Prior to retrieving the testing data from state and federal sources, NEBRA chose approximately 10 facilities in each state that were representative of the common types of biosolids recycling and final products in that state. An attempt was also made to choose facilities of varying sizes, serving both rural and urban areas, in each state. The chosen facilities, listed by the name of the communities they serve, were:

Chart A-6: Biosolids Trace Metal Data Sources

Maine	Massachusetts	New Hampshire	Vermont
Bath	Boston	Allenstown	Barre
Bethel	Holyoke	Claremont	Bennington
Brunswick	Lowell	Concord	Chelsea
Gardiner	Mansfield	Dover	Johnson
Jay	Marlborough	Franklin	Middlebury
Kennebec Sanitary Dist. - Waterville	Pepperell	Hooksett	Randolph
Lewiston-Auburn	Williamstown	Keene	Richmond
Ogunquit		Milford	St. Albans
Portland		Nashua	St. Johnsbury
York		Plymouth	Stowe

All of the data in this report is compared to the strictest federal (Exceptional Quality or "EQ") and state standards. U. S. EPA and state limits were determined based on studies of potential receptors and are designed to be fully protective of the environment and public health and safety.

A.3 Trace Metal Data Quality Control

To create graphs and determine state averages, the collected trace metal data was transcribed into Microsoft Excel workbooks and reviewed for accuracy. Specific quality control checks were performed on any data points that deviated from the state averages by more than 20%. All of the data were linked electronically to create the state averages and graphs, thus reducing the chance of error due to incorrect data transfer.

Data quality is also provided by comparing data from different sources, compiled and reported by different people. A few data points do not say much, but when there is a large amount of consistent data, collected over time and involving many different people, it begins to be possible to have a great deal of confidence in the accuracy of the data. Such is the case with biosolids trace metal data for New England.

For example, Chart A-7 was compiled in 2000 from data collected from random samples taken from biosolids products in New Hampshire. The samples were collected by regulatory personnel at random times and sites. The New Hampshire trace metal averages reported in Chart 3.5 of this NEBRA report are provided at the bottom of the Chart A-7, for comparison. Note that while there is some variability, as expected, the random sampling data confirms the general accuracy of the data collected and reported by facility personnel.

Chart A-7: New Hampshire Quality Control Data
(from NH Dept. of Environmental Svcs.)

Lab #	Arsenic (32)	Cadmium (14)	Copper (1500)	Chromium (1000)	Lead (300)	Mercury (10)	Molybdenum (35)	Nickel (200)	Selenium (28)	Zinc (2500)
A2980-1	7.5	3.86	534	171	87.9	NT	10.1	162	3	628
A4326-1	7.2	2.36	268	43.9	90.2	3.06	<10	19.9	3.6	643
A4326-2	7.4	6.36	1300	51.6	134	2.35	18.9	39.2	6.2	2020
A4326-3	6.4	1.27	282	14.4	23.5	2.51	20.7	5.8	2.7	358
A4558-1	8.1	<1.98	249	34.7	50.7	1.68	<10	12.7	3.6	511
A4786-1	4.3	<1.96	182	44.2	45.1	0.11	<19.6	13	2.4	395
A4786-2	<3	<3.46	1320	17.4	42.9	0.16	<34.6	21	3.5	2230
A4786-3	7.4	5.94	916	47.4	125	1.75	<41.2	45.4	5.8	1430
A5816-1	6.3	4.89	860	46	123	4.42	<28.8	43	4.9	1360
A5816-2	3.6	<1.79	123	18.4	38	1.09	<17.9	10	<1.8	320
A5999-1	2.8	<1.64	NT	NT	18	0.451	NT	NT	<1.6	NT
A6718-2	7.9	3.95	212	35.8	41.5	1.55	<20.4	18	2	479
A6718-3	6.1	2.92	803	34.2	84.2	1.63	11	28.6	4	45.5
A13395-4	***34***	5.6	***1500***	63	170	3.7	23	56	<18	2100
Standard Deviation*	7.79	2.04	489.52	39.64	46.95	1.32	6.09	40.77	2.19	763.11
Mean	7.89	3.04	657.62	47.85	76.71	1.88	13.46	36.51	3.74	963.04
Average from NEBRA-compiled data, for comparison (from Chart 3.5)	**2**	**3**	**433**	**20**	**49**	**2**	**11**	**18**	**2**	**663**

< - Indicates that the metal concentration is below the minimum detection level shown
NT – not tested

A 1997 analysis of Vermont biosolids quality data conducted by the Vermont Department of Environmental Conservation (VT DEC) provides another independent confirmation of the accuracy of the data compiled by NEBRA in this report (see Chart A-8, below). Some variation exists due to the fact that the data analyzed by VT DEC was from a different year.

