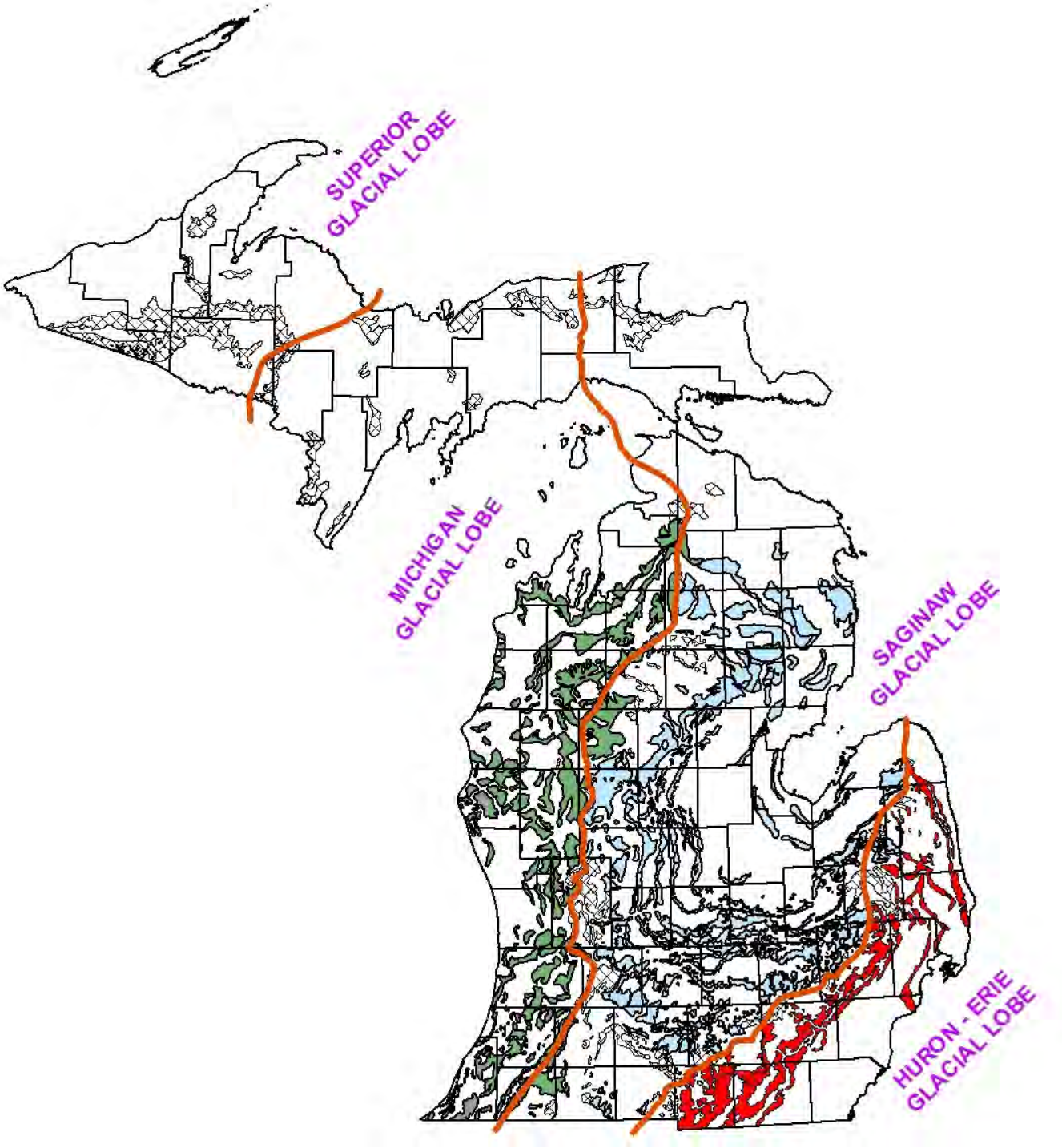
Send Survey Comments

MICHIGAN BACKGROUND SOIL SURVEY 2005
(Updated 2015)



Permit & Corrective Action Unit
Hazardous Waste Section
Office of Waste Management & Radiological Protection

Michigan Background Soil Survey 2005 (Updated 2015)

Introduction

In 1991, the Michigan Department of Natural Resources (MDNR) released a compilation of soil sampling data that represented what is assumed to be the naturally occurring background concentration of metals in Michigan soils. The data were presented in the "Michigan Background Soil Survey" (MBSS) in April 1991 and after the creation of the Michigan Department of Environmental Quality (MDEQ) the 2005 version was published. In 2014, additional soil sampling data from locations that represent background conditions were collected from files of the Remediation and Redevelopment Division (RRD), and the MBSS 2005 has been updated in 2015 by the MDEQ [(1)].

History

During the mid-1980s, closure plans were submitted to the state pursuant to cleanups and corrective action work at regulated hazardous waste treatment, storage, and disposal facilities. In order to assure that soil removal performed to achieve clean closure was accomplished, standards were established that mandated the removal of contaminants until concentrations were non-detectable or within the naturally occurring background range. Therefore, facilities undergoing closure or corrective action for metals were required to submit analyses of soil from their specific location to determine the criteria to be met, which is statistically equivalent to the local, un-impacted background conditions. In order to evaluate the validity of these site-specific background values, a Michigan soil background database was compiled. That background soils database included information gathered by regulated facilities, as well as samples collected and analyzed by the state.

Background soil data from the regulated facilities were obtained using standard sampling and analytical techniques at the time of collection, which were approved by the state, usually as part of a closure plan or remediation efforts. Common analytical methods from EPA/SW-846 were used (EPA method 200.7, SW-846 method series 6000/7000, etc.). Samples collected by the state were analyzed by an approved contract laboratory, or through the State of Michigan Environmental Laboratory. Some data included was from United States Geological Survey (USGS) and the Army Corp of Engineers. All results represent a total (environmentally available) metals analysis.

Data Reduction

The background soil data for each metal has been reviewed in two basic ways. The first is looking at the data by general soil type. Based usually on a visual observation, and occasionally a soil classification system, soil samples were divided into the following general soil types: topsoil, sand or clay. The other breakdown was by geographic location, using glacial geology distinctions. In Michigan there were several different glacial ice sheets (lobes) that covered distinct areas. The glacial lobes have varying points of origin and traverse differing types of bedrock, and thus the resulting glacial sediments could have varying chemical characteristics based on source rock influences. The assumed boundaries of the glacial lobes have been revised for the 2015 update based on additional information resources [(2)]. Summary statistics are presented for general soil types and for broad geographic areas based on the location of major glacial lobes.

