

**PRELIMINARY EXPOSURE ASSESSMENT SUPPORT DOCUMENT
FOR
THE TSCA SECTION 21 PETITION ON
LEAD WHEEL-BALANCING WEIGHTS**

Office of Pollution Prevention and Toxics
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

1.0	INTRODUCTION	6
2.0	OVERVIEW OF THE LIFE CYCLE OF WHEEL-BALANCING WEIGHTS	7
3.0	OVERVIEW OF LITERATURE SEARCH ON GENERAL POPULATION, CONSUMER, AND ENVIRONMENTAL EXPOSURE TO LEAD WHEEL-BALANCING WEIGHTS	8
4.0	FATE OF LEAD IN THE ENVIRONMENT	10
4.1	Environmental Fate of Lead in Surface Water and Sediments	10
4.2	Sorption of Lead in the Environment	11
4.3	Environmental Fate of Lead Wheel-balancing Weights	12
5.0	EXPOSURE SCENARIOS ASSOCIATED WITH POTENTIAL RELEASES OF LEAD TO THE ENVIRONMENT FROM LEAD WHEEL-BALANCING WEIGHTS	12
5.1	Inhalation of Airborne Dust In and Near Roadways	14
5.2	Dust from Roadways Migrating to Residential Front Yards (ingestion of yard soils route, i.e., soil to mouth)	17
5.3	Dust Migrating into Residence via Pathways 5.1 and 5.2 Above (i.e., dust from road into residence, and dust from soil in yard into residence); And Dust into Residence from Residential Yards via Tracking into House (i.e., ingestion of dust that has settled in the home and inhalation of airborne dust that has entered the home)	19
5.4	Weights/particles Swept Up by Municipal Street Cleaners and Incinerated (i.e., inhalation of airborne releases from incinerator)	20
5.5	Weights/Particles Swept Up by Municipal Street Cleaners and Landfilled, Leading to Increased Levels of Lead in Groundwater, and Reaching Nearby Drinking Water wells (ingestion of drinking water route)	22
5.6	Vapors from Home Smelting of Used Wheel-Balancing Weights Obtained by Non-Commercial Persons from Gas Stations and Small Wheel-Balancing Retailers (i.e., inhalation of airborne releases from home smelter)	27
5.7	Weights Left on Cars That May Be Collected and Burned in Electric Arc Furnaces (i.e., inhalation of airborne releases from furnace) And Releases Associated with Auto Shredder Activities (inhalation route) (i.e., inhalation of airborne releases from shredder)	29
5.8	Releases from Roadways to Streams - Aquatic Life	30
6.0	DATA GAPS AND UNCERTAINTIES ASSOCIATED WITH ENVIRONMENTAL AND HUMAN HEALTH EXPOSURE ASSESSMENT OF LEAD WHEEL-BALANCING WEIGHTS	33

APPENDICES

A Summary of Environmental Lead Literature Search on Lead Wheel-Balancing Weights 43

LIST OF TABLES

1. Hypothetical Exposure Concentrations of Lead from Roadside Soil using ISC 16

2. Hypothetical Exposure Concentrations of Lead from Wheel-balancing Weights Swept up from Streets and Incinerated, Estimated using E-FAST 21

3. Hypothetical Exposure Concentrations of Lead from Wheel-balancing Weights Swept up from Streets and Landfilled, Estimated using E-FAST 25

4. Estimated surface water concentrations from lead run-off 32

5. Summary of Uncertainties and Data Gaps Table associated with Lead Wheel-Balancing Weight Exposure Assessment 33

EXECUTIVE SUMMARY

EPA has reviewed the supporting information included with the petition, as well as other available information on lead wheel-balancing weights and concludes that additional, verifiable data is needed in order to develop a quantitative assessment of the potential environmental and human health exposures associated with releases to the environment from lead wheel-balancing weights. In particular, as described in further detail in section 6.0 of this report, data is needed on the following topics: a) amount of lead wheel-balancing weights that are lost per year to roadways on a national scale, b) the variables and the exposure pathway for the lead wheel-balancing weights falling off tires, c) the variables and the exposure pathway for a solid lead wheel-balancing weight to be converted into lead that is bioavailable, d) the distribution of lead in the asphalt, water, soil, air from lead wheel-balancing weights deposited nationwide, e) the geographical/climatic/socioeconomic factors that would increase/decrease the number of wheel-balancing weights lost to streets; and f) the amount of lead emitted to the environment during home smelting operations.

The EPA has developed an evaluation of potential exposures to the environment and humans from the manufacture and use of lead wheel-balancing weights based on the available data and information. The available data with which to construct the exposure assessment is quite limited, especially in determining the quantity of lead which results from the manufacture and use of lead wheel-balancing weights in the environment. Because of this important limitation, the exposure assessment presented in this report is based on “what-if scenarios”. This exposure assessment presents hypothetical estimates of exposure which are based on available data and information and postulated questions which are specific to the assessment. The assumptions made in answering these assessment-specific postulated questions do not give information about how likely the combination of values might be in the actual population or about how many (if any) members of a population might actually be subjected to the estimated concentration. The hypothetical estimates of exposure are helpful in evaluating postulated questions such as “What if all of the lead wheel-balancing weights on 1 million vehicles traveling on a one mile stretch of road over one year entered the environment?” These hypothetical estimates of exposure provide context for consideration but do not provide information on how likely the combination of values might be in the real world and therefore should not be used in a risk assessment.

1.0 INTRODUCTION

A petitioner has requested that EPA establish regulations prohibiting the manufacture, processing, distribution in commerce, use, and improper disposal of wheel-balancing weights made from lead (Ecology Center, 2005). This report provides background information on EPA's consideration of exposure analyses to support the Agency's response to this petition. This exposure assessment utilizes an exposure scenario approach, whereby EPA has attempted to determine the concentrations of lead in a given environment or location and link the concentrations with the time that the identified population is in the exposure scenario. The scenario evaluation approach uses the estimated concentration of lead in the identified environment and estimated time of contact data, as well as information on the potentially exposed population.

It is important to note that the level of detail of an assessment is a function of the amount of resolution of the data used in the assessment and the sophistication of the analysis prepared. If very limited data is available and many assumptions are needed in order to develop the exposure assessment, a hypothetical exposure scenario assessment which is simple to perform and which poses hypothetical questions such as "What is the exposure to an individual if all of the lead wheel-balancing weights from a million cars traveling a 1 mile distance of road over one year are deposited in an area 1 to 20 meters from the roadway, and a person is standing there?" may be the best that can be done. Detailed exposure assessments provide an in-depth evaluation of exposure. The approach used for a detailed exposure assessment is to use the best data available and develop the best estimate of the spatial and temporal distributions of chemicals. Detailed exposure assessments typically require much more data of higher quality, and in the absence of data, models of greater sophistication (USEPA, 1992a).

The available data with which to construct the exposure assessment for lead wheel-balancing weights is quite limited, especially in determining the quantity of lead in the environment that results from the manufacture, processing, distribution in commerce, use, and improper disposal of wheel-balancing weights made from lead. Because of this important limitation, the exposure assessment presented in this report is based on "what-if scenarios." This exposure assessment presents hypothetical estimates of exposure, which are based on available data and information. These hypothetical estimates of exposure provide context for consideration but do not provide information on how likely the combination of values might be in the real world and therefore should not be used in a risk assessment.

This report provides the results of EPA's preliminary exposure assessment for the TSCA Section 21 petition on lead wheel-balancing weights. An overview of the life cycle analysis of lead wheel-balancing weights follows in section 2.0. In section 3.0, an overview of the literature search on lead wheel-balancing weights is provided. A general discussion of the fate of lead in the environment is given in section 4.0. Section 5.0 provides the detailed exposure scenarios, followed by conclusions and references. Finally, section 6.0 describes the relevant data gaps and

uncertainties associated with environmental and human health exposure assessment of lead wheel-balancing weights.

2.0 OVERVIEW OF THE LIFE CYCLE OF WHEEL-BALANCING WEIGHTS

The lifecycle of lead wheel-balancing weights includes the manufacturing in primary and secondary lead smelting, processing at lead wheel-balancing weight producers, consumer use in tires, and, other end uses, i.e., recycling into other products, reuse as fishing weights and lures, disposal in landfills/ incinerators. Each of these stages is discussed briefly below.

In primary lead smelting, mined lead ore is typically processed using the following operations: sintering, smelting in a blast furnace, the dressing process, and finally, refining before being cast or made into alloys. A lead-antimony alloy is the most commonly produced alloy for lead-wheel-balancing weight use. Lead releases occur during primary smelting, and they include: air emissions, process wastes (i.e., liquid wastes from wastewater and slurries), and solid wastes (i.e., blast furnace slag). Air emissions are typically controlled by baghouse filters. Liquid wastes are considered RCRA K065 hazardous wastes and transported to a RCRA-approved waste facility. Solid wastes such as slag are usually reused or treated to recover metals (USEPA, 1995).

During secondary lead smelting, various sources of processed lead are combined together in a blast furnace, including scrap lead from batteries, cable coverings, pipes, lead coated (or terne coated) metals, and used lead wheel-balancing weights. After processing in the blast furnace, the product enters smelting and casting steps similar to primary lead smelting. The predominant lead releases during secondary smelting include air emissions and solid waste. Dust is generated from breaking batteries and slag during the smelting process, and these emissions are collected and disposed of as RCRA K069 hazardous wastes (USEPA,1995). Portions of this release are expected to include lead associated with wheel-balancing weights.

The cast ingots and alloys from primary and secondary lead smelters are sold to lead wheel-balancing weight producers to be recast into wheel-balancing weights. EPA estimates that 50 to 60 million pounds a year of lead go into lead weight manufacture (USEPA, 2005a) . Typically 5% of the alloy is comprised of antimony. Lead wheel-balancing weights are then sold to weight distributors, tire manufacturers, and tire retailers. The tire manufactures and retailers apply the weights to the vehicle when balancing new and used vehicle tires.

