

Case Study: Lead Contamination and Local Exposure



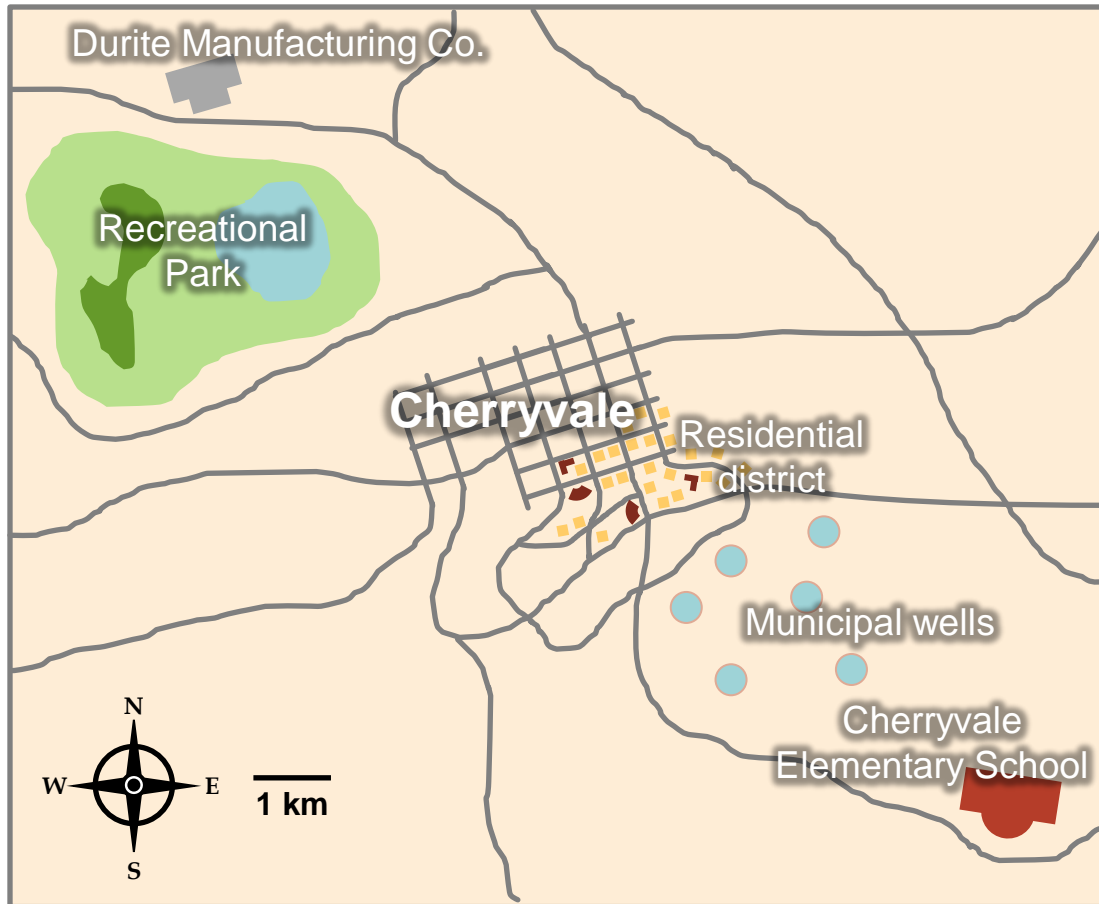
RISK ASSESSMENT TRAINING AND EXPERIENCE
Exposure Assessment Course Series – EXA 409

What You Can Expect to Learn from This Course

- How to apply exposure assessment concepts in the analysis of a “real-world” chemical exposure scenario
- Background information on factors affecting lead exposures and health effects due to these exposures
- Stakeholder perspectives on application of exposure assessment to risk management decisions

PROBLEM OVERVIEW: LEAD-CONTAMINATED COMMUNITY NEAR MANUFACTURING FACILITY

Durite Manufacturing and Surrounding Community



- Cherryvale population: 2,386
- Durite Manufacturing located:
 - 5 km NW of Cherryvale
 - 7 km NW of residential district
 - consists of individual dwellings and high-rise apartments
 - 9 km NW of municipal wells
 - public water source for Cherryvale
 - 14 km NW of Cherryvale Elementary
 - Attended by children of Cherryvale
 - Largest elementary school in the area

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- Since 1879

DURITE MANUFACTURING ACCUSED OF POISONING CHILDREN



Local environmental activist finds levels of lead in soil at factor exceed allowable standards.

