

**Metals**  
**in**  
**Pennsylvania Soils**

**by**

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Mary Kay Amistadi,  
and  
Nelson C. Thurman**

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## **INTRODUCTION**

The content of metals in soils has been studied for many years. The objective of early studies was to characterize and investigate the genesis of soils. Recent interest in metals in soils revolves around the ability of soils to supply certain elements to plants and the potential toxic effect of these elements on humans and animals (Risser and Baker, 1990). In addition, many of these elements are pollutants that have or could be added to soils in the form of sewage sludge or other materials. Baseline data on the naturally-occurring levels of metals in soils is needed to provide a better understanding of the interactions of these metals in soils. In Pennsylvania, this type of baseline data is not available. Because of this shortcoming, a study was initiated to characterize the metal content of an array of Pennsylvania soils developed from a number of parent materials.

## **MATERIALS AND METHODS**

Two hundred and ten (210) samples representing 67 soil profiles were selected from the Penn State University Soil Characterization Laboratory library of soil samples (Ciolkosz and Thurman, 1993). These samples were collected and analyzed for basic soil characteristics and properties over a number of years as a part of an inventory of Pennsylvania's soil resources. A surface horizon (A) and two or three subsoil horizons (B or C) were selected from each profile (Table 1).

The U.S. EPA Acid Digestion of Sediments, Sludges, and Soils Method 3050 was used to analyze the soils (USEPA, 1986). The Pennsylvania Department of Environment Resources recommends this method for sludge and soil analysis in their Municipal Waste Management program (PADER, 1988). Additional information on sludges is given in NERRP (1985). With this method, the fine earth (< 2 mm) soil sample material is digested in nitric acid, hydrogen peroxide, and hydrochloric acid, and the extract is analyzed by atomic absorption

spectroscopy.

The following elements were analyzed according to Method 3050: Aluminum (Al), Cadmium (Cd), Calcium (Ca), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Magnesium (Mg), Manganese (Mn), Nickel (Ni), Potassium (K), Sodium (Na), Zinc (Zn). Total Phosphorous (P) was determined on the sample extracts using the vanadomolybdate method of Olsen and Sommers (1982). Additional soil characterization data obtained as a part of the Pennsylvania State University Soil Characterization program (Ciolkosz and Thurman, 1993; Thurman et al., 1992) includes pH (1:1 soil to water); percentages of sand, silt, and clay (pipette method); and percent Fe<sub>2</sub>O<sub>3</sub> (Citrate-Bicarbonate-Dithionite, CBD, method). Many of these samples have also been used in a study on the amorphous material in Pennsylvania soils (Ciolkosz et al., 1989). Additional data on metals in Pennsylvania soils are provided in studies by Ciolkosz et al (1993a, 1993b).

## RESULTS AND DISCUSSION

The data for Fe, Al, Mn, Ca, Mg, Na, and K are given in Table 1, and the data for Cu, Zn, Ni, Pb, Cd, Cr, and P are given in Table 2. Table 3 summarizes the median, minimum, and maximum values of each element for the surface and subsurface horizons by parent material origin. This study does not provide a representative sampling of all soils in Pennsylvania and does not lend itself to extrapolating baseline data in all cases. For instance, while baseline estimates of elemental extractions for soils forming from limestone residuum may be possible, such estimates may not be reliable for soils forming in other parent materials which have fewer samples.

Most of the values for the extracted elements do not follow a normal distribution (Table 3). The data are predominantly skewed toward the low end of the range, with a few high values. This is especially true in the subsurface horizons. The surface horizons show evidence of additions of many of the elements. Mechanisms for additions probably include application by humans (as in the case of agricultural activities), atmospheric deposition,

biocycling, or a combination of processes. Some general differences in parent materials are evident. Specific trends are noted in the discussion that follows.

An examination of the data shows, with some exceptions, the following trends:

1. Iron (Fe): The nitric acid-hydrogen peroxide-hydrochloric acid method extracts more Fe than the CBD method. The content of extracted Fe is greatest in the subsurface (Bt > Bx > Bw) and least in the surface (A) horizons. The largest quantity of extracted Fe occurs in soils developed from crystalline rock and calcareous shale parent materials. Some limestone-derived soils, particularly those with high clay contents, also had high concentrations. The lowest quantities of extracted Fe occur in soils of glacial till and sandstone parent materials.
2. Aluminum (Al): The extracted Al content is generally high but usually lower than the extracted Fe content. The highest concentrations usually occur in the upper B horizons. The greatest content of extracted Al typically is found in soils derived from crystalline rock and limestone parent materials, and the lowest content usually occurs in sandstone residuum soils.
3. Manganese (Mn): The maximum extracted Mn contents are in the surface (A) horizons; the lowest occur in the the upper B horizons. In some cases, extracted Mn concentrations increase below the B horizon. Poorly drained soils frequently show slightly different trends. The upper B horizons of some limestone and basic crystalline rock soils show high concentrations of Mn. This may be associated with black coatings observed in these soils.
4. Calcium (Ca): The highest contents of extracted Ca occur in soils derived from limestone, red calcareous shale, and basic crystalline parent materials. Soils of acidic parent materials have the lower extracted Ca contents. Surface enrichment of Ca is evident, particularly in the Ap horizons. In soils of calcarous parent materials, the extracted Ca content increases below the B horizon.
5. Magnesium (Mg): The extracted Mg content generally increases with depth in all soils except those forming from crystalline rock parent materials. In these soils, the Mg

content either decreases with depth or reaches a maximum in the upper B horizon. Soils forming in limestone residuum have the greatest extracted Mg content; pre-Wisconsinan till, acid crystalline rock, and sandstone soils have the lowest contents of Mg.

6. Sodium (Na): The greatest concentrations of extracted Na occur in soils derived from basic crystalline rock parent materials. In these soils, the Na content increases with depth. No consistent trend in extracted Na is evident in any of the other soils.
7. Potassium (K): Extracted K content is generally greater in the shale and limestone residuum and colluvial soils and lowest in the crystalline, sandstone, and pre-Wisconsinan till soils. No consistent trend with depth is evident.
8. Phosphorus (P): Total P is typically greatest in the surface (A) horizons and is lowest in the subsurface (generally the Bt horizon).
9. Copper (Cu): The content of extracted Cu generally increases with depth (lowest in the A horizons). Soils forming in basic crystalline rock and red calcareous shale parent materials tend to have the greatest amounts of extracted Cu.
10. Zinc (Zn): Extracted Zn content tends to be greater in soils forming in Wisconsinan till and gray (acid and calcareous) shale parent materials and lower in soils forming in pre-Wisconsinan till, crystalline rock, and sandstone parent materials. No regular trend with depth is evident.
11. Nickel (Ni): The content of extracted Ni generally increases with depth. Soils forming in basic crystalline rock parent materials tend to have the greatest amounts of extracted Ni while soils forming in acid crystalline rock, sandstone, and pre-Wisconsinan till parent materials have the lowest contents.
12. Lead (Pb): The greatest contents of extracted Pb are usually found in the surface horizons (A). Soils forming in limestone and red calcareous shale parent materials generally have greater extracted Pb contents while soils forming in crystalline rock and pre-Wisconsinan till parent materials have lower contents.
13. Cadmium (Cd): The content of extracted Cd tends to be greatest in the surface

horizons (A) and lowest in the B horizons. Soils forming in calcareous parent materials generally have greater extracted Cd contents in the subsurface than soils forming in other parent materials.

14. Chromium (Cr): The B horizons typically have a greater content of extracted Cr than do the A or C horizons. Extracted Cr is generally greater in soils forming in basic crystalline rock parent materials.

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Table 1. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
<u>Grayish-Brown Wisconsinan Glacial Till</u>																
Bath (Well drained)	008-011-01	Ap	0-18	5.5	28.2	56.8	15.0	1.5	1.14	0.80	1.55	495	1120	2450	45.7	717
	008-011-03	Bw2	30-43	5.0	36.6	50.3	13.1	1.6	1.86	1.30	1.95	340	257	3275	57.7	1125
	008-011-06	Bx3	69-107	5.0	40.9	45.6	13.5	1.7	2.43	1.70	1.60	585	355	3600	60.8	1700
Bath (Well drained)	008-099-02	A	0-5	4.3	42.3	46.8	10.9	1.2	2.06	1.44	1.04	407	245	1600	44.2	635
	008-099-05	Bw2	36-51	4.4	38.3	47.3	14.4	1.6	2.17	1.52	1.29	337	3	3075	49.2	868
	008-099-09	Bx4	135-180	5.0	22.3	56.4	21.3	2.0	2.93	2.05	1.35	672	667	3925	62.7	1215
	008-099-12	Bx7	285-361	5.2	36.0	48.8	15.2	1.6	3.00	2.10	1.40	697	705	3950	81.7	1600
Volusia (Somewhat poorly drained)	008-014-01	Ap	0-20	6.9	24.4	53.7	21.9	1.6	1.72	1.20	1.60	695	1560	2525	52.0	1200
	008-014-03	E2	28-36	6.7	24.9	53.8	21.3	1.8	2.00	1.40	1.37	225	462	2825	42.0	940
	008-014-06	Bxg3	74-97	5.0	24.5	48.0	27.5	2.1	2.93	2.05	1.68	615	462	3550	63.5	1375
Chippewa (Very poorly drained)	008-016-01	Ap	0-15	5.6	11.6	63.4	25.0	2.2	2.60	1.82	1.82	1325	1250	2900	89.7	1100
	008-016-03	Eg	30-43	5.5	14.2	60.7	25.1	2.4	3.69	2.58	2.12	893	660	3325	89.5	1200
	008-016-06	Bxg3	94-130	6.3	20.0	69.2	10.8	1.4	2.57	1.80	1.27	772	1147	3700	67.5	725
<u>Red Wisconsinan Glacial Till</u>																
Lackawanna (Well drained)	045-080-01	Ap	0-18	5.3	42.3	45.6	12.1	1.4	2.69	1.88	1.24	132	42	1295	35.2	495
	045-080-03	Bw2	36-51	5.7	44.4	43.9	11.7	1.1	3.03	2.12	1.40	322	80	2725	49.7	777
	045-080-05	Bx1	71-109	5.6	51.7	37.6	10.7	1.3	2.53	1.77	0.90	540	70	2400	38.0	520
Morris (Somewhat poorly drained)	058-003-01	Ap	0-18	5.7	34.1	44.9	21.0	1.7	3.15	2.20	2.52	857	1350	3025	92.5	1900
	058-003-03	BA	28-43	6.0	45.9	42.3	11.8	1.2	3.19	2.23	1.60	787	250	3100	60.3	1525
	058-003-07	Bx4	79-117	6.6	41.5	45.2	13.3	1.2	3.55	2.48	1.50	662	840	3600	78.0	2000
Norwich (Poorly drained)	058-021-01	A	0-20	5.0	18.5	36.7	44.8	3.2	4.86	3.40	3.30	2350	2372	2950	76.0	1675
	058-021-03	Bwg	25-64	5.2	21.1	47.0	31.9	1.4	3.03	2.12	2.30	280	1623	3075	63.2	1250
	058-021-05	2Bxg2	76-91	5.7	22.5	49.8	27.7	1.7	3.75	2.62	1.24	930	1312	3650	48.2	1212

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method.