An unintentional release of these weights occurs when the lead weights “fly off” when a vehicle is jarred or during sudden velocity changes. These abrupt velocity changes are typical in urban areas because there is a higher traffic loading and the increased number of required stops, (i.e., stop lights, stop signs, buses, etc.). The Root study estimated that 55 million pounds (25 million kilograms) of lead exist on American cars and light trucks and that 33 million pounds (15 million kilograms) of lead exists on urban vehicles (Root, 2000). The study calculated an annual lead loss rate of 10% and claimed that the lead is further broken down into smaller pieces or

ground into a dust by traffic although no data were provided to support this claim . Root estimated that 3.3 million pounds/yr (1.5 million kg/yr) of lead are deposited in urban streets and claimed this residual lead can be washed into waterways or sewers, migrate into nearby residential yards or land, or become airborne particulates (Root, 2000). However, no data or studies were provided that show how or how much of the lead from wheel-balancing weights would be partitioned to the various media. This data is necessary in accurately quantifying exposures to lead wheel-balancing weights.

Many used wheel-balancing weights are recycled. It is estimated that 50 (to 60) million pounds (22.7 million kg) of lead per year are used to make lead wheel-balancing weights in the United States. Out of that 50 million pounds, it is estimated that 16 million pounds are sent to secondary lead smelters for recycling, 5 million pounds of lead are sent to the used weight market for reuse, and 8 million pounds may be processed in automobile recycling. Therefore, approximately 21 million pounds of lead used in wheel-balancing weights are unaccounted for in these estimates (Gust, 2004). It was noted by Gust that approximately 1.5 million pounds of off-spec wheel-balancing weights and other lead-containing waste are collected each year from process waste streams by lead wheel-balancing weight manufacturers.

3.0. OVERVIEW OF LITERATURE SEARCH ON GENERAL POPULATION, CONSUMER, AND ENVIRONMENTAL EXPOSURE TO LEAD WHEEL-BALANCING WEIGHTS

EPA conducted a literature search for lead wheel-balancing weights and associated exposure pathways and assessments. EPA conducted literature searches in the PubMed, ToxLine, AGRICOLA, Science Direct, and DIALOG databases, as well as general Internet searches using the GOOGLE search engine. A summary of the literature search is provided as Appendix A to this document (USEPA, 2005b). A brief overview of the key findings from the literature search is provided below.

- In general, the availability of data and information on exposure to lead from the manufacture and use of lead wheel-balancing weights is very limited. Specific documents that included some information on lead wheel-balancing weights include: California Department of Transportation Environmental Program Proposed Soil Lead Management Criteria as Part of Caltrans Highway Construction and Maintenance (Lee and Taylor, 1998); Environmental Defense, Ecology Center, Clean Car Campaign *Getting the Lead Out - Impacts of and Alternatives for Automotive Lead Uses* (Gearhart, et.al., 2003); Lead Loading of Urban Streets by Motor Vehicle Wheel Weights, Robert A. Root (Root 2000); and *Lead Use in Ammunition and Automotive Wheel Weights: An Examination of Lead's Impact on Environmental and Human Health, the Alternatives to Lead Use, and the Case for a Voluntary Phase-Out* (Bodanyi, 2003).
- The internet sites managed by EPA provide generic monitoring data on lead wheel-

balancing weights and the toxicity of lead but do not provide information on exposure pathways specifically for lead wheel-balancing weights.

- The references cited in the TSCA petition also did not provide information on exposure to lead wheel-balancing weights. The referenced papers did provide information regarding urban runoff and lead concentrations in the runoff. The papers also provided some information on the percentage vehicular traffic played in regards to lead in the urban runoff. However, there were no specific references to lead wheel-balancing weights, save the Root (2000) and Bodanyi (2003) papers.
- Analyses regarding previous EPA rulemakings (e.g., EPA's TRI Lead rule, the lead based paint debris rule, and the hazard standards for lead-based paint and lead in dust and soil) were covered in Internet searches. In particular, the lead in dust and soil was covered in searches on www.epa.gov/opptintr/lead/403risk.html and www.epa.gov/opptintr/lead/403risksupp.html, and the lead based paint debris rule was covered in searches at www.epa.gov/epaoswer/non-hw/muncpl/landfill/pb-paint.htm. Exposure pathway scenarios were identified, but they focused primarily on residential exposure from lead-based paint.
- Additional searches of EPA documents available on the Internet, of lead exposure scenarios on military or civilian shooting/trap ranges, and other Internet sites did not provide exposure data of relevance to lead wheel-balancing weights.

Of the relevant studies identified, the Root (Root, 2000) and Bodanyi (Bodanyi, 2003) studies provided the most information on exposure to lead wheel-balancing weights, but these studies have some significant shortcomings. The Root study performed a street survey where lead wheel-balancing weights were counted along eight six-lane divided street segments, totaling 19.2 km in an urban environment. The Root study uses two methods to estimate the rate of deposition of lead from wheel-balancing weights from their counts. However, there are various shortcomings of the Root study that limit its applicability on a national scale. The study was limited in geographic scope. The Root study was conducted on one type of road in one city in Arizona. There is a significant potential for error in the author's detection of lead wheel-balancing weights within the test area. The cleaning history of the test area is not known. The nature of the study is not conducive to making detailed conclusions about what happens to individual wheel-balancing weights during their time on the road surface, i.e., initial ejection from a car's wheel rim, coming to rest on the road surface, being impacted an unknown number of times by passing vehicles, and (possibly) arriving at a position where automobile impacts are unlikely, but degradation from other environmental factors may continue at an unknown rate. The author's assumptions tend to overestimate the amount of lead placed into the environment by assuming that all of the missing wheel-balancing weights were pulverized into dust and distributed into the environment.

Bodanyi (2003) sought to corroborate the findings of the Root (2000) study and further

characterize the loss rate of lead wheel-balancing weights in the environment using a street and parking lot survey. While the study was largely successful in the former, it failed in the latter due to flaws in the study design. The study is not published and did not go through the peer review process. Because it followed the methodology of the Root study, the Bodanyi study shares many of the Root study's shortcomings.

4.0 FATE OF LEAD IN THE ENVIRONMENT

4.1 Environmental Fate of Lead in Surface Water and Sediments

The concentration of dissolved lead in water is controlled by many factors including the pH, redox potential, concentration of inorganic anions, and organic contents of the water and the nature of the organic matter. For typical dissolved salt levels and pH, the maximum concentrations of lead in solution in hard (pH >5.4) and soft (pH <5.4) water is about 30 $\mu\text{g/l}$ and 500 $\mu\text{g/l}$, respectively (USEPA, 1977). Long and Angino (1977) studied the speciation of lead as a function of pH in freshwater-seawater systems. They considered complexes of the type PbL_n at pH values from 3.5 to 11 at 25 °C where the ligand, L, was Cl^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , and OH^- . Results were presented graphically for 100% freshwater, 50% freshwater-50% seawater, and 100% seawater as the percent of the various species in solution as a function of pH. In freshwater, free Pb^{2+} was the dominant species below pH 7.5, above which complexes with CO_3^{2-} (PbCO_3) dominated. Above pH 9.5, $(\text{OH})_2^{2-}$ was the dominant ligand. In seawater, complexes with Cl^- (PbCl^+) were the dominant species below a pH of about 8.3, above which CO_3^{2-} complexes dominated until pH 9.5. Chloride and carbonate ions are the major ligands at a pH that would be expected in estuaries environments. Complexing with chloride increases rapidly with minor additions of seawater.

The major speciation change upon addition of seawater is the disappearance of free Pb^{2+} and the appearance of chloride complexes. The percentage of carbonate complexing does not change appreciably with changes in other ligand concentrations. Lead carbonate is generally the controlling factor in determining the solubility of lead in natural waters. Many rivers in the United States have lead concentrations that are consistent with the solubility limits determined by their pH levels and dissolved CO_2 content. Even small concentrations of carbonate ions due to the dissolution of atmospheric CO_2 are sufficient to reduce lead concentrations to nearly the computed solubility limits within a few hours (Callahan et al., 1979, USEPA, 1986). More recently, Fernando (1995) calculated the distribution of Pb(II) species in seawater as a function of chloride concentration. The principal lead species present in seawater at a chloride ion concentration of 0.56 M are PbCl_3^- and the ion association complex PbCO_3 , followed by PbCl_2 and PbCl^+ . It is interesting to note that even at this high chloride ion concentration, there is a significant concentration of $\text{Pb}(\text{OH})^+$ and uncomplexed Pb^{2+} .

In the natural environment, water contains substances other than the major inorganic ions

considered by Long and Angino that will affect lead speciation and cycling. In a speciation study of lead flowing from a French river to the sea, the carbonate-bound and exchangeable lead decreased while Fe-Mn oxide-sorbed and organically-bound lead increased (Elbaz-Poulichet et al., 1984). These changes reflected the increased levels of organic matter and Fe-Mn oxides in the seawater. Changes in the redox potential of different media can also affect speciation. For example, a chemical equilibrium model of the Los Angeles County sewage indicates that lead would be present as the insoluble sulfide (Morel et al., 1975). On being discharged into aerobic seawater, mobilization would be expected, although no significant mobilization was demonstrated in laboratory experiments over one day in aerated sewage-seawater mixtures. Off the sewage outfall, lead was effectively trapped, and even showed some enrichment, in the top 4 cm of reduced sediment.

4.2 Sorption of Lead in the Environment

A large fraction of lead introduced into the aquatic environment is associated with suspended solids that settle down into the sediments. A study of the distribution of lead between filtrate and solids in stream water from urban and rural areas reported the ratio of lead in suspended solids to that in filtrate varied from 4% in rural areas to 27% in urban areas (USEPA, 1977). Cycling of lead in the aquatic environment involves a complex exchange between dissolved and particulate phases. Dissolved phases are those that pass through a filter and can include complexes with organic ions and colloidal organic matter. Particulate lead would include precipitates formed when the solubility of the relevant ions is exceeded, lead adsorbed to soil, lead associated with hydrous oxides of iron, manganese, and aluminum.

