age-adjusted vegetable ingestion factor - resident) g
188.5 $IRF_{res\text{-}a}$ (fruit consumption rate - resident adult) g/day
68.1 $IRF_{res\text{-}c}$ (fruit consumption rate - resident child) g/day
128.9 $IRV_{res\text{-}a}$ (vegetable consumption rate - resident adult) g/day
41.7 $IRV_{res\text{-}c}$ (vegetable consumption rate - resident child) g/day
1.0E-6 TR (target cancer risk) unitless

A screen shot for residential exposure to groundwater is provided below (with new input circled in red).



6104 $DFA_{res\text{-}adj}$ (age-adjusted immersion factor - resident) hr
20 $ED_{res\text{-}a}$ (exposure duration - resident adult) yr
6 $ED_{res\text{-}c}$ (exposure duration - resident child) yr
350 $EF_{res\text{-}a}$ (exposure frequency - resident adult) day/yr
350 $EF_{res\text{-}c}$ (exposure frequency - resident child) day/yr
24 $ET_{res\text{-}a}$ (exposure time - resident adult) hr
24 $ET_{res\text{-}c}$ (exposure time - resident child) hr
1 $EV_{res\text{-}a}$ (bathing events per day - resident adult) event/day
1 $EV_{res\text{-}c}$ (bathing events per day - resident child) event/day
0.25 F (irrigation period) unitless
161000 $IFA_{res\text{-}adj}$ (age-adjusted inhalation factor - resident) m^3
0.42 I_f (interception fraction) unitless
[illegible] $IFW_{res\text{-}adj}$ (adjusted intake factor - resident) L-yr/kg-day
20 $IRA_{res\text{-}a}$ (inhalation rate - resident adult) m^3/day
10 $IRA_{res\text{-}c}$ (inhalation rate - resident child) m^3/day
3.62 I_r (irrigation rate) L/m^2-day
2.5 $IRW_{res\text{-}a}$ (water intake rate - resident adult) L/day
0.78 $IRW_{res\text{-}c}$ (water intake rate - resident child) L/day
0.5 K (volatilization factor of Andelman) L/m^3
0.000027 λ_{HL} (soil leaching rate) 1/day
0.26 $MLF_{produce}$ (produce plant mass loading factor) unitless
240 P (area density for root zone) kg/m^2
1 T (translocation factor) unitless
0.71 $ET_{event\text{-}res\text{-}a}$ (duration of bathing event - adult) hr/event
10950 t_b (long term deposition and buildup) day
0.54 $ET_{event\text{-}res\text{-}c}$ (duration of bathing event - child) hr/event
1.0E-6 TR (target cancer risk) unitless
60 t_v (above ground exposure time) day
14 t_w (weathering half-life) day
2 Y_v (plant yield - wet) kg/m^2

10. Poll RAWG Members/Open Discussion

- Updating groundwater model: The groundwater modeling working group expects a new model by the end of September 2016. The new model includes the entire Paducah site.

- New definitions are being used for volatile organics in RAIS. This needs to be watched to see if there are any impacts (especially for PCBs and PAHs).

Risk Assessment Working Group
Meeting Minutes—September 7, 2016

✓Brian Begley
✓Nathan Garner
✓Jeri Higginbotham
✓Jerri Martin
✓Tim Frederick
✓Jon Richards
✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

2. Status of U.S. Environmental Protection Agency's (EPA's) acknowledgement of the 2016 Risk Methods Document (RMD)

DOE requested acknowledgment or concurrence. EPA requested a copy of last year's email/letter. (DOE sent last year's email and letter to EPA after the meeting. Subsequently, EPA sent an email concurring on the 2016 RMD.)

3. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

Quarterly Meeting (September)	9/7/2016

Quarterly meetings will be held via Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

The FY 2016 RAWG Work Plan is complete following today's meeting.

4. Status of EPA's Policy for Lead in Blood

Policy still is working through channels.

5. Status of CERCLA 120(h) Informational Briefing in Regards to Property Transfer Requests and Activities.

The CERCLA 120(h) Informational Briefing package has advanced through U.S. Department of Energy's (DOE's) reviews. Federal Facility Agreement (FFA) Managers are discussing location and date for briefing/workshop. The workshop currently is scheduled for September 19–20, 2016, in Frankfort or Lexington. Other meetings (including FFA Managers meeting) are being scheduled in conjunction.

6. Draft FY 2017 Schedule/Work Plan

Submit Work Plan (i.e., this schedule)	9/7/2016
RAWG concurs with Work Plan	10/17/2016
Suggested revisions/corrections to Human Health (HH) RMD text should be sent to LeAnne	11/2/2016
Submit HH Appendix A [i.e., Preliminary Remediation Goals (PRGs)] to RAWG for review	11/14/2016
Quarterly Meeting (December)	12/7/2016
Submit revised HH Main Text and HH Appendix B and D to RAWG for review	12/12/2016
Comments due for HH Appendix A	1/13/2017
RAWG concurs with HH Appendix A	2/13/2017
Comments due for HH Main Text and HH Appendix B and D	2/13/2017
Quarterly Meeting (March)	3/8/2017
RAWG concurs with HH Main Text and HH Appendix B and D	4/10/2017
Submit entire revised HH RMD to RAWG for review	4/17/2017
Comments due for entire revised HH RMD	5/15/2017
Quarterly Meeting (June)	6/7/2017

Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R8/V1)	6/20/2017
FFA Managers acknowledge receipt of HH RMD	7/17/2017
Quarterly Meeting (September)	9/13/2017

Quarterly meetings will be held via Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

DOE asked for RAWG members' comments and/or concurrence on this draft schedule/work plan by October 17, 2016.

7. **Risk Assessment Information System (RAIS) Radionuclide PRG Calculator**
The RAIS radionuclide PRG calculator (found at https://rais.ornl.gov/) has been revised to be more like EPA's calculator. There are some inputs that will need to be included for the 2017 revision; new default values will be sent with Appendix A (11/14/2016, as shown in the above Work Plan/Schedule for FY 2017) for review/comment by the RAWG.

8. **Current List of Main Text Revisions**
Any other revisions should be sent to LeAnne by 11/2/2016, as shown in the Work Plan/Schedule for FY 2017 presented above.

- Revise terminology for polycyclic aromatic hydrocarbons (PAHs) from "Total PAHs" to "Total Carcinogenic PAHs," based on Kentucky's comment to the Soils OU SWMU 229 Remedial Investigation (RI) Report Addendum.

- Executive Summary: DOE suggested adding explanatory text that radiological dose assessments are those associated with human health risk assessments. "Additional discussion should be held with regulatory agencies prior to initiating any radiological dose assessment project that is to be part of a risk assessment."

- DOE suggested considering adding radon-222 as a "Significant COPC at PGDP" (Table 2.1 in the RMD) because radon emission could be considered when developing cleanup goals or disposal limits for the On-site Waste Disposal Facility project. Radon-222 would need to be footnoted to explain that it is not included as a COC in previous baseline risk assessments at Paducah. Radon-222 would not be included with a PRG (Appendix A). Radium is similar to radon in that it previously was included as a Significant COPC, but no longer is listed. Radium-226 also will be included in Table 2.1 with a footnote (but PRGs will not be provided in Appendix A). Once the footnote is articulated, it will be sent to the RAWG for review and comment (in the revised RMD).

- Replace Figure 3.1, "Example Risk-Based Conceptual Model," with a more up-to-date example, if a better example is readily available. Check all example figures and exhibits to see if updates can be made.

- DOE suggested adding relevant DOE guidance (if any is appropriate) and Programmatic Quality Assurance Program Plan (P-QAPP) to list of Guidance Documents in the 2017 update of the RMD.

- DOE suggested adding an explanatory text box regarding the Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS). (Training for upgraded PEGASIS may be available by this fall.)

- Additional changes with input from the anticipated revised EPA guidance for lead are forthcoming.

- (Appendix D) DOE suggested revising table titles to remove scenario (e.g., Table D.13. Reasonable Maximum Exposure Assumptions for Consumption of Deer ~~by a Recreational User~~ and Table D.29. Reasonable Maximum Exposure Assumptions for Consumption of Home-Grown Vegetables ~~by a Rural Resident~~).

- (Appendix E) DOE suggested revising title to "Technical Information."

9. **Area Vegetation and Wildlife**
   Is any information available from any of the state or federal groups regarding western Kentucky vegetation and wildlife [e.g., *Amphibian Habitat Assessment at the Paducah Gaseous Diffusion Plant and the West Kentucky State Wildlife Management Area* (KRCEE 2016) at http://www.ukrcee.org/Challenges/Documents/Ecological/Wetland-Assessment-Final-Report-011516.pdf]? RAWG participants are encouraged to provide updated information to LeAnne.

10. **Watch Topics:**

    - New definitions are being used for volatile organics in RAIS. This needs to be watched to see if there are any impacts (especially for PCBs and PAHs).

    - **Derivation of Risk-based Surface Water Effluent Limits**
      Burial Grounds Operable Unit Solid Waste Management Units 2, 3, 7, and 30 Feasibility Study (FS) and Waste Disposal Alternative RI/FS are in formal dispute right now. Derivation of the surface water effluent limits is pending that outcome.
      Update: DOE currently is waiting for a path forward from management.

11. **Poll RAWG Members/Open Discussion**
    P-QAPP meeting is scheduled for October 26, 2016. However, EPA/Kentucky/DOE have tentatively scheduled an FFA/Paducah Site Strategy Meeting for the week of October 24, and the PQAPP meeting might be rescheduled.

Risk Assessment Working Group
Meeting Minutes—December 7, 2016

✓Gaye Brewer
✓Nathan Garner
✓Jeri Higginbotham
✓Chris Jung
✓Jerri Martin

✓Julie Corkran
✓Tim Frederick
✓Jon Richards

✓Rich Bonczek
✓Martin Clauberg
✓LeAnne Garner
✓Bobette Nourse
✓Joe Towarnicky

1. Call for Issues from Risk Assessment Working Group (RAWG) Members

2. CERCLA 120(h) Informational Briefing in Regard to Property Transfer Requests and Activities.

The CERCLA 120(h) Informational Briefing was held in September. Ohio has requested residential comparison at the Portsmouth site. Industrial comparisons were performed in Oak Ridge. Paducah will benefit from lessons learned at these sites.

3. FY 2017 Schedule/Work Plan

Accepted 10/31/2016 by the RAWG

Suggested revisions/corrections to Human Health (HH) Risk Methods Document (RMD) text should be sent to LeAnne	11/2/2016
Submit HH Appendix A [i.e., Preliminary Remediation Goals (PRGs)] to RAWG for review	11/14/2016
Quarterly Meeting (December)	12/7/2016
Submit revised HH Main Text and HH Appendix B and D to RAWG for review	12/12/2016
Comments due for HH Appendix A	1/13/2017
RAWG Concur with HH Appendix A	2/13/2017
Comments due for HH Main Text and HH Appendix B and D	2/13/2017
Quarterly Meeting (March)	3/1/2017
RAWG concur with HH Main Text and HH Appendix B and D	4/10/2017
Submit Entire Revised HH RMD to RAWG for Review	4/17/2017
Comments due for entire revised HH RMD	5/15/2017
Quarterly Meeting (June)	6/7/2017
Submit HH RMD to FFA Managers (DOE/LX/07-0107&D2/R8/V1)	6/20/2017
FFA Managers acknowledge receipt of HH RMD	7/17/2017
Quarterly Meeting (September)	9/13/2017

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

Color code for schedule:

Due date	Quarterly meeting
Submittal date	Concurrence/acknowledgement date

The March 2017 quarterly meeting was moved from 3/8/2017 to 3/1/2017.

