

Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006

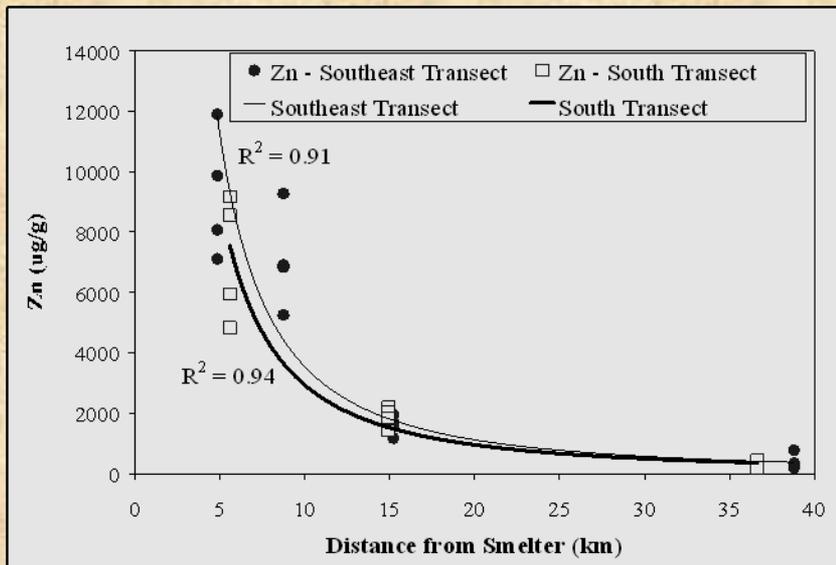
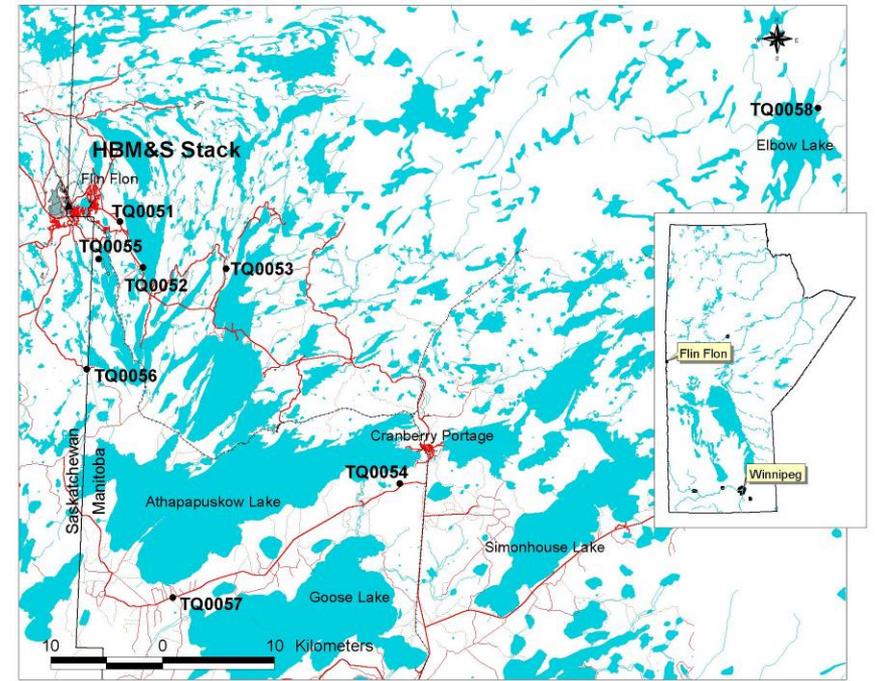


October 1, 2007

Manitoba Conservation

Introduction & Background

- Government programs to monitor the effects of emissions from HBM&S smelter on the natural environment in the Flin Flon region have been underway since the late 1970s.
- Monitoring at permanent sites in the boreal forest near Flin Flon have shown that levels of As, Cd, Cu, Pb, Hg, Se, and Zn are elevated in snow, soils, and vegetation.



- Concentrations of these elements decrease rapidly with distance away from the smelter and are near background at approximately 35 – 40 km.

Introduction & Background

- Data on concentrations of metals and other elements in the city of Flin Flon is limited
 - Manitoba Environment – Pb in sod/soil on boulevards in 1983
 - Pip & HBM&S – garden studies in 1990s
 - Manitoba Conservation – garden study 2002
- These studies suggested that levels might be elevated across the entire community.
- Manitoba Conservation decided this required further investigation and designed a systematic soil survey for the area.