Lead forms strong complexes with organic matter. Complexation with humic acids and other organic complexing agents can maintain lead in a bound form at pH's as low as 3 (Callahan et al., 1979). Organic-lead interaction increased with pH and decreased with water hardness. At highly polluted sites, the high anthropogenic organic content of the water controls lead speciation (Botelho et al. 1994). In surface waters of Eastern North Pacific, about 50% of the total lead was organically complexed, 48% was complexed with inorganic ligands, and about 1.4% was free (Capadaglio et al., 1990). No difference in speciation was noted between filtered and unfiltered samples indicating that the complexes existed in a dissolved phase.

Sorption also appears to be an important process in removing lead from both fresh and estuarine natural waters into sediment. The amount adsorbed depends on parameters such as the availability of ligands, pH, redox conditions, salinity, iron concentration, composition of dissolved particulate matter and sediment, and lead concentration (Callahan et al., 1979). Sorption is to organic matter, clay and mineral surfaces, and coprecipitation and/or sorption by hydrous iron and manganese oxides. Adsorptivity increases with increasing pH. Lead is adsorbed by polar particulate matter as is evidenced by its dominance in sediment of specific gravity 2.0-2.9, where the clay fraction is found. It is almost absent from less dense sediment fractions, characterized by organic matter not active in complex formation, or denser fractions, characterized by precipitation

(Callahan et al., 1979). In several Kansas streams, lead has been shown to be highly correlated with iron and manganese in sediment. Another study showed that the organic content of bottom mud was the most significant factor affecting adsorptivity (Tada and Suzuki, 1982). In a 38-day intertidal benthic mesocosm experiment, lead equally distributed between the dissolved and particulate matter in the water column during high tide, with the levels decreasing during ebb tide due to exchange with the sediment, porewater and benthic fauna (Schulz-Baldes et al., 1983). The lead accumulated primarily in the uppermost centimeter of sediment.

4.3 Environmental Fate of Lead Wheel-balancing Weights

As shown in Section 4.1 and 4.2, general information on the fate of lead in the environment is readily available. However, no data were found in the literature that specifically provided information on the fate of lead wheel-balancing weights in the environment. Root (2000) attempted to address the degradation issue by distributing a known quantity of wheel-balancing weights over the same street he had previously surveyed for wheel-balancing weight deposition. Although he was able to come up with a loss rate, EPA believes the methodology used is not scientifically valid due to the lack of controls. For example, if a weight disappeared, the study design assumed that this lead was pulverized into dust and did not account for other likely and possible fates of the weight, such as, being flipped into bushes, becoming bound into the asphalt of the street, being picked up by a street cleaner or hobbyist, etc. There were no soils collected at the side of the road and analyzed for its lead content. Air sampling was not performed to see if the lead became air borne. Without analytical data, EPA believes there is a high degree of uncertainty associated with the fate of lead wheel-balancing weights. With a better designed degradation study that includes testing, more accurate data would be available for use in preparing a quantitative exposure assessment.

5.0 EXPOSURE SCENARIOS ASSOCIATED WITH POTENTIAL RELEASES OF LEAD TO THE ENVIRONMENT FROM LEAD WHEEL-BALANCING WEIGHTS

EPA reviewed the literature and identified the most likely exposure scenarios associated with human and environmental exposures to lead wheel-balancing weights. EPA developed the following nine possible exposure scenarios associated with releases to the environment from lead wheel-balancing weights:

- a) inhalation of airborne dust in and near roadways
- b) dust from roadways migrating to residential front yards (ingestion of yard soils route, i.e., soil to mouth)
- c) dust migrating into residence via pathways A and B above (i.e., dust from road into residence, and dust from soil in yard into residence); and dust into residence from residential yards via

tracking into house (i.e., ingestion of dust that has settled in the home and inhalation of airborne dust that has entered the home).

d) weights/particles swept up by municipal street cleaners and incinerated (inhalation route) (i.e., inhalation of airborne releases from incinerator).

e) weights/particles swept up by municipal street cleaners and landfilled, leading to increased levels of lead in groundwater, and reaching nearby drinking water wells (ingestion of drinking water route).

f) vapors from home smelting of used wheel-balancing weights obtained by non-commercial persons from gas stations and small wheel-balancing retailers (inhalation route) (i.e., inhalation of airborne releases from home smelter).

g) weights left on cars that may be collected and burned in electric arc furnaces (inhalation route) (i.e., inhalation of airborne releases from furnace).

h) releases associated with auto shredder activities (inhalation route) (i.e., inhalation of airborne releases from shredder).

i) releases from roadways to streams

- aquatic life and terrestrial exposure route ;
- terrestrial eats aquatic life exposure route ;
- human ingestion of drinking water route.

There may be additional potential exposure routes associated with releases to the environment from lead wheel-balancing weights, but these nine scenarios were believed to be the most likely scenarios based on the Agency's understanding of how lead wheel-balancing weights are manufactured and used.

Each potential exposure route is described in further detail below. Each scenario writeup includes a discussion of available data regarding wheel-balancing weight losses associated with the route of exposure, other data associated with lead in the environment in media associated with the route of exposure, the method used to calculate/quantify an exposure estimate for the route of exposure, and limitations and uncertainties associated with the model/calculation method.

5.1 Inhalation of Airborne Dust In and Near Roadways

5.1.1. Available data regarding wheel-balancing weight losses for this route

Root (2000) observed an annual loss rate of $4\text{E-}05$ weights per vehicle-mile along a 1 km urban thoroughfare in New Mexico; along one 600-m section with a higher rate of stopping and turning traffic, the loss rate was $8\text{E-}05$ weights per vehicle-mile. In a similar, non-peer-reviewed study conducted in Michigan, Bodanyi (2003) observed a loss rate of $5\text{E-}05$ weights per vehicle-mile. On a one-mile stretch of road traversed by 1 million cars per year, using the highest of these loss estimates ($8\text{E-}05$ weights per year) and a mean weight of 21 g per wheel-balancing weight, the estimated lead loading is 1680 g/yr or 4.6 g/day.

The rate at which wheel-balancing weights are ground into fine particles is uncertain. Root (2000) placed a measured quantity of wheel-balancing weights along an urban thoroughfare that had previously been cleared of wheel-balancing weights and measured the rate of recovery at the end of two weeks. He calculated a daily loss rate of 2.74%. An alternative method of calculation, based on a loss of 50% of lead mass in 8 days, leads to an estimated loss rate of 6.25% of the total accumulated lead per day. It should be noted that in this study, any lead that the study author did not observe on his inspection of the test area was considered lost; the fate of this lead (washed away, ground to dust, or simply overlooked due to intermingling with other roadside debris) was not determined.

A conservative assumption based on the Root (2000) study would be that each day, 4.6 grams of lead are deposited per mile of road, and 6.25% of the lead present on the roadside is ground to dust. There are significant limitations associated with the Root study, as described in section 3.0 of this document.

5.1.2. Other data associated with lead in the environment in media associated with this route

Howard and Sova (1993) investigated soil lead concentrations in soil at varying depths and distances from interstate highways in the Detroit, Michigan area. Concentrations of lead in all forms (organic, free, exchangeable, etc.) in shallow soils at a distance of 10 m from the roadside ranged from 23.8 to 374.7 mg/kg, a range that is 1 to 2 orders of magnitude higher than the estimated concentrations found in the Root (2000) study described in Section 3.0. The discrepancy may indicate that lead wheel-balancing weights are only a small contributor to the total lead deposited in the soil near highways. The concentrations may also be higher if the lead persists in the soil for a longer period than that assumed by Root, i.e., on a time scale of decades rather than years.

5.1.3. Methods used to calculate “what if” exposure estimates for this route:

A first-order approximation of the emission rate of lead from roadside soil was calculated using parameters identified by EPA and derived from the Root (2000) and Bodanyi (2003)

studies. This emission rate was used as an input in a fate and transport model in a hypothetical exposure scenario for a person standing within 20 meters of the roadside emission source. The following assumptions were made:

- the exposed person is standing anywhere from 1 - 20 m from the road;
- the lead wheel-balancing weight emissions from the road are treated as area source that is 1609 m x 0.6 m (965.4 m²). This conforms to a road 1 mile long, with the lead wheel-balancing weights in the outer curb as described by Root;
- the lead wheel-balancing abrasion occurs constantly during 14 hour period (6 am to 8 pm). This time period was selected as being the most probable time a bystander would be standing next to the road;
- the maximum annual wheel weight loss is 8×10^{-5} weights/Vehicle Mile Traveled (VMT), as estimated by Root (2000) and Bodanyi (2003);
- the vehicular traffic along the one mile road is 1×10^6 VMT/year;
- the amount of lead in a wheel weight is approximately 21 g Pb/weight, per Root (2000);
- the lead loading in the soil is at steady state, i.e., the stock of lead in the soil is neither increasing nor decreasing over the long term, and the mass emitted per day is equal to the mass deposited;
- the complete pulverization of lead wheel-balancing weights and equal distribution throughout the affected area is on a short time scale ($\ll 1$ year); and,
- the breathing height is 1.5 m for adults and 1.2 m for a child. The breathing height for a child was derived from the average height estimated using CDC Growth Charts for boys and girls, ages 5-13 (CDC, 2002).

To model air concentrations, the Industrial Source Complex, Short Term model was used. A series of 268 rectangular areas, 6m x 0.6m, were assembled to model the emission from the road. A conservative wind speed of 1 m/s was used and the wind was assumed to blow in a southeasterly direction, with the road oriented north to south. As the bystander would be standing at a location parallel to the north-south orientation of the road, the southeasterly wind direction would provide the most conservative exposure concentration estimate. Four stability classes, A-D, were also used in the modeling, as these would be the most prevalent atmospheric stability categories for the time of day under consideration. It was assumed that the bystander would be located between 1 to 20 meters from the edge of the street, near the origin of the modeling runs.