2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million																	
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K											
<u>Pre-Wisconsinan Glacial Till</u>																											
Allenwood (Well drained)	013-061-01	Ap	0-18	5.7	26.2	56.7	17.1	2.0	1.12	0.78	1.70	227	517	667	56.5	1025											
	013-061-04	Bt2	61-84	5.2	31.2	32.2	36.6	3.9	3.96	2.77	2.58	355	115	340	58.2	1075											
	013-061-07	Bt5	155-190	5.2	45.6	37.9	16.5	2.9	2.25	1.57	0.99	627	32	177	34.5	335											
Watson (Moderately well drained)	055-002-01	Ap	0-23	6.0	26.5	52.5	21.0	2.5	2.97	2.08	1.16	317	720	582	51.7	860											
	055-002-03	Bt2	46-56	4.8	28.6	28.9	42.5	3.8	4.68	3.27	1.70	18	140	472	52.2	730											
	055-002-05	Bx2	89-114	4.5	42.3	30.7	27.0	2.2	2.83	1.98	2.05	15	60	760	85.2	1375											
<u>Acid Grayish-brown Shale and Sandstone Colluvium and Limestone Colluvium</u>																											
Laidig (Well drained)	014-031-03	A	0-8	4.6	34.2	49.7	16.1	1.3	2.43	1.70	1.98	4250	80	1325	44.7	1175											
	014-031-06	Bt2	51-58	4.9	42.8	37.4	19.8	2.9	4.62	3.23	2.60	237	120	2425	49.5	2650											
	014-031-10	Bx1	102-150	4.9	43.3	36.1	20.6	3.1	5.18	3.62	2.73	955	167	3100	68.8	3200											
Murrill (Well drained)	014-088-01	Ap1	0-13	6.1	7.6	69.8	22.6	1.9	3.18	2.23	1.52	1325	1352	1475	48.2	807											
	014-088-04	Bt2	40-55	5.5	6.6	60.7	32.7	3.3	5.36	3.75	2.33	410	1415	2425	71.2	1600											
	014-088-07	Bt5	110-143	4.8	13.7	62.1	24.2	2.7	5.14	3.60	1.57	1225	510	1500	52.2	1210											
	014-088-10	BCt	215-304	5.2	16.6	41.8	41.6	3.5	5.36	3.75	2.00	1090	1952	1115	57.7	1050											
Andover (Poorly drained)	018-013-01	Ap	0-23	6.0	29.6	46.6	23.8	2.3	3.50	2.45	2.08	3975	1385	2100	62.7	1475											
	018-013-03	Bt	36-46	6.1	33.5	42.4	24.1	3.6	4.72	3.30	2.05	257	295	2275	60.5	2000											
	018-013-06	Bxg3	81-97	5.1	41.0	39.5	19.5	3.0	4.58	3.20	2.08	235	42	2300	80.2	2025											
<u>Brown Wisconsinan Loess</u>																											
Duncannon (Well drained)	009-005-01	Ap	0-25	5.4	8.6	74.0	17.4	1.6	2.43	1.70	1.90	843	542	1875	59.5	101											
	009-005-03	Bt1	43-61	6.0	7.9	69.9	22.2	3.0	4.58	3.20	3.05	225	355	3000	111.7	1700											
	009-005-05	BC	86-114	6.2	6.6	83.0	10.4	2.5	3.90	2.73	2.05	365	200	3250	90.2	1400											
Lawrenceville (Moderately well drained)	009-003-01	Ap	0-28	6.3	11.6	73.0	15.4	1.4	2.25	1.57	1.82	665	745	2000	87.2	113											
	009-003-03	Bt2	48-64	6.4	8.6	73.4	18.0	2.0	3.50	2.45	2.25	117	495	2575	82.0	1275											
	009-003-05	Bx2	86-102	5.4	12.0	73.4	14.6	2.6	3.82	2.67	1.62	428	295	2550	78.0	1300											

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
Doylestown (Poorly drained)	009-011-01	Ap	0-18	5.5	4.5	73.7	21.8	2.5	3.72	2.60	2.35	428	785	1950	110.5	1162
	009-011-02	Btg	18-38	5.5	2.9	61.7	35.4	3.1	4.58	3.20	3.60	72	622	2650	124.5	1525
	009-011-04	Bxtg2	46-69	5.2	7.4	76.0	16.6	2.3	4.05	2.83	2.02	435	407	3550	124.7	1525
<u>Residual Acid Sandstone</u>																
Clymer (Well drained)	014-083-03	E	0-8	3.8	68.1	30.3	1.6	0.3	0.53	0.37	0.30	10	80	63	17.2	470
	014-083-07	Bw2	43-71	4.6	59.8	29.8	10.4	1.3	1.50	1.05	0.80	100	3	688	44.7	822
	014-083-09	Bt2	94-122	4.6	54.1	23.9	22.0	2.8	4.43	3.10	0.86	455	8	210	36.2	877
	014-083-11	C1	137-168	4.8	69.3	30.3	0.4	1.2	2.04	1.43	0.88	467	92	55	31.3	870
Hazleton (Well drained)	017-012-02	A	0-5	4.8	26.6	52.3	21.1	2.4	2.43	1.70	1.68	1300	582	1825	82.5	1525
	017-012-05	Bt2	33-61	4.8	37.3	43.4	19.3	2.4	4.36	3.05	2.27	810	275	3675	68.5	1675
	017-012-08	Bt5	104-127	5.0	45.1	41.1	13.8	2.2	3.96	2.77	1.65	1032	315	4350	44.7	1107
Cookport (Moderately well drained)	017-015-02	BA	5-15	4.8	31.1	47.4	21.5	3.0	5.92	4.14	1.57	79	100	1157	40.2	690
	017-015-04	Bt2	25-38	4.9	35.0	44.8	20.2	2.7	2.25	1.58	1.60	106	95	1600	47.5	805
	017-015-07	Bx3	84-119	5.2	35.5	43.7	20.8	2.8	4.22	3.25	0.93	712	162	1387	46.0	770
Cookport (Somewhat poorly drained)	014-082-01	A	0-8	3.4	48.6	41.9	9.5	0.5	0.96	0.67	0.33	262	247	197	45.2	450
	014-082-04	Bw2	41-61	4.6	42.9	42.2	14.9	1.8	2.62	1.83	1.09	79	30	1145	44.2	882
	014-082-07	Bx3	104-132	4.8	67.2	19.1	13.7	2.3	3.28	2.30	0.67	247	57	267	35.0	800
	014-082-10	Bx6	203-243	4.9	70.0	21.1	8.9	1.5	2.33	1.63	0.51	165	110	460	41.5	805
Nolo (Poorly drained)	017-019-02	A	0-10	4.2	27.2	63.2	9.6	0.3	0.50	0.35	1.29	10	240	225	52.5	1005
	017-019-04	Btg	28-36	4.7	37.5	43.2	19.3	3.1	3.64	2.55	1.11	39	55	990	50.0	818
	017-019-06	Bxg2	79-124	5.3	47.3	37.2	15.5	1.8	2.61	1.33	1.83	217	497	712	56.5	537
<u>Residual Acid Gray Shales</u>																
Bedington (Well drained)	006-012-02	A	0-5	4.2	36.0	44.5	19.5	2.0	3.00	2.10	1.95	1825	370	1475	48.0	1105
	006-012-05	Bt2	30-58	4.4	44.0	37.9	18.1	2.9	3.46	2.42	2.25	285	3	2775	46.2	1400
	006-012-08	Bt5	119-150	4.6	43.3	21.7	35.0	4.8	5.08	3.55	2.55	790	40	2525	53.2	2350
	006-012-10	Ct	178-208	.	.	.	.	.	5.43	3.80	2.52	1225	22	3675	53.5	1700

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
Gilpin (Well drained)	032-054-01	Ap	0-23	6.6	41.6	52.5	5.9	1.7	3.86	2.70	2.27	1225	1120	2725	69.0	1245
	032-054-03	Bt	36-58	5.3	27.3	50.1	22.6	2.1	4.29	3.00	2.67	325	190	3725	77.7	1575
	032-054-05	C	66-76	5.0	25.9	53.3	20.8	2.4	4.53	3.17	2.30	220	115	3875	75.0	1625
Rayne (Well drained)	056-002-04	Bt3	66-97	4.8	29.9	29.5	40.6	5.5	6.15	4.30	2.27	125	63	1050	71.7	2075
	056-002-07	C1	168-208	4.8	47.4	28.5	24.1	3.5	4.36	3.05	2.23	645	25	1650	59.5	1525
Wharton (Moderately well drained)	032-053-01	Ap	0-25	6.2	17.3	69.7	13.0	2.7	1.60	1.12	1.90	1750	1550	1875	58.5	835
	032-053-04	Bt2	48-61	4.9	10.3	62.5	27.2	3.8	2.86	2.00	2.52	342	360	3150	74.5	1600
	032-053-06	C	91-137	4.9	21.7	56.7	21.6	3.1	3.36	2.35	2.10	675	155	3425	58.0	1050
Cavode (Somewhat poorly drained)	010-039-01	Ap	0-28	5.3	20.1	52.3	27.6	2.6	3.90	2.73	1.37	957	755	852	54.2	920
	010-039-04	Btg2	53-69	4.9	3.6	40.1	56.3	3.1	4.64	3.25	1.43	20	455	770	83.5	1475
	010-039-07	2Btg5	104-130	4.8	30.9	46.1	23.0	2.3	5.04	3.53	1.62	770	428	1775	75.5	1800
Cavode (Somewhat poorly drained)	032-059-01	Ap	0-28	5.2	22.8	61.5	15.7	2.3	2.72	1.90	2.17	2075	530	1270	69.0	1825
	032-059-03	Bt1	41-53	4.9	12.4	48.4	39.2	2.7	4.10	2.87	3.25	160	500	2725	89.2	2750
	032-059-06	Cg	119-145	4.9	28.3	50.6	21.1	1.5	2.83	1.98	1.45	255	105	2700	66.0	2500
<u>Residual Calcareous Red Shales</u>																
Upshur (Well drained)	002-023-01	Ap	0-20	4.8	13.6	66.2	20.2	3.4	5.61	3.93	1.80	1450	927	1925	110.0	2700
	002-023-03	Bt2	41-64	4.5	0.9	32.2	66.9	3.6	5.83	4.08	2.33	35	1517	2575	113.5	2750
	002-023-07	C1	117-142	6.1	2.2	66.4	31.4	5.5	7.93	5.55	1.50	180	6375	3100	147.5	2800
Vandergrift (Moderately well drained)	004-001-01	Ap	0-18	5.0	9.2	60.9	29.9	1.9	1.79	1.25	1.37	1775	900	1192	67.7	1475
	004-001-04	Bt3	41-58	5.1	3.3	27.9	68.8	2.7	5.86	4.10	2.00	44	1867	1525	127.5	2600
	004-001-08	C1	147-180	8.2	3.1	63.9	33.0	1.7	2.72	1.90	1.39	170	4795	2500	115.3	2100