Since the data comes from investigations at different sites, each with various parameters of concern, the suite of metals analyzed was not the same in each case. Depending on how commonly the metal was a pollutant of concern, and the number of samples taken for site-specific background determinations, each metal will have a different total number of individual samples and number of sites/locations the samples came from.

Statistics

A basic statistical analysis was performed for each metal represented in the database [(3)]. First, the percentage of non-detect values was determined, followed by analysis of the underlying distribution of the data. Finally, summary statistics such as the mean, median, standard deviation, quantiles and the range of concentrations for a metal were calculated with normal, lognormal, or nonparametric methods as appropriate.

In terms of detection limits, metals with 0 – 15 % non-detect results had a value equal to one half (1/2) of the respective detection limit substituted for calculation of summary statistics (Al, As, Ba, Cr, Cu, Fe, Mg, Mn, Sr, Ti, V, Zn). Metals with 15 - 50% non-detect results had summary statistics calculated using Cohen's adjustment (Co, Li, Na, Ni, Pb). For metals with over 50% non-detects, a nonparametric method was used (Ag, Be, Cd, Hg, Mo, Sb, Se, Tl).

The data distribution was analyzed using graphical techniques (histogram, probability plot, box plot) and the Shapiro-Francia or Shapiro-Wilk Goodness-of-Fit test. For simplicity's sake, only normal or lognormal distributions were checked and the best fit to the respective metals' data was chosen. Subsequently, summary statistics were calculated as appropriate for a normal, lognormal, or nonparametric distribution. Tables are attached that list the summary statistics for each metal.

Summary

The MBSS is meant to provide a resource for information regarding the concentration of naturally occurring metals that can be expected in various general soil types and geographic areas of Michigan. Site-specific data is recommended to get the best representation of a local background concentration.

Contact Information

If there are any questions, or a desire to obtain data, please contact those listed below:

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Attachments

Table 1…… General Information – all data combined
Tables 2, 3, 4……Topsoil, Sand and Clay - typical range of concentrations
Figure 1……All Sample Locations and glacial lobe boundaries
Figures 2, 3, 4……..Topsoil, Sand and Clay - sample locations

Statewide Information

METAL	Number of samples	Sites	Percent Non-detect	Assumed Distribution of Data	{a} Mean (mg/kg)	{b} Standard Deviation	Median (mg/kg)	{c} Typical Range of data (mg/kg)
Aluminum (Al)	508	171	0 %	Lognormal	3085	2.317	3205	594 - 16014
Antimony (Sb)	259	82	83.8 %	Non-para	na	na	< 0.30	<0.04 - 11.5
Arsenic (As)	1795	490	6.3 %	Lognormal	2.5	3.088	2.8	< 0.3 - 22.8
Barium (Ba)	1241	401	2.0 %	Lognormal	20.2	2.981	21.7	2.4 - 172
Beryllium (Be)	390	155	71.3 %	Non-para	na	na	< 0.21	<0.09 – 1.0
Cadmium (Cd)	1347	413	69.9 %	Non-para	na	na	< 0.23	<0.05 – 2.0
Chromium (Cr)	861	247	12.5 %	Lognormal	5.7	3.197	6.1	< 0.6 - 55.6
Cobalt (Co)	1161	426	18.4 %	Cen-Log	4.9	2.378	5.1	<0.9 – 26.8
Copper (Cu)	1393	437	7.4 %	Lognormal	6.2	2.920	7.3	<8 - 50.6
Iron (Fe)	568	197	0 %	Lognormal	5533	2.537	5825	86 - 34311
Lead (Pb)	1619	482	18.0 %	Cen-Log	4.0	3.192	5.0	<0.4 - 38.9
Lithium (Li)	312	124	28.5 %	Cen-Log	3.8	3.231	3.5	<0.4 - 37.9
Magnesium (Mg)	248	88	0 %	Lognormal	1884	4.508	1715	98 - 36049
Manganese (Mn)	574	209	0 %	Lognormal	121	3.240	152	12 - 1212
Mercury (Hg)	1168	414	89.1 %	Non-para	na	na	< 0.05	<0.01 - 0.5
Molybdenum (Mo)	275	116	89.1 %	Non-para	na	na	< 1	<0.25 – 5.0
Nickel (Ni)	850	255	18.8 %	Cen-Log	7.4	2.788	8.2	<1- 55.2
Selenium (Se)	1209	420	77.3 %	Non-para	na	na	< 0.44	<0.05 – 1.3
Silver (Ag)	973	320	92.2 %	Non-para	na	na	<0.20	<0.03 – 1.4
Sodium (Na)	216	76	31.9 %	Cen-Log	58.7	3.041	85	<6.6 - 519
Strontium (Sr)	81	51	0 %	Non-para	na	na	31	1.7 - 150
Thallium (Tl)	369	124	90.2 %	Non-para	na	na	< 0.50	<0.08 – 2.7
Titanium (Ti)	97	41	0 %	Normal	118	45.0	108	28 - 208
Vanadium (V)	406	167	1.7 %	Lognormal	9.9	2.500	9.9	1.6 - 59.6
Zinc (Zn)	1392	433	2.2 %	Lognormal	18.3	2.593	22	3 - 118

{a} For lognormal distributions, this represents the geometric mean. For normal distributions this represents the arithmetic mean. The mean was not estimated for data with non-parametric distributions (greater than 50% non-detect).

{b} For lognormal distributions, this represents the geometric standard deviation and is unit-less. The standard deviation is not estimated for data with non-parametric distributions.

{c} Typical range given is the central 95% of the data, or two standard deviations, calculated using the appropriate normal or lognormal formulas. The non-parametric range is based on the 2.5^{th} and 97.5^{th} quantiles of the data set.

na = not applicable for nonparametric data distribution
Non-para = nonparametric (> 50% non-detect)
Cen-Log – censored lognormal (<15 – <50% non-detect)

