Stericycle Medical Waste Incinerator Health Assessments

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Utah Department of Health

Environmental Epidemiology Program

Environmental Epidemiology Program, UDOH

Who We Are

- CDC-funded state partner with the federal Agency for Toxic Substances and Disease Registry (ATSDR)/Centers for Disease Control and Prevention (CDC)

What We Do

- Provide health assessments-evaluation of community exposures to hazardous contaminants
  - Mandated for all National Priorities List sites in accordance with CERCLA (Superfund)
  - Upon request
    - Regulators (EPA, UDEQ)
    - Local Health Departments
    - Governor’s Office
  - Upon public petition

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We Can Provide

- Independent, objective health impact evaluations based upon the best available science and data
- Health education to minimize exposure
- Recommendations to the EPA, UDEQ, and other regulatory and public health agencies for further actions

We Cannot Provide

- Remediation or "site clean-up"
- Legal advice
- Enforcement of regulatory standards
- Medical attention or health care services

Stericycle Medical Waste Incinerator

- Constructed in the early 1990s (~1992)
  - Residential development began roughly 10 years later (late 2003, early 2004)
- Disposes of medical waste primarily from the Pacific coast and intermountain states
- The incinerator and neighboring residential areas occupy three census tracts
  - Combined 2010 population of 19,653

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UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
AUG 11 2009
DIVISION OF AIR QUALITY

August 10, 2009

Dear Ms. Hines:

I live in Foxboro in North Salt Lake and have been here 3 years. I am complaining to you about a place named Stericycle at 90 North 1100 West in North Salt Lake.

Every morning except Sunday, at about 1:30 AM and for about 2½ hours they burn medical waste and the pollution and smell are terrible. I know this is not healthy for me and all the families with many young children who have homes here. It wakes me up every … seek fe… up, close … g, but it just circulates the bad air until they stop.

ent Date 8/10/2009
Q-2009-005897

“I’d like to be able to sleep through the night, enjoy fresh air, and not awake every morning with a headache.” –retired Health Department employee.

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Operating Permit Violations

The Utah Division of Air Quality (UDAQ) identified multiple operating permit violations occurring between 2011 and 2013:

- Emissions exceeding the permit limits for dioxins, NO_x, and HCl
- Failure to report these emission exceedances to UDAQ in the requisite time frame
- Failure to maintain normal operating conditions during the December 2011 stack test
- Failure to include the test results demonstrating these emission exceedances in the requisite annual and semi-annual monitoring reports

Community Health Concerns

Photo courtesy of blog.utahmomsforcleanair.org

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Health Concerns

"I looked out my backyard, and I see the huge black smoke coming out of their bypass stack. That was going out into our neighborhood for 20 minutes, and that has no filters. You know we're breathing that, and it had huge flames coming out of the stack," "That's one more incident after another. We're very concerned." –Area resident

"What little toxicity assessment has been made of the safety of Stericycle's emission has only examined exposures of one compound at a time."

-Utah environmental activism group

Health Concerns

- Incineration of waste has been widely practiced but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash residue. Incinerated materials containing chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. **Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment. Dioxins, furans and metals are persistent and bio-accumulate in the environment.** Materials containing chlorine or metal should therefore not be incinerated. -World Health Organization Fact Sheet 253, Nov. 2011

- A number of toxic air pollutants, including dioxins, mercury, lead, and cadmium, are released into the air during the incineration process- EPA Hospital/Medical/Infectious Waste Incinerators
  Final rule published September 15, 1997

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Dioxins in Medical Waste

- Medical Waste Source: mainly PVC
- Formed @ 400-500°C
- Dioxin incineration[1]: 0.78ng/g newspaper; 8,490ng/g PVC
- Destroyed @ 850°C and up[1,2]

    Stericycle NSL facility averages 950°C[3]

- Environmental half-life in soil: 1-3 years on surface; up to 12 years below surface

1 Shibamoto et al. 2007 Rev. Environ Contam Toxicol 190:1-41
2 EPA, 1990 530-SW-90-029A, ATSDR ToxProfile Dioxin, 1998
3 UDEQ/EPA Performance Test Report, 11/24/14

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Heavy Metals in Medical Waste

- Cadmium (Cd) sources in MW: dyes for plastics “red bags”; Cd-containing batteries; some medical devices
- Mercury (Hg) sources in MW: medical devices (thermometers, sphygmomanometers, esophageal bougies).
- Lead (Pb) sources in MW: Pb-containing batteries, radiation shielding (aprons), paint dyes, autoclave indicator tape.
- Cd, Hg, and Pb, are <u>not destroyed</u> during incineration.
- Environmental half-life in soil: <u>Persistent</u>

Initiatives to Reduce Dioxins and Heavy Metals from Medical Waste

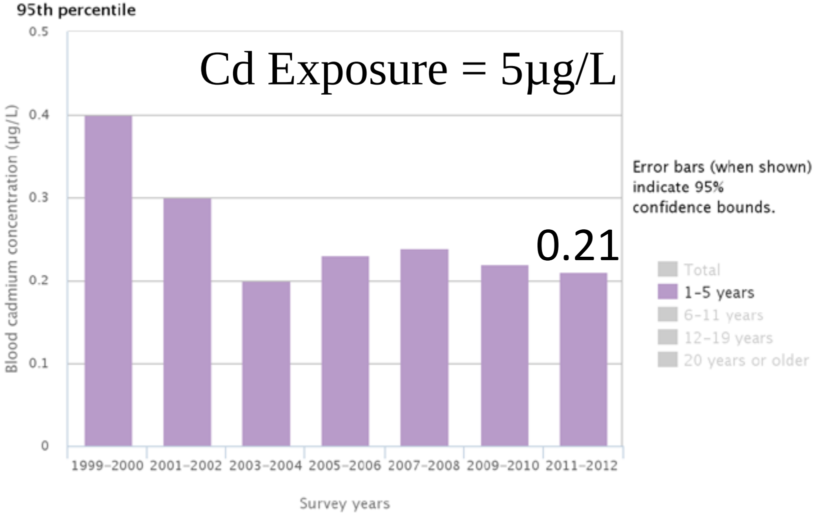
- 1994 - EPA's Dioxin Reassessment identifies MWI as single largest source of dioxin air pollution
- 1997 - EPA's Mercury Report to Congress - MWIs identified as major source of Hg emission
- 1997 - EPA's Final Rule for MWI Emissions (identifies dioxins, Hg, Cd, and Pb as MWI pollutants)
- 1998 - EPA launches Hospitals for a Healthy Environment (H2E)
- National organizations and state governments establish initiatives to raise awareness and reduce Hg, Cd, Pb, and PVC in medical waste stream
  - Pediatric Environmental Health Specialty Unit (PEHSU), PracticeGreenhealth, Healthcare Env. Res. Center (HERC), Health Care Without Harm, Sustainable Hospitals Program, etc.
  - UDEQ Pollution Prevention (electronics recycling: Hg, Cd, and Pb)
  - UPCC Mercury Reduction

Mercury Emissions from Medical Waste Incinerators

Exhibit 1. Anthropogenic mercury emissions in the U.S. by source category, 1990–2011

National Emissions Inventory Database, 2014
Online on EPA's "Report on the Environment (ROE) website.

