

Determination of Heavy Metal Contamination in Surface Soils of BLM Tracts along the Clark Fork River, Montana

Final Report Prepared by

**Dr. Johnnie N. Moore
Professor of Geology
University of Montana
October 2000**

**Under Agreement No. ESA990004, Task Order No. 2
July 3, 2000 through September 30, 2000**

Introduction

At the request of the U.S. Department of Interior, Bureau of Land Management (BLM) surface soil samples were collected from three tracts of BLM land along the Clark Fork River. These tracts are designated Tracts 1, 4 and 5 and located in previous BLM work at the sites. The tracts are located adjacent to the present or past channels of the Clark Fork River and likely received deposition of mining/milling wastes from the Butte/Anaconda area. The methods used followed those used in a similar study at the Grant-Kohrs Ranch National Historic Site. All methods and QA/QC can be found in the SOPs for that project. Presented here are the results of the BLM Surface Soil project that describe the concentrations of certain heavy metals and arsenic in the upper 12 inches of soil. Values are reported for arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). All samples except one for Cd were above the detection limits of the methods. For descriptive statistical purposes, the one sample (T1-9), is considered a missing value for Cd instead of assigning it some arbitrary value below the detection limit.

Descriptive statistics of all the data is presented in Table 1 and all the data is presented in Table 2 in Appendix I. The numbering scheme is used to denote a tract and a sample site within the tract. For example, T1-9 is sample site number 9 in tract number 1. In Table 1, the descriptive statistics for the five elements discussed are presented for all the samples (termed "total") and each tract (termed "T1", "T4" and "T5"). All the individual sampling sites are located on DLGs of each tract in the figures in Appendix II. Metals concentrations are given for each of those sites on accompanying maps.

Arsenic

The mean concentration of As for the three tracts was 77 ppm (Table 1) and ranged from a high of 115 for T5 (Tract 5) to a low of 48 for T4 (Tract 4). Maximum values were similar for the three tracts at 115 to 171 ppm. Minimum values were from 14 to 50 ppm.

At T1, the highest As value (171 ppm) was near the river channel at site T1-5 (see maps). In general, higher values were near the channel but there was not a simple distribution of

decreasing As concentrations away from the channel. Arsenic concentrations ranged from a low of 14 to a high of 171 ppm at T1, with a mean of 74 ppm.

Arsenic values at T4 were somewhat lower than those found at T1 ranging from 19 to 115 ppm, with a mean of 48 ppm. Five of six sample sites had values less than 52 ppm.

Tract Five had arsenic concentrations in the surface soil ranging from 50 to 158 ppm, with a mean of 115 ppm. The mean value is intermediate between T1 and T4, however there is less of a range in concentration at T5 than at either of the other tracts.

The median arsenic concentration of western U.S. soils is 7 ppm¹. All the values for all the tracts are above this value. Compared to the U.S. DoI "revised interim wildlife criteria"² mean arsenic concentrations at all the tracts are above the criteria established for Canada goose (61 ppm), trumpeter swan (76 ppm) and robin (4 ppm). Many individual sites at the three tracts exceed these criteria as well those for mallard ducks. Many of the values at all the tracts are above the "human risk management criteria" by U.S. DoI³. The risk criteria for a child resident is 0.6 ppm, well below all the values found all the tracts. The minimum value of 14 ppm for all the tracts is alone near or above the criteria for camp host (15 ppm), child camper (11 ppm) and worker (13 ppm). The highest values at T1 and T5 are above the criteria for surveyor (134 ppm). These data show that according to these criteria there is some risk from arsenic in these soils to wildlife and humans.

Cadmium

The mean concentration of cadmium in the surface soils of the three tracts averaged 3.8 ppm, and ranged from less than 1.0 ppm (the lower detection limit) to 11.4 ppm (Table 1). The highest values was at T1, where the mean Cd concentration was 4.7 ppm. Tract four had the lowest Cd values, with a mean of 1.8 ppm and range of 1.4 to 2.6 ppm. Tract five ranged from 1.8 ppm to 3.9 ppm with a mean of 3.0 ppm. These values are several times higher than the western U.S. soil median concentration of 0.32 ppm¹. The distribution of Cd concentrations was not uniformly related to proximity to the river channel (see maps).

The mean values of Cd in soils at all the tracts (3.8 ppm) is above the interim wildlife criteria for white-tailed deer (3 ppm), mule deer (3 ppm), elk (3 ppm), mallard (1 ppm), Canada goose (2 ppm), trumpeter swan (2), and robin (0.3 ppm). The highest value at T1 (11.4 ppm) is above the criteria for these animals plus deer mouse (7 ppm), cottontail (6 ppm), and bighorn sheep (9 ppm). It is close to the criteria for domestic sheep (12 ppm) and cattle (15 ppm). Mean concentrations of Cd are also above the human risk criteria set for child resident (2 ppm).

¹ Cited in Table 3, Risk Management Criteria for Wildlife in USDoI, BLM Information Bulletin No. RS-99-004 supplied by Peter Bierbach, August 29, 2000.

² Ibid, Table 1.

³ Ibid, Table 2.

These data show that based on the U.S. DoI criteria, there is some risk to wildlife from the Cd in the soils at the three tracts and possibly some risk to humans.

Copper

The mean copper value for all the tracts is 712 ppm, ranging from 449 to 1638 ppm. Tract five had the highest values with a mean concentration of 1256 ppm (range, 448 to 1638 ppm). Tract four had a mean concentration of 528 ppm (range, 359 to 1054 ppm) and T1 a mean concentration of 609 ppm (range, 107 to 1299 ppm). All values of Cu found in all the tracts were several times higher than the western U.S. median concentration of 27 ppm⁴. In general, the Cu concentrations were higher at sample sites closer to the river, but there is no simple relationship between Cu values to proximity to the river (see maps).

Mean Cu concentration for all the tracts combined (712 ppm), was above all the U.S. DoI interim wildlife risk management criteria for all the animals listed (see Table 1 in citation above). The combined tract minimum Cu concentration (107 ppm) was above the criteria for 4 of the animals listed and the minimum concentrations for T4 and T5 were above all the criteria for all but two of the animals listed.

Comparison to U.S. DoI human risk criteria show that copper values in the soils are of potential risk to a child resident (74 ppm) at all the sample sites (minimum value of 107 ppm). The highest values at T5 (1638 ppm) were also above the criteria set for child camper (1319 ppm); the high value at T1 (1299 ppm) was also very close to this criteria.

These data show that according to the U.S. DoI criteria, there is a potential for risk to wildlife and children from Cu contamination in these soils.

Lead

Lead concentrations at the tracts range from 34 to 298 ppm, with a mean for 121. The highest values of Pb are in samples from T5, where the mean concentration was 206 ppm (range, 95 to 298 ppm). Mean concentrations at T4 were 147 ppm (range 107 to 218) and 89 (range, 34 to 173) at T1. The median concentration of Pb in western U.S. soils is 20 ppm⁴; all the values found in the tracts were above this value (see maps for the distribution of Pb at each site).

Mean Pb concentrations for all the tracts combined were above U.S. DoI interim wildlife criteria for mule deer (106 ppm), mallard (59 ppm), Canada goose (34 ppm), trumpeter swan (43 ppm), and robin (6 ppm). The mean was close to Pb criteria set for white-tailed deer (124 ppm). The maximum value of Pb in the soil at T5 (298 ppm) was above all the wildlife and livestock criteria listed. The high value for T4 (218 ppm) was above the criteria set for 11 of the 12 animals listed.

⁴ Ibid, Table 3.

Lead concentrations were not above any criteria set for human risk management criteria.

Zinc

The mean Zn values for all the samples combined from all the tracts is 944 ppm with a very large range from 187 to 4113 ppm. This overall range was defined by the range in values at T1. The other tracts had lower concentrations and smaller ranges. T1 had a mean value of 1256 ppm and a range of 187 to 4113. T4 had a mean of 275 ppm and a range from 215 to 460 ppm. T5 had a mean of 521 and a range of 241 to 652. All the values found in all the tracts were above the western U.S. median Zn concentration of 65 ppm⁵

Many of these values lie above the U.S. DoI interim wildlife criteria. The mean value at T1 is above the criteria for all 12 animals listed. The high value at T T5 is above the criteria for 11 of the 12 animals listed (all but cattle) and the mean value is above the criteria for 10 of the 12 animals listed (all but cattle and sheep). The high value at T4 is above the criteria for 10 of the 12 animals (all but cattle and sheep) and the mean value is above 6 of the 12 listed animals.

Comparison to U.S. DoI human risk criteria show that mean concentrations at all the sites are above the criteria set for child resident. The highest values at T1 are above the criteria set for camp host, child camper and worker.

These data show that there is some potential risk, based on the U.S. DoI criteria, to wildlife, livestock and humans from Zn concentrations in the surface soils at the three tracts.

Summary

All the tracts have sites with metals elevated over median values found in western U.S. soils. Many sites are elevated in respect to wildlife and human health risk criteria used by the U.S. DoI, BLM. The distribution of metals at each tract is complex. To establish the detailed configuration of metal contamination will require a higher resolution of sampling. The data presented here is only for the upper 12 inches of soil. There is no information on the depth the contamination reaches below 12 inches. To determine the vertical distribution and the total volume of contaminated soils would require more extensive sampling the soil profile to determine the lower level of contamination.

⁵ Ibid, Table 3.