TABLE 1

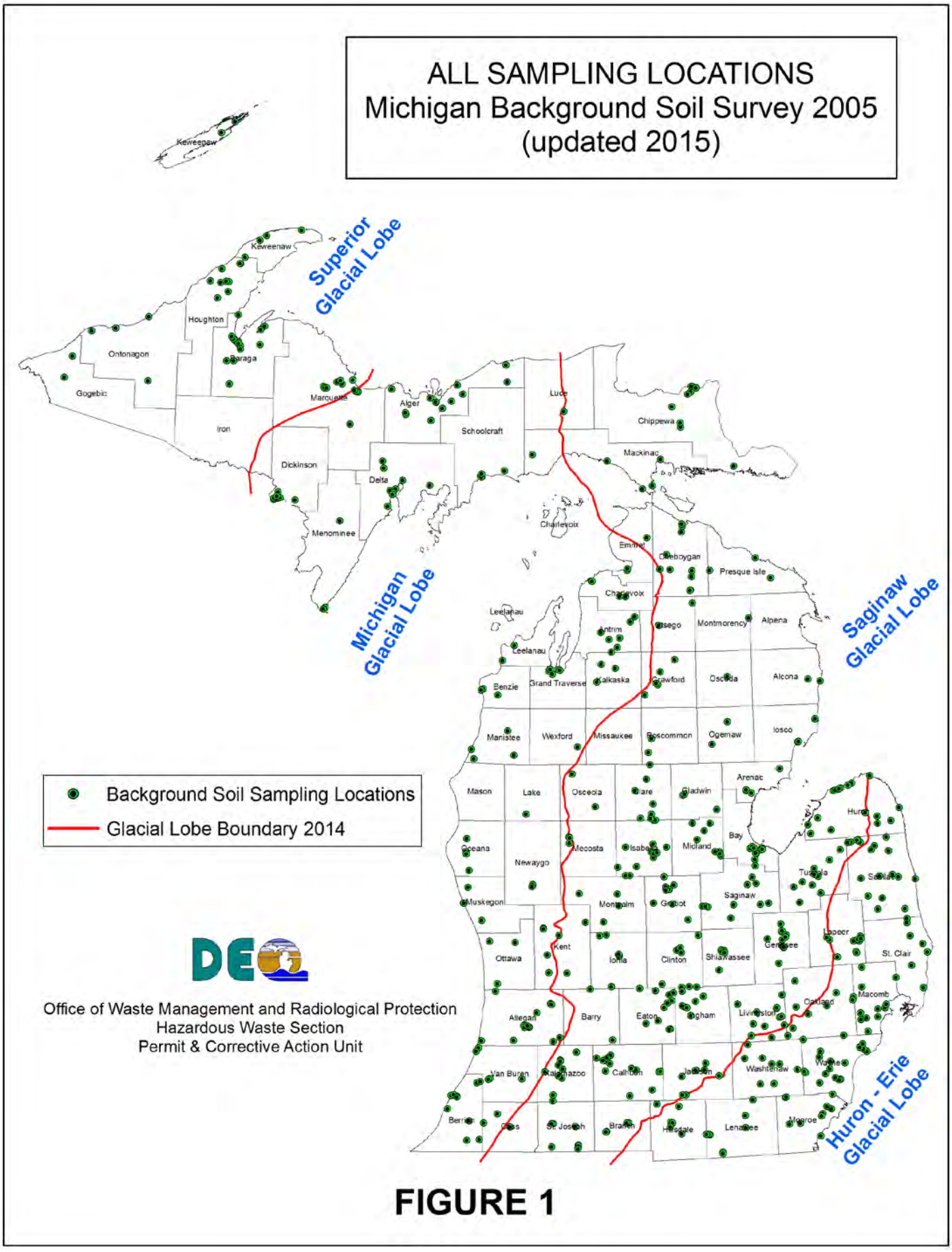

ALL SAMPLING LOCATIONS
Michigan Background Soil Survey 2005
(updated 2015)
Keweenaw
Superior Glacial Lobe
Houghton
Ontonagon
Baraga
Gogebic
Marquette
Alger
Luce
Chippewa
Iron
Schoolcraft
Mackinac
Dickinson
Delta
Menominee
Charlevoix
Emmet
Cheboygan
Presque Isle
Michigan Glacial Lobe
Saginaw Glacial Lobe
Leelanau
Antrim
Otsego
Montmorency
Alpena
Benzie
Grand Traverse
Kalkaska
Crawford
Oscoda
Alcona
Manistee
Wexford
Missaukee
Roscommon
Ogemaw
Iosco
Arenac
Mason
Lake
Osceola
Clare
Gladwin
Oceana
Newaygo
Mecosta
Isabella
Midland
Bay
Muskegon
Montcalm
Gratiot
Saginaw
Tuscola
Sanilac
Ottawa
Kent
Ionia
Clinton
Shiawassee
Genesee
Lapeer
St. Clair
Allegan
Barry
Eaton
Ingham
Livingston
Oakland
Macomb
Van Buren
Kalamazoo
Calhoun
Jackson
Washtenaw
Wayne
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
Monroe
Huron - Erie Glacial Lobe
Background Soil Sampling Locations
Glacial Lobe Boundary 2014
DEQ
Office of Waste Management and Radiological Protection
Hazardous Waste Section
Permit & Corrective Action Unit