Exhibit 3. Blood cadmium concentrations for the U.S. population age 1 year and older by age group, 1999-2012

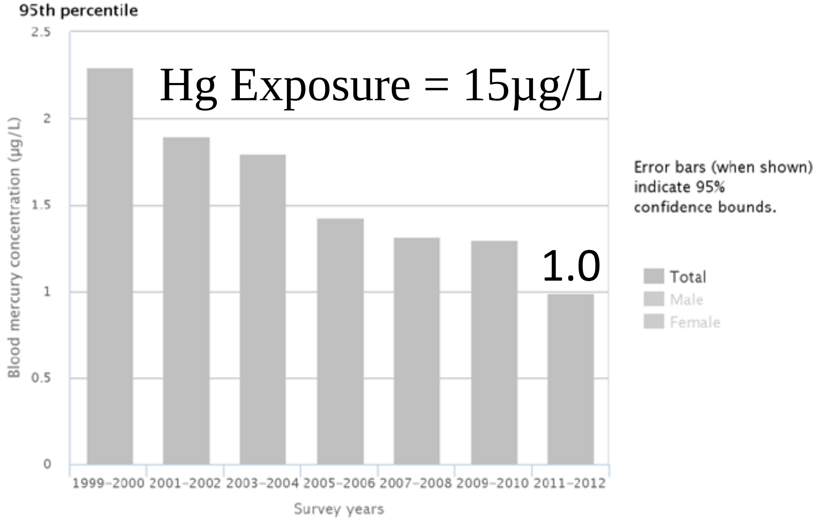


Error bars are not displayed if the upper and lower bounds were reported as the same rounded value.

Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2014

Exhibit 2. Blood mercury concentrations for U.S. children age 1-5 years by sex, 1999-2012



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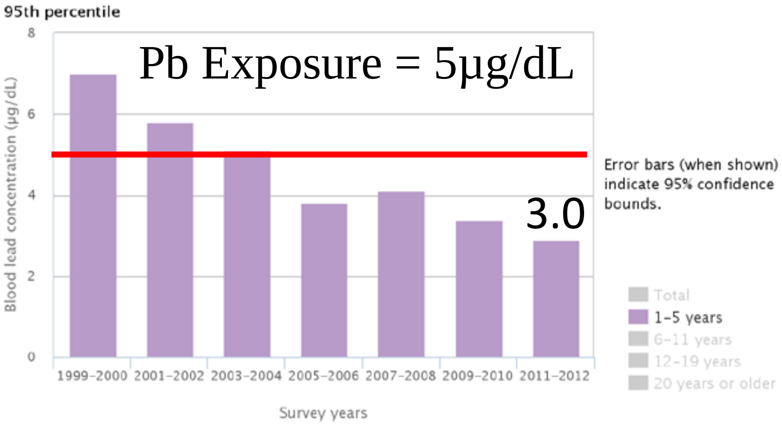
Data source: CDC, 2014

Exhibit 3. Blood lead concentrations for the U.S. population age 1 year and older by age group, 1999-2012



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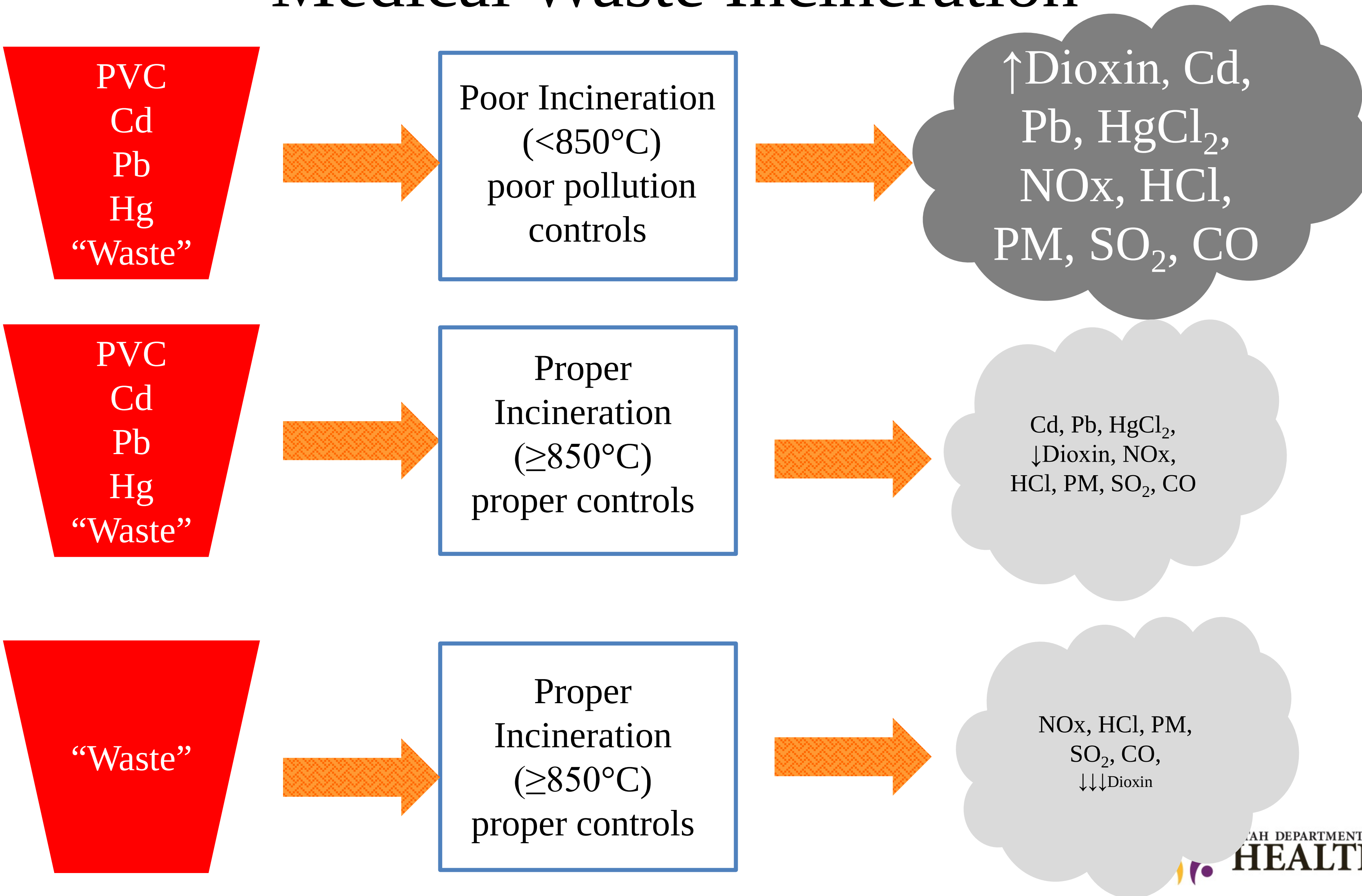
Medical Waste Incineration



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Toxicological Assessment

Are sample values higher than health-based comparison values (CVs)?

