CQ Inc.

Coal Cleanability Characterization of Pratt and Utley Seam Coals

Trace Element Addendum

to

U.S. Department of Energy
Pittsburgh, Pennsylvania
DE-FC22-90PC89663

Electric Power Research Institute
Palo Alto, California
RP1400-25

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INTRODUCTION

This is an addendum to a project report titled "Coal Cleanability Characterization of Pratt and Utley Seam Coals" that CQ Inc. issued on August 11, 1992, to the U.S. Department of Energy and the Electric Power Research Institute as part of a U.S. Clean Coal Technology project (Contract Number (DE-FC22-90PC89663) to develop the Coal Quality Expert™ (CQE). That report detailed a Coal Cleanability Characterization performed in December 1991 and January 1992 on 400 tons of Pratt and 100 tons of Utley seam coals. This addendum completes the report by detailing the results of a trace element study done as part of the coal characterization.

The coal characterizations performed at CQ Inc. were not specifically designed to target trace element removal, but rather to determine raw coal qualities and predict and verify the effects of coal cleaning on ash and sulfur removal. However, including trace element analyses in coal characterizations makes it possible to better understand the occurrences of potential air toxics resulting from the combustion of coals in power stations. In addition, if power plants are identified as major sources of hazardous air pollutants, it may become necessary to specifically remove certain volatile elements such as mercury, beryllium, and selenium from boiler feed-coals prior to combustion.

Trace Element Concerns

Title III Trace Elements

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chlorine
- Chromium
- Cobalt
- Lead
- Manganese
- Mercury
- Nickel
- Selenium

Trace elements have become a major concern for coal-fired utilities because Title III of the 1990 Clean Air Act Amendments has identified 12 elements and their compounds commonly found in coal as hazardous air pollutants. Although the power generation industry has not yet been identified as a major source of hazardous air pollutants, the act does mandate a study of utility toxic air pollutants be completed by 1995 and included in a report to Congress. In addition, the U.S. Environmental Protection Agency is required by law to recommend new air toxics regulations found necessary to protect human health and the environment. Finally, the legislation requires three separate studies of mercury emissions, deposition, and health effects. Therefore, regulations aimed at coal-fired electric utilities may be forthcoming when these federally-mandated studies are complete. Because of this, it is important that utilities and their coal suppliers understand the relationship between toxic elements that enter the boiler and those that exit as emissions. If legislation is passed, power plant operators will need to re-evaluate their fuel supplies to determine what, if any, control options exist. Coal suppliers with high concentrations of potentially toxic elements in their coals may be forced to remove these elements in order to market their fuel.

Trace Element and Occurrences Associations

Just as coals differ widely in ash and sulfur contents, they also differ in the amount of trace elements. Many trace elements in coal are associated with mineral matter such as silicates, oxides, sulfides, sulfates, and carbonates found in clays and shales and other mineral forms. For example, arsenic is commonly associated with pyrite; cadmium with sphalerite; chromium with clay minerals; mercury with pyrite and cinnabar; nickel with millerite, pyrite, and other sulfides; and selenium with lead selenide, pyrite, and other sulfides (Finkelman, 1980). There are also cases in which some of these elements can be found organically bound or as part of the mineral matter, just as organic sulfur and pyritic sulfur can be found in the same coal.

Moreover, there are differences in trace element concentrations by coal rank, as shown in Table 1.

Table 1. Trace Elements in U.S. Coals by Rank. *(ppm).*

Element	Bituminous	Subbituminous
Antimony	1.2	0.9
Arsenic	20.3	6.2
Beryllium	2.2	1.3
Cadmium	0.9	0.4
Chromium	20.5	14.9
Fluorine	88.5	83.0
Lead	14.3	6.4
Mercury	0.2	0.1
Nickel	16.9	7.0
Selenium	3.4	1.4
Zinc	92.4	17.4

Source: D. M. White et al., 1984.

Moreover, the data shown in Table 2 indicate that trace elements in coal can also vary by geological area.

Table 2. Trace Elements in U.S. Coals by Geological Area. *(ppm).*

Element	Appalachian	Interior	Gulf
Arsenic	22.2	16.3	4.7
Beryllium	2.3	2.3	2.1
Chromium	18.2	27.2	21.2
Fluorine	89.9	77.4	67.8
Lead	8.9	10.5	14.4
Mercury	0.2	0.1	0.2
Nickel	15.4	26.7	14.0
Zinc	22.9	44.2	18.7

Source: D. M. White et al., 1984.

One possible reason for the variability of trace elements from coal to coal and region to region is that the trace element content of some coals is dependent on the availability of the elements and the amount of organic material in the depositional environment during coal formation (Zibrovic et al., 1961). In coals where the availability of metallic elements is limited and large amounts of organic material are present, organic-metal complexes form. In such cases, reducing trace elements using physical cleaning processes is not possible. However, in those cases where the metals-to-inorganic ratio is high, physical cleaning processes may be able to reduce some fraction of these metals.

Physical coal cleaning using gravity separation of coarse fractions can be effective in decreasing a coal's trace element contents because they are proven methods of reducing associated mineral matter forms such as clays, rocks, and slates. In some cases where physical coal cleaning decreases trace elements, these reductions track closely with ash removal, indicating that these elements were reduced at the same rate as the ash-bearing minerals. In other cases, decreasing trace elements is more complex and is a function of the method of cleaning employed. Coal cleaning methods that involve deep cleaning of fine coal fractions can also increase mineral matter liberation and, therefore, can be used to reduce associated trace elements. Since individual particles may react to cleaning differently, some elements may or may not be reduced. For example, sulfides may be captured in the froth from a flotation cell and carry associated metals with them into the coal.

For these reasons, characterizing the mode and occurrences of sulfur-bearing, ash-forming, and trace element-bearing minerals in raw coals can provide important information about their potential for cleaning.

RAW COAL TRACE ELEMENT COMPARISONS

As is generally the case for most coals, the raw Pratt and Utley coals have differences in constituents and trace elements. For example, the Pratt Seam coal has considerably higher ash (25.86 percent) compared to the Utley Seam (12.12 percent) while the Utley Seam has over 1.6 times more sulfur that the Pratt Seam coal (3.54 percent and 2.24 percent, respectively). Moreover, as Table 3 shows, the Pratt Seam generally has higher concentrations of trace elements than the Utley Seam coal. The complete set of laboratory trace element analyses for both coals are contained in appendices A and B.

Table 3. Pratt and Utley Raw Coal Trace Element Concentrations. *(Dry Basis, ppm).*

	Pratt Seam Coal	Utley Seam Coal
Arsenic	8.3	9.5
Barium	188.4	110.4
Chromium	31.3	17.9
Lead	14.9	10.7
Mercury*	381.7	356.8
Nickel	37.0	26.6
Selenium	2.0	1.6
Manganese	45.6	51.6
Zinc	70.8	43.0

* Mercury in parts-per-billion.

Pratt Seam Raw Coal Trace Element Characteristics

The Pittsburg & Midway Coal Company's (P&M) North River No. 1 Mine is the lone underground mine in Alabama producing Pratt Seam coal. Typically, this coal is crushed to 3-in. x 0 topsize before it is cleaned in P&M's McNally Pittsburg jig plant that has a Baum jig and froth flotation cells.

Summaries of the raw coal laboratory trace element data (by size) for the Pratt coal are given in Table 4. Analyses from these tests allow an evaluation of possible cleaning scenarios to be developed.

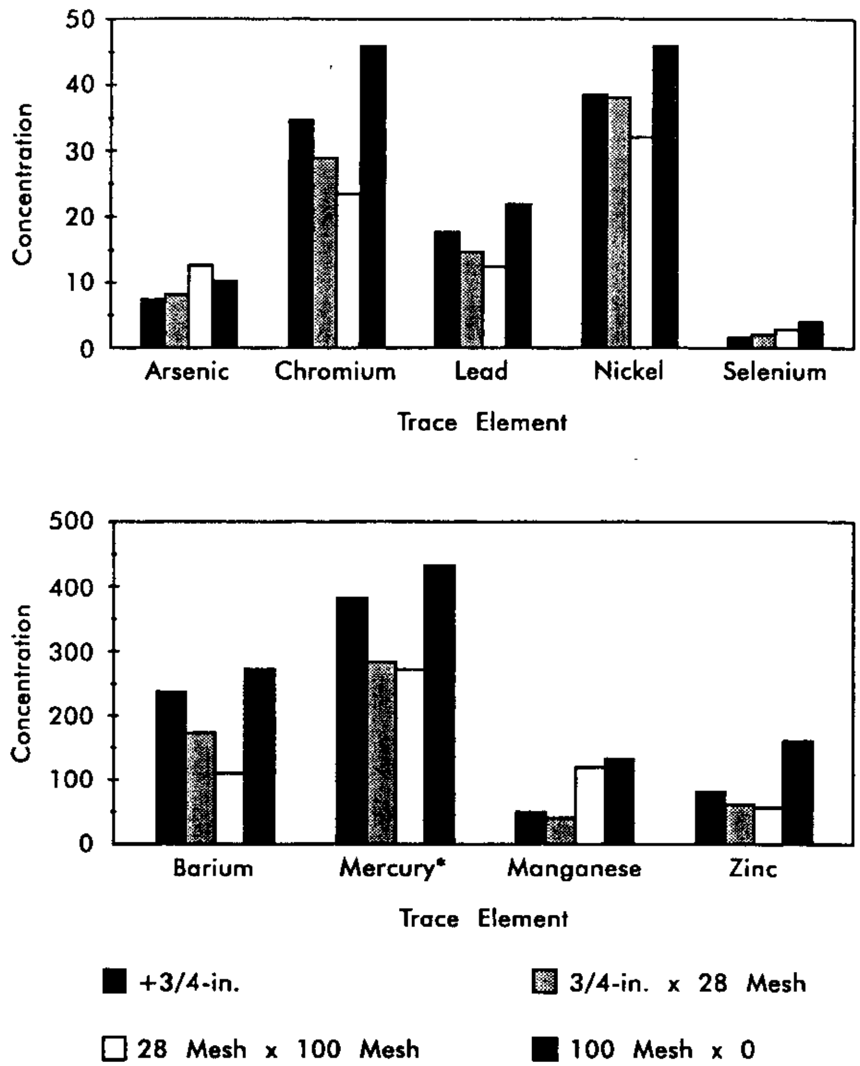
Table 4. Raw Coal Trace Element Summary. *Pratt Seam Coal (Dry Basis, ppm).*