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
<u>Residual Calcareous Gray Shales</u>																
Westmoreland (Well drained)	063-043-01	Ap	0-25	7.1	12.8	71.6	15.6	2.4	3.25	2.27	1.57	2400	1873	2350	55.7	1070
	063-043-04	Bt2	53-74	4.6	21.0	48.6	30.4	3.4	5.93	4.15	2.05	1275	367	2925	53.7	2025
	063-043-07	C	127-147	4.7	41.5	46.5	12.0	2.5	4.98	3.48	1.73	675	577	4425	80.2	2350
Dormont (Moderately well drained)	002-007-02	Ap	0-18	4.7	9.7	68.6	21.7	3.1	4.32	3.02	1.43	2125	252	1377	56.3	1325
	002-007-05	Bt2	38-48	5.3	11.5	59.2	29.3	4.5	5.08	3.55	1.50	557	855	2075	60.8	1400
	002-007-08	Bw1	79-102	4.8	29.5	51.1	19.4	3.3	3.96	2.77	1.27	620	420	3075	51.5	1375
Library (Somewhat poorly drained)	063-045-01	Ap	0-25	5.7	9.1	68.8	22.1	2.6	4.18	2.92	1.31	1295	1637	1775	64.2	1475
	063-045-04	Btg1	48-61	6.0	9.0	58.3	32.7	3.7	4.48	3.13	1.85	850	1570	2075	84.7	1625
	063-045-08	C1	124-132	6.8	5.0	39.5	55.5	2.1	2.76	1.93	1.35	1295	2805	1925	109.5	1900
<u>Residual Limestones</u>																
Duffield (Well drained)	014-074-01	A	0-18	5.3	6.8	75.9	17.3	1.2	2.22	1.55	1.31	2575	1567	1532	36.2	1475
	014-074-05	Bt2	71-94	4.9	3.5	57.2	39.3	3.3	4.29	3.00	2.89	547	470	6275	46.7	2950
	014-074-11	3C1	193-211	5.3	8.7	51.8	39.5	3.6	4.86	3.40	2.75	627	267	7125	57.0	3625
Duffield (Well drained)	036-017-01	Ap	0-18	5.8	11.7	69.9	18.4	2.0	2.29	1.60	1.11	1370	925	1600	35.7	660
	036-017-03	Bt1	30-56	6.4	10.9	54.7	34.4	4.7	4.82	3.37	1.35	395	620	1022	31.7	610
	036-017-06	C	102-132	6.6	31.1	40.1	28.8	1.6	4.36	3.05	2.23	237	852	4450	41.0	1600
Hagerstown (Well drained)	014-005-01	Ap	0-23	5.7	6.0	70.0	24.0	3.2	3.43	2.40	1.11	1137	900	1807	32.2	1342
	014-005-04	Bt3	66-79	4.9	1.7	32.5	65.8	5.1	5.29	3.70	1.95	642	1392	3075	45.0	2375
	014-005-07	C	135-173	7.5	8.7	53.1	38.2	3.7	3.96	2.77	1.74	567	34450	11425	80.0	2650
Hagerstown (Well drained)	014-007-01	Ap	0-25	6.1	16.5	72.2	11.3	3.0	2.53	1.77	1.17	1625	1915	1277	38.7	940
	014-007-05	Bt2	79-109	4.8	2.2	36.0	61.8	4.7	4.40	3.08	2.21	415	722	1510	46.2	2375
	014-007-07	BC1	142-183	5.2	1.9	29.5	68.6	3.4	4.68	3.27	2.44	435	767	1785	49.7	1950
Hagerstown (Well drained)	014-014-01	Ap	0-30	6.7	1.5	87.2	11.3	1.8	2.22	1.55	1.19	1500	1495	1252	48.0	772
	014-014-04	Bt1	51-76	6.9	0.8	46.2	53.0	4.3	5.22	3.65	2.21	740	4875	1347	56.7	1342
	014-014-05	Bt2	76-102	7.5	1.0	41.6	57.4	3.9	4.86	3.40	2.47	640	9225	1640	73.0	1250

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth		Percent										Parts Per Million						
			in cm	pH	Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K					
Hagerstown (Well drained)	014-066-01	A	0-8	5.5	4.7	77.2	18.1	1.5	4.48	3.13	0.78	430	220	441	38.0	1007					
	014-066-05	Bt2	53-76	4.8	5.4	44.4	50.2	4.4	4.58	3.20	2.38	620	2950	1842	39.5	1325					
	014-066-08	3C	112-178	7.5	3.3	65.2	31.5	3.6	5.25	3.67	2.94	672	30525	18475	82.0	2200					
Hagerstown (Well drained)	014-067-01	A	0-10	5.4	3.4	79.1	17.5	1.5	2.54	1.78	1.10	1825	3675	2300	43.0	1045					
	014-067-05	Bt2	53-76	4.8	2.9	40.7	56.4	4.5	6.40	4.48	3.68	275	1277	8175	61.5	5225					
	014-067-08	3C2	137-155	7.9	9.0	56.0	35.0	1.6	2.61	1.83	0.95	177	132775	78600	195.0	1200					
Hagerstown (Well drained)	014-068-01	A	0-8	5.8	8.1	75.3	16.6	1.2	1.64	1.15	0.85	2350	5350	6025	44.5	1110					
	014-068-05	Bt2	61-84	5.8	20.2	45.9	33.9	2.3	2.69	1.88	3.20	242	870	28050	63.2	8450					
	014-068-08	3Cr1	140-160	6.6	19.2	51.4	29.4	2.2	2.47	1.73	3.01	192	2267	33500	89.2	7675					
Hagerstown (Well drained)	014-069-01	A	0-10	5.8	4.5	75.2	20.3	1.5	1.57	1.10	1.24	2475	3600	1962	45.7	1200					
	014-069-05	Bt2	53-69	5.1	3.5	38.6	57.9	4.4	5.76	4.03	3.49	325	1002	6100	64.2	4000					
	014-069-08	3C	99-147	8.0	5.4	57.2	37.4	2.0	2.97	2.08	1.32	225	117525	62225	150.0	1775					
Hagerstown (Well drained)	014-070-01	A	0-8	5.3	10.8	73.9	15.3	1.0	2.65	1.85	1.25	3075	7125	2825	97.0	693					
	014-070-06	3Bt3	66-89	5.3	7.4	51.0	41.6	3.2	4.68	3.27	2.97	335	695	3425	49.7	2025					
	014-070-09	3Bt6	160-183	5.7	1.7	43.9	54.4	3.8	5.08	3.55	4.18	367	977	9800	63.0	4125					
Hagerstown (Well drained)	014-071-01	A	0-8	5.0	9.2	73.4	17.4	1.4	2.47	1.73	1.22	2650	625	1110	51.2	772					
	014-071-05	Bt2	61-86	5.3	2.7	41.0	56.3	4.4	5.89	4.12	3.15	305	537	3375	40.2	232					
	014-071-07	3C	112-142	6.9	3.2	50.1	46.7	4.4	5.36	3.75	2.73	387	3700	6575	68.0	2650					
Hagerstown (Well drained)	014-072-01	A	0-8	5.4	9.4	74.6	16.0	1.2	2.29	1.60	1.26	3125	1748	1302	39.2	655					
	014-072-05	Bt2	46-79	5.1	2.9	54.2	42.9	3.1	3.65	2.55	2.44	300	503	3750	38.0	1825					
	014-072-09	3BC	145-157	6.9	2.5	77.0	20.5	3.6	4.18	2.92	3.56	327	2467	13725	107.5	5125					
Hagerstown (Well drained)	014-073-01	A	0-8	5.4	9.8	73.8	16.4	1.2	2.12	1.48	1.37	2900	1180	21700	78.5	877					
	014-073-05	Bt2	61-86	5.6	10.4	48.3	41.3	2.9	3.43	2.40	2.62	295	397	13275	42.7	3200					
	014-073-08	3C1	140-165	6.6	18.3	45.1	36.6	3.8	4.36	3.05	2.19	385	1692	5975	56.7	1750					
Hagerstown (Well drained)	014-075-01	A	0-10	6.6	10.3	73.2	16.5	1.2	3.07	2.15	1.25	3475	2700	1365	33.7	970					
	014-075-05	3Bt2	61-86	5.4	3.8	38.4	57.8	4.1	4.76	3.33	3.37	340	820	6500	40.0	3100					
	014-075-08	3Bt5	150-160	7.5	4.3	42.6	53.1	3.8	4.26	2.98	3.15	247	3000	10725	43.8	2925					

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Depth		Percent							Parts Per Million						
		Horizon	in cm	Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K		
			pH														
Hagerstown (Well drained)	014-080-01	A	0-8	4.9	19.2	73.4	7.4	1.5	2.72	1.90	1.32	5150	2023	1177	32.7	672	
	014-080-05	Bt2	61-89	4.6	9.1	26.3	64.6	5.5	5.58	3.90	2.66	470	630	1165	36.2	1475	
	014-080-09	BC	183-254	4.9	4.1	45.5	50.4	4.2	3.86	2.70	1.53	295	370	1045	34.5	5100	
Hagerstown (Well drained)	018-009-01	Ap	0-18	6.2	15.8	62.5	21.7	3.1	3.25	2.27	1.15	932	1095	1102	39.7	732	
	018-009-04	Bt3	38-53	6.0	4.9	19.2	75.9	8.4	7.82	5.47	4.01	197	1510	2102	56.7	1925	
	018-009-06	BC	71-81	6.2	9.1	29.3	61.6	6.3	7.94	5.55	3.30	457	1767	2215	52.0	1750	
Hagerstown (Well drained)	018-010-01	Ap	0-15	6.0	19.3	64.1	16.6	2.1	2.60	1.82	1.34	1037	692	732	28.0	667	
	018-010-05	Bt2	53-71	5.3	11.8	56.0	32.2	2.7	3.60	2.52	1.39	365	428	827	32.2	652	
	018-010-08	BC2	112-137	5.2	6.6	40.8	52.6	4.8	4.86	3.40	1.61	135	410	685	30.7	755	
Hagerstown (Well drained)	022-006-01	Ap	0-23	6.5	21.6	62.2	16.2	3.2	3.55	2.48	1.82	1800	1890	1892	55.5	1085	
	022-006-05	Bt3	74-89	7.0	9.5	14.3	76.2	4.2	7.65	5.35	3.13	790	1750	1482	67.7	1075	
	022-006-08	BC	147-152	6.7	2.8	19.2	78.0	5.0	7.55	5.28	3.61	855	2335	5475	74.5	1975	
Hagerstown (Well drained)	022-007-01	Ap	0-18	6.6	15.3	65.3	19.4	2.6	3.60	2.52	1.89	1277	1810	1975	42.7	840	
	022-007-05	Bt3	64-71	6.8	26.9	42.3	30.8	4.8	5.69	3.98	2.36	1575	1022	1375	41.7	1025	
	022-007-09	BC	142-163	6.2	6.9	33.3	59.8	5.5	6.86	4.80	3.77	557	1067	4875	62.0	2350	
Hagerstown (Well drained)	036-014-01	Ap	0-20	7.0	14.2	63.2	22.6	2.5	3.29	2.30	1.91	1187	1882	1540	41.7	955	
	036-014-04	Bt2	56-84	5.5	6.7	35.3	58.0	.	5.15	3.60	2.22	240	1662	895	43.2	690	
	036-014-08	Bt6	163-190	4.9	8.3	59.4	32.3	.	3.46	2.42	2.16	637	330	962	32.0	705	
Hagerstown (Well drained)	036-015-01	Ap	0-18	6.0	12.9	68.5	18.6	2.0	3.04	2.13	1.73	1222	962	1425	38.5	697	
	036-015-04	Bt2	58-84	6.8	9.7	31.2	59.1	4.5	7.07	4.95	3.41	217	1827	1112	52.7	972	
	036-015-07	BCt2	157-203	5.1	18.0	32.1	49.9	4.2	7.00	4.90	2.59	220	807	970	37.7	960	
Hagerstown (Well drained)	036-019-01	Ap	0-25	6.0	11.2	64.3	24.5	3.2	5.48	3.83	1.69	1082	745	1252	34.7	922	
	036-019-04	Bt3	71-86	5.3	7.6	43.6	48.8	4.7	7.58	5.30	2.64	395	627	1257	34.7	797	
	036-019-07	C1	142-168	5.1	9.0	47.7	43.3		6.79	4.75	2.06	340	210	1217	30.2	655	
Clarksburg (Moderately well drained)	014-081-01	A	0-8	5.0	12.2	69.8	18.0	1.7	2.47	1.73	1.24	3925	1087	1475	49.7	835	
	014-081-04	Bt	36-69	4.6	9.1	64.6	26.3	3.1	4.71	3.30	1.65	447	492	2825	63.2	1375	
	014-081-06	Bx2	104-140	5.0	23.5	57.5	19.0	2.7	4.97	3.48	1.45	685	665	2525	60.5	1775	
014-081-10	2C3	223-259	4.7	20.8	44.0	35.2	2.8	4.29	3.00	1.75	877	467	1750	60.0	2375		

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).



Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
<u>Residual Acid Crystalline Rocks</u>																
Chester (Well drained)	036-049-01	A	0-8	4.1	41.0	41.6	17.4	2.8	3.07	2.15	1.10	55	372	542	49.7	647
	036-049-04	Bw1	36-56	4.5	47.2	33.7	19.1	4.0	5.48	3.83	2.15	61	117	905	31.3	712
	036-049-08	3C2	135-152	5.4	79.2	18.4	2.4	3.9	5.53	3.87	0.63	128	110	28	18.2	330
	036-049-12	3C3	244-386	5.4	75.3	22.3	2.4	3.6	4.72	3.30	0.40	94	112	25	23.2	480
Chester (Well drained)	036-052-01	A	0-8	4.5	26.2	54.5	19.3	2.9	3.57	2.50	2.35	745	38	680	68.0	680
	036-052-04	Bt1	33-48	5.0	27.7	41.4	30.9	6.1	6.48	4.53	3.40	84	20	975	63.2	1050
	036-052-07	2Bt4	97-119	5.8	52.6	21.1	26.3	6.5	8.62	6.03	4.67	31	13	262	45.5	445
	036-052-08	2Bt5	119-160	5.8	49.9	23.8	26.3	6.0	8.18	5.72	4.78	40	742	487	58.7	475
Chester (Well drained)	067-008-01	Ap	0-20	5.1	31.6	46.0	22.4	4.0	5.15	3.60	2.52	1202	1052	1040	57.0	777
	067-008-04	Bt2	53-66	6.9	37.6	30.8	31.6	5.7	7.55	5.28	3.90	440	1207	927	69.0	890
	067-008-06	C	171-86	6.1	53.8	16.5	29.7	6.2	8.29	5.80	3.87	802	592	557	50.7	570
Chester (Well drained)	036-050-01	A	0-5	4.8	32.7	50.8	16.5	2.4	3.25	2.27	1.82	725	390	955	41.0	607
	036-050-04	Bt	30-66	5.2	38.1	40.1	21.8	3.9	5.51	3.85	2.48	188	125	1290	40.0	977
	036-050-08	3Bt	157-203	5.7	41.4	29.1	29.5	4.8	6.26	4.38	3.50	95	22	672	43.0	797
	036-050-14	9C	328-338	5.6	43.6	22.2	34.2	5.9	7.91	5.53	3.77	205	5	720	63.2	1002
Glenelg (Well drained)	006-011-02	A	0-12	4.3	45.3	35.5	19.2	2.3	3.54	2.48	2.40	1142	335	852	49.7	375
	006-011-05	Bt2	46-66	4.4	48.4	31.0	20.6	2.8	5.90	4.13	4.20	130	208	1230	55.2	780
	006-011-08	C1	124-160	4.6	69.1	19.6	11.3	1.9	4.26	2.98	3.35	242	82	445	43.2	592
	006-011-11	C4	246-322	4.3	60.2	31.8	8.0	3.2	5.83	4.08	2.45	352	5	1340	56.0	1070
Glenelg (Well drained)	036-027-01	Ap	0-25	7.3	51.6	34.2	14.2	2.3	3.03	2.12	1.01	685	737	882	32.0	685
	036-027-02	Bt1	25-48	7.3	35.1	41.0	23.9	3.9	4.26	2.98	1.77	277	1265	1192	39.7	922
	036-027-05	C1	84-107	7.1	61.0	35.3	3.7	4.76	3.33	0.50	397	20	630	24.0	185	
Manor (Well drained)	036-028-01	Ap	10-13	6.9	38.1	45.4	16.5	2.9	4.15	2.90	1.88	805	1255	2625	53.0	930
	036-028-03	Bw	25-51	6.5	46.5	41.4	12.1	2.5	4.29	3.00	1.35	547	297	2375	27.0	405
	036-028-06	C1	84-94	7.2	59.7	36.0	4.3	2.0	2.97	2.08	0.67	1032	52	1875	23.5	117

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 1. Cont. Selected soil characterization data and major elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Fe <sub>2</sub> O <sub>3</sub> <sup>1</sup>	Fe <sub>2</sub> O <sub>3</sub> <sup>2</sup>	Fe	Al	Mn	Ca	Mg	Na	K
<u>Residual Basic Crystalline Rocks</u>																
Neshaminy (Well drained)	009-051-01	Ap	0-18	6.6	20.2	57.4	22.4	5.3	6.84	4.78	4.22	1357	1462	2175	101.0	557
	009-051-03	Bt2	33-58	6.6	29.0	37.2	33.8	7.7	11.40	7.97	6.62	1220	1492	1900	120.0	552
	009-051-05	C	91-163	6.6	50.6	21.4	28.0	6.0	6.58	4.60	6.95	902	2100	2275	145.0	357
Neshaminy (Well drained)	046-013-01	Ap	0-15	5.9	25.4	57.2	17.4	6.1	8.79	6.15	4.80	1450	1410	2750	110.7	525
	046-013-05	Bt2	41-51	6.6	38.2	34.0	27.8	5.3	8.69	6.08	3.55	1092	1192	5375	122.7	322
	046-013-08	C1	84-99	7.0	60.4	25.2	14.4	3.1	5.76	4.03	5.30	680	2075	4050	445.0	720
Mount Lucas (Moderately well drained)	001-016-01	Ap	0-20	6.5	19.7	68.1	12.2	2.1	1.79	1.25	1.50	1235	1652	2100	100.5	337
	001-016-04	Bt2	46-61	6.6	43.8	31.5	24.7	1.9	3.75	2.62	3.40	597	4688	7325	575.0	405
	001-016-06	C	71-99	6.9	79.7	14.1	6.2	0.6	1.39	0.97	3.00	285	10782	6075	2050.0	335
Watchung (Poorly drained)	009-012-01	Ap	0-20	6.4	9.2	76.6	14.2	1.7	2.06	1.44	1.17	375	1047	1112	61.8	202
	009-012-04	Btg3	53-71	7.0	14.8	55.3	29.9	2.6	4.15	2.90	2.33	150	2580	2875	65.0	382
	009-012-06	Bx2	99-135	6.9	26.9	64.4	8.7	4.6	6.03	4.22	3.73	732	3508	2550	220.0	395
Watchung (Poorly drained)	009-013-01	Ap	0-18	6.3	5.6	70.0	24.4	2.3	1.89	1.32	2.30	460	1777	1650	90.0	492
	009-013-04	Btg2	53-71	6.8	19.7	57.6	22.7	5.5	5.72	4.00	3.37	820	1625	2275	110.0	455
	009-013-06	Bxg2	104-127	5.5	32.7	43.4	23.9	6.8	8.98	6.28	5.72	1145	1492	1725	165.0	478
<u>Gray Acid Floodplain</u>																
Pope (Well drained)	014-084-01	A	0-10	4.3	34.7	46.8	18.5	2.0	3.33	2.33	1.16	585	557	1475	56.5	1325
	014-084-05	Bw3	61-86	4.1	30.2	47.6	22.2	2.4	4.14	2.90	1.24	485	217	1825	53.5	932
	014-084-08	2C1	114-142	4.9	51.9	31.3	16.8	3.1	5.69	3.98	1.30	522	547	1875	57.5	1150

1 - Fe<sub>2</sub>O<sub>3</sub> data from Ciolkosz and Thurman (1992) by the CBD method. 2 - Fe<sub>2</sub>O<sub>3</sub> data calculated from the Fe data (Fe x 1.43).

Table 2. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million				
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P
<u>Grayish-Brown Wisconsinan Glacial Till</u>														
Bath (Well drained)	008-011-01	Ap	0-18	5.5	28.2	56.8	15.0	11.7	54.7	13.5	18.2	0.175	14.2	572.5
	008-011-03	Bw2	30-43	5.0	36.6	50.3	13.1	15.5	51.2	17.2	15.5	0.100	18.0	527.5
	008-011-06	Bx3	69-107	5.0	40.9	45.6	13.5	22.0	54.2	19.7	16.5	0.150	16.2	427.5
Bath (Well drained)	008-099-02	A	0-5	4.3	42.3	46.8	10.9	9.5	50.0	15.5	44.0	0.300	12.5	457.5
	008-099-05	Bw2	36-51	4.4	38.3	47.3	14.4	24.5	55.0	18.0	12.0	0.100	14.7	350.0
	008-099-09	Bx4	135-180	5.0	22.3	56.4	21.3	25.5	75.0	26.0	15.7	0.125	20.0	475.0
	008-099-12	Bx7	285-361	5.2	36.0	48.8	15.2	25.7	72.5	25.2	17.2	0.175	18.5	532.5
Volusia (Somewhat poorly drained)	008-014-01	Ap	0-20	6.9	24.4	53.7	21.9	12.7	58.0	14.5	22.5	0.100	14.5	645.0
	008-014-03	E2	28-36	6.7	24.9	53.8	21.3	14.2	50.0	17.0	16.0	0.075	14.7	237.5
	008-014-06	Bxg3	74-97	5.0	24.5	48.0	27.5	22.5	65.0	22.5	18.8	0.100	15.7	442.5
Chippewa (Very poorly drained)	008-016-01	Ap	0-15	5.6	11.6	63.4	25.0	12.2	90.0	16.0	24.5	0.275	18.5	572.5
	008-016-03	Eg	30-43	5.5	14.2	60.7	25.1	9.5	90.0	17.0	18.0	0.050	23.0	392.5
	008-016-06	Bxg3	94-130	6.3	20.0	69.2	10.8	24.5	60.0	22.7	14.0	0.150	14.5	467.5
<u>Red Wisconsinan Glacial Till</u>														
Lackawanna (Well drained)	045-080-01	Ap	0-18	5.3	42.3	45.6	12.1	8.5	44.5	8.2	9.5	0.325	12.5	137.5
	045-080-03	Bw2	36-51	5.7	44.4	43.9	11.7	18.0	42.7	14.7	4.5	0.200	15.0	82.5
	045-080-05	Bx1	71-109	5.6	51.7	37.6	10.7	16.5	39.5	13.8	2.7	0.175	10.2	56.3
Morris (Somewhat poorly drained)	058-003-01	Ap	0-18	5.7	34.1	44.9	21.0	11.5	98.2	12.5	15.7	0.500	22.2	592.5
	058-003-03	BA	28-43	6.0	45.9	42.3	11.8	8.2	55.2	13.0	8.0	0.200	16.5	122.5
	058-003-07	Bx4	79-117	6.6	41.5	45.2	13.3	15.0	59.5	17.0	12.2	0.300	16.7	375.0
Norwich (Poorly drained)	058-021-01	A	0-20	5.0	18.5	36.7	44.8	16.2	162.7	15.0	47.5	0.700	27.3	658.7
	058-021-03	Bwg	25-64	5.2	21.1	47.0	31.9	17.5	54.7	14.0	18.5	0.175	22.5	281.3
	058-021-05	2Bxg2	76-91	5.7	22.5	49.8	27.7	22.2	78.5	22.5	42.2	0.175	15.7	272.5