A STATUS REPORT
ON THE LEAD CONCENTRATION
IN SOIL AND SOIL FOR FLIN FLON-CAMBRIDGE,
MANITOBA, 1983

Heavy Metals in Flin Flon Area Gardens

Final Report

Prepared By:
HBM&S Environment

Bull. Environ. Contam. Toxicol. (1991) 46:790-796
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Environmental
Contamination
and Toxicology

Cadmium, Copper, and Lead in Soils and Garden Produce near a Metal Smelter at Flin Flon, Manitoba

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Towns in the vicinity of base metal smelters are subject to contamination from atmospheric fallout containing heavy metals. Many smelters have been in operation for decades, and have resulted in substantial accumulation of metals in the surrounding soils. Metal contamination of edible vegetation near mines and smelters has been the source of health concerns in a number of countries (Jennett et al., 1977).

One smelter that has operated for more than half a century is located at Flin Flon, Manitoba. Smelting activities in Flin Flon have been associated with a decline in the native vegetation surrounding the town. Deer mice trapped near the smelter have been shown to contain increased tissue levels of copper, lead and arsenic, and elevated hemoglobin concentrations. Background levels of these elements in tissues were not reached until approximately 40 km from the stack (Fairbridge and Sabesky 1987). However even at this distance, background levels in blueberries have been reported to exceed the average Canadian level of 0.05 µg/g wet weight (McEachern and Phillips 1983).

Many Flin Flon residents utilize home vegetable gardens year after year. However little is known regarding heavy metal contamination, as well as total body uptake of metals (Ewing and Pearson 1974). It is important to identify any sources which may account for a disproportionate share. The objective of the present study was to determine concentrations of cadmium, copper and lead in soils and garden produce in the vicinity of the Flin Flon smelter.

MATERIALS AND METHODS

Flin Flon (population ca. 8,000) is located on the Manitoba-Saskatchewan boundary at approximately 55°N, 102°W. The area lies on the Precambrian Shield and surface soil is thin and patchy. Sulphide ores of copper, zinc, silver and gold have been mined and smelted in the Flin Flon region since 1930. The smelter is located on the west side of the town. A 250 m stack was constructed in 1960. Sand reprint requests to author at above address.

Metal Concentrations in Soils and Produce from Gardens in Flin Flon, Manitoba, 2002

By Geoff Jones and Viki Henderson

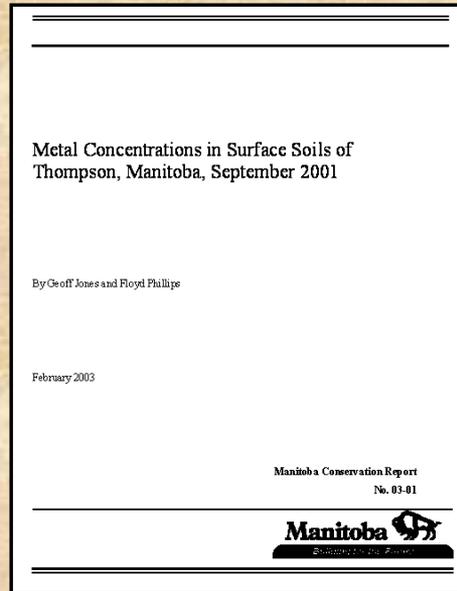
April 2006

Report No. 2006-01

Manitoba
Building for the Future

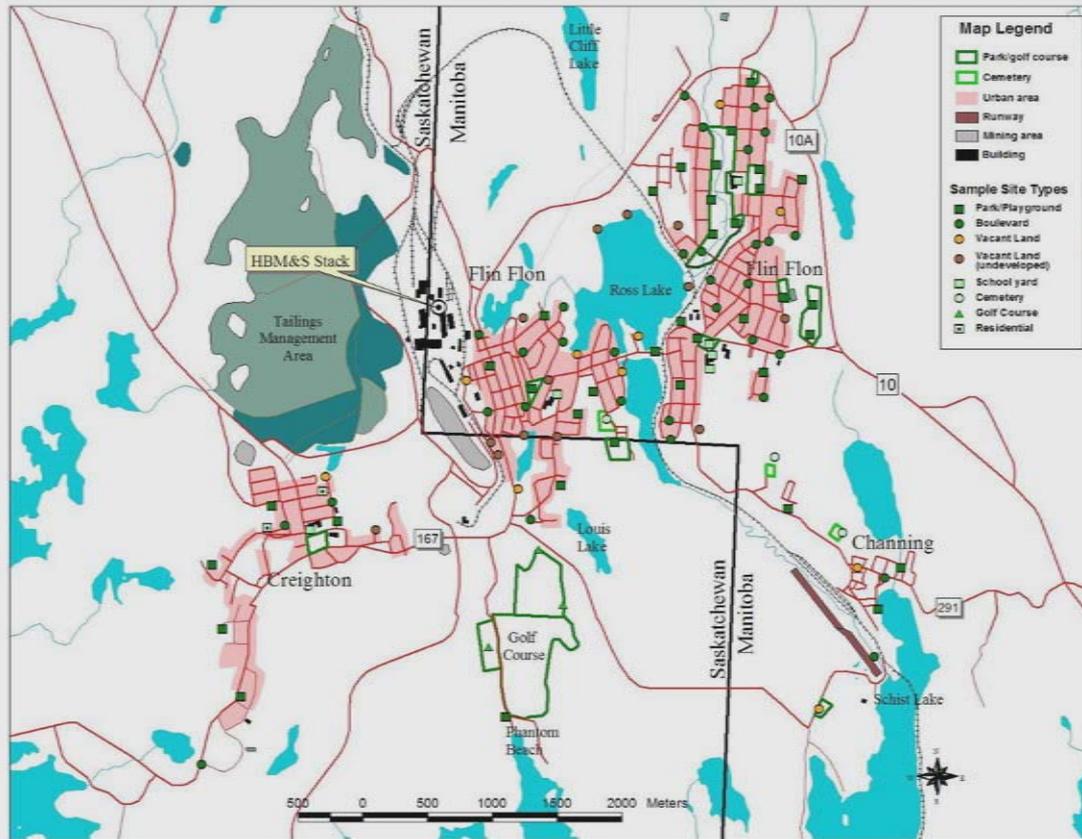
Survey Objectives and Preliminary Activities