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HOSPITAL FINDS ELEVATED BLOOD-LEAD LEVELS IN LOCAL CHILDREN



Three children show high levels of lead; others show symptoms of exposure.

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LEAD FOUND IN GROUNDWATER

Routine tests show contamination of town drinking water.

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PARENTS MARCH ON TOWN HALL

CITY HALL



Parents and other concerned citizens want answers about lead poisoning of children

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- Since 1879

A black and white photograph showing the lower half of a man's face and his torso. He is wearing a dark suit jacket, a white dress shirt, and a patterned tie. He is speaking into a cluster of at least five microphones positioned in front of him. The background is plain and light-colored.

The image shows three hand-drawn waveforms on a grid background. The first waveform is a periodic square wave. The second waveform is a complex periodic signal with multiple peaks and troughs. The third waveform is a non-periodic signal that starts with a series of peaks and then ends with a sharp drop to zero.

Problem Overview

- Soil surrounding facility contaminated with lead levels at levels of concern
- Three children with measured elevated blood-lead levels and others show symptoms of lead exposure
- Groundwater contaminated with lead
- Community is concerned
- Durite Manufacturing uses best available control technology

LEAD BACKGROUND INFORMATION AND DATA

Lead Characterization and Use

- What is lead?

Lead is a heavy, corrosion-resistant metal that occurs naturally in the environment (primarily found as lead compounds) and can persist for a very long time.

- What has lead been used in?

- Batteries
- Ceramic glazes
- Cable covers
- Dyes
- Weights
- Paints – Banned in 1978*
- Gasoline – Phased out starting in 1973; banned entirely in 1996*
- Solder – Banned if >0.2% lead in 1986; banned in food cans entirely in 1995*
- Plumbing – Restricted lead content of faucets, pipes, and other plumbing materials to 8% in 1986*
- Ammunition – Banned for waterfowl hunting in 1991*

*U.S. regulations only



Lead Environmental Fate and Transport

- What happens to lead when it enters the environment?
 - Can travel long distances in air before depositing onto soil or water
 - Adsorbs strongly to soil particles. Remains in the upper levels of soil profile, but can also be transported to surface water via erosion and runoff.
 - Unlikely to migrate to groundwater from soil
 - Adsorbs strongly to sediment particles, where it can persist for many years. Can also re-suspend into water column. Fish are exposed via suspended and bottom sediment.
 - Bioconcentrates in plants and animals



Lead Exposure

- What are the sources of lead exposure?
- **General population:** ingesting dusts, breathing air, drinking water, or eating foods that contain lead

Source	Exposure Media	Origin
Primary:	Lead-contaminated dust	Lead paint, lead emissions
Secondary:	Lead-contaminated drinking water	Lead pipes, erosion of natural deposits
	Food	Plant uptake, atmospheric deposition, formerly from lead-soldered food cans

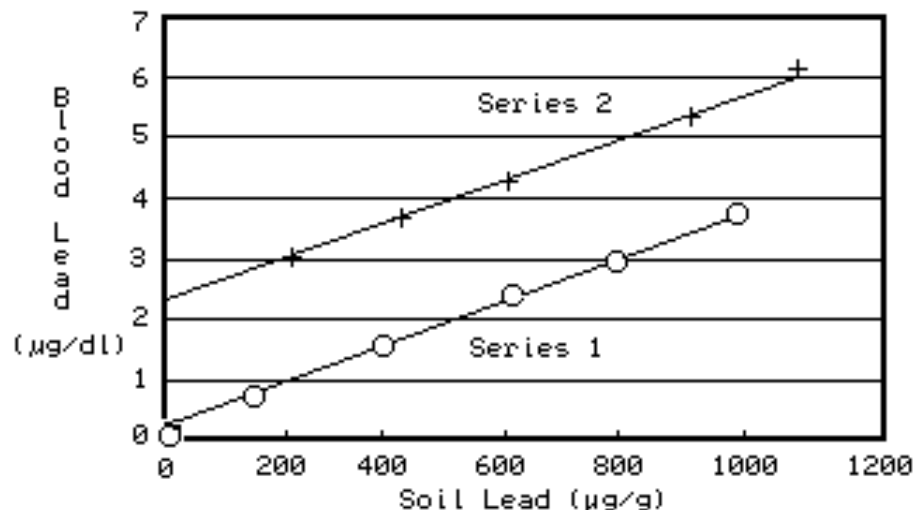
- **Children:** swallowing paint chips or dust from deteriorated lead-based paints
 - Deteriorated lead paint is number-one cause of severe lead poisoning in U.S. children
 - Particularly vulnerable due to non-adult behavior (e.g., crawling, mouthing)
 - Correlation between lead in soil and lead in blood of children has been studied extensively