TABLE 1

**Descriptive Statistics
Split By: Tract**

	As (ppm), Total	As (ppm), T1	As (ppm), T4	As (ppm), T5
Mean	77	74	49	115
Std. Dev.	45	43	34	40
Std. Error	8	9	14	16
Count	33	21	6	6
Minimum	14	14	19	50
Maximum	171	171	115	158
# Missing	0	0	0	0

	Cd (ppm), Total	Cd (ppm), T1	Cd (ppm), T4	Cd (ppm), T5
Mean	3.8	4.7	1.8	3.0
Std. Dev.	2.7	3.1	.5	.8
Std. Error	.5	.7	.2	.3
Count	32	20	6	6
Minimum	1.1	1.1	1.4	1.8
Maximum	11.4	11.4	2.6	3.9
# Missing	1	1	0	0

	Cu (ppm), Total	Cu (ppm), T1	Cu (ppm), T4	Cu (ppm), T5
Mean	712	609	528	1256
Std. Dev.	449	384	264	433
Std. Error	78	84	108	177
Count	33	21	6	6
Minimum	107	107	359	448
Maximum	1638	1299	1054	1638
# Missing	0	0	0	0

	Pb (ppm), Total	Pb (ppm), T1	Pb (ppm), T4	Pb (ppm), T5
Mean	121	89	147	206
Std. Dev.	67	43	38	77
Std. Error	12	9	15	31
Count	33	21	6	6
Minimum	34	34	107	95
Maximum	298	173	218	298
# Missing	0	0	0	0

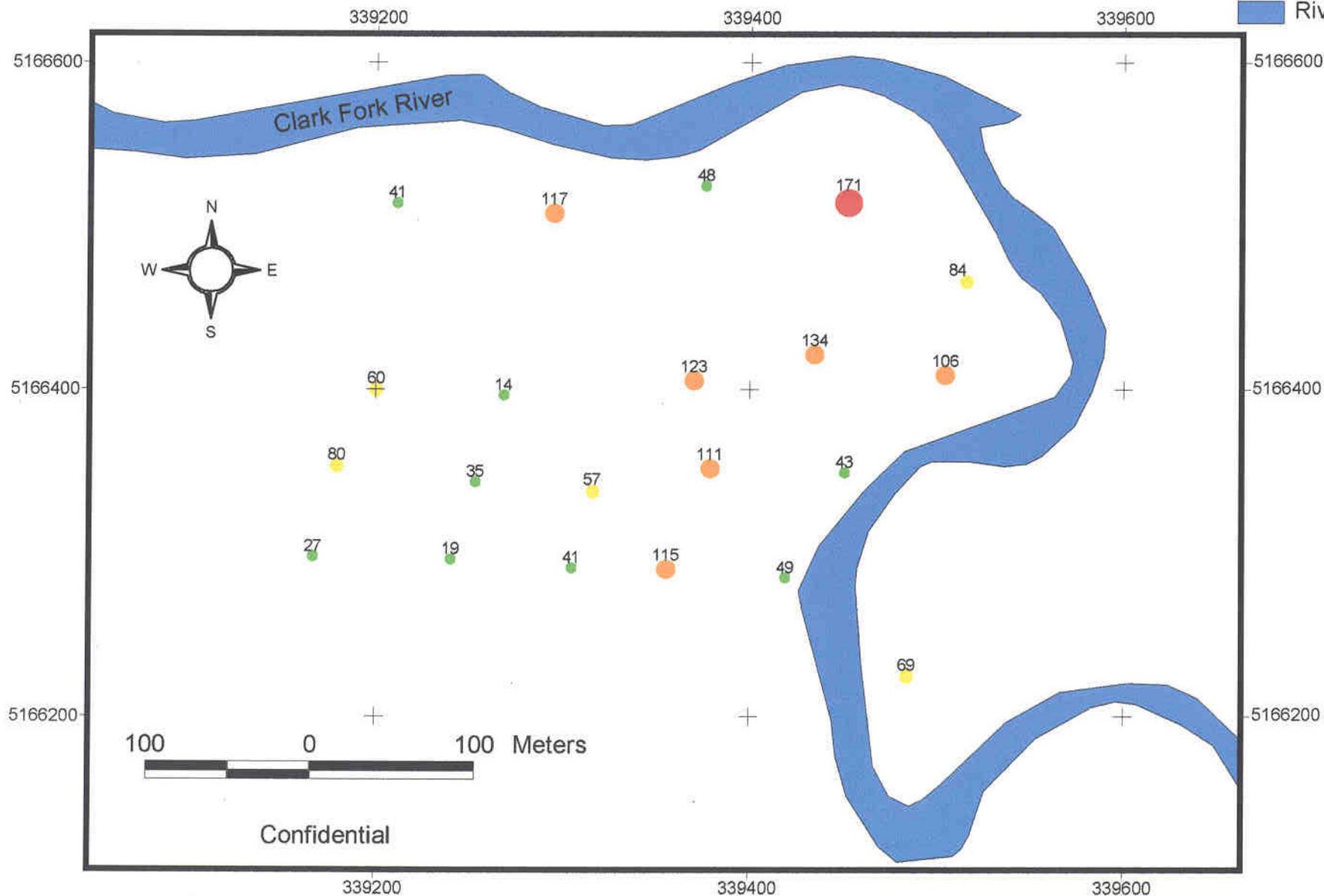
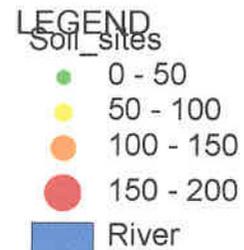
	Zn (ppm), Total	Zn (ppm), T1	Zn (ppm), T4	Zn (ppm), T5
Mean	944	1256	275	521
Std. Dev.	968	1096	93	149
Std. Error	168	239	38	61
Count	33	21	6	6
Minimum	187	187	215	241
Maximum	4113	4113	460	652
# Missing	0	0	0	0

TABLE 2

Soil Sample Site pql =	pH	As (ppm) 10	Cd (ppm) 1	Cu (ppm) 6	K (ppm) 80	Pb (ppm) 8	Zn (ppm) 1
T1-1	7.62	49	2.6	382	2,801	64	584
T1-2	7.92	43	2.0	346	2,299	63	556
T1-3	7.39	106	8.8	927	3,186	124	2,602
T1-4	7.55	84	7.0	740	2,411	103	2,373
T1-5	7.45	171	6.9	1,299	3,003	173	2,231
T1-6	7.45	48	3.8	427	2,201	73	1,260
T1-7	7.70	117	9.4	1,092	3,314	156	3,037
T1-8	7.73	41	3.5	347	2,221	60	757
T1-9	7.85	14	<1.0	107	3,324	34	187
T1-10	7.25	123	3.9	1,166	3,774	130	1,060
T1-11	7.58	134	5.8	1,068	2,960	143	1,930
T1-12	7.13	115	11.4	1,082	2,442	144	4,113
T1-13	7.00	41	1.4	195	3,673	41	284
T1-14	7.68	19	1.1	126	3,830	40	222
T1-15	7.22	27	1.2	141	3,544	42	212
T1-16	7.19	80	1.6	696	4,147	74	279
T1-17	7.39	60	4.2	532	3,649	79	716
T1-18	7.59	35	1.9	216	3,769	47	347
T1-19	7.30	58	3.8	452	4,020	74	621
T1-20	7.49	111	9.4	902	3,386	130	1,768
T1-21	7.46	69	3.9	552	2,876	81	1,246
T4-1	7.75	115	2.6	1,054	3,553	218	460
T4-2	7.31	19	2.0	496	2,025	107	274
T4-3	8.14	28	1.6	412	3,001	145	229
T4-4	7.89	52	1.5	368	3,230	130	229
T4-5	7.79	41	1.4	359	3,568	132	215
T4-6	7.51	36	1.7	482	3,073	151	244
T5-1	8.06	158	3.9	1,340	3,051	159	573
T5-2	7.87	87	2.6	1,146	3,481	229	472
T5-3	7.46	139	3.6	1,394	3,260	178	584
T5-4	7.08	137	3.3	1,638	2,864	278	601
T5-5	7.32	118	2.7	1,572	3,030	298	652
T5-6	7.59	50	1.8	448	3,500	95	241

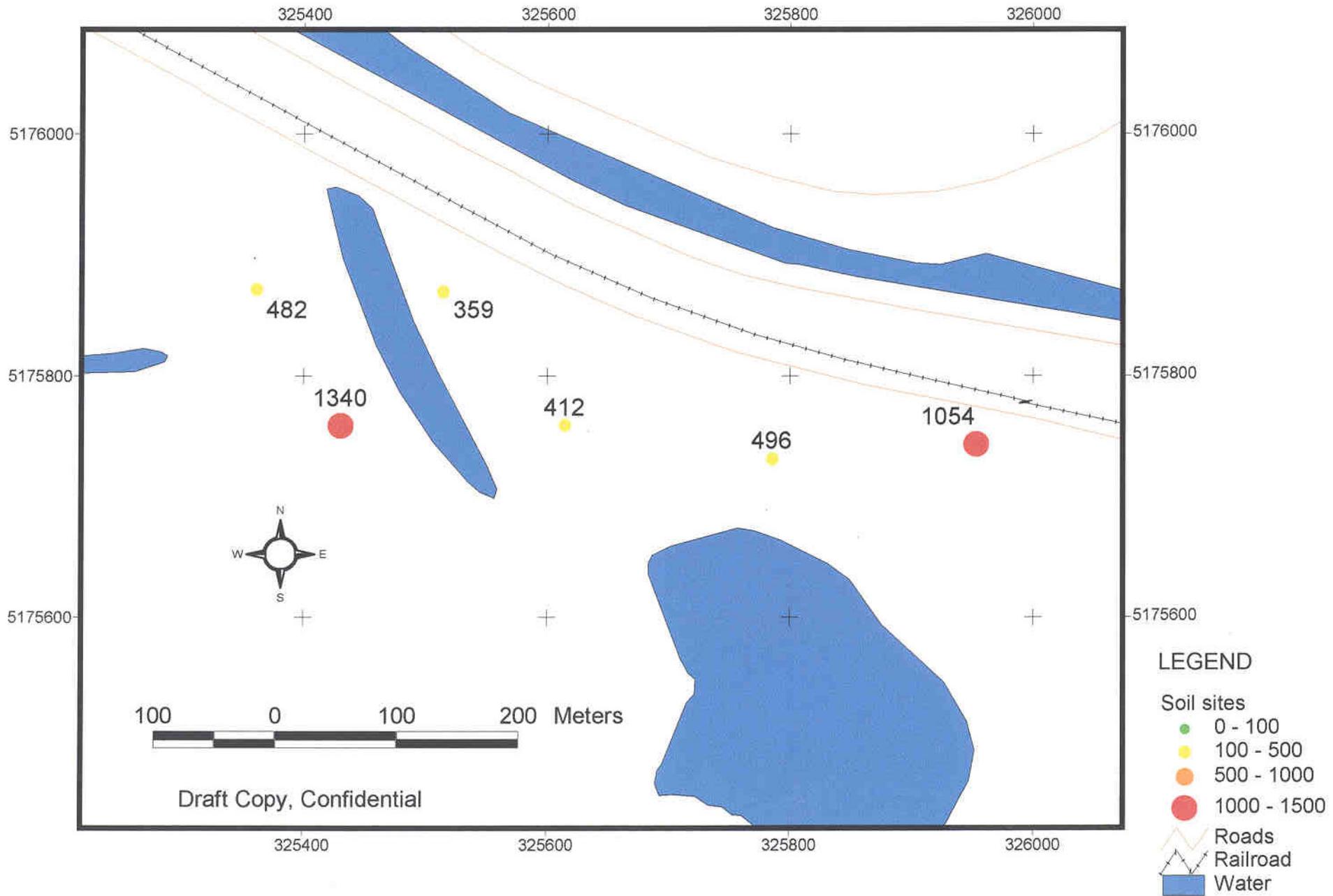
This data is presented in numerical format instead of scientific notation for clarity of presentation. The values should be considered valid to only 3 significant figures or the significant figures presented where less than 3. pql = practical quantification limit.

