REVISED CALIFORNIA HUMAN HEALTH SCREENING LEVELS FOR LEAD

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Office of Environmental Health Hazard Assessment
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Introduction

The California Office of Environmental Health Hazard Assessment (OEHHA) has recently developed a 1 µg/dL benchmark for source-specific incremental change in blood lead levels for protection of school children and fetuses (OEHHA, 2007). The publication of this value required a review of the residential Soil Screening Level for lead (CHHSL), which currently stands at 150 mg/kg and the commercial/industrial CHHSL, which currently stands at 3500 mg/kg (OEHHA, 2005 revision). Application of this Soil Screening Level is explained in "Use of California Human Health Screening Levels in Evaluation of Contaminated Properties" (Cal/EPA, 2005).

Methods

The essence of this task was to estimate a concentration in soil that would lead to an incremental increase in blood lead (Pb_B) of up to 1 µg/dL, in people exposed to that soil. For the residential CHHSL for lead we evaluated the exposure to a child resident. For the commercial/industrial CHHSL we evaluated the exposure to a pregnant adult worker.

Residential Child Scenario

The Department of Toxic Substances Control's Leadspread model (DTSC, 2007) was used to estimate blood lead concentrations in children. The Leadspread model considers exposure to lead in soil by three pathways: ingestion, re-suspension and inhalation, and dermal contact. The Leadspread model was queried for the soil lead concentrations that would give rise to a 90th percentile estimate of increase in blood lead of 1 µg/dL using the "goal seek" function in Excel™. Model inputs and outputs for the Child Scenario are shown in Table 1.

Table 1: Leadspread Input Values

FACTOR	LEVEL	UNITS
Lead in Soil/Dust	77	µg/g
Soil ingestion	100	mg/day
Ingestion constant	0.16	(µg/dl)/(µg/day)
Oral bioavailability	0.44	unitless
Skin area	2900	cm^2
Soil adherence	200	µg/cm^2
Dermal uptake constant	0.0001	(µg/dl)/(µg/day)
Respirable dust	1.5	ug/m^3
Breathing rate	6.8	m^3/day
Inhalation constant	0.192	(µg/dl)/(µg/day)
Exposure days per week	7	days/wk
Geometric Standard Deviation[1]	1.6	µg/dL
Background lead in air[2]	0	µg/m^3
Lead in water[2]	0	µg/L
Home-grown produce[3]	0	percent
Resulting 90th percentile increase in blood lead	1	µg/dL

[1] Based on blood lead levels in geographically limited populations of children (EPA, 2007)
[2] Because this soil screening level is based on a change in blood lead due to the exposure under evaluation, no background exposures are included.
[3] As explained in (OEHHA, 2005) the food pathway is not used in calculating soil screening levels. These screening levels may not be appropriate for sites to be used for gardening or farming.

Occupational Adult Scenario

U.S. EPA's Adult Lead Model (ALM) (EPA, 2005) was used to estimate the blood lead concentration in a fetus of an adult worker exposed to lead-contaminated soil. The model was queried directly for the soil lead concentrations that would give rise to the 90th percentile estimate of change in blood lead of 1 µg/dL using the "goal seek" function in Excel™. Model inputs and outputs are shown in Table 2. Inputs that were changed from default values are in bold.

Table 2: ALM Input and Output Values for the Occupational Scenario

FACTOR	UNITS	VALUE
Fetal/maternal Pb_B ratio	--	0.9
Biokinetic Slope Factor	µg/dL per µg/day	0.4
Geometric standard deviation Pb_B (GSD)	--	**1.8**[2]
Baseline Pb_B	µg/dL	**0.0**[3]
Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
Absorption fraction	--	0.12
Exposure frequency	days/yr	**250**[4]
Averaging time	days/yr	365
Pb_B of adult worker, geometric mean	µg/dL	0.6[1]
90th percentile Pb_B among fetuses of adult workers	µg/dL	1.0
Target Pb_B level of concern	µg/dL	**1.0**
Probability that fetal Pb_B > Pb_Bt, assuming lognormal distribution	percent	10 %
Soil lead concentration	µg/g or ppm	320[1]