Lead Health Effects

- What are the health effects of lead?
 - **General population:**
 - High blood pressure and hypertension
 - Coronary heart disease
 - Cognitive function decrements, depression and anxiety
 - Reduced kidney function, immune effects
 - **Children:**
 - Damage to brain and nervous system
 - Level of concern: ≥ 5 $\mu\text{g}/\text{dL}$ -blood
 - Possibly no threshold for effect
 - Behavior and learning problems: IQ, academic performance, learning and memory, inattention, impulsivity, hyperactivity
 - Impaired motor skills
 - Atopic and Inflammatory conditions (e.g., asthma and allergy)

Correlation between Lead Levels in Soil and in Blood

Figure 3. EPA UPTAKE/BIOKINETIC MODEL FOR LEAD:
BLOOD AND SOIL LEAD CORRELATION



Legend:

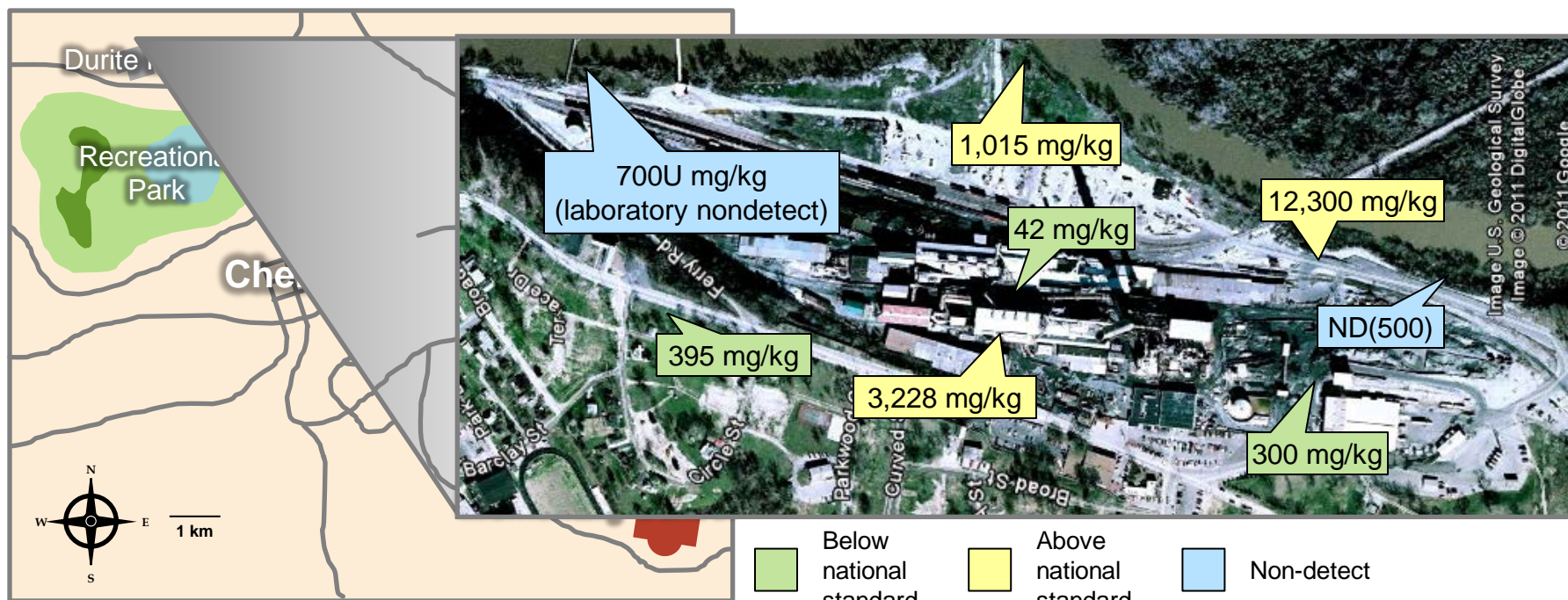
	<u>Series 1</u>	<u>Series 2</u>
AIR CONCENTRATION:	0.000 µg Pb/m ³	0.200 µg Pb/m ³
DIET Intake:	0.00 µg/day	6.79 µg/day
DRINKING WATER:	0.000 L/day 0.0 µg/L	0.52 L/day 4µg/L
SOIL:	0-1000 µg Pb/g	0-1000 µg Pb/g
HOUSE DUST:	0.0 µg Pb/g	200.0 µg Pb/g
PAINT Intake:	0.00 µg Pb/day	0.00 µg Pb/day
MATERNAL CONTRIBUTION:	Infant Model	Infant Model
Maternal Blood Conc.	0.00 µg Pb/dL	7.50 µg Pb/dL
AGE OF CHILDREN:	24-36 months	24-36 months