- Three principle objectives:
 - determine the concentrations of metals and other elements in surface soil in the communities of Flin Flon and Creighton.
 - map the distribution of metals and other elements using GIS,
 - provide a preliminary assessment of the results by comparing the concentration data to existing CCME environmental quality guidelines.
- Survey to be based on similar work done in Thompson in 2001.
- Plan submitted to and approved by Executive (in Conservation) in June/July 2006.
- Study design and objectives sent out to stakeholders for 30 day comment period.
- Creighton added to study area after consultation with SK.
- Study conducted August 20 – 24, 2006.



Site Selection

- Total of 108 sites selected for sampling (93 in Flin Flon, 13 in Creighton, 2 controls).
- Main criteria for selection – publicly accessible areas such as playgrounds, parks, school yards, vacant lots, and boulevards.



Site Type	Number of Sites
park/playground (includes controls)	38
boulevard	34
vacant land (undeveloped)	13
vacant land	10
school yard	6
cemetery	2
golf course	3
residence (Creighton only)	2

Soil Sampling

- Sampled top 2.5 cm of soil.
- Each sample was a composite of 20 soil cores extracted at approximately 5 cm intervals along a metre stick.



- Metre stick was placed at 3 random locations at each site to collect 3 replicate samples per site.

Soil Analysis

- Soil sampling tool was cleaned and rinsed with distilled water between sites.
- Cores were placed in labeled plastic bags and kept cool prior to laboratory analysis.
- Vegetation cover and soil texture recorded for each site.
- Each site was geo-referenced and photographed.

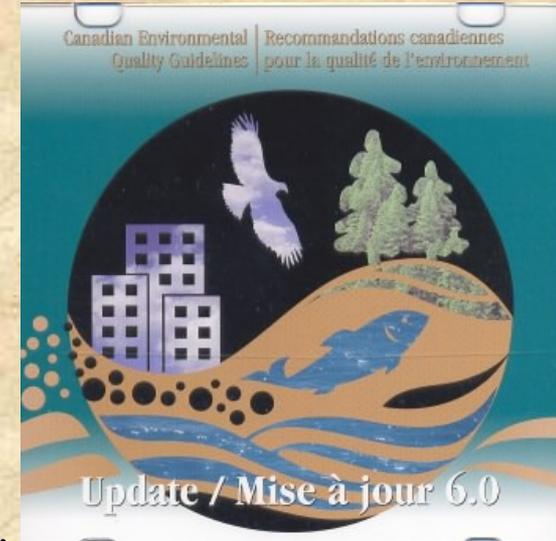


Variables Analyzed

Aluminum - Al	Nickel - Ni
Antimony - Sb	Phosphorus - P
Arsenic - As	Potassium - K
Barium - Ba	Selenium - Se
Beryllium - Be	Silver - Ag
Boron - B	Sodium - Na
Cadmium - Cd	Strontium - Sr
Calcium - Ca	Sulphur - S
Chromium - Cr	Thallium - Tl
Cobalt - Co	Tin - Sn
Copper - Cu	Titanium - Ti
Iron - Fe	Vanadium - V
Lead - Pb	Zinc - Zn
Magnesium - Mg	Zirconium - Zr
Manganese - Mn	pH
Mercury - Hg	Bulk Density
Molybdenum - Mo	