A.4 Trace Metal Detection Limits

Laboratories report concentrations of the targeted metals compounds in milligrams per kilogram. If a metal is not detected, the laboratory reports that the concentration of that metal was "less than X", where X represents the lowest detection limit of the analytical machinery. To be conservative, in those cases where laboratory analysis failed to detect a metal, for purposes of averaging, NEBRA chose to assign the detection limit as the concentration of that metal, even though the actual concentration may have been below that level. Therefore, even though the stated average concentrations of most metals are well below the strictest federal and state standards, the actual average concentrations may be even lower than that.

Chart A-8: Comparison of Vermont Biosolids Quality Data Reported Here and by VT DEC (parts per million or mg/kg)		
	Saving Soil **Report - VT 1999 data**[1]	**VT DEC Data - 1997 study**[2]
Arsenic	9	10.47
Cadmium	3	6.08
Chromium	31	58.69
Copper	490	783.8
Mercury	2	2.58
Molybdenum	9	N/A
Nickel	22	34.82
Lead	72	112.14
Selenium	6	5.07
Zinc	649	994.52

1 - see Chart 3.3
2 - from a 1997 study by VT DEC, reported in Vermont Final Proposed Revised Solid Waste Master Plan, July 2001.

A.5 Variability of Trace Metal Levels

This question sometimes comes up: "Couldn't there be an elevated level of a trace contaminant that goes through the system undetected and could negatively impact the site where biosolids are put to use?"

There are several checks and balances that provide assurance that any particular truckload of biosolids is unlikely to cause significant negative impact. Indeed, because of the amount of scrutiny applied to biosolids recycling, it presents fewer "unknowns" than many other commonly accepted practices, such as land applying animal manures that may contain antibiotics, trace metals, excessive nutrients, and other potential pollutants.

First, remember that biosolids are produced by wastewater treatment facilities that are living systems. Any high level of toxic material entering the system would disrupt the facility's operations and lead to additional testing and monitoring of biosolids coming from the facility at that time.

Secondly, the wastewater treatment process is a long, continuous process, that mixes, dilutes, and spreads out any variability in the quality of the wastewater entering it.

Thirdly, statistical analyses are occasionally conducted on biosolids testing data. Because it is impossible or excessively expensive to test every cubic yard of biosolids, or even every truckload, assessments of biosolids quality often rely on statistical analysis. Statistics can help answer the question, "How likely is it that a given truckload of biosolids will contain some trace contaminant at a level that exceeds the regulatory standard?"

For example, during the past two years, New Hampshire Department of Environmental Services (NHDES) scientists asked Professor Thomas Ballestero of the University of New Hampshire's

Department of Civil Engineering to conduct a statistical analysis of the trace metals data for New Hampshire biosolids. According to the report compiled by NHDES,

> "A review of the metals data obtained in the 2000 field season shows that, except for copper and zinc, the probability of exceeding a state standard is less than 1% (less than 1 in 100). For copper and zinc, the probability of a violation is approximately 5% (5 times in 100)."

Dr. Ballestero is continuing this work and will be delivering another report to NHDES in the fall of 2001.

And, finally, it is helpful just to review the data from one facility and look at the high and low test results along with the calculated average concentrations. Chart A-9 below shows the variability in concentrations of selected metals from individual samples collected and analyzed at one facility (Lewiston-Auburn, ME) between 1994 and 1999. All of the test data for arsenic, cadmium, mercury, and lead--the trace metals of greatest concern--are presented.