4. Appendix A Submitted

A redline of the 2017 RMD Appendix A was sent to the RAWG on 11/14/2016. Comments are due 2/13/2017. Remedial Action Information System (RAIS) screens also were submitted for information so that inputs could be identified.

Dose PRGs included revision previously omitted as an oversight. These are noted with a comment in the redline version that is out for review.

It was decided to leave uranium isotope MCLs as they are currently in Table A.14 of the RMD. (Note: uranium isotope MCLs are for the respective isotope alone, not "+D" values as shown in the RAIS values provided as a comparison.)

5. Suggested Revisions to the 2017 RMD

Revisions discussed in September 2016 have been added to the redline documents that the RAWG will be receiving 12/12/2016.

The previous comment to add radon-222 to Table 2.1 "Significant Chemicals and Radionuclides of Potential Concern at PGDP," was revised. Radon-222 information will be added to Appendix E and not to Table 2.1. Adding Radon-222 to Appendix E is consistent with information regarding lead-210, which also is an ingrowth product. Radon-222 information derived for the CERCLA Cell project will be added to Appendix E when the information is final, until then, the RMD will include a placeholder.

In addition, adding mutagenic effects to equations in Appendix D was discussed. Mutagenic effects can vary. The current EPA guidance is to apply age dependent adjustments factors to toxicity values. The RMD will highlight that PRGs include mutagenic effects and that Appendix D equations do not include mutagenic effects. The RMD also will include information regarding the toxicity of the mutagens and recommendation that most recent guidance be researched prior to risk assessment of mutagenic chemicals. Text (including references to EPA Guidance) will be added to the redline RMD that is expected to be sent to the RAWG for comments next week.

6. Watch Topics:

- New definitions are being used for volatile organics in RAIS. This needs to be watched to see if there are any impacts [especially for polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs)].

- **Derivation of Risk-based Surface Water Effluent Limits**
  Burial Grounds Operable Unit Solid Waste Management Units 2, 3, 7, and 30 Feasibility Study (FS) and Waste Disposal Alternative RI/FS are in formal dispute right now. Derivation of the surface water effluent limits is pending that outcome.

- **Status of EPA's Policy for Lead in Blood**
  EPA's Policy for lead in blood is still in the works. Guidance with respect to soil sampling for lead (sieving) will be sent by Tim, so that the reference will be included in minutes.

7. Poll RAWG Members/Open Discussion

The following watch topics will be added to future meeting agenda:

- Reassessment of PAHs to change toxicity equivalence factor to relative potency factors.

- Status of groundwater modeling effort at Paducah: trying to get model update complete by summer.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 1 - 2016

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE
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OFFICE OF LAND
AND EMERGENCY
MANAGEMENT

MEMORANDUM **OLEM Directive 9200.1-128**

SUBJECT: Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion

FROM: for Dana Stalcup, Director Schatzi Fitz-James
Assessment and Remediation Division
Office of Superfund Remediation and Technology Innovation

TO: Superfund National Program Managers, Regions 1 - 10

The purpose of this memorandum is to transmit the Technical Review Workgroup for Metals and Asbestos (TRW) Technical document entitled "Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion." This document contains a review of the current data on the relationship between the particle size fractions sieved at lead-contaminated sites and the likelihood that they will adhere to hands and be incidentally ingested.

Based on their review, the TRW recommends moving from the current < 250 µm particle size to < 150 µm particle size. The recommendation is based upon an expanding body of evidence illustrating that dermally adhered soil is dominated by particle fractions < 150 µm. The weight of evidence is sufficiently strong to update the recommended sieving size while the impact on the Integrated Exposure Uptake Biokinetic Model (IEUBK) is assessed and the standard operation procedure for the *in vitro* bioavailability assay (IVBA) is updated. In the interim, the TRW Lead Committee recommends that the particle size fraction used for soil lead concentration in the fine fraction be the same as the particle size fraction used for the determination of site-specific bioavailability using the IVBA, and used for determining site-specific background.

This report and other efforts related to addressing lead in soil can be found on the Internet at https://www.epa.gov/superfund/lead-superfund-sites-technical-assistance. Please contact Michele Burgess at Burgess.Michele@epa.gov or (703) 603-9003 if you have questions or concerns.

Attachment

1. "Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion"

cc: Mathy Stanislaus, OLEM
Nitin Natarajan, OLEM
Barry Breen, OLEM
Reggie Cheatham, OLEM/OEM
Barnes Johnson, OLEM/ORCR
David Lloyd, OLEM/OBLR
Charlotte Bertrand, OLEM/FFRRO
Carolyn Hoskinson, OLEM/OUST
Cyndy Mackey, OECA/OSRE
Richard Albores, OECA/FFEO
John Michaud, OGC/SWERLO
OSRTI Managers
Regional Superfund Branch Chiefs, Regions 1 – 10
Kristin Giacalone, Superfund Lead Region Coordinator, Region 2
NARPM Co-Chairs
TRW Committee Members

RECOMMENDATIONS FOR SIEVING SOIL AND DUST SAMPLES AT LEAD SITES FOR ASSESSMENT OF INCIDENTAL INGESTION

OVERVIEW

The purpose of this document is to review the data currently available on the relationship between the particle sizes, dermal adherence and lead enrichment, as well as to revise the definitions of coarse and fine fractions for soil and dust for use in lead risk assessment. This document provides the technical basis for updating the recommended particle size fractions sieved at lead-contaminated sites. The intended audience for this document is human health risk assessors who are familiar with sieving soil and dust samples for use in risk assessments. For further background information on sampling procedures in lead risk assessment, refer to U.S. Environmental Protection Agency (2013, 2007a, 2003) or the Technical Review Workgroup for Lead (TRW) website (https://www.epa.gov/superfund/lead-superfund-sites).

Since 2000, the Office of Land and Emergency Management (OLEM) has recommended sieving dry (<10% moisture) soil and dust samples through a No. 4 (4.75 mm) or a No. 10 (2.0 mm) sieve (ASTM, 1999) to remove any large debris (*e.g.*, sticks, stones; U.S. EPA, 2000). The resulting material, referred to as the "total soil sample", is then weighed and sieved through a No. 60 sieve to produce the "coarse" (>250 μm) and the "fine" (<250 μm) fractions. This fine fraction is intended to represent a reasonable upper- bound estimate of the soil and dust fraction that is most likely to stick to hands (or other objects that a child may put it its mouth) and be subsequently ingested (U.S. EPA, 2007a, 2000). In addition, the concentration of lead in the <250 μm particle size fraction was used to calibrate the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK model; U.S. EPA, 2000, 1994), and in the development of the *in vivo* and *in vitro* bioavailability assays for lead in soil (Smith et al., 2011; U.S. EPA, 2009, 2007b; Casteel et al., 1997; Maddaloni et al., 1998; Ruby et al., 1996).[1]

U.S. EPA performed a literature search for relevant data on the relationship between particle size and dermal adherence, and between particle size and lead enrichment (January 2000-December 2011). Based on more recent information, the TRW now recommends that dry total samples (as defined above) be weighed and sieved using a No. 100 W.S. Tyler® sieve[2], or equivalent, to identify the "coarse" (>150 μm) and the "fine" (<150 μm) fractions for use in the assessment of human health risks for soil and dust exposures (see Appendix A for further sampling information). This recommendation is based on a growing body of evidence showing that dermally-adhered soil and dust, representative of soil and dust exposure to young children via incidental ingestion, is dominated by particles <150 μm (see Tables 1 and 3, Figure 1). In addition, the more recent information also indicates the potential for enrichment of lead in

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[1] The <250 μm particle size fraction was used for the development of the default lead bioavailability value and recommended for use in laboratory analyses to develop site-specific lead bioavailability values.

[2] Mention of specific products or manufacturers should not be interpreted as an endorsement.

smaller sized particles at some sites (see Tables 2 and 4). The TRW recognizes, however, that this recommendation to sieve to 150 μm to obtain the fine fraction may be fractionated further (*e.g.*, 125, 50, 10 μm) or larger particle size fractions considered as site-specific history or circumstances warrant.[3]

INTRODUCTION

Incidental ingestion is the primary pathway for childhood exposure to lead in soil and dust (with the exception of pica behavior) and is governed by dermal adherence (Ruby and Lowney, 2012; Lanphear et al. 2002; Lanphear et al. 1998; Succop et al. 1998; Landrigan et al. 1975).[4] Blood lead (PbB) levels associated with incidental ingestion are related to the concentration of lead in soils in the vicinity of and dust on surfaces of a child's home, as well as lead adhered to hands of infants and the hands of their parents (Ruby and Lowney, 2012; Simon et al., 2007; Laidlaw et al., 2005; NRC, 2005; Mielke and Reagan, 1998; Succop et al. 1998; Lanphear and Roghmann, 1997; Landrigan et al. 1975). Links between lead in environmental media and blood samples have also been corroborated with statistical models predictive of PbB and isotopic studies which "follow the lead" from yards and house dust to the hands and blood of children (Gulson et al., 2009; Manton et al., 2000; Angle et al., 1995). Lead-contaminated house dust typically includes a soil component, and is a strong predictor of PbB levels in children (NRC, 2005; Lanphear et al., 2002, 1998).

Site-specific risk assessment requires that soil and dust samples accurately represent incidentally ingested material. Soil particle size, an important determinant of dermal adherence, is inversely associated with contaminant concentration, mobility, and bioavailability (Beamer et al., 2012; Madrid et al., 2008; ATSDR, 2007; Madrid et al., 2002; Lanphear et al., 2002; Manton et al., 2000; Lanphear et al., 1998; Sterling et al., 1998). As such, reliable data on the particle size fraction that is most likely to adhere to children's hands and on the lead concentration found in that particle size can improve the accuracy of exposure and risk calculations in lead risk assessments. The TRW Lead Committee previously determined that the lead concentration in the <250 μm particle size fraction is more representative of ingestion exposure than unsieved soil (U.S. EPA, 2000). While this remains true, more recent studies identified by the TRW Lead Committee were reviewed and the findings support using the <150 μm particle size fraction, as it is more representative of exposure to lead via incidental ingestion of soil and dust.