- Linear correlation between lead in soil and lead in blood
- Introducing exposures via other routes only marginally increases blood-lead levels
 - In this scenario, soil intake is the driving blood-lead levels
 - Note that paint intake is not modeled

LOCAL MONITORING DATA

Lead in Soil

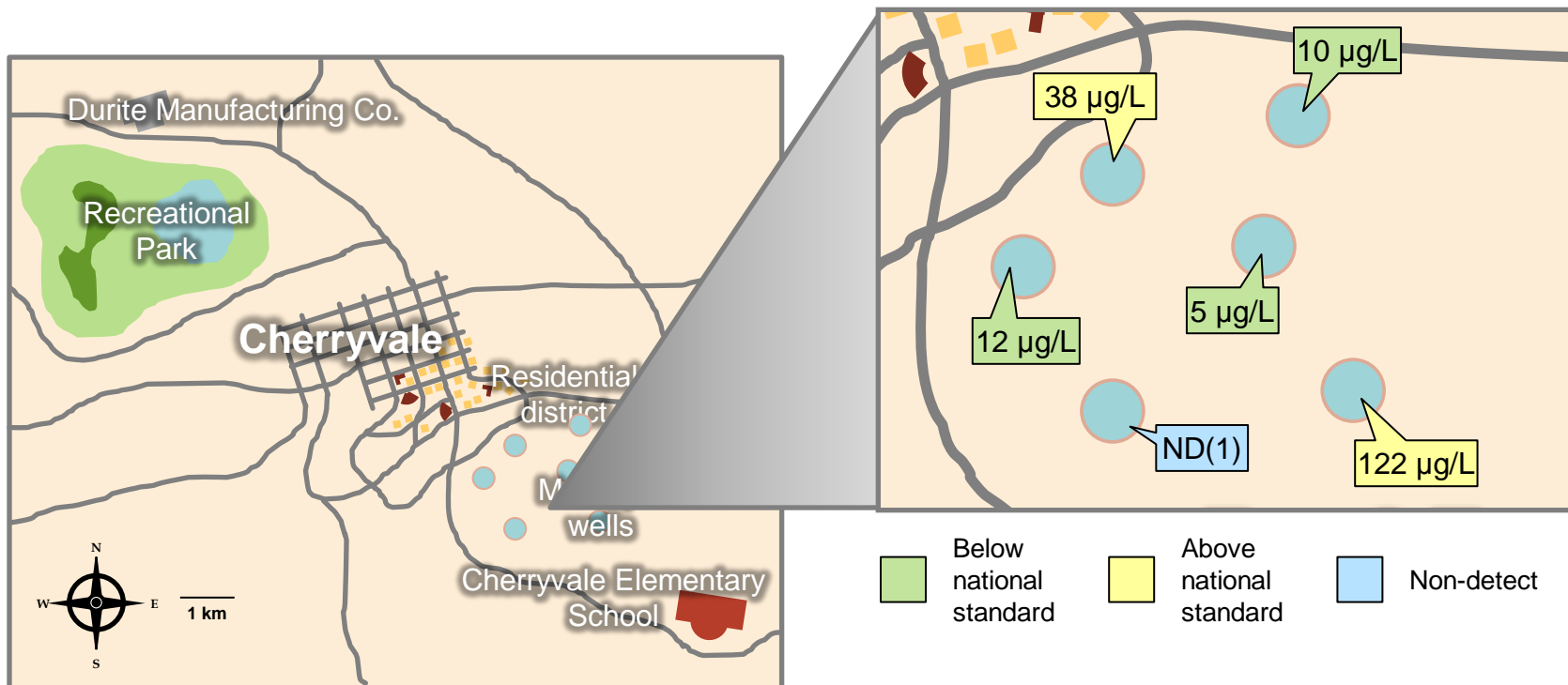
• Soil lead standard, children's play areas	400 mg/kg (ppm) * from TSCA Section 403
• Soil lead standard for other residential soils	1,200 mg/kg*(ppm) * from TSCA Section 403
• Natural levels of lead in soils:	<50 mg/kg * from CDC - ATSDR
• Concentrations found at Durite Manufacturing Site (see figure below)	