Element	+3/4-in.	3/4-in. x 28M	28M x 100M	100M x 0
Wt (%)	37.9	51.5	3.8	6.8
Arsenic	7.4	8.2	12.7	10.3
Barium	237.5	172.7	110.0	272.6
Chromium	34.7	28.9	23.5	45.9
Lead	17.7	14.7	12.5	21.9
Mercury*	381.7	283.6	272.0	432.6
Nickel	38.6	38.1	32.0	45.9
Selenium	1.7	2.1	2.8	4.0
Manganese	50.1	40.9	119.1	132.5
Zinc	81.8	62.1	57.0	160.7

* Mercury in parts-per-billion.

Table 4 indicates a coarse size distribution of the raw Pratt Seam coal, with 38 percent of the coal coarser than 3/4-in. and nearly 90 percent larger than 28 mesh. Figure 1 shows the trace element concentration of each of the four size fractions. With the exception of arsenic, the largest concentrations of trace elements are found in the smallest size fraction (100 mesh x 0) and with the exceptions of arsenic, selenium, and manganese, the second largest concentrations of trace elements are found in the plus 3/4-in. size fraction. Both the size distribution and trace element concentrations of the material in each size fraction must be considered when formulating a coal cleaning strategy to reduce the trace element content of this coal. In this case, cleaning should focus on the plus 28 mesh size fraction, since it represents 90 percent of the raw coal. However, if trace element removal were a high priority, efficient cleaning of the 100 mesh x 0 may be necessary.

Washability information produced by laboratory float/sink tests is also used by coal process engineers to determine what gravity-based cleaning techniques would produce the best cleaning results. These analytical procedures partition a coal sample into a series of specific gravity fractions. These data are also used to determine operating parameters for cleaning processes and equipment. Tables 5 and 6 summarize the laboratory float/sink data for the Pratt raw coal.



* Mercury in parts-per-billion.

Figure 1. Pratt Seam Raw Coal Trace Element Size Characteristics. *(Dry Basis, ppm).*

Table 5. Cumulative Float Sink Data. *Pratt Raw Coal (Dry Basis, ppm).*

	1.30 Float	1.40 Float	1.60 Float	1.80 Float	2.00 Float	2.00 Sink
Wt (%)	31.88	62.88	75.20	79.47	81.56	99.99
Arsenic	5.54	5.81	6.40	6.55	6.74	8.40
Barium	113.52	93.07	102.51	108.54	112.79	187.07
Chromium	8.43	12.96	17.06	19.21	20.50	33.31
Lead	3.92	5.94	8.44	9.39	10.03	15.37
*Mercury**	177.15	253.61	281.86	288.34	300.75	327.78
Nickel	11.75	16.09	19.81	22.03	23.38	36.58
Selenium	1.78	1.80	1.80	1.79	1.78	2.26
Manganese	12.33	16.47	20.23	22.34	23.56	49.85
Zinc	17.89	20.86	28.35	32.63	35.84	66.25

* Mercury in parts-per-billion.

Table 6. Direct Float Sink Data. *Pratt Raw Coal (Dry Basis, ppm).*

	1.30 Float	1.40 Float	1.60 Float	1.80 Float	2.00 Float	2.00 Sink
Wt (%)	31.88	31.00	12.33	4.27	2.09	18.34
Arsenic	5.54	6.09	9.38	9.25	13.77	15.82
Barium	113.52	72.04	150.64	214.87	274.23	517.45
Chromium	8.43	17.62	38.00	57.14	69.20	90.31
Lead	3.92	8.02	21.16	26.13	34.49	39.10
Mercury*	177.15	332.22	425.97	402.57	772.47	447.98
Nickel	11.75	20.56	38.76	61.12	74.87	95.28
Selenium	1.78	1.81	1.84	1.49	1.44	4.39
Manganese	12.33	20.72	39.44	59.50	69.89	166.81
Zinc	17.89	23.91	66.55	108.07	157.90	201.51

* Mercury in parts-per-billion.

Figure 2 shows that much of the chromium, lead, nickel, barium, manganese, and zinc found in the Pratt coal sample are within the 2.0 sink material, suggesting an inorganic affinity for these elements in this particular coal. Conversely, most of the arsenic, mercury, and selenium found in this coal are in the 1.3 float material, suggesting that either these elements are associated with mineral matter not yet liberated or that the elements have a possible relationship with the organic material. From this information it can be concluded that gravity-based separation techniques can be effective in removing inorganically-associated trace elements, especially if crushing and grinding are used.

From the raw coal liberation data given in the original coal cleanability report, CQ Inc. engineers determined that separations at specific gravities above 1.65 will be relatively simple while those below 1.45 will be difficult to formidable and that cleaning Pratt coal below 1.6 will not be economical. Significant removals of barium, chromium, lead, nickel, manganese, and zinc, therefore, can be predicted at separation gravity of 1.6. However, at this same gravity, only small removals of arsenic, mercury, and selenium can be expected.

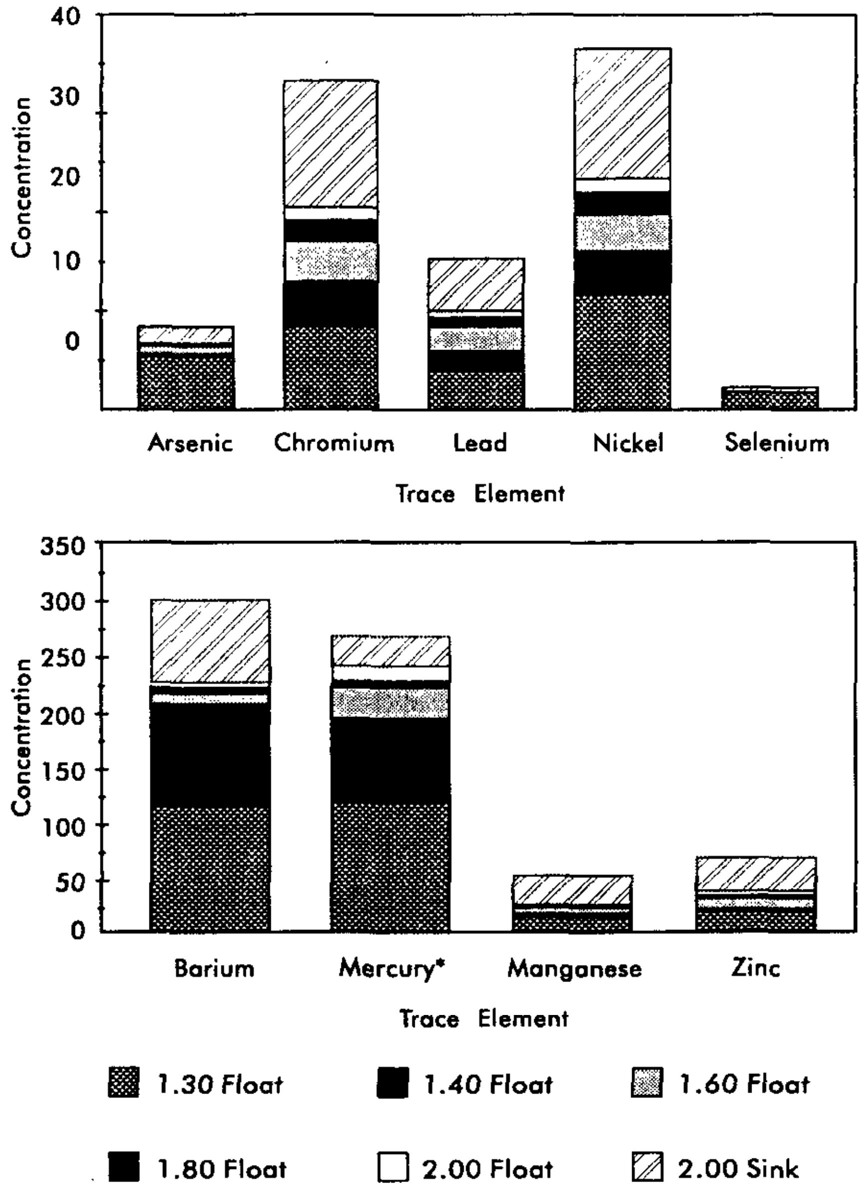
Utley Seam Raw Coal Trace Element Characteristics

Summaries of the raw coal laboratory trace element data (by size) for the Utley coal are given in Table 7.

