Health Consultation

Evaluation of Metals and Synthetic Organic Chemicals in Biota

Ringwood Mines/Landfill Site
Ringwood Borough, Passaic County, New Jersey

DRAFT for PUBLIC COMMENT

June 30, 2009

Public Comment Period:
June 30, 2009 – July 31, 2009

Prepared by:

New Jersey Department of Health and Senior Services
Division of Epidemiology, Environmental and Occupational Health
Consumer and Environmental Health Services
Hazardous Site Health Evaluation Program

Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary

Introduction

The New Jersey Department of Health and Senior Services (NJDHSS) and the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) recommended testing of game animals and edible plants at the Ringwood Mines/Landfill site in Passaic County, N.J., to better understand the potential for human exposures to site-related contaminants.

In response, the U.S. Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection (NJDEP) collected biota and analyzed specimens for contaminants potentially related to the site, including metals and synthetic organic chemicals.

Conclusions

NJDHSS and ATSDR have reached three conclusions in this Health Consultation on the Ringwood Mines/Landfill site:

Conclusion 1

NJDHSS and ATSDR cannot conclude whether eating wild carrots from the Ringwood Mines/Landfill site could harm people's health. The reason for this is that data for wild carrots from the reference area in Ringwood State Park were not consistent with known background levels, casting doubt on the accuracy of the reference area and site data.

Basis for Conclusion

Lead levels detected in wild carrot composites from the Ringwood State Park reference area were much higher than would be expected based on the low levels of lead in soil at the Park. These results were many times higher than levels reported as background in carrots in other studies and by the U.S. Food and Drug Administration (FDA) Total Diet Study.

Next Steps

The USEPA should consider additional sampling and testing of wild carrots at the site and the reference area. This testing should employ methods that result in reporting limits with adequate sensitivity and that allow comparison to FDA Total Diet Study or other appropriate data. Until such testing is completed, it is prudent to recommend against consuming plants from the on-site Ringwood Mines/Landfill areas.

Conclusion 2

NJDHSS and ATSDR conclude that eating game animals (deer, squirrel, rabbit and turkey) at the Ringwood Mines/Landfill site should not harm people's health.

Basis for Conclusion

USEPA and NJDEP contract laboratories produced discrepant test results for game animals. Based on adequate reporting limits and consistency of results for reference area deer with FDA Total Diet

	Study data for beef, the USEPA's laboratory data were chosen for evaluation in this Health Consultation. Using these data, the estimated average or maximum intakes of metals and organic chemicals are either below ATSDR's minimal risk levels or known effect levels for non-cancer effects. The lifetime excess cancer risk from exposure to site-related chemicals of concern is estimated to be low, in comparison to the background risk of cancer. Based on lead exposure models, consumption of game animals collected from the Ringwood Mines/Landfill site does not substantially affect the blood lead levels of fetuses, children or adults. Model results show that soil and dust, under site-specific conditions, are the primary sources of lead exposure in children.
Next Steps	The NJDEP should withdraw the advisory regarding squirrel consumption at the Ringwood Mines/Landfill site.
Conclusion 3	*Currently, the primary source of lead exposure in children is likely to be residential soils and associated dusts.*
Basis for Conclusion	Based on a lead exposure model and site-specific assumptions, lead from residential soils and associated dusts would be the largest contributor to blood lead levels in children.
Next Steps	Efforts to characterize lead levels in residential soils and dusts should continue, and remedial measures should be implemented as needed.
For More Information	Questions about this Health Consultation should be directed to the NJDHSS at (609) 584-5367.

Background and Statement of Issues

In May 2006, the New Jersey Department of Health and Senior Services (NJDHSS) and the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) released the Ringwood Mines/Landfill Public Health Assessment (Draft for Public Comment) (ATSDR 2006a). One of the recommendations made in the draft Public Health Assessment was to characterize contaminant levels in on-site biota, to better understand the potential for human exposures to site-related contaminants. In response, the U.S. Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection (NJDEP) collected biota in the period September 2006 to March 2007, and analyzed specimens for contaminants potentially related to the site.

Site-related contaminants of concern in paint sludge, soils and sediments at the Ringwood Mines/Landfill site include several metals (lead, antimony, arsenic, cadmium, chromium, copper and thallium), and synthetic organic chemicals (polychlorinated biphenyls (PCBs), benzo(a)pyrene, and bis(2-ethylhexyl)phthalate) (ATSDR 2006a). Lead is of particular interest because of the high levels found in paint sludge and soils in parts of the Ringwood Mines/Landfill site.

This Health Consultation provides an evaluation of contaminant levels in game animals (deer, squirrel, rabbit and turkey) and wild carrots, which have been reported to be consumed by residents from the area of the Ringwood Mines/Landfill site. Testing was conducted on edible portions of these animals and plants: muscle tissue from the four game animal species; liver from deer; and roots from wild carrots. These tissues were selected for testing because they are consumed, not because contaminants are necessarily expected to accumulate in them. In addition to game animals and wild carrots collected at the site, deer and wild carrots were collected from reference areas for comparison purposes.

In December 2006, the USEPA provided validated data from its Lockheed Martin Laboratory for six squirrels collected in November 2006 to the NJDHSS, ATSDR, and NJDEP (USEPA 2009a). Together, the four agencies completed an evaluation of lead concentrations in these squirrels in January 2007 (NJDHSS 2007). On the basis of this evaluation, and since squirrels are reported to be hunted at the site, the NJDEP issued an advisory to area residents and hunters regarding limits on consumption of squirrel meat (NJDEP 2007a). Subsequently, the USEPA rejected these data on lead in squirrels based on probable contamination during specimen preparation (USEPA 2009a), and had these tissues re-analyzed. This was announced by the USEPA at a public meeting on November 1, 2007. At that meeting, the USEPA and NJDEP released sets of tables containing the complete results of biota testing for the Ringwood Mines/Landfill area (USEPA 2007a; NJDEP 2007b), including results of the reanalyses of squirrel tissues. The USEPA distributed a draft report of its biota testing in February 2009 (USEPA 2009a).

Biota Sampling and Analyses

Overview of Biota Collection and Analyses

The USEPA and the NJDEP collected biota samples from the Ringwood Mines/Landfill site and reference areas. Wild carrots were collected at three on-site areas: Peter's Mine Pit, O'Connor Disposal Area, and SR-6. Reference area wild carrots were collected from a part of Ringwood State Park with similar topography to the Ringwood Mines/Landfill site, approximately two miles from the site (where Morris Road crosses over Cupsaw Brook). At each area, multiple carrots were composited into three analyzable groups (between 15 and 67 individual carrots), because individual carrots were too small to analyze separately. Soils at the site and reference areas were also tested for metals and synthetic organic chemicals.

Game animals (deer, squirrel, rabbit and turkey) were collected at the Ringwood Mines/Landfill site from the O'Connor Disposal area. In addition, deer were collected from a reference area located near the border of East Hanover and Morris Plains, New Jersey. The site was a patch of woods surrounded by residential and light commercial properties off American Road, near Forest Way. Details on biota selection, collection procedures and locations are provided elsewhere (USEPA 2009a).

Table 1 summarizes the species collected, the number of specimens collected, and months of collection. The table also lists the numbers of specimens tested, and the analyses conducted by each laboratory. All biota specimens were tested for metals, PCBs and semi-volatile organic chemicals. The plant contaminant level data reported by the USEPA and game animal contaminant level data reported by the NJDEP and USEPA are presented in Tables 2, 3 and 4, respectively (USEPA 2007a; NJDEP 2007b). For each species tested, the number of specimens tested and the range of results (low and high values) are presented for site-related contaminants of concern in paint sludge, soils and sediments that were identified in the draft Public Health Assessment (ATSDR 2006a). The levels and evaluation of non-site-related metals and organic chemicals in biota at the Ringwood Mines/Landfill site are presented in Appendix A.

In addition to game animals and wild carrots, small non-game mammals (mice, voles and shrews) were collected and tested. Since non-game mammals are not consumed, data are not summarized in this Health Consultation. Crayfish and frogs were also collected, and tested on a whole-body basis. These data are not summarized since contaminant levels in edible portions are not available.

Laboratory Data Issues

Before discussing analytical results of the biota specimens in detail, it is important to raise three issues encountered with the laboratory data in the preparation of this Health Consultation:

1) Differences in analytical methods and reporting limits of metals between laboratories;

2) Inconsistency of laboratory results with literature values for biota; and

3) Discrepancies in results between laboratory analyses of the same specimens.

Because there was sample contamination during specimen preparation in the Lockheed Martin Laboratory, i.e, introduction of metal fragments from blenders used to homogenize tissues, the ATSDR and NJDHSS conducted a review of relevant literature to assess consistency between laboratories and with the published literature. The data from the U.S. Food and Drug Administration (FDA 2007) Total Diet Study[1] was an important resource for background levels of metals in food.

Differences in Analytical Instrumentation and Reporting Limits for Metals

The laboratories used by USEPA (i.e., Lockheed Martin, Severn Trent, and Pace Analytical) and NJDEP (i.e., Chemtech) utilized different analytical instrumentation for analysis of metals, resulting in differences in analytical sensitivity. The Lockheed Martin laboratory (which generated the metal results for the original six squirrels and the wild carrots for USEPA), and the Chemtech laboratory (which generated the metal results for game animals for NJDEP) used Inductively Coupled Plasma – Atomic Emissions Spectrometry (ICP-AES[2]), while the Severn Trent and Pace Analytical laboratories (which generated metals results for game animals for USEPA) used Inductively Coupled Plasma – Mass Spectrometry (ICP-MS[3]) (Gowers, personal communication, September 11, 2007).

In general, ICP-AES and ICP-MS are widely used as routine techniques for multi-elemental determination in different matrix compositions; reporting limits vary between the ng/ml[4] range in ICP-AES down to the fg/ml[5] range in ICP-MS (Becker 2005). For the same game animals, the Chemtech Laboratory (using ICP-AES) showed reporting limits about 10-30 times higher than those of Severn Trent and Pace Analytical (using ICP-MS). For carrot data, the only results are from the Lockheed Martin laboratory using ICP-AES, with relatively high detection limits; no carrot data were generated using ICP-MS.

Inconsistency of Results with Literature Values

Soil lead levels in the Ringwood State Park reference area location (i.e., 15 to 32.6 mg/kg) were similar to natural background soil lead levels reported in the literature (ATSDR 2002), and were more than an order[6] of magnitude lower than the NJDEP residential direct contact soil remediation standard (400 mg/kg). However, the lead levels reported by the Lockheed Martin laboratory in the reference area wild carrots (Table 2) were at least two orders

---

[1]The U.S. Food and Drug Administration (FDA) has conducted a long-term survey of the nation's food supply to monitor the safety and nutritional quality of the diet of Americans. The Total Diet Study, as it is known, includes tests of hundreds of foods for levels of metals and other contaminants.
[2]ICP-AES uses an inductively coupled plasma to produce excited atoms and ions that emit electromagnetic radiation at wavelengths characteristic of a particular element.
[3]ICP-MS is based on joining an inductively coupled plasma for producing ions (ionization) with a mass spectrometer as a method of separating and detecting the ions.
[4]nanograms per milliliter or 10^{-9} gram per milliliter.
[5]femtogram per milliliter or 10^{-12} gram per milliliter.
[6]Ten times

of magnitude higher than those reported for carrots in the FDA Total Diet Study. The table below shows the average lead concentrations in Ringwood State Park reference area wild carrot composites and the corresponding soil lead concentrations. The table also shows the mean lead levels detected in raw and processed carrot reported in the FDA Total Diet study.