[1] Calculated value
[2] The default GSD in ALM (2.1) was changed to 1.8. EPA (2001) recommended a value of 1.8 for relatively homogeneous populations. The default GSD in ALM reflects variability in the population as a whole. This variability has many components, including variability in exposure concentration. The latter source of variability is reduced or eliminated in a population exposed to soil containing 320 ppm.
[3] No baseline Pb_B is assumed, since the target change in blood lead is an incremental change due to the soil in question.
[4] The value of 250 days per year is consistent with other CHHSLs.

Results

The Soil Screening Levels resulting from the analyses described above are shown in Table 3.

Table 3: Comparison of 2005 CHHSLs to Revised CHHSLs

Residential CHHSL* (mg/kg)		Commercial/Industrial CHHSL[1] (mg/kg)	
2005	Revised	2005	Revised
150	80	3500	320

[1] Rounded to nearest multiple of 10.

Discussion

The previous CHHSLs for lead were calculated as the maximum soil concentration which, combined with an assumed background lead exposure from food, air, and water, would result in a total blood lead not to exceed 10 µg/dl. The proposed CHHSLs are calculated differently: they are calculated as the level in soil that could result in up to a 1 µg/dl increase in blood lead, irrespective of background exposures. Background exposures are not typically considered in other CHHSLs or other screening levels.

The proposed CHHSLs for lead consider two sources of uncertainty: the relationship between blood lead level and cognitive ability, and the relationship between lead levels in the environment and blood lead levels. The first source of uncertainty involves the fitting of a model to the blood lead and IQ data in the meta-analysis of Lanphear et al. (2005) that was used to determine the relationship between blood lead and IQ. To be conservative OEHHA (2007) used a 97.5% upper confidence limit on the slope of the IQ versus Pb_B curve.

The other source of uncertainty is the relationship between environmental lead levels and blood lead levels. Both Leadspread and the ALM account for this by predicting a distribution of blood lead values for any given set of environmental inputs. The percentiles of the Pb_B versus soil Pb curve reflect physiological and behavioral variability in individual responses to similar environmental concentrations. Although the previous CHHSL for lead was based on the 99th percentile of that distribution, the revised CHHSL is based on the 90th percentile of the distribution. The reason for this change is that the benchmark change in blood lead concentration is a health-protective estimate, based on risk to children, whereas the previous target blood lead level was based on a “level of concern” that did not incorporate recent scientific information and focused on individual - rather than population - risks.

The overall approach to accommodating the two sources of uncertainty can be summarized as follows: the CHHSLs represent concentrations in soil that have no more than a 2.5% probability of decreasing IQ by more than 1 point in a 90th percentile child or fetus.

References

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Lanphear, BP, Hornung R, Khoury J, Yolton K, Baghurst P, et al., 2005. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. Environ. Health Perspect. 113:894-899.

EPA 2001, Review of Adult Lead Models: Evaluation of Models for Assessing Human Health Risks Associated with Lead Exposures at Non-Residential Areas of Superfund and Other Hazardous Waste Sites U.S. EPA, Office of Solid Waste and Emergency Response OSWER #9285.7-46 (Table 1.1).

EPA, 2007, Lead: Human Exposure and Health Risk Assessments for Selected Case Studies, Volume I. Human Exposure and Health Risk Assessments - Full-scale, EPA-452/R-07-014a October 2007

Appendix

Response to comments

OEHHA received two comments on the draft CHHSL for lead. Both commentors suggested that the lead CHHSL should be applied only to anthropogenic lead, i.e. that background lead should not be included.

OEHHA response: In its response to comment #48 to the original 2005 CHHSL document, OEHHA stated "The health-based screening number for arsenic is intended for arsenic contamination resulting from human activity." This could also be applied to lead and other elements. However, the final determination of background levels and how they will be accounted for in any site-specific decision is ultimately up to those making the site-specific decision.