Table 7. Raw Coal Trace Element Summary. *Utley Seam Coal (Dry Basis, ppm).*

Element	+3/4-in.	3/4-in. x 28M	28M x 100M	100M x 0
Wt (%)	34.3	53.4	4.2	8.1
Arsenic	7.0	9.0	8.6	6.2
Barium	70.3	96.1	70.8	244.6
Chromium	11.1	16.3	33.3	61.2
Lead	6.0	8.7	20.8	27.0
Mercury*	347.0	373.8	352.2	221.8
Nickel	16.8	23.2	33.4	66.8
Selenium	1.4	1.7	2.6	1.4
Manganese	36.9	36.4	52.7	91.6
Zinc	25.1	35.5	53.2	166.3

* Mercury in parts-per-billion.



* Mercury in parts-per-billion.

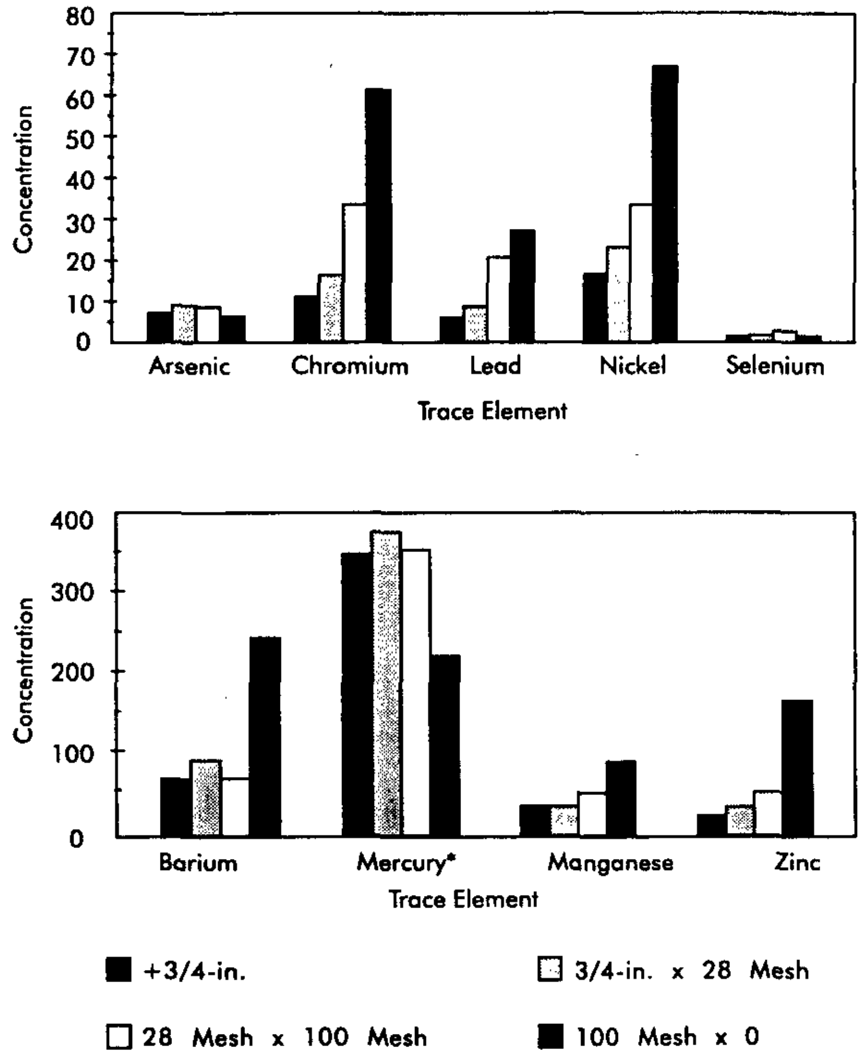
Figure 2. Pratt Seam Raw Coal Trace Element Washability Characteristics. *(Dry Basis, ppm).*

As Figure 3 shows, with the exceptions of arsenic, selenium, and mercury, the largest concentrations of trace elements are found in the 100 mesh x 0 size fraction of the Utley coal. Unlike the Pratt seam coal that had the second largest concentrations in the plus 3/4-in. size fraction, with the exceptions of barium and mercury, the Utley coal's second largest concentrations are found in the 28 mesh x 100 mesh size fraction. However, like the Pratt Seam coal, cleaning of the Utley Seam coal should concentrate on the plus 28 mesh material since this size fraction represents 88 percent of the total raw coal. Tables 8 and 9 summarize the laboratory float/sink data for the Utley raw coal.

Figure 4 shows that the largest concentrations of chromium, lead, nickel, and zinc found in Utley Seam coal are within the 2.00 sink material, while the largest concentrations of arsenic, barium, mercury, and selenium are found in the 1.30 float material. From the raw coal liberation data for the previous cleanability report, it was determined that a fairly simple separation should be achieved when cleaning the Utley coal at a specific gravity of 1.60. Moderate reductions of all of the trace elements in this study can be expected at this gravity except for arsenic, mercury, and selenium.

Pratt and Utley Raw Coal Trace Element Comparison

Figure 5 illustrates that, for the most part, trace element concentrations are coal specific and therefore coal cleaning operations that remove trace elements from one coal might not necessarily remove trace elements from a different coal, or might in fact concentrate certain trace elements in the product coal. For example, the two raw coals contain similar amounts of arsenic, selenium, mercury, manganese, and zinc in the 1.30 float fraction, which indicates that little or no reductions of these elements can be expected as a result of physical coal cleaning. Moreover, removal of heavy minerals will likely result in an increase in concentrations of trace elements in the lighter coal.



* Mercury in parts-per-billion.

Figure 3. Utley Seam Raw Coal Trace Element Size Characteristics. *(Dry Basis, ppm).*

Table 8. Cumulative Float Sink Data. *Utley Raw Coal (Dry Basis,,ppm).*

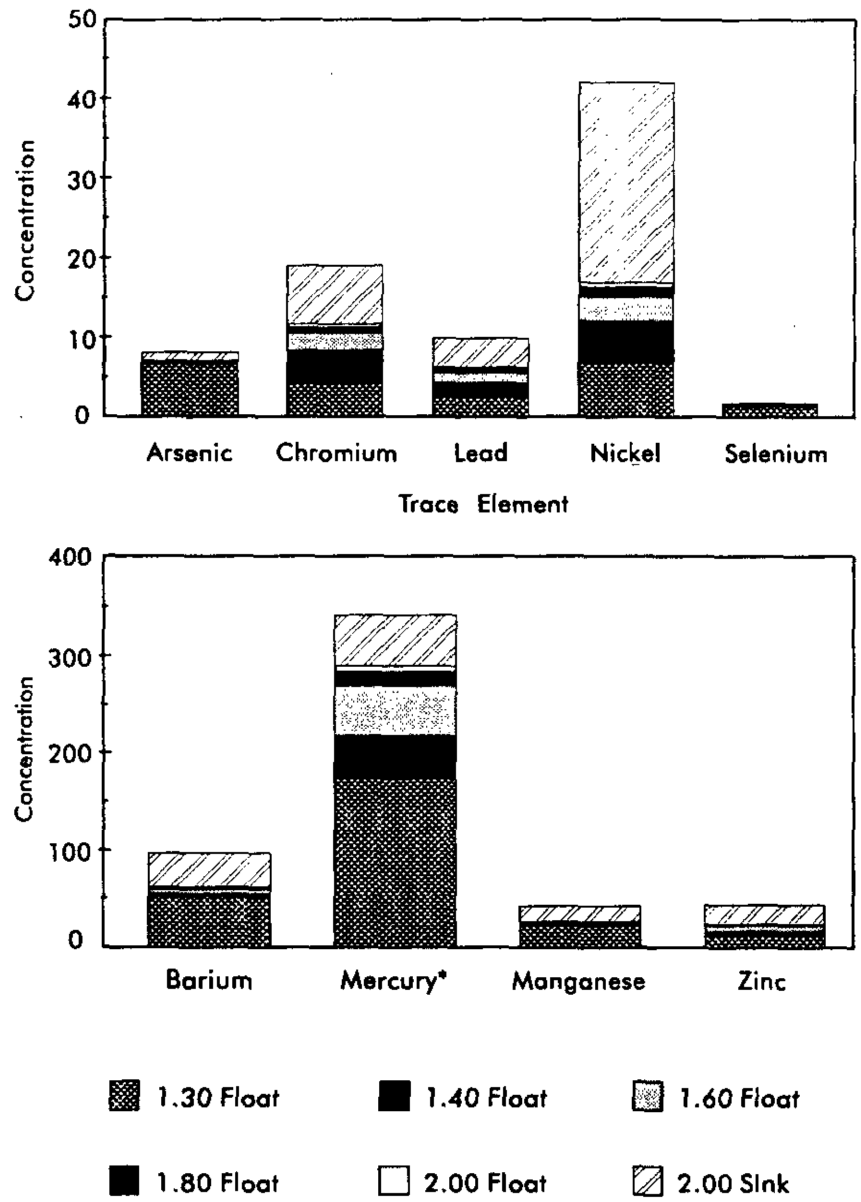
	1.30 Float	1.40 Float	1.60 Float	1.80 Float	2.00 Float	2.00 Sink
Wt (%)	45.88	77.88	87.16	89.20	90.10	100.00
Arsenic	6.41	6.55	6.95	7.04	7.08	8.02
Barium	51.41	55.49	58.60	60.89	62.23	96.63
Chromium	4.25	8.35	10.39	11.20	11.63	18.89
Lead	2.47	4.31	5.40	5.91	6.17	9.77
Mercury*	184.07	227.95	279.34	293.74	300.16	351.33
Nickel	6.82	11.99	15.11	16.33	16.96	24.96
Selenium	1.14	1.17	1.22	1.23	1.24	1.60
Manganese	21.33	24.51	25.39	26.05	26.46	41.73
Zinc	12.19	17.43	21.97	23.92	25.09	43.30

* Mercury in parts-per-billion.