No → This substance is not expected to present a health hazard

Yes ↓

Are calculated exposure doses higher than established health guideline values? (ATSDR MRLs; EPA RfDs, etc.)

No → This substance is not expected to present a health hazard

Yes ↓

- Specifics of the contaminant must be assessed.
- Substance may present a health hazard to the community.
- Form recommendations for action.

Toxicological Assessment

Exposure calculations include:

- Type of contaminant
- Amount of contaminant
- Type of exposure (ingestion, inhalation, dermal)
- Intake rates
- Duration of exposure (everyday, recreational, etc.)

Calculations made for adults and children

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Soil Exposure Pathway

Contaminants of concern in soil

- Dioxins and dioxin-like compounds
  - Dioxins, furans, dioxin-like polychlorinated biphenyls (PCBs)

- Heavy metals (RCRA 8)
  - Arsenic
  - Barium
  - Cadmium
  - Chromium
  - Lead
  - Mercury
  - Selenium
  - Silver

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Soil Sampling

- DCHD collected 6 soil samples in October 2013
  - 5 samples within the predicted extent of the emission deposition plume
  - 1 control sample collected 23 miles away to the north-northwest
  - All samples from undeveloped land
  - Analyzed for dioxin content

- The EEP collected 6 soil samples in November 2013
  - 3 soil samples from residential backyards
  - 1 soil sample from the Caleb Dr. playground
  - 1 sand sample from the Caleb Dr.
  - 1 sand sample from Buckingham Dr. playgrounds
  - Analyzed for dioxin and heavy metal content

Plume Deposition Analysis

- At EEP request, UDAQ modeled the deposition of contaminants released from the incinerator to identify optimal areas for soil sampling

- Based on:
  - AERMOD modeling system version 13350
  - Predicted maximum emission outputs for a 20-year period
  - Stack characteristics and testing data
  - Emission temperature and velocity
  - A 5-year historical record of meteorology recorded near the site

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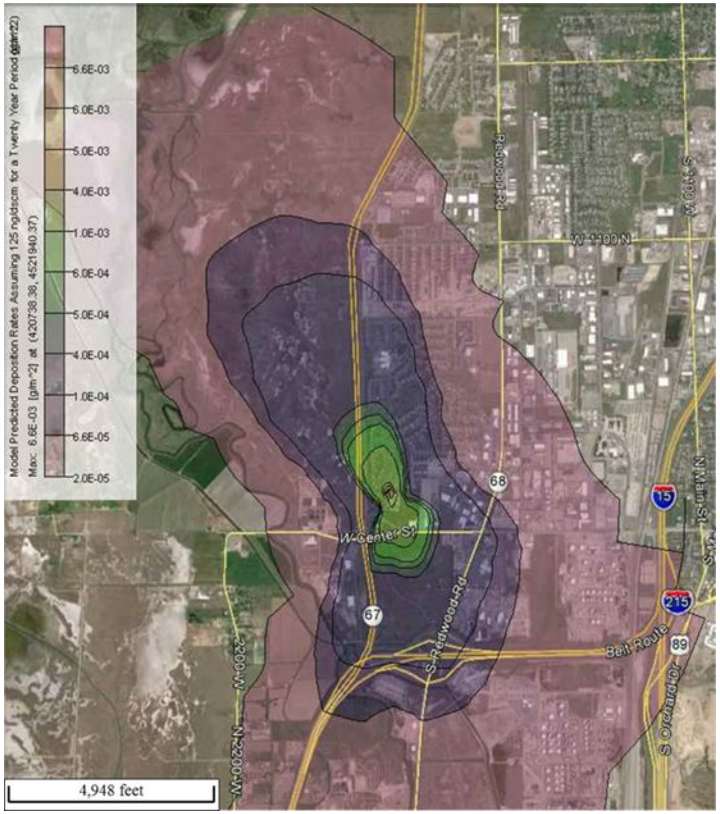
Predicted Contaminant Deposition Gradient

- Modeling indicated that the highest deposition would occur roughly 110 meters north-northwest of the incinerator
  - Contaminant deposition is predicted to decline further from the facility



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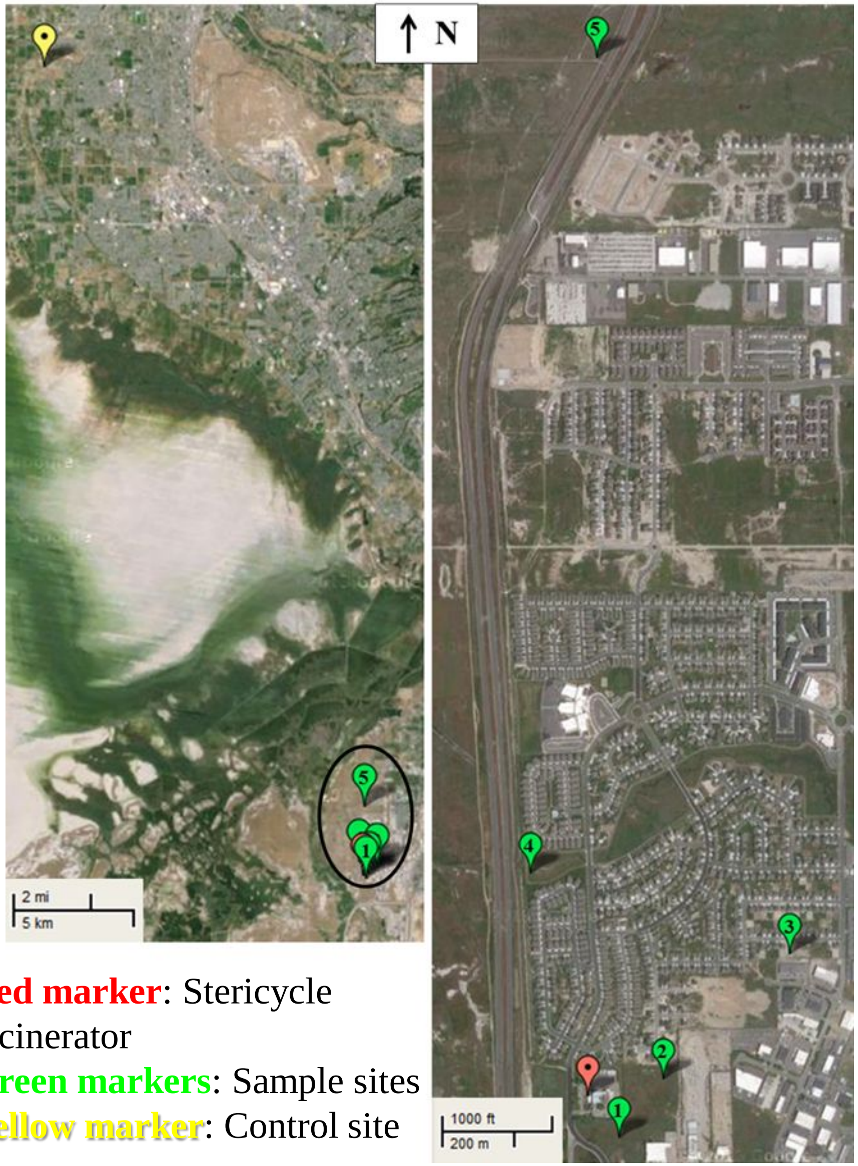
DCHD Sampling