BLM Tract 1: As Concentrations (units are ppm) 2000

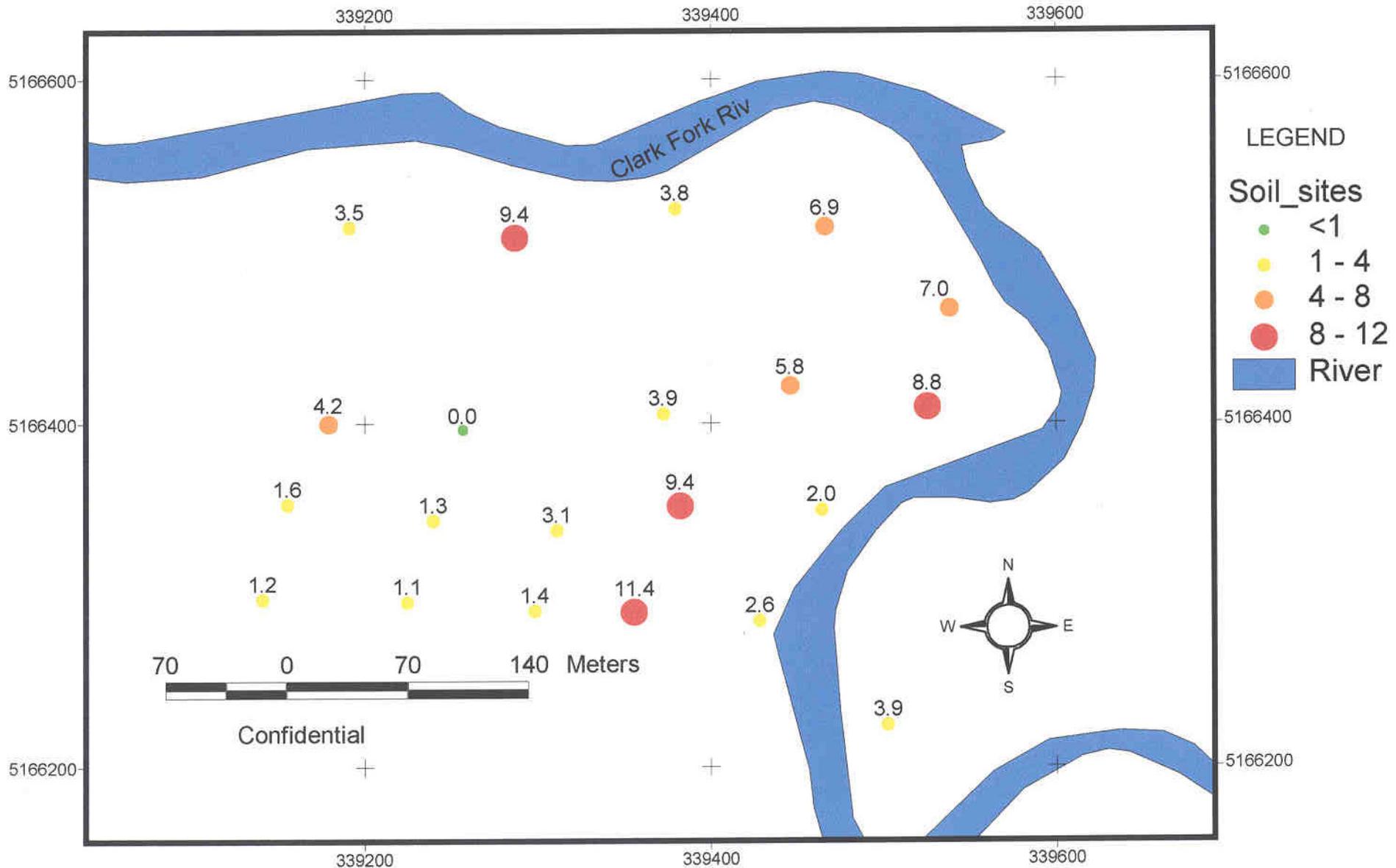


Confidential

BLM Tract 4: Cu Concentrations (units are ppm) 2000



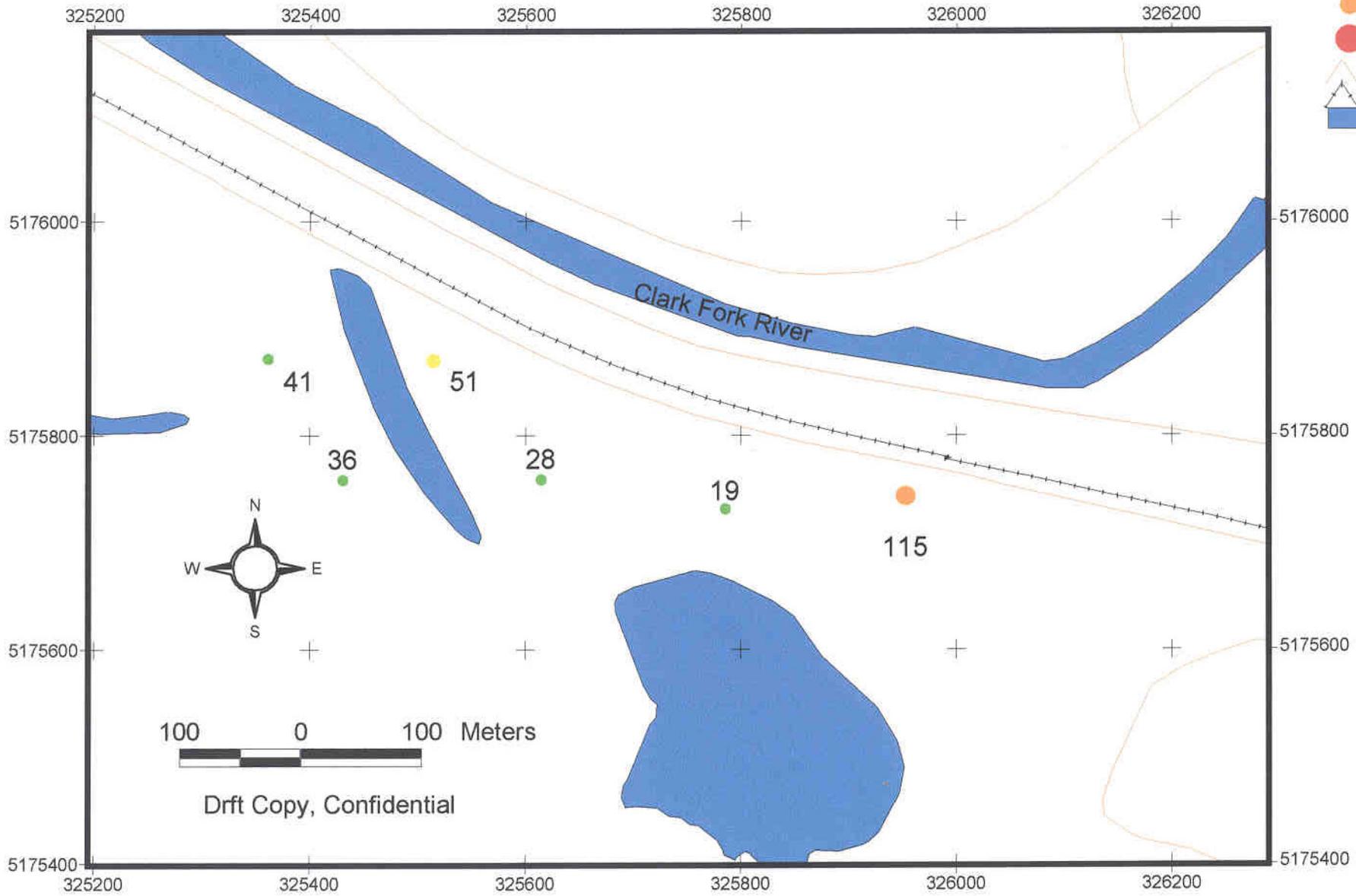
BLM Tract 1: Cd Concentrations (units are ppm) 2000