In the ISC model analysis, the wet and dry deposition of particles on surfaces was not addressed. The complexity of the modeling of these transport mechanisms is beyond the scope of this “what if” assessment, and each model run may take up to several days of computing time, putting it outside the realm of possibility for this analysis. This aspect of the exposure pathway may be revisited in the future using the ISC model if more definitive source information becomes available.

Based on the assumptions above, the loss of lead due to wheel-balancing weight abrasion was estimated at 9×10^{-8} g Pb/m²-s (see calculation below).

$$\frac{(8 \times 10^{-5} \text{ weights} / \text{VMT})(1 \times 10^6 \text{ VMT} / \text{yr})(21 \text{ gPb} / \text{weight})}{(365 \text{ days} / \text{yr})(14 \text{ hours} / \text{day})(3600 \text{ s} / \text{hour})(965.4 \text{ m}^2)}$$

After running ISC, the maximum hourly average concentration was estimated using the worst case wind speed/stability category combination. The results from the modeling are shown in the table 1 below. As the ISC modeling effort was used to generate a maximum one hour average concentration, the maximum daily average concentration and the maximum annual average concentration were derived using conversion factors of 0.4 and 0.08, respectively, per EPA guidance (USEPA, 1992b).

Table 1. Hypothetical Exposure Concentrations of Lead from Roadside Soil using ISC

Distance (m)	Maximum Hourly Average Concentration (µg/m ³)		Maximum Daily Average Concentration (µg/m ³)		Maximum Annual Average Concentration (µg/m ³)	
	Adult	Child	Adult	Child	Adult	Child
1	7E-03	1E-02	3E-03	5E-03	6E-04	1E-03
5	3E-02	3E-02	1E-02	1E-02	2E-03	3E-03
10	2E-02	3E-02	10E-03	1E-02	2E-03	2E-03
15	2E-02	2E-02	7E-03	8E-03	2E-03	2E-03
20	1E-02	2E-02	6E-03	6E-03	1E-03	1E-03

Exposure point concentrations for use in the hypothetical exposure assessment were derived from the maximum (across all distance categories) of the maximum annual average concentration: 2E-03 µg/m³ for adults and 3E-03 µg/m³ for children.

5.1.3. Conclusions drawn from this analysis

As stated above, EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenarios evaluated. Exposure assessments of this kind should be considered “what-if scenarios”. At the time of this assessment there was no data available to determine the releases/loading of lead wheel-balancing weights from roadways to any of the potential exposure routes; therefore, it was assumed, for purposes of these initial assessments, that all releases would go to each exposure route separately.

This assumption is highly conservative, since it is very unlikely that any one route would receive the entire loading of lead released from lead wheel-balancing weights left on streets. Additional well designed studies could fill in these data gaps and would result in refined and improved estimates.

5.2 Dust from Roadways Migrating to Residential Front Yards (ingestion of yard soils route, i.e., soil to mouth)

5.2.1 Available data regarding wheel-balancing weight losses for this route

Root (2000) observed an annual loss rate of $4E-05$ weights per vehicle-mile along a 1 km urban thoroughfare in New Mexico; along one 600-m section with a higher rate of stopping and turning traffic, the loss rate was $8E-05$ weights per vehicle-mile. In a similar, non-peer-reviewed study conducted in Michigan, Bodanyi (2003) observed a loss rate of $5E-05$ weights per vehicle-mile. On a one-mile stretch of road traversed by 1 million cars per year, using the highest of these loss estimates ($8E-05$ weights per year) and a mean weight of 21 g per wheel-balancing weight, the estimated lead loading is 1680 g/yr or 4.6 g/day. There are significant limitations associated with the Root study as described in section 3.0 of this document.

The rate at which wheel-balancing weights are ground into fine particles is uncertain. Root (2000) placed a measured quantity of wheel-balancing weights along an urban thoroughfare that had previously been cleared of wheel-balancing weights and measured the rate of recovery at the end of two weeks. He calculated a daily loss rate of 2.74%. An alternative method of calculation, based on a loss of 50% of lead mass in 8 days, leads to an estimated loss rate of 6.25% of the total accumulated lead per day. It should be noted that in this study, any lead that the study author did not observe on his inspection of the test area was considered lost; the fate of this lead (washed away, ground to dust, or simply overlooked due to intermingling with other roadside debris) was not determined.

A conservative assumption would be that each day, 4.6 grams of lead are deposited per mile of road, and 6.25% of the lead present on the roadside is ground to dust.

5.2.1. Other data associated with lead in the environment in media associated with this route

Other data available for this pathway are discussed in the summaries in section 5.1.2.

5.2.3 Methods used to calculate hypothetical exposure estimates for this route

A first-order approximation of the lead concentration in roadside soil was calculated using

parameters derived from the Root (2000) and Bodanyi (2003) studies. The following assumptions were made:

- a loss rate of 8E-05 weights per vehicle-mile;
- a mass of 21g per wheel-balancing weight;
- a traffic rate of 1,000,000 vehicles per year;
- an affected area of roadside soil one mile long, 25 meters wide, and 1 inch deep;
- the complete pulverization of lead wheel-balancing weights and equal distribution throughout the affected area on a short time scale ($\ll 1$ year);
- a soil density of 1.5 g/cm³;
- a mean residence time of lead in soil on the order of 2 years (Watmough et al., 2005);
- and,
- steady-state conditions.

Using the dimensions listed above, the lead deposited in the top inch of soil in an area 25 meters wide along one mile of road in one year would result in a lead concentration of 1 ppm. For a mean lead residence time of two years, under steady-state conditions, at any given point in time there would be two years' accumulation of lead deposits in the affected area, which may be expressed as a concentration of 2 ppm. This concentration was used as a baseline for lead concentration in affected soils.

5.2.4. Conclusions drawn from this analysis

The estimated hypothetical soil concentration for this scenario is 2 ppm. This analysis assumes that the soil to which individuals are exposed have the same level of contamination as the roadside soil; in other words, no dispersion or attenuation of the contaminated soil is taken into account, and exposure to yard soil is assessed as if the subject's yard is entirely within the affected roadside area. This assumption would tend to overestimate the level of exposure.

As stated above, EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenarios evaluated. Exposure assessments of this kind should be considered "what-if scenarios". At the time of this assessment there was no data available to determine the releases/loading of lead wheel-balancing weights from roadways to any of the potential exposure routes; therefore, it was assumed, for purposes of these initial hypothetical scenario assessments, that all releases would go to each exposure route separately. This assumption is highly conservative, since it is very unlikely that any one route would receive the entire loading of lead released from lead wheel-balancing weights left on streets. Additional well designed studies could fill in these data gaps and would result in refined and improved estimates.

5.3 Dust Migrating into Residence via Pathways 5.1 and 5.2 Above (i.e., dust from road into residence, and dust from soil in yard into residence); And Dust into Residence from Residential Yards via Tracking into House (i.e., ingestion of dust that has settled in the home and inhalation of airborne dust that has entered the home)

5.3.1 Available data regarding wheel-balancing weight losses for this route

The available data for this pathway are discussed in the summaries for Pathways 5.1 and 5.2.

5.3.2 Other data associated with lead in the environment in media associated with this route

The intake of household dust via the inhalation and dermal routes has not been well characterized. U.S. EPA (2003a) states that 70% of indoor dust is derived from outdoor soil. In the same document, indoor dust and outdoor soil contribute jointly to the adult soil ingestion rate of 0.05 g/day. However, the amount of indoor dust inhaled or ingested is not known. As a worst-case scenario, it may be assumed that the entire daily soil ingestion consists of indoor dust, of which 70% is derived from outdoor soil. This would result in ingestion exposure levels in the indoor environment that are 30% lower than those determined for Pathway 5.2. For the inhalation route, the same approach may be taken as a first-order approximation. However, this approach does not account for the possibility of accumulation of lead particles in the indoor environment, but rather assumes the presence of outdoor air in the indoor environment, without any concentrating effects that would tend to increase the indoor concentration.

5.3.3 Methods used to calculate hypothetical scenario exposure estimates for this route

For this pathway, the methods and sources were identical to those for the ingestion and inhalation scenarios. Exposure point concentrations were reduced by 30% to represent a scenario in which 100% of the daily contact with soil was through contact with house dust, and 70% of the house dust was composed of outdoor soil that entered the home through the air or through personal contact with soil (i.e., adherence to shoes and clothing).

5.3.4 Conclusions drawn from this analysis

As stated above, EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenarios evaluated. Exposure assessments of this kind should be considered “what-if scenarios”. At the time of this assessment there was no data available to determine the releases/loading of lead wheel-balancing weights from roadways to any of the potential exposure routes; therefore, it was assumed, for purposes of these initial hypothetical exposure scenario assessments, that all releases would go to each

exposure route separately. This assumption is highly conservative, since it is very unlikely that any one route would receive the entire loading of lead released from lead wheel-balancing weights left on streets. Additional well designed studies could fill in these data gaps and would result in refined and improved estimates.

5.4 Weights/particles Swept Up by Municipal Street Cleaners and Incinerated (i.e., inhalation of airborne releases from incinerator)

This hypothetical exposure scenario assumes wheel-balancing wheel weights that are lost from vehicles to the streets are then swept up by municipal street cleaners and a portion of them are incinerated. The amount of the wheel-balancing weights that go to incinerations is apportioned using data from 2003 (USEPA, 2003b) which shows 14% of all municipal waste goes to 'Combustion'. For this assessment, combustion is assumed to be the same as incineration.