Comparison of Lead Levels (dry weight) in Wild Carrot Samples from the Reference Area and the FDA Total Diet Study

Ringwood State Park		FDA Total Diet Study		
Soil (mg/kg)	Wild Carrot (mg/kg)	Mean Lead Concentration (mg/kg)		
		Carrot, strained/junior	Carrot, fresh, boiled	Carrot, baby, raw
32.6	12.6	0.018	0.009	0.015
17.8	5.8			
15	<2.4			

A number of researchers have reported lead levels in carrots and other vegetables grown on various types of lead-contaminated soil; soil lead levels were also reported in some of these studies (see Table 5). In many of these studies, lead levels in control carrots grown on uncontaminated or background soil were also reported. The ratio of lead levels in soils to lead levels in carrots in controls varied from 30.6 to 508. In Figure 1, carrot lead levels reported for samples collected from uncontaminated or background soil are plotted against the soil lead levels. Although the lead levels and the physical/chemical properties of the soil at the Ringwood State Park reference area and the other literature studies are not the same, it is clear that for similar soil lead levels, the corresponding carrot lead levels reported by the Lockheed Martin Laboratory from the Ringwood State Park reference area are many times higher than those reported in the literature (see Figure 1). The ratios of soil lead to carrot lead in the reference area ranged from 2.5 to 12.5. Other metals reported in the reference area wild carrots also show a similar difference when compared to metal levels reported in the FDA Total Diet Study (see Figure 2). It should be noted that the carrot lead levels reported in the FDA Total Diet Study are similar and consistent with the background lead levels reported in the literature (see Table 5).

The lead results from the Ringwood State Park reference area carrots do not appear to be consistent with the FDA or the literature values, nor is the soil-carrot relationship in the reference area consistent with other studies. As such, the NJDHSS and ATSDR are unable to conduct a quantitative exposure evaluation of carrot intake from the Ringwood Mines/Landfill site.

Discrepancies in Results Between Laboratories

Game animals from the Ringwood Mines/Landfill site and reference area were tested by laboratories under contract to USEPA (Severn Trent and Pace Analytical) and the NJDEP (Chemtech). It is apparent (see Table 3 and 4) that although laboratories analyzed split deer muscle and liver samples collected from the reference area, the reported lead levels and certain other metals differed considerably between the laboratories.

The following table shows the lead level detected in split samples from the same homogenized deer muscle and liver sample collected from the reference area and tested by the two laboratories. The table also shows the mean lead levels in ground beef[7] muscle and beef liver reported in the FDA Total Diet study.

Comparison of Lead Level (dry weight) in Deer Tissue Sample from Reference Area (border of East Hanover and Morris Plains) and FDA Total Diet Study

Organ	Chemtech Laboratory (mg/kg)	Severn Trent (mg/kg)	Mean lead level in ground beef reported in the FDA Total Diet Study (mg/kg)
Muscle	2.1 J[a] and 3.1	<0.18 – <0.22	0.004
Liver	3.6 and 4.0	<0.18 – <0.22	0.096

[a]estimated value

Severn Trent did not detect lead in reference area deer muscle or liver, at a reporting limit of about 0.2 mg/kg. In contrast, Chemtech detected lead levels from the same homogenized specimens at concentrations about an order of magnitude higher than the much lower Severn Trent reporting limits. The reported lead levels in reference area deer muscle and liver from Chemtech were also about an order of magnitude higher than the mean levels reported in ground beef and beef liver in the FDA Total Diet Study[8].

The NJDHSS and ATSDR brought the data disparity issues between the laboratories to USEPA's and NJDEP's attention. The laboratories were requested to explain the source(s) of the differences between the laboratories. According to the laboratory representatives, these differences may be attributable to differences in sample masses analyzed, instrument "noise" near the detection limits, specimen storage and preparation, and sensitivities of the analytical methods (Joe Gowers, USEPA, personal communication, September 11, 2007).

Since the reporting limits of the Severn Trent and Pace Analytical Laboratories were low, and the results from Severn Trent reference area deer muscle and liver lead levels were similar to FDA mean background levels for beef, only the results for game animals (i.e., deer muscle and liver, squirrel, rabbits and turkeys) from those two laboratories will be evaluated in this Health Consultation.

Environmental Guideline Comparison

Since Environmental Guideline Comparison Values for game animals is unavailable, all site-related COCs will be evaluated for their potential to cause adverse health effects[9].

[7]As deer muscle and liver lead levels were unavailable in the FDA Total Diet Study, ground beef results were selected for comparison.
[8]Since other game animals (i.e., squirrels, rabbits and turkeys) from the reference area were not sampled and tested for lead content, similar comparison with the FDA values could not be conducted.
[9]See Appendix A for non site-related contaminant exposure evaluation.

Discussion

To assess whether a health hazard exists to a community, it is necessary to determine whether there is a completed exposure pathway from a contaminant source to a receptor population, and whether exposures to contamination are high enough to be of health concern (ATSDR 2005). In the draft Public Health Assessment for the Ringwood Mines/Landfill site (ATSDR 2006a), consumption of biota was considered a potential exposure pathway since it was not known whether contaminants moved from paint sludge, soils, sediments, or surface water into games animals and edible plants, and therefore became available for human consumption.

Since the contaminant levels in game animals are now available, an assessment of ingestion exposures may be conducted. The site-specific exposure assessment involves looking closely at site-specific exposure parameters to estimate exposure doses, and the comparison with health guideline CVs. Health guideline CVs are based on data drawn from the epidemiologic and toxicologic literature and often include uncertainty or safety factors to ensure that they are amply protective of human health.

Public Health Implications

Non-Cancer Health Effects

To assess the public health implications of site-specific exposures, exposure doses estimated from site-specific exposure conditions are compared to dose-based comparison values. For non-cancer health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites. An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of adverse, non-cancer health effects. When MRLs for specific contaminants are unavailable, other health based comparison values, such as the USEPA Reference Dose (RfD), may be used. Health-based comparison values include a margin of safety such that exceedances of the MRL do not necessarily mean that a health effect is likely to occur.

The potential health effects (ATSDR 2006b) associated with lead exposures were evaluated using the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK, Build 264) model (USEPA 2007b).

Exposures estimates are based on ingestion of contaminated biota; non-cancer exposure doses were calculated using the following formula:

$$\textit{Exposure Dose (mg/kg/day)} = \frac{\mathrm{C \times IR \times EF}}{\mathrm{BW}}$$

where, mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = concentration of contaminant in game animal tissue (mg/kg);
IR = meat ingestion rate (kg/day);
EF = exposure factor representing the site-specific exposure scenario;

BW = body weight (kg)

Based on the USEPA Exposure Factors Handbook (USEPA 1997) and site-specific conditions, the following exposure factors were used to estimate chronic exposure doses for children and adults:

Media	Receptor Population	Ingestion Rate (g/day)	No. of Days Per Week with Game Meat Meal	Body Weight (kg)
Biota (game)	Child	121[a]	1	17
	Adult	350[b]		70

[a]Game meat ingestion rate for children, [b]95th percentile meat ingestion rate for adults

Based on maximum detected concentrations (or reporting limits with detects) of the site-related contaminants, chronic exposure doses estimated for children and adults for arsenic, chromium, copper and bis(2-ethylhexyl) phthalate in deer muscle, arsenic, cadmium, chromium and copper in deer liver, arsenic, cadmium, chromium and copper in squirrel muscle, antimony, cadmium, chromium and copper in rabbit muscle, and, cadmium, chromium and copper in turkey muscle were lower than the corresponding health guideline; as such, past exposures to these contaminants are unlikely to cause non-cancer adverse health effects (see Table 6).

The maximum exposure dose calculated for thallium detected in squirrel muscle, and PCBs detected in turkey muscle exceeded the corresponding health guideline CV. As such, the potential exists for non-cancer health effects; a brief evaluation of the non-cancer health implications is presented below:

Thallium in squirrel muscle: Thallium, a naturally occurring trace metal, can be found in pure form or combined with other substances to form salts. It is used mostly in the manufacture of electronic devices, switches and closures. Thallium was used as a rat poison but was banned in 1972 because of its harmful effects. Based on the maximum thallium concentration detected in squirrel muscle tissue (i.e., 0.07 mg/kg), the calculated exposure dose for children (i.e., 0.000071 mg/kg/day) were above the chronic oral EPA Reference Dose for oral exposures (RfD_o) of 0.000065 mg/kg/day. However, based on the mean concentration of thallium (i.e., the more likely exposure scenario) detected in the squirrel muscle, the child exposure dose (i.e., 0.000015 mg/kg/day) was 4.3 times lower than the chronic oral EPA RfD_o. As such, it is unlikely that non-cancer health effects from thallium would occur in residents consuming squirrel meat in the Ringwood Mines/Landfill site.

PCBs in turkey muscle: Chronic exposure doses calculated for children based on maximum PCB levels detected in turkey muscle were higher than the corresponding health guideline CVs (see Table 6). The most commonly observed non-cancer health effects in individuals exposed to large amounts of PCBs are skin conditions such as acne and rashes (ATSDR 1992b). Occupational exposure studies have shown changes in blood and urine that may indicate liver damage. Animals administered with small exposure doses for several weeks or months developed health effects including anemia, acne-like skin conditions, and liver, stomach, and thyroid gland injuries. Additional health effects in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects.

Based on the mean concentration of PCBs (i.e., Aroclor 1260) detected in the turkey muscle sample, the chronic exposure dose calculated for children (i.e., 0.000027 mg/kg/day) also exceeded the EPA RfD_o (see Table 6). Although the toxicity assessment information for Aroclor 1260 is unavailable, the relevant information for Aroclor 1254 are available and the likely health implications of consuming Aroclor 1260 contaminated turkey muscle may be evaluated using the Aroclor 1254. The LOAEL and the uncertainty factor for Aroclor 1254 are 0.005 mg/kg/day and 300, respectively and is based on ocular exudate, inflamed and prominent meibomian glands, distorted growth of finger and toe nails and decreased antibody response to sheep erythrocytes. Based on the mean Aroclor 1260 concentration detected in the turkey muscle, the child exposure dose was about 185 times (based on Aroclor 1254) lower than the LOAEL. As such, it is unlikely that non-cancer health effects from PCBs would occur in residents consuming turkey meat from the contaminated area.

Impact of Biota Consumption on Blood Lead Levels

As indicated earlier, the USEPA/Pace Analytical and Severn Trent laboratory values for game animals were used to estimate the contribution of game animal consumption to fetal, child and adult blood lead intake and blood lead levels.