Dermal Adherence is Dominated by Fine Particles

The TRW identified ten studies reporting dermal adherence of soil and dust as a function of particle size fractions (*e.g.*, <150, <125, <40 μm) from a variety of sample types (*e.g.*, shooting ranges, mining sites, urban environments). See Tables 1 and 3; also Figure 1. These studies

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[3] Representative site-specific data are essential for developing a risk assessment (as well as cleanup goals) that reflect the current or potential future conditions. Ultimately, lead exposure is determined by the ingested dose (μg Pb/kg-body mass/day). For this report, the mass of ingested lead (μg/Pb) is intended to equal to the concentration of lead in the contaminated media multiplied by the mass of this media that is ingested.

[4] It is known that some individuals deliberately ingest soil (pica) and that these individuals may have soil ingestion rates well in excess of the typical ingestion levels used in most U.S. EPA risk assessments. Pica exposure is generally not assessed in Superfund lead risk assessments.

indicated that dry (<10% moisture) soil and dust particles in the <150 μm fraction were more likely to adhere to hands than larger fractions (Gong et a., 2013; Bergstrom et al., 2011; Juhasz et al., 2011; Siciliano et al., 2009; Choate et al., 2006a; Yamamoto et al., 2006; U.S. EPA, 2000, 1995; Sheppard and Evenden, 1994; Duggan et al., 1985; Que Hee et al., 1985; Duggan, 1983). In general, adherence generally increases with decreasing particle size (Choate et al., 2006a; Driver et al., 1989). As shown in Figure 1, approximately 90% of the cumulative mass of soil adhered to children's hands falls within the <150 μm fine fraction. Smaller particles are more mobile than larger fractions and are more likely to accumulate in the indoor environment, as a result of deposition of wind-blown soil or track-in transport of soil on clothes, shoes, pets, toys, and other objects, providing additional opportunity for exposure to this particle size fraction (Luo et al., 2011; Schmidt, 2010; Layton and Beamer, 2009; Laidlaw and Filippelli, 2008; Qian et al., 2008; Bright et al., 2006; Laidlaw et al., 2005; Gulson et al., 1995). See Tables 1 and 3.

Contaminant Concentration Typically Increases as Particle Size Decreases

The TRW identified 19 studies concerning lead concentrations in soil and dust for different particle size fractions (see Tables 2 and 4). Together these studies indicated that enrichment in concentration for smaller particle size fractions is dependent upon site-specific characteristics, and enrichment in smaller particle sizes may not occur at all sites. However, particle size distribution of metals in shooting ranges, incinerators, mine tailings and associated background soil samples from three mining sites, as well as urban soils and dusts demonstrated consistent enrichment in particle size fractions smaller than <150 μm (Kim et al., 2011; Luo et al., 2011; Juhasz et al., 2011; Madrid et al., 2008; Pye et al., 2007; Ljung et al., 2007, 2006; Weiss et al., 2006; Momani, 2006; Tawinteung et al., 2005).

RECOMMENDATIONS FOR SIEVING AT LEAD CONTAMINATED SITES

Based on this analysis, the TRW generally recommends that "total" samples (as defined as the total of dust and soil on page 1) be weighed and sieved through a No. 100 W.S. Tyler® sieve[5] or equivalent to identify the "coarse" (>150 μm) and the "fine" (<150 μm) fractions for use in the assessment of human health risks for soil and dust exposures to lead (see Appendix A for further sampling information). The fine fraction (<150 μm) has increased potential for incidental ingestion based on stronger relative dermal adherence, an increased likelihood to accumulate in the indoor environment (through deposition of wind-blown soil and/or transport track-in of soil on clothes, shoes, pets, toys, and other objects), and the likelihood of enrichment of lead in smaller particle size.

On a site-specific basis, it may be appropriate for risk management decisions to consider the benefits of obtaining information on the other particle size fractions (*e.g., <250,* <125, <63, <50 μm) to better relate ingestible size fractions with site history or site-specific conditions.[6] For example, it may be appropriate to consider larger particle size fractions at some sites such

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[5] See ASTM E11 and ISO 565 for more information.

[6] Representative site-specific data are essential for developing a risk assessment (as well as cleanup goals) that reflect the current or potential future conditions. Ultimately, lead exposure is determined by the ingested dose (μg Pb/kg-body mass/day). For this report, the mass of ingested lead (μg/Pb) is intended to equal to the concentration of lead in the contaminated media multiplied by the mass of this media that is ingested.

as firing ranges (where lead bullet fragments may exist) or sites where wet soil contact may be expected (larger particles can adhere to hands when wet). Soil and house dust samples in the <175 μm fraction collected from the Bunker Hill Superfund Site in Kellogg, ID have been used in the IEUBK model (after an initial calibration) to accurately and consistently predict PbB levels in the community for more than 15 years (von Lindern et al., 2003; PHD, 1986; Snee, 1982; Yankel et al., 1977). Alternatively, smaller particle size fractions may also be informative for certain sites. At this time, the TRW Lead Committee does not have specific recommendations for alternative particle size intervals for soil and dust. Users may contact the TRW Lead Committee to discuss site-specific conditions that may warrant consideration of alternative particle size fractions[7].

This recommendation is consistent with U.S. EPA recommendations for particulate sampling under RCRA (U.S. EPA, 2002). In addition, particulate sampling theory recognizes that sampling errors are reduced when smaller particles are sampled (Barcan et al., 1998; Gy, 1998, 1992, 1982). To promote defensible and reproducible site investigations and decision making, while maintaining flexibility needed to respond to different site conditions, EPA recommends the Data Quality Objectives process (U.S. EPA, 2006). Data Quality Objectives provide a structured approach to collecting environmental data that will be sufficient to support decision-making: http://www.epa.gov/QUALITY/dqos.html.

Currently, these recommendations specifically apply to lead risk assessment, but the importance of particle size as it relates to dermal adherence, consequent ingestion, and variance in contaminant levels may also apply to other metals, polyaromatic hydrocarbons, or other contaminants in soil and dust (Ruby and Lowney, 2012; Beamer et al., 2012; Bergstrom et al., 2011; Siciliano et al., 2009; Yamamoto et al., 2006).

The TRW Lead Committee recognizes that the recommendation to sieve soil samples to a particle size fraction representing <150 μm differs from previous recommendations and also differs from the particle size used for validation of the IEUBK model and the *in vitro* bioaccessibility assay for lead (IVBA) (U.S. EPA, 2009, 2007b). However, the weight of evidence is sufficiently strong to update the recommended sieving size while the impact on the IEUBK model is assessed and Standard Operating Procedure for the IVBA is updated. In the interim, the TRW Lead Committee recommends that the particle size fraction used for soil lead concentration in the fine fraction be the same as the particle size fraction used for the determination of site-specific bioavailability using the IVBA and use for determining site-specific background.

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[7] https://www.epa.gov/superfund/lead-superfund-sites-guidance

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Table 1. Summary of soil adherence studies.*

Study	Year	Data Reporting Method	Study Type and Conditions	Particle Size Cutoff Accounting for 50% of Adhering Mass	Particle Size Cutoff Accounting for 90% of Adhering Mass
Bergstrom et al.	2011	Estimated mass adhering for each size fraction	Laboratory	NR	NR
Siciliano et al.	2009	Mass of soil adhering for each size fraction	Field Laboratory: agricultural soils Laboratory: Brownfield soil	40 μm 40 μm 125 μm	130 μm 370 μm 760 μm
Choate et al.	2006	Mass of soil adhering for each size fraction	Laboratory: low moisture soil Laboratory: medium moisture soil Laboratory: high moisture soil	33 μm 44 μm 80 μm	110 μm 120 μm 220 μm
Yamamoto et al.	2006	Mass of soil adhering for each size bin	Field	67 μm[d]	134 μm[d]
Kissel et al.	1996	Mass of soil adhering for each size fraction	Laboratory: dry soil Laboratory: wet soil	62 μm 150 μm	210 μm 350 μm
Sheppard and Evenden	1994	Enrichment ratios of the mass of specific size fractions adhering	Laboratory	NR	NR
Driver et al.	1989	Mass of soil adhering for each size fraction	Laboratory	NR[c]	NR
Duggan and Inskip	1985	Mass of soil adhering for each size fraction	Laboratory	57 μm	130 μm
Duggan et al.	1985	Number of particles adhering in each size range	Field	NM[a]	NM
Que Hee et al.	1985	Mass of house dust adhering for each size fraction	Laboratory	NA[b]	NA

[a] NM = No mass-based estimate of soil adherence. 90% of particles were <10 μm.

[b] NA = Not applicable (study used house dust not soil).

[c] NR = Not reported or not calculable from data presented.

[d] Average value for the population of children (three of nine) with the largest soil particles adhering.

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Table 2. Summary of soil enrichment studies.

Study	Year	Sample Type	Particle Size Cutoff for Pb Enrichment	Comment
Gong et al.	2013	Arable soils	<53 μm	The distribution of most heavy metals in different size particles was increased with decreasing particle size. The mass loading of heavy metals in micro-aggregates was high while their leachability was very low.
Beamer et al.	2012	Residential	<63 μm	Outdoor soil had an increased Pb concentration at <63 μm.
Juhasz et al.	2011	Shooting range	<50 μm	<50 μm fraction, the average concentration of lead was approximately twice the average concentration of lead in the <2 mm fraction but varied between 0.86 - 5.31. Lead enrichment in the <50 μm particle size fraction was up to 5 times the concentration observed in the bulk soil.
Kim et al.	2011	Mining site	<125 μm	Increased Pb concentration with decreased particle size.
Lou et al.	2011	Urban	<10 μm	2-10 μm had increased metal concentrations; 50-280 μm was less marked.
Smith et al.	2011	Shooting range, incinerator, fill, mining, gas work	<250 μm	Pb concentration in the <250 μm fraction was greater than the <2mm fraction.
Acosta et al.	2009	Urban soils	<75 μm	Pb concentration in the <75 μm fraction was consistently higher in two of four parks sampled. This was attributed to vehicular depositions.
Siciliano et al.	2009	Agricultural, Brownfield	<45 μm	Increasing metal concentrations with decreasing particle size fractions.
Ajmone-Marsan et al.	2008	Urban	<10 μm	≥50% of the total Pb accumulated in the <10 μm fraction.
Madrid et al.	2008	Urban	<50 μm	Particle sizes <50μm had generally higher lead concentrations than >50 μm
Ljung et al.	2007	Urban	<50 μm	Lead concentrations were consistently higher in <50 μm fraction
Pye et al.	2007	Near River	<150 μm	Mean and maximum Pb concentrations increased with decreasing particle size fraction
Ljung et al.	2006	Urban	<50 μm	Demonstrated average 1.5 times enrichment for metals in finest fraction (<50 μm) compared with either the bulk sample or the 50-100 μm fraction.
Momani	2006	Urban	<63 μm	The greatest Pb concentrations were in the <63 μm fraction.
Weiss et al.	2006	Urban	<63 μm	84% of the particles were in the range of 125–500 μm. The highest concentration of lead was in the smallest fraction analyzed (<63 μm).
Tawinteung et al.	2005	Battery recycling plant, lead smelting factory	<150 μm	Pb concentration was ~2 times higher in the <150 μm than in the 250μm-2mm fraction.
Young et al.	2002	Industrial facilities, roadways	<38 μm	Pb in PM_{10} was enriched by 1.10 to 8.31times compared with bulk soil samples. Pb in fine soil (<38 μm) was enriched by 1.12 to 7.83 times compared with coarse soil samples (300-2000 μm).
Al-Raijhi et al.	1996	Urban	<20 μm	Pb in the 20 μm size fraction was enriched 1.5- to 3.0 times compared with the 250 μm size, and 2.5- to 6.4 times compared with the 1500 μm size fraction.