Table 9. Direct Float Sink Data. *Utley Raw Coal (Dry Basis, ppm).*

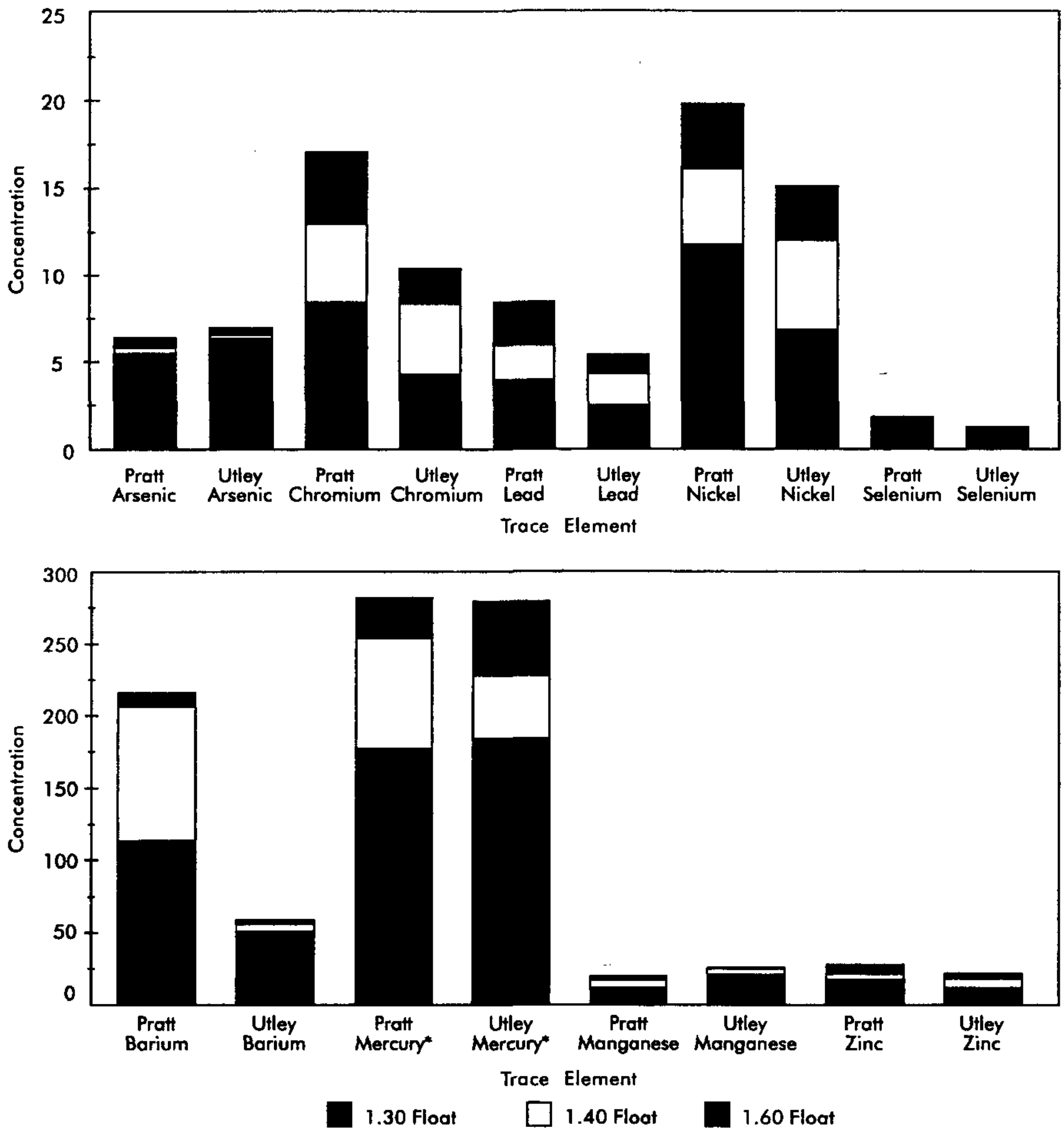
	1.30 Float	1.40 Float	1.60 Float	1.80 Float	2.00 Float	2.00 Sink
Wt (%)	45.88	32.01	9.28	2.04	0.90	9.89
Arsenic	6.41	6.74	10.36	10.63	11.11	16.57
Barium	51.41	61.34	84.72	158.59	195.22	409.93
Chromium	4.25	14.23	27.47	45.98	53.86	84.97
Lead	2.47	6.94	14.58	27.50	32.23	42.52
Mercury*	184.07	290.84	710.72	907.98	936.61	817.42
Nickel	6.82	19.40	41.27	68.43	79.65	97.83
Selenium	1.14	1.22	1.61	1.70	2.42	4.90
Manganese	21.33	29.07	32.75	54.07	67.81	180.77
Zinc	12.19	24.94	60.09	107.29	141.08	209.14

* Mercury in parts-per-billion.



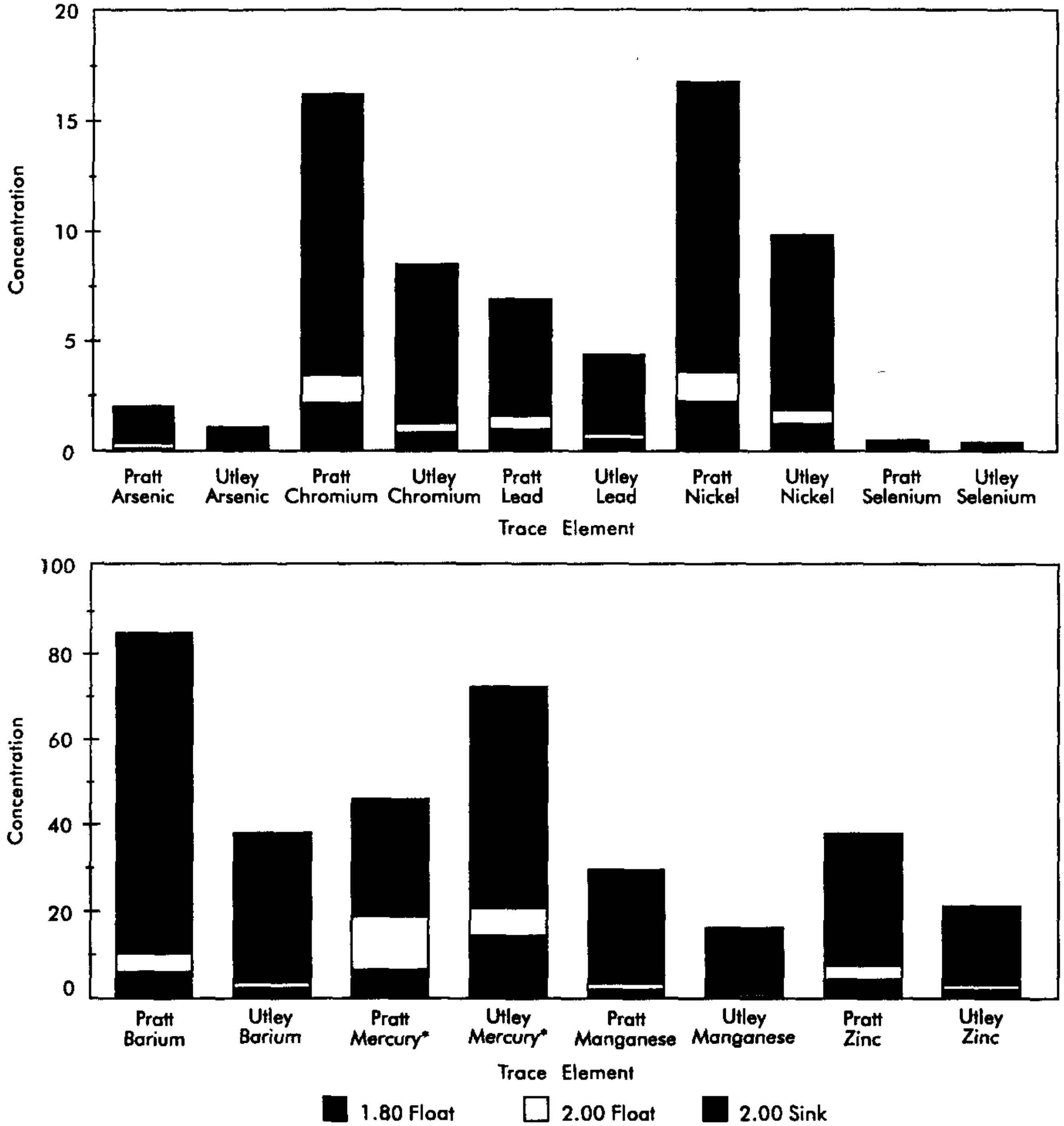
* Mercury in parts-per-billion.