Lead Concentrations in Game Animals: The mean wet weight basis concentrations of lead in game animal meat were calculated using dry weight and solids content (see Table 7). For specimens with lead concentrations below the reporting limit, a value of one-half the reporting limit was assumed. This approach is consistent with the protocol for handling “non-detect” values in other environmental media. Since average lead concentrations in muscle meat among the four game animal species at the site were similar, the average concentration from all species, 0.03 mg/kg, was chosen to represent game meat lead levels in this analysis. It should be noted that this average value is based largely on one-half the reporting limit, rather than on detected values.

***Adult and Child Blood Lead Models, Site-specific and Default Parameters*:** The NJDHSS and ATSDR modified the USEPA’s Adult Lead Methodology model (USEPA 2005) to include the capability to account for contributions of lead intake from the diet. Based on adult meat consumption and other input parameters (see Table 8), the model was used to predict both fetal and adult blood lead levels.

The NJDHSS and ATSDR used the USEPA’s Integrated Exposure Uptake Biokinetic (IEUBK, Build 264) model to predict children’s lead intake and resulting blood lead levels, based on children’s meat consumption (USEPA 2007b). The parameters used in the IEUBK model are described in Table 9.

In both models, default model parameters were used except the following, which were site-specific:

Soil lead: In order to account for the exposure to incidental ingestion of soil, site-specific soil concentrations from a limited number of residential properties were evaluated, and a conservative value of 350 milligrams of lead per kilogram of soil (mg/kg) was used in the model. In the IEUBK model, a lead concentration of 200 mg/kg was assumed for indoor dust.

Consumption rates and exposure periods, Modified ALM Model: For the purpose of these analyses, it was conservatively assumed that when game animals are eaten, it comprises the entire meat consumption for the day. The model was run for the average (median), 95^{th} percentile, and 99^{th} percentile meat consumption quantity for adult populations in the northeast U.S. (USEPA 1997). The median meat consumption quantity by adults is 130 grams (4.6 ounces, or between one-quarter and one-third of a pound) per day; the high (95^{th} percentile) meat consumption quantity by adults is 350 grams (12.3 ounces, or about three-quarters of a pound) per day, and the very high (99^{th} percentile) amount is 580 grams (20.6 ounces, or between one and one-quarter and one and one-third pounds) per day. Since exposure to Native Americans is of concern at the Ringwood Mines/Landfill Superfund site, national meat consumption quantities for Native Americans were also considered. However, since these consumption quantities are slightly less than those for northeast U.S. populations, this evaluation of exposure to lead in meat used the higher consumption rates for the northeast U.S. Since game meat may be frozen for later consumption, an exposure period of 365 days was assumed for analysis of wild game consumption.

Background Diet, IEUBK Model: The most recent FDA total dietary lead intake estimates were downloaded from the USEPA IEUBK web site and used in the model (USEPA 2008).

Alternate Intake from Biota Consumption, IEUBK Model: Lead intake from biota was included in the model through the Alternate Intake module. Lead intake was calculated by age by multiplying default values for meat consumption rates by the mean concentration of lead in game meat. The default meat consumption rates increased with age, ranging between 30 and 121 grams of meat per day for children aged up to seven years. These daily intake values were then multiplied by the proportion of days on which game meat is eaten, to result in an adjusted daily intake over the exposure period.

Modeling Objectives: The modified ALM model was run to predict the *average fetal blood lead levels and the percent that would exceed 10 micrograms of lead per deciliter of blood (µg/dL)*, for median and upper percentile meat consumption rates, varying frequencies of meal consumption, and the distribution of background exposures to other sources of lead. For this analysis, the fetal blood lead level of concern is taken to be the same as the one for children established by the U.S. Centers for Disease Control and Prevention (CDC 1991). The goal was to identify whether game meat consumption frequencies would result in no more than a five percent chance that a fetal blood lead level would exceed this level of concern. This approach is consistent with the application of the ALM model to set site-specific remediation goals for soil lead concentrations. Similarly, the ALM model was run to predict the *average adult blood lead* *levels and the percent that would exceed 25 µg/dL*. The U.S. Department of Health and Human Services has a goal to reduce adult blood lead concentrations below this level (CDC 1991).

The IEUBK Model was run to predict the *average blood lead levels in children (aged 12 to 84 months) and the percent that would exceed 10 µg/dL*, for varying frequencies of meat consumption, and taking into account the distribution of background exposures to other sources of lead. Because of the importance of lead in soil and dust in total exposure to lead in children, the IEUBK Model was also used to *estimate the relative contribution of lead in game animals to overall lead exposure*.

Results of Modified ALM and IEUBK Models

Adult Blood Lead Levels**:** As shown in Table 10, eating game meat does not substantially affect adult blood levels at median, high (95^{th} percentile) and very high (99^{th} percentile) meat consumption quantities, if eaten as often as weekly (365 days per year).

Fetal Blood Lead Levels**:** Table 11 shows that, at median, high (95^{th} percentile), and very high (99^{th} percentile) maternal game meat consumption quantities, fetal blood lead levels are not substantially affected at meat consumption frequencies as often as weekly (52 times per year). At high and very high meat consumption quantities, the consumption frequency would have to be 320 and 193 times per year, respectively, for 5% of fetal blood lead levels to exceed 10 µg/dL (not shown in table).

Children Blood Lead Levels**:** The potential risk for children residing in the area who were exposed to site related contaminants was evaluated. The modeled blood lead levels at varying consumption frequencies and standard default meat intake rate indicated that game meat ingestion does not substantially affect child blood lead levels (see Table 12). A comparison of the relative contribution of each lead exposure source shows that lead from residential soil and associated dust, based on site-specific assumptions, would be the largest contributor to blood lead levels in children (see Figure 3). This finding emphasizes the importance of characterizing levels of lead in residential soils and dusts, and taking appropriate control measures as necessary at the site.

Cancer Health Effects

The site-specific lifetime excess cancer risk (LECR) indicates the cancer potential of contaminants. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 46 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of several common types of cancer ranges approximately between 1 in 100 and 10 in 100 (SEER 2005). Typically, health guideline CVs developed for carcinogens are based on a lifetime risk of one excess cancer case per 1,000,000 individuals. ATSDR considers estimated cancer risks of less than one additional cancer case among one million persons exposed as insignificant or no increased risk (expressed exponentially as 10^{-6}).

According to the United States Department of Health and Human Services (USDHHS), the cancer class of contaminants detected at a site is as follows:

1 = Known human carcinogen
2 = Reasonably anticipated to be a carcinogen
3 = Not classified

Lead has been classified as a carcinogen by the USDHHS[10] and the USEPA[11]. The carcinogenicity of inorganic lead and lead compounds has been evaluated by the USEPA (USEPA 1986, 1989). The USEPA has determined that data from human studies are inadequate for evaluating the carcinogenicity of lead, but there are sufficient data from animal studies which demonstrate that lead induces renal tumors in experimental animals. In addition, there are some animal studies which have shown evidence of tumor induction at other sites (i.e., cerebral gliomas; testicular, adrenal, prostate, pituitary, and thyroid tumors). A cancer slope factor has not been derived for inorganic lead or lead compounds, so no estimation of LECR can be made for lead exposure.

Exposure doses for cancer risk assessment were calculated using the following formula:

$$\textit{Cancer Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF}{BW} \times \frac{ED}{AT}$$

where C = concentration of contaminant in game animals (mg/kg);
IR = meat ingestion rate (kg/day);
EF = exposure factor representing the site-specific exposure scenario;
ED = exposure duration (year);
BW = body weight (kg); and,
AT = averaging time (year).

The cancer class of the contaminants detected in on-site areas is given in Table 13. The table shows that arsenic and bis(2-ethylhexyl) phthalate in deer muscle, arsenic in deer liver and squirrel muscle and PCBs in turkey are carcinogens. Based on maximum concentration of arsenic, bis(2-ethylhexyl) phthalate and PCBs concentration and an exposure duration of 30 years, the LECR varied from is 2 in 10,000,000 to 7 in 100,000 to the exposed population. Based on mean (i.e., the more likely exposure scenario) concentration of arsenic, bis(2-ethylhexyl) phthalate and PCBs concentration, the cumulative LECR is 9 in 100,000 to the exposed population (see Table 13); which is considered to pose a low increased LECR, compared to the background risk of cancer from all causes.

---

[10]Lead and Lead Compounds are listed in the Eleventh Edition of the Report on Carcinogens as "reasonably anticipated to be human carcinogens" (NTP 2006).
[11]Probable human carcinogen (B2).

Child Health Considerations

The NJDHSS and ATSDR recognize that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination in their environment. Children are at greater risk than adults from certain types of exposures to hazardous substances. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most important, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

The NJDHSS and ATSDR evaluated the potential risk for children residing in the area who were exposed to site contaminants. The modeled blood lead levels at varying consumption frequencies and standard default meat intake quantities indicated that game meat ingestion does not substantially affect child blood lead levels (see Table 12). A comparison of the relative contribution of each lead exposure source shows that lead from residential soil and associated dust, based on site-specific assumptions, would be the largest contributor to blood lead levels in children (see Figure 3). This finding emphasizes the importance of characterizing levels of lead in residential soils and dusts, and taking appropriate control measures as necessary at the site.

Conclusions

The NJDHSS and ATSDR have reached three conclusions in this Health Consultation:

1) NJDHSS and ATSDR cannot conclude whether eating wild carrots from the Ringwood Mines/Landfill site could harm people's health. The reason for this is that data for wild carrots from the reference area in Ringwood State Park were not consistent with known background levels, casting doubt on the accuracy of the reference area and site data.

Lead levels detected in wild carrot composites from the Ringwood State Park reference area were much higher than would be expected based on the low levels of lead in soil at the Park. These results were also orders of magnitude higher than levels reported as background in carrots in other studies and by the U.S. Food and Drug Administration (FDA) Total Diet Study.

2) NJDHSS and ATSDR conclude that eating game animals (deer, squirrel, rabbit and turkey) at the Ringwood Mines/Landfill site should not harm people's health.

USEPA and NJDEP contract laboratories produced discrepant test results for game animals. Based on adequate reporting limits and consistency of results for reference area deer with FDA Total Diet Study data for beef, the USEPA's laboratory data were chosen for evaluation in this Health Consultation. Using these data, the estimated average or maximum intakes of metals and organic chemicals are either below ATSDR's minimal risk levels or known effect levels for non-cancer effects. The lifetime excess cancer risk from exposure to site-related chemicals of concern is estimated to be low in comparison to the background cancer risk.

Based on lead exposure models, consumption of game animals collected from the Ringwood Mines/Landfill site does not substantially affect the blood lead levels of fetuses, children or adults.

3) Currently, the primary source of lead exposure in children is likely to be residential soils and associated dusts.

IEUBK model results indicate that lead from residential soils and associated dusts, based on site-specific assumptions, would be the largest contributor to blood lead levels in children.