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million																	
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P													
<u>Pre-Wisconsinan Glacial Till</u>																											
Allenwood (Well drained)	013-061-01	Ap	0-18	5.7	26.2	56.7	17.1	12.2	95.0	6.5	18.5	0.525	16.0	412.5													
	013-061-04	Bt2	61-84	5.2	31.2	32.2	36.6	31.3	39.2	14.0	15.5	0.025	25.7	355.0													
	013-061-07	Bt5	155-190	5.2	45.6	37.9	16.5	16.5	18.5	4.7	13.0	0.025	18.0	247.5													
Watson (Moderately well drained)	055-002-01	Ap	0-23	6.0	26.5	52.5	21.0	12.0	28.0	5.7	11.7	0.200	15.2	250.0													
	055-002-03	Bt2	46-56	4.8	28.6	28.9	42.5	10.5	17.7	5.5	5.2	0.125	15.7	32.5													
	055-002-05	Bx2	89-114	4.5	42.3	30.7	27.0	10.2	19.5	8.8	6.3	0.125	17.5	72.5													
<u>Acid Grayish-brown Shale and Sandstone Colluvium and Limestone Colluvium</u>																											
Laidig (Well drained)	014-031-03	A	0-8	4.6	34.2	49.7	16.1	8.5	48.7	9.7	8.0	0.175	15.2	322.5													
	014-031-06	Bt2	51-58	4.9	42.8	37.4	19.8	35.5	66.2	23.0	7.7	0.075	27.3	180.0													
	014-031-10	Bx1	102-150	4.9	43.3	36.1	20.6	42.5	63.5	27.8	9.5	0.150	28.7	440.0													
Murrill (Well drained)	014-088-01	Ap1	0-13	6.1	7.6	69.8	22.6	14.7	48.7	13.8	20.5	0.150	19.2	620.0													
	014-088-04	Bt2	40-55	5.5	6.6	60.7	32.7	27.8	140.0	18.8	17.7	0.075	31.3	345.0													
	014-088-07	Bt5	110-143	4.8	13.7	62.1	24.2	19.5	49.5	17.2	21.7	0.100	33.2	302.5													
	014-088-10	BCt	215-304	5.2	16.6	41.8	41.6	22.2	40.2	16.0	23.5	0.175	35.2	177.5													
Andover (Poorly drained)	018-013-01	Ap	0-23	6.0	29.6	46.6	23.8	15.0	64.5	20.0	20.0	0.275	17.5	327.5													
	018-013-03	Bt	36-46	6.1	33.5	42.4	24.1	21.5	39.2	14.5	7.0	0.200	25.7	87.5													
	018-013-06	Bxg3	81-97	5.1	41.0	39.5	19.5	28.7	48.7	20.5	12.2	0.200	25.7	232.5													
<u>Brown Wisconsinan Loess</u>																											
Duncannon (Well drained)	009-005-01	Ap	0-25	5.4	8.6	74.0	17.4	12.5	55.5	11.2	21.2	0.200	21.7	395.0													
	009-005-03	Bt1	43-61	6.0	7.9	69.9	22.2	21.2	44.2	15.2	18.2	0.050	41.0	213.8													
	009-005-05	BC	86-114	6.2	6.6	83.0	10.4	13.8	37.5	12.5	8.5	0.050	29.7	255.0													
Lawrenceville (Moderately well drained)	009-003-01	Ap	0-28	6.3	11.6	73.0	15.4	11.7	47.0	10.5	16.0	0.175	22.0	377.5													
	009-003-03	Bt2	48-64	6.4	8.6	73.4	18.0	25.2	38.5	10.7	11.0	0.075	33.5	225.0													
	009-003-05	Bx2	86-102	5.4	12.0	73.4	14.6	18.0	39.5	13.0	9.5	0.100	26.5	362.5													

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million				
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P
Doylestown (Poorly drained)	009-011-01	Ap	0-18	5.5	4.5	73.7	21.8	11.0	52.2	10.5	23.0	0.175	34.0	267.5
	009-011-02	Btg	18-38	5.5	2.9	61.7	35.4	16.2	41.2	12.0	13.5	0.125	53.5	83.7
	009-011-04	Bxtg2	46-69	5.2	7.4	76.0	16.6	20.0	60.0	15.5	12.2	0.125	39.5	352.5
<u>Residual Acid Sandstone</u>														
Clymer (Well drained)	014-083-03	E	0-8	3.8	68.1	30.3	1.6	3.8	7.2	0.5	2.2	0.025	1.3	67.5
	014-083-07	Bw2	43-71	4.6	59.8	29.8	10.4	23.0	24.0	5.2	10.7	0.025	8.0	110.0
	014-083-09	Bt2	94-122	4.6	54.1	23.9	22.0	23.2	33.5	5.7	20.5	0.025	15.7	155.0
	014-083-11	C1	137-168	4.8	69.3	30.3	0.4	6.5	11.5	1.3	9.2	0.025	2.7	92.5
Hazleton (Well drained)	017-012-02	A	0-5	4.8	26.6	52.3	21.1	18.0	87.5	12.7	26.5	0.325	22.2	795.0
	017-012-05	Bt2	33-61	4.8	37.3	43.4	19.3	26.5	90.0	29.2	18.0	0.025	33.2	357.5
	017-012-08	Bt5	104-127	5.0	45.1	41.1	13.8	30.5	92.5	31.0	19.0	0.025	29.5	377.5
Cookport (Moderately well drained)	017-015-02	BA	5-15	4.8	31.1	47.4	21.5	9.0	35.0	6.5	8.8	0.075	17.5	250.0
	017-015-04	Bt2	25-38	4.9	35.0	44.8	20.2	10.2	53.2	9.2	9.5	0.125	13.0	360.0
	017-015-07	Bx3	84-119	5.2	35.5	43.7	20.8	20.5	53.5	16.0	13.0	0.125	14.2	382.5
Cookport (Somewhat poorly drained)	014-082-01	A	0-8	3.4	48.6	41.9	9.5	29.7	37.7	4.2	83.2	0.400	7.5	450.0
	014-082-04	Bw2	41-61	4.6	42.9	42.2	14.9	22.5	38.0	7.2	13.5	0.025	15.7	130.0
	014-082-07	Bx3	104-132	4.8	67.2	19.1	13.7	13.2	40.5	7.5	18.2	0.025	9.5	147.5
	014-082-10	Bx6	203-243	4.9	70.0	21.1	8.9	25.2	43.2	6.8	10.2	0.025	7.0	160.0
Nolo (Poorly drained)	017-019-02	A	0-10	4.2	27.2	63.2	9.6	4.7	12.0	0.8	6.0	0.200	2.2	255.0
	017-019-04	Btg	28-36	4.7	37.5	43.2	19.3	7.5	18.8	4.5	10.7	0.025	10.7	117.5
	017-019-06	Bxg2	79-124	5.3	47.3	37.2	15.5	13.8	25.7	7.2	13.0	0.125	11.5	147.5
<u>Residual Acid Gray Shales</u>														
Bedington (Well drained)	006-012-02	A	0-5	4.2	36.0	44.5	19.5	17.2	112.5	14.0	85.2	0.525	19.5	627.5
	006-012-05	Bt2	30-58	4.4	44.0	37.9	18.1	25.0	95.0	25.2	17.2	0.025	28.7	392.5
	006-012-08	Bt5	119-150	4.6	43.3	21.7	35.0	35.2	92.5	24.0	28.2	0.025	32.5	497.5
	006-012-10	Ct	178-208	.	.	.	.	38.5	117.5	39.0	39.5	0.050	32.0	540.0

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million				
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P
Gilpin (Well drained)	032-054-01	Ap	0-23	6.6	41.6	52.5	5.9	16.7	86.5	21.2	17.0	0.325	30.0	612.5
	032-054-03	Bt	36-58	5.3	27.3	50.1	22.6	19.5	75.7	24.5	10.7	0.175	36.5	155.0
	032-054-05	C	66-76	5.0	25.9	53.3	20.8	24.7	67.5	26.0	13.5	0.150	37.0	295.0
Rayne (Well drained)	056-002-04	Bt3	66-97	4.8	29.9	29.5	40.6	19.7	43.8	10.7	14.0	0.200	32.0	195.0
	056-002-07	C1	168-208	4.8	47.4	28.5	24.1	16.5	58.7	18.0	16.2	0.175	25.2	372.5
Wharton (Moderately well drained)	032-053-01	Ap	0-25	6.2	17.3	69.7	13.0	12.2	77.5	17.5	19.7	0.300	21.2	422.5
	032-053-04	Bt2	48-61	4.9	10.3	62.5	27.2	24.2	67.5	23.2	14.5	0.050	37.7	267.5
	032-053-06	C	91-137	4.9	21.7	56.7	21.6	28.7	82.5	30.5	16.5	0.050	31.5	470.0
Cavode (Somewhat poorly drained)	010-039-01	Ap	0-28	5.3	20.1	52.3	27.6	25.7	82.5	12.7	24.7	0.375	16.7	432.5
	010-039-04	Btg2	53-69	4.9	3.6	40.1	56.3	25.0	37.2	8.8	15.2	0.025	25.7	110.0
	010-039-07	2Btg5	104-130	4.8	30.9	46.1	23.0	20.0	102.5	26.2	19.0	0.100	21.0	110.0
Cavode (Somewhat poorly drained)	032-059-01	Ap	0-28	5.2	22.8	61.5	15.7	11.5	84.7	15.0	18.5	0.400	22.0	320.0
	032-059-03	Bt1	41-53	4.9	12.4	48.4	39.2	91.0	252.5	16.7	12.2	0.250	40.0	136.2
	032-059-06	Cg	119-145	4.9	28.3	50.6	21.1	27.8	88.5	20.5	13.0	0.325	23.7	100.0
<u>Residual Calcareous Red Shales</u>														
Upshur (Well drained)	002-023-01	Ap	0-20	4.8	13.6	66.2	20.2	16.5	58.0	18.0	35.0	0.275	38.2	252.5
	002-023-03	Bt2	41-64	4.5	0.9	32.2	66.9	22.5	35.5	17.7	23.2	0.125	49.0	37.5
	002-023-07	C1	117-142	6.1	2.2	66.4	31.4	66.7	57.7	47.7	21.2	0.200	40.7	1697.5
Vandergrift (Moderately well drained)	004-001-01	Ap	0-18	5.0	9.2	60.9	29.9	24.0	77.5	16.0	33.5	0.525	23.2	322.5
	004-001-04	Bt3	41-58	5.1	3.3	27.9	68.8	66.5	38.5	21.5	38.5	0.075	51.5	162.5
	004-001-08	C1	147-180	8.2	3.1	63.9	33.0	68.0	68.2	43.2	21.5	0.200	29.0	126.2