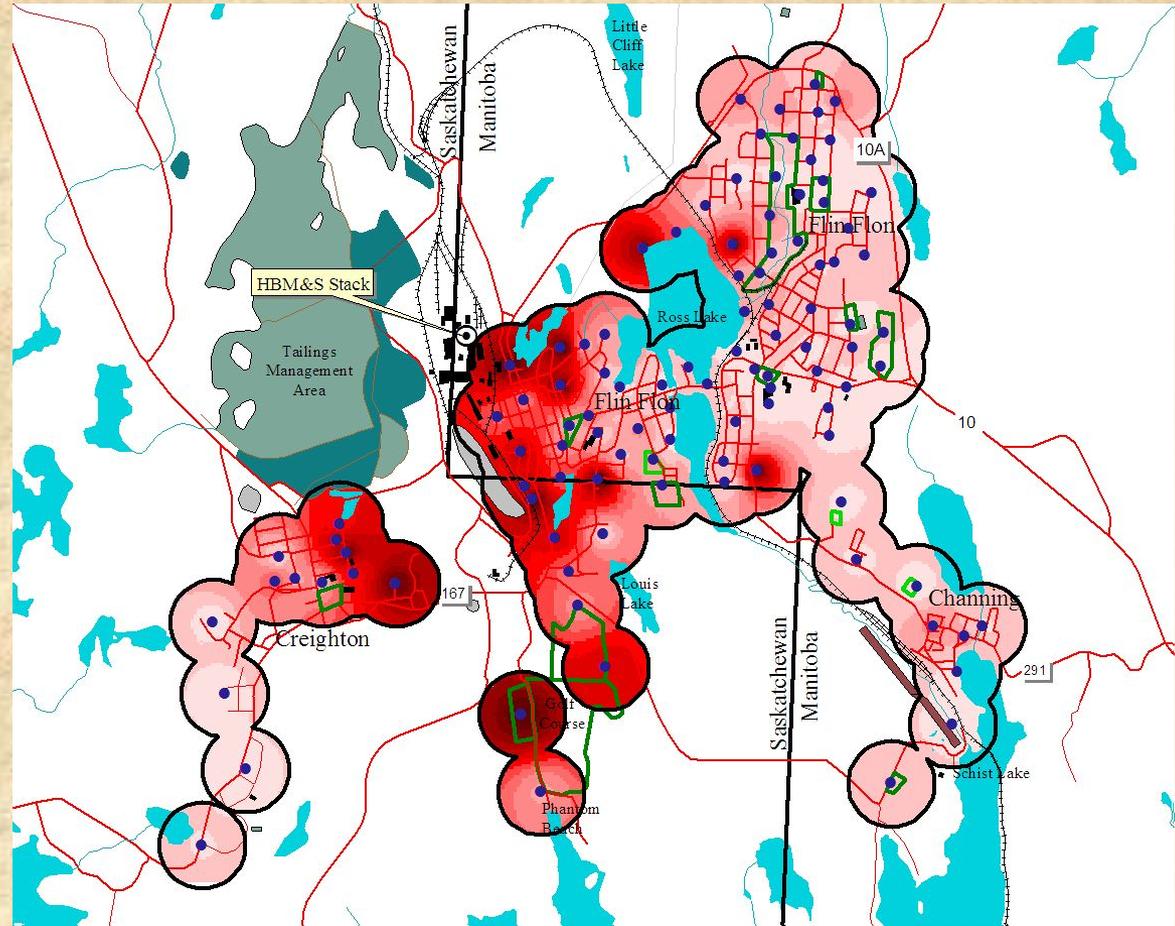
CCME Soil Quality Guidelines

- Mean concentration was calculated for each site and compared to CCME soil quality guidelines
- CCME guidelines are:
 - scientifically defensible limits developed to protect environmental and/or human health for four land use categories:
 - (1) agricultural, (2) residential/parkland, (3) commercial, and (4) industrial.
 - exist for As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Se, Tl, V, and Zn.
 - generally are **very conservative** (significant safety margins).
 - **are for guidance only and site-specific conditions have to be considered when applying guidelines and criteria.**
- Separate guidelines are derived to for protection of the environment and for the protection of human health.
- Because the survey is concentrated in an urban area, guidelines for the protection of human health for residential/parkland land use will be used to assess the results.