Recommendations

1. The USEPA should consider additional sampling and testing of wild carrots at the site and the reference area. This testing should employ methods that result in reporting limits with adequate sensitivity and that allow comparison to FDA Total Diet Study or other appropriate data. Until such testing is completed, the ATSDR and NJDHSS recommend against consuming plants from the on-site Ringwood Mines/Landfill areas.

2. The NJDEP should withdraw the advisory regarding squirrel consumption at the Ringwood Mines/Landfill site.

3. Efforts to characterize lead levels in residential soils and dusts should continue, and remedial measures should be implemented as needed.

Public Health Action Plan

The purpose of a PHAP is to ensure that this public health assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR and NJDHSS to follow up on this plan to ensure that it is implemented. The public health actions to be implemented by the NJDHSS and the ATSDR are as follows:

Actions Undertaken

1. NJDHSS and ATSDR prepared a draft Public Health Assessment that recommended testing of biota consumed by area residents for evaluating the biota exposure pathway associated with site-related contaminants.

2. Based on concern about initial validated data on lead in a squirrel from the O'Connor Disposal area on site, NJDHSS, ATSDR, NJDEP and USEPA recommended against consumption of squirrels from the site. Subsequently, USEPA discovered that the

specimen was contaminated during sample preparation, and the community was notified of the error.

3. NJDHSS and ATSDR attend Ringwood Community Advisory Group (CAG) and other public meetings with local residents.

Actions Planned

1. Copies of this Health Consultation will be provided to concerned residents in the vicinity of the site via direct mail, the township library and the Internet.

2. NJDHSS and ATSDR will discuss the findings of this report at a Ringwood CAG meeting, and address any community concerns.

3. NJDHSS and ATSDR will evaluate additional, relevant data when it becomes available.

Preparers of Report:

Jerald Fagliano, MPH, PhD
Health Science Specialist/Program Manager
New Jersey Department of Health and Senior Services

Tariq Ahmed, PhD, PE, BCEE
Research Scientist
New Jersey Department of Health and Senior Services

ATSDR Regional Representatives:

Leah T. Graziano, R.S.
Senior Regional Representative

ATSDR Technical Project Officer:

Gregory V. Ulirsch, MS, PhD
Technical Project Officer
Superfund Site Assessment Branch
Division of Health Assessment and Consultation

Any questions concerning this document should be directed to:

Hazardous Site Health Evaluation Program
Consumer and Environmental Health Services
Division of Epidemiology, Environmental and Occupational Health
New Jersey Department of Health and Senior Services
P.O. Box 369
Trenton, New Jersey 08625-0369
(609) 584-5367

References

Alegria, A, Barbera, R, Boluda, R, Errecalde, F, Farre, R, and Lagarda, MJ. 1991. Environmental cadmium, lead and nickel contamination: possible relationship between soil and vegetable content. Fresenius' Journal of Analytical Chemistry, vol. 339, page 654-657, 1991.

Alegria, A, Barbera, R, Farre, R, Lagarda, MJ, Roig, MJ and Romero, I. 1990. Evaluation of Antimomy, Cadmium, and Lead Levels in Vegetables, Drinking and Raw Water from Different Agricultural Areas. International Journal Environmental Analytical Chemistry, vol. 38, page 65-73, 1990.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1992a. Toxicological profile for Thallium. US Department of Health and Human Services, Atlanta, Georgia, July, 1992.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1992b. Toxicological profile for Polychlorinated Biphenyls. US Department of Health and Human Services, Atlanta, Georgia, September, 1992.

[ATSDR] Agency for Toxic Substances and Disease Registry 2002. Impact of Hazardous Chemicals on Public Health, Policy, and Service. Edited by: De Rosa, CT, Holler, JS and Mehlman, MA. US Department of Health and Human Services, Atlanta, Georgia., ISBN: 0-97121-66-0-6, International Toxicology Books, Inc, Princeton, NJ.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual. US Department of Health and Human Services, Atlanta, Georgia.

[ATSDR] Agency for Toxic Substances and Disease Registry 2006a. Public Health Assessment for the Ringwood Mines/Landfill Site, Borough of Ringwood, Passaic County, New Jersey (Draft for Public Comment). US Department of Health and Human Services, Atlanta, GA, May 1, 2006.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2006b. Toxicological profile for Lead. US Department of Health and Human Services, Atlanta, Georgia.

Becker, JS. 2005. Trace and Ultratrace Analysis in liquid by atomic spectrometry. Trends in Analytical Chemistry, vol. 24, No. 3, page 243-254, 2005.

Bunzl, K, Trautmannsheimer, M, Schramel, P and Reinfenhauser, W. 2001. Availability of Arsenic, Copper, Lead, and Zinc to various Vegetables Grown in Slag-Contaminated Soils. Journal of Environmental Quality, vol. 30, page 934-939, 2001.

[CDC] Centers for Disease Control. 1991. Preventing lead poisoning in young children. U.S. Department of Health and Human Services, October.

De Pieri, LA, Buckley, WT and Kowalenko, GG. 1997. Cadmium and Lead concentrations of commercially grown vegetables and of soils in the Lower Fraser Valley of British Columbia. Canadian Journal of Soil Science, vol. 77, no. 1, page 51-57, February, 1997.

[FDA] Food and Drug Administration 2007. Total Diet Study Statistics on Element Results, Revision 4.1, Market Baskets 1991-3 through 2005-4. U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition, College Park, MD, December 11, 2007. Accessed online at: http://www.cfsan.fda.gov/~acrobat/tds1byel.pdf.

Gowers, J, personal communication, September 11, 2007. E-mail from Joe Gowers, USEPA, to Leah Escobar [Graziano], ATSDR. Subject: Laboratory conference call - Ringwood Mines site, with attached file: Analytical sample variability issues.doc by Mark Sprenger, USEPA.

Hooda, PS, McNulty, D, Alloway, BJ and Aitken, MN. 1997. Plant availability of heavy metals in soils previously amended with heavy applications of sewage sludge. Journal of the Science of Food and Agriculture, vol 73, page 446-454, 1997.

[NJDEP] New Jersey Department of Environmental Protection 2007a. Advisory for the Consumption of Squirrels from the Ringwood Mines/Landfill Superfund Site. New Jersey Department of Environmental Protection, January 23, 2007.

[NJDEP] New Jersey Department of Environmental Protection 2007b. Ringwood Mines Landfill Superfund Site, NJDEP Biota Sample Analytical Results Summary. New Jersey Department of Environmental Protection, October 2007.

[NJDHSS] New Jersey Department of Health and Senior Services 2007. Memorandum from Jerald Fagliano, NJDHSS Hazardous Site Health Evaluation Program to Ken Petrone, NJDEP Site Remediation and Waste Management. Basis for Advisory on Squirrel Meat Consumption, Ringwood Mines/Landfill Superfund Site, January 16, 2007.

[NTP] National Toxicology Program. 2006. 11th Report on Carcinogens. Accessed April 18, 2006, at: http://ntp.niehs.nih.gov/

Pendergrass, A and Butcher, DJ. 2006. Uptake of lead and arsenic in food plants grown in contaminated soil from Barber Orchard, North Carolina. Microchemical Journal, vol 83, page 14-16, 2006.

Salim, R, Al-Subu, AA, Douleh, A, Chenavier, L and Hagemeyer, J. 1992. Effects of Root and Foliar Treatments of Carrot Plants with Lead and Cadmium on the Growth, Uptake and the Distribution of Uptake of Metals in Treated Plants, Journal of Environmental Science and Health, vol. A27, No. 7, page 1739-1758, 1992.

Samsoe-Peiersen, L, Larsen EH, Larsen, PB and Bruun, P. 2002. Uptake of Trace Elements and PAHs by Fruit and Vegetables from Contaminated Soils. Environmental Science and Technology, vol 36, page 3057-3063, 2002.

[SEER] Surveillance Epidemiology and End Results 2005. SEER Cancer Statistics Review, 1975 - 2002. Accessed February 3, 2006 at: http://seer.cancer.gov/csr/1975_2002/.

[USEPA] United States Environmental Protection Agency 1986. Air Quality Criteria for Lead. Environmental Criteria and Assessment Office, Office of Research and Development, Research Triangle Park, N.C. EPA 600/8-83-028 a-f, June 1986.

[USEPA] United States Environmental Protection Agency 1989. Evaluation of the Potential Carcinogenicity of Lead and Lead Compounds. Office of Health and Environmental Assessment. EPA/600/8-89/045A.

[USEPA] U.S. Environmental Protection Agency 1997. Exposure Factors Handbook, Volume II: Food Ingestion Factors. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, August 1997.

[USEPA] U.S. Environmental Protection Agency 2005. Adult Lead Methodology, version date May 19, 2005. U.S. Environmental Protection Agency. Available online at: http://www.epa.gov/superfund/health/contaminants/lead/products.htm

[USEPA] U.S. Environmental Protection Agency 2007a. USEPA summary data tables, Ringwood Biological Sampling Site, Ringwood, NJ. U.S. Environmental Protection Agency, October 2007.

[USEPA] U.S. Environmental Protection Agency 2007a. Integrated Exposure Uptake Biokinetic Model for Lead in Children, 32-bit Windows version (IEUBKwin v1.0 build 264). U.S. Environmental Protection Agency, August 2007. Available online at: ttp://www.epa.gov/superfund/health/contaminants/lead/products.htm

[USEPA] U.S. Environmental Protection Agency 2007b. Integrated Exposure Uptake Biokinetic Model for Lead in Children, 32-bit Windows version (IEUBKwin v1.0 build 264). U.S. Environmental Protection Agency, August 2007. Available online at: ttp://www.epa.gov/superfund/health/contaminants/lead/products.htm

[USEPA] U.S. Environmental Protection Agency 2008. Recent Food and Drug Administration (FDA) dietary lead in food data. U.S. Environmental Protection Agency. Available online at: http://www.epa.gov/superfund/health/contaminants/lead/ieubkfaq.htm#FDA

[USEPA] U.S. Environmental Protection Agency 2009a. Draft Final Report of Data Summary: Ringwood Biological Sampling, Ringwood Paint Site, Ringwood, New Jersey. U.S. EPA Contract No.: EP-C-04-032, February 2009.

[USEPA] U.S. Environmental Protection Agency 2009b. Appendix F: Partition Coefficient for Lead, Available online at: http://www.epa.gov/rpdweb00/docs/kdreport/vol2/402-r-99-004b_appf.pdf.

Zandstra, BHI and De Kryger, T. 2007. Arsenic and Lead residue in carrots from foliar application of monosodium methanearsonage (MSMA): A comparison between mineral and organic soils, or from soil residues. Food Additives and Contaminants, vol. 24, No. 1, page 34-42, January 2007.

Certification

This Health Consultation was prepared by the New Jersey Department of Health and Senior Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the Health Consultation was initiated.

Gregory V. Ulirsch, MS, PhD
Technical Project Officer, CAT, CAPEB, DHAC
Agency for Toxic Substances and Disease Registry

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with its findings.