Red marker: Stericycle incinerator
Green markers: Sample sites
Yellow marker: Control site

	Dioxins (TEQ) (ppt)
Child c-EMEG	50
Pica Child i-EMEG	40
Adult c-EMEG	700
EPA Carcinogenic Screening Level	4.8
1	1.64
2	0.86
3	0.67
4	0.72
5	1.14
Off-site "Control"	0.17

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EEP Sampling

EEP Sampling

Substance (ppm)	A	B	C	D (Soil)	D (Sand)	E (Sand)	Cancer Screening Value	Child CV cEMEG	Pica Child CV iEMEG	Adult CV cEMEG
Arsenic	<8.5	9.4	<7.3	<7.7	**20.8**	<7.2	**0.47**	**15**	**10 (a-EMEG)**	210
Barium	130.4	151.5	129.5	122.5	44.6	47.7	N/A	10,000	400	140,000
Cadmium	<1.7	<1.6	<1.5	<1.5	<1.4	<1.4	2,100	5	1	70
Total Chromium	**17.1**	**16.9**	**16.9**	**17.8**	6.8	4.9	N/A	45*	**10***	630*
Lead	15.9	16.3	19.7	17.7	<7.1	<7.2	N/A	400 (TSCA)	400 (TSCA)	400 (TSCA)
Mercury	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	N/A	15	14	100
Selenium	<8.5	<8.1	<7.3	<7.7	<7.1	<7.2	N/A	250	NA	3,500
Silver	<1.7	<1.6	<1.5	<1.5	<1.4	<1.4	N/A	250 (RMEG)	NA	3,500 (RMEG)
Dioxins (TEQ) (ppt)	2.6	2.6	0.62	1.2	0.05	0.06	4.8	50	40	700

Red marker: Stericycle incinerator

Dark blue markers: Residential sample sites

Light blue markers: Playground sample sites

***:** Chromium CVs are for hexavalent Cr(VI) chromium

Comparison Values

EMEG: Environmental media evaluation guide

- **a-EMEG:** Acute EMEG (14 days or fewer)
- **i-EMEG:** Intermediate EMEG (14 to 365 days)
- **c-EMEG:** Chronic EMEG (over 365 days)

RMEG: Reference media evaluation guide

TSCA: Toxic Substances Control Act

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Soil-Pica Behavior

- The recurrent ingestion of unusually high amounts of soil
  - 1,000 – 5,000 mg/day vs. 200 mg/day for a typical child
- Relatively rare condition
  - Information on prevalence is very limited
- Higher risk groups include children under 6 years of age and developmentally delayed individuals

Arsenic Exposure Doses

Minimal risk level (MRL): an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse, non-cancer health effects over a specific time period

- Acute: 14 days or fewer
- Chronic: greater than 365 days

Arsenic (ppm)	Exposure Route	Adult Exposure Dose (mg/kg/day)	Child Exposure Dose (mg/kg/day)	Soil-Pica Child Exposure Dose (mg/kg/day)	Acute MRL (mg/kg/day)	Chronic MRL (mg/kg/day)
20.8	Ingestion	1.46E-05	1.28E-04	3.20E-03	5.00E-03	**3.00E-04**
	Dermal	5.22E-06	1.55E-05	1.55E-05		
	Total	1.98E-05	1.44E-04	**3.22E-03**		

ppm: Parts per million
mg/kg/day: Milligrams per kilogram body weight per day

Exposure assumptions:

- 180 days per year of exposure to sand from the Caleb Dr. playground
- Ingestion
  - Children: 200 mg sand/day
  - Children with soil-pica: 5,000 mg sand/day
  - Adults: 100 mg sand/day

70 year cancer risk: 6.22E-05

- About 6 excess cases in 100,000 exposed people

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MRLs

- MRLs and RELs
  - An estimate of the daily human exposure to a substance that is not expected to result in risk of adverse, non-cancer health effects over a specific time period (i.e, acute, intermediate, chronic)
  - Exceeding an MRL/REL does not necessarily indicate an adverse health effects will occur, rather, it provides guidance for health professionals as they treat exposed individuals
  - Never based on serious health effects or cancer outcomes
    - Based on "no observable adverse effect level" or "least observable adverse effect level"
  - Based on human studies when available
    - Based on animal studies if human data is insufficient
  - When a study adequately identifies a chemical's "no effect" or "least effect" dosage, then that dosage is divided by uncertainty factors (UF) to protect the most sensitive individuals in a population (infants, pregnant women, those with chronic health conditions, etc.)
    - UFs can range from 10 (well-designed human studies) to 3,000 (well-designed animal studies with data gaps)

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Arsenic Exposure Doses

- The calculated exposure dose for soil-pica children exceeded the chronic MRL. Is this a potential health hazard?
- **1.40E-02 mg/kg/day:** dose associated with cancers related to chronic oral exposure
- **2.00E-03 mg/kg/day:** chronic threshold dose for skin pigment darkening
- **3.00E-04 mg/kg/day: MRL**
  - based upon study of Taiwanese farmers exposed to arsenic in drinking water. At the dosage of 8.00E-04 mg/kg/day no observed adverse health effects resulted from long-term exposure.
  - UF of 3 (rounded up)
- **3.22E-03 mg/kg/day:** the highest calculated dosage for playground sand
- Conservative (protective) exposure assumptions:
  - 25 times greater intake than a typical child's, every day for half a year
  - All soil intake for each of those days is playground sand from the Caleb Dr. playground

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Chromium Exposure Doses

Minimal risk level (MRL):

- Intermediate: 14 – 365 days
- Chronic: greater than 365 days

Total Chromium (ppm)	Exposure Route	Adult Exposure Dose (mg/kg/day)	Child Exposure Dose (mg/kg/day)	Soil-Pica Child Exposure Dose (mg/kg/day)	Cr(VI) Intermediate MRL (mg/kg/day)	Cr(VI) Chronic MRL (mg/kg/day)
17.8	Ingestion	1.25E-05	1.10E-04	2.74E-03	5.00E-03	**9.00E-04**
	Dermal	4.47E-06	1.32E-05	1.32E-05		
	Total	1.70E-05	1.23E-04	**2.75E-03**		

ppm: Parts per million
mg/kg/day: Milligrams of substance per kilogram body weight per day

Exposure assumptions:

- 180 days per year of exposure to residential soil
- All chromium in the soil is in the hexavalent Cr(VI) form
- Ingestion
  - Children: 200 mg soil/day
  - Children with soil-pica: 5,000 mg soil/day
  - Adults: 100 mg soil/day

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Chromium Exposure Doses

- The calculated exposure dose for soil-pica children exceeded the chronic MRL. Is this a potential health hazard?
- **9.00E-04 mg/kg/day: MRL**
  - based on benchmark dose of 0.09 mg/kg/day associated with a 10% increase in the probability of cell proliferation in the small intestine of female mice after 2 years of exposure
  - UF of 100
- **2.75E-03 mg/kg/day:** highest calculated exposure dosage for soil-pica child
- Conservative exposure assumptions:
  - 25 times greater intake than a typical child's, every day for half a year
  - All chromium in the soil is in the toxic hexavalent Cr(VI) form
    - Most or all is likely to be in the far less harmful trivalent Cr(III) form

- Chromium can be detected in hair, blood and urine. Elevated levels may indicate an exposure, however, as Cr(III) is an essential nutrient, it can't be used to predict if there are potential adverse health effects.