Gulson et al.	1995	Mining, residential	<150 µm (soil) <100 µm (dust)	Finer fractions contain 2-9 times higher concentration than bulk fractions.
Kitsa et al.	1992	Chromium Contaminated Site	<38 µm	Increased Pb concentrations with decreased particle size.

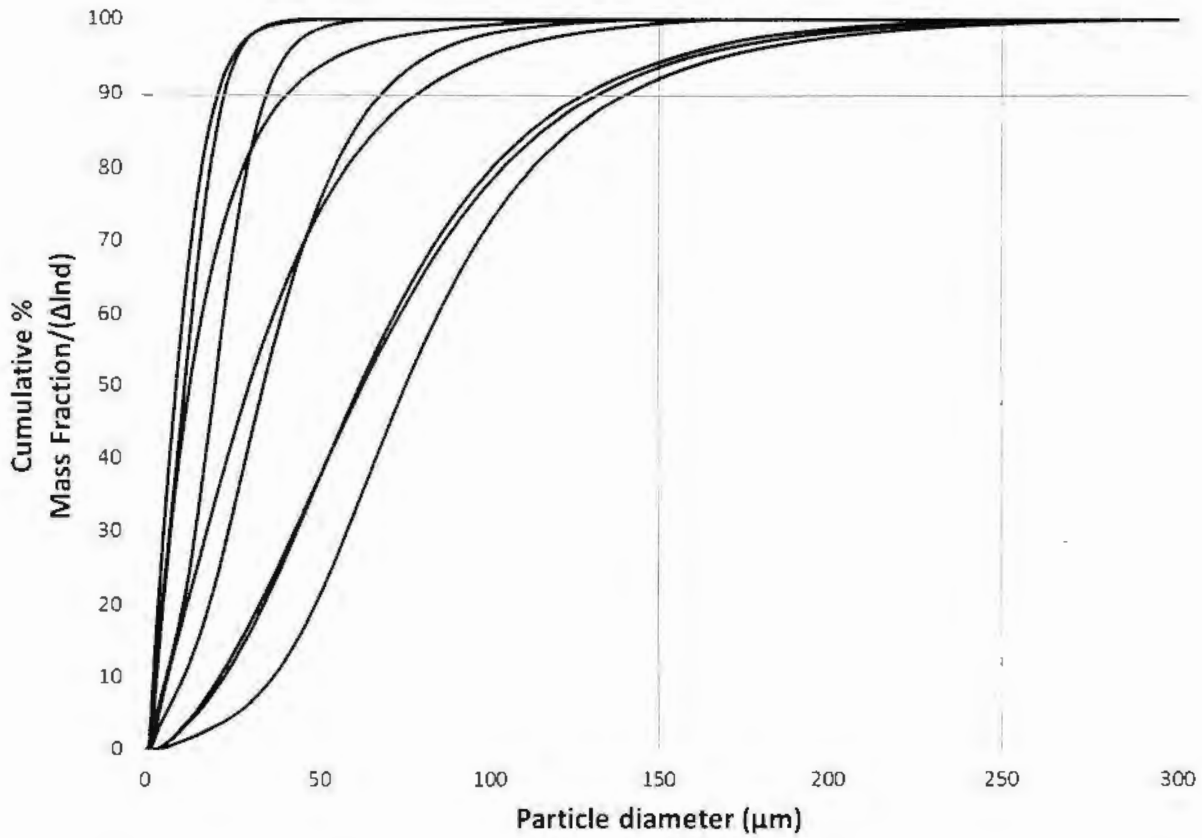

Figure 1. Mass fraction of soil adhering to children's hands as a function of particle size (data from Yamamoto et al., 2006). The curves represent the cumulative mass fraction adhering as a function of particle size for 9 individual children. The published figure was provided courtesy of Michael V. Ruby and adapted above with permission from Ruby and Lowney (2012). Copyright 2012 American Chemical Society.

Table 3. Summary of available particle adherence studies.

Site-Specific Information	Subjects	Sampling Procedure	Particle Size Tested (µm) Moisture Content (% Moisture)	Comments	Reference
Mining and smelting sites, quarry – river banks and slag (Coeur d' Alene River Basin, ID)	Adult volunteers (3M, 3F)	Hand washing method with soil Dry and wet conditions	<63 63-150 150-250 250-2000 Wet: 3.5-14.7%; Dry: <0.25%	Wet media always adhered to a greater extent than dry media. Adhered media generally had higher elemental concentrations than bulk media. Over 60% of the adhered fraction was <63 µm; this is particularly interesting for the Black Sand Beach (BSB) because the data show approximately 97% of the BSB material is in the 250 µm - 2mm fraction. While most metals concentrations increased with decreasing particle size, this paper includes some data that show the highest concentration in the bulk soil (e.g., slag material), and others that show little trend with particle size. Regression analyses suggest smaller particle fractions may have higher elemental concentrations. Results of application of a maximum likelihood estimation technique generally indicate that handling of dry media leads to preferential adherence of smaller particle sizes, while handling of wet media does not. Because adhered material can differ greatly in particle size distribution from that found in bulk material, use of bulk concentrations in exposure calculations may lead to poor estimation of actual exposures.	Bergstrom et al., 2011
Clay loam (CSU, Colorado); Silty clay loam (ISU, Iowa)	Adult volunteers (n=108)	Unwashed hands; hand press technique – soil removed with distilled water or adhesive tape Also evaluated washing hands prior to exposure	<25 25-38 38-63 63-125 125-250 250-500 500-2000 Wet: 3.35-10.1% Dry: <2%	This study measured the effect of soil moisture, particle size distribution (PSD) of soil and organic carbon content on the particle sizes that adhere to human skin. Adhered fraction consisted primarily: • <63 µm for dry and 'moderately moist' soils (<3.81 %) • <250 µm for wet soils (>3.81%) No estimates of potential ingestion were made in this analysis. Also investigated the effect of commonly used method of removing the adhered soil mass (by washing with water) on the disaggregation of soil particles (which would bias the measurement of adhered particle size towards the smaller particle sizes). The authors are interested in dermal exposure rather than incidental ingestion; therefore, they are interested in studying how long soil sticks to skin because that dictates how much of the contaminant transfers into the skin (they cite EPA 2001).	Choate et al., 2006a
				This paper does not include data on adherence or data on the concentration as a function of soil/sediment particle size; however, the paper assesses the potential bias introduced when water is used to remove the adhered material from the skin (water tends to disaggregate some soil particles). The authors developed an algorithm for estimating the PSD of a (dry) from the results of wet-sieving the soil. Two soil types were included: clay loam and silty loam. The data indicate disaggregation was not significant for the silt loam for the particles sizes less than 500 µm but it was significant for the clay loam. This paper is useful for the discussion of methodology issues & limitations.	Choate et al., 2006b
Five soil types (Virginia, US) (11 soils samples)	Adult Males	Hand press; pre-post contact weights were measured Dry-sieved	≤150 ≤250 Unsieved soil moisture content not measured;	Summarized in EPA 1995: Researchers examined soil adherence to skin by particle size. Increasing mass and size of the larger particles may reduce the total soil mass that adheres. <150 increased adherence more than <250 µm: An average of 0.6, 0.9, and 1.4 mg of soil for the unseived fractions, <250, and <150, respectively, adhered to each square centimeter of skin on hands (mg/cm^2). Results showed that an obvious conclusion from the data is that finer soil particles adhere more readily to hands than do coarser particles. The most important factor to determine soil adherence (based on particle size, soil type, and organic content) was particle size, followed by soil type. Used to support 250 µm recommendation in 2000 TRW Soil Sampling Guidance.	Driver et al., 1989

Site-Specific Information	Subjects	Sampling Procedure	Particle Size Tested (µm) Moisture Content (% Moisture)	Comments	Reference
Street dust collected from gutters or pavement of main and side roads (London, England)	NR	"taking a pinch of dust" between the thumb and forefinger and rubbing the digits together such that the surplus falls off; weight difference used to estimate adherence	<500	Authors reported that "a number of tests with several different people" gave a range of 2 to 7 mg or a mean of about 4 mg dust retained per finger and thumb, or 2 mg per digit. No other particle sizes were tested.	Duggan & Williams, 1977
Review of the literature	NA	NA	NA	Retrospective analysis using NHANES and UK PbB data, plus extensive literature review. In attempt to explain observed discrepancy in child vs. adult exposure, propose that dust lead levels correlate with PbB levels. Used to support 250 µm recommendation in 2000 TRW Soil Sampling Guidance.	Duggan, 1983
Schoolyard dusts (London, UK)	Children (n=368; 5-6 yrs old)	Hand wipe, hand wash "dry conditions"	<180 <500 (bulk – dried and ground until it was sieved to 180 µm)	90-98% of particles were less than 10 µm; largest particles were 100-180 µm (as cited by US EPA, 1995) Used to support 250 µm recommendation in 2000 TRW Soil Sampling Guidance.	Duggan et al., 1985
Activity-based soil samples (soccer/rugby field, farmers, groundskeepers, kids in mud, tae kwon do, greenhouse)	Adults, Children (n=101: 92 subjects outdoor; 9 subjects indoor)	Skin surface wash (legs, hands, forearms, faces, feet)	Varied wet and dry conditions	Soil loading study that did not differentiate between specific particle sizes, but are activity dependent.	Kissel et al., 1996a
Five soil samples (Washington State, US) (sand, loamy sand, sandy loam, silt loam)	1 adult female	Hand press; measured dermal soil loading and adherence Clay and organic carbon contents were determined	≤150 150-250 ≥250 Wet: (12-18%) Dry: (<2%)	Discusses that for wet samples, >150 µm may be appropriate, but for dry samples, "mass adherence is predominantly attributable to sub-150 µm, and perhaps even sub-65 µm particles." Under dry conditions adherence varied inversely with grain size <150, 150-250, >250 µm fractions. In general much greater soil loading with wet samples, in some cases finest fraction had less adherence when wet.	Kissel et al., 1996b