FIGURE 1

TOPSOIL

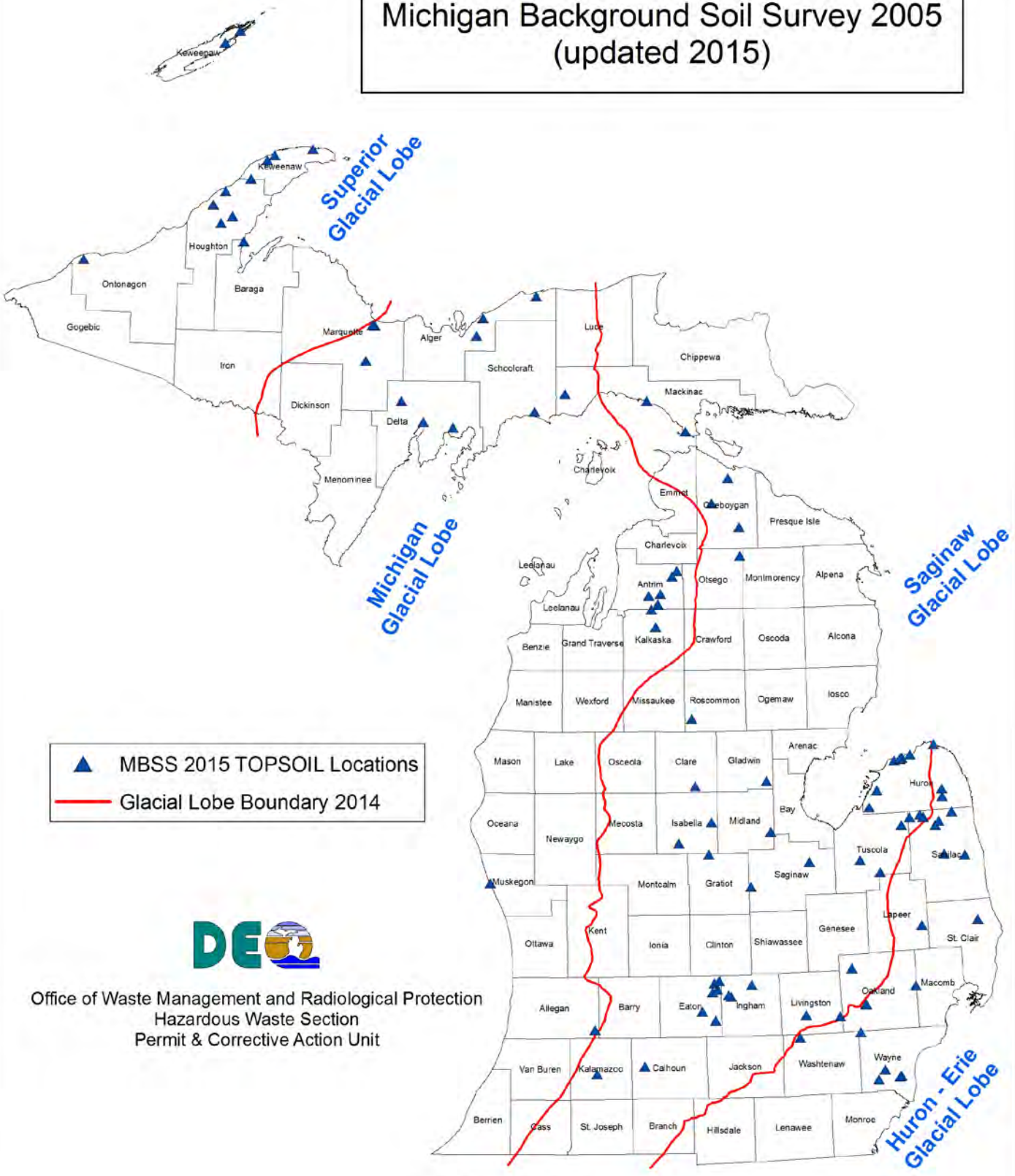
	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					TOPSOIL – Combined Statewide Data						
		n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	min	max	x	SD	1 SD	**2 SD**
Al	L	11	4554	1.439	6553	**9294**	47	2253	2.236	5038	**10908**	25	1041	1.751	1823	**3121**	15	3488	2.110	7360	**15072**	98	340	9950	2141	2.330	4989	**11237**
Sb	Np	0	--	--	--	**--**	1	--	--	--	**--**	0	--	--	--	**--**	0	--	--	--	**--**	1	--	--	--	--	--	**--**
As	L	51	5.7	1.630	9.3	**14.9**	103	2.2	2.357	5.2	**11.8**	29	1.0	2.149	2.1	**4.5**	17	1.4	1.707	2.4	**4.0**	200	<0.25	34	2.4	2.537	6.1	**14.9**
Ba	L	16	40	2.602	104	**261**	52	22.7	1.876	42.6	**77.9**	29	13.5	2.242	30.3	**65.7**	17	41.4	1.749	72.4	**124**	114	<2.2	103	23.6	2.272	53.6	**118**
Be	Np	2	<0.20	--	--	**--**	13	<0.30	--	0.31	**0.71**	0	--	--	--	**--**	0	--	--	--	**--**	15	<0.20	0.84	<0.30	--	0.3	**0.69**
Cd	Np	16	<2.0	--	2.0	**2.0**	52	<2.0	--	<2.0	**<2.0**	29	<2.0	--	<2.0	**<2.0**	17	<2.0	--	<2.0	**<2.0**	114	<0.12	2.0	<2.0	--	<2.0	**2.0**
Cr	L	19	13.1	1.698	22.2	**37.0**	53	5.3	2.459	13.0	**30.9**	29	3.2	1.851	5.9	**10.7**	17	7.7	2.227	17.1	**37.0**	118	<0.70	36	5.7	2.438	13.9	**32.7**
Co	Np	11	<5.0	--	5.7	**7.0**	39	<5.0	--	<5.0	**6.1**	23	<5.0	--	<5.0	**<5.0**	15	<5.0	--	6.1	**11.8**	88	<2.5	14	<5.0	--	<5.0	**7.0**
Cu	L	16	9.9	2.343	23.2	**52.5**	53	4.3	2.377	10.2	**23.5**	29	2.4	2.308	5.5	**12.4**	17	31.3	2.290	71.7	**159**	115	<0.50	82.5	5.6	3.270	18.3	**57.1**
Fe	L	11	9476	1.473	13958	**20244**	51	4439	2.540	11275	**27590**	29	2175	1.840	4002	**7186**	17	5247	2.060	10809	**21632**	108	320	22300	4065	2.431	9882	**23185**
Pb	CL	42	11.6	1.973	22.9	**43.9**	67	8.0	1.968	15.7	**30.2**	29	6.9	1.825	12.6	**22.4**	17	12.1	2.524	30.5	**74.3**	155	<2.3	66.2	9.1	2.048	18.6	**37.1**
Li	V	11	4.3	1.581	6.8	**10.6**	43	2.3	2.581	5.9	**14.8**	23	< 2.0	--	2.3	**3.0**	17	2.9	1.932	5.6	**10.5**	94	<2.0	12	2.2	2.363	5.2	**11.9**
Mg	L	5	3184	2.088	6648	**13489**	5	1410	1.829	2579	**4604**	0	--	--	--	**--**	0	--	--	--	**--**	10	490	8900	2119	2.152	4560	**9517**
Mn	L	11	524	2.224	1165	**2510**	52	113	2.891	327	**905**	29	109	3.441	375	**1228**	17	154	2.413	372	**866**	109	3.0	1500	137	3.154	432	**1302**
Hg	Np	16	<0.10	--	0.10	**0.16**	52	<0.10	--	<0.10	**0.4**	29	<0.10	--	<0.10	**0.10**	17	<0.10	--	<0.10	**0.12**	114	<0.05	0.5	<0.10	--	<0.10	**0.27**
Mo	Np	2	<5.0	--	--	**--**	12	<5.0	--	<5.0	**<5.0**	0	--	--	--	**--**	0	--	--	--	**--**	14	<5.0	<5.0	<5.0	--	<5.0	**<5.0**
Ni	V	12	9.3	3.7	13.0	**16.6**	52	< 5.0	--	9.0	**14.0**	29	<5.0	--	<5.0	**7.1**	17	8.2	3.012	24.7	**71.2**	110	<3.5	47	4.3	2.448	10.5	**24.9**
Se	Np	23	<0.5	--	1.3	**4.7**	51	<0.50	--	<0.50	**0.65**	29	<0.50	--	<0.50	**0.53**	17	<0.50	--	<0.50	**0.65**	120	<0.05	8	<0.50	--	<0.50	**1.3**
Ag	Np	6	<0.25	--	0.75	**1.6**	5	<0.25	--	<0.25	**<0.25**	0	--	--	--	**--**	0	--	--	--	**--**	11	<0.20	1.7	<0.25	--	0.35	**1.4**
Na	V	2	125	--	--	**--**	5	92	24.6	117	**140**	0	--	--	--	**--**	0	--	--	--	**--**	7	<65	130	101	25.9	127	**153**
Sr	Np	0	--	--	--	**--**	7	106	--	148	**156**	0	--	--	--	**--**	0	--	--	--	**--**	7	73	157	106	--	148	**156**
Tl	Np	2	<1.0	--	--	**--**	5	<1.0	--	<1.0	**<1.0**	0	--	--	--	**--**	0	--	--	--	**--**	7	<1.0	<1.0	<1.0	--	<1.0	**<1.0**
Ti	N	2	94.5	--	---	**--**	12	133	43.9	177	**219**	0	--	--	--	**--**	0	--	--	--	**--**	14	73	210	127	42.8	170	**211**
V	L	2	21	--	--	**--**	12	14.1	1.483	20.9	**30.5**	0	--	--	--	**--**	0	--	--	--	**--**	14	<8.0	28	14.9	1.480	22.1	**32.1**
Zn	L	27	39.8	1.770	70.4	**122**	53	18.5	2.057	38.1	**76.1**	29	9.7	2.207	21.4	**45.8**	17	36.7	2.039	74.8	**148**	126	<2.5	99	20.6	2.400	49.4	**115**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg)

Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x+ (1.96)SD	97.5^{th} quantile

TABLE 2

TOPSOIL SAMPLING LOCATIONS
Michigan Background Soil Survey 2005
(updated 2015)



Office of Waste Management and Radiological Protection
Hazardous Waste Section
Permit & Corrective Action Unit

FIGURE 2

SAND

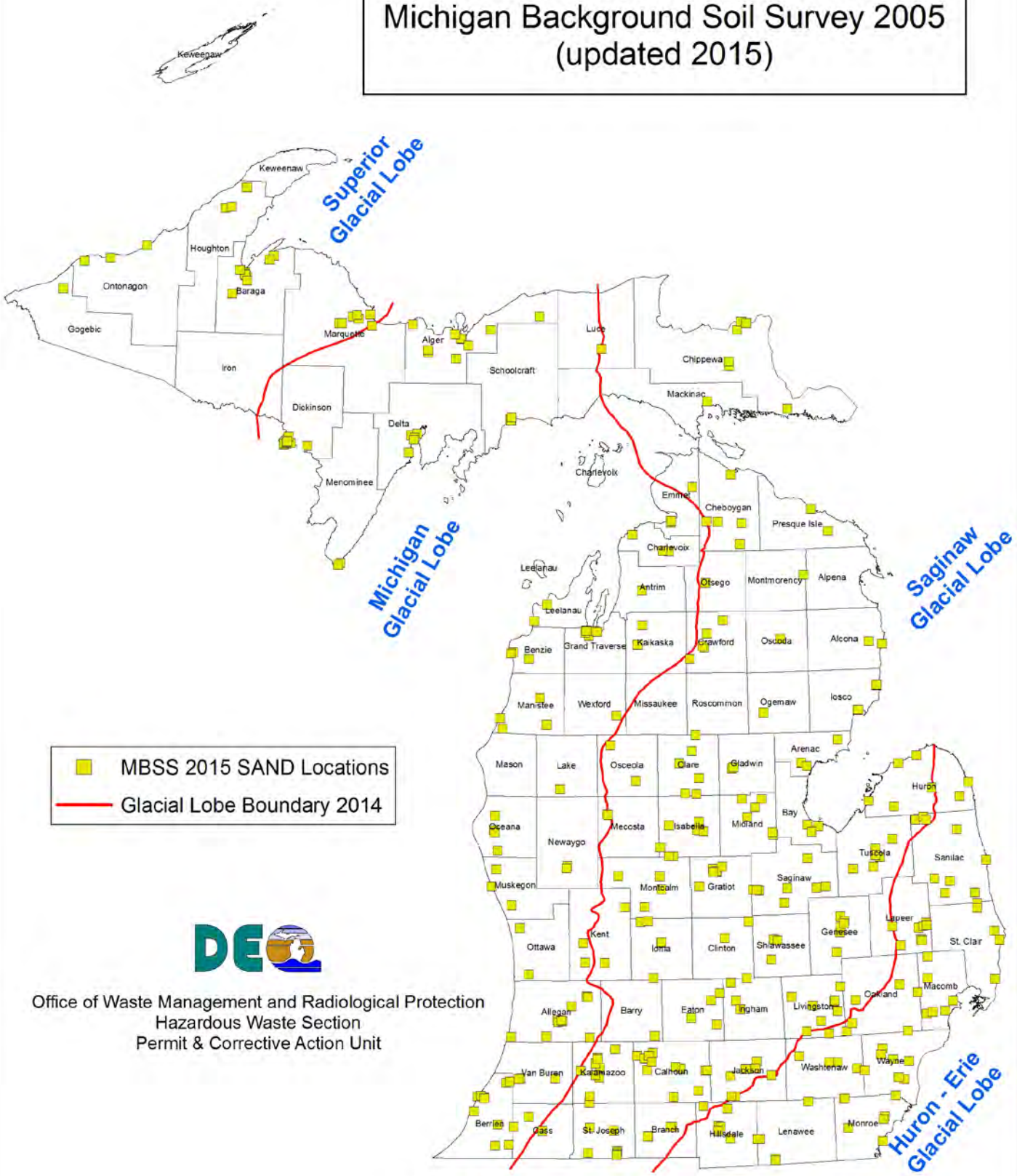
	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					SAND – Combined Statewide Data						
		n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	x	SD	1 SD	**2 SD**	n	min	max	x	SD	1 SD	**2 SD**
Al	L	31	3024	1.667	5041	**8233**	162	2265	1.930	4371	**8218**	67	1842	1.850	3408	**6151**	26	5256	2.324	12215	**27446**	286	250	24900	2404	2.031	4883	**9639**
Sb	Np	15	<0.33	--	0.65	**8.7**	58	<0.42	--	< 1.0	**10.8**	50	<0.30	--	<2.9	**5**	57	<0.30	--	0.30	**1.9**	180	<0.08	12.9	<0.30	--	< 1.0	**5.9**
As	L	175	4.1	2.580	10.6	**26.3**	509	1.8	3.140	5.7	**17**	194	0.86	2.630	2.3	**5.7**	87	1.0	2.052	2.1	**4.1**	965	<0.05	40	1.7	3.189	5.4	**16.5**
Ba	L	103	28.1	2.713	76.2	**199**	374	12.4	2.350	29.1	**66.2**	199	8.4	2.784	23.4	**62.5**	85	18.9	2.399	45.3	**105**	761	<0.50	240	13.1	2.713	35.5	**92.6**
Be	Np	31	<0.20	--	0.51	**0.78**	125	<0.20	--	<1.0	**1.0**	74	<0.20	--	<0.50	**1.0**	57	<0.20	--	0.31	**0.86**	287	<0.04	2	<0.20	--	0.50	**1.0**
Cd	Np	97	<0.24	--	2.0	**2.0**	378	<0.2	--	2.0	**2.0**	214	<0.2	--	0.76	**2.0**	79	<0.2	--	0.20	**2.0**	768	<0.01	2.1	<0.20	--	2.0	**2.0**
Cr	L	67	4.1	2.778	11.4	**30.4**	219	3.7	2.347	8.7	**19.7**	100	1.7	3.401	5.8	**18.7**	60	3.1	2.782	8.6	**23.0**	446	<0.25	50	3.1	2.835	8.8	**23.9**
Co	CL	78	6.6	1.666	11.0	**17.9**	376	3.8	2.037	7.7	**15.3**	226	2.9	2.327	6.7	**15.2**	95	7.9	2.137	16.9	**35.0**	775	<0.50	36.7	4.1	2.265	9.3	**20.4**
Cu	L	116	6.5	1.928	12.5	**23.5**	397	3.6	2.412	8.7	**20.2**	210	2.9	3.282	9.5	**29.8**	92	12.7	3.139	39.9	**120**	815	<0.25	375	4.3	2.937	12.6	**35.5**
Fe	L	36	5863	1.934	11339	**21359**	165	4005	2.270	9091	**19972**	80	3032	1.973	5982	**11486**	60	7398	2.270	16793	**36891**	341	100	39000	4351	2.289	9959	**22054**
Pb	CL	132	6.1	2.017	12.3	**24.1**	429	2.8	2.586	7.2	**18.0**	245	1.8	3.206	5.8	**17.7**	155	1.4	4.357	6.1	**25.1**	961	<0.07	36	2.5	3.173	7.9	**24.0**