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Soil Sampling Results

- Soil and sand concentrations of barium, mercury, selenium, silver, and dioxins did not exceed the applicable CVs
  - Not expected to harm people's health
- Soil lead levels were low and did not exceed the CV
  - However, the best available science indicates that there is no safe level of lead exposure, particularly for children

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Soil Sampling Results

- The concentration of arsenic in sand from the Caleb Dr. playground exceeded the chronic CV for children
  - The sand likely originated from off-site
  - Exposure dose calculations indicate a potential risk for soil-pica children
  - Exposure dose calculations do not indicate a health risk for children
- Concentrations of total chromium in the 4 residential soil samples exceeded the Cr(VI) intermediate CV for children with soil-pica behavior
  - Exposure dose calculations indicate a potential risk for soil-pica children
  - Exposure dose calculations do not indicate a health risk for children
  - The exact composition of the total chromium is unknown, but most is likely to be the less toxic trivalent state
- USGS sampling data indicates that arsenic and total chromium levels in residential soil are similar to background levels for the region

Plume Deposition Analysis

- At EEP's request, UDAQ modeled the deposition of contaminants released from the incinerator to determine annual air concentrations of pollutants emitted from Stericycle

- Based on:
  - AERMOD modeling system version 13350
  - Predicted maximum emission outputs for a 20-year period
  - Stack characteristics and testing data
  - Emission temperature and velocity
  - A 5-year historical record of meteorology recorded near the site

- NOTE: For air assessment, the same values is used for CVs and MRLs

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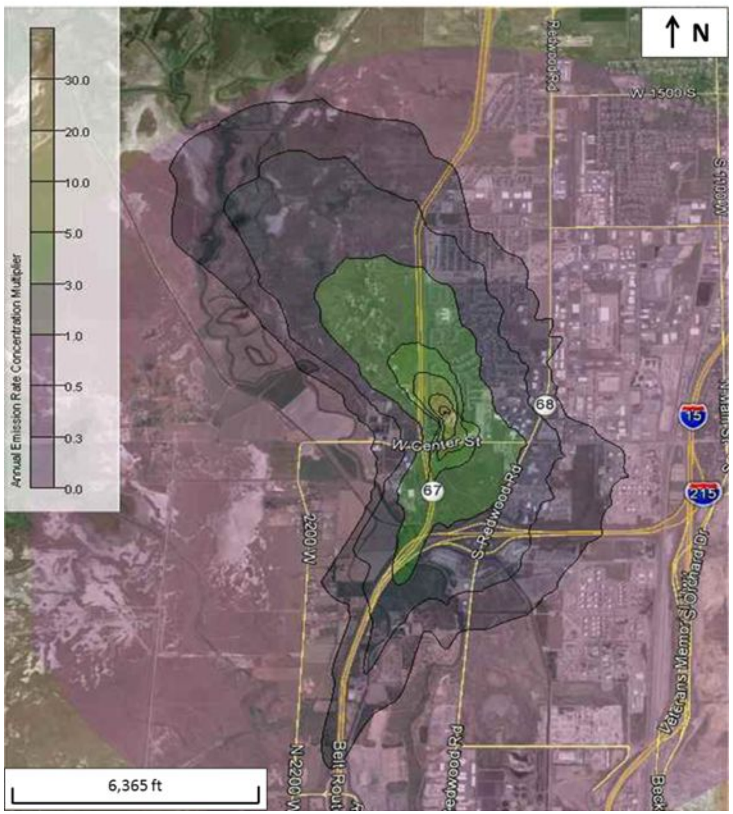
Predicted Airborne Contaminant Gradient

- Modeling indicated that the highest air concentrations would occur roughly 110 meters north-northwest of the incinerator
  - Contaminant air concentrations are predicted to decline further from the facility



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Maximum Predicted Air Concentrations

Pollutant	Based on:	Highest Predicted Residential Air Concentration (µg/m^3)	Cancer CV (µg/m^3)	Non-Cancer CV (µg/m^3)	CV Source
Cadmium	Emissions Limit	**7.60E-03**	**5.60E-04**	1.00E-02	ATSDR CREG; ATSDR Chronic EMEG
Cadmium	Max Measured	1.40E-04			
Carbon Monoxide	Emissions Limit	2.21	NA	10,000	NAAQS 8-Hour Primary Standard
Dioxins (TEQ)	Emissions Limit	**1.49E-07**	**6.40E-08**	4.20E-05	EPA Regional Screening Levels
Dioxins (TEQ)	Max Measured	1.95E-08			
Dioxins (TEQ)	Permit Violation	**7.59E-07**			
Hydrogen Chloride	Emissions Limit	7.25	NA	20	EPA Reference Concentration
Hydrogen Chloride	Permit Violation	10.37			
Lead	Emissions Limit	0.057	NA	0.15	NAAQS 3 Month Avg. Primary Standard
Mercury	Emissions Limit	0.026	NA	0.2	ATSDR Chronic EMEG
Nitrogen Oxides	Emissions Limit	22.83	NA	99.73	NAAQS NO_2 Annual Primary Standard
Nitrogen Oxides	Permit Violation	40.01			
Particulate Matter	Emissions Limit	1.64	NA	150	NAAQS PM_{10} 24-Hour Primary Standard
Sulfur Dioxide	Emissions Limit	0.034	NA	26	ATSDR Acute EMEG

Emissions Limit: Modeling based on the permitted emissions limit
Max Measured: Modeling based on the highest non-violation measured emissions
Permit Violation: Modeling based on the highest emissions measured during the period of permit violation

CVs
CREG: Cancer risk evaluation guide

EMEG: Environmental media evaluation guide

NAAQS: National ambient air quality standard

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Air Exposures Modeling Results

- The maximum predicted residential air concentrations of carbon monoxide, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter, and sulfur dioxide did not exceed the CVs
  - Not expected to harm people's health
  - Based on operating permit emissions limits

- The maximum predicted residential air concentrations of hydrogen chloride and nitrogen oxides during the periods of permit violation did not exceed the CVs

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Air Modeling Results: Cadmium

- Modeling based on the permitted emissions limit indicates that the maximum air concentration may exceed the cancer-based CV

- The highest <u>measured</u> cadmium emission was over 50 times lower than the limit
  - The maximum air concentration based on this value does not exceed the CVs, and is not expected to harm people's health

- New air quality regulations effective October 2014 reduce the permitted cadmium emission level and eliminate this potential issue

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Compliance with New Emission Standards