Figure 4. Utley Seam Raw Coal Trace Element Washability Characteristics. *(Dry Basis, ppm).*



* Mercury in parts-per-billion.

Figure 5. Pratt and Utley Raw Coal Trace Element Washability Characteristics. *(Dry Basis, ppm).*



* Mercury in parts-per-billion.

Figure 5. Pratt and Utley Raw Coal Trace Element Washability Characteristics (Continued).
(Dry Basis, ppm).

TRACE ELEMENT REDUCTION EVALUATION

Both the Pratt and Utley Seam coals were cleaned in CQ Inc.'s commercial-scale cleaning plant, the Coal Quality Development Center (CQDC). CQ Inc. engineers devised four flowsheet configurations to evaluate the practical cleanability of both coals. Flowsheet 1 was used to clean a blend of 90 percent Pratt and ten percent Utley raw coals. Each coal was also evaluated separately using a common flowsheet--Flowsheet 2 cleaned raw Pratt coal and Flowsheet 3 cleaned raw Utley coal. Pratt Seam coal was cleaned alone using a flowsheet specifically designed to remove sulfur-bearing minerals because it was the intention of the program to reduce sulfur dioxide emissions while improving boiler performance.

Flowsheet 1, which cleaned the blended coals, utilized heavy-media cyclones, water-only cyclones, and froth flotation cells. As a demonstration of a least-cost method of coal cleaning, a Deister concentrating table was used to minimally clean each individual coal in flowsheets 2 (Pratt Seam coal) and 3 (Utley Seam coal). Finally, Flowsheet 4 used the Deister concentrating table in conjunction with a spiral concentrator.

In each case the coal was crushed to a nominal topsize of 3/8-in. to facilitate ash and sulfur liberation.

Flowsheet 1 Trace Element Reduction Evaluation

Flowsheet 1 used a combination heavy-media cyclone/water-only cyclone/froth flotation configuration to clean the blended Pratt and Utley coals. The raw coal blend was fed to a double-deck screen that scalped off coal larger than 3/8-in. and the bottom deck made a 28 mesh separation. The 3/8-in. x 28 mesh coal was mixed with magnetite in water and pumped through a 14-in.-diameter heavy-media cyclone. The 28 mesh x 0 raw coal was cleaned in a two-stage water-only cyclone circuit. The 28 mesh x 0 primary water-only cyclone overflow was sized at 100 mesh by a fine-coal sieve bend. The sieve bend overflow was further cleaned in froth flotation cells. The clean coal flotation concentrate was dewatered and then discharged onto the clean coal conveyor, along with the 28 mesh x 100 mesh primary water-only cyclone overflow and 3/4-in. x 28 mesh heavy-media cyclone overflow products.

Flowsheet 1--Trace Element Reductions. *(Percent)*

Arsenic	29
Barium	84
Chromium	57
Fluorine	50
Lead	60
Mercury	0
Nickel	46
Selenium	38
Zinc	65
Ash	69
Pyrite	11

Flowsheet 1 had the best overall coal cleaning performance in terms of weight yield (70 percent), energy recovery (86 percent), and ash reduction (69 percent). In addition, trace element reductions were mostly in the 40 to 70 percent range. The exceptions were mercury, which had a zero net change in concentration, arsenic, which had a 29 percent reduction, and selenium, which had a 38 percent reduction. Barium, in contrast, had an 84 percent reduction.

Table 10 contains the trace element reductions, by size fractions, for Flowsheet 1.

Table 10. Flowsheet 1 Trace Element Reductions. *Pratt/Utley Blend (Percent).*

Element	+28 M	28M x 100M	100M x 325M	325M x 0
Arsenic	29	36	37	-28
Barium	83	95	48	82
Chromium	59	39	28	46
Fluorine	45	52	28	73
Lead	61	65	22	26
Mercury	-10	40	18	-16
Nickel	45	54	21	17
Selenium	40	42	23	-98
Zinc	66	48	56	23
Ash	69	72	57	28

Note: Negative values indicate an increase of trace element concentration in the clean coal product.

As the data and Figure 6 indicate, for the most part, cleaning the smallest size fractions had minimal effect on overall trace element removal, as shown in a comparison of the plus 3/8-in. x 0 coal and the plus 28 mesh size fraction. Figure 6 shows that trace element reductions are nearly the same for all of the elements. The one possible exception is fluorine, which shows that cleaning the 325 mesh x 0 size fraction and returning it to the product coal resulted in an overall increase its percent reduction. However, there is an indication that cleaning the minus 100 mesh material may tend to lower the net reductions of selenium and chromium. Finally, although reductions are shown for mercury for the minus 100 mesh size fraction, they were not enough to produce a significant overall reduction in the clean coal product because of the small amount of this material in the plant feed coal. However, this information does show that mercury can be removed from this size fraction and advanced coal cleaning technologies that are capable of cleaning this size coal can be used to reduce mercury in some coals.

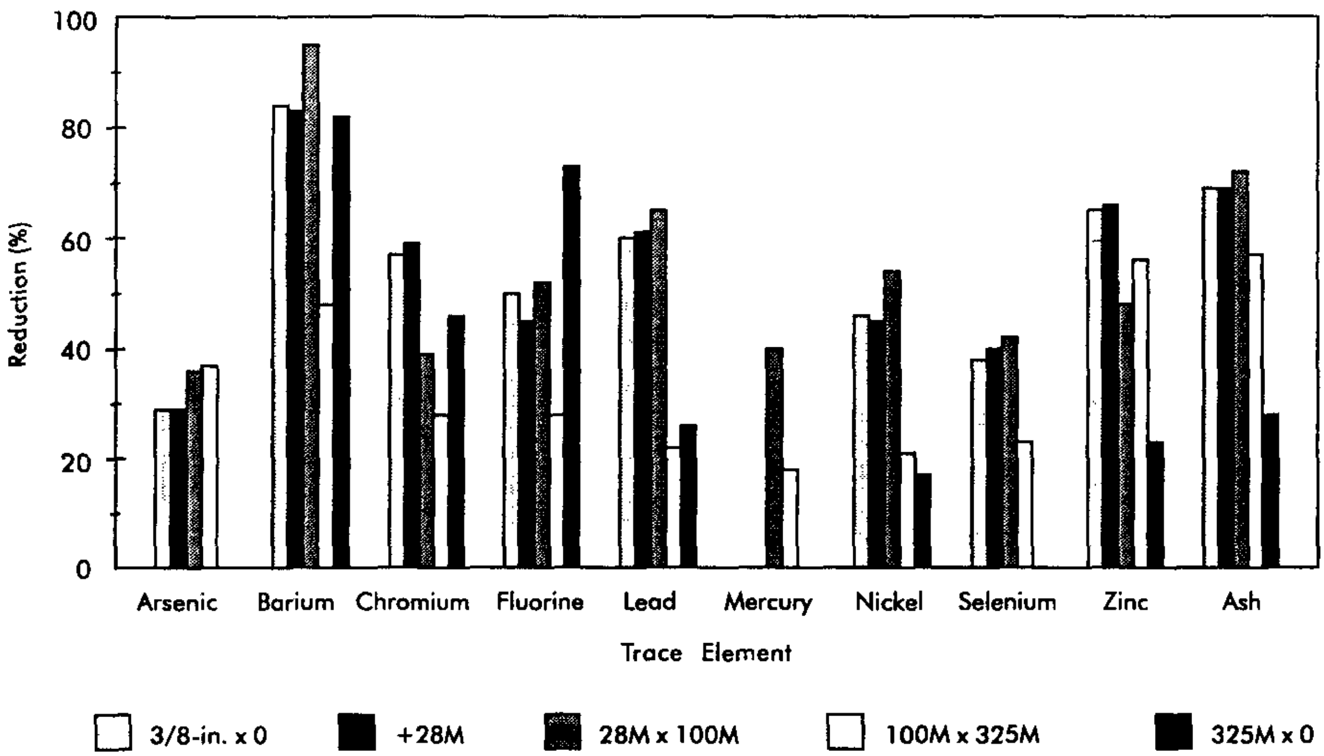


Figure 6. Flowsheet 1 Trace Element Reductions By Size Fraction. *Pratt/Utley Blend Characterization (Dry Basis).*

Table 11 contains the percent trace element reductions of the major sizing devices and coal cleaning units used in Flowsheet 1.

Table 11. Flowsheet 1 Unit Trace Element Reductions. *(Percent).*

Element	DSS	HMC	WOC	SB	FF
Arsenic	-1	11	32	-71	16
Barium	20	21	-39	-27	65
Chromium	13	65	-17	7	46
Fluorine	14	41	-43	-131	48
Lead	26	64	-4	10	39
Mercury	-19	-83	65	-256	-49
Nickel	8	54	-2	-68	51
Selenium	2	31	66	-177	38
Zinc	-4	72	47	18	45
Ash	20	64	-35	11	52

DSS = Deslime Screen
HMC = Heavy-Media Cyclone
WOC = Water- Only Cyclone
SB = Sieve Bend
FF = Froth Flotation

Although sizing and screening devices are not generally perceived as coal cleaning equipment, the data show that screening alone can remove a percentage of many trace elements. For example, the deslime screen's barium reduction of 20 percent and lead reduction of 26 percent show a correlation between these two elements and large-size material--possibly rock or shale since the ash was also reduced 20 percent.