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million				
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P
<u>Residual Calcareous Gray Shales</u>														
Westmoreland (Well drained)	063-043-01	Ap	0-25	7.1	12.8	71.6	15.6	17.7	65.5	15.7	19.7	0.450	19.2	215.0
	063-043-04	Bt2	53-74	4.6	21.0	48.6	30.4	22.5	67.0	20.0	14.5	0.200	28.2	130.0
	063-043-07	C	127-147	4.7	41.5	46.5	12.0	21.5	85.2	26.2	14.5	0.200	32.7	257.5
Dormont (Moderately well drained)	002-007-02	Ap	0-18	4.7	9.7	68.6	21.7	16.5	85.7	17.0	28.2	0.650	22.7	512.5
	002-007-05	Bt2	38-48	5.3	11.5	59.2	29.3	29.5	66.2	19.5	17.2	0.350	22.5	272.5
	002-007-08	Bw1	79-102	4.8	29.5	51.1	19.4	45.0	90.0	23.0	13.0	0.325	21.2	241.2
Library (Somewhat poorly drained)	063-045-01	Ap	0-25	5.7	9.1	68.8	22.1	19.0	86.5	16.0	24.5	0.400	22.0	322.5
	063-045-04	Btg1	48-61	6.0	9.0	58.3	32.7	24.5	52.2	21.7	17.0	0.100	23.2	123.7
	063-045-08	C1	124-132	6.8	5.0	39.5	55.5	45.5	62.7	34.2	18.2	0.250	19.2	105.0
<u>Residual Limestones</u>														
Duffield (Well drained)	014-074-01	A	0-18	5.3	6.8	75.9	17.3	14.0	85.0	13.0	34.5	0.325	25.0	601.2
	014-074-05	Bt2	71-94	4.9	3.5	57.2	39.3	20.7	36.7	24.5	14.7	0.050	54.2	175.0
	014-074-11	3C1	193-211	5.3	8.7	51.8	39.5	20.7	28.7	29.7	14.2	0.325	62.5	108.0
Duffield (Well drained)	036-017-01	Ap	0-18	5.8	11.7	69.9	18.4	14.2	48.0	12.0	20.7	0.225	26.0	402.5
	036-017-03	Bt1	30-56	6.4	10.9	54.7	34.4	22.7	54.7	17.5	14.5	0.050	17.7	252.5
	036-017-06	C	102-132	6.6	31.1	40.1	28.8	23.7	49.7	22.7	14.5	0.075	20.5	477.5
Hagerstown (Well drained)	014-005-01	Ap	0-23	5.7	6.0	70.0	24.0	13.8	40.5	15.5	17.5	0.125	20.7	450.0
	014-005-04	Bt3	66-79	4.9	1.7	32.5	65.8	27.3	51.0	35.7	18.8	0.125	25.5	233.7
	014-005-07	C	135-173	7.5	8.7	53.1	38.2	23.0	47.5	27.5	17.2	0.150	26.2	335.0
Hagerstown (Well drained)	014-007-01	Ap	0-25	6.1	16.5	72.2	11.3	18.5	48.0	13.5	24.0	0.250	22.5	477.5
	014-007-05	Bt2	79-109	4.8	2.2	36.0	61.8	32.5	75.0	27.0	22.5	0.150	29.2	152.5
	014-007-07	BC1	142-183	5.2	1.9	29.5	68.6	34.0	82.5	32.2	23.7	0.150	34.5	168.7
Hagerstown (Well drained)	014-014-01	Ap	0-30	6.7	1.5	87.2	11.3	11.5	40.7	12.0	19.0	0.225	19.7	495.0
	014-014-04	Bt1	51-76	6.9	0.8	46.2	53.0	20.2	43.2	20.2	23.0	0.225	38.2	260.0
	014-014-05	Bt2	76-102	7.5	1.0	41.6	57.4	20.5	43.8	20.5	21.0	0.225	34.7	240.0

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P		
Hagerstown (Well drained)	014-066-01	A	0-8	5.5	4.7	77.2	18.1	18.2	34.0	10.0	16.7	0.050	13.0	351.2		
	014-066-05	Bt2	53-76	4.8	5.4	44.4	50.2	21.0	39.0	24.0	20.2	0.025	45.7	217.5		
	014-066-08	3C	112-178	7.5	3.3	65.2	31.5	26.7	67.5	39.0	18.5	0.075	53.0	227.5		
Hagerstown (Well drained)	014-067-01	A	0-10	5.4	3.4	79.1	17.5	15.2	65.0	14.2	21.5	0.225	23.0	601.2		
	014-067-05	Bt2	53-76	4.8	2.9	40.7	56.4	24.5	40.2	43.2	14.7	0.050	74.0	257.5		
	014-067-08	3C2	137-155	7.9	9.0	56.0	35.0	12.0	15.5	23.0	12.7	0.025	28.5	201.3		
Hagerstown (Well drained)	014-068-01	A	0-8	5.8	8.1	75.3	16.6	19.2	125.0	11.2	43.8	0.600	35.7	485.0		
	014-068-05	Bt2	61-84	5.8	20.2	45.9	33.9	20.2	32.0	37.2	9.7	0.075	73.7	231.2		
	014-068-08	3Cr1	140-160	6.6	19.2	51.4	29.4	26.2	36.0	36.7	12.0	0.025	82.7	342.5		
Hagerstown (Well drained)	014-069-01	A	0-10	5.8	4.5	75.2	20.3	19.2	100.0	16.2	32.0	0.450	29.7	585.0		
	014-069-05	Bt2	53-69	5.1	3.5	38.6	57.9	27.0	49.7	44.5	16.2	0.150	71.5	248.7		
	014-069-08	3C	99-147	8.0	5.4	57.2	37.4	19.7	24.5	31.5	14.5	0.050	35.5	260.0		
Hagerstown (Well drained)	014-070-01	A	0-8	5.3	10.8	73.9	15.3	18.8	117.5	12.2	39.7	0.550	35.0	633.7		
	014-070-06	3Bt3	66-89	5.3	7.4	51.0	41.6	19.2	29.0	20.7	19.0	0.050	61.5	151.2		
	014-070-09	3Bt6	160-183	5.7	1.7	43.9	54.4	23.2	42.0	33.7	14.2	0.050	70.5	175.0		
Hagerstown (Well drained)	014-071-01	A	0-8	5.0	9.2	73.4	17.4	23.2	80.0	12.5	40.2	0.425	26.0	495.0		
	014-071-05	Bt2	61-86	5.3	2.7	41.0	56.3	26.2	36.2	32.5	21.5	0.025	68.2	112.5		
	014-071-07	3C	112-142	6.9	3.2	50.1	46.7	22.5	40.2	38.5	15.5	0.050	66.7	196.2		
Hagerstown (Well drained)	014-072-01	A	0-8	5.4	9.4	74.6	16.0	19.7	125.0	12.0	42.5	0.550	27.5	523.7		
	014-072-05	Bt2	46-79	5.1	2.9	54.2	42.9	20.7	45.5	19.5	15.2	0.100	45.0	103.8		
	014-072-09	3BC	145-157	6.9	2.5	77.0	20.5	24.5	47.5	31.0	15.2	0.125	55.2	157.5		
Hagerstown (Well drained)	014-073-01	A	0-8	5.4	9.8	73.8	16.4	14.0	77.5	12.7	24.5	0.225	21.5	433.8		
	014-073-05	Bt2	61-86	5.6	10.4	48.3	41.3	17.7	23.5	23.7	9.7	0.050	56.0	151.2		
	014-073-08	3C1	140-165	6.6	18.3	45.1	36.6	21.0	25.7	29.2	15.0	0.000	58.0	220.0		
Hagerstown (Well drained)	014-075-01	A	0-10	6.6	10.3	73.2	16.5	18.5	127.5	11.0	46.5	0.675	37.2	544.0		
	014-075-05	3Bt2	61-86	5.4	3.8	38.4	57.8	22.7	37.0	25.5	17.5	0.850	55.0	93.8		
	014-075-08	3Bt5	150-160	7.5	4.3	42.6	53.1	20.7	32.2	26.0	14.7	0.200	54.7	105.0		



Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent				Parts Per Million						
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P	
Hagerstown (Well drained)	014-080-01	A	0-8	4.9	19.2	73.4	7.4	16.7	75.0	12.5	77.5	0.600	19.5	486.2	
	014-080-05	Bt2	61-89	4.6	9.1	26.3	64.6	55.2	87.5	28.0	45.5	0.050	26.5	183.7	
	014-080-09	BC	183-254	4.9	4.1	45.5	50.4	36.0	46.7	19.5	24.5	0.000	21.2	167.5	
Hagerstown (Well drained)	018-009-01	Ap	0-18	6.2	15.8	62.5	21.7	12.2	33.0	14.5	16.7	0.125	24.7	425.0	
	018-009-04	Bt3	38-53	6.0	4.9	19.2	75.9	33.0	46.2	39.7	19.0	0.150	71.7	308.7	
	018-009-06	BC	71-81	6.2	9.1	29.3	61.6	32.7	42.5	43.0	20.2	0.100	64.0	438.7	
Hagerstown (Well drained)	018-010-01	Ap	0-15	6.0	19.3	64.1	16.6	10.7	33.0	11.5	32.7	0.125	19.5	210.0	
	018-010-05	Bt2	53-71	5.3	11.8	56.0	32.2	12.2	34.7	13.2	17.5	0.025	23.5	113.7	
	018-010-08	BC2	112-137	5.2	6.6	40.8	52.6	18.2	28.0	20.5	19.5	0.125	27.5	185.0	
Hagerstown (Well drained)	022-006-01	Ap	0-23	6.5	1.6	62.2	16.2	19.2	75.0	14.5	52.5	0.300	26.0	643.7	
	022-006-05	Bt3	74-89	7.0	9.5	14.3	76.2	38.2	160.0	24.0	66.2	0.100	43.2	352.5	
	022-006-08	BC	147-152	6.7	2.8	19.2	78.0	38.5	170.0	34.7	46.7	0.250	43.0	561.2	
Hagerstown (Well drained)	022-007-01	Ap	0-18	6.6	15.3	65.3	19.4	13.2	53.7	13.2	26.7	0.175	35.5	490.0	
	022-007-05	Bt3	64-71	6.8	26.9	42.3	30.8	23.0	50.7	19.7	31.7	0.100	43.0	290.0	
	022-007-09	BC	142-163	6.2	6.9	33.3	59.8	35.5	87.5	39.5	30.5	0.125	32.5	360.0	
Hagerstown (Well drained)	036-014-01	Ap	0-20	7.0	14.2	63.2	22.6	15.7	40.7	11.7	20.0	0.100	43.0	665.0	
	036-014-04	Bt2	56-84	5.5	6.7	35.3	58.0	16.0	35.2	12.2	19.7	0.025	32.5	333.7	
	036-014-08	Bt6	163-190	4.9	8.3	59.4	32.3	10.2	29.0	7.7	19.0	0.000	30.5	262.5	
Hagerstown (Well drained)	036-015-01	Ap	0-18	6.0	12.9	68.5	18.6	22.0	37.0	9.7	20.0	0.125	24.2	667.5	
	036-015-04	Bt2	58-84	6.8	9.7	31.2	59.1	20.7	50.2	18.5	21.5	0.175	34.5	527.5	
	036-015-07	BCt2	157-203	5.1	18.0	32.1	49.9	17.0	39.7	13.5	18.0	0.075	49.7	475.0	
Hagerstown (Well drained)	036-019-01	Ap	0-25	6.0	11.2	64.3	24.5	12.5	38.0	12.0	23.7	0.150	33.5	442.5	
	036-019-04	Bt3	71-86	5.3	7.6	43.6	48.8	25.5	75.0	26.5	27.3	0.075	27.5	602.5	
	036-019-07	C1	142-168	5.1	9.0	47.7	43.3	24.2	95.0	26.0	23.5	0.100	28.2	378.7	
Clarksburg (Moderately well drained)	014-081-01	A	0-8	5.0	12.2	69.8	18.0	12.5	82.5	16.7	55.5	0.700	14.5	882.5	
	014-081-04	Bt	36-69	4.6	9.1	64.6	26.3	27.8	87.5	19.0	15.7	0.225	22.2	347.5	
	014-081-06	Bx2	104-140	5.0	23.5	57.5	19.0	35.7	45.7	19.0	15.2	0.150	27.0	342.5	
	014-081-10	2C3	223-259	4.7	20.8	44.0	35.2	18.5	34.5	18.0	17.7	0.225	33.7	330.0	