Site-Specific Information	Subjects	Sampling Procedure	Particle Size Tested (µm) Moisture Content (% Moisture)	Comments	Reference
Soils (Cincinnati, OH) Dust (residential)	Adults (n=10); Children (n=6; 3-10 yrs old)	Hand wipes Dry sieved and ground until it passed through a 149 µm sieve	<149 Subset of house dust (1 house) <44 44-149 149-177 177-246 246-392 392-833	Found no relationship between particle size and skin adherence of dry house dust in very limited measurements following artificial loading. Assumptions were made – soil is composed of particles of the indicated diameters, all soil types and particle sizes adhere to the skin, and an equivalent weight of particles of any diameter adhere to the same surface area of skin. Adherence of house dust particles to hands, for fractions less than 246 µm, no particle size difference in dermal adhesion. Concluded that loose dust particles less than 246 µm, sieved from dust collected in their study houses, would be more likely to adhere to a child 's hands than would larger particles and, therefore, would be more likely to be ingested by the child The particle size-specific adherence results were produced using a single "small adult."	Que Hee et al., 1985
Garden soils (Ontario, Manitoba Canada enriched with Pb)	1 subject	Hand press/ soil crumbling/ hand wash Dry sieved	<50 <41 <114 114-500 Dry	The largest enrichment of the investigated contaminants was associated with sandy soils, where the bulk of the adsorbed contaminants were found on the finer particles that adhere readily to skin but make up only a small fraction of the total soil mass. Lower soil loads on the skin showed greater enrichment, with a marked increase at soil loads below levels that would call for obvious washing of the hands. Clay particles (<2 µm) fit in size with the roughness characteristics of the skin, implying that the finest particle sizes may be resistant to the washing of hands, but soil particles <50 µm in diameter tended to preferentially adhere to dry skin, regardless of soil type. Adsorbed soil constituents (Pb, Hg, I, U and C6Cl6) were also found to be largely associated with fine adhering soil particles, because of the relatively large surface area per unit mass of these particles. Up to ten-times contaminant enrichment was found when the original soil was compared with the adhering soil. Soil particles >50 µm were excluded when the soil was dry, implying that the particle size fraction of 0–50 µm is most likely to be ingested involuntarily by children (particles <50-100 µm did not adhere well). Used to support 250 µm recommendation in 2000 TRW Soil Sampling Guidance.	Sheppard & Evenden, 1994
Agricultural and Brownfield soils (Saskatchewan and Nunavut, Canada, respectively)	25 adults (14M; 11F)	Soil crumbling/ hand wash Dry sieved	0.01 <4000 (bulk sample)	Measured dermal adhesion of Canadian soils, found increased adherence with decreasing size, reported metal particle size enrichment, especially for arsenic (420%). Particle size was measured with laser particle size analyzer. The silt fraction (2-50 µm) is the dominant adhered size. The average particle size of adhered soil varied from 34-105 µm, depending on the soil type. The authors define bulk sediment as <4 mm rather than <2 mm early in the paper; however, 4 mm is only mentioned again in the paper in the caption of Figure 3. The Methods section states the bulk soils were sieved through a 2 mm sieve for measurement of TOC, total metals and presumably, for the adherence experiments. The authors define (concentration) enrichment as (adhered-bulk)/bulk, rather than concentration in adhered fraction / concentration in the bulk soil. Authors recommend that soil samples should be sieved through a	Siciliano et al., 2009

Site-Specific Information	Subjects	Sampling Procedure	Particle Size Tested (μm) Moisture Content (% Moisture)	Comments	Reference
				45 μm sieve before estimating risk associated with contaminated soils. Statements about TOC should be carefully reviewed.	
Schoolyard soils (Japan)	Children (n=10; Nursery school ages)	Hand wash analyzed with laser scattering particle size analyzer dry sieved	<10 10-100 100-500 500-1000 2000	Found particle size distributions (PSDs) of adhered soils were shifted to the finer fractions, relative to the soil PSDs of the bulk soil; found particles adhered to children's hands are mostly less than 100 μm, while the largest particles were in the 200-300 μm range. Total mass of adhered soil varied greatly between children: mean, median, max = 26.2, 15.2, and 162.5 mg/hand. The average modal diameter was 39 μm +/- 26 μm.	Yamamoto et al., 2006

Table 4. Summary of available of particle enrichment studies.

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
Tawinteung et al. 2005 (Thailand soils, industrial sources – lead recycling/ smelting) Weiss et al. 2006 (US roadside) Yarlagadda et al. 1995 (manufacturing facility in NYC) Momani 2006 (roadside soils in Jordan)	NA	<63 µm 850-2000 µm	With particle sizes decreases, lead concentration increased	Review and reanalysis of 4 published studies of lead concentrations and soil particle size, suggests a consistent mathematical relationship between particle diameter and lead concentration enrichment.	Abouelnasr, 2009
Soil samples including: igneous, metamorphic and sedimentary rocks (Murica, Spain)	Air dried, sieved; total elemental composition was determined using ICPAES; mineral and chemical composition was determined by XRD and SEM	< 2mm Three fractions: "clay, silt, sand"	Results showed that Pb, Cd, Cu and Zn are associated with Al and/or Fe-containing minerals such as micas, pyroxenes, and amphiboles and exhibit preferential partitioning into fine particle size fractions in the soils studied.	The study evaluated the contribution of parent geological materials (PGM) to the geochemical composition of the soil, and attempted to establish the distribution and enrichment of major and trace elements (including Pb) in sand, silt and clay particle size fractions. Specific nominal particle sizes were not provided.	Acosta et al., 2011

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
Urban soils taken form parks (Murcia, Spain)	Surface soils (0-5 cm); bulk samples were air-dried and sieved	850 425 180 150 106 75	Mean Pb content (19 mg Pb/kg) for all bulk samples was 3 times higher than background samples; however, enrichment was not observed with smaller particle size fractions. Consistently high enrichment factors for Pb in the 0–75 µm in two parks were attributed to vehicular depositions.	Metal contents in bulk soil samples are commonly used to assess contamination but metal accumulations in soils are known to increase with decreasing particle size. We investigated the distribution of metals in various particle size fractions, particle morphology and metal enrichment factors to characterize the properties of soils in four urban parks in Murcia City (SE, Spain) Soil samples were fractionated and concentrations of Al, Si, Ti, Na, Mg, Ca, P, K, Fe, Cu, Cr, Zn, Pb, Co, Mn and Ni were determined in nine particle size fractions. The contents of metals in playgrounds were below some European cities and low enrichment factors (EF) indicate limited anthropogenic metal depositions. However, The presence of high amounts (60- 80 %) of calcite and dolomite in fine fractions might have contributed to metal accumulation through the formation of metal carbonate complexes. Goethite, especially in PM10 and PM2.5 can also serve as sink for metals. The study authors suggested that risk assessment of urban soils in Murcia City (and elsewhere) should be based on (fine) particle size because of the tendency of metal to accumulate in fine particles. In addition, the mineral composition of fine particles should also be considered in risk assessment.	Acosta et al., 2009
Urban soils (Aveiro, Glasgow, Ljubljana, Sevilla and Torino)	Whole Soil	<2 2-10 10-22 22-50 50-2000	Found consistent enrichment in smaller particle size fraction – more than 50% of the total Cu, Pb and Zn accumulate in the <10 µm fraction. Accumulation in the finer fractions is higher where the overall contamination is lower.	Soils in Torino and Sevilla had increased Pb levels in the 50-2000 µm fractions. Discussed industrialization parameters of the soil sources and speculated that anthropogenic sources of lead contribute to particle size partitioning as demonstrated in soils from the most urban settings.	Ajmone-Marsan et al., 2008
Atmospherically-deposited dust from wide-ranging environments (Riyadh, Saudi Arabia)	Samples collected by ground sweeping, dried overnight and then sieved	20 60 110 170 250 400 750 1500	Metal concentrations increased with decreasing particle size. Using concentration expressed as µg/g of each particle size, Pb in the 20 µm size fraction was enriched 1.5- to 3.0-times compared with the 250 µm size, and 2.5- to 6.4-times compared with the 1500 µm size fraction.	This study evaluated alternative methods for expressing the concentration of metals in particle sizes, using two sets of samples (labeled Group I [n=110] and Group II [n=121]) that were expected to be highly correlated because they were collected, tested, and analyzed under identical conditions. Using the alternative methods for expressing concentration and comparing the particle size concentrations in the two sets of samples, the authors concluded that 1) average concentration of metal in 1 g of a certain particle size gave better correlation than average concentration of metal of a certain size in 1 g bulk soil; and 2) to find correlation between groups fractionated by size, it is important to use the average of particle ratios (calculated as the ratio of the metal concentration per gram of particle of a certain size to the sum of that metal concentration across all particle sizes).	Al-Rajhi et al., 1996a

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
Outdoor dust samples from pavements or similar surfaces in 231 areas including urban, suburban, rural, motorway, and two industrial sites; indoor dust from 20 public community centers (Riyadh, Saudi Arabia)	Oven dried	Indoor and outdoor: 20-40 40-80 80-140 Outdoor only: 140-200 200-300 300-500 500-1000 1000-2000	Indoor dust did not show clear pattern of enrichment of Pb concentration at smaller particle sizes. Outdour dust showed decrease in concentration with increasing particle size up to 400 mm; no further decreases were seen at larger sizes.	No additional details on particle size enrichment were provided.	Al-Rajhi et al., 1996b
Residential yard soil samples near an abandoned mine were paired with indoor dust samples; 10 households (Tucson, AZ, US)	Composite yard samples (surface soil); settled floor dust was vacuumed until achieving 2 g; Oven dried	<63 63-150	Indoor dust was did not show a clear enrichment of Pb concentration at <63 µm; however, house dust had a much greater GSD. Authors speculated that this is due to house-to-house characteristics. Outdoor soil had an increased Pb concentration at <63 µm.	All samples were sieved and analyzed for 30 elements via ICP-MS following nitric acid digestion. In house dust, significant differences in concentration were observed for Be, Al, and Mo between particles sizes, with a higher concentration observed in the smaller particle sizes. Approximately 42 and 66% (geometric mean) of soil and house dust mass, respectively, were smaller than 63 µm. Significant differences were also determined for Mg, Ca, Cr, Co, Cu, Ge, Zr, Ag, Ba, concentration in yard soil samples, with the higher concentration observed in the smaller particles size for each element. Authors mention that a questionnaire was administered for each house, but the results were not reported.	Beamer et al., 2012
Street dust collected from pavement, gutter, and road across a roadway	No information in secondary source.	<38 63-125 500-1000	Pb concentration in smallest size fraction (<38 µm) was 1.4- to 4.8 times higher than corresponding 63-125 µm size fraction (in pavement and gutter samples only; in road sample, enrichment was 0.5) and 6.0- to 13.3 times higher than concentration in corresponding 500-1000 µm size fraction.	As cited in literature review (Fergusson and Kim 1991)	Beckwith et al., 1985
Mining and smelting sites, quarry – river banks and slag (Coeur d' Alene River Basin, ID)	Adult volunteers (3M, 3F)	Hand washing method with soil Dry and wet conditions	<63 63-150 150-250 250-2000 Wet: 3.5-14.7%; Dry: <0.25%	Wet media always adhered to a greater extent than dry media. Adhered media generally had higher elemental concentrations than bulk media. Over 60% of the adhered fraction was <63 µm; this is particularly interesting for the Black Sand Beach because the data show approximately 97% of the BSB material is in the 250 µm - 2mm fraction. While most metals concentrations increased with decreasing particle size, this paper includes some data that show the highest concentration in the bulk soil (e.g., slag material), and others that show little trend with particle size. Regression analyses suggest smaller particle fractions may have higher elemental concentrations. Results of application of a maximum likelihood estimation technique generally indicate that handling of dry media leads to preferential adherence of smaller particle sizes, while handling of wet media does not. Because adhered material can differ greatly in particle size distribution from that found in bulk material, use of bulk concentrations in exposure calculations may lead to poor estimation of actual exposures.	Bergstrom et al., 2011