5.4.1 Available Data regarding wheel-balancing weight losses associated with this route

Amount of lead wheel-balancing weights swept up by municipal street cleaners. No data or studies were available that directly measures this amount, however, Root (2000) estimated 1.5 million kg/yr of lead is deposited in urban streets. The Root study suggested that this residual lead can be washed into waterways or sewers, migrate into nearby residential yards or land, or become airborne particulates. In addition to these pathways, it is possible that municipal street cleaners would capture the lead wheel-balancing weights and that this waste could then be incinerated. For this scenario it is conservatively assumed that the street cleaners remove entire amount of lead wheel-balancing weights from the road. There are significant limitations associated with the Root study, but the most important of them are as follows: (1) it is limited in scope, both geographically and in its time scale; (2) error may results from imperfect observation of wheel-balancing weights during the weekly surveys; (3) street sweeping activities were not accounted for; (4) no attempt is made to measure lead in soil and dust near the test area and establish a link between wheel-balancing weights and measured lead in the environment; and (5) the route of human exposure to lead from wheel-balancing weights is not addressed.

The amount that could be captured is estimated as follows:

$$\frac{\text{Loading in kg/yr} \times \text{Portion of municipal waste to incineration}}{\text{Number of Municipal incineration units in the U.S.}} = \text{Kg of Pb wheel-balancing weights per unit}$$

$$(1,500,000\text{kg/yr} \times 0.14)/167 \text{ units} = 1257 \text{ kg/yr/unit}$$

Where,

Loading = 1.5 Million kg/yr of lead deposited in urban streets - Root (2000)

Portion of municipal waste to incineration = 14.0% of municipal solid waste goes to incineration (USEPA, 2003b).

Number of Municipal incineration units in U.S. = There are 66 large municipal incinerators in the U.S. with 167 units burning waste (Stevenson, 2005). This assessment assumed that an equal amount of the waste is burned in each of the 167 units as a 'what- if' assumption.

5.4.3 Method used to calculate/quantify exposure estimate for this route

EPA/OPPT's Exposure and Fate Screening Assessment Tool (E-FAST) was used to estimate exposure to an adult, child and infant that might occur as the result of Pb Weights/particles being swept up by municipal street cleaners and incinerated in municipal incinerators. E-FAST uses a simple, conservative method for estimating ambient air concentrations that may result from air emissions from sources with stacks such as boilers and incinerators. Maximum annual average ground level air concentrations are predicted using a relationship ("generic ISCLT model method") between release amount and maximum annual average concentration that was derived by OPPT using Industrial Source Complex B Long Term (ISCLT) modeling of emissions from a hypothetical facility. The calculations for the derivation of concentrations are provided in the Exposure and Fate Assessment Screening Tool (E-FAST) Documentation Manual (USEPA, 2000). Hypothetical air concentrations are provided in table 2.

Table 2. Hypothetical Exposure Concentrations of Lead from Wheel-balancing Weights Swept up from Streets and Incinerated, Estimated using E-FAST

Assumed Destruction and Removal Efficiency %	Potential Average Daily Concentration (mg/m ³)
0%	4E-06
99%	4E-08
99.9%	4E-09

5.4.3 Conclusions drawn from the analysis

As stated above, EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead

released and available during the use of lead wheel-balancing weights in the scenarios evaluated. An exposure assessment of this kind should be considered a what-if scenario. At the time of this assessment there was no data available to determine the loading of lead wheel-balancing weights from street cleaners to each incineration unit; therefore, it was assumed that it would be equally distributed to all incineration units in the United States. Also, national data was used to determine what percent of municipal waste is combusted and does not necessarily apply to the Pb wheel-balancing weights that would be picked up by street cleaners and incinerated. The assumption that all weights would be picked up by street cleaners as opposed to being picked by Do-It-Yourselfers vs. ground into the asphalt vs. ground into dust, etc. is highly conservative. Additional well designed studies could fill in these data gaps and would result in refined and improved estimates.

5.5 Weights/Particles Swept Up by Municipal Street Cleaners and Landfilled, Leading to Increased Levels of Lead in Groundwater, and Reaching Nearby Drinking Water wells (ingestion of drinking water route)

5.5.1 Available Data regarding wheel-balancing weight losses associated with this exposure route

The number of kilograms of lead wheel-balancing weights deposited on USA highways per year is estimated to be 2,702,132 kg lead. (Bodanyi, 2003). Bodanyi's estimate of 2,702,132 kg lead wheel-balancing weights deposited on USA highways per year was estimated based on a calculation that multiplied Bodanyi's estimate for the average number of wheel weights lost per vehicle-mile/year by 2.778 trillion vehicle-miles traveled in the USA in 2001 (NHTSA, 2002). The NHTSA estimate is assumed to be an accurate estimate of vehicle-miles traveled in the USA. The Bodanyi study is not published and did not go through the peer review process. The study cites a reference that states that a typical car has ten wheel balancing weights— two on each wheel, including the spare. In an assessment of roadside deposition of lead, only four wheels should be considered.

For this hypothetical exposure scenario analysis, EPA assumed that the lead wheel-balancing weight loading per landfill per year in the USA would be 1,529.22 kilograms (2,702,132 kg lead deposited on nations highways per year from lead wheel-balancing weights; divided by

1767 (the number of municipal solid waste landfills (MSWLF)¹ operating in USA in 2002 with capacity). (See USEPA, 2005c). This estimate is very conservative because it assumes that all wheel-balancing weights deposited on USA highways are swept up and deposited in landfills.

The number of available MSWLFs is decreasing over time but appears to be leveling out. The available landfill capacity has remained relatively constant over time because newer landfills are much larger than those built many years ago (USEPA, 2003b).

The hypothetical exposure scenario analysis assumption that all wheel-balancing weights deposited on USA highways are swept up and deposited in landfills is very uncertain. It is highly conservative to assume that all wheel-balancing weights that may be deposited on roadways in a given town in the USA for a given year are swept up and deposited into the town's landfill.

5.5.2 Other data associated with lead in the environment in media associated with this route

Leach Rate information:

There is limited data available regarding the leach rate of lead from wheel-balancing weights within MSWLFs. The leach rate may be defined as the amount of lead that dissolves or otherwise is released from the lead wheel-balancing weight over time. One report published by Steil (2000) identified a leaching rate of 0.88 g from a wheel-balancing weight during a 12-year duration of use and a 10 cm² surface area. As described further below, an extrapolation of this research indicates that the number of grams that could leach out from a landfill per year from a MSWLF is 730 grams/year, based on the following calculations and assumptions:

- a) Average wheel-balancing weight mass: 21 grams (Root, 2000.)
- b) Average leach rate per year per wheel-balancing weight: 0.07 grams (0.88g/12 years) (Steil,2000.)
- c) Average leach rate per year per gram of wheel-balancing weight: 0.000476 grams (0.07 gram per year leached divided by 21 grams average wheel-balancing weight mass)
- d) Mass of wheel-balancing weights deposited in a MSWLF per year: 1,529,220 grams (2,702,132 kg lead deposited on nations highways per year from lead wheel-balancing weights; divide 2,702,132 kg by 1767 (# MSWLF landfills operating in US in 2002 with capacity).
- e) Number of grams leached out per year per MSWLF: 730 grams/year (0.000476 grams x 1,529,220)

¹A MSWLF is a discrete area of land or an excavation that receives household waste and other types of wastes as defined under Subtitle D of the Resource Conservation and Recovery Act (RCRA), such as commercial solid waste, nonhazardous sludge, small quantity generator waste, and industrial solid waste. Such a landfill maybe publicly or privately owned. (USEPA 1993a).

There is limited data available regarding the leach rate of lead from wheel-balancing weights within MSWLFs (with the leach rate defined as the amount of lead that dissolves or otherwise is released from the lead wheel-balancing weight over time). It is uncertain whether Steil's research results (2000) represent expected leach rates for releases that would occur from lead wheel-balancing weights disposed within municipal landfills. It is thus uncertain whether an extrapolation of this research would be appropriate to use in estimating the number of grams that could leach out from a landfill per year from a MSWLF. Additional data would be preferable regarding the expected releases of lead from lead wheel-balancing weights in a landfill environment.

5.5.3 Method used to calculate/quantify exposure estimate for this Route

EPA's Exposure and Fate Assessment Screening Tool (EFAST) model was used to calculate a preliminary, hypothetical exposure scenarios exposure concentration at a drinking water well downgradient of a landfill that is assumed to have received a loading of lead wheel-balancing weights.

EFAST is a publicly available suite of models that contains databases, models and algorithms for screening-level exposure assessment of chemical releases to air, water, land, and from consumer products, and provides detailed information on environmental fate of a wide variety of existing chemicals. A description of EFAST and its baseline assumptions and methodology is summarized below. Additional details on EFAST is available on the following website: <http://www.epa.gov/opptintr/exposure/docs/efast.htm>.

EPA ran the EFAST landfill scenario assuming the lead wheel-balancing weight loading per landfill per year to be 1,529.22 kilograms (2,702,132 kg lead deposited on nations highways per year; divided by 1767 (the number of Municipal solid waste landfills operating in USA in 2002 with capacity)). This estimate is conservative because it assumes that all wheel-balancing weights deposited on USA highways are swept up and deposited in landfills. The EFAST model output for Average Daily Concentrations (ADC) of lead in drinking water for the hypothetical exposure scenario is noted below.

Table 3. Hypothetical Exposure Concentrations of Lead from Wheel-balancing Weights Swept up from Streets and Landfilled, Estimated using E-FAST

	Slow Migration Rate Average Daily Concentration mg/L	Rapid Migration Rate Average Daily Concentration mg/L
1529.22 kg to landfill/year; 365 days/year exposure	8E-03	<<<1
1146.10 kg to landfill/year; 365 days/year exposure	5E-03	2E-02
766.50 kg to landfill/year; 365 days/year exposure	3E-03	1E-02
383.25 kg to landfill/year; 365 days/year exposure	2E-03	5E-03

The above concentrations were developed using EFAST and assuming four scenarios:

- 100% of lead on roadways went to the landfill (1529.22 kg to landfill/year);
- 75% of lead on roadways went to the landfill (1146.1 kg to landfill/year);
- 50% of lead on roadways went to the landfill (766.5 kg to landfill/year); and
- 25% of lead on roadways went to the landfill (382.25 kg to landfill/year).