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent					Parts Per Million						
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P		
<u>Residual Acid Crystalline Rocks</u>																
Chester (Well drained)	036-049-01	A	0-8	4.1	41.0	41.6	17.4	12.0	26.5	4.2	29.0	0.225	12.7	368.7		
	036-049-04	Bw1	36-56	4.5	47.2	33.7	19.1	23.2	25.0	7.5	9.2	0.050	21.0	362.5		
	036-049-08	3C2	135-152	5.4	79.2	18.4	2.4	22.2	8.5	3.5	6.5	0.075	17.5	376.2		
	036-049-12	3C3	244-386	5.4	75.3	22.3	2.4	16.2	14.2	4.5	10.0	0.050	5.0	360.0		
Chester (Well drained)	036-052-01	A	0-8	4.5	26.2	54.5	19.3	10.0	35.5	8.0	31.5	0.275	23.0	296.2		
	036-052-04	Bt1	33-48	5.0	27.7	41.4	30.9	17.2	29.5	9.5	14.0	0.150	41.7	241.2		
	036-052-07	2Bt4	97-119	5.8	52.6	21.1	26.3	18.8	12.5	5.7	14.7	0.225	37.0	257.5		
	036-052-08	2Bt5	119-160	5.8	49.9	23.8	26.3	20.5	19.2	7.0	20.0	0.150	34.2	225.0		
Chester (Well drained)	067-008-01	Ap	0-20	5.1	31.6	46.0	22.4	28.7	37.0	11.2	18.5	0.100	32.7	730.0		
	067-008-04	Bt2	53-66	6.9	37.6	30.8	31.6	45.7	27.5	10.7	16.5	0.050	38.0	452.5		
	067-008-06	C1	71-86	6.1	53.8	16.5	29.7	62.3	23.7	9.2	15.7	0.075	32.2	535.0		
Chester (Well drained)	036-050-01	A	0-5	4.8	32.7	50.8	16.5	20.7	32.2	7.5	21.7	0.150	24.5	218.8		
	036-050-04	Bt	30-66	5.2	38.1	40.1	21.8	18.5	31.0	9.7	16.2	0.200	38.5	237.5		
	036-050-08	3Bt	157-203	5.7	41.4	29.1	29.5	21.2	26.7	8.0	16.2	0.150	38.0	262.5		
	036-050-14	9C	328-338	5.6	43.6	22.2	34.2	28.2	41.2	13.0	28.7	0.250	33.0	197.5		
Glennlg (Well drained)	006-011-02	A	0-12	4.3	45.3	35.5	19.2	9.5	72.5	7.0	39.5	0.225	10.2	610.0		
	006-011-05	Bt2	46-66	4.4	48.4	31.0	20.6	7.7	45.0	7.7	9.0	0.025	14.2	300.0		
	006-011-08	C1	124-160	4.6	69.1	19.6	11.3	10.7	36.5	1.8	4.7	0.075	1.0	220.0		
	006-011-11	C4	246-322	4.3	60.2	31.8	8.0	9.0	49.2	2.7	4.5	0.050	5.7	285.0		
Glennlg (Well drained)	036-027-01	Ap	0-25	7.3	51.6	34.2	14.2	13.0	29.5	8.8	13.5	0.200	14.7	156.3		
	036-027-02	Bt1	25-48	7.3	35.1	41.0	23.9	21.2	33.5	11.2	10.2	0.125	26.5	251.3		
	036-027-05	C1	84-107	7.1	61.0	35.3	3.7	35.0	33.7	11.7	8.8	0.175	14.7	201.3		
Manor (Well drained)	036-028-01	Ap1	0-13	6.9	38.1	45.4	16.5	28.7	91.2	21.7	17.2	0.250	24.0	637.5		
	036-028-03	Bw	25-51	6.5	46.5	41.4	12.1	33.2	79.0	20.2	11.0	0.150	19.0	322.5		
	036-028-06	C1	84-94	7.2	59.7	36.0	4.3	12.0	68.0	16.7	9.7	0.150	10.7	86.2		

Table 2. Cont. Selected soil characterization data and minor elements for the soil samples used in this study. Characterization data from Ciolkosz and Thurman (1992).

Soil and Drainage Class	Soil Number	Horizon	Depth in cm	pH	Percent				Parts Per Million						
					Sand	Silt	Clay	Cu	Zn	Ni	Pb	Cd	Cr	P	
<u>Residual Basic Crystalline Rocks</u>															
Neshaminy (Well drained)	009-051-01	Ap	0-18	6.6	20.2	57.4	22.4	71.5	85.0	45.7	21.5	0.175	141.0	647.5	
	009-051-03	Bt2	33-58	6.6	29.0	37.2	33.8	119.7	49.7	76.7	10.7	0.075	172.5	487.5	
	009-051-05	C	91-163	6.6	50.6	21.4	28.0	98.7	44.2	64.0	7.2	0.125	139.2	442.5	
Neshaminy (Well drained)	046-013-01	Ap	0-15	5.9	25.4	57.2	17.4	68.5	71.2	57.5	15.2	0.200	112.0	558.7	
	046-013-05	Bt2	41-51	6.6	38.2	34.0	27.8	75.2	44.5	47.5	5.0	0.175	108.0	100.0	
	046-013-08	C1	84-99	7.0	60.4	25.2	14.4	87.0	36.5	43.2	4.2	0.225	62.7	190.0	
Mount Lucas (Moderately well drained)	001-016-01	Ap	0-20	6.5	19.7	68.1	12.2	16.5	34.0	19.2	13.0	0.100	134.5	265.0	
	001-016-04	Bt2	46-61	6.6	43.8	31.5	24.7	50.0	33.2	47.2	8.0	0.050	280.0	85.0	
	001-016-06	C	71-99	6.9	79.7	14.1	6.2	62.7	22.5	35.2	4.7	0.050	129.7	352.5	
Watchung (Poorly drained)	009-012-01	Ap	0-20	6.4	9.2	76.6	14.2	12.7	47.0	9.5	18.0	0.175	32.5	227.5	
	009-012-04	Btg3	53-71	7.0	14.8	55.3	29.9	36.2	38.0	25.7	11.2	0.025	104.2	52.5	
	009-012-06	Bx2	99-135	6.9	26.9	64.4	8.7	67.7	39.5	41.2	9.5	0.075	127.5	337.5	
Watchung (Poorly drained)	009-013-01	Ap	0-18	6.3	5.6	70.0	24.4	17.2	70.0	20.7	24.5	0.250	94.2	430.0	
	009-013-04	Btg2	53-71	6.8	19.7	57.6	22.7	28.7	33.7	40.7	12.7	0.050	170.0	142.5	
	009-013-06	Bxg2	104-127	5.5	32.7	43.4	23.9	45.0	39.2	65.5	14.5	0.050	360.0	245.0	
<u>Gray Acid Floodplain</u>															
Pope (Well drained)	014-084-01	A	0-10	4.3	34.7	46.8	18.5	11.7	65.0	15.2	19.5	0.125	16.0	390.0	
	014-084-05	Bw3	61-86	4.1	30.2	47.6	22.2	13.2	82.5	17.5	11.0	0.075	18.8	285.0	
	014-084-08	2C1	114-142	4.9	51.9	31.3	16.8	19.5	77.5	23.7	18.2	0.250	19.5	455.0	

Table 3. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon									
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum						
Fe, %	Glacial Till														
	brown Wisconsinan	4	1.32	0.80	1.82	9	1.80	1.30	2.58						
	red Wisconsinan	3	2.20	1.88	3.40	6	2.18	1.77	2.62						
	pre-Wisconsinan	2	--	0.78	2.08	4	2.38	1.57	3.27						
	Colluvium	3	2.23	1.70	2.45	7	3.60	3.20	3.75						
	Loess	3	1.70	1.57	2.60	6	2.78	2.45	3.20						
	Residuum														
	sandstone	5	0.67	0.35	4.14	12	2.06	1.05	3.25						
	gray acid shale	5	2.10	1.12	2.73	13	3.05	1.98	4.30						
	red calcareous shale	2	--	1.25	3.93	4	4.09	1.90	5.55						
	gray calcareous shale	3	2.92	2.27	3.02	6	3.30	1.93	4.15						
	limestone	23	1.82	1.10	3.83	47	3.40	1.73	5.55						
	acid crystalline	7	2.48	2.12	3.60	18	3.98	2.08	6.03						
	basic crystalline	5	1.44	1.25	6.15	10	4.12	0.97	7.97						
	Alluvium, acid floodplain	1	2.33	--	--	2	--	2.90	3.98						
	Al, %	Glacial Till													
brown Wisconsinan		4	1.58	1.04	1.82	9	1.40	1.27	2.12						
red Wisconsinan		3	2.52	1.24	3.30	6	1.45	0.90	2.30						
pre-Wisconsinan		2	--	1.16	1.70	4	1.88	0.99	2.58						
Colluvium		3	1.98	1.52	2.08	7	2.08	1.57	2.73						
Loess		3	1.90	1.82	2.35	6	2.15	1.62	3.60						
Residuum															
sandstone		5	1.29	0.33	1.68	12	1.01	0.51	2.27						
gray acid shale		5	1.95	1.37	2.27	13	2.27	1.43	3.25						
red calcareous shale		2	--	1.37	1.80	4	1.75	1.39	2.33						
gray calcareous shale		3	1.43	1.31	1.57	6	1.62	1.27	2.05						
limestone		23	1.25	0.78	1.91	47	2.59	0.95	4.18						
acid crystalline		7	1.88	1.01	2.52	18	2.92	0.40	4.78						
basic crystalline		5	2.30	1.17	4.80	10	3.64	2.33	6.95						
Alluvium, acid floodplain		1	1.16	--	--	2	--	1.24	1.30						

Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon			
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum
Mn, ppm	Glacial Till								
	brown Wisconsinan	4	595	407	1325	9	615	225	893
	red Wisconsinan	3	857	132	2350	6	601	280	930
	pre-Wisconsinan	2	--	227	317	4	186	15	627
	Colluvium	3	3975	1325	4250	7	410	235	1225
	Loess	3	665	428	843	6	295	72	435
	Residuum								
	sandstone	5	79	10	1300	12	232	39	1032
	gray acid shale	5	1750	957	2075	13	325	20	1225
	red calcareous shale	2	--	1450	1775	4	107	35	180
	gray calcareous shale	3	2125	1295	2400	6	762	557	1295
	limestone	23	1800	430	5150	47	385	135	1575
	acid crystalline	7	745	55	1202	18	196	31	1032
	basic crystalline	5	1235	375	1450	10	776	150	1220
	Alluvium, acid floodplain	1	585	--	--	2	--	485	522
Ca, ppm	Glacial Till								
	brown Wisconsinan	4	1185	245	1560	9	462	3	1147
	red Wisconsinan	3	1350	42	2372	6	545	70	1623
	pre-Wisconsinan	2	--	517	720	4	88	32	140
	Colluvium	3	1352	80	1385	7	295	42	1952
	Loess	3	745	542	785	6	381	200	622
	Residuum								
	sandstone	5	240	80	582	12	94	3	497
	gray acid shale	5	755	370	1550	13	115	3	500
	red calcareous shale	2	--	900	927	4	3331	1517	6375
	gray calcareous shale	3	1637	252	1873	6	716	367	2805
	limestone	23	1567	220	7125	47	977	210	132775
	acid crystalline	7	390	38	1255	18	111	5	1265
	basic crystalline	5	1462	1047	1777	10	2088	1192	10782
	Alluvium, acid floodplain	1	557	--	--	2	--	217	547

Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon				
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum	
Mg, ppm	Glacial Till									
	brown Wisconsinan	4	2487	1600	2900	9	3550	2825	3950	
	red Wisconsinan	3	2950	1295	3025	6	3088	2400	3650	
	pre-Wisconsinan	2	--	582	667	4	406	177	760	
	Colluvium	3	1475	1325	2100	7	2300	1115	3100	
	Loess	3	1950	1875	2000	6	2825	2550	3550	
	Residuum									
	sandstone	5	225	63	1825	12	851	55	4350	
	gray acid shale	5	1475	852	2725	13	2725	770	3875	
	red calcareous shale	2	--	1192	1925	4	2538	1525	3100	
	gray calcareous shale	3	1775	1377	2350	6	2500	1925	4425	
	limestone	23	1475	441	21700	47	3075	685	78600	
	acid crystalline	7	882	542	2625	18	812	25	2375	
	basic crystalline	5	2100	1112	2750	10	2713	1725	7325	
	Alluvium, acid floodplain	1	1475	--	--	2	--	1825	1875	
	Na, ppm	Glacial Till								
		brown Wisconsinan	4	48.8	44.2	89.7	9	62.7	42.0	89.5
red Wisconsinan		3	76.0	35.2	92.5	6	55.0	38.0	78.0	
pre-Wisconsinan		2	--	51.7	56.5	4	55.2	34.5	85.2	
Colluvium		3	48.2	44.7	62.7	7	60.5	49.5	80.2	
Loess		3	87.2	59.5	110.5	6	101.0	78.0	124.7	
Residuum										
sandstone		5	45.2	17.2	82.5	12	44.7	31.3	68.5	
gray acid shale		5	58.5	48.0	69.0	13	71.7	46.2	89.2	
red calcareous shale		2	--	67.7	110.0	4	121.4	113.5	147.5	
gray calcareous shale		3	56.3	55.7	64.2	6	70.5	51.5	109.5	
limestone		23	39.7	28.0	97.0	47	52.0	30.2	195.0	
acid crystalline		7	49.7	32.0	68.0	18	43.1	18.2	69.0	
basic crystalline		5	100.5	61.8	110.7	10	155.0	65.0	2050.0	
Alluvium, acid floodplain		1	56.5	--	--	2	--	53.5	57.5	

Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon								
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum					
K, ppm	Glacial Till													
	brown Wisconsinan	4	908	635	1200	9	1200	725	1700					
	red Wisconsinan	3	1675	495	1900	6	1231	520	2000					
	pre-Wisconsinan	2	--	860	1025	4	902	335	1375					
	Colluvium	3	1175	807	1475	7	2000	1050	3200					
	Loess	3	113	101	1162	6	1462	1275	1700					
	Residuum													
	sandstone	5	690	450	1525	12	820	537	1675					
	gray acid shale	5	1105	835	1825	13	1625	1050	2750					
	red calcareous shale	2	--	1475	2700	4	2675	2100	2800					
	gray calcareous shale	3	1325	1070	1475	6	1763	1375	2350					
	limestone	23	877	655	1475	47	1825	232	8450					
	acid crystalline	7	680	375	930	18	652	117	1070					
	basic crystalline	5	492	202	557	10	400	322	720					
	Alluvium, acid floodplain	1	1325	--	--	2	--	932	1150					
	P, ppm	Glacial Till												
		brown Wisconsinan	4	572.5	457.5	645.0	9	442.5	237.5	532.5				
red Wisconsinan		3	592.0	138.0	659.0	6	197.5	56.3	375.0					
pre-Wisconsinan		2	--	250.0	412.5	4	160.0	32.5	355.0					
Colluvium		3	327.5	322.5	620.0	7	232.5	87.5	440.0					
Loess		3	377.5	267.5	395.0	6	240.0	83.7	362.5					
Residuum														
sandstone		5	255.0	67.5	795.0	12	151.3	92.5	382.5					
gray acid shale		5	432.5	320.0	627.5	13	267.5	100.0	540.0					
red calcareous shale		2	--	252.5	322.5	4	144.0	93.8	1697.0					
gray calcareous shale		3	322.5	215.0	512.5	6	185.6	105.0	272.5					
limestone		23	495.0	210.0	882.5	47	255.0	36.2	602.5					
acid crystalline		7	368.7	156.3	730.0	18	260.0	86.2	535.0					
basic crystalline		5	430.0	227.5	647.5	10	217.5	52.5	487.5					
Alluvium, acid floodplain		1	390.0	--	--	2	--	285.0	455.0					

Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon								
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum					
Cu, ppm	Glacial Till													
	brown Wisconsinan	4	12.0	9.5	12.7	9	22.5	9.5	25.7					
	red Wisconsinan	3	11.5	8.5	16.2	6	17.0	8.2	22.2					
	pre-Wisconsinan	2	--	12.0	12.2	4	13.5	10.2	31.3					
	Colluvium	3	14.7	8.5	15.0	7	27.8	19.5	42.5					
	Loess	3	11.7	11.0	12.5	6	19.0	13.8	25.2					
	Residuum													
	sandstone	5	9.0	3.8	29.7	12	21.5	6.5	30.5					
	gray acid shale	5	16.7	11.5	25.7	13	25.0	16.5	91.0					
	red calcareous shale	2	--	16.5	24.0	4	66.6	22.5	68.0					
	gray calcareous shale	3	17.7	16.5	19.0	6	27.0	21.5	45.5					
	limestone	23	15.7	10.7	23.2	47	23.4	10.2	55.2					
	acid crystalline	7	13.0	9.5	28.7	18	20.8	7.7	62.3					
	basic crystalline	5	17.2	12.7	71.5	10	65.2	28.7	119.7					
	Alluvium, acid floodplain	1	11.7	--	--	2	--	13.2	19.5					
	Zn, ppm	Glacial Till												
		brown Wisconsinan	4	56.4	50.0	90.0	9	60.0	50.0	90.0				
red Wisconsinan		3	98.2	44.5	162.7	6	55.0	39.5	78.5					
pre-Wisconsinan		2	--	28.0	95.0	4	19.0	17.7	39.2					
Colluvium		3	48.7	48.7	64.5	7	49.5	39.2	140.0					
Loess		3	52.2	47.0	55.5	6	40.4	37.5	60.0					
Residuum														
sandstone		5	35.0	7.2	87.5	12	39.2	11.5	92.5					
gray acid shale		5	84.7	77.5	112.5	13	82.5	37.2	252.5					
red calcareous shale		2	--	58.0	77.5	4	48.1	35.5	68.2					
gray calcareous shale		3	85.7	65.5	86.5	6	66.6	52.2	90.0					
limestone		23	65.0	33.0	127.5	47	45.6	15.5	170.0					
acid crystalline		7	35.5	26.5	91.2	18	30.2	8.5	79.0					
basic crystalline		5	70.0	34.0	85.0	10	38.6	22.5	49.7					
Alluvium, acid floodplain		1	65.0	--	--	2	--	77.5	82.5					



Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon							
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum				
Ni, ppm	Glacial Till												
	brown Wisconsinan	4	15.0	13.5	16.0	9	19.7	17.0	26.0				
	red Wisconsinan	3	12.5	8.2	15.0	6	14.4	13.0	22.5				
	pre-Wisconsinan	2	--	5.7	6.5	4	7.2	4.7	14.0				
	Colluvium	3	13.8	9.7	20.0	7	18.8	14.5	27.8				
	Loess	3	10.5	10.5	11.2	6	12.8	10.7	15.5				
	Residuum												
	sandstone	5	4.2	0.5	12.7	12	7.2	1.3	31.0				
	gray acid shale	5	15.0	12.7	21.2	13	24.0	8.8	39.0				
	red calcareous shale	2	--	16.0	18.0	4	32.4	17.7	47.7				
	gray calcareous shale	3	16.0	15.7	17.0	6	22.4	19.5	34.2				
	limestone	23	12.5	9.7	16.7	47	26.2	7.7	44.5				
	acid crystalline	7	8.0	4.2	21.7	18	8.6	1.8	20.2				
	basic crystalline	5	20.7	9.5	57.5	10	45.2	25.7	76.7				
	Alluvium, acid floodplain	1	15.2	--	--	2	--	17.5	23.7				
	Pb, ppm	Glacial Till											
brown Wisconsinan		4	23.5	18.2	44.0	9	16.0	12.0	18.8				
red Wisconsinan		3	15.7	9.5	47.5	6	10.1	2.7	42.2				
pre-Wisconsinan		2	--	11.7	18.5	4	9.6	5.2	15.5				
Colluvium		3	20.0	8.0	20.5	7	12.2	7.0	23.5				
Loess		3	21.2	16.0	23.0	6	11.6	8.5	18.2				
Residuum													
sandstone		5	8.8	2.2	83.2	12	13.0	9.2	20.5				
gray acid shale		5	19.7	17.0	85.2	13	15.2	10.7	39.5				
red calcareous shale		2	--	33.5	35.0	4	22.4	21.2	38.5				
gray calcareous shale		3	24.5	19.7	28.2	6	15.8	13.0	18.2				
limestone		23	26.7	16.7	77.5	47	18.9	9.7	66.2				
acid crystalline		7	21.7	13.5	39.5	18	10.6	4.5	28.7				
basic crystalline		5	18.0	13.0	24.5	10	8.8	4.2	14.5				
Alluvium, acid floodplain		1	19.5	--	--	2	--	11.0	18.2				

Table 3. Cont. Median, minimum, and maximum values for extracted elements of surface (A) and subsurface (B or C) horizons by parent material origin.

Element	Parent Material	Surface Horizon				Subsurface Horizon														
		No.	Median	Minimum	Maximum	No.	Median	Minimum	Maximum											
Cd, ppm	Glacial Till																			
	brown Wisconsinan	4	0.225	0.100	0.300	9	0.100	0.050	0.175											
	red Wisconsinan	3	0.500	0.325	0.700	6	0.188	0.175	0.300											
	pre-Wisconsinan	2	--	0.200	0.525	4	0.075	0.025	0.125											
	Colluvium	3	0.175	0.150	0.275	7	0.150	0.075	0.200											
	Loess	3	0.175	0.175	0.200	6	0.088	0.050	0.125											
	Residuum																			
	sandstone	5	0.200	0.025	0.400	12	0.025	0.025	0.125											
	gray acid shale	5	0.375	0.300	0.525	13	0.100	0.025	0.325											
	red calcareous shale	2	--	0.275	0.525	4	0.162	0.075	0.200											
	gray calcareous shale	3	0.450	0.400	0.650	6	0.225	0.100	0.350											
	limestone	23	0.225	0.050	0.700	47	0.100	0.000	0.850											
	acid crystalline	7	0.225	0.100	0.275	18	0.138	0.025	0.250											
	basic crystalline	5	0.175	0.100	0.250	10	0.062	0.025	0.225											
	Alluvium, acid floodplain	1	0.125	--	--	2	--	0.075	0.250											
	Cr, ppm	Glacial Till																		
		brown Wisconsinan	4	14.4	12.5	18.5	9	16.2	14.5	23.0										
red Wisconsinan		3	22.2	12.5	27.3	6	16.1	10.2	22.5											
pre-Wisconsinan		2	--	15.2	16.0	4	17.8	15.7	25.7											
Colluvium		3	17.5	15.2	19.2	7	28.7	25.7	35.2											
Loess		3	22.0	21.7	34.0	6	36.5	26.5	53.5											
Residuum																				
sandstone		5	7.5	1.3	22.2	12	12.2	2.7	33.2											
gray acid shale		5	21.2	16.7	30.0	13	32.0	21.0	40.0											
red calcareous shale		2	--	23.2	38.2	4	44.8	29.0	51.5											
gray calcareous shale		3	22.0	19.2	22.7	6	22.8	19.2	32.7											
limestone		23	25.0	13.0	43.0	47	36.4	17.7	82.7											
acid crystalline		7	23.0	10.2	32.7	18	23.8	1.0	41.7											
basic crystalline		5	112.0	32.5	141.0	10	134.4	62.7	360.0											
Alluvium, acid floodplain		1	16.0	--	--	2	--	18.8	19.5											