Alan Yarbrough
Team Leader, CAT, CAPEB, DHAC
Agency for Toxic Substances and Disease Registry

Table 1: Details of Biota Specimen Collection at the Ringwood Mines/Landfill Site

Species (Location)	No. of Specimens Collected	Collection Months	Agency/Contract Laboratory	Number of Specimens Tested	Analytes	Excitation Instrument and Detector used for Metals
Wild Carrot (O'Connor Disposal Area, Peter's Mine Pit, and SR-6)	9 composites, 3 from each site area[a]	September 2006	USEPA/ Lockheed Martin	9	Metals, PCBs SVOCs	ICP - AES
Wild Carrot (Reference)	3 composites	September 2006	USEPA/ Lockheed Martin	3	Metals, PCBs SVOCs	ICP - AES
Squirrel (O'Connor Disposal Area)	6	October 2006	USEPA/Pace Analytical[b]	6	Metals	ICP - MS
			NJDEP/Chemtech	5	Metals, PCBs	ICP - AES
	3	March 2007	USEPA/Pace Analytical	3	Metals, PCBs, SVOCs	ICP - MS
			NJDEP/Chemtech	3	Metals, PCBs	ICP - AES
Deer (O'Connor Disposal Area)	3	January 2007	USEPA/Severn Trent	3	Metals, PCBs, SVOCs	ICP - MS
			NJDEP/Chemtech	3	Metals, PCBs	ICP - AES
Deer (Reference Area)	10	February 2007	USEPA/Severn Trent	10	Metals, PCBs, SVOCs	ICP - MS
			NJDEP/Chemtech	2	Metals, PCBs	ICP - AES
Rabbit (O'Connor Disposal Area)	3	March 2007	USEPA/Pace Analytical	3	Metals, PCBs SVOCs	ICP - MS
			NJDEP/Chemtech	2	Metals, PCBs	ICP - AES

Table 1: (Contd.)

Species (Location)	No. of Specimens Collected	Collection Months	Agency/Contract Laboratory	Number of Specimens Tested	Analytes	Excitation Instrument and Detector used for Metals
Turkey (O'Connor Disposal Area)	5	March 2007	USEPA/Pace Analytical	5	Metals, PCBs, SVOCs	ICP – MS
			NJDEP/Chemtech	2	Metals, PCBs	ICP - AES

[a]Wild carrot specimens were composited since individual carrots were too small for analysis; [b]Reanalyses of squirrel specimens. The six squirrels had previously been tested for the USEPA by the USEPA/ Lockheed Martin laboratory.

Table 2: USEPA wild carrot test results (in milligrams of analyte per kilogram of tissue; dry weight basis) from the Ringwood Mines/Landfill site (Peter's Mine Pit, O'Connor Disposal Area, and SR-6) and reference areas. Sources: USEPA 2009

Analyte	Range of Concentrations in Wild Carrot Roots			
	Wild Carrot (Reference) N[a] = 3	Wild Carrot (Peter's Mine Pit) N = 3	Wild Carrot (O'Connor Disposal) N = 3	Wild Carrot (SR-6) N = 3[b]
Antimony	<3.3 - <4.0	<3.6 - <5.1	<3.5 - <5.1	<3.5 - <4.1
Arsenic	<3.6 - <4.3	<3.8 - <5.5	<3.8 - <5.5	<3.8 - <4.4
Cadmium	<1.1 - 1.3	<1.2 - 1.7	<1.3 - 3.1	<1.0 - 1.5
Chromium	<1.2 - 1.4	<1.3 - 1.8	<1.2 - 1.8	<1.3 - 1.9
Copper	5.2 – 13	9.8 – 18	7.1 – 14	6.9 – 11
Lead	<2.4 – 13	3.6 – 28	6.6 – 48	3.6 – 12
Thallium	<4.0 - <4.8	<4.4 - <6.2	<4.2 - <6.2	<4.3 - <5.0
PCBs[c]	<0.42 - <0.57	<0.42 - <0.57	<0.46 - <0.69	<0.33 - <0.78
Bis(2-ethylhexyl)phthalate	<2.6 - <6.2	1.0 J[d] - <4.8	1.6 J - <4.6	<2.9 - <6.4
Benzo(a)pyrene	<2.6 - <6.2	<2.8 - <4.8	<3.3 - <4.6	<2.9 - <6.4

[a]Number of specimens (composites) tested; [b]At this location, one composite was analyzed in duplicate. For this table, both results are considered in the range; [c]Reporting limits for all Aroclors except Aroclor 1221, whose reporting limit was twice that of the others; [d]Estimated value

Table 3: NJDEP Game Animal Test Results (in milligrams of analyte per kilogram of tissue; dry weight basis) from the O'Connor Disposal Area and reference area (Sources: NJDEP 2007)

Analyte	Range of Concentrations in Game Animal Tissue (mg/kg) (Location) Number of Specimens Tested						
	Deer Liver (Reference) N[a]=2	Deer Liver (O'Connor Disposal) N=2	Deer Muscle (Reference) N=2	Deer Muscle (O'Connor Disposal) N=3	Squirrel Muscle (O'Connor Disposal) N=8	Rabbit Muscle (O'Connor Disposal) N=2	Turkey Muscle (O'Connor Disposal) N=2
Antimony	2.4 J[b] - 4.4 J	2.4 J - 3.5 J	3.4 J – 4.0 J	1.4 J - 2.8 J	0.67 J - 2.6 J	1.7 J - 2.5 J	2.3 J - 2.5 J
Arsenic	<7.0 - <8.0	<7.4 - <7.4	<7.5 - <7.7	<7.2 - <7.4	<2.3 - <8.5	<7.2 - <7.4	<6.8 - <6.9
Cadmium	<0.88 - <1.0	<0.92 - 3.1	<0.94 - <0.97	<0.90 - <0.93	<0.29 - <1.1	<0.90 - <0.93	<0.86 - <0.86
Chromium	2.1 - 2.9	2.4 – 4.0	2.0 - 2.1	1.3 J - 4.2	0.55 J - 6.8	1.4 J - 2.7	1.4 J - 1.4 J
Copper	128 - 161	107 - 245	7.4 - 7.7	6.4 - 8.9	1.6 - 8.1	4.2 - 4.8	3.4 J - 4.2
Lead	3.6 – 4.0	4.4 - 4.5	2.1 J - 3.1	0.9 J - 1.9 J	0.66 J - 3.7	1.2 J - 2.2 J	1.9 J - 2.2
Thallium	<1.8 - <2.1	<1.9 - <1.9	<2.0 - <2.0	<1.9 - <2.0	<0.60 - <2.2	<1.9 - <2.0	<1.8 - <1.8
PCBs	ND[c]	ND	ND	ND	ND	ND	ND

[a]Number of specimens tested; [b]Estimated value; [c]Not detected; detection limits variable by Aroclor (PCB mixture)

Table 4: USEPA Game Animal Test Results (in milligrams of analyte per kilogram of tissue; dry weight basis) from the O'Connor Disposal Area and reference area (Sources: USEPA 2009)

Analyte	Range of Concentrations in Game Animal Tissue (mg/kg) (Location) Number of Specimens Tested						
	Deer Liver (Reference) N[a] =10[b]	Deer Liver (O'Connor Disposal) N=3	Deer Muscle (Reference) N=10	Deer Muscle (O'Connor Disposal) N=3	Squirrel Muscle (O'Connor Disposal) N=9[c]	Rabbit Muscle (O'Connor Disposal) N=3	Turkey Muscle (O'Connor Disposal) N=5
Antimony	<0.63 – <0.76	<0.43 – <0.5	<0.62 – <0.76	<0.49 – <0.54	<0.16 – <0.25	<0.16 – <0.17	<0.14 – <0.15
Arsenic	0.25 – 0.42	0.31 – 0.48	0.25 J[c]+ – 0.62 J+	0.39 – 0.58	<0.14 – 0.31	<0.14 – <0.15	<0 13 – <0.14
Cadmium	0.21 – 0.84	1.2 – 3.6	<0.04 – <0.05	<0.03 – <0.04	<0.040 – 0.30	<0.040 – 0.42	<0.037 – 0.058
Chromium	0.61 – 0.85	1.8 J – 2.4 J	0.56 – 1.3	1.13 J – 2.5 J	<0.58 – 2.7	0.74 – 0.83	0.65 – 1.4
Copper	42 – 185	86 – 231	4.5 – 8.1	6.5 – 7.4	5.2 – 13	3.4 – 4.9	2.6 – 3.7
Lead	<0.18–<0.22	<0.1 – 0.17	<0.18 – <0.22	<0.12 – <0.13	<0.14 – 0.79	<0.14 – <0.15	<0.12 – <0.13
Thallium	<0.44 J – <0.53 J	<0.35 – <0.42	<0.43 – <0.53	<0.41 – <0.45	<0.066 – 0.28	<0.066 – <0.072	<0.059 – <0.063
PCBs[d]	<0.017 – <0.022	<0.016 – <0.019	<0.018 – <0.021	<0.018 – 0.019	<0.20 – <0.26	<0.20 - <0.21	<0.18 – 0.18
Bis(2-ethylhexyl) phthalate	0.25 J – <0.77 J	<0.65 – <0.74	<0.71 – 2.2 J	0.2 J – <0.75	<1.4 – <5.4 J	<1.3 – <1.4	<1.2 – <1.2
Benzo[a]pyrene	<0.69 – <0.87	(all rejected)	<0.71 – <0.83	<0.70 – <0.77	<1.4 – <5.4 J	<1.3 – <1.4	<1.2 – <1.2

[a]Number of specimens tested; [b]For metals, one (R-1) of the reference deer liver specimen is excluded from ranges since values for many analytes were considered outliers; [c]Estimated value (J-, estimated value with negative bias; J+, estimated value with positive bias); [d]N=3 for PCB and synthetic organic chemicals

Table 5: Lead levels reported in literature as a function of soil lead concentration

Reference	Lead Concentration (mg/kg)		Measurement Technique
	Soil	Carrot[a]	
Bunzl et al. 2001	20 ± 1 (Control) 800 ± 40 (Black Slag) 2740 ± 150 (Red Slag)	0.27 4.1 9.1	Microwave assisted high pressure acid digestion. High resolution ICP-MS.
Algeria et al. 1991	23.21 (Soil #1) 66.09 (Soil #12) 34.47 (Soil #15)	0.16 0.13 0.07	Acid digestion. Graphite Furnace with AA.
Pendergrass and Butcher 2006	<5 (control) 584 ± 27 (cont. soil)	<5 20 ± 11	Acid Digestion. ICP-OES[b]
De Pieri et al. 1997	4.9 to 26.4	0.03 to 0.16[c]	Not Available
Algeria et al. 1990	12.24[d] (µg/L) 38.15 (µg/L) 18.84 (µg/L)	0.16 ± 0.084 0.13 ± 0.025 0.075 ± 0.011	Acid Digestion. Graphite Furnace and hollow cathode lamps.
Salim et al. 1992	Background soil	0.06 (basis unknown)	Acid digestion under pressure and Graphite Furnace with AA
Hooda 1997	70	0.33	
Samsoe-Petersen et al. 2002	20	0.04	Elevated temperature Acid digestion. ICP-AES.
Zandstra and De Kryger 2007	6.52	0.147	Not Available