BLM Tract 4: Arsenic Concentrations (units in ppm)
2000

LEGEND

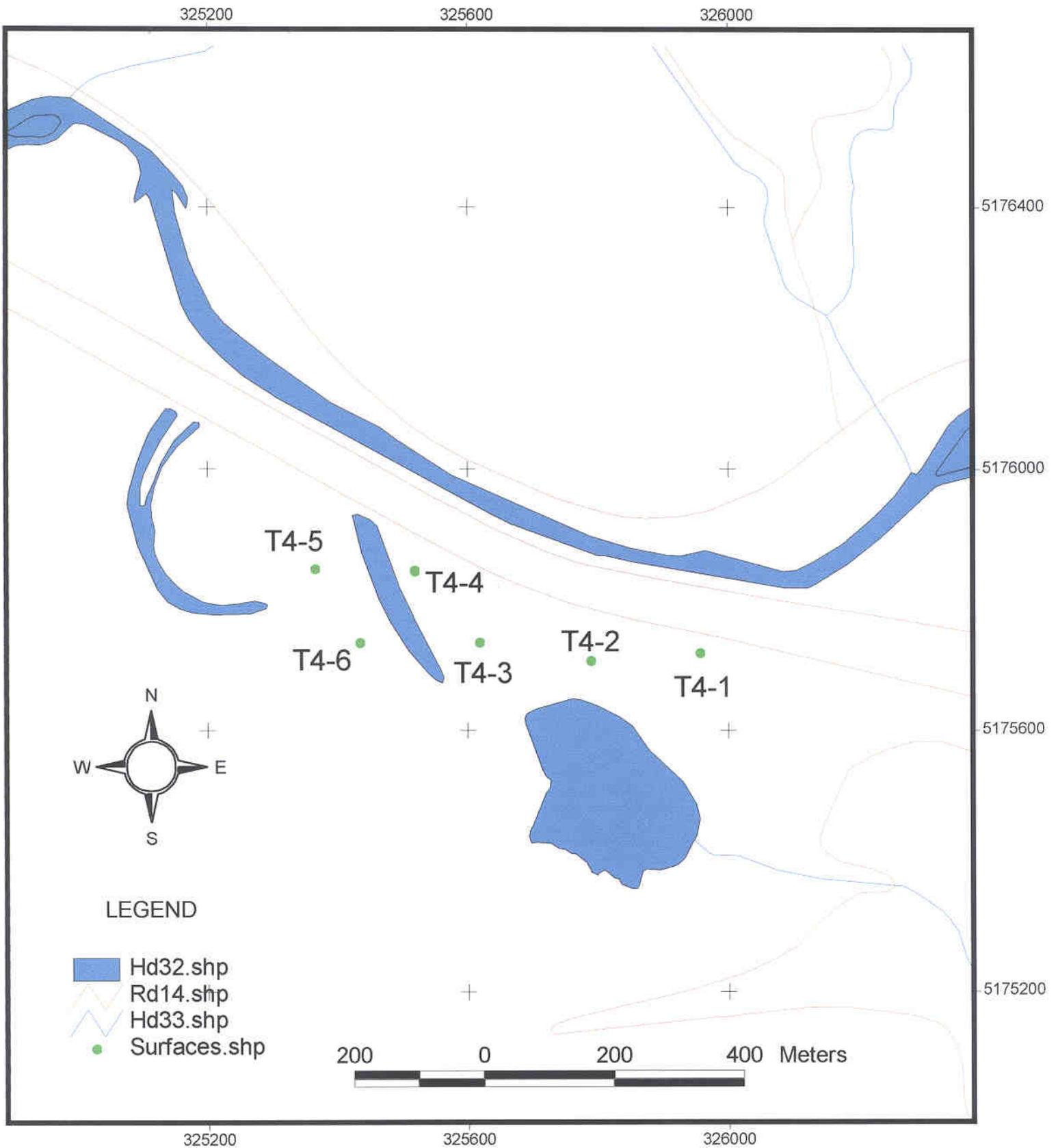
- Soil sites
- 0 - 50
 - 50 - 100
 - 100 - 150
 - 150 - 200
- Roads
Railroad
Water



100 0 100 Meters

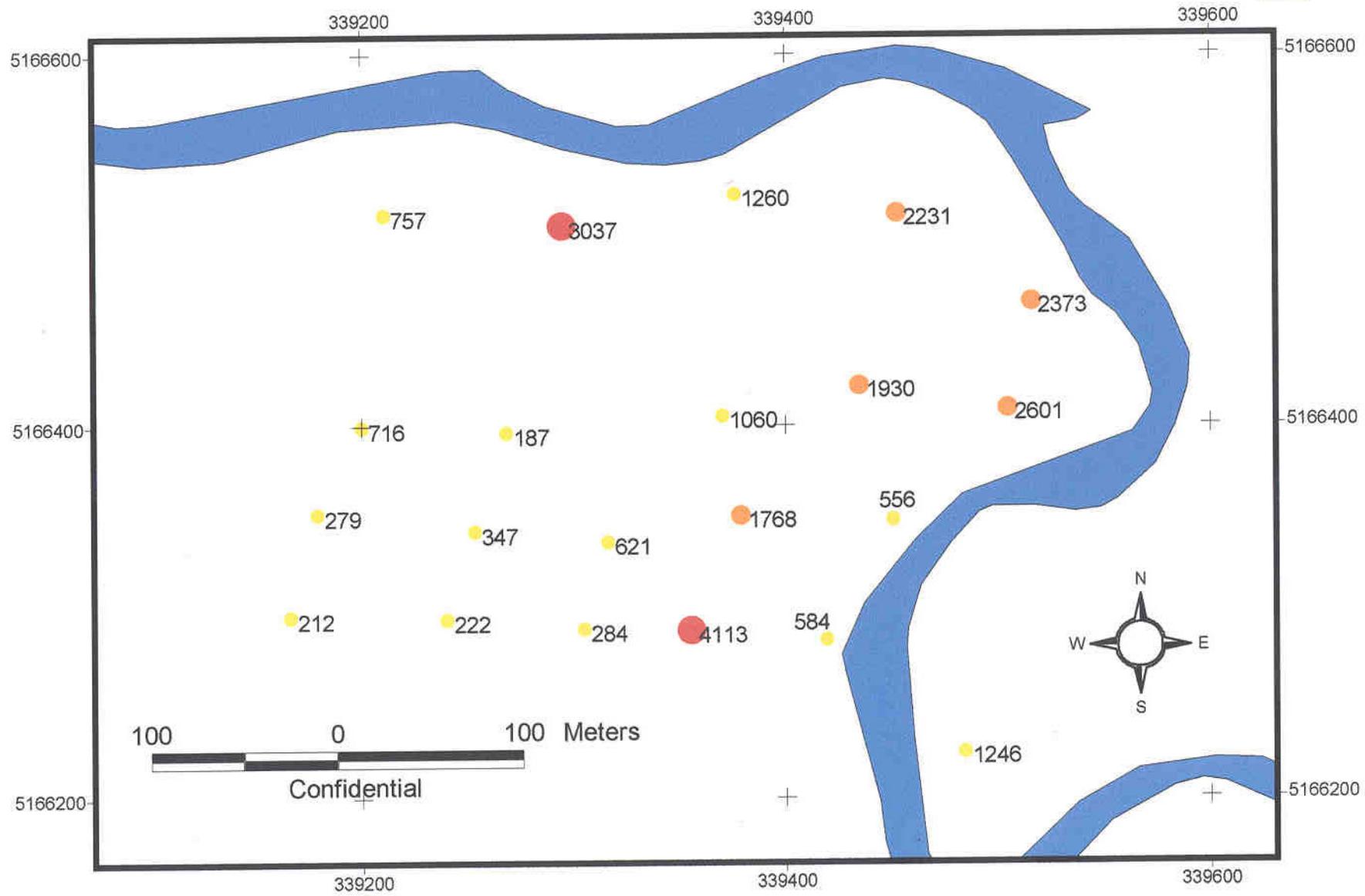
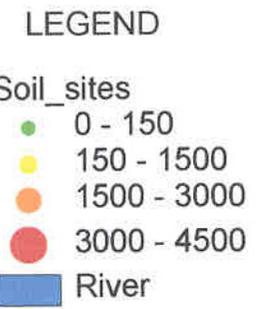
Drft Copy, Confidential