As the data and Figure 7 show, the greatest reduction of most trace elements was produced by the heavy-media cyclone that cleaned the 3/8-in. x 28 mesh material at a 1.60 specific gravity. This corresponds well with CQ Inc.'s raw coal washability studies that indicated that such reductions were possible. Conversely, mercury content was increased 83 percent in the heavy-media cyclone (HMC) clean coal product. Moreover, apparent operational problems with the water-only cyclone (WOC) circuit, indicated by its 35 percent increase in ash, probably contributed to the significant increases in barium (39 percent), chromium (17 percent), and fluorine (43 percent). On the other hand, this circuit produced the largest overall decreases of arsenic, mercury, and selenium than the other units in this flowsheet. This also corresponds well to the raw coal washability studies.

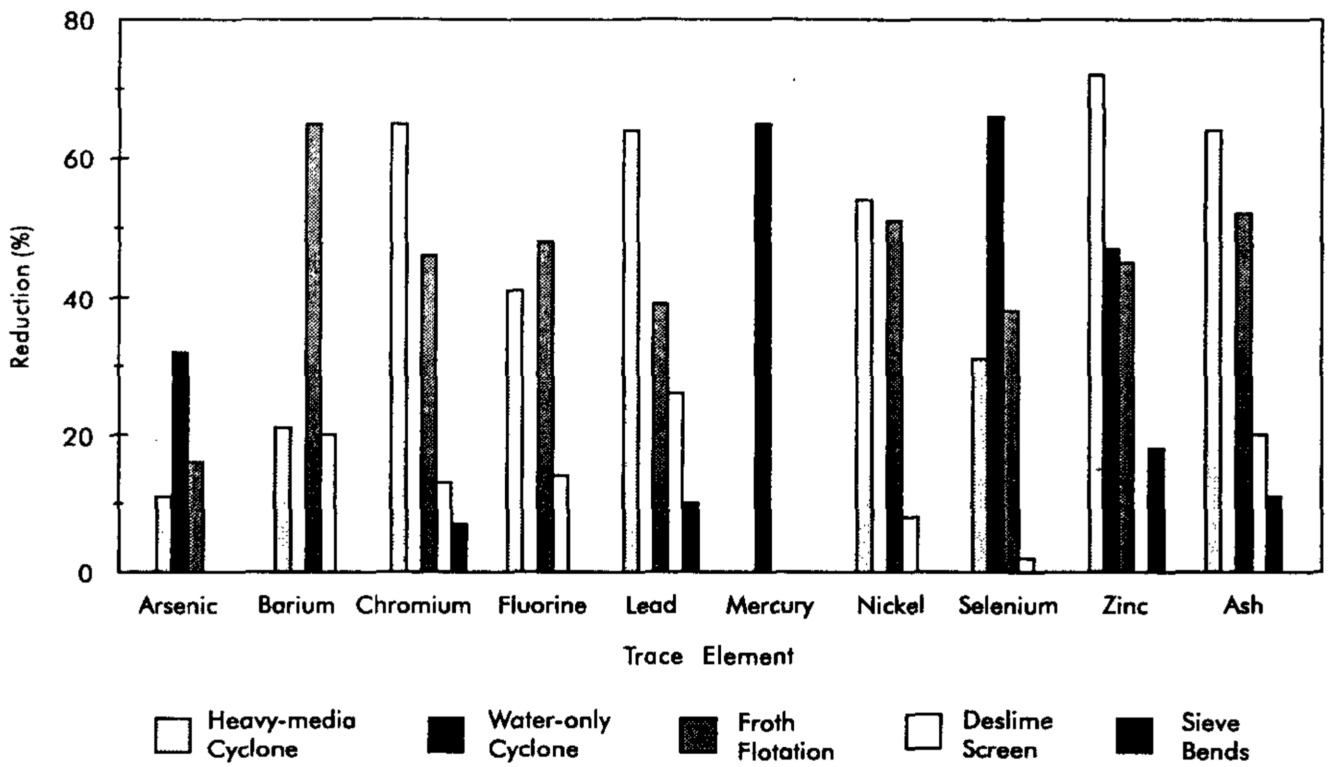
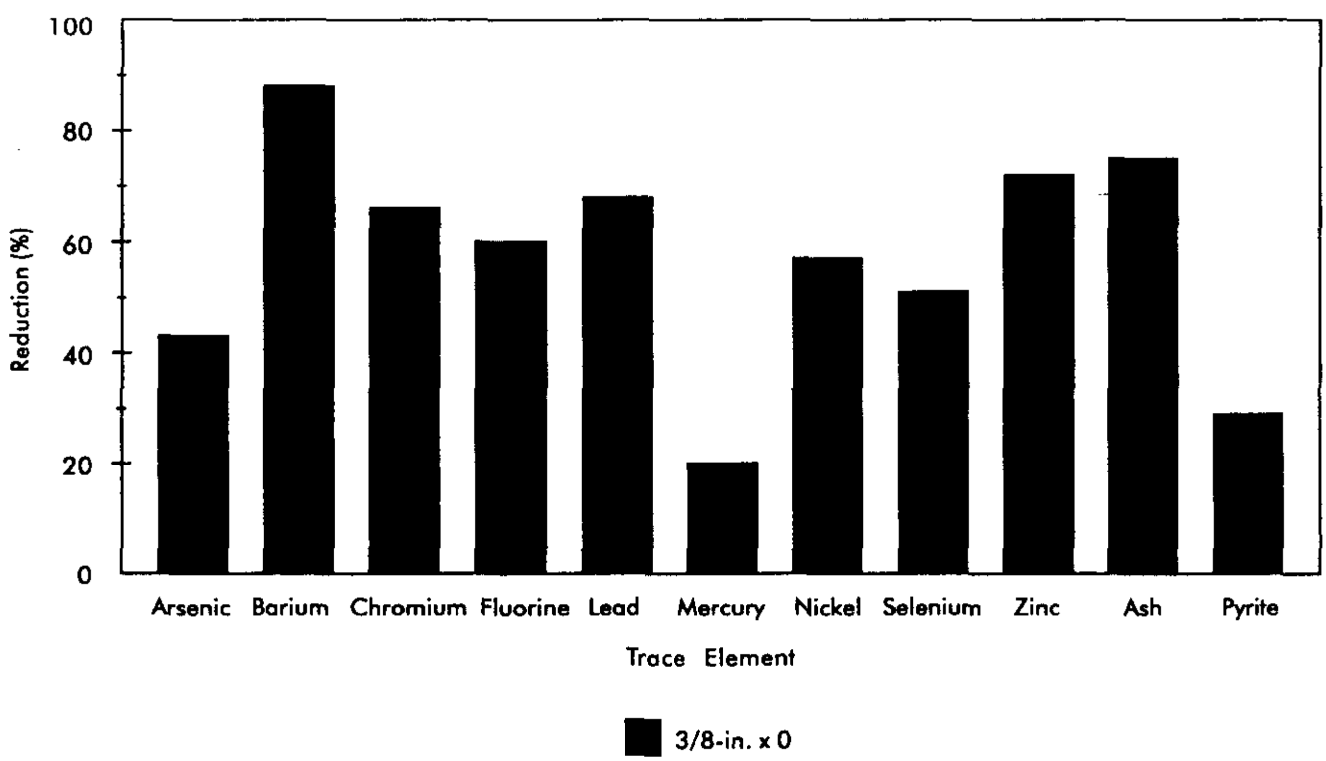


Figure 7. Flowsheet 1 Unit Operations. *Pratt/Utley Blend Characterization.*

Overall, Flowsheet 1 produced significant decreases in most elements. When these reductions are shown on a heat-unit basis, the reductions of chromium, fluorine, lead, nickel, and zinc are nearly equal to the ash reduction (Figure 8). Reductions in these units illustrate the positive effects of coal cleaning in removing potential toxic air emissions.



Note: Percent reductions, heat unit basis (grams-per-billion Btus).

Figure 8. Flowsheet 1 Trace Element Reductions. *Pratt/Utley Blend Characterization.*

Flowsheet 2 Trace Element Reduction Evaluation

Flowsheet 2--Trace Element Reductions. *(Percent)*	
Arsenic	15
Barium	38
Chromium	51
Fluorine	16
Lead	47
Mercury	10
Nickel	51
Selenium	37
Zinc	28
Ash	55
Pyrite	15

Flowsheet 2 used a concentrating table to simulate a least-cost coal cleaning option. The run-of-mine Pratt was fed to a double-deck deslime screen that scalped off plus 3/8-in. material with the remaining coal going to a classifying cyclone that made a 100 mesh cut. The plus 100 mesh material was fed to the concentrating table that made a separation at approximately 1.70 specific gravity. The minus 100 mesh material was discarded as refuse, along with the table middlings and refuse streams.

Flowsheet 2 produced a low weight yield (52 percent) and energy recovery (64 percent) with an ash removal of 55 percent. All raw coal trace elements concentrations were lowered by cleaning--in the range of ten percent for mercury to 51 percent for chromium and nickel.