There are various uncertainties and limitations associated with the use of EFAST for these model runs. First, EFAST assumes that 100% of the lead wheel-balancing weight loading per year to the landfill (1,529,220 grams) was released to the groundwater. This is a very conservative assumption, since it is unlikely that 100% of a wheel weight would dissolve or release lead within one year of the time of disposal within a landfill. It would thus be more realistic and reasonable to reduce the assumption for the landfill release term used in the model runs for landfill leachate resulting from lead wheel-balancing weights. An extrapolation of limited available research (Steil, 2000) indicates that the number of grams that could leach out from the assumed lead wheel-balancing weight loading per year to a MSWLF landfill (1,529,220 grams) could be 730 grams/year. Additional data would be preferable regarding the expected releases of lead from lead wheel-balancing weights in a landfill environment.

Second, EFAST model runs assume that the lead wheel-balancing weight waste is being disposed of in an unlined landfill with no leachate collection systems, with uncontrolled releases to receptor wells. This is a very conservative assumption, since it is likely that towns and cities that

dispose of municipal waste in landfills use either new landfills that are lined with leachate collection systems, or older existing landfills that are required to monitor groundwater and perform corrective action to contaminated groundwater if necessary.

Two basic options are provided for in the federal municipal landfill regulations for the design of new municipal landfills and lateral expansions to existing municipal landfills. The first option is that the landfill or expansion must meet the EPA performance standard, i.e., that Maximum Contaminant Levels (MCLs) will not be exceeded in the uppermost aquifer at a “relevant point of compliance.” The second option is a design developed by EPA that consists of a composite liner and a leachate collection system. Also, a municipal landfill cannot accept bulk or noncontainerized liquid waste unless (1) the waste is nonseptic household waste, or (2) it is leachate or gas condensate that is recirculated to the landfill, and the unit is equipped with a composite liner and leachate collection system (USEPA, 1993b).

The federal municipal landfill regulations require that all existing MSWLF units, lateral expansions of existing units, and new MSWLF units must conduct groundwater monitoring (unless a State that is delegated the RCRA municipal landfill program finds that no potential exists for migration of hazardous constituents from the MSWLF unit to the uppermost aquifer during the active life of the unit, including closure or post-closure care periods). If a significant change in groundwater quality occurs, the federal municipal landfill regulations require an assessment of the nature and extent of contamination followed by an evaluation and implementation of remedial measures (USEPA, 1993b). Additional information on Federal requirements for municipal landfills can be found at the following EPA websites: <http://www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm> and <http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm>, and in EPA’s Criteria for Solid Waste Disposal Facilities (USEPA, 1993a).

Third, additional data would be preferable regarding the type of landfills that cities and towns use for disposal of waste collected by street cleaning machines.

5.5.4 Conclusions drawn from the analysis

As stated above, EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenarios evaluated. An exposure assessment of this kind should be considered a what-if scenario. At the time of this assessment there was no data available to determine the loading of lead wheel-balancing weights from street cleaners to landfills; therefore, it was assumed that it would be equally distributed to all municipal landfills in the United States. The assumption that unlined landfills without leachate collection systems would be used for disposal of lead wheel-balancing weights is highly conservative, since federal regulations for municipal landfills require use of lined landfills with leachate collection systems. The assumption that all lead from lead wheel-balancing weights

disposed of in landfills would leach within a year is also highly conservative, since it is unlikely that all wheel-balancing weights would dissolve or release all lead within one year within a landfill.

Additional well designed studies could fill in these data gaps and would result in refined and improved estimates.

5.6 Vapors from Home Smelting of Used Wheel-Balancing Weights Obtained by Non-Commercial Persons from Gas Stations and Small Wheel-Balancing Retailers (i.e., inhalation of airborne releases from home smelter)

Both the Office of Pollution Prevention and Toxics and the Office of Solid Waste identified hobbyist melting and recasting of lead wheel weights as a source of potential lead exposure. OSW and ORD began the development of a scenario for lead exposure from this use that considered both oral and inhalation routes of exposure for individuals collecting, melting and casting lead wheel weights into new articles for commercial sales. The scenario was intended to yield lead concentrations in relevant media for use in biokinetic models to predict blood lead levels in exposed individuals. Although key variables in the exposure scenario were identified, and input values were suggested to determine if the scenarios and modeling could be successfully used, no input values based on measured data, or documentation for the selected inputs were developed. If this scenario is further developed so that it includes documented, measured, reliable input values, then it would be helpful in developing a quantitative exposure assessment of the home smelting of lead wheel-balancing weights.

5.6.1 Available Data regarding lead exposure associated with this route

There are many sources of information on how to melt and cast lead into various products (bullets, sinkers, ingots), but no quantitative information could be found on exposure to lead during the process. Virtually all of the lead casting equipment manufacturers supply warning information with their products on lead hazard and methods to minimize exposure during product use.

Lead melts at approximately 327 degrees C. Melted lead gives off fumes at temperatures above 500 degrees C. Lead can be melted by the hobbyist using a variety of devices. These devices range from cast iron pots that can be heated using any heat source (propane, electric heating element, etc.) with little temperature control, to electric melting pots with temperature adjustment. Electric stoves heating elements are known to reach a temperatures in excess of 660 C causing aluminum cookware to fail and natural gas burns at a range of 1600 to 2000 degrees C. Thus there is a possibility of generating lead fumes using these heat sources. At least one major manufacturer of electric melting devices builds their equipment to heat to a maximum temperature below 500 C to minimize lead fuming.

No information was found on airborne lead concentrations in the air around these melting

devices. However, workplace air monitoring data do exist for industrial operations where lead is melted. Workplace air at three sites in the fishing tackle industry where lead sinkers are cast was monitored for lead. Eight hour TWA in personal breathing zones were determined.. The average concentrations for job category lead pot tender was 49 ug/m³ (OSHA, 1994).

Field surveys of three radiator repair shops (where lead containing solder is used for repairs) in the Cincinnati, OH area showed that the highest concentration of airborne lead measured during a brief period of continuous soldering in a shop equipped with local exhaust ventilation was 7.1 µg/m³. In a shop where no exhaust was used, the 13 personal samples averaged 209 µg/m³ with a maximum of 810 µg/m³ measured for a 56-minute sample worn while tearing down and resoldering a single radiator (Tharr, 1993).

A study on worker exposure to lead in Korea reported geometric mean values for total airborne lead concentrations of 758 ug/m³ in secondary smelting furnace operations, 436 ug/m³ in scrap and furnace operations, and 25 ug/m³ in radiator soldering.

5.6.2 Other data associated with lead in the environment in media associated with this route

No specific studies on the fuming of lead at high temperatures were found, but many references to lead fume formation at temperatures above 500 degrees C can be found in the available information on reducing worker exposure to lead and prevention of worker lead poisoning. The reported vapor pressure of lead increases from 10E-6 Torr at 429 Degrees C to 10E-4 Torr at 547 degrees C, supporting the potential for volatilization as temperatures are elevated.

5.6.3 Method used to estimate exposure concentration for this hypothetical exposure scenario

Due to a number of considerations (see 5.6.4) exposure to lead in this scenario was not estimated. EPA did, however, find information on procedures for hobbyist lead melting and casting. Generally lead is added to the melting pot and melted over a 20-30 minutes period while the contents to reach about 600 F. Temperature may be adjusted to approximately 650 F for best lead flow and mold fill-out. Lead is fluxed as needed by adding a small amount of wax or flux, stirring vigorously and scraping sides and bottom of pot to dislodge impurities. Impurities are then skimmed off the surface of the melted lead. Once lead is melted the mold is heated by dipping a corner of it into melted lead for about 15 seconds. When the mold is hot, it is filled with molten lead, excess lead removed (sprue cut off) and allowed to cool slightly. The mold is then opened and the object tapped out into a soft cloth. The length of the casting session is indeterminate and largely dependent on the desires of the hobbyist.

5.6.4 Conclusions drawn from the analysis

There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenarios evaluated. It is not possible to characterize the accuracy of the scenario because each hobbyist may use different procedures which could result in more or less exposure. No monitoring data were available for this scenario. EPA believes that the use of airborne lead concentration taken from workplace monitoring studies would result in unrealistically high estimated exposures. Information on the routine practices for hobbyist lead melting and casting suggest that some amount of exposure is possible, but reliable quantitative estimates for exposure from those practices cannot be made at this time due to lack on information on factors including airborne concentrations of lead generated during home melting and the prevalence of different lead melting and casting practices.

5.7 Weights Left on Cars That May Be Collected and Burned in Electric Arc Furnaces (i.e., inhalation of airborne releases from furnace) And Releases Associated with Auto Shredder Activities (inhalation route) (i.e., inhalation of airborne releases from shredder)

5.7.1 Available Data regarding wheel weight releases associated with this route

Automobile shredders (AS): There are 200 automobile shredding facilities in the U.S. which are assumed to operate over 250 days per year. There are no studies that estimate the amount of lead wheel weights processed in these automobile shredding facilities. Both dust and water releases of lead are possible, the amounts released could not be quantified due to the lack of data (USEPA, 2005a)

Electric Arc Furnaces (EAF): There are 95 facilities utilizing EAF in the U.S. with workers being exposed up to 250 days/year (USEPA, 2005a). There are no studies that estimate the amount of lead wheel weights processed in these EAF facilities. There are data in the 2003 Toxics Release Inventory for facilities in the secondary smelting and Refining of nonferrous metals industry (SIC 3341), however, these lead releases are from all operations at these facilities. The amount of these releases that is associated with lead wheel-balancing weights cannot be ascertained or estimated from this value (USEPA, 2005a).