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
Total suspended particulate from urban areas (Sicily, Italy)	24-hour air samples collected at low flow (15-20 L/m)	Particles collected on 0.4 µm pore size filters	NA	No information on enrichment by particle size. Reports a range of enrichment values for Pb, S, and Br of 10-1000 relative to crustal composition using Ti as reference element.	Boni et al., 1988
Mine tailings Review of soil particle size enrichment	NA	40-100 100-200 >200	Concludes that human health risk assessors should look at fractions smaller than 250 µm.	Discusses dermal loading. Discusses enrichment of indoor dust as compared to soil. Discusses differences between sources of contamination and the role of organic matter in bioavailability.	Bright et al., 2006
Residential soils (Anaconda, Montana)	Children (n=62) Soil, food and fecal samples	≤250 <2000	Lead concentration increased with decreasing particle size.	Authors paired particle size data with soil ingestion estimates by using food and fecal marker data. Lead concentrations were estimated with ICP-MS.	Calabrese et al., 1996
Dust, sand, earth collected from roadside gutters and pavements, gardens, schoolyards, and playgrounds (Manchester, England and Christchurch, New Zealand)	Samples were extracted at various pH	NA	NA	Experiments were designed to evaluate effect of pH on lead extractability from soils. Extractability increased from <10% at pH ~5 to >90% at pH ~1.	Day et al., 1979
Urban street dusts (London, UK; Manhattan, US; Halifax, Canada; Kingston, Jamaica; Christchurch, New Zealand)	Footpaths, gutters Dry sieved	<33 33-54 54-88 88-111 111-148 148-165 165-192 192-213 213-963	Increased Pb concentration with decreasing particle size	The metals (Cd, Pb, Cu, Zn, Mn, and Fe) were sequentially extracted from the dust. The overall mass of the dust sampled fell below 200 µm, and <111 µm contained 10-20% of the material for 8 of the samples. Authors state that ~50% of the dust that occurs in the largest particles (213-963 µm), has a major soil component. Organic content was measured.	Fergusson & Ryan, 1984

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
		<963			
Street dusts	NA	NA	NA	Review of sources of trace elements in dusts. Reports log enrichment factor (street dust:soil, calculated using cerium as reference element) of ~2 (shown graphically) using median soil concentration data reported in the literature. Reports log enrichment factor for house dust compared with soil of ~1.5.	Fergusson & Kim, 1991
Residential and street dust; garden soil samples (Christchurch, New Zealand)	3-4 sample/ house/10-12 houses/6 areas Vacuum Dry sieved	NA	NA	Discusses lead concentration and incidental ingestion of lead. The authors discuss the influence of organic matter, and historical sources of lead. No information on particle size.	Fergusson & Schroeder, 1985
Residential house and street dust; garden soil (Christchurch, New Zealand)	1 sample/house; 12 houses; 6 areas Dry sieved	NA	Reports > 3 times enrichment of Pb in house dust and street dust compared with local soils, and > 3 times enrichment in house dust, street dust, and soil compared with crustal abundance.	No information on particle size.	Fergusson et al., 1986
Particles generated by combustion of coal or coal with dried municipal sewage sludge (MSS) (Stuttgart, Germany)	Particles collected at surface of bag house filter with nominal mean diameter of 3.5 µm	Mean diameter of ~3.5 µm	Pb concentration was reportedly higher in MSS/coal ash particles than in coal ash alone.	Details of analysis and particle sizes were not reported. Particle size distribution of MSS/coal ash did not differ from coal ash.	Fernandez et al., 2002
Arable soils (tropical) (Hainan Island, China)	Three composite samples were air-dried and sieved	<53 53-250 250-1000 1000-2000 2000-4000 >4000	The distribution of heavy metals increased with decrease of particle size. The smallest fractions (<53 µm) occupied only 5.08–9.57%, but had the highest distribution factor for Pb (2.11).	The residues of Pb were correlated positively with the contents of organic carbon as well as Fe in fractions, while a large variation distribution of As was found in particles, indicating its high activity in soil microenvironment.	Gong et a., 2013

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
Mining (Broken Hill, Port Pirie, Australia; Hobart, Tazmania) Urban Soil (Sydney, Adelaide, Australia)	Soil: top <25 mm - Roadside Dusts: vacuum cleaner dust; surface wipe; dust fall	<5 5-10 10-38 38-53 53-75 75-150 150-250 250-500 500-1000 >1000	Considerable variation was observed in the weight percentages for the various fractions Finer fractions contain 2-9 times higher concentration than bulk fractions	Authors suggest that it is necessary to analyze the bulk fractions as well as the <150 µm (or even better, the <100 µm) fraction for soils and the <100 µm fraction for dusts.	Gulson et al., 1995
Small arms shooting ranges, incinerators, historical fill material, mining and smelting, and gasworks (Australia)	16 soil samples	<50 <100 <250 <2000	Increasing concentration with decreasing particle size. <50 µm fraction, the average concentration of lead was approximately twice the average concentration of lead in the <2 mm fraction but varied between 0.86 - 5.31. Lead enrichment in the <50 µm particle size fraction was up to 5 times the concentration observed in the bulk soil.	The slopes and coefficient of determinations (R2) reported by the authors for regression models of lead concentration in particle size intervals (i.e., <50, <100 and <250 µm) on lead concentration in the bulk sample (i.e., <2 mm fraction) appear to be highly influenced by the two samples collected from a mining/smelting site. This paper also reports data on bioaccessibility, determined using the Solubility Bioavailability Research Consortium (SBRC) in vitro assay (3 replicates for the three grain size fractions provided above for each of the 16 soils). They report trends of increasing bioaccessibility with decreasing particle size fraction for 9 of the 16 soils; 6 of the 9 were statistically-significant trends. The authors compare IEUBK-predicted PbB levels to measured PbB levels for two of the mining/smelting sites. The comparisons are made at three particle size fractions, with and without adjusting the IEUBK model bioavailability parameter.	Juhasz et al., 2011
Mine tailings, unprocessed waste rock, background samples (Randsburg, CA, US)	40 soil samples	<20 20-32 32-45 45-75 75-125	Increased Pb concentration with decreased particle size <250 µm collectively comprise 25.3-61.4% of the samples' mass;	Authors suggest incidental ingestion of adhered particles in the <250 µm fraction	Kim et al., 2011

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
		125-250 250-500 500-1000 1000-1700 1700-2830 >2830			
Chromium-contaminated site (New Jersey, US)	21 soil samples Dry sieved; XRF analysis	<400 250-400 175-250 75-175 45-75 38-45 <38 10 2.5 1.0	Increased Pb levels with decreased particle size (<38 µm).	The study focuses on the inspirable, thoracic and respirable particles that would enter the respiratory tract. Particles were resuspended to determine size fractions <38 µm. ICP-AES was used to extract chromium. Enrichment factors for lead and chromium were determined by XRF analysis.	Kitsa et al., 1992
Urban playgrounds (Uppsala, Sweden)	Wet sieved	<50 50-100 <4000	Demonstrated average 1.5 times enrichment for metals in finest fraction (<50 µm) compared with either the bulk sample or the 50-100 µm fraction.	For two soils with high (58%) and low (13%) sand content, Pb was enriched in smaller size particles (1.6- to 2.7 times) in high sand soils but was not enriched by size in low sand soils. Metals content inversely correlated with sand content.	Ljung et al., 2006
Urban playgrounds (Uppsala, Sweden)	Assessed for in vitro bioaccessibility using a three compartment digestion model.	<50 <4000	Lead levels were consistently higher in <50 µm fraction	It was concluded that in soils with low metal load and sufficient number of binding sites, the effect of particle size range is diminished. "The difference in bioaccessibility between elements was concluded to be due to differences in origin, sorption behavior and pH dependence. The study also found that the bioaccessible amount of metal in ingested soil is not always related to particle size or to soil mass in soils with low contaminant levels. Factors such as pH dependence of the metal and the soil's clay content are also significant in determining bioaccessibility." The particle size range only had an effect on Pb bioaccessibility when there was limited access to binding sites. With a clay content >10%, the strong pH dependence of Pb was found to have a greater effect on the distribution of bioaccessible Pb. As suggested before, the preference for sorption to clay particles diminishes the effect of particle size range in unpolluted soils, since most metal ions are bound to these small particles, which were present in both scenarios.	Ljung et al., 2007

Site-Specific Information	Sample Preparation	Particle Size Tested (μm)	Enrichment	Comments	Reference
				However, when the number of clay particles was limited, an effect of particle size was observed.	
Urban soils (Hong Kong)	8 soil samples Wet sieved	<2 2-10 10-50 50-100 100-280 280-2000	2-10 μm had increased metal concentrations; 50-280 μm less marked	Variability in distribution of contaminants by particle size fraction supports argument against generalization. Reported increased bioaccessibility with finer particle size, - there was no measure of bioavailability in this study. "The mobility, bioavailability, and human bioaccessibility of Pb and Zn in bulk soils correlated significantly with metal concentrations in fine silt and/or very fine sand fractions."	Luo et al., 2011
Urban soils (Torino, Italy; Sevilla, Spain)	10 soil samples Dry sieved Bioaccessibility (SBET, EDTA)	<2 2-10 10-22 22-50 50-2000	Particle sizes <50μm had generally higher lead concentrations than >50 μm	In soil samples from both cities, the finest fractions had the highest EDTA extractability for lead and lowest SBET lead bioaccessibility as compared to other fractions and whole soil. The authors suggest the differences in bioaccessibility between the fractions are due to the presence of humic content.	Madrid et al., 2008
Urban soils/street dust (Al Zarqa, Jordan)	18 soil samples	<63 63-125 125-250 250-600	<63 μm had the greatest Pb concentrations	Samples were obtained from the sides of busy roads where leaded gas still in use	Momani, 2006
Mining (Coeur d' Alene River Basin, ID, US)		<175		The rationale for this particular sieve size includes compatibility with earlier soil sampling protocols in the Coeur d'Alene River basin and consistency with soil adherence data for dermal exposures. Although enhanced lead enrichment would be expected in soils processed with the 175 μm sieve instead of the 250 μm sieve, the real issue from a human exposure assessment standpoint is not lead enrichment, but rather the accurate characterization of lead in the particles that play the dominant role in the soil/dust-to-hand-to-mouth pathway. Data derived for analysis of Bunker Hill exhibited acceptable agreement between observed and predicted PbB levels for 15 consecutive years using model inputs based on soil and dust samples sieved to less than 175 μm	NRC, 2005
Sediment samples near the River Avon	17 soil samples	<20 20-63	Mean and maximum Pb concentrations increased with decreasing particle size fraction.	Authors state, "It was concluded that, while in certain specific circumstances it may be most appropriate to make forensic comparisons based on a very narrowly defined particle size range, for the majority of purposes the <150 μm fraction	Pye et al., 2007