Pollutant	Test Frequency (years)	Test Date	Result	Limit
Cadmium (mg/dscm)	5	10/18/2006	0.001	0.16
		12/28/2011	0.001	0.16
		1/25/2013	0.003	0.16
		10/1/2014	0.0003	0.04
Carbon Monoxide (ppmdv)	3	11/11/2009	20	40
		11/8/2012	2	40
		1/25/2013	5	40
		4/10/2013	3	40
		10/1/2014	0.2	11
Dioxins/Furans (ng/dscm)	5	10/18/2006	2	125
		12/28/2011	**616.4**	**125**
		2/15/2012	2	125
		1/25/2013	6	125
		10/1/2014	0.4	9.3
Dioxins/Furans (TEQ) (ng/dscm)	5	10/18/2006	0.1	2.3
		12/28/2011	**11.7**	**2.3**
		2/15/2012	0.1	2.3
		1/25/2013	0.3	2.3
		10/1/2014	0.0088	0.54
Hydrogen Chloride (ppmdv)	3	11/11/2009	6	100
		11/8/2012	0.03	100
		1/25/2013	**143.4**	**100**
		4/10/2013	5	100
		10/1/2014	0.1	6.6

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Compliance with New Emission Standards

Pollutant	Test Frequency (years)	Test Date	Result	Limit
Lead (mg/dscm)	5	10/18/2006	0.004	1.2
		12/28/2011	0.001	1.2
		1/25/2013	0.02	1.2
		10/1/2014	0.0003	0.036
Mercury (mg/dscm)	5	10/18/2006	0.004	0.55
		12/28/2011	0.04	0.55
		1/25/2013	0.005	0.55
		12/4/2014	0.001	0.018
Nitrogen Oxides (ppmdv)	5	10/18/2006	250	250
		12/28/2011	**336**	**250**
		9/13/2012	**438**	**250**
		1/25/2013	122	250
		4/10/2013	177	250
		10/1/2014	116	140
Particulate Matter (mg/dscm)	3	11/11/2009	2	34
		11/8/2012	25	34
		1/25/2013	20	34
		10/1/2014	4	25
Sulfur Dioxide (ppmdv)	5	10/18/2006	6	55
		12/28/2011	1	55
		1/25/2013	10	55
		10/1/2014	1.8	9

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Air Modeling Results: Dioxins/Furans

Pollutant	Stack Concentration ($\mu g/m^3$) [a]	Maximum Predicted Residential Air Concentration ($\mu g/m^3$)	Carcinogenic RSL	Non-Carcinogenic RSL
1) Dioxins TEQ [b]	3.00E-04	1.95E-08	**7.40E-08**	4.20E-05
2) Dioxins Old Permit Limit TEQ [c]	2.30E-03	**1.49E-07**		
3) Dioxins Violation TEQ [d]	1.17E-02	**7.60E-07**		
4) Current Dioxin TEQ (2014) [e]	8.8E-06	5.72E-10		
5) Current Dioxin Permit Limit TEQ (2014) [f]	5.40E-05	3.50E-09		

[a] Concentration of dioxin at the Stericycle incinerator stack.
[b] The highest non-violation measured dioxin emission pre-2014.
[c] The maximum dioxin emission limit listed in Stericycle's previous operating.
[d] Dioxin emission when Stericycle was in violation of their operating permit.
[e] Most current dioxin sampling data (2014-)
[f] Maximum dioxin emission limit listed in Stericycle's current permit

- **Cancer risk: 2.52E-06** (about 2.5 excess cases in 1,000,000 exposed people)
  - Total time: 11 years (2003 – 2014)
  - Assumptions
    - Emissions at the maximum permit violating level for 6 years (2006 – 2012)
    - Emissions at the highest measured non-violation level for the remaining 5 years

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Cumulative Site Contaminant Cancer Risk

Pollutant	Estimated Cancer Risk	EPA excess cancer target risk range
Dioxin (air/inhalation) - 11 years (2003-2014)	2.52E-06	**1.0E-04 to 1.0E-06 (1 in 10,000 to 1 in 1,000,000)**
Arsenic (soil/ingestion and dermal) - lifetime	6.22E-05	
TOTAL	**6.47E-05**	

Exposure to Multiple Contaminants

Highest Reported Values including Violations

Pollutant	Highest Reported Stack Test	Highest Modeled Residential Concentration (µg/m^3)	Non-Cancer CV (µg/m^3)	Hazard Quotient (HQ) [Conc./CV]	CV Source
Cadmium (1/25/13)	0.003 (mg/dscm)	0.00012	0.01	0.012	ATSDR Chronic EMEG
Carbon Monoxide (11/11/09)	20 (ppmdv)	1.11	10,000	0.0001	NAAQS 8-Hour Primary Standard
Dioxins/Furans TEQ^V (12/28/11)	11.7 (ng/dscm)	0.00000076	0.00004	0.018	CalEPA Chronic REL
Hydrogen Chloride^V (1/25/13)	143.4 (ppmdv)	10.4	20	0.519	EPA RfC
Lead (1/25/13)	0.02 (mg/dscm)	0.00088	0.15	0.006	NAAQS 3 Month Avg. Primary Standard
Mercury (12/28/2011)	0.04 (mg/dscm)	0.0013	0.2	0.006	ATSDR Chronic EMEG
Nitrogen Oxides^V (9/13/12)	438 (ppmdv)	40.1	99.73	0.402	NAAQS NO_2 Annual Primary Standard
Particulate Matter (11/8/12)	25 (mg/dscm)	1.02	150	0.007	NAAQS PM_{10} 24-Hour Primary Standard
Sulfur Dioxide (1/25/13)	10 (ppmdv)	1.15	26	0.044	ATSDR Acute EMEG
Hazard Index (HI) [Contaminants with HQ ≥ 0.1]				**0.92**	

^{V}: violation
mg: milligram
dscm: dry standard cubic meter (m^3)
ng: nanograms

m^3: cubic meter
ppmdv: parts per million dry volume
µg: micrograms
EMEG: environmental media evaluation guide

NAAQS: national ambient air quality standard
REL: reference exposure level
RfC: reference concentration

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Exposure to Multiple Contaminants

Current Stack Test Data (after Oct. 2014)

Pollutant	Highest Reported Stack Test	Highest Modeled Residential Concentration (μg/m³)	Non-Cancer CV (μg/m³)	Hazard Quotient (HQ)	CV Source
Cadmium[a]	0.0003 (mg/dscm)	0.000013	0.01	0.001	ATSDR Chronic EMEG
Carbon Monoxide	0.2 (ppmdv)	0.053	10,000	0.000005	NAAQS 8-Hour Primary Standard
Dioxins/Furans TEQ	0.0088 (ng/dscm)	0.00000000078	0.00004	0.000018	CalEPA Chronic REL
Hydrogen Chloride	0.1 (ppmdv)	0.0084	20	0.0004	EPA RfC
Lead	0.0003 (mg/dscm)	0.000018	0.15	0.0001	NAAQS 3 Month Avg. Primary Standard
Mercury	0.001 (mg/dscm)	0.000047	0.2	0.0002	ATSDR Chronic EMEG
Nitrogen Oxides	116 (ppmdv)	10.4	99.73	0.105	NAAQS NO_2 Annual Primary Standard
Particulate Matter	4 (mg/dscm)	0.18	150	0.001	NAAQS PM_{10} 24-Hour Primary Standard
Sulfur Dioxide	1.8 (ppmdv)	0.00067	26	0.0007	ATSDR Acute EMEG
Hazard Index (HI) [Contaminants with HQ ≥ 0.1]				**0.11**	