A-6: Accumulation of Trace Metals in Agricultural Soils

For many years, one of the greatest concerns with the practice of biosolids recycling has been the potential long-term impacts of accumulation of trace metals--especially arsenic, cadmium, mercury, and lead--in soils to which biosolids are applied for many years. U. S. Department of Agriculture and other researchers have extensively studied this concern (see Chaney, 1999).

Chart A-10 shows how biosolids managers and farmers calculate the *agronomic rate* --the rate at which biosolids may be applied so that only enough nitrogen is supplied to grow the crop. Using the agronomic rate ensures little risk of excess nitrogen negatively impacting groundwater.

Agronomic rate applications determine how much biosolids is applied to each acre of soil for each crop cycle. Chart A-10 also shows how biosolids managers and farmers can calculate approximately how much of each trace metal is applied to the land with the biosolids application. In this example, a typical application rate of 3.1 dry tons of biosolids per acre results in, for instance, 3 pounds of zinc being applied per acre (see Chart A-10).

U. S. EPA and other scientists assessed the risks of trace metals levels in soils and established regulatory standards for cumulative soil metals levels as part of the federal Part 503 rule. In order to give a sense of how small is each annual addition of trace metals from a typical New England biosolids application, Chart A-10 shows how many years a typical application of biosolids could be made before the U. S. EPA limit is reached. In this example, a typical biosolids application could occur for more than two hundred years before any of the trace metals begin to reach the current regulatory maximum. And this is a conservative figure; given current biosolids management practices, the actual period of time might be two or three times greater, because

- many farmers use biosolids on a particular field only every few years, and
- the first-year agronomic rate of application is higher than in future years.

Chart A-11 shows a similar calculation, using an average Vermont biosolids for an example.

Charts A-10 and A-11 include comparisons to Washington state and Canadian limits for annual additions of metals to soils applied in fertilizers (biosolids are not covered by these laws, unless they are sold with fertilizer claims; biosolids have been shown to make metals less bioavailable, which is not the case with fertilizers). And Charts A-10 and A-11 include comparisons to the very conservative recommendations of the Cornell Waste Management Institute (see Harrison et. al., 1999)

Additional Charts

- Chart A-12 provides data on the Use and Disposal of Biosolids in each New England state. This data is graphed in Chart 2.4.
- The last set of charts shows the averages, by state, of trace metals levels over time.

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Chart A-9: Assessing Variability--High, Low, and Average Concentrations for Arsenic, Cadmium, Mercury, and Lead in a Typical Biosolids Recycling Facility in New England

Year	Metal	Number of Samples Tested *	Average	Lowest Concentration	Highest Concentration	State and (Federal EQ) Standards
1994	Arsenic	6	9.25	7.00	10.60	41 (41)
	Cadmium		2.27	0.90	4.30	10 (39)
	Mercury		0.66	0.52	0.82	10 (17)
	Lead		84.67	58.00	109.00	300 (300)
1995	Arsenic	12	14.31	3.40	67.00	41 (41)
	Cadmium		3.58	2.00	5.00	10 (39)
	Mercury		0.16	0.10	0.78	10 (17)
	Lead		87.92	72.00	132.00	300 (300)
1996	Arsenic	12	10.71	0.90	57.00	41 (41)
	Cadmium		3.50	1.00	7.00	10 (39)
	Mercury		0.10	0.10	0.10	10 (17)
	Lead		73.58	53.00	100.00	300 (300)
1997	Arsenic	12	4.12	1.00	11.00	41 (41)
	Cadmium		3.75	2.00	7.00	10 (39)
	Mercury		0.17	0.10	0.40	10 (17)
	Lead		60.58	10.00	86.00	300 (300)
1998	Arsenic	12	2.59	1.00	14.00	41 (41)
	Cadmium		1.75	1.00	4.00	10 (39)
	Mercury		1.00	0.50	1.80	10 (17)
	Lead		56.92	39.00	76.00	300 (300)
1999	Arsenic	12	4.38	2.60	6.10	41 (41)
	Cadmium		2.79	1.00	6.30	10 (39)
	Mercury		0.55	0.04	0.97	10 (17)
	Lead		40.48	27.00	78.30	300 (300)

* Number of samples tested – composite samples submitted during the year by the facility for laboratory analysis for trace