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
(United Kingdom)	Wet and dry sieved	63-150 150-2000		provides the best compromise between sample size requirements and data resolution." Also includes mean, max, min and variance (coefficient of variation) for 49 metals and oxides, and multivariate statistical methods that could be useful.	
Agricultural and Brownfield soils (Saskatchewan and Nunavut, Canada, respectively)	13 agricultural soil samples 17 Brownfield soil samples Dry sieved	0.01 <2000 <4000 (bulk sample)	Increasing metal concentrations with decreasing particle size fractions.	Measured dermal adhesion of Canadian soils, found increased adherence with decreasing size, reported metal particle size enrichment, especially for arsenic (420%). Mean dermal adherence for agricultural and Brownfield soils were 34 µm and 105 µm, respectively. Particle size was measured with laser particle size analyzer. The silt fraction (2-50 µm) is the dominant adhered size. The average particle size of adhered soil varied from 34-105 µm, depending on the soil type. The authors define bulk sediment as <4 mm rather than <2 mm early in the paper; however, 4 mm is only mentioned again in the paper in the caption of Figure 3. The Methods section states the bulk soils were sieved through a 2 mm sieve for measurement of TOC, total metals and presumably, for the adherence experiments. The authors define (concentration) enrichment as (adhered-bulk)/bulk, rather than concentration in adhered fraction / concentration in the bulk soil. Authors recommend that soil samples should be sieved through a 45 µm sieve before estimating risk associated with contaminated soils. Statements about TOC should be carefully reviewed.	Siciliano et al., 2009
Urban soils (shooting range, incinerator, historical fill, mining smelting, gaswork activities) (Australia, New Zealand)	31 soil samples Dry sieved	<250 <2000	Pb concentration in the <250 µm fraction was greater than the <2mm fraction.	Demonstrated variable enrichment between the size fractions. Used in vitro assay to measure lead bioaccessibility in the <250 µm (dry sieved) fraction only. Compared the bioaccessibility using either USEPA Pb IVBA method or SBRC assay. Demonstrated wide variety of gastric phase lead bioaccessibility 35-105%.	Smith et al., 2011
Battery recycling plant Lead-smelting factory (Thailand - sandy loam, sandy clay, clay)	6 soil samples Surface soil (0-15 cm) Subsoil (15-30 cm)	<150 150-250 250-2000	Pb concentration was ~2 times higher in the <150 µm than in the 250µm-2mm fraction.	The primary objective of this study was to characterize the chemical forms of lead in soil that affect the extraction of lead from the soil; however, the paper includes data on enrichment of lead from 6 samples collected from three locations (two contaminated areas and one reference area) and two depths below the ground surface.	Tawinteung et al., 2005
Urban roadway "grit" (8 sites, New York City, NY, US)	225 soil samples Dry sieved	<63 63-125 125-250 250-500 500-2000	84% of the particles were in the range of 125–500 µm. The highest concentration of lead was in the smallest fraction analyzed (<63 µm).	Pb concentrations ranged from 20-7460 ug/g.	Weiss et al., 2006

Site-Specific Information	Sample Preparation	Particle Size Tested (µm)	Enrichment	Comments	Reference
		2000-4000			
Bulk surface soil samples obtained near five industrial facilities and along roadsides (5 locations in California, US)	Soil was collected up- and down-wind of each facility; samples of the soil were resuspended in a laboratory chamber to generate PM_{10}	PM_{10} <38 (fine soil) 300-2000 (coarse soil) Bulk soil	Pb in PM_{10} was enriched by 1.10 to 8.31 times compared with bulk soil samples Pb in fine soil was enriched by 1.12 to 7.83 times compared with coarse soil samples	Pb in PM_{10} was enriched 5.36 – 88.7 times compared with uncontaminated California soils (highest enrichment value was associated with a Pb smelter site). The geometric mean particle diameters of the bulk soil samples ranged from 41.2 to 344 µm. Facilities included the following: glass manufacturing, perlite mining, borax processing, lead smelter, sandblasting, and roadside.	Young et al., 2002

APPENDIX A. Sample Preparation and Analytical Considerations

The TRW Lead Committee (TRW) recommends the following procedures for sample preparation and analysis of lead in soil and dust at Superfund sites to improve the representativeness of samples used to estimate concentrations of ingested lead in soil and dust. There may be site-specific instances where the recommendations below do not apply, such as sites where the soil is typically wet (larger particles may adhere to skin when the soil is wet). Further information on soil sampling is available from U.S. EPA (2013, 2003).

After drying, soil or dust samples are passed through a No. 4 (4.75 mm) or a No. 10 (2.0 mm) sieve (ASTM, 1999) to remove any large debris. The resulting material is referred to as the total sample. The total sample is weighed and sieved through a No. 100 W.S. Tyler® sieve to identify the "coarse" (>150 μm) and the "fine" (<150 μm) fractions. The fine fraction may be further fractionated if site-specific circumstances warrant.

If only one analysis is to be performed on a soil or dust sample at a lead-contaminated site, as is sometimes the case at a removal site, the TRW Lead Committee recommends analyzing the lead concentration in the fine fraction (fraction which passes through a No. 100 W.S. Tyler® mesh sieve) at a minimum, with site-specific consideration for the need for further assessment. The particle size fraction used should provide the most accurate characterization of the current risk from exposure by incidental ingestion at the site.

To account for the potential for enrichment of lead, the concentration of lead should be analyzed in both the fine and coarse fractions, at least for a subset of samples. After determining the concentration of lead in the coarse and fine particle size fractions, the lead concentration of the total sample may be reconstructed using a weighted average of the coarse and fine fractions. The resulting ratio (*i.e.*, the enrichment ratio) between the concentrations of lead in the fine fraction relative to the concentration in the total sample may be used to develop a site-specific "adjusted" cleanup level that would be applicable to total soil sampling data if the data supports an assumption that the enrichment ratio is constant across the site or within an exposure unit. In addition, if prior soil sampling data are available, such analysis may allow for comparison with earlier sampling data.

When there is potential for the total sample to contain higher concentrations of lead than the fine fraction (*e.g.*, if coarse material from mining or industrial operations contains higher concentrations of lead than the fine fraction), the future degradation of these coarser materials into finer particles should also be considered (*e.g.*, addressed by using the total soil concentration for the risk assessment of potential future exposures). In addition, total sample concentrations represent deliberate soil or dust ingestion (Lenoir et al., 1997). In these instances, at least 20% of the surface soil samples, or a minimum of 20 samples, should be analyzed for lead concentration in both the coarse (>150 μm) and the fine (<150 μm) particle size fractions. This recommendation to consider the lead concentration in larger particle size fractions may be particularly relevant to sites where large particles of lead may be present in soil, such as shooting ranges or battery recycling operations.

While the sieving of all samples is preferred, at some sites this may not be practical. When sieving is limited, a constant (*e.g.*, relative standard deviation [RSD] <30%) enrichment ratio across sampling locations, the concentration of lead in the fine fraction may be used to estimate the concentration of lead in the total sample. For this estimation, the TRW Lead Committee recommends using a statistical regression model (*i.e.*, full regression analysis) to examine the relationship between concentrations of lead in the different soil fractions.

The TRW Lead Committee recommends assistance from a statistician to develop and evaluate such regression models[8]. Unless prediction errors are relatively small (*e.g.*, RSD <30%) (10–20% of the best estimates), the TRW Lead Committee further recommends that upper prediction limit to estimate concentrations of lead in the fine fraction be used for site applications. Large prediction errors indicate that the concentration in the fine fraction should be measured rather than predicted using a regression model, particularly if the predicted concentration of lead in the fine fraction is close to the risk management decision range.

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[8] Regression models often provide the best estimates of lead concentrations in the fine fraction (*i.e.*, the regression line) and predict errors about the regression line. In some instances, however, mixed models may be needed.

ATTACHMENT E1

1995 QUESTIONAIRE AND RESPONSES REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS

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1409
North Forbes Road
Lexington, Kentucky
40511-2050

606-233-0574
606-254-4800 FAX

Fuller
Mossbarger
Scott &
May
FMSM
ENGINEERS

October 26, 1995

O.1.1.94355L05

Mr. Charles Logsdon
Kentucky Department of Fish and Wildlife Resources
10535 Ogden Landing Road
Kevil, Kentucky 42053

Re: PCB Risk Calculations
Paducah Gaseous Diffusion Plant

Dear Mr. Logsdon:

FMSM is conducting a preliminary risk calculation for the Little Bayou and Big Bayou areas around the Paducah Gaseous Diffusion Plant. This subject was discussed at a meeting in which you attended on September 7, 1995. During that meeting you indicated that your office could provide information on the recreational use of these areas. In response to your suggestion, we have developed the following list of questions. Please try to research your site use data and answer as many of these questions as possible. If data is not directly available to answer these questions we would appreciate an estimate based on your best professional judgment.

<u>Big Bayou</u>

1. What is the average number of visitors per year to Big Bayou?
2. Of this number, how many are adults and how many are children?
3. Are most of your visitors repeat or one-time visitors on a yearly basis?
4. What is the average time (hours) spent in Big Bayou? Is there a difference in average time spent between adult and child usage?
5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?
6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

8. Is there a harvestable fish population in Big Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

Little Bayou

I realize that during the September 7th meeting, you stated there is little to no recreational use of the Little Bayou areas. However, it would be helpful if you could answer the same questions about Little Bayou, as asked of Little Bayou. Therefore, we are repeating the following questions.

1. What is the average number of visitors per year to Little Bayou?

2. Of this number, how many are adults and how many are children?

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

4. What is the average time (hours) spent in Little Bayou? Is there a difference in average time spent between adult and child usage?

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?

6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

8. Is there a harvestable fish population in Little Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

We appreciate your help in answering these questions. After you have reviewed these, if you have any questions, or if the questions need clarification, please call.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Stephen L. Scott, P.E.
Project Manager

/esh

c: David Asburn ✓
Tom McGee ✓
Bob Sneed ✓
David Brancato ✓

facsimile
TRANSMITTAL

to: Stephen Scott, P.E.
fax #: 606-254-4800
re: Big Bayou & Little Bayou
date: November 8, 1995
pages: 4, including this cover sheet.

From the desk of...

Charlie Logsdon
WMA Supervisor
Ky. Dept. Of Fish & Wildlife Resources
10535 Ogden Landing Rd.
Kevil, KY. 42053

(502)488-3233
Fax

Stephen Scott, P.E.
Fuller, Mossbarger, Scott and May
Engineers, Inc.
1409 North Forbes Road
Lexington, Ky. 40511-2050

Dear Mr. Scott:

I have answered these question as accurately as possible. If you have any other questions, or questions about my answers feel free to contact me. Sorry about the delay, but you're letter came during some of our deer hunting seasons.