[a]dry weight basis; [b]Inductively Coupled Plasma – Optical Emissions Spectroscopy; [c]Potato, cabbage, cauliflower, carrot, turnip, corn and lettuce; [d]Water Concentration. Assuming neutral pH conditions, the corresponding soil concentrations (USEPA 2009b) are 32.93 mg/kg, 102.66 mg/kg and 50.61 mg/kg, respectively

Table 6: Comparison of game animal meat consumption exposure doses with health guideline Comparison Values (CVs) for site-related contaminants

Contaminant	Maximum Conc., Wet[a] Weight Basis (mg/kg)	Maximum Exposure Dose (mg/kg/day)		Health Guideline CVs (mg/kg/day)	Potential for Non-cancer Health Effects
		Child[b]	Adult[c]		
Deer Muscle					
Arsenic	0.14	0.00015	0.00010	0.0003 (MRL)	No
Chromium	0.62	0.00064	0.00045	0.003 (RfD)	No
Copper	1.8	0.0019	0.0013	0.01 (Int. MRL)	No
Bis(2-ethylhexyl) phthalate	0.094	0.000096	0.000067	0.02 (EPA RfD_o)	No
Deer Liver					
Arsenic	0.12	0.000028	0.00002	0.0003 (MRL)	No
Cadmium	0.9	0.00021	0.00015	0.001 (RfD)	No
Chromium	0.6	0.000142	0.0001	0.003 (RfD)	No
Copper	58	0.014	0.009	0.04 (EPA RfD_o)	No
Squirrel Muscle					
Arsenic	0.078	0.000079	0.000055	0.0003 (MRL)	No
Cadmium	0.075	0.000076	0.000054	0.0002 (MRL)	No

Table 6: (Contd.)

Contaminant	Maximum Conc., Wet Weight Basis (mg/kg)	Maximum Exposure Dose (mg/kg/day)		Health Guideline CVs (mg/kg/day)	Potential for Non-cancer Health Effects
		Child[a]	Adult[b]		
Squirrel Muscle					
Chromium	0.68	0.00069	0.00048	0.003 (RfD)	No
Copper	3.2	0.0033	0.0023	0.01 (Int. MRL)	No
Thallium	0.07 (0.015)	0.000071 (0.000016)	0.00005 (0.00001)	0.000065 (EPA RfD_o)	**Yes**
Rabbit Muscle					
Antimony	0.021125	0.000021	0.000015	0.0004 (RfD)	No
Cadmium	0.10525	0.000107	0.000075	0.0002 (MRL)	No
Chromium	0.2085	0.000212	0.000149	0.003 (RfD)	No
Copper	1.2225	0.001243	0.000873	0.01 (Int. MRL)	No
Turkey Muscle					
Cadmium	0.014	0.000015	0.000010	0.0002 (MRL)	No
Chromium	0.35	0.00036	0.00025	0.003 (RfD)	No
Copper	0.92	0.00094	0.00066	0.01 (Int. MRL)	No
PCBs	0.045 (0.027)	0.000046 (0.000027)	0.000032 (0.000019)	0.00002 (EPA RfD_o)	**Yes**

[a]Dry weight concentrations are converted to wet weight concentrations assuming 25% percent solids in meat specimens; [b]Child exposure scenario: 1 day/week (muscle meat) or 1 day/month (liver), 121 g/day consumption rate, 17 kg body weight; [c]Adult exposure scenario: 1 day/week (muscle meat) or 1 day/month (liver), 350 g/day consumption rate, 17 kg body weight; [d]Mean concentration

Table 7: Average lead concentrations in specimens from game animals collected from the Ringwood Mines/Landfill site[a]

Species (Location) and Specimen Number	USEPA Contract Laboratory Reported Lead Concentration (mg/kg)			
	Dry Weight Basis (mg/kg)	Percent Solids	Wet Weight Basis (mg/kg)	Concentration for Calculation of Average[b] (mg/kg)
Deer (Reference Area)				
R1 (muscle)	<0.22	25%	<0.055	0.028
R1 (liver)	<0.19	28%	<0.053	0.027
R2 (muscle)	<0.18	28%	<0.050	0.025
R2 (liver)	<0.21	26%	<0.055	0.027
R3 (muscle)	<0.20	27%	<0.054	0.027
R3 (liver)	<0.20	27%	<0.054	0.027
R4 (muscle)	<0.21	26%	<0.055	0.027
R4 (liver)	<0.22	24%	<0.053	0.026
R5 (muscle)	<0.19	26%	<0.049	0.025
R5 (liver)	<0.19	26%	<0.049	0.025
R6 (muscle)	<0.22	25%	<0.055	0.028
R6 (liver)	<0.18	29%	<0.052	0.026
R7 (muscle)	<0.19	28%	<0.053	0.027
R7 (liver)	<0.18	28%	<0.050	0.025
R8 (muscle)	<0.19	27%	<0.051	0.026
R8 (liver)	<0.19	27%	<0.051	0.026
R9 (muscle)	<0.20	26%	<0.052	0.026
R9 (liver)	<0.20	25%	<0.050	0.025
R10 (muscle)	<0.20	26%	<0.052	0.026
R10 (liver)	<0.19	27%	<0.051	0.026
	USEPA Data Estimated Average Concentration (mg/kg, Wet Weight Basis)			**0.026 (muscle)** **0.026 (liver)**
Deer (O'Connor Disposal Area)				
A (muscle)	<0.12	27%	<0.032	0.016
A (liver)	<0.11	29%	<0.032	0.016
B (muscle)	<0.12	29%	<0.032	0.016
B (liver)	0.17	27%	0.046	0.046
C (muscle)	<0.13	26%	<0.034	0.017
C (liver)	<0.10	31%	<0.031	0.016
	USEPA Data Estimated Average Concentration (mg/kg, Wet Weight Basis)			**0.016 (muscle)** **0.026 (liver)**

Table 7: (Contd.)

Species (Location) and Specimen Number	USEPA Contract Laboratory Reported Lead Concentration (mg/kg)			
	Dry Weight Basis (mg/kg)	Percent Solids	Wet Weight Basis (mg/kg)	Concentration for Calculation of Average[b] (mg/kg)
Squirrels (O'Connor Disposal Area)				
OB17-A	<0.14	24%	<0.034	0.017
OB17-B	<0.14	26%	<0.035	0.018
OB17-C	0.24	25%	0.059	0.059
OB17-D	0.41	25%	0.10	0.1
S-7	<0.14	25%	<0.035	0.018
S-8	0.79	25%	0.02	0.2
S-9	0.15	24%	0.036	0.036
SWTP-73A	<0.14	25%	<0.034	0.017
SWTP-73B	<0.14	25%	<0.035	0.018
	USEPA Data Estimated Average Concentration (mg/kg, Wet Weight Basis)			**0.054**
Rabbits (O'Connor Disposal Area)				
B-1	<0.14	26%	<0.035	0.018
B-2	<0.15	24%	<0.036	0.018
B-3	<0.14	26%	<0.035	0.018
	USEPA Data Estimated Average Concentration (mg/kg, Wet Weight Basis)			**0.018**
Turkeys (O'Connor Disposal Area)				
T-1	<0.13	27%	<0.034	0.017
T-2	<0.12	29%	<0.035	0.018
T-3	<0.13	27%	<0.035	0.018
T-4	<0.13	27%	<0.034	0.017
T-5	<0.13	28%	<0.035	0.018
	USEPA Data Estimated Average Concentration (mg/kg, Wet Weight Basis)			**0.018**

[a]USEPA 2009; [b]For detection below reporting limit, a value of one-half the reporting limit is used for calculation of the average

Table 8: Assumptions used in modified USEPA Adult Lead Methodology model for estimation of fetal and adult lead exposure from consumption of game meat at the Ringwood Mines/Landfill site

Model Parameter	Units	Value(s)	Explanation
Soil/Dust Exposure Parameters			
Soil lead concentration	mg/kg	350	Site-specific value[a]
Soil ingestion rate (including soil-derived dust)	g/day	0.05	Model default value
Absorption fraction from soil	--	0.12	Model default value
Exposure frequency for soil	days/yr	350/365	Model default value
Game Meat Exposure Parameters			
Game meat lead concentration	mg/kg	0.03	Mean lead concentration in game meat (See text and Table 7)
Game meat ingestion rate[b]	g/day	130 350 580	Median meat meal for 70 kg person 95th percentile meat meal for 70 kg person 99th percentile meat meal for 70 kg person (USEPA 1997) [a]
Absorption fraction for lead from game meat	--	0.20	Assumed value for food sources
Game meat ingestion frequency	days/yr	Variable	Number of meals varied in models
Other Parameters			
Fetal/maternal blood lead ratio	--	0.9	Model default value
Biokinetic slope factor	µg/dL per µg/day	0.4	Model default value
Baseline blood lead	µg/dL	2.0	Regional default value for northeast states
Geometric standard deviation of blood lead	--	2.0	Regional default value for northeast states

[a]Derived from NJDEP samples on residential properties and reported in Public Health Assessment; [b]Meat consumption data are from Chapter 11, Table 11-1, Per-capita intake of total meats (g/kg-day as consumed). Used 1.9 g for median, 5.0 g for 95th percentile, and 8.3 g for 99th percentile (values for northeast region), multiplied by 70 kg body weight (USEPA 1997).

Table 9: Assumptions used in USEPA IEUBK model for estimation of children's lead exposure from consumption of game meat at the Ringwood Mines/Landfill site. (Default model parameters were used for all other parameters not included in this table)

Model Parameter	Units	Value(s)	Explanation
Soil/Dust, Drinking Water and Outdoor Air Exposure Parameters			
Soil lead concentration	mg/kg	350	Site-specific value *
Indoor dust lead concentration	mg/g	200	Set at constant value in model
Soil and dust ingestion rate	g/day	0.085 to 0.135	Model default values varying with age
Proportion lead accessible from soil and dust	--	0.30	Model default value
Drinking water lead concentration	μg/L	4	Model default value
Drinking water intake	L/day	0.2 to 0.59	Model default values varying with age
Outdoor air lead concentration	$\mu g/m^3$	0.1	Model default value
Ventilation rate	m^3/day	2 to 7	Model default values varying with age
Game Meat Exposure Parameters			
Game meat lead concentration	mg/kg	0.03	Mean lead concentration in game meat (See text and Table B-1)
Game meat ingestion rate	g/day	30 to 121	Model default values varying with age
Proportion lead accessible from game meat	--	0.50	Model default value
Game meat ingestion frequency	days/yr	Variable	Values may range from 1 to 365 days/yr
Averaging time for game meat consumption	days/yr	365	Model default value
Other Parameters			
Mother's blood lead level at childbirth	μg/dL	2.5	Model default value

*Derived from NJDEP samples on residential properties and reported in draft Public Health Assessment.