[V]**:** violation
mg: milligram
dscm: dry standard cubic meter (m^3)
ng: nanograms
m^3: cubic meter
ppmdv: parts per million dry volume
μg: micrograms
EMEG: environmental media evaluation guide
NAAQS: national ambient air quality standard
REL: reference exposure level
RfC: reference concentration

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Photos courtesy of KUER, KSTU, FOX13

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Bypass Events

- Malfunction or power outage that may result in severe damage to the facility if emissions are not diverted to a bypass stack
- Emissions from the incinerator are vented directly to the atmosphere
- Emissions still pass through secondary combustion chamber removing some, but not all, emissions
- Feed is shut off to the incinerator, contents allowed to burn out
- Events are random and the content of the incinerator is variable
- Sampling is not feasible due to high temperatures of stack emissions
- Realistic assessment difficult to accurately predict

Photo courtesy of KUER

Bypass Events

Based upon EPA Emissions Factors, 1993

Pollutant	Maximum Predicted Residential Air Concentration (µg/m³)	Acute Exposure Health Comparison Values (µg/m³)	Source	NIOSH IDLH Acute Exposure Level (µg/m³)
NOx	77.43	188	NAAQS 1-hour Primary Standard	37,600
PM/PM10	101.58	150	NAAQS 24-hour Primary Standard	5,000 [a]
SO_2	**47.2**	**26**	ATSDR Acute MRL	262,000
CO	2.18	40,250	NAAQS 1-hour Primary Standard	1,380,000
VOC	6.5	29 [b]	ATSDR Acute MRL Benzene	1,595,000
Lead	**1.58**	**0.15**	NAAQS 3-month Primary Standard	100,000
Hydrogen Chloride	728.65	2,100	CalEPA Acute REL	74,500
Hydrogen Fluoride	3.24	16	ATSDR Acute MRL	24,600
Cadmium	**0.12**	**0.03**	ATSDR Acute MRL	9,000
Mercury - total (elemental + inorganic compounds)	**2.33**	**0.6** [c]	CalEPA Acute REL	10,000
Mercury - elemental	0.47	0.6 [c]	CalEPA Acute REL	10,000
Dioxins/Furans	1.34E-05	4.20E-05	CalEPA Chronic REL/RfC [d]	NA

[a] No IDLH available, listed value is OSHA 8-hour time-weighted average

[b] Benzene values used for evaluation of general VOCs

[c] The CalEPA REL is based on elemental mercury exposures

[d] No acute health comparison or IDLH value available

IDLH: immediately dangerous to life or health
NAAQS: national ambient air quality standard
REL: reference exposure level
MRL: minimal risk level

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Bypass Events

- MRLs and RELs
  - An estimate of the daily human exposure to a substance that is not expected to result in risk of adverse, non-cancer health effects over a specific time period (i.e, acute, intermediate, chronic)
  - Exceeding an MRL/REL does not necessarily indicate an adverse health effects will occur, rather, it provides guidance for health professionals as they treat exposed individuals
  - Never based on serious health effects or cancer outcomes
    - Based on “no observable adverse effect level” or “least observable adverse effect level”
  - Based on human studies when available
    - Based on animal studies if human data is insufficient
  - When a study adequately identifies a chemical’s “no effect” or “least effect” dosage, then that dosage is divided by uncertainty factors (UF) to protect the most sensitive individuals in a population (infants, pregnant women, those with chronic health conditions, etc.)
    - UFs can range from 10 (well-designed human studies) to 3,000 (well-designed animal studies with data gaps)

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Mercury Exposures from Bypass Events

- Mercury
  - REL based on study of offspring of pregnant rats exposed to Hg vapors during pregnancy
  - 1,800 µg/m^3 for 1 hour/day for six days (Foxboro bypass exposure calculated as 2.33 µg/m^3, duration ~20 minutes)
  - Effect in rat pups observed as decreased motor activity at 3 months of age
  - Hg effect gone when retested at 14 months of age
  - REL UF of 3,000
- Considerations
  - EPA EFs established in 1993 (prior to Hg reduction initiatives)
  - 80-98% of Hg incinerator emissions are $HgCl_2$ (poorly absorbed, far less toxic)[1]
- Conclusions
  - EEP calculations likely overestimate elemental Hg emissions
  - Unlikely that adverse health effects will occur due to Hg in bypass smoke
- Hg readily detected in urine samples; half-life ~55days

[1] EPA, 1997; ATSDR 1999; Pichtel, 2010

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Cadmium Exposures from Bypass Events

- Cadmium
  - MRL based on study of rats exposed to cadmium vapors
  - 88 µg/m^3 for 6 hours/day, 5 days/week, for two weeks (Foxboro bypass exposure calculated as 0.12 µg/m^3, duration ~20 minutes)
  - Rats developed mild inflammation in lungs (measured by increased numbers of macrophage cells).
  - MRL UF of 300
- Considerations
  - EPA EFs established in 1993 (prior to Cd reduction initiatives)
- Conclusions
  - EEP calculations likely overestimate elemental Cd emissions
  - Unlikely that adverse health effects will occur due to Cd in bypass smoke
- Cd readily detected in blood (recent exposures) and urine (shows recent and cumulative exposures); half-life ~6-38 years; smokers have roughly twice the body Cd of non-smokers

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Lead Exposures from Bypass Events

- Lead
  - No established MRL
  - Available CV is NAAQS 3-month average (bypass exposure ~20 minutes)
  - OSHA 8-hour time-weighted average (TWA) lead action level is 30 µg/m^3 (indicates need for surveillance, monitoring, and hazard education for worker)
  - EEP divided OSHA value by a UF of 10 to be protective of most sensitive individuals (3 µg/m^3). Foxboro exposure calculated as 1.58 µg/m^3 for event duration
- Considerations
  - EPA EFs established in 1993 (prior to Pb reduction initiatives)
- Conclusions
  - EEP calculations likely overestimate elemental Pb emissions
  - Unlikely that adverse health effects will occur due to Pb in bypass smoke

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Lead Exposures Continued

- No Safe Level of Lead
  - Exposures to high levels of lead or low levels for long periods
    - Mental and physical growth affected
    - Adverse birth outcomes (premature, small, low birth weight)
    - Learning difficulties
- EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK)

Lead Exposure Route	Lead Concentration
Outdoor Soil	19.7 ppm
Indoor Dust	23.8 ppm
Food	1.95 - 2.26 µg/day (default)
Water	4 µg/L; 0.20 - 0.59 L/day (default)
Air	0.1 µg/m^3 (default)
Geometric Mean BLL (0 - 60 months old)	1.03 µg/dL
Percent above 5.0 µg/dL (0 - 60 months old)	0.038%

- CDC considers blood lead levels (BLLs) values above 5 µg/dL as excessive

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Sulfur Dioxide Exposures from Bypass Events