Sincerely,
Charlie Logsdon
Charlie Logsdon

cc: Wayne Davis
Don Walker

Little Bayou

1. The number of people visiting Little Bayou is essentially zero, with the exception of PGDP personnel and a few fishermen(maybe, 20 visits annually) that fish a large beaver pond above the outfalls of the plant. A few people (bowhunters and dog trainers) may cross the creek occasionally, but these visits would be brief(the majority would be measured in seconds or minutes). Field trial galleries do cross the creek(over a large dirt-covered culvert) north of McCaw Road, however, they do not enter the creek and the whole process takes seconds.

2. The visitors would be adults.

3. Refer to Big Bayou question 3. Visitors to Little Bayou would be repeat users, probably less than 10 visits per year and most of them in the brief encounter scenario described in question 1.

4. Most encounters with Little Bayou would be measured in seconds. Fishermen that use the beaver pond above the outfalls, may fish on average 2 hours.

5. See Big Bayou question 5.

6. Field trials that cross the creek may occur 12-15 weekends of the year. Most of the participants would be repeat users. The sum of all the encounters with Little Bayou would be measured in minutes for the most frequent user and most would only cross the creek on the culvert and dirt crossings.

7. All fishermen in the beaver pond would be bank fishermen as the pond is too deep to wade.

8. Other than the beaver pond above the outfalls, it would be nearly impossible to catch 0.284 kgs of fish from Little Bayou. There is a fish population, but most would fall in the minnow category and are not desirable by fishermen. In the beaver pond, it would be possible to catch this amount, but it would not support subsistence fishing(128 meals/year).

Big Bayou

Question 1: The number of visits by people using Big Bayou specifically, is estimated to be 150 visits. This is for a specific activity involving Big Bayou, such as fishing. More people may be in the vicinity while using the WKWMA, but their use of Big Bayou maybe for only an instant(i.e., using a log to cross Big Bayou to hunt on the other side of the creek).

Question 2: Of the 150 visits of people using Big Bayou, 100 are adults and 50 are children. This is an estimate based on our observations of people using the area.

Question 3: Most of these people would be one time users. However, 10% of the total number of users could be classified as repeat users. The highest number of visits by one person specifically using Big Bayou, would probably be <10.

Question 4: The average time spent in Big Bayou by users is unknown. However, I feel the amount of time spent/trip would be similar to other activities. During 1994, the average number of hours spent/trip for the following activities were: Quail hunting - 3.49 hrs/trip(n= 158), rabbit hunting - 3.25(n=168), bowhunting for deer - 3.48(n=1115), duck hunting - 2.4(n=69), and raccoon hunting - 2.63(n=20). Raccoon hunting and duck hunting would be the activities most likely associated with Big Bayou. There would be little, if any, difference between adult and child usage of the area.

Question 5: This question is difficult to answer. Do you mean for WKWMA or Big Bayou? WKWMA is heavily used by a wide variety of users. Annually, the estimated number of visits for the following activities are: fishing - 5000 visits/year, hunting and dog training 4-6000, field trials - 1500, hiking - 100, berry & nut picking - 200, driving through for a variety of reasons - 50,000.
For activities involving Big Bayou alone: fishing - 150, hunting - ?(explained in question 1).

Question 6: Refer to questions 3 and 4.

Question 7. Most, if not all would be bank fishermen. Most of the fishing would occur at 3 points: 1) where the iron bridge in tract 4 crosses Big Bayou, 2) where the collapsed bridge in tract 4 crosses Big Bayou(by weir constructed by PGDP), and 3) where the concrete crossing bridges Big Bayou in tract 6. While it may occur, no wade fishing has been observed. No actual data is available, but should be similar to the length of visits noted in question 4.

Question 8: There is a harvestable fish population in Big Bayou. A person could potentially expect to catch 0.284 kgs of fish on a regular basis(depending on the skill of the fisherman), however, this is assuming that the person is not culling(throwing back extremely small fish). The frequency of being able to catch 0.248 kgs of fish would increase as one approaches the mouth of Big Bayou. Also, the only way the creek could support 128 meals a year is if there was major influx of fish from the Ohio River. This does occur when there is a backwater. During the backwater periods catches of 50 to several hundred pounds of catfish can be taken(this has been observed) on trotlines. This would not be indicative of risks associated with the plant.

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ATTACHMENT E2

2014 E-MAIL UPDATE REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS

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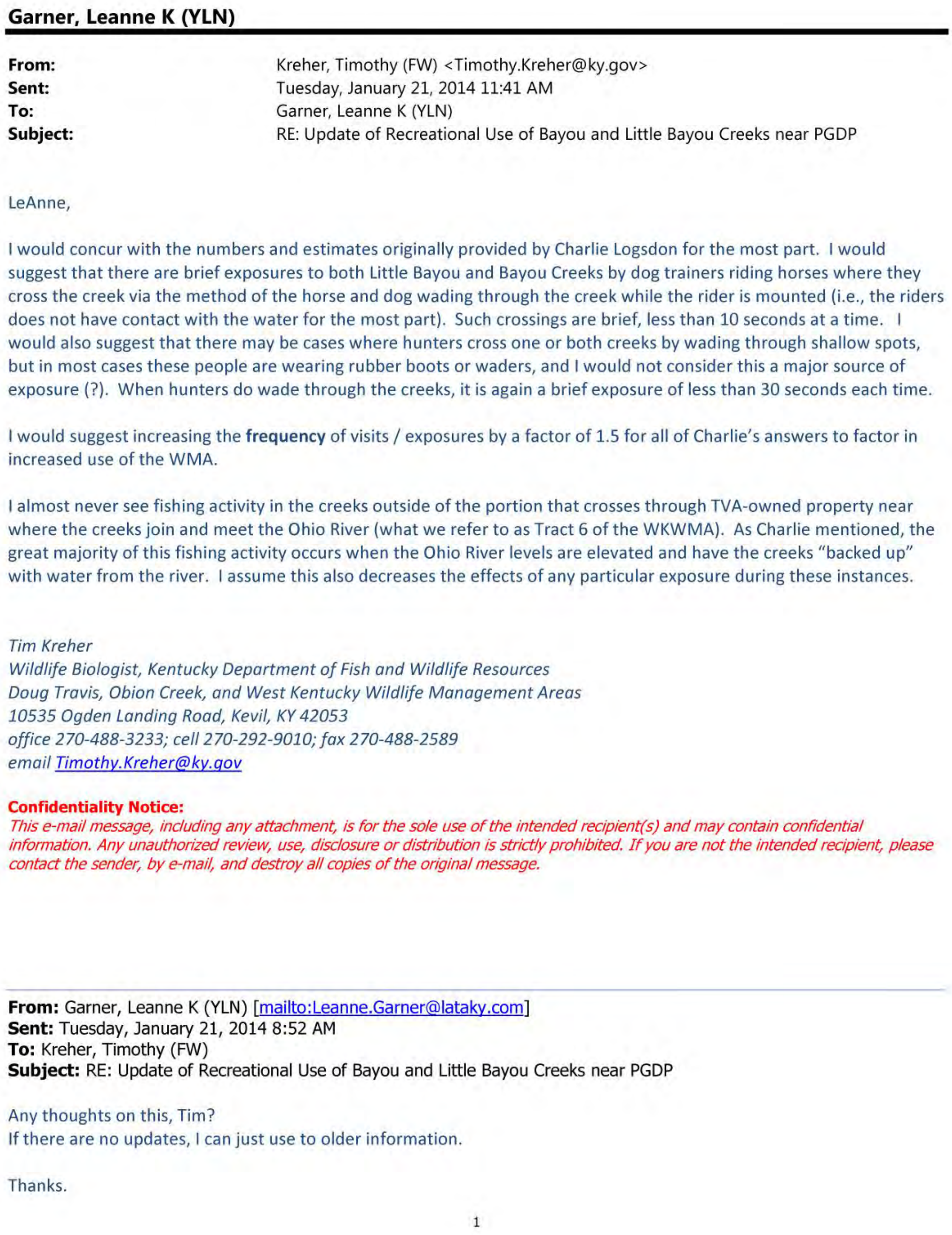

Garner, Leanne K (YLN)

From:	Kreher, Timothy (FW) <Timothy.Kreher@ky.gov>
Sent:	Tuesday, January 21, 2014 11:41 AM
To:	Garner, Leanne K (YLN)
Subject:	RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

LeAnne,

I would concur with the numbers and estimates originally provided by Charlie Logsdon for the most part. I would suggest that there are brief exposures to both Little Bayou and Bayou Creeks by dog trainers riding horses where they cross the creek via the method of the horse and dog wading through the creek while the rider is mounted (i.e., the riders does not have contact with the water for the most part). Such crossings are brief, less than 10 seconds at a time. I would also suggest that there may be cases where hunters cross one or both creeks by wading through shallow spots, but in most cases these people are wearing rubber boots or waders, and I would not consider this a major source of exposure (?). When hunters do wade through the creeks, it is again a brief exposure of less than 30 seconds each time.

I would suggest increasing the **frequency** of visits / exposures by a factor of 1.5 for all of Charlie's answers to factor in increased use of the WMA.

I almost never see fishing activity in the creeks outside of the portion that crosses through TVA-owned property near where the creeks join and meet the Ohio River (what we refer to as Tract 6 of the WKWMA). As Charlie mentioned, the great majority of this fishing activity occurs when the Ohio River levels are elevated and have the creeks "backed up" with water from the river. I assume this also decreases the effects of any particular exposure during these instances.

Tim Kreher
Wildlife Biologist, Kentucky Department of Fish and Wildlife Resources
Doug Travis, Obion Creek, and West Kentucky Wildlife Management Areas
10535 Ogden Landing Road, Kevil, KY 42053
office 270-488-3233; cell 270-292-9010; fax 270-488-2589
email Timothy.Kreher@ky.gov

From: Garner, Leanne K (YLN) [mailto:Leanne.Garner@lataky.com]
Sent: Tuesday, January 21, 2014 8:52 AM
To: Kreher, Timothy (FW)
Subject: RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

Any thoughts on this, Tim?
If there are no updates, I can just use to older information.

Thanks.

LeAnne

From: Garner, Leanne K (YLN)
Sent: Tuesday, January 07, 2014 8:56 AM
To: 'Timothy.Kreher@ky.gov'
Subject: RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

Good morning, Tim!
I hope you had a good holiday!

We are updating the Risk Methods Document (the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health*) with more current information.

Some of the information we are updating is "Recreational Use of Bayou and Little Bayou Creeks near PGDP." I have attached that information.
The entire document can be found here:
http://www.paducaheic.com/media/112385/ENV1.A-00440-ARI41.pdf

If you could, please look at the attached and let me know if you think any of the information needs updating.
If so, do you have that information?

I would appreciate any help you could give.

Thank you.

LeAnne Garner
Scientist
LATA Kentucky
leanne.garner@lataky.com
270-441-5436