BLM Project: Tract 4 2000



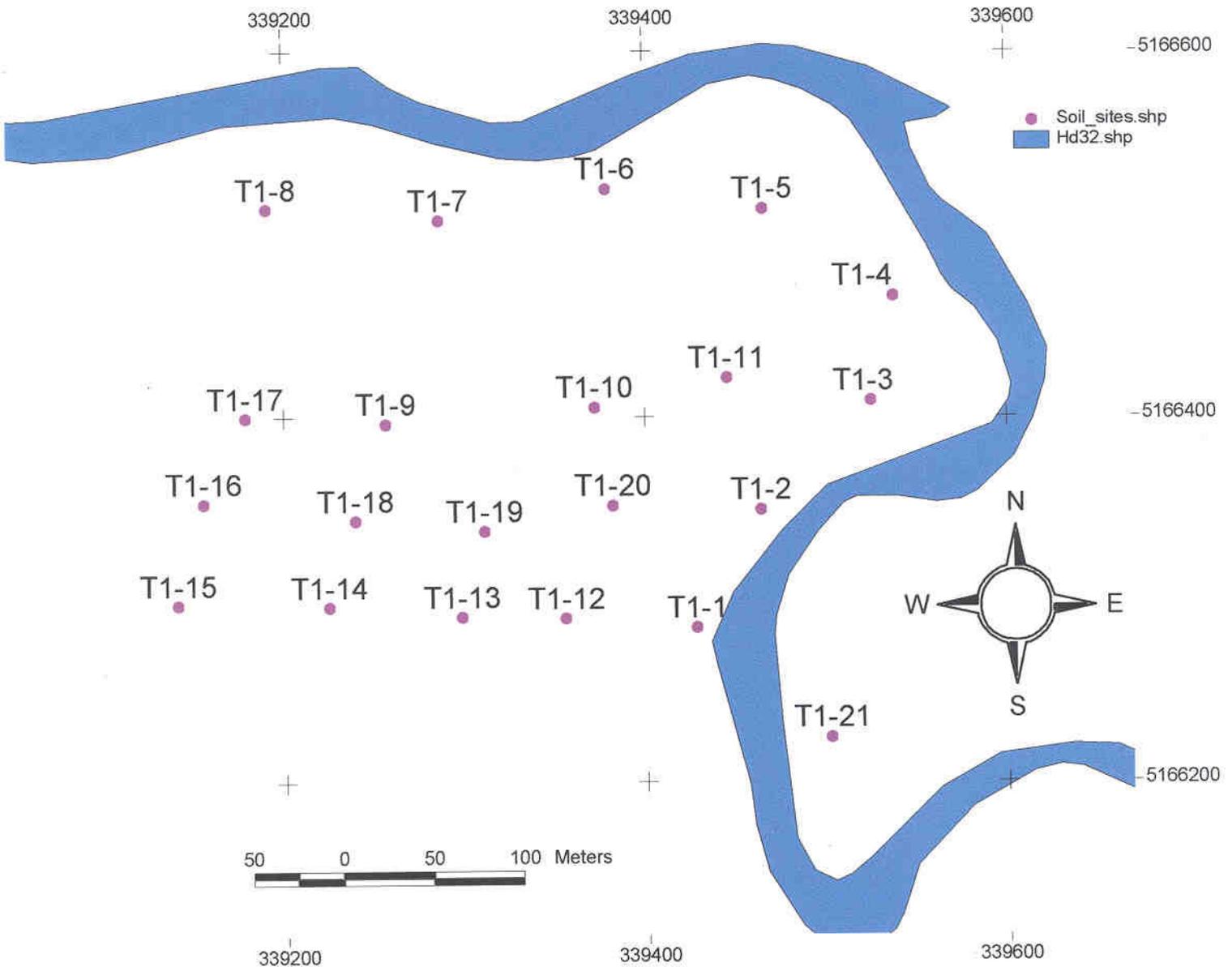
Draft Copy, Confidential

BLM Tract 1: Zn Concentrations (units are ppm) 2000



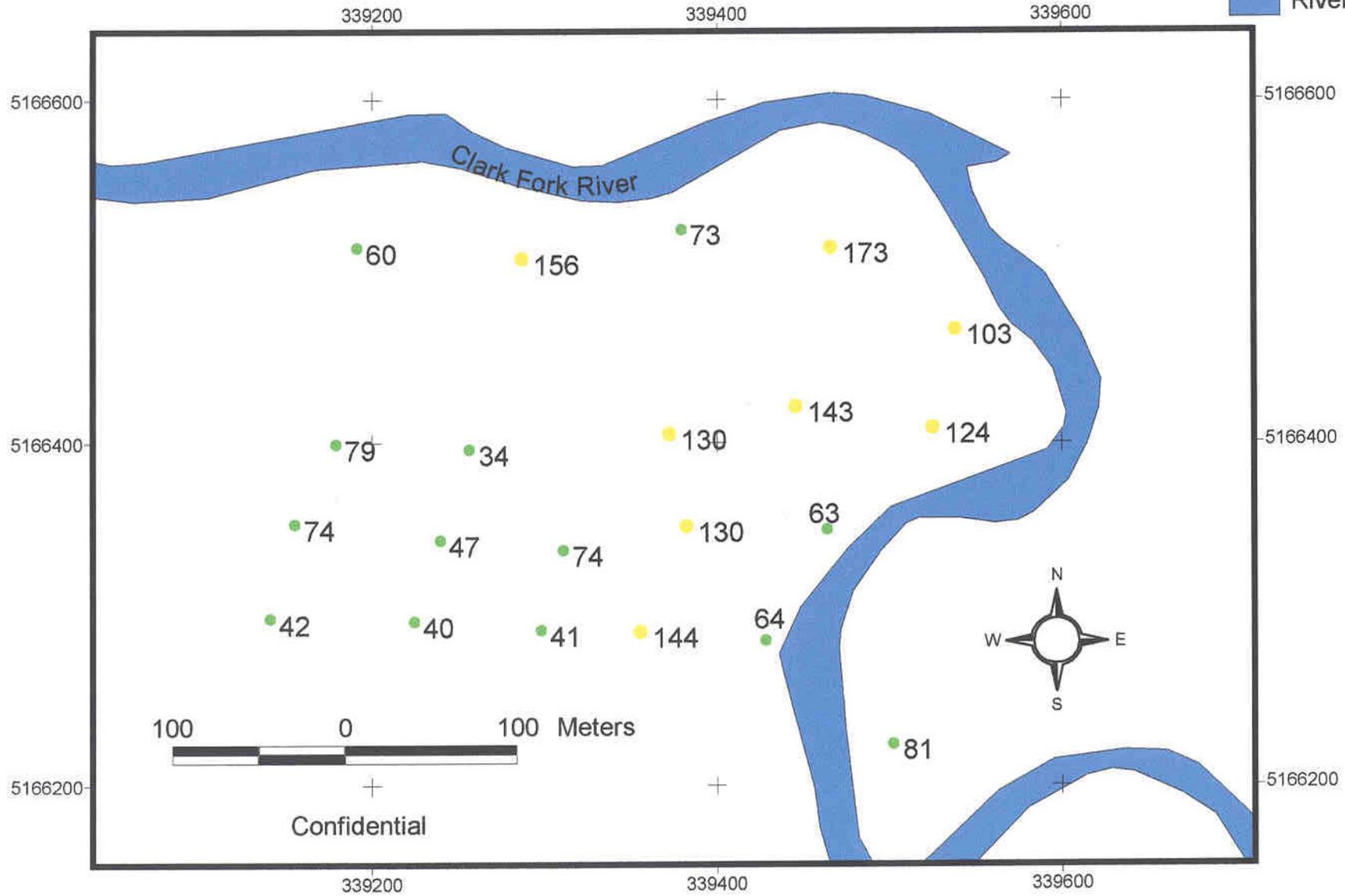
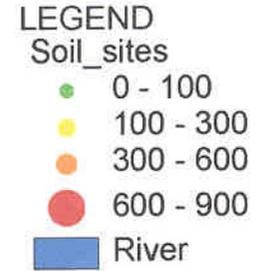
Tract 1: BLM Project 2000