Table 12 lists the reductions of trace elements by size fraction and Figure 9 shows a comparison of size fraction reductions and total flowsheet reductions (plus 3/8-in. x 0).

Table 12. Flowsheet 2 Trace Element Reductions. *Pratt Seam Coal (Percent).*

Element	+28 M	28M x 100M
Arsenic	-8	10
Barium	29	27
Chromium	60	48
Fluorine	15	-1
Lead	39	70
Mercury	-4	-4
Nickel	51	42
Selenium	26	18
Zinc	61	47
Ash	70	56

As shown in Figure 9, the concentrating table flowsheet used in this test performed well in reducing all the targeted trace elements except mercury.

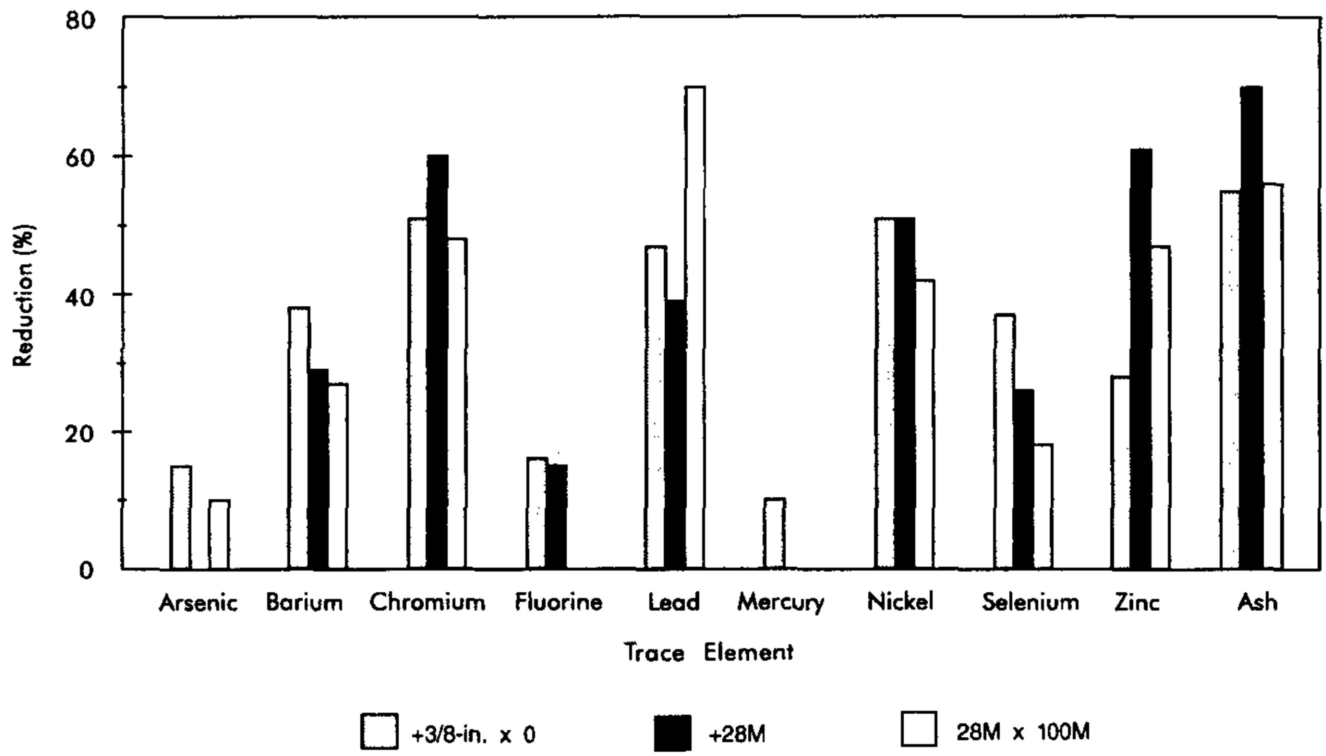


Figure 9. Flowsheet 2 Trace Element Reduction By Size Fraction. *Pratt Coal Cleaning Characterization.*

Table 13 contains the trace element reductions of the deslime screen and classifying cyclone/concentrating table circuit used in Flowsheet 2.

Table 13. Flowsheet 2 Unit Trace Element Reductions. *(Percent).*

Element	DSS	CC/CT
Arsenic	14	1
Barium	-41	56
Chromium	-5	53
Fluorine	-51	45
Lead	-41	62
Mercury	10	1
Nickel	6	48
Selenium	54	-35
Zinc	12	18
Ash	-11	61

DSS = Deslime Screen
CC/CT = Classifying Cyclone/Concentrating Table

As the data and Figure 10 show, even relatively simple operations such as desliming and the use of a concentrating table can remove large amounts of most trace elements as well as ash-bearing mineral matter. Again, the removals of arsenic (14 percent), mercury (10 percent), and selenium (54 percent) produced by the desliming and sizing operation indicates some association with the oversize material in the Pratt coal.

Figure 11 shows that when the reductions are put on a heat unit basis, there is a strong correlation between pyrite reduction and the reductions of arsenic, fluorine, and mercury and an equally strong relationship among the reductions of chromium, lead, and nickel with the reduction of ash-bearing mineral matter.

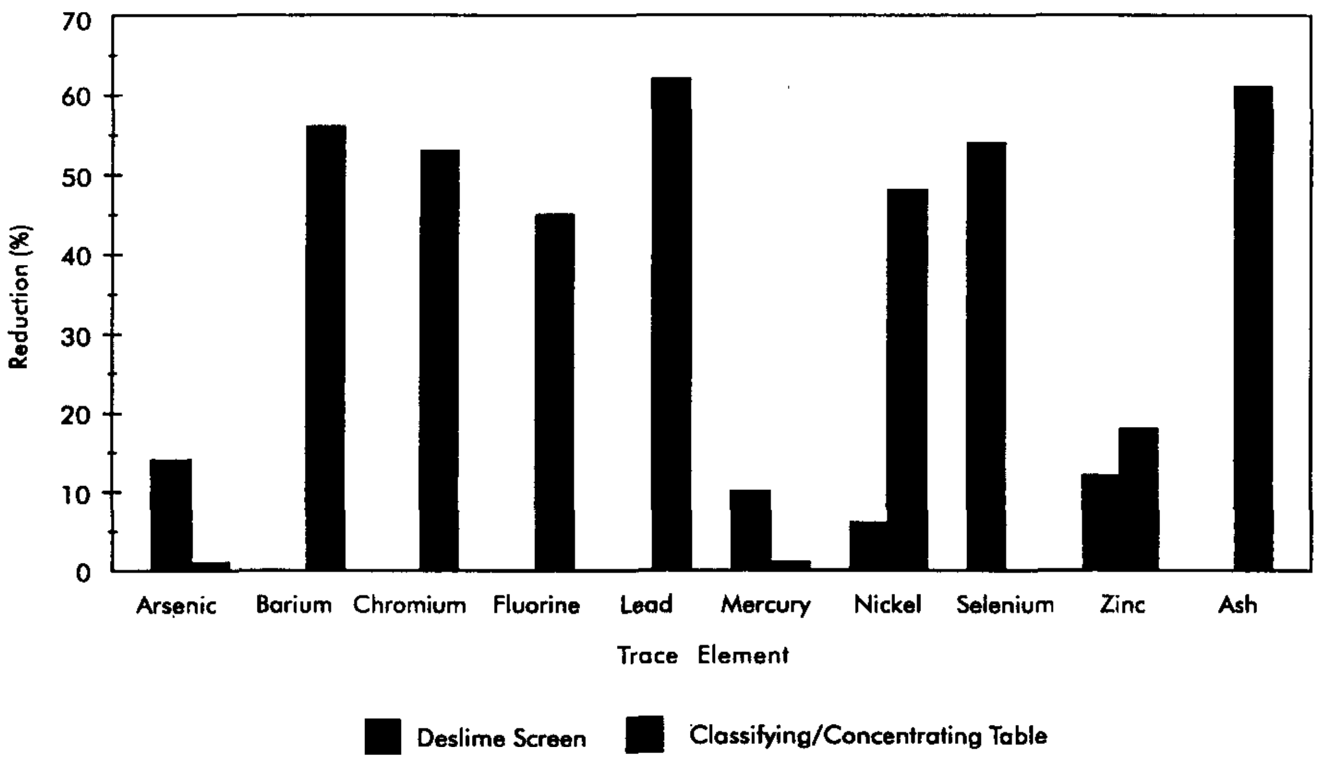
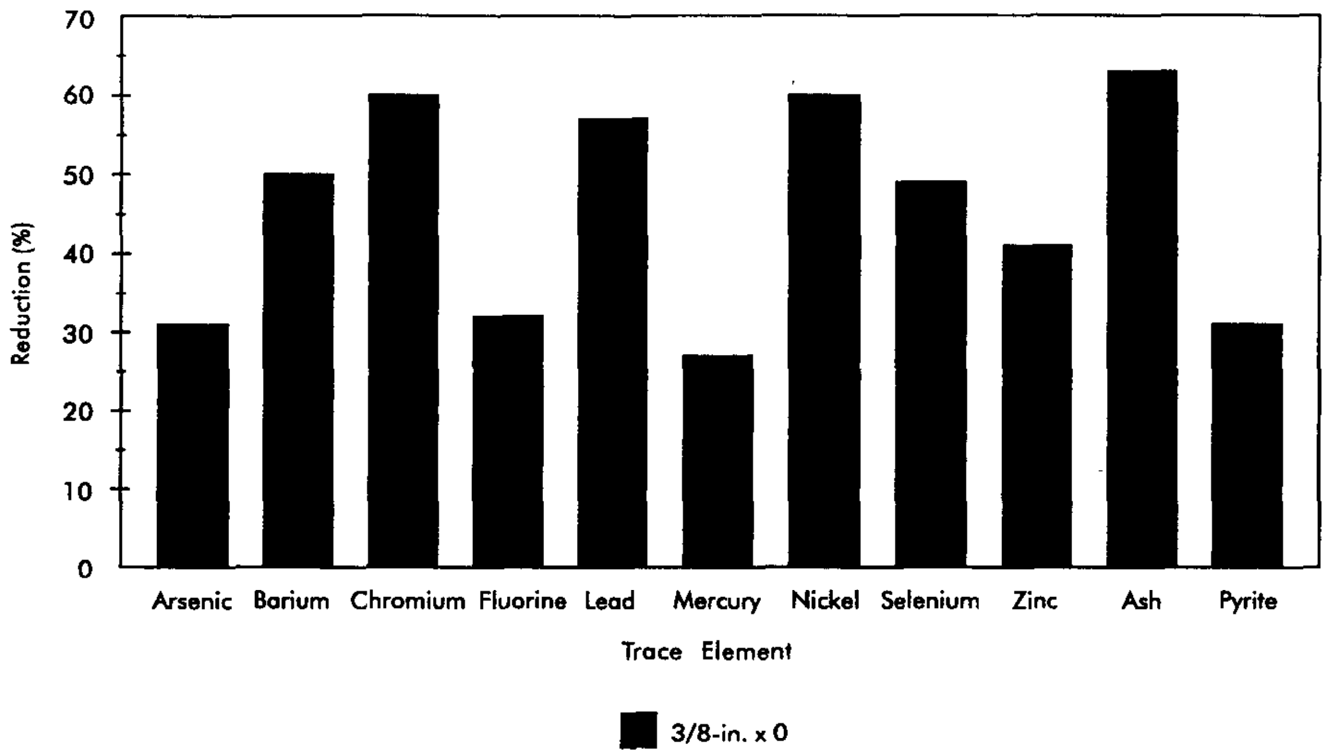