Table 10: Estimated average (geometric mean) adult blood lead level and percent of adult blood lead levels exceeding 25 µg/dL from consumption of game meat at the Ringwood Mines/Landfill site using modified USEPA Adult Lead Methodology model

Game Meat Lead Concentration (mg/kg)	Meat Meal Ingestion Rate (g/day)	Adult Blood Lead Measure	Game Meat Meal Consumption Frequency (number of meals in a 365-day period)				
			0	12	24	52	365
0.03	130 (median)	% > 25 µg/dL	0.1%	0.1%	0.1%	0.1%	0.1%
		Average µg/dL	2.8	2.8	2.8	2.8	3.1%
	350 (95th percentile)	% > 25 µg/dL	0.1%	0.1%	0.1%	0.1%	0.3%
		Average µg/dL	2.8	2.8	2.9	2.9	3.6%
	580 (99th percentile)	% > 25 µg/dL	0.1%	0.1%	0.1%	0.1%	0.5%
		Average µg/dL	2.8	2.9	2.9	3.0	4.2%

Note: Exposure scenarios do not result in exceedance of adult blood lead limits: Fewer than 5% of values should be above 25 µg/dL.

Table 11: Estimated average (geometric mean) fetal blood lead level and percent of fetal blood lead levels exceeding 10 µg/dL from consumption of game meat at the Ringwood Mines/Landfill site using modified USEPA Adult Lead Methodology model

Game Meat Lead Concentration (mg/kg)	Meat Meal Ingestion Rate (g/day)	Fetal Blood Lead Measure	Game Meat Meal Consumption Frequency (number of meals in a 365-day period)				
			0	12	24	52	365
0.03	130 (median)	% > 10 µg/dL	2.4%	2.4%	2.4%	2.5%	3.3%
		Average µg/dL	2.5	2.5	2.5	2.6	2.8%
	350 (95th percentile)	% > 10 µg/dL	2.4%	2.4%	2.5%	2.7%	5.4%
		Average µg/dL	2.5	2.5	2.6	2.6	3.3%
	580 (99th percentile)	% > 10 µg/dL	2.4%	2.5%	2.6%	3.0%	8%
		Average µg/dL	2.5	2.6	2.6	2.7	3.8%

Note: Exposure scenarios do not result in exceedance of fetal blood lead limits: Fewer than 5% of values should be above 10 µg/dL

Table 12: Estimated average (geometric mean) blood lead level and percent of child (age 12 to 84 months) blood lead levels exceeding 10 µg/dL from consumption of game meat at the Ringwood Mines/Landfill site using USEPA IEUBK Model

Game Meat Lead Concentration (mg/kg)	Child Blood Lead Measure	Game Meat Meal Consumption Frequency (number of meals in a 365-day period)				
		0	12	24	52	365
0.03	% > 10 µg/dL	1.8%	1.8%	1.9%	1.9%	3.1%
	Average µg/dL	3.7	3.7	3.8	3.8	4.2%

Note:Exposure scenarios do not result in exceedance of child blood lead limits: Fewer than 5% of values should be above 10 µg/dL.

Table 13: Calculated lifetime excess cancer risks associated with contaminants detected in game animal meat

Contaminant	Maximum Conc., Wet Weight Basis (mg/kg)	DHHS[a] Cancer Class	Exposure Dose[b] (mg/kg/day)	CSF[c] $(mg/kg/d)^{-1}$	LECR[d]
Deer Muscle					
Arsenic	0.14	1	0.000042	1.5	6.4×10^{-5} (5.7×10^{-5})[e]
Bis(2-ethylhexyl) phthalate	0.094	2	0.000028	0.014	4×10^{-7} (3.5×10^{-7})
Deer Liver					
Arsenic	0.12	1	0.0000085	1.5	1.28×10^{-5} (1.04×10^{-5})
Squirrel Muscle					
Arsenic	0.078	1	0.000024	1.5	3.5×10^{-5} (1.1×10^{-5})
Turkey Muscle					
PCBs	0.045	2	0.000014	2	2.7×10^{-5} (1.6×10^{-5})
			Cumulative Risk	=	1.4×10^{-4} (9.5×10^{-5})

[a]U.S Department of Health and Human Services Cancer Class: 1 = known human carcinogen; 2 = reasonably anticipated to be a carcinogen; [b]Exposure scenario: 1 day/week (muscle meat) or 1 day/month (liver), 350 g/day consumption rate, 70 kg body weight and 30 year exposure duration; [c]Cancer Slope Factor; [d]Lifetime Excess Cancer Risk; [e]Cumulative cancer risk based on mean concentration

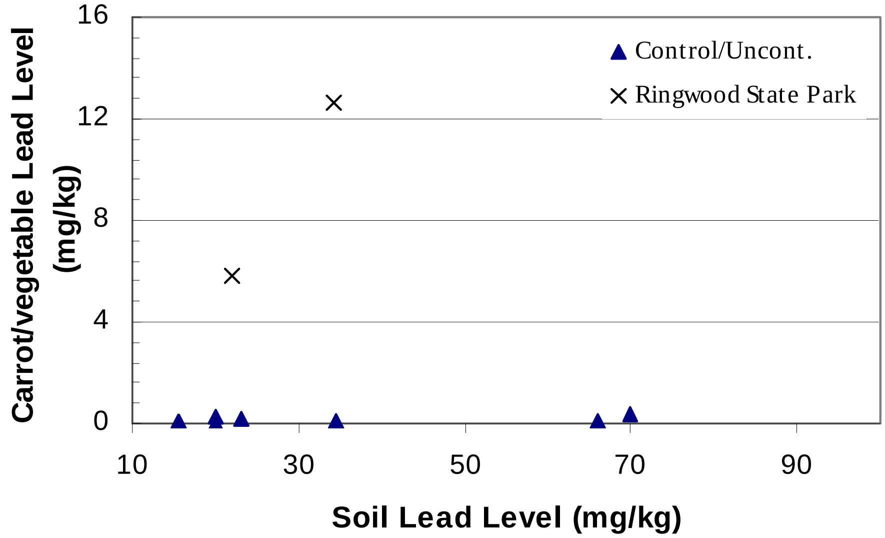

Figure 1: Carrot lead level versus soil lead level of Ringwood Mines/Landfil site and other studies reported in the literature (levels reported as below detection level was not plotted)

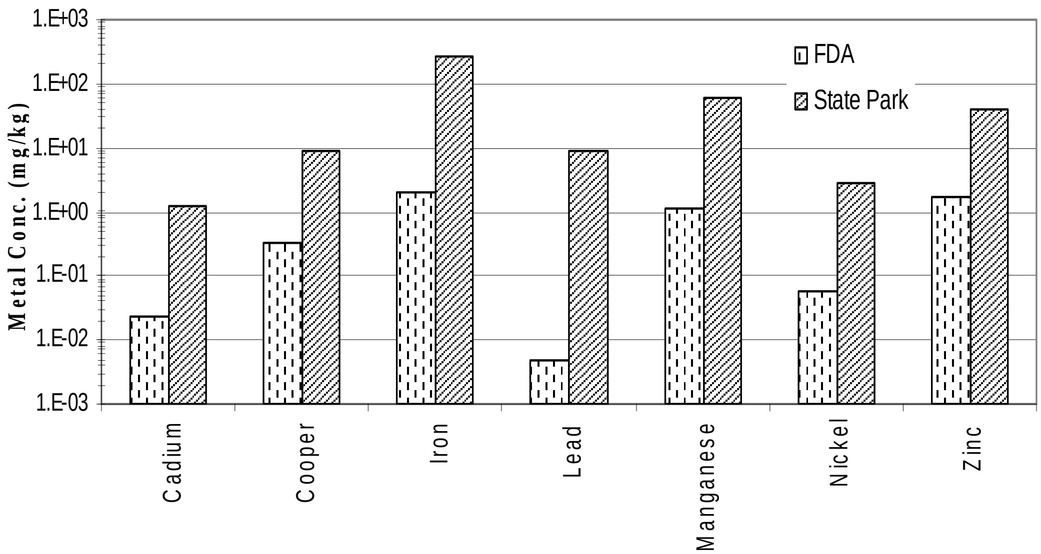

Figure 2: Comparison of background metal concentrations in carrots reported by FDA with those reported from samples collected from the Ringwood State Park reference area (levels reported as below detection level were excluded)

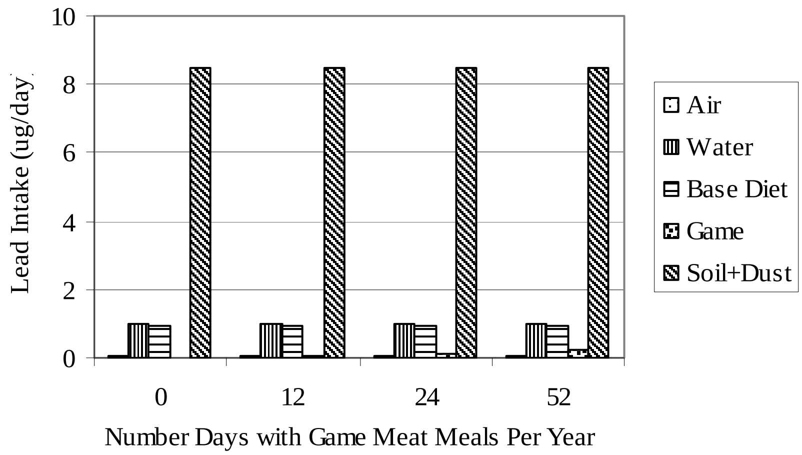

Figure 3: Child's total lead intake (in micrograms per day) by exposure source, at varying levels of game meat consumption

Appendix A

Evaluation of Non-Site-Related Metals and Organic Chemicals in Biota

Ringwood Mines/Landfill Site

This appendix to the Health Consultation evaluates the public health implications of non-site-related metals and organic chemicals detected in biota collected from the Ringwood Mines/Landfill site (see Table A-1).

Health Effects Associated with Consumption of Biota

Non-Cancer: To assess the public health implications of site-specific exposures, estimated exposures are compared to dose-based comparison values. The ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites to assess non-cancer health effects. When MRLs for specific contaminants are unavailable, other health based comparison values may be used, such as the USEPA Reference Dose (RfD).

Exposures estimates are based on ingestion of contaminated biota; non-cancer exposure doses were calculated using the following formula:

$$\textit{Exposure Dose (mg/kg/day)} = \frac{\text{C x IR x EF}}{\text{BW}}$$

where, mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = concentration of contaminant in biota (mg/kg);
IR = meat ingestion rate (kg/day);
EF = exposure factor representing the site-specific exposure scenario;
BW = body weight (kg).

Based on the USEPA Exposure Factors Handbook (USEPA 1997) and site-specific conditions, the following exposure factors were used to estimate exposure doses for children and adults:

Media	Receptor Population	Ingestion Rate (g/day)	No. of Days Per Week with Game Meat Meal	Body Weight (kg)
Biota (game)	Child	121[a]	1	17
	Adult	350[b]		70

[a]Game meat ingestion rate for children, [b]95th percentile meat ingestion rate for adults

Based on maximum detected concentrations (or reporting limits with detects) of phenol, benzoic acid, 2,4-dinitrophenol, pentachlorophenol, butylbenzylphthalate, aluminum, barium, beryllium, cobalt, iron, manganese, nickel, selenium, silver, vanadium and zinc detected in game meat, chronic exposure doses estimated for children and adults were lower than the corresponding health guideline CVs (see Table A-2). As such, past exposures to these contaminants are unlikely to result in non-cancer adverse health effects.