5.7.2 Method used to calculate/quantify exposure estimate for the EAF pathway

There were no release estimates available from either shredder operations or EAF facilities to allow EPA is estimate exposure via these pathways. If data were available, the Exposure and Fate Screening Assessment Tool (E-FAST) which uses a simple, conservative method for estimating ambient air concentrations that may result from air emissions from sources with stacks such as boilers and incinerators (and in this case electric arc furnaces) could be used to estimate exposure.

5.7.3 Conclusions

EPA was unable to construct a hypothetical exposure scenario due to the lack of available data and information, specifically, the amount of lead from shredder operation and EAF facilities that is associated with lead wheel-balancing weights. Additional research may result in refined and improved estimates. Although this is a possible scenario, EPA could not determine what likelihood of lead wheel-balancing weights being left on ELVs that would then be processed in Automotive Shredder (AS) facilities and subsequently sent to EAF facilities in the U.S. There is no information available at this time to make **any** assumption on what amount of lead wheel weights will undergo treatment in AS/EAF facilities. Additional information/research is needed to develop this scenario.

5.8 Releases from Roadways to Streams - Aquatic Life

5.8.1 Available Data regarding wheel-balancing weight losses associated with this route.

No information on wheel-balancing weight losses other than Root (2000) and Bodanyi (2003) are available. This variable is the primary input for most of the air, water, and soil scenarios assessed, and quantitatively provides the mass of lead released to the environment upon which fate and transport processes act. Error in this value proportionally impacts predicted environmental concentrations and exposure estimates.

Many data gaps exist for this scenario and a series of assumptions were made to fill them. The mechanism of physical abrasion of wheel weights on road surfaces, rate of loss of mass of intact weight by abrasion, and particle size of abraded lead is unknown. In the absence of this information EPA assumed rapid, complete abrasion to fine particles. The rate of abrasion and lead surface area (related to particle size) significantly impacts predicted environmental concentrations and exposure. EPA believes that this assumption is conservative and would result in estimates of environmental concentrations and exposures higher than those that would actually occur.

The retention / release of lead on road surfaces is unknown. This process would impact how much particulate lead from abraded wheel weights is free to enter air, water or soil. The effect of surface type (asphalt, concrete, etc.) on retention is also unknown. The retention of lead on road surface significantly impacts predicted environmental concentrations and exposure. EPA assumed 100% of wheel weight lead is available for transport (not retained on road surface). EPA believes that this assumption is conservative and would result in estimates of environmental concentrations and exposures higher than those that would actually occur.

Partitioning of particulate lead from wheel weight lead abrasion between air, water and soil is unknown. EPA assumed that 100% of wheel weight lead either goes to air, or water, or soil for many scenarios.

Amount of wheel weight lead on road surfaces removed per unit of rainfall is unknown. EPA assumed 100% of previously deposited lead is removed with each rainfall event.

National precipitation data average frequency and amount was not available for this assessment. EPA assumed 8 rain events per year and each rain removed 100% deposited wheel weight lead.

Information on typical stormwater collection and conveyance practices, and flow rates of stormwater receiving streams was not available for this assessment. EPA selected an increasing range of receiving stream flow rates beginning at 50 cubic feet per second to estimate surface water concentrations.

Information on the range, average and distribution of chemical characteristics of stormwater and surface waters (e.g., pH, hardness, dissolved organic carbon (DOC), total suspended solids (TSS), sulfate, etc) on a National basis. Water chemistry has major influence on limiting lead solubility, but because a conservative approach was taken, the assessment did not address metal speciation, and EPA estimated total lead concentration.

5.8.2 Method used to calculate/quantify the exposure estimate for this Route

The surface water concentration for total lead was calculated as follows:

$$C = L/Q$$

C = average concentration mg/liter

L = loading mg/day

Q = flow liters/day

The following assumptions are used in constructing the hypothetical exposure scenario:

- 1 mile roadway runoff drains directly into stream with flow of 122 million liters per day (default low flow of 50 CFS)
- stream loading and flow are constant for the length of the stream
- annual loading from wheel-balancing weights is 1.68 kg/mile of road
- precipitation does not appreciably add to stream flow
- deposited lead is completely washed off road in each of 8 annual rain events
- all lead is soluble

Table 4. Estimated surface water concentrations from lead run-off

Stream Flow (CFS)	Stream Flow (MLD)	Pb concentration (ppb)
50	122	1.7
100	245	8.2
1000	2453	0.82
5000	12268	0.16
10000	24538	0.08
100000	245376	0.01

5.8.3 Conclusions drawn from the analysis

EPA has constructed a hypothetical exposure scenario using available data and information. There are numerous uncertainties associated with the exposure scenario; the more important assumptions and uncertainties concern the source term, or the amount of lead released and available during the use of lead wheel-balancing weights in the scenario evaluated. There are also important environmental variables impacting the fate of lead in surface waters that can vary geographically (see uncertainties in this section and the discussion of the environmental fate of lead). Rather than attempting to account for these variables, the scenario used simplifying assumptions that would result in conservative estimates of lead concentrations in surface waters.

6.0 DATA GAPS AND UNCERTAINTIES ASSOCIATED WITH ENVIRONMENTAL AND HUMAN HEALTH EXPOSURE ASSESSMENT OF LEAD WHEEL-BALANCING WEIGHTS

Table 5 provides a listing of the data gaps and uncertainties identified by USEPA. Such data is needed to provide an improved understanding of the potential environmental and human health impacts associated with environmental releases from lead wheel-balancing weights.

Table 5. Summary of Uncertainties and Data Gaps Table associated with Lead Wheel-Balancing Weight Exposure Assessment

Scenario/data element	Data gap	How the data could be used
I. Data needs regarding lead wheel-balancing weights from point of manufacture to point of deposition on roadways.		
Data on the total mass of lead wheel-balancing weights that are lost to roadways throughout the USA per year.	Updated information on the number of cars and trucks that travel US roadways per year, including information on areas with high or low traffic volumes.	To develop relative loss rates for wheel weights from vehicles to estimate number of wheel weights lost per road mile.
	Updated information on the mass of lead wheel-balancing weights released onto roadways from cars and trucks ranging in age from new to near end-of-service life and are currently on roadways.	To incorporate the effect of vehicle age into the estimation of wheel-balancing weight loss to roads.
	Updated information on the mass of lead wheel-balancing weights released onto roadways from “replacement tires” on cars and trucks that are currently on roadways.	To incorporate the effect of the use of replacement tires into the estimation of wheel-balancing weight loss to roads.

Scenario/data element	Data gap	How the data could be used
	<p>Data on factors that increase or decrease rate of loss of wheel weights from a new or old car or truck, or from replacement tires on cars and trucks, e.g., climate; precipitation events; speed of vehicles; vehicle stopping and turning; relative age of car or wheels; reuse of wheel weights.</p>	<p>This information would assist EPA in developing a better understanding of whether there are certain factors that should be considered when assessing potential for loss of wheel-balancing weights onto or near roadways.</p>
	<p>Additional field studies for comparison to the field studies conducted by Root (2000) and Bodanyi (2003) regarding the potential loss of wheel-balancing weights from vehicles into the environment.</p>	<p>Additional studies on potential releases to the environment from lead wheel-balancing weight loss for comparison and to establish ranges for use in an exposure assessment.</p>
<p>II. Data needs regarding releases of lead from lead wheel-balancing weights from point of deposition on roadways to various potential exposure routes.</p>		
<p>Quantitative information on the ultimate fate of lead from lead wheel-balancing weights on roadways .</p>	<p>Mechanics of physical abrasion of wheel-balancing weights on road surfaces, rate of loss of mass of intact weight by abrasion, particle size of abraded lead, entry into air as particulates, deposition of particulates on soil and road surfaces.</p>	<p>More accurate modeling of fate and transport of wheel weight derived lead. Needed for most air, water, and soil scenarios.</p>

Scenario/data element	Data gap	How the data could be used
	Retention/release of lead on road surfaces. How much particulate lead from abraded wheel weights is free to enter air, water or soil. The effect of surface type (asphalt, concrete, aggregate, etc.) on retention.	More accurate modeling of fate and transport of wheel-balancing weight derived lead is needed for most exposure scenarios. Retention of lead on road surface significantly impacts predicted environmental concentrations and exposure.
III. Data needs to assess particular exposure routes associated with potential releases from roadways to the environment		
a) Dust in and near roadways from soil lead and neat lead (soil/dust inhalation).	Information on the amount of lead left on roadways from lead wheel-balancing weights which is released into dust on and near roadways	Input to estimation of lead dust concentration from abraded wheel-balancing weights. Lack of this information results in the use of simplifying assumptions which may overpredict or underpredict environmental concentrations and exposures.
b) dust from roadways migrating to residential soil (ingestion of soils route - (i.e., soil to mouth)).	Information on the amount of lead left on roadways from lead wheel-balancing weights which is released into dust on and near roadways	Input to estimation of lead dust concentration from abraded wheel-balancing weights.
	deposition pattern of particulate lead abraded from wheel weights on roadside soil.	Input to estimation of soil lead concentration from abraded wheel-balancing weights.