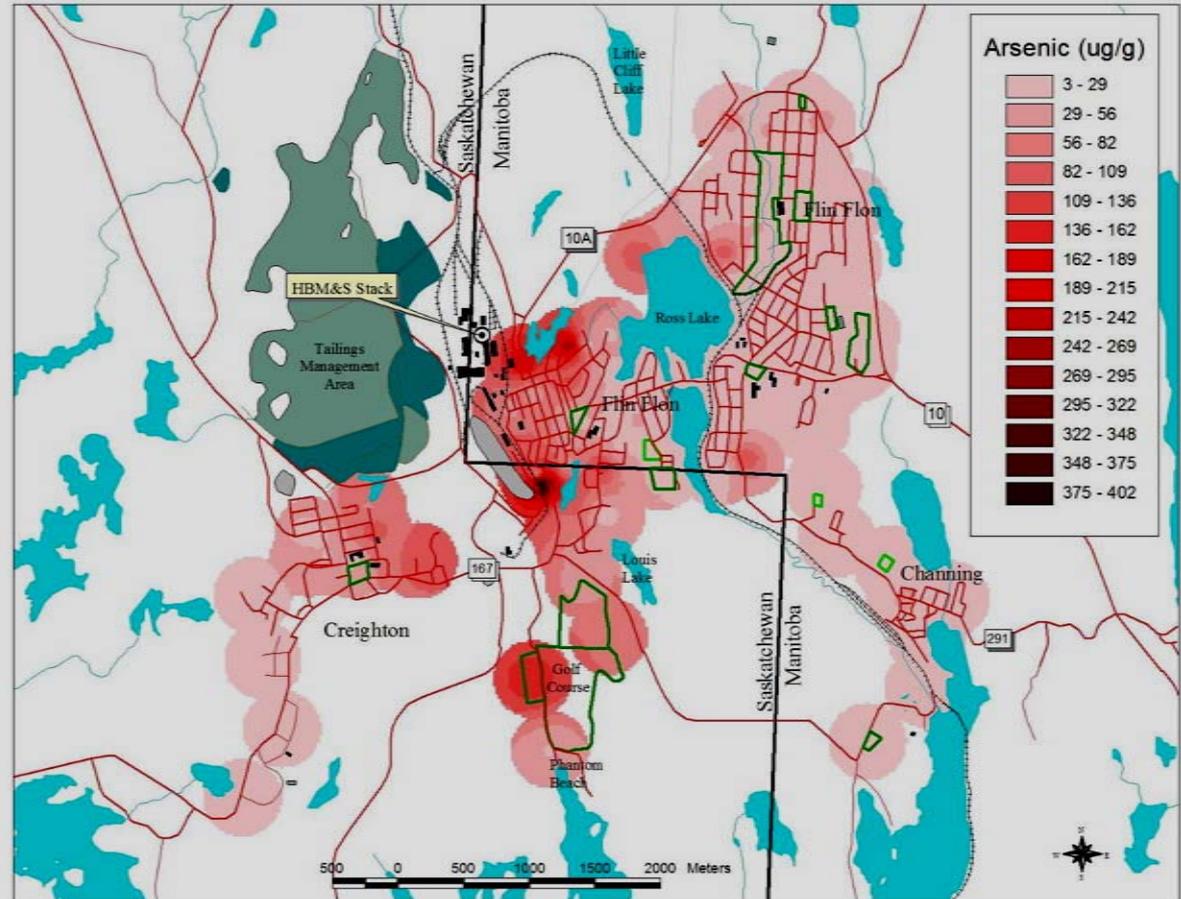
Distribution Maps

- Used Arcview GIS and Spatial Analyst
- Interpolation of existing data to create a surface grid showing distribution of elements across study area.
- More points the greater the confidence in the surface grid – accuracy is lower around points along edge of distribution and around isolated points.
- Used 300 m buffer (arbitrary) to extract surface grid covering Flin Flon and Creighton.