LEGEND

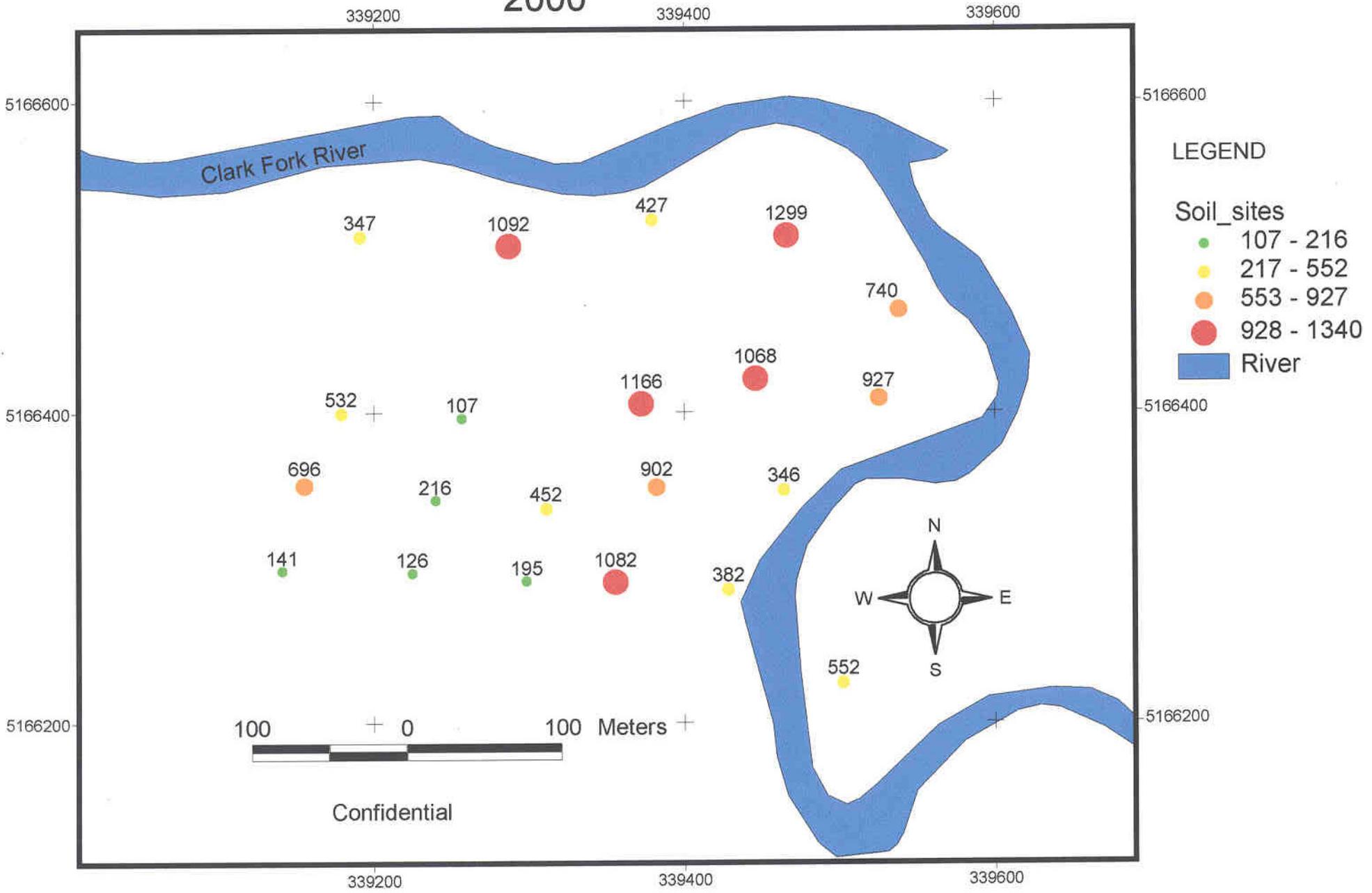


Draft Copy, Confidential

BLM Tract 1: Pb Concentrations (units are ppm) 2000



BLM Tract 1: Cu Concentrations (units are ppm) 2000



Confidential

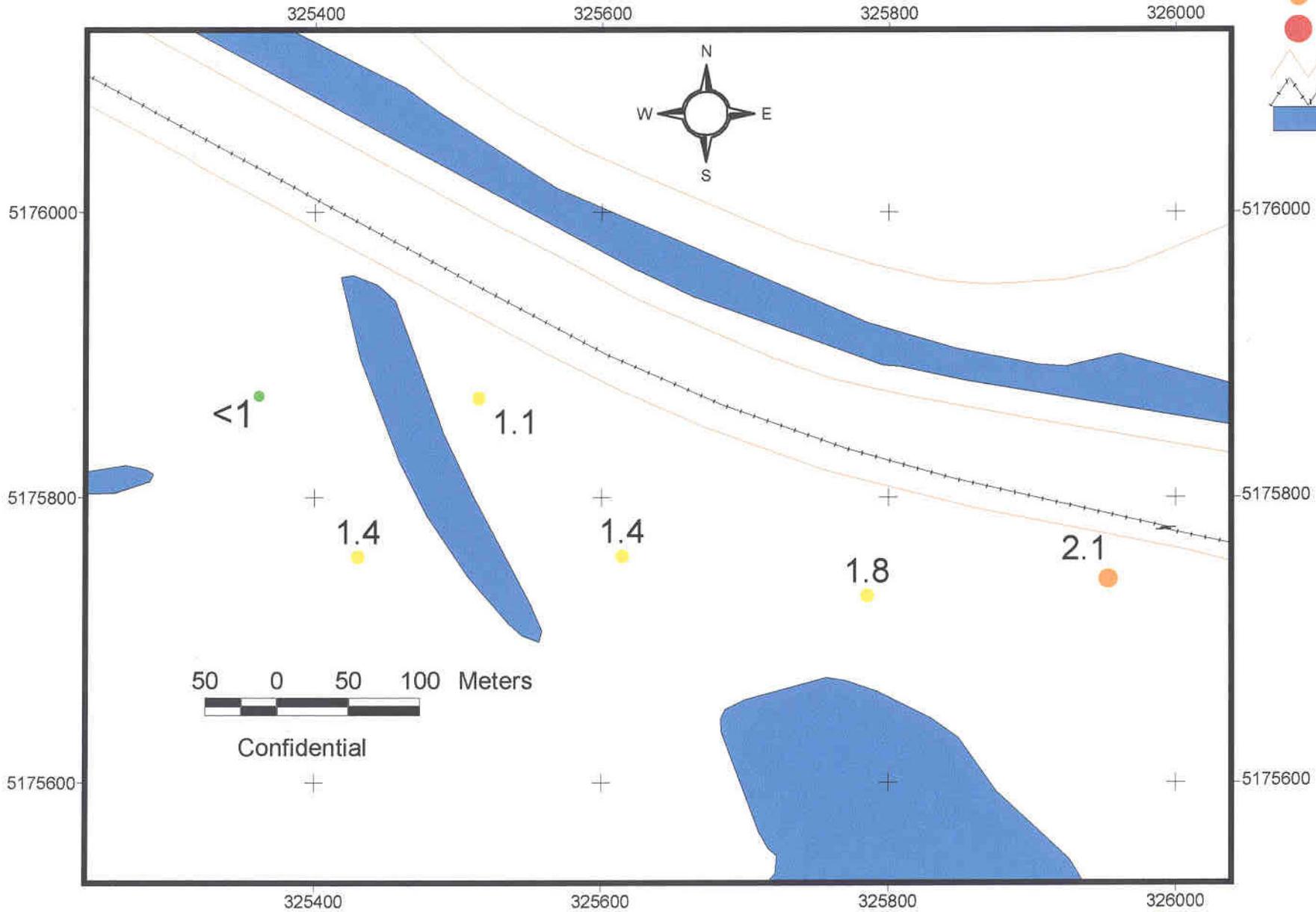
BLM Tract 4: Cd Concentrations (units are ppm) 2000

LEGEND

Soil sites

- <1
- 1 - 2
- 2 - 3
- 3 - 4

- Roads
- Railroad
- Water



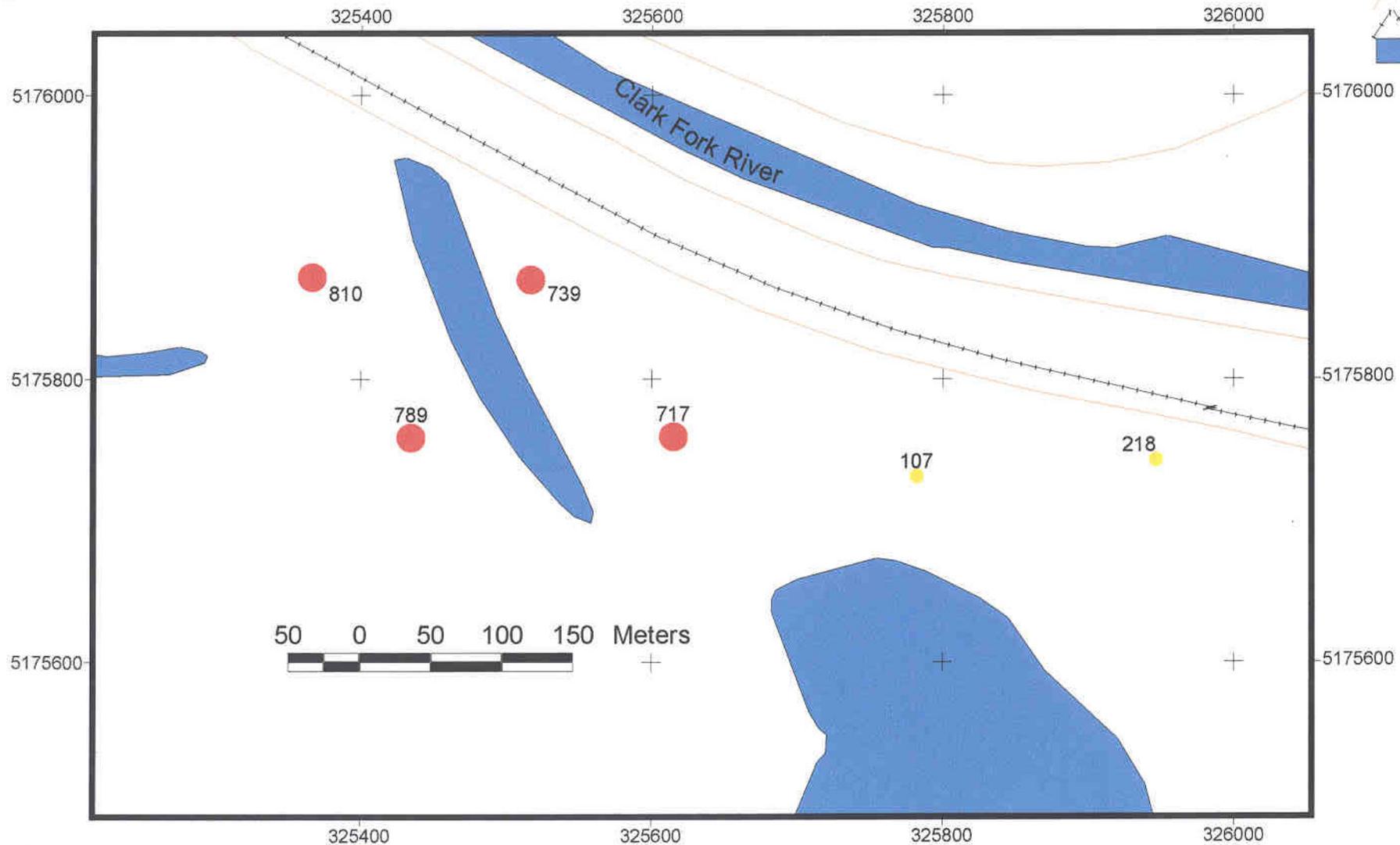
50 0 50 100 Meters

Confidential

BLM Tract 4: Pb Concentrations (units are ppm) 2000

LEGEND

- Soil sites
- 0 - 100
 - 100 - 300
 - 300 - 600
 - 600 - 900
- Roads
- Railroad
- Water