Cancer: The site-specific lifetime excess cancer risk (LECR) indicates the carcinogenic potential of contaminants. According to the United States Department of Health and Human Services (USDHHS), the cancer class of contaminants detected at a site is as follows:

1 = known human carcinogen
2 = reasonably anticipated to be a carcinogen
3 = not classified

The cancer class of the contaminants detected in game meat is investigated. With the exception of beryllium and nickel, all the contaminants detected in game meat have a DHHS cancer class of 3. Cancer slope factors are used to relate dose levels to the degree of cancer risk. However, cancer slope factors for oral exposure to beryllium and nickel are unavailable because the toxicological information in the literature is considered inadequate. As such, the NJDHSS and ATSDR were unable to evaluate the lifetime excess cancer risk associated with these contaminants.

Table A-1: USEPA Game Animal Test Results. Ranges of non-site-related metals and organic chemicals found in game animal tissues, O'Connor Disposal Area and reference area. All results in milligrams of analyte per kilogram of tissue (mg/kg), dry weight basis. Results are from testing by Severn Trent and Pace Analytical Laboratory

Analyte	Range of Concentrations in Game Animal Tissue (mg/kg) (Location) Number of Specimens Tested						
	Deer Liver (Reference) N=10 *	Deer Liver (O'Connor Disposal) N=3	Deer Muscle (Reference) N=10	Deer Muscle (O'Connor Disposal) N=3	Squirrel Muscle (O'Connor Disposal) N= **	Rabbit Muscle (O'Connor Disposal) N=3	Turkey Muscle (O'Connor Disposal) N=5
Aluminum	<2.0 - 9.4	<1.3 - 1.5	<2.0 - <2.4	<1.5 - 1.6	<2.9 – 16	<2.8 - <3.0	<2.5 - 2.7
Barium	<0.39 - <0.47	<0.2 - <0.24	<0.38 - <0.47	<0.23 - <0.26	<0.28 - 1.1	<0.28 - <0.30	<0.25 - <0.26
Beryllium	0.022 J+ - 0.041 J+	0.01 - 0.01	<0.01 - <0.02	0.01 - 0.02	<0.060 - 0.27	<0.060 - <0.066	<0.054 - <0.058
Calcium	125 - 256	98 - 166	106 - 141	114 – 118	199 – 2,,930	158 - 187	93 - 129
Cobalt	0.14 - <0.17	<0.08 - <0.27	<0.14 - <0.17	<0.1 - <0.11	<0.13 - 0.26	<0.13 - <0.14	<0.12 - <0.13
Iron	427 J- - 1240 J-	714 – 1,180	92 J - 172 J	118 - 123	56 - 128	53 – 62	25 – 30
Magnesium	420 - 613	375 - 596	898 – 1,110	867 - 969	872 J – 1,430	948 J – 1,050 J	913 J – 1,060 J
Manganese	8.9 - 12	7.1 – 9.8	0.51 - 0.69	0.65 – 0.68	<1.1 - 2.3	<1.1 - <1.2	<1.0 - <1.1
Nickel	<0.17 - 0.22	0.36 J - 0.77 J	<0.17 - 0.39	0.27 J - 5.3 J	0.15 - 4.0	<0.14 – 0 36	<0.13 - 0.30
Potassium	6,870 – 12,000	10,900 J – 11,600 J	11,300 J – 16,500 J	12,100 J – 15,000 J	12,700 J – 20,800 J	12,000 J – 15,100 J	10,800 J – 12,700 J
Selenium	1.4 - 2.6	0.98 - 1.3	0.47 - 1.1	0.81 - 0.98	<0.42 - 1.1	<0.41 - <0.45	<0.39 - 0.56
Silver	<0.22 - <0.27	<0.11 - 0.33	<0.22 - <0.27	<0.12 - <0.14	<0.032 - <0.053	<0.032 - <0.035	<0.029 - <0.031

Table A-1: (Contd.)

Analyte	Range of Concentrations in Game Animal Tissue (mg/kg) (Location) Number of Specimens Tested						
	Deer Liver (Reference) N=10 *	**Deer Liver (O'Connor Disposal) N=3**	**Deer Muscle (Reference) N=10**	**Deer Muscle (O'Connor Disposal) N=3**	**Squirrel Muscle (O'Connor Disposal) N= ****	**Rabbit Muscle (O'Connor Disposal) N=3**	**Turkey Muscle (O'Connor Disposal) N=5**
Sodium	2,650 – 6,420	1,970 – 3,050	1,300 – 1,540	1,330 – 1,600	1,870 – 3,360	1,660 J – 1,910 J	1,150 – 1,470
Vanadium	<0.21 - <0.25	<0.11 - <0.13	<0.20 - <0.25	<0.13 - <0.14	<0.36 - 0.74	<0.35 - <0.38	<0.32 – 0.37
Zinc	76 - 157	90 - 128	60 - 136	121 – 131	69 – 106	44 – 50	31 – 37
Phenol	<0.69 - <0.87	<0.65 - <0.74	<0.71 - <0.83	0.20 J - <0.77	<1.4 - <5.4	<1.3 - <1.4	<1.2 - <1.2
2-Methylphenol	0.24 J - <0.87	<0.65 - <0.74	<0.71 - <0.83	<0.70 - <0.77	<1.4 - <5.4	<1.3 - <1.4	<1.2 - <1.2
4-Methylphenol	0.14 J - <0.77	<0.26 J - 1.9	<0.71 - <0.83	<0.70 - <0.77	<1.4 - <5.4	<1.3 - <1.4	<1.2 - <1.2
Benzoic acid	0.51 J - 0.80 J	0.46 J - 0.91 J	0.65 J - 8.7 J	0.63 J - 1.6 J	--	--	--
2,4-Dinitrophenol	<1.7 - <2.2	<1.8 J – < 1.9 J	1.1 J	<1.8 J – < 1.9 J	(all rejected)	(all rejected)	<2.4
Pentachlorophenol	<1.8 - <2.2	<1.6 J – < 1.9 J	1.3 J	<1.8 J – < 1.9 J	(all rejected)	(all rejected)	<2.4
Butylbenzylphthalate	<0.69 - <0.87	<0.65 - <0.74	0.63 J – <0.83 J	<0.70 – <0.77	<1.4 - <5.4 J	<1.3 - <1.4	<1.2 - <1.2

Table A-2: Comparison of game animal meat consumption exposure doses with health guideline Comparison Values (CVs) for non-site-related contaminants. Dry weight concentrations are converted to wet weight concentrations assuming 25% percent solids in meat specimens (Non-detect contaminants were not listed)

Contaminant	Maximum Conc., Wet Weight Basis (mg/kg)	Maximum Exposure Dose (mg/kg/day)		Health Guideline CV[c]s (mg/kg/day)	Potential for Non-cancer Health Effects
		Child[a]	Adult[b]		
Deer Muscle					
Aluminum	0.4	0.00041	0.00029	2 (Int. MRL[d])	No
Beryllium	0.005	0.000005	0.000004	0.002 (MRL[e])	No
Iron	31	0.031	0.022	0.7 (EPA SL[f])	No
Manganese	0.17	0.00017	0.00012	0.05 (RfD[g])	No
Nickel	1.3	0.0013	0.00095	0.02 (RfD)	No
Selenium	0.24	0.00025	0.00018	0.005 (MRL)	No
Zinc	33	0.033	0.023	0.3 (MRL)	No
Phenol	0.05	0.000051	0.000036	0.3 (RfD)	No
Benzoic acid	0.4	0.00041	0.00029	4 (RfD)	No
Deer Liver					
Aluminum	0.38	0.000089	0.000063	2 (Int. MRL[d])	No
Beryllium	0.0025	0.000001	0.0000004	0.002 (MRL[e])	No
Iron	300	0.06999	0.049167	0.7 (EPA SL[f])	No
Manganese	2.4	0.000581	0.000408	0.05 (RfD[g])	No
Nickel	0.19	0.000046	0.000032	0.02 (RfD)	No
Selenium	0.32	0.000077	0.000054	0.005 (MRL)	No
Silver	0.082	0.00002	0.000014	0.005 (RfD)	No
Zinc	32	0.007592	0.005333	0.3 (RfD)	No
4-Methylphenol	0.48	0.000113	0.000079	NA	--
Benzoic acid	0.23	0.000054	0.000038	4 (RfD)	No
Squirrel Muscle					
Aluminum	4	0.0041	0.0029	2 (Int. MRL)	No
Barium	0.28	0.00028	0.00020	0.6 (MRL)	No
Beryllium	0.068	0.000069	0.000048	0.002 (MRL)	No

Table A-2: (Contd.)

Contaminant	Maximum Conc., Wet Weight Basis (mg/kg)	Maximum Exposure Dose (mg/kg/day)		Health Guideline CV[c]s (mg/kg/day)	Potential for Non-cancer Health Effects
		Child[a]	Adult[b]		
Cobalt	0.065	0.000066	0.000046	0.01 (Int. MRL)	No
Iron	32	0.032	0.023	0.7 (EPA SL)	No
Manganese	0.58	0.00058	0.00041	0.05 (RfD)	No
Nickel	1	0.0010	0.00071	0.02 (RfD)	No
Selenium	0.28	0.00028	0.00020	0.005 (MRL)	No
Vanadium	0.18	0.00019	0.00013	0.003 (Int. MRL)	No
Zinc	26.5	0.027	0.019	0.3 (MRL)	No
Rabbit Muscle					
Iron	16	0.016	0.011	0.7 (EPA SL)	No
Nickel	0.09	0.000092	0.000064	0.02 (RfD)	No
Zinc	12	0.013	0.0089	0.3 (MRL)	No
Turkey Muscle					
Aluminum	0.68	0.00069	0.00048	2 (Int. MRL)	No
Iron	7.5	0.0076	0.0054	0.7 (EPA SL)	No
Nickel	0.075	0.000076	0.000054	0.02 (RfD)	No
Selenium	0.14	0.00014	0.00010	0.005 (MRL)	No
Vanadium	0.092	0.000094	0.000066	0.003 (Int. MRL)	No
Zinc	9.2	0.0094	0.0066	0.3 (MRL)	No

[a]Child exposure scenario: 1 days/week, 121 gm/day ingestion rate and 17 kg body weight; [b]Adult exposure scenario: 1 days/week, 350 gm/day ingestion rate and 70 kg body weight; [c]Comparison Value; [d]ATSDR Minimal Risk Level for intermediate exposures; [e]ATSDR Minimal Risk Level for chronic exposures; [f]USEPA Screening Level; [g]USEPA Chronic Oral Reference Dose; [h]Comparison value not available