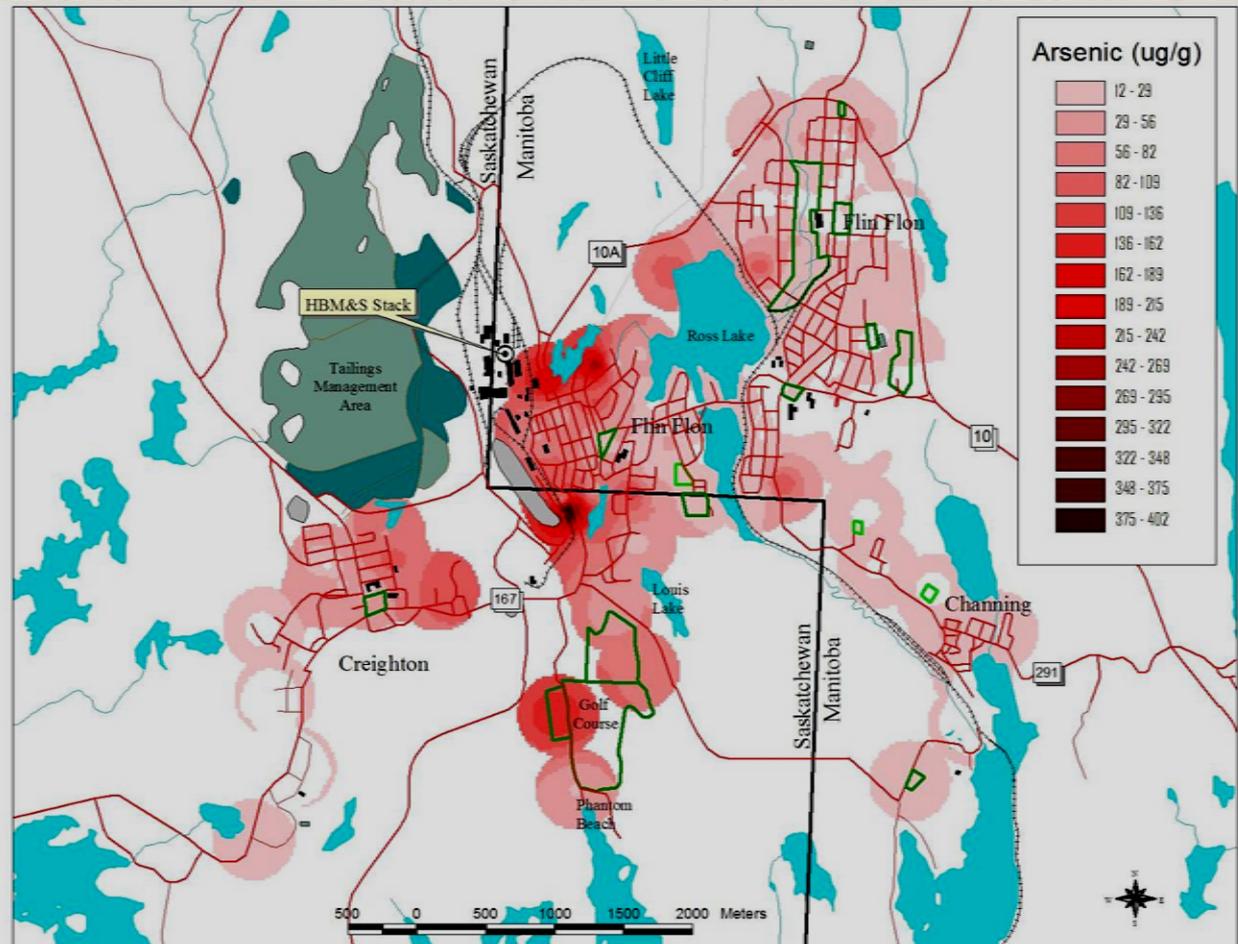
Results – Arsenic

- As concentrations ranged from 2.5 $\mu\text{g/g}$ to 407 $\mu\text{g/g}$, and all except one were higher than Cranberry Portage site.
- Highest concentrations in down town area and at undeveloped sites closest to and NE of the smelter.
- Variability between sites was high - due to differences in distance and direction to smelter, topography, soil origin, vegetation cover, organic matter, and duration of exposure.