- Sulfur Dioxide
  - MRL based on human subjects (asthmatics)
  - Subjects exposed to 262 µg/m^3 for 10 minutes during moderate exercise (Foxboro bypass exposure calculated at 47.2 µg/m^3)
  - Subjects developed slight bronchorestriction (increased airway resistance). Subjects did not develop wheezing or shortness of breath
  - MRL UF of 10
- Conclusions
  - The most sensitive individuals (those with existing respiratory disorders) may experience bronchorestriction and/or nose, throat, and lung irritation

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Limitations

- Air studies assess only the Stericycle incinerator. There are multiple pollutant sources in this area including petroleum refineries, factories, and high traffic freeways. These factors may alter the overall health risks associated with a particular pollutant or combination of pollutants.
- Air modeling is based upon facility dimensions, meteorological data, and historic stack-test data. Many factors, including variance in facility operation practice, could result in over- or underestimation of true annual air pollutant concentrations.
- Bypass event pollution estimates are further limited by lack of actual sampling data and rely on 1993 EPA assumptions of the most likely waste content and incineration by-products generated by this type of incinerator

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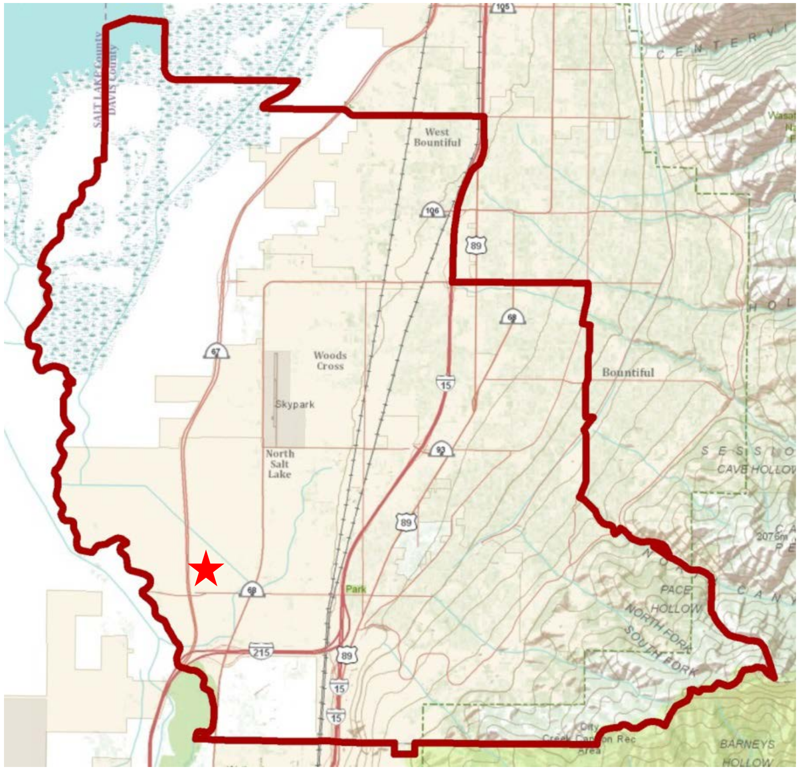
Adverse Birth Outcomes Statistical Review

- Reviewed the incidence of adverse birth outcomes in the study area between 1991 and 2012
  - Low birth weight, prematurity, infant death, and small-for-gestational-age

- No evidence was found to indicate that the risk for these adverse birth outcomes was higher for the study area than the rest of Utah

Map of South Davis County. The study area is outlined, and the location of the Stericycle incinerator is shown with a red star.



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Cancer Incidence Statistical Review

- Reviewed the incidence of all 42 cancer categories in the study area between 1976 and 2011
  - Colon cancer, anal cancer among women, bone and joint cancer, cutaneous melanoma, breast cancer, and prostate cancer were elevated in the last analytical period (2006 – 2011)
    - These may indicate emerging clusters, or they could be random variation in the data.
    - Breast cancer was elevated for the last two analytical periods (2000 – 2011)
    - A historical cluster of prostate cancer was also detected (1988 – 1999)
  - These types of cancer are typically not associated with environmental exposures
    - They are linked more with behavioral and genetic factors
  - The elevated cancer types are often preventable
    - Making healthy life choices is always encouraged, such as smoking cessation, maintaining a healthy diet and weight, avoiding excessive sun exposure, and getting enough physical exercise

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Conclusions

- Soil exposures to analyzed dioxins and heavy metals are not expected to result in adverse health effects.
- Based on the available CVs, inhalation exposure to dioxins released from the Stericycle medical waste incinerator is not expected to result in adverse, non-cancer health effects. While modeled residential exposures to dioxins during Stericycle's violation of their operating permit exceeded the cancer-based RSL, cumulative exposure from the first development of the neighboring community to 2014 is not expected to result in substantial excess cancer risk.
- Based upon the highest recorded stack testing data, exposure to the mixture of chemicals emitted from the incinerator stack is not expected to result in adverse health effects.
- Compliance with new emissions regulations, effective as of October 2014, are expected to be adequately protective of human health for both cancer and non-cancer adverse health effects.

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Conclusions

- Excess cancer risks from all contaminants that exceeded cancer-based CVs at this site (arsenic in soil and dioxins in air) are not expected to result in significant excess cancer risk.

- Exposures to bypass event smoke plumes may result in minor adverse health effects for those with severe respiratory disorders and should be reduced as much as possible.

- Elevation of certain cancer types were found in the study area that includes the Foxboro neighborhood. However, these cancer types are not associated with environmental contaminants, but rather are strongly linked to genetics and lifestyle choices.

- No evidence was found to indicate that the risk for adverse birth outcomes was higher for the study area than the rest of Utah.

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Recommendations

- Limit children's’ hand-to-mouth behavior when playing in playgrounds
- Limit children's’ exposure to lead containing material
- Avoid exposure to bypass smoke
  - Move indoors if you may be in direct contact with a smoke plume outdoors
  - Close windows and doors once indoors
  - Turn off non-filtering air-handling devices that bring outdoor air inside (window fans, window A/C units, evaporative coolers) until the smoke plume dissipates
  - Regularly maintain all home heating, ventilation, and air conditioning (HVAC) filters
  - Consider a portable home air purifier unit with carbon and HEPA filtration
  - The community (residents and Stericycle) should consider establishing a notification system alerting residents in real-time of bypass events (e.g., text alerts)

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Recommendations

- Make healthy life choices for yourself and <u>your children</u>
  - Major causes of chronic disease (heart disease, diabetes, cancer)[1]
    - Obesity/overweight/poor nutrition
    - Tobacco use/smoking
    - Excessive alcohol use
    - Lack of exercise
  - Healthy life choices decrease the adverse impacts of environmental pollutants[2]
- Take action to protect your mental health
  - All major causes of chronic disease life choices are affected by stress, anxiety, and depression[3]

[1]CDC Chronic Disease and Health Promotion website.
[2]Hennig et al. Enviro. Health Pers. 120, 6, June 2012; Murphy et al. Env. Sci Pollut. Res. Int. 2015 Jan 15., many more
[3] Perry et al. Am J Public Health, v.100 (12):2337-2339; CDC sources; WHO Sources;

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Comment period for these documents will close November 5th, 2015

url: http://health.utah.gov/enviroepi/appletree/SouthDavisCounty

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