Li	V	7	3.5	--	7.3	**9.6**	101	2.8	2.232	6.2	**13.5**	22	2.3	2.287	5.3	**11.6**	18	9.7	8.1	17.8	**25.9**	148	<0.80	24.4	2.9	2.575	7.5	**18.5**
Mg	L	18	1411	3.341	4714	**15008**	112	1184	4.016	4755	**18063**	46	1288	3.868	4982	**18255**	26	2010	2.162	4346	**9110**	202	6.9	28000	1312	3.689	4840	**16946**
Mn	L	24	89.2	3.202	286	**873**	170	73.3	3.079	226	**664**	73	64.8	3.478	225	**745**	65	133	3.104	413	**1225**	332	1.0	3600	81.3	3.252	264	**820**
Hg	Np	102	<0.05	--	<0.10	**0.12**	320	<0.05	--	<0.10	**0.23**	188	<0.05	--	<0.10	**0.10**	82	<0.05	--	0.10	**0.11**	692	<0.01	1.2	<0.05	--	<0.10	**0.13**
Mo	Np	17	< 1.0	--	<5.0	**5.0**	95	<5.0	--	<5.0	**5.0**	45	<1.0	--	<5.0	**<5.0**	53	<1.0	--	1.0	**1.4**	210	<0.20	5.0	<1.0	--	<5.0	**5.0**
Ni	V	49	7.8	1.987	15.5	**30.0**	201	4.9	1.968	9.6	**18.5**	128	3.3	2.862	9.4	**25.9**	78	9.3	6.8	16.1	**22.9**	456	<0.08	39.9	4.8	2.469	11.9	**28.2**
Se	Np	109	<0.40	--	0.6	**3.9**	336	<0.35	--	0.54	**1.1**	175	<0.40	--	<0.50	**1.0**	74	<0.20	--	0.47	**0.91**	694	<0.05	4.4	<0.34	--	0.53	**1.2**
Ag	Np	92	<0.20	--	<0.89	**1.2**	296	<0.21	--	<0.50	**<2.0**	185	<0.15	--	<0.50	**0.79**	78	<0.10	--	0.19	**0.50**	651	<0.01	2.0	<0.18	--	<0.50	**1.1**
Na	V	17	<88	--	316	**487**	103	52.6	3.364	177	**567**	40	68.3	41.0	109	**150**	24	43.7	1.750	76.5	**131**	184	<1.9	680	50.9	2.978	152	**432**
Sr	Np	4	28	--	93	**141**	31	28	--	77	**150**	9	4.9	--	70	**94**	15	10	--	16	**72**	59	1.3	150	12.3	--	70	**150**
Tl	Np	39	<0.50	--	<2.7	**3.2**	127	<1.0	--	<1.0	**2.0**	63	<0.50	--	<1.0	**1.7**	58	<0.50	--	0.50	**1.2**	287	<0.02	6.1	<0.50	--	<1.0	**2.8**
Ti	N	4	150	45.5	196	**239**	58	115	40.3	155	**194**	12	111	54.8	166	**218**	0	--	--	--	**--**	74	13	250	117	43.3	160	**202**
V	L	39	9.7	2.020	19.6	**38.5**	145	7.6	2.245	17.1	**37.1**	77	5.2	2.305	12.0	**26.7**	59	15.8	2.251	35.6	**77.5**	320	<0.05	100	8.2	2.412	19.8	**46.1**
Zn	L	115	23.7	1.928	45.7	**85.8**	391	11.3	2.602	29.4	**73.6**	200	9.3	2.509	23.3	**56.4**	91	15.8	2.177	34.4	**72.6**	797	<0.50	95	12.4	2.558	31.7	**78.1**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg).

Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x+ (1.96)SD	97.5^{th} quantile

TABLE 3

SAND SAMPLING LOCATIONS
Michigan Background Soil Survey 2005
(updated 2015)



Office of Waste Management and Radiological Protection
Hazardous Waste Section
Permit & Corrective Action Unit

FIGURE 3

CLAY

	Dist.	Glacial Lobe Area																				Statewide						
		HURON - ERIE					SAGINAW					MICHIGAN					SUPERIOR					CLAY – Combined Statewide Data						
		n	x	SD	1 SD	2 SD	n	x	SD	1 SD	2 SD	n	x	SD	1 SD	2 SD	n	x	SD	1 SD	2 SD	n	min	max	x	SD	1 SD	2 SD
Al	L	56	7445	1.615	12024	**19049**	62	6994	1.451	10148	**14508**	3	10430	1.577	16448	**25470**	3	9490	1.131	10733	**12080**	124	1240	19000	7318	1.530	11197	**16842**
Sb	Np	42	<0.52	--	11.3	**13**	33	<0.03	--	<0.5	**1.0**	3	<0.50	--	<3.6	**<50**	0	--	--	--	**--**	78	<0.04	14.4	<0.40	--	2.2	**13.0**
As	L	237	6.9	2.166	14.9	**31.4**	354	3.7	2.182	8.1	**17.1**	29	2.8	1.783	5.0	**8.7**	10	3.2	1.829	5.9	**10.4**	630	<0.20	88	4.6	2.298	10.6	**23.5**
Ba	L	166	64.4	1.903	123	**227**	171	37.6	2.334	87.8	**198**	25	30.5	1.905	58.1	**108**	4	51.8	3.338	173	**550**	366	<2.5	291	47.5	2.229	106	**229**
Be	V	35	0.48	1.744	0.84	**1.43**	42	0.26	2.608	0.68	**1.70**	5	<0.50	--	1.0	**1.0**	6	<1.0	--	2.2	**2.9**	88	<0.09	3.9	0.36	2.348	0.84	**1.9**
Cd	Np	196	<1.1	--	2.0	**3.1**	240	<0.50	--	2.0	**2.4**	25	<0.13	--	0.21	**2**	4	<1.0	--	<1.0	**<1.0**	465	<0.04	4.7	<0.66	--	2.0	**2.5**
Cr	L	139	16.9	2.168	36.6	**77.0**	141	11.5	1.971	22.7	**43.5**	8	11.0	2.608	28.7	**72.0**	9	29.4	1.543	45.4	**68.8**	297	<0.25	70	14.1	2.138	30.1	**62.5**
Co	CL	98	10.1	1.665	16.8	**27.4**	167	9.4	2.126	20.0	**41.2**	30	7.8	1.904	14.9	**27.6**	19	6.5	2.444	15.9	**37.5**	298	<0.20	85.1	9.3	2.019	18.8	**36.9**
Cu	L	192	14.2	1.840	26.1	**46.9**	232	11.1	1.722	19.1	**32.2**	29	7.9	1.760	13.9	**23.9**	10	19.4	2.066	40.1	**80.4**	463	<0.56	130	12.2	1.825	22.3	**39.7**
Fe	L	59	18110	1.438	26042	**36908**	52	11920	1.814	21623	**38301**	5	10620	1.701	18065	**30082**	3	10970	1.119	12275	**13674**	119	2100	32000	14560	1.690	24606	**40721**
Pb	CL	196	8.6	1.767	15.2	**26.2**	267	8.2	2.327	19.1	**42.9**	29	5.1	1.745	8.9	**15.2**	11	6.2	2.387	14.8	**34.1**	503	<0.86	32	8.1	2.097	17.0	**34.6**
Li	L	32	19.3	1.458	28.1	**40.4**	25	13.5	1.719	23.2	**39.0**	4	13.0	--	16.5	**16.9**	9	14.4	1.596	23.0	**36.0**	70	<3.5	77	15.9	1.611	25.6	**40.5**
Mg	L	20	11760	2.883	33904	**93692**	15	16700	3.269	54592	**170203**	1	24000	--	--	**--**	0	--	--	--	**--**	36	895	140000	13880	3.002	41668	**119706**
Mn	L	53	321	1.725	554	**935**	65	267	1.588	424	**661**	6	243	1.593	387	**605**	9	335	1.517	508	**758**	133	67	1200	290	1.648	478	**772**
Hg	Np	168	<0.06	--	<0.11	**0.58**	164	<0.07	--	<0.10	**0.5**	20	<0.05	--	0.10	**0.70**	10	0.11	--	0.55	**0.61**	362	<0.01	1.2	<0.06	--	<0.10	**0.57**
Mo	Np	14	<2.5	--	4.9	**5.0**	27	<1.0	--	<5.0	**5.0**	4	<3.0	--	<3.0	**<3.0**	6	<3.0	--	<3.0	**<3.0**	51	<0.22	5.0	<2.2	--	<5	**5.0**
Ni	V	140	23.0	10.2	33.2	**43.4**	126	18.9	8.7	27.6	**36.0**	9	10.8	2.001	21.6	**42.1**	9	18.0	6.3	24.3	**30.6**	284	<0.56	53	20.7	9.7	30.4	**40.1**
Se	V	189	<0.50	--	1.0	**1.2**	169	<0.50	--	0.60	**1.1**	27	<0.2	--	0.48	**1.5**	10	0.45	0.11	0.56	**0.67**	395	<0.05	2.4	<0.50	--	0.70	**1.2**
Ag	Np	139	<0.50	--	1.2	**6.0**	148	<0.20	--	<0.50	**1.0**	23	<0.10	--	<0.31	**0.50**	1	<0.5	--	--	**--**	311	<0.02	6.2	<0.25	--	<0.90	**2.8**
Na	V	10	114	240	354	**594**	14	186	1.382	257	**351**	1	--	--	--	**--**	0	--	--	--	**--**	25	<4.5	477	178	129	307	**436**
Sr	Np	6	102	--	150	**150**	1	100	--	--	**--**	2	110	--	--	**--**	6	100	--	150	**150**	15	53	150	100	--	150	**150**
Tl	Np	39	<0.56	--	1.1	**1.7**	33	<1.5	--	<1.5	**<1.5**	3	<0.50	--	<0.50	**<0.50**	0	--	--	--	**--**	75	<0.09	1.8	<0.50	--	<1.0	**1.6**
Ti	N	1	100	--	--	**--**	8	123	67.3	190	**255**	0	--	--	--	**--**	0	--	--	--	**--**	9	42	210	120	63.4	183	**244**
V	L	28	22.9	2.068	47.4	**95.1**	33	16.4	1.742	28.6	**48.7**	5	19.0	2.455	46.6	**110**	6	57.7	1.509	87.1	**129**	72	<4.3	150	21.0	2.050	43.1	**85.8**
Zn	L	218	43.9	1.537	67.5	**102**	212	27.8	1.841	51.2	**91.9**	29	24.0	1.705	40.9	**68.3**	10	26.8	2.819	75.5	**204**	469	<1.5	140	34.0	1.805	61.4	**108**