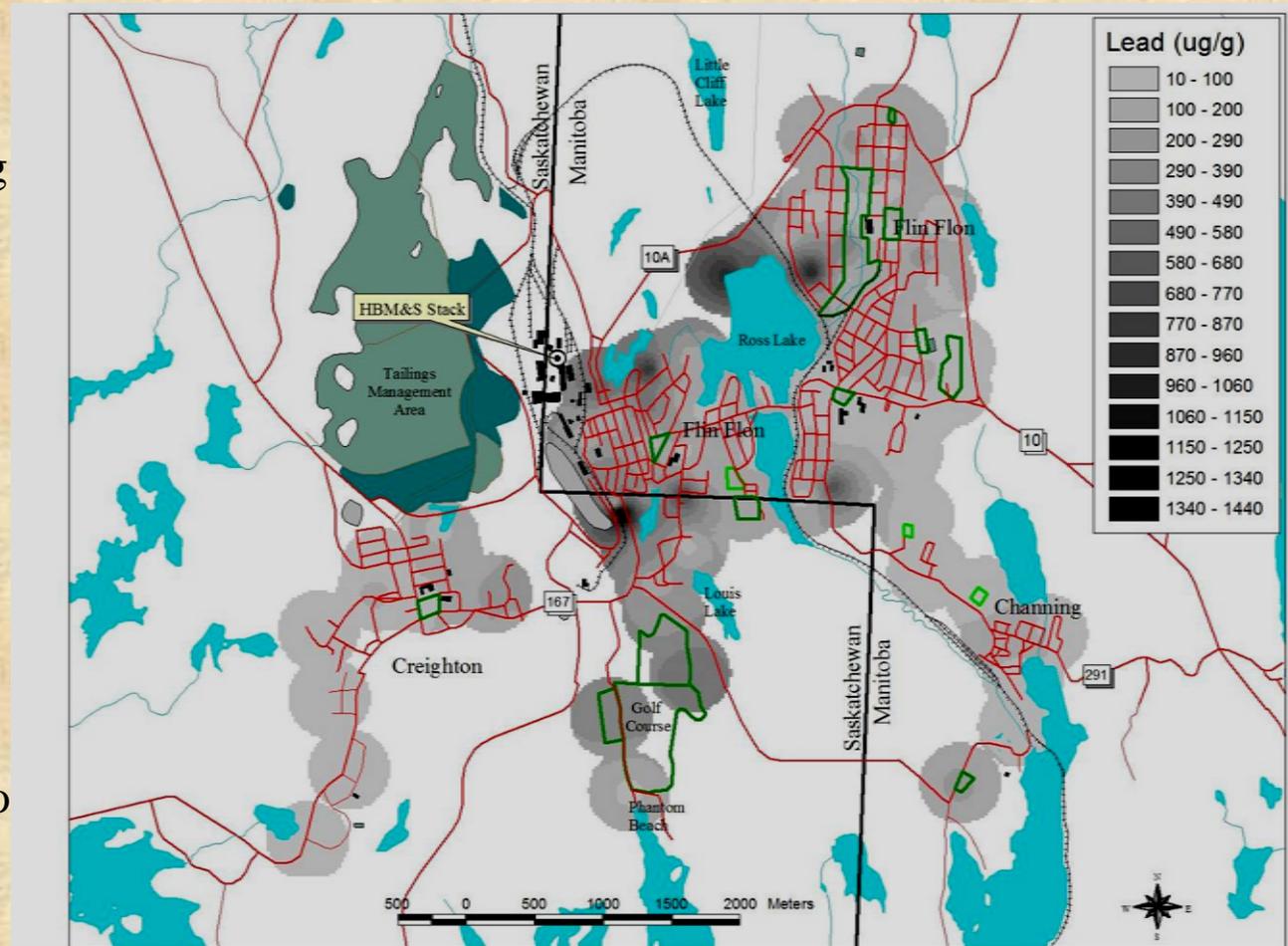
Results – Arsenic

- Soil quality guideline for the protection of human health is 12 µg/g for all land uses.
- Guideline was exceeded at 61 sites in Flin Flon and 9 sites in Creighton.
- Almost all vacant land sites exceeded guideline.
- More than half of the parks/playgrounds and school yards were **below** guideline levels.