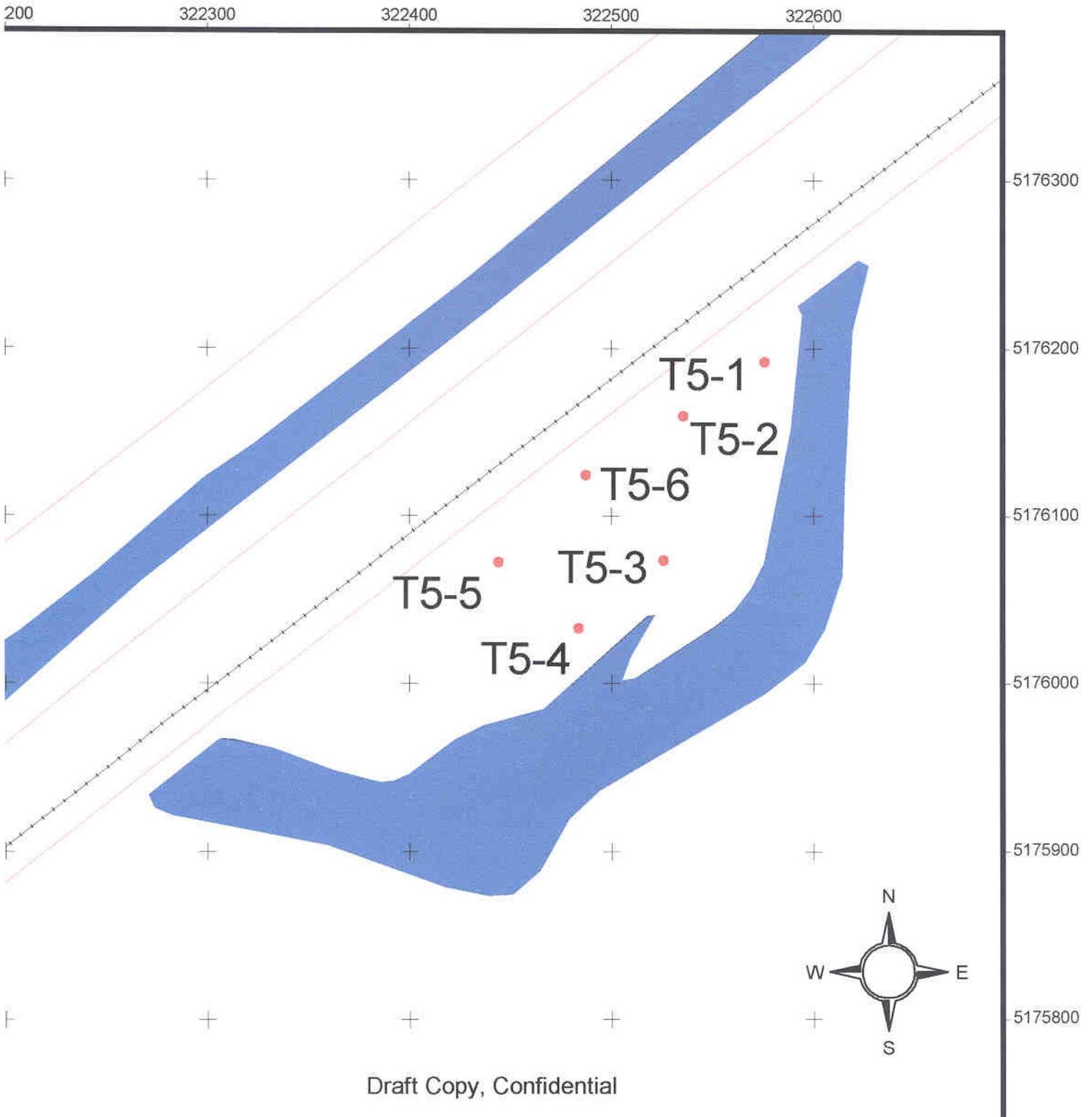


BLM Project: Tract 5 2000

LEGEND

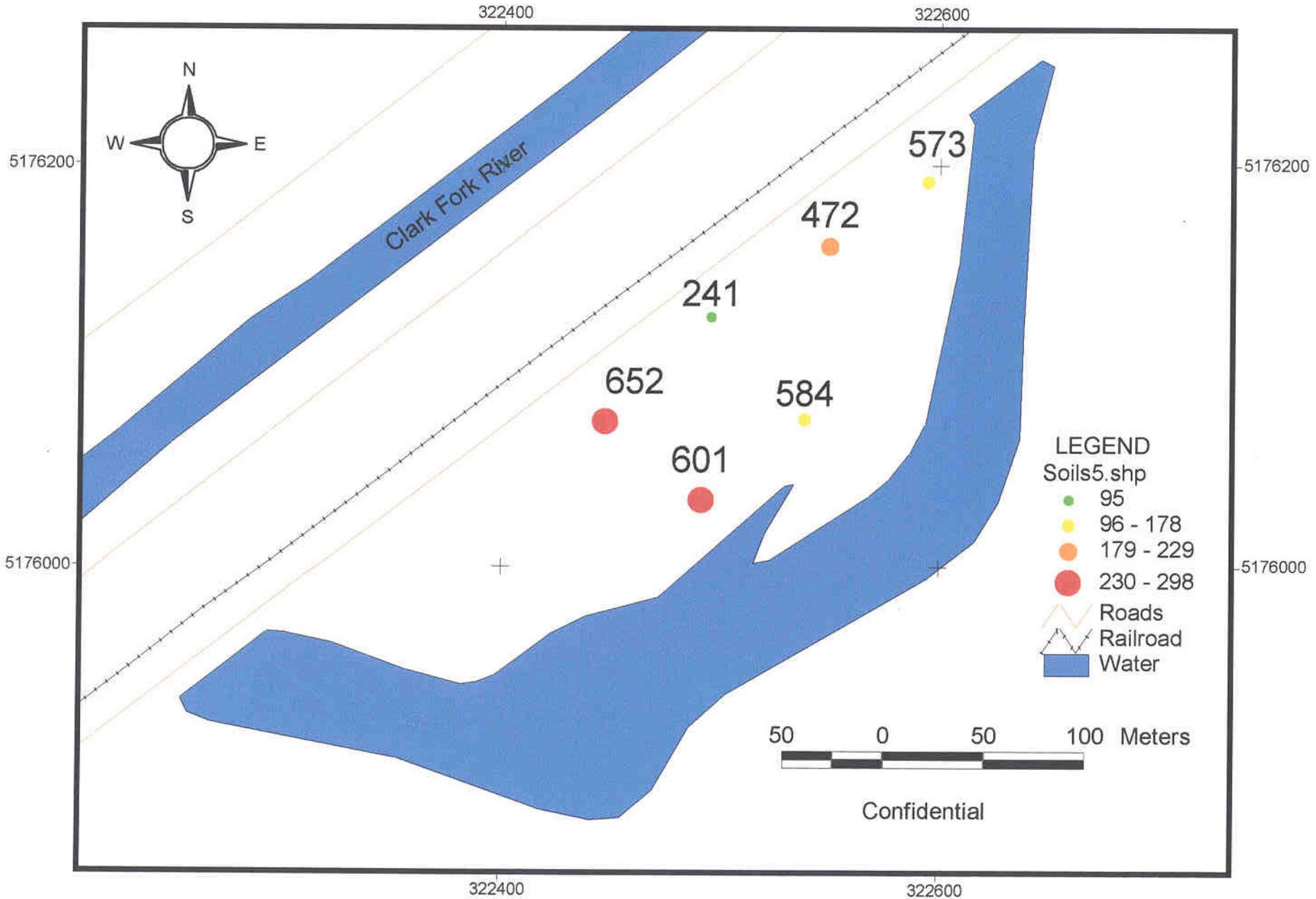
- RR
- Roads
- Water_outline
- Water
- Soil samples