- No data collected on lead in soil in the nearby park or at residences in Cherryvale

Lead in Ground Water

- | | | |
|--|---|--|
| • EPA Drinking water standard for lead: | 15 $\mu\text{g/L}$ (ppb)* | * from Safe Drinking Water Act of 1974 |
| • Natural levels of lead in ground water: | 1–100 $\mu\text{g/L}$ (average ~ 3 $\mu\text{g/L}$) | |
| • Concentrations found in Cherryvale municipal drinking water wells: | | |



- No data collected for ground water wells recently installed at the Durite Manufacturing site.

Lead Levels in Children's Blood

- CDC levels of concern:
 - $\geq 5 \mu\text{g/dL}$ - Community-wide lead poisoning prevention activities are advised
 - $\geq 20 \mu\text{g/dL}$ - Medical evaluation and environmental investigations and remediation is advised
 - $\geq 45 \mu\text{g/dL}$ - Medical treatment (i.e., chelation therapy) may be necessary
- NHANES levels of lead in blood of children, ranges 1-6, 6-11, and 12-19:

Average: $0.8 - 1.6 \mu\text{g/dL}$
 95th Percentile: $1.8 - 4.0 \mu\text{g/dL}$

Concentrations found in blood of children at Cherryvale municipal hospital:	
$<1 \mu\text{g/dL}$	$11 \mu\text{g/dL}$
$3 \mu\text{g/dL}$	$15 \mu\text{g/dL}$
$8 \mu\text{g/dL}$	$25 \mu\text{g/dL}$

- Highest level found in 2 year-old child whose parents worked at Durite and who was rumored to have spent the last year at the on-site Durite Day Care Center.

STAKEHOLDER PARTICIPATION

Activity Instructions

- Separate into stakeholder groups representing these perspectives:
 - Manufacturers
 - Local Environmental Agency
 - Local Health Department
 - Citizens/Activists
- 🕒 30 minutes: Preparation
 - Each group reviews the data in their packet, develops a position, and prepares a presentation.
- 🕒 20 minutes (5 minutes each):
 - Each group presents its position in 3 minutes, leaving 2 minutes for questions.
- 🕒 5 minutes: Resolution
 - The local Environmental Agency concludes the meeting with a final resolution.

Activity Instructions, continued

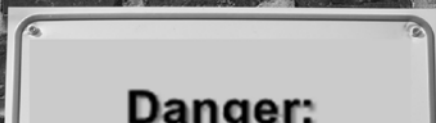
- Assume you have an unlimited budget.
- Use the knowledge you've picked up from previous EXA courses to develop your presentation.
- Has new information come to light during the past 6 months?

DEVELOPING STAKEHOLDER PERSPECTIVES

(What did you learn in the last
six months?)

- Since 1879

This image contains 15 hand-drawn wavy lines, arranged in two groups of seven and one group of one. The lines are drawn in black ink on a white background. Some lines have small circles at the peaks, while others do not. The lines vary in frequency and amplitude, creating a variety of wave patterns.



**Danger:
Contaminated
Area**

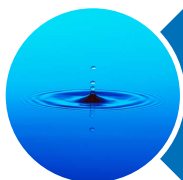
Town Hall Meeting



Activity Wrap-Up



Were the original data problematic?



How did the municipal wells become contaminated?



What is the responsibility of industry in an arena of uncertainty?



How does problem formulation affect risk management?