Scenario/data element	Data gap	How the data could be used
	horizontal and vertical concentration gradient of lead abraded from wheel-balancing weights in roadside soil.	Input to estimation of soil lead concentration from abraded wheel-balancing weights.
	rate of loss of wheel weight lead in roadside soil and important loss mechanisms	Input to estimation of soil lead concentration from abraded wheel-balancing weights.
	Residence time of wheel weight lead in roadside soil available for exposure	Input to estimation of soil lead concentration from abraded wheel-balancing weights.
c) Dust migrating into residence via pathways a) and b) above (i.e., dust from road into residence, and dust from soil into residence); and dust into residence from residential soil via foot traffic into house (inhalation/ingestion routes) (i.e., ingestion of dust that has settled in the home (i.e., dust to mouth); and inhalation of airborne dust that has entered the home).	Information on the amount of lead left on roadways from lead wheel-balancing weights which is released into dust on and near roadways and which transports into homes near roadways.	Input to estimation of lead dust concentration in home from releases from abraded wheel-balancing weights.
	Information on the amount of lead left on residential soil which is released into dust.	Input to estimation of lead dust concentration in home from releases from soil.
	Information on the amount of lead dust tracked into residence from residential yards	Input to estimation of lead dust in home from releases from lead tracked into residence from residential soil.
d) weights/particles swept up by municipal street cleaners and incinerated (inhalation route) (i.e., inhalation of airborne releases from incinerator)	Information on the amount of lead left on roadways from lead wheel-balancing weights which is swept up by municipal street cleaners and incinerated.	Input to estimation of releases from incinerators from wheel-balancing weights collected by street cleaners and general population exposure.
	Loading of lead wheel-balancing weights in kilograms per year per incinerator	As input to air dispersion modeling of incinerator emissions.

Scenario/data element	Data gap	How the data could be used
	Quantity of sweepings from street cleaners that goes to incinerators	As input to air dispersion modeling of incinerator emissions.
	Removal efficiency of lead from wheel-balancing weights during incineration	As input to air dispersion modeling of incinerator emissions.
	Air emissions stack parameters for municipal incinerators.	As input to air dispersion modeling of incinerator emissions.
e) weights/particles swept up by municipal street cleaners and landfilled, potential migration to groundwater, and drinking water wells (ingestion of drinking water route);	Information on the amount of lead left on roadways from lead wheel-balancing weights which is swept up by municipal street cleaners and landfilled.	Input to estimation of releases from landfills from wheel-balancing weights collected by street cleaners.
	Data regarding the expected leach rate of lead from wheel-balancing weights within municipal solid waste landfills.	To estimate potential general population exposure to lead via ingestion of contaminated groundwater .
	Data regarding the type of landfills that cities and towns use for disposal of waste collected by street cleaning machines, including whether the landfills are lined and have leachate collection systems.	To estimate potential general population exposure to lead via ingestion of contaminated groundwater .
IV. Data needs to assess particular exposure routes associated with potential consumer exposure from reuse of lead wheel-balancing weights		

Scenario/data element	Data gap	How the data could be used
f) vapors from home melting of used wheel-balancing weights obtained by hobbyists to cast objects, e.g., sinkers, bullets, etc(inhalation route)	general practice/procedure for hobby wheel-balancing weight melting and lead casting including frequency and duration of hobby activity	Input into exposure estimate.
	breathing zone lead concentration resulting from hobby lead wheel-balancing weight melting in home melting pot	Input into exposure estimate.
	temperature range used for lead melting	Assess potential for lead fume generation.
g) Quantity of lead wheel balancing-weights left on cars collected and burned in electric arc furnaces (EAF) (inhalation route) (i.e., inhalation of airborne releases from furnace).	Yearly loading of lead wheel weights from automobiles sent to End-of- Life Vehicle (ELV) reclamation facilities in the U.S.: yearly lead loading to Automobile Shredder (AS) operations; yearly lead loading to EAF operations;	Estimation of releases of lead to air and input into exposure calculation.
h) releases associated with auto shredder activities (inhalation route) (i.e., inhalation of airborne releases from shredder)	Distribution of lead in various waste streams associated with the processing of ELVs in AS and EAF operations during automobile reclamation activity	Estimation of releases of lead to air and input into exposure calculation
	Environmental release factors associated with each reclamation facility waste stream containing lead from lead wheel weights.	Estimation of releases of lead to air and input into exposure calculation
i) releases from roadways to surfacewaters	Amount of wheel weight lead on road surfaces removed per unit of rainfall	Input into exposure calculation. Needed to determine reasonable scenario for lead wash-off from road surface and into stormwater conveyance system

Scenario/data element	Data gap	How the data could be used
	National precipitation data: frequency and amount	Needed to determine reasonable scenario for wheel weight lead wash-off from road surface and into stormwater conveyance system, and potential wheel weight lead concentration in stormwater
	Information on typical stormwater collection and conveyance practices, and flow rates of stormwater receiving streams	Needed to determine reasonable scenario for discharge of stormwater conveyance system to surfacewaters
	characterization of stormwater and surface waters (e.g., pH, hardness, DOC, TSS, sulfate, etc)	Needed to predict metal speciation if estimates beyond total lead are desired. Water chemistry has major influence on lead solubility.

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Attachment 1

Summary of Environmental Lead Literature Search on Lead Wheel-Balancing Weights



MEMORANDUM

TO: Conrad Flessner
Edward Hanlon
Richard Wormell

cc: 111126.1000.008

FROM: Chris Greene/Jim Buchert/Mike Nelson/Chuck Peck

DATE: May 26, 2005

SUBJECT: Literature Search for Exposure and Risk Assessments for Lead Tire Weights

Attached are the results of the literature search conducted for lead tire weights and associated exposure/risk pathways and assessments. Versar conducted literature searches in the PubMed, ToxLine, AGRICOLA, Science Direct, and DIALOG databases, as well as general Internet searches using the GOOGLE search engine. Below is a summary of Versar's findings. Hard copies (along with PDF files on CD) of the publications and Internet sites, along with the summary of findings for each document, are provided in the following Attachments:

- Attachment A: Environmental lead literature search focusing on identification of reasonable exposure pathways associated with releases from lead tire weights into the environment.
- Attachment B: Literature search for lead tire weight-related information using EPA recommended websites listed in Technical Direction.
- Attachment C: Literature search using references in TSCA petition.
- Attachment D: Literature searches for lead exposure scenarios on military or civilian shooting/trap ranges
- Attachment E: European Union literature searches for heavy metals and waste reduction methods related to motor vehicles.

Discussion

- In general, the availability of information pertaining to exposure and/or risk assessments for lead tire weights is very limited. Specific documents that focused on lead tire weights include: California Department of Transportation Environmental Program Proposed Soil Lead Management Criteria as Part of Caltrans Highway Construction and Maintenance (Document #26); Environmental Defense, Ecology Center, Clean Car Campaign *Getting the Lead Out - Impacts of and Alternatives for Automotive Lead Uses* (Document #27); Lead Loading of Urban Streets by Motor Vehicle Wheel Weights, Robert A. Root (Document #29); and *Lead Use in Ammunition and Automotive Wheel*

Weights: An Examination of Lead's Impact on Environmental and Human Health, the Alternatives to Lead Use, and the Case for a Voluntary Phase-Out, Ryan Bodanyi (Document #48).

- The Internet sites provided by EPA did not provide information on exposure or risk pathways specifically for lead tire weights (refer to Documents #1 through #9 in Attachment B). They did provide generic information on lead tire weights and the toxicity of lead. The EPA Internet sites did not focus on lead tire weights, but instead provided information on residential exposure to lead, including some limited information on pathways. The residential exposure was primarily the result of home renovations and lead-based paint removal.
- The references cited in the TSCA petition (refer to Documents #10 through #16 in Attachment C) also did not provide information on exposure or risk assessments for lead tire weights. The papers did provide information regarding urban runoff and lead concentrations in the runoff. The papers also provided some information as to the percentage vehicular traffic played in regards to lead in the urban runoff. However, there were no specific references to lead tire weights, save the Root (i.e., Lead Loading of Urban Streets by Motor Vehicle Wheel Weights, Robert A. Root (Document #29)) and Bodanyi papers.
- Analyses regarding previous EPA rulemakings (e.g., EPA's TRI Lead rule, the lead based paint debris rule, and the hazard standards for lead-based paint and lead in dust and soil) were covered in the analyses on the Internet searches provided by EPA (refer to Attachment B). In particular, the lead in dust and soil was covered in searches on www.epa.gov/opptintr/lead/403risk.html and www.epa.gov/opptintr/lead/403risksupp.html, and the lead based paint debris rule was covered in searches at www.epa.gov/epaoswer/non-hw/muncpl/landfill/pb-paint.htm. Exposure pathway scenarios were identified, but they focused primarily on residential exposure from lead-based paint. Also, the exposure pathway scenario analysis for EPA's TRI lead rule could not be located by Versar or EPA.
- With regards to EPA mobile source rulemaking efforts, the documents available on the Internet did not discuss exposure and risk associated with lead.
- Searches that focused on lead exposure scenarios on military or civilian shooting/trap ranges generated documents (refer to Documents #49 through #71 in Attachment D) with information on lead exposure and poisoning, fate and transport of lead from bullets, risk analyses, estimates of lead on a local and national scale at shooting/trap ranges, reclamation of lead at shooting/trap ranges, and best management practices.
- Analyses of other pertinent Internet sites were conducted using the GOOGLE search engine. In particular, 7 searches were conducted using the following key word combinations:

- (exposure, lead, wheel, weight)
- (lead, exposure, non-occupational)
- (automotive, lead, exposure)
- (lead, tire, weights, fall, off)
- (lead tire, wheel, weights)
- (lead, exposure, hobby)
- (automotive shredder lead)

The results are included in Attachment A. However, none of the Internet links provided significant information pertaining to exposure or risk associated with lead tire weights.

- Based on review of the literature searches the most reasonable exposure pathways for lead tire weights are as follows:
 1. Roadside - runoff - surface water - aquatic life - fish consumption by anglers
 2. Roadside - pulverized - dust in ambient air - redeposited near residences - tracked into home - children (dermal, ingestion, inhalation)
 3. Roadside - picked up by hobbyist - melted in home (to make bullets, lead sinkers, lead soldiers, etc.) - inhalation by family
 4. Roadside - leach into soil - groundwater - drinking water sources

Please feel free to contact us if you have any comments or questions.