Data in mg/kg
Dist. = Distribution of data (CL – Censored Lognormal, L-Lognormal, Np- Nonparametric, N- Normal, V-various).
n = number of samples.
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SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
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Data Range	Lognormal Distribution	Normal Distribution	Nonparametric equivalent
1 SD	(x)(SD)	x + (1)SD	84th quantile
2 SD	(x)(SD)$^{1.96}$	x+ (1.96)SD	97.5th quantile

TABLE 4

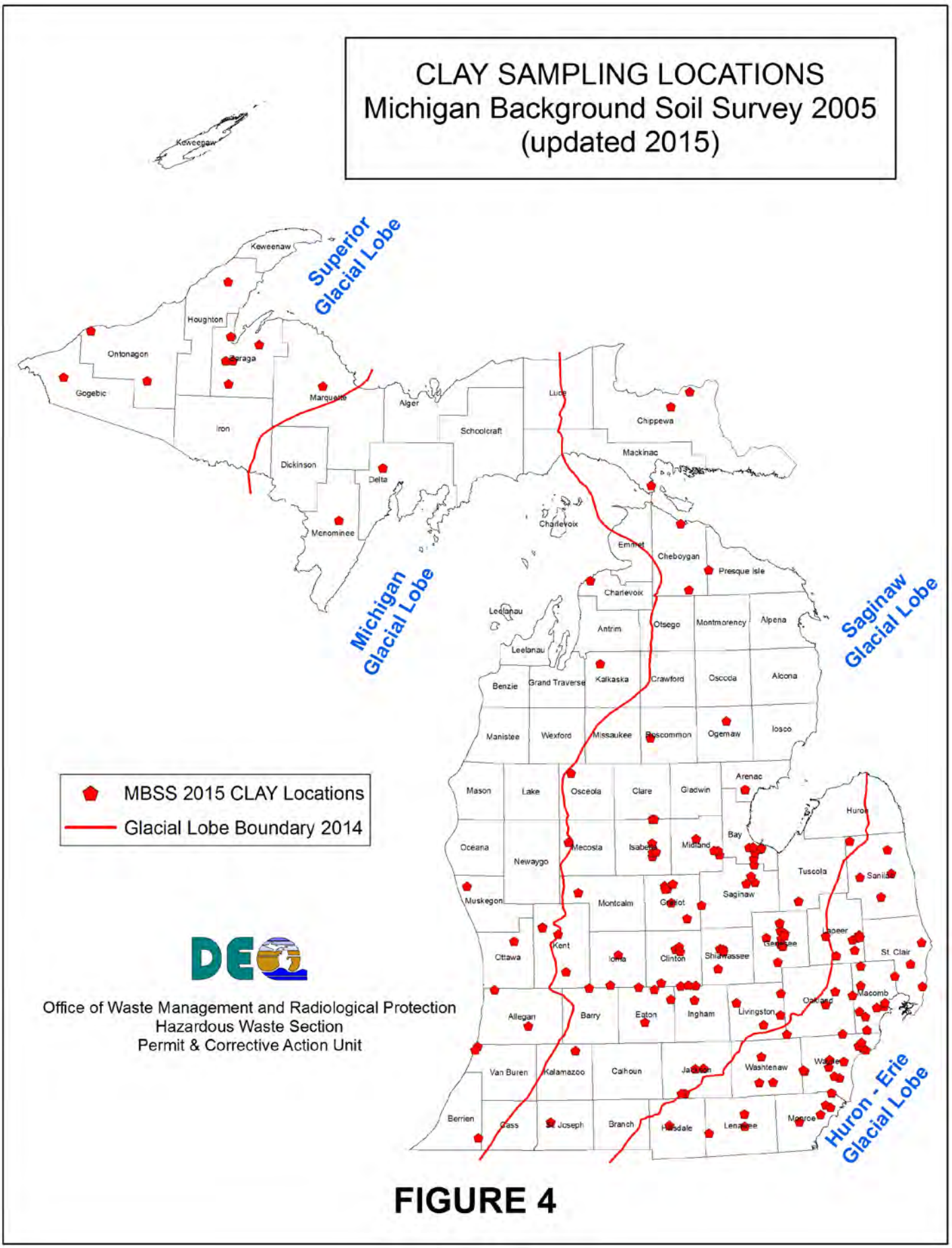
CLAY SAMPLING LOCATIONS
Michigan Background Soil Survey 2005
(updated 2015)
Keweenaw
Houghton
Ontonagon
Baraga
Gogebic
Marquette
Alger
Luce
Chippewa
Iron
Schoolcraft
Mackinac
Dickinson
Delta
Menominee
Charlevoix
Emmet
Cheboygan
Presque Isle
Leelanau
Antrim
Otsego
Montmorency
Alpena
Benzie
Grand Traverse
Kalkaska
Crawford
Oscoda
Alcona
Manistee
Wexford
Missaukee
Roscommon
Ogemaw
Iosco
Mason
Lake
Osceola
Clare
Gladwin
Arenac
Huron
Oceana
Newaygo
Mecosta
Isabella
Midland
Bay
Tuscola
Sanilac
Muskegon
Montcalm
Gratiot
Saginaw
Lapeer
Ottawa
Kent
Ionia
Clinton
Shiawassee
Genesee
St. Clair
Allegan
Barry
Eaton
Ingham
Livingston
Oakland
Macomb
Van Buren
Kalamazoo
Calhoun
Jackson
Washtenaw
Wayne
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
Monroe
Superior Glacial Lobe
Michigan Glacial Lobe
Saginaw Glacial Lobe
Huron - Erie Glacial Lobe
MBSS 2015 CLAY Locations
Glacial Lobe Boundary 2014
DEQ
Office of Waste Management and Radiological Protection
Hazardous Waste Section
Permit & Corrective Action Unit

FIGURE 4

References

(1) Background soil data:

a) The RRD Soil Background Technical Assistance Program Support (TAPS) Team was formed, that includes technical staff with backgrounds in geology, environmental engineering, quality assurance, soil science, chemistry and statistics, including a representative from each of DEQ's District offices. The TAPS Team developed the data collection Data Quality Objective (DQO). This team compiled and analyzed the new data to ensure that it met the data quality objectives specified. This TAPS team will work with stakeholders to ensure that the process is transparent and the results are technically sound.

b) Data was collected, organized, scanned and data entered into spreadsheets by Zachary Spots (student intern from Western Michigan University) and RRD staff in Lansing and the District offices.

c) A Data Quality Objective (DQO) dated September 20, 2013 was developed to describe how to collect new data and accept as valid natural background. Data collection followed this DQO.

(2) Glacial Lobe Boundaries:

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