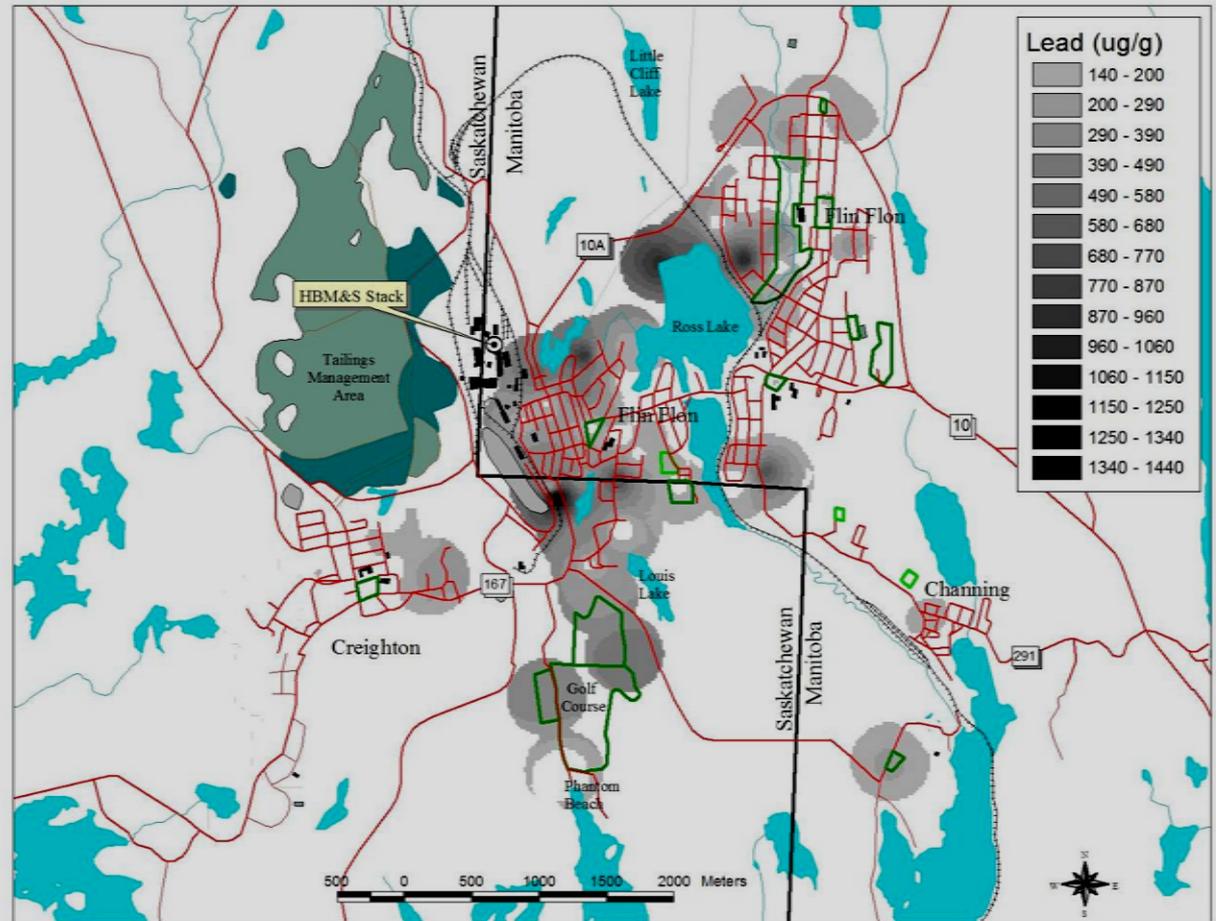
Results – Lead

- Mean concentrations of Pb ranged from 5.0 $\mu\text{g/g}$ to 1447 $\mu\text{g/g}$ in Flin Flon.
- Overall mean in Flin Flon was 196 $\mu\text{g/g}$.
- Generally highest in the core area and central northeast of Flin Flon.
- Ranged from 6.3 $\mu\text{g/g}$ to 250 $\mu\text{g/g}$ in Creighton.



Results – Lead

- Guideline for the protection of human health for is $140 \mu\text{g/g}$.
- Guideline was exceeded at 39 sites in Flin Flon and 4 sites in Creighton.
- Guideline was exceeded most frequently at sites located on vacant lands and boulevards.
- Only 5 of the 36 park/playground sites and one of the school yard sites exceeded guideline.



Results – Continued

- Concentrations of Cd, Cu, Hg, Se, Tl, and Zn were highly correlated with As and Pb, shared similar distribution, and also often exceeded established guidelines at the sites sampled.
- Metals such as Cr and Ni were generally low at most sites, only exceeded guideline levels at a few locations. Levels of Ba and V were below guideline levels.

Summary of CCME guideline exceedences at sites sampled in Flin Flon and Creighton.

Site Type	Guideline	Arsenic		Cadmium		Copper		Lead		Mercury		Selenium		Thallium		Zinc	
		12 ug/g		14 ug/g		1100 ug/g		140 ug/g		6.6 ug/g		28 ug/g		1 ug/g		200 ug/g*	
	No. of Sites Sampled	No.	%	No.	%	No.	%	No.	%								
Park/Playground	36	17	47	8	22	4	11	5	14	14	39	0	0	0	0	30	83
Boulevard	34	23	68	7	21	9	26	14	41	17	50	3	9	1	3	33	97
Vacant Land (undeveloped)	13	13	100	10	77	11	85	12	92	11	85	2	15	1	8	13	100
Vacant Land	10	9	90	4	40	2	20	5	50	5	50	0	0	0	0	10	100
School yard	6	2	33	0	0	0	0	1	17	2	33	0	0	0	0	4	67
Golf Course	3	3	100	2	67	1	33	3	100	3	100	0	0	0	0	3	100
Cemetery	2	1	50	1	50	1	50	1	50	1	50	0	0	0	0	2	100
Residence	2	2	100	1	50	0	0	2	100	1	50	0	0	0	0	2	100
Total	106	70	66	33	31	28	26	43	41	54	51	5	5	2	2	97	92

* environmental health guideline

(Note this summary does not include results from sites in Cranberry Portage and Bakers Narrows).

Conclusions

- Concentrations of several elements exceeded guideline levels at numerous sites in Flin Flon and Creighton.
- In general highest concentrations were recorded at sites in Flin Flon – usually in the core area near the smelter and the northeast area.
- Undeveloped lands and vacant lots usually had the highest concentrations and most often exceeded guidelines.
- Park/playgrounds and school yards often had the lowest concentrations and lowest frequency of guideline exceedence.



- www.gov.mb.ca/conservation/wildlife/managing/mon_ecoflinflon.html

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July 2007

Report No. 2007-01



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Flin Flon

The community of Flin Flon is located in west-central Manitoba adjacent to the Manitoba-Saskatchewan border. Several significant sulphide ore bodies containing major deposits of copper and zinc occur in the general vicinity of the community. A base metal mining and smelting facility has operated in Flin Flon since 1930. Metal production from the facility has varied over time, but is dominated by copper and zinc, with smaller amounts of cadmium, lead, gold, and silver.

Atmospheric emissions include sulphur dioxide and particulates (dust) of arsenic and metallic elements such as cadmium, copper, iron, lead, mercury, and zinc. While these substances still make up the majority of material emitted from the smelter, the actual composition and amount of emissions has varied over time, depending on the grade of ore used and the volume of ore smelted. Improvements to the smelting process and the installation of more effective pollution control devices have helped to significantly reduce atmospheric emissions over the past 30 years.

Programs to assess the impacts of past and present atmospheric emissions on natural ecosystems in the region include long-term

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