100 0 100 Meters



Draft Copy, Confidential

BLM Tract 5: Pb Concentrations (units in ppm)
2000



BLM Tract 5: Cu Concentrations (units are ppm)
2000

LEGEND

Soils5.shp

0 - 100

100 - 500

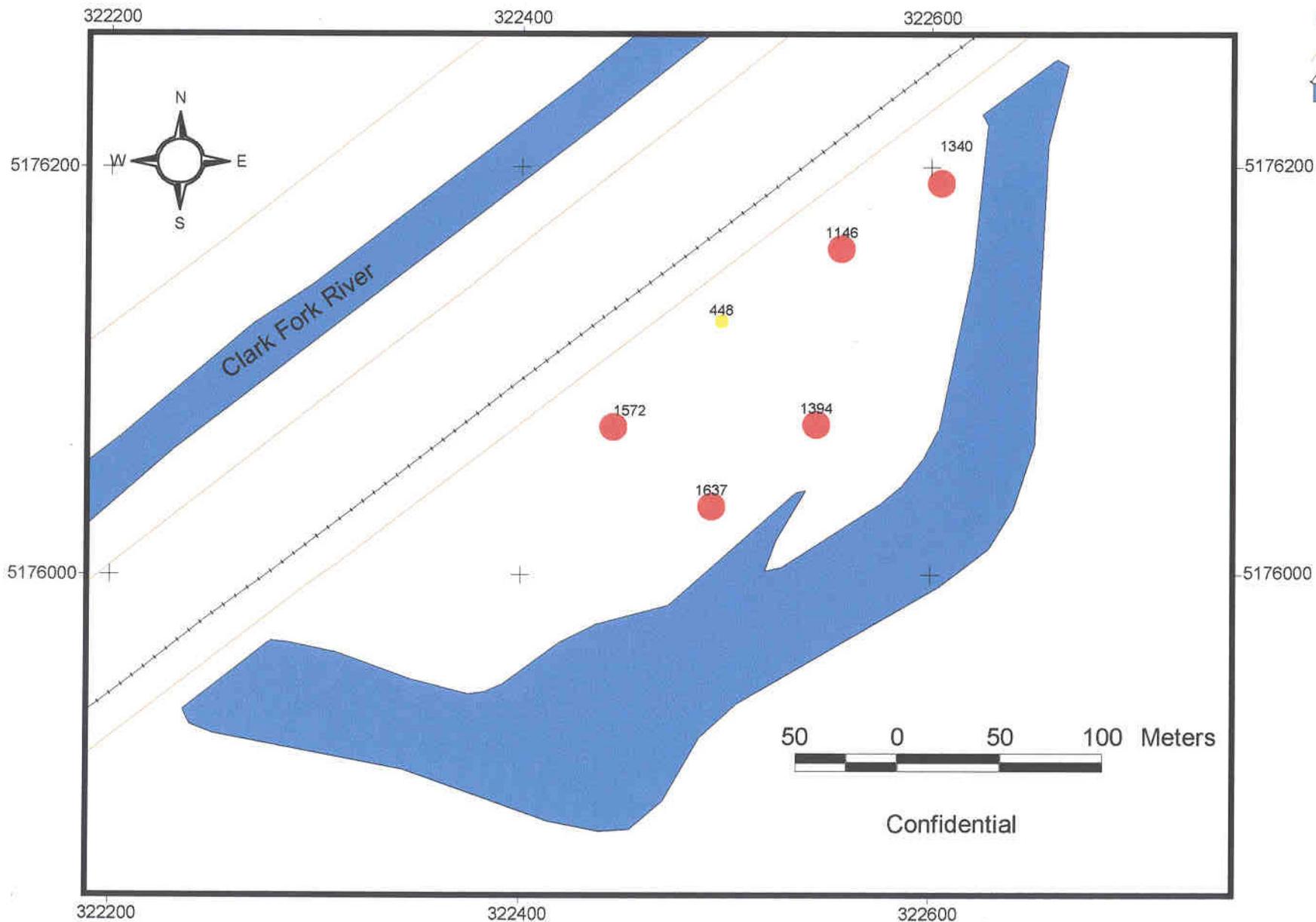
500 - 1000

1000 - 2000

Roads

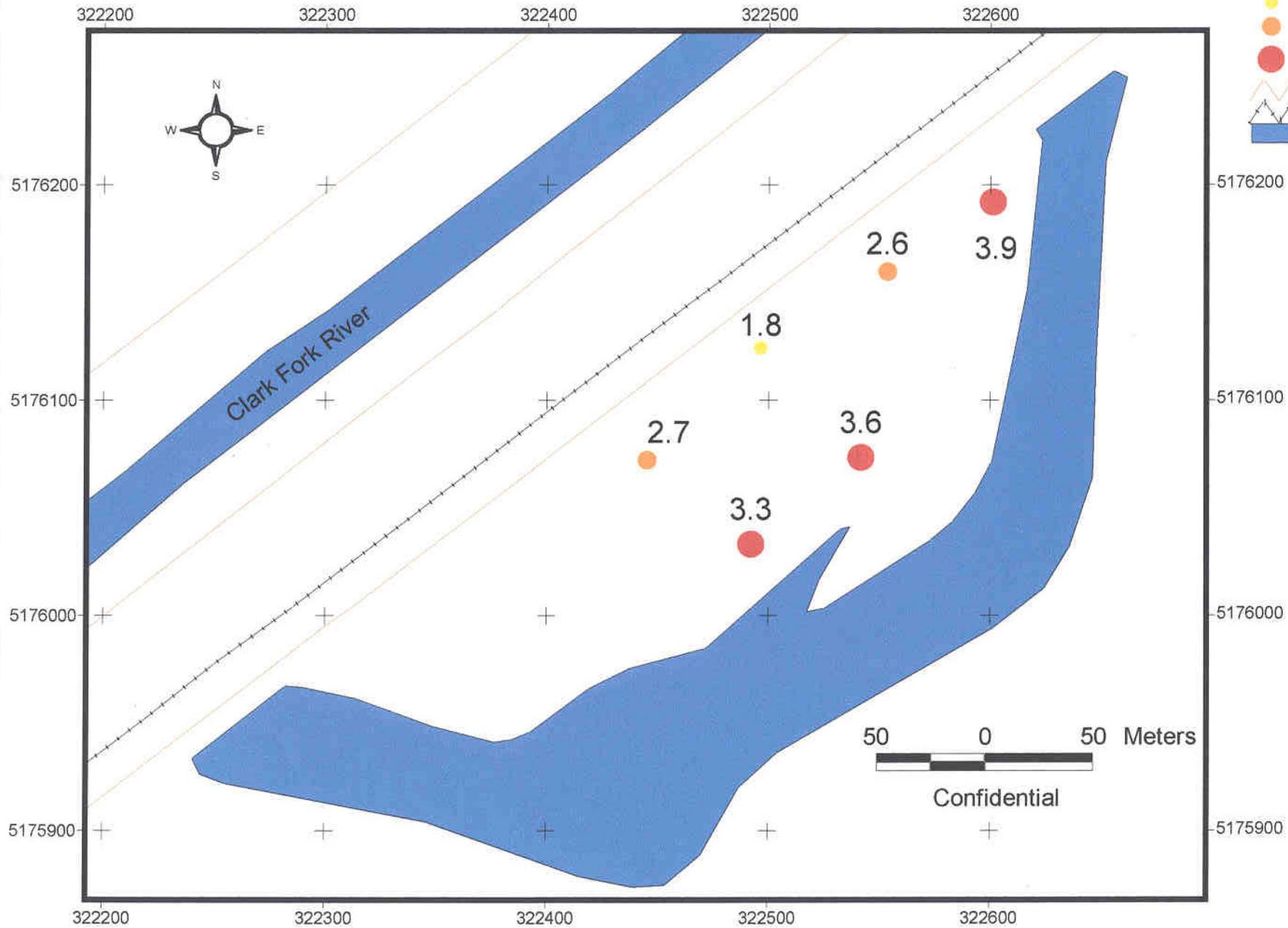
Railroad

Water



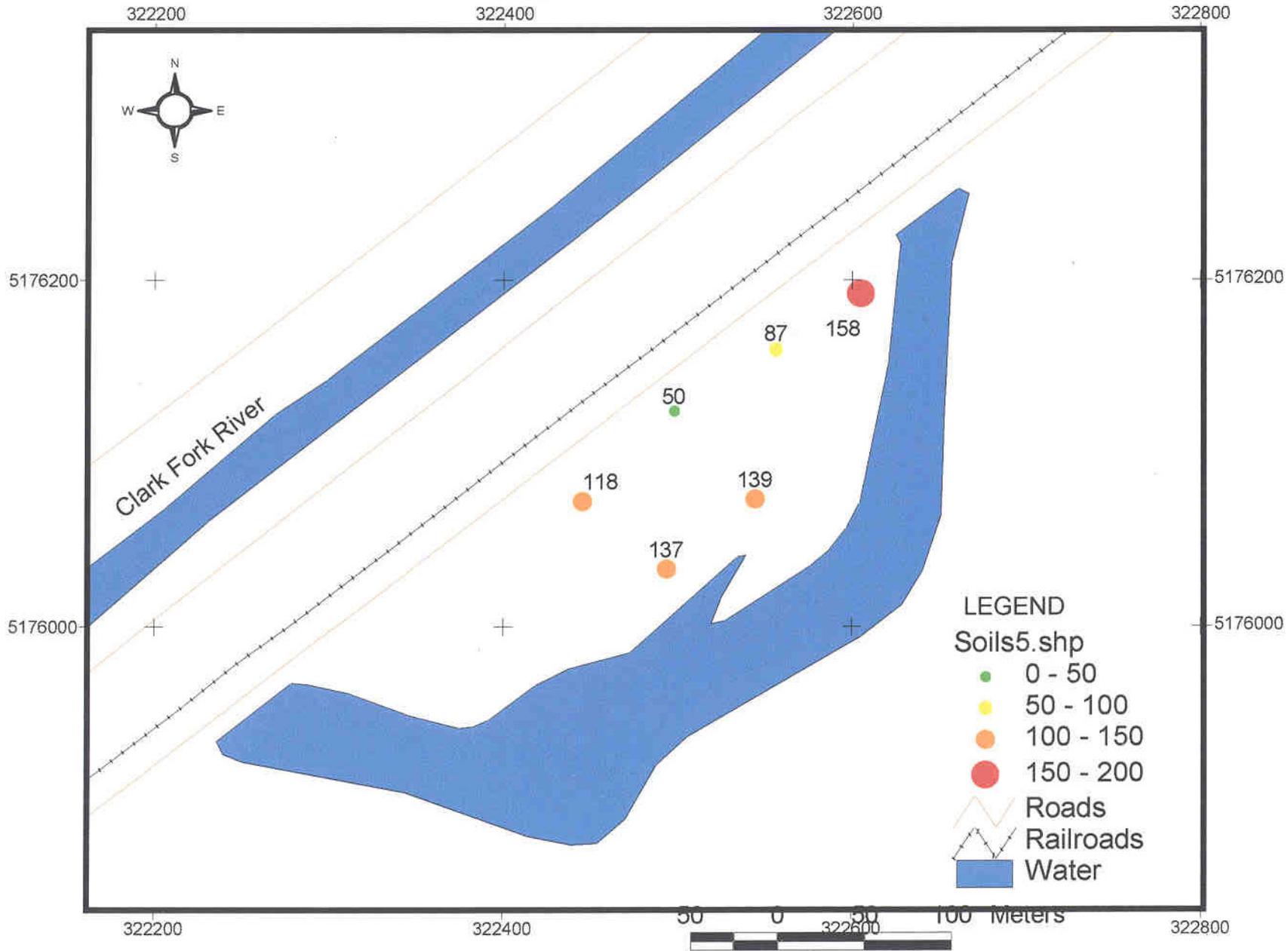
BLM Tract 5: Cd Concentrations (units are ppm)
2000

- LEGEND**
Soils5.shp
- <1
 - 1 - 2
 - 2 - 3
 - 3 - 4
- Roads
Railroad
Water



Confidential

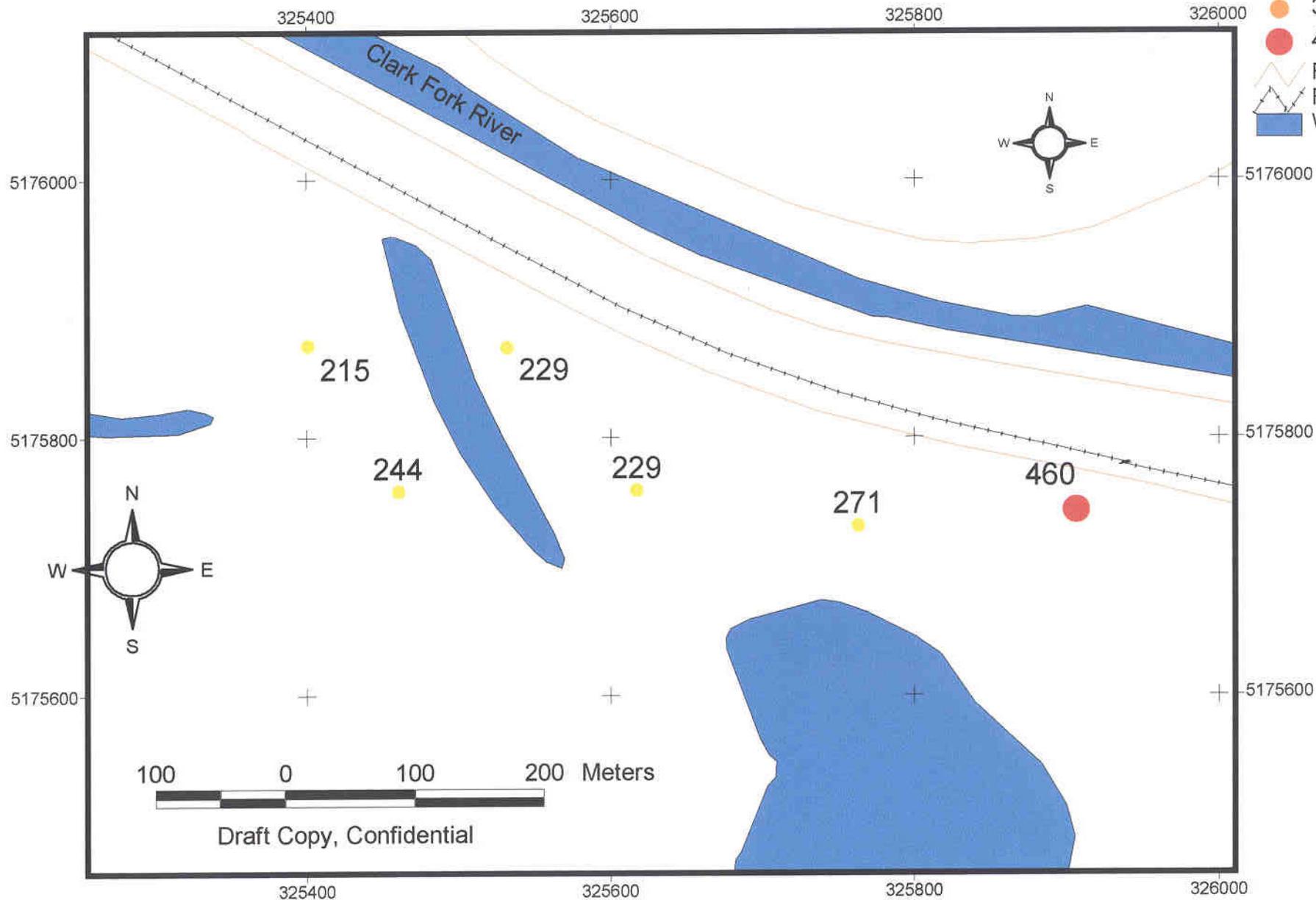
BLM Tract 5: As Concentrations
(units are ppm)
2000



Confidential

BLM Tract 4: Zn Concentration (units are ppm) 2000

- LEGEND
- Soil sites
 - 0 - 150
 - 150 - 300
 - 300 - 450
 - 450 - 600
 - Roads
 - Railroad
 - Water



BLM Tract 5: Zn Concentrations (units in ppm)
2000