Figure 10. Flowsheet 2 Unit Operations. *Pratt Coal Cleaning Characterization.*



Note: Percent reductions, heat unit basis (grams-per-billion Btus).

Figure 11. Flowsheet 2 Trace Element Reductions. *Pratt Coal Cleaning Characterization.*

Flowsheet 3 Trace Element Reduction Evaluation

Flowsheet 3--Trace Element Reductions. *(Percent)*	
Arsenic	36
Barium	48
Chromium	20
Fluorine	18
Lead	29
Mercury	44
Nickel	31
Selenium	30
Zinc	53
Ash	40
Pyrite	59

Flowsheet 3 was used to simulate the least-cost option for cleaning Utley Seam coal and to investigate the effectiveness of the same cleaning process on different coals--in this case the Pratt coal cleaned in Flowsheet 2. As with the previous test, the raw Utley coal was crushed and fed to the double-deck deslime screen that discarded the plus 3/8-in. size fraction and fed the remaining coal to the classifying cyclone/concentrating table circuit. The classifying cyclone made a 100 mesh separation with the minus 100 mesh fraction going to refuse and the plus 100 mesh reporting to the concentrating table. The concentrating table made a separation near 1.60 specific gravity.

Flowsheet 3 produced a low weight yield (58 percent) and energy recovery (63 percent) with a moderate ash reduction of 40 percent. As with Flowsheet 2, all raw coal trace element concentrations were lowered by cleaning--in the range of 18 percent for fluorine to 53 percent for zinc.

Table 14 lists the percent reductions of trace elements by size fraction and Figure 12 compares size fraction removals with total flowsheet reductions (plus 3/8-in. x 0).

Table 14. Flowsheet 3 Trace Element Reductions. *Utley Seam Coal (Percent).*

Element	+3/8-in.	3/8-in. x 28M	28M x 100M
Arsenic	23	41	29
Barium	56	22	13
Chromium	46	17	32
Fluorine	30	21	-1
Lead	75	33	29
Mercury	46	55	63
Nickel	17	46	45
Selenium	27	45	54
Zinc	-23	37	53
Ash	47	44	33

As Figure 12 also shows, each individual size fraction responded differently to the cleaning operation of the table. From the data, it appears that conventional coal cleaning will produce significant trace element reductions from the Utley coal.

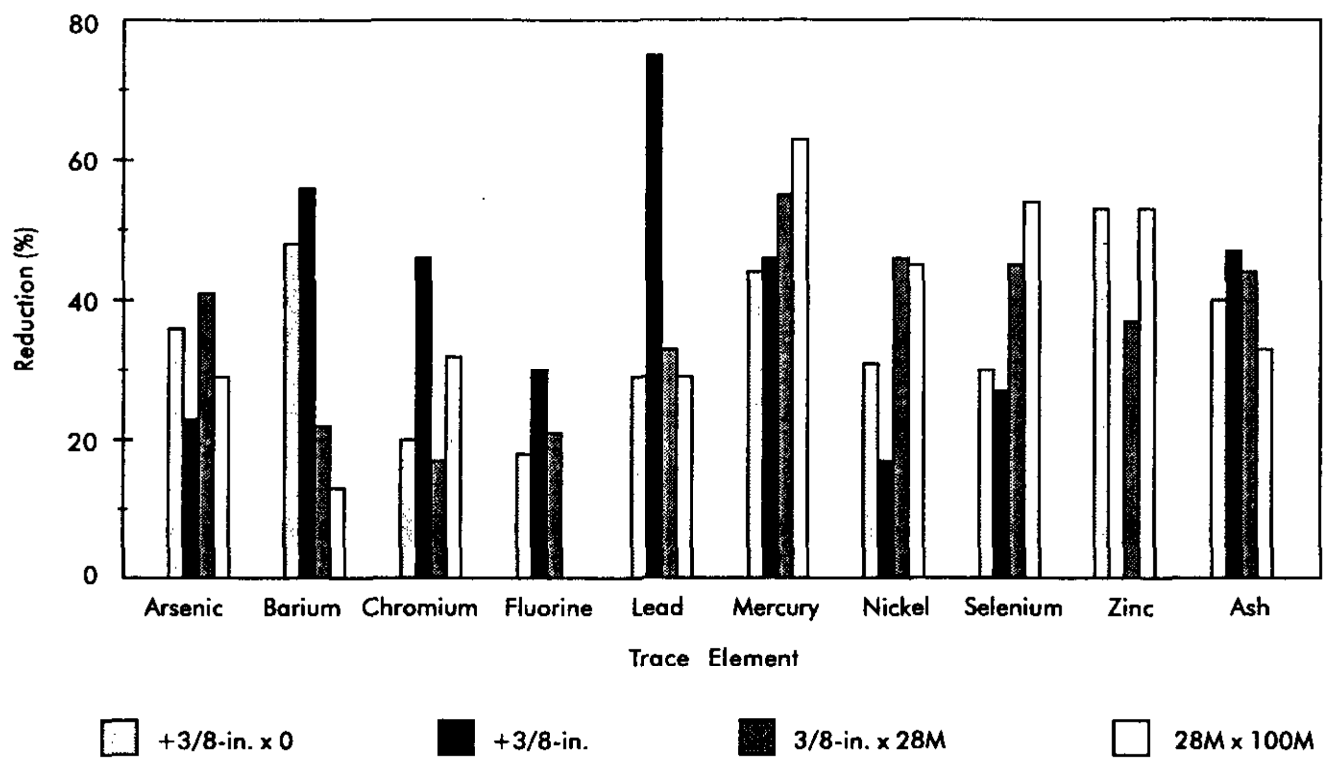


Figure 12. Flowsheet 3 Trace Element Reductions By Size Fraction. *Utley Seam Coal Cleaning Characterization.*

Table 15 contains the percent trace element removals of the deslime screen and classifying cyclone/concentrating table circuit used in Flowsheet 3.

Table 15. Flowsheet 3 Unit Trace Element Reductions.
(Percent).

Element	DSS	CC/CT
Arsenic	-32	51
Barium	61	-34
Chromium	-62	51
Fluorine	-42	42
Lead	-90	62
Mercury	-39	60
Nickel	-100	65
Selenium	8	24
Zinc	10	48
Ash	-83	67

DSS = Deslime Screen
CC/CT = Classifying Cyclone/Concentrating Table

As the data and Figure 13 show, the concentrating table removed large amounts of most trace elements as well as ash-bearing mineral matter and the ash reduction (67 percent) tracks closely with the reductions of nickel (65 percent), mercury (60 percent), and lead (62 percent). The reductions of zinc (10 percent), barium (61 percent) and selenium (8 percent) produced by the desliming and sizing operation indicate sizing alone, in some cases, can be an effective trace element reduction tool. In fact, the sizing operation was responsible for all of the barium reduction of this flowsheet since the deslime screen reduced 61 percent of the barium from the feed coal, while the concentrating table caused an enrichment of barium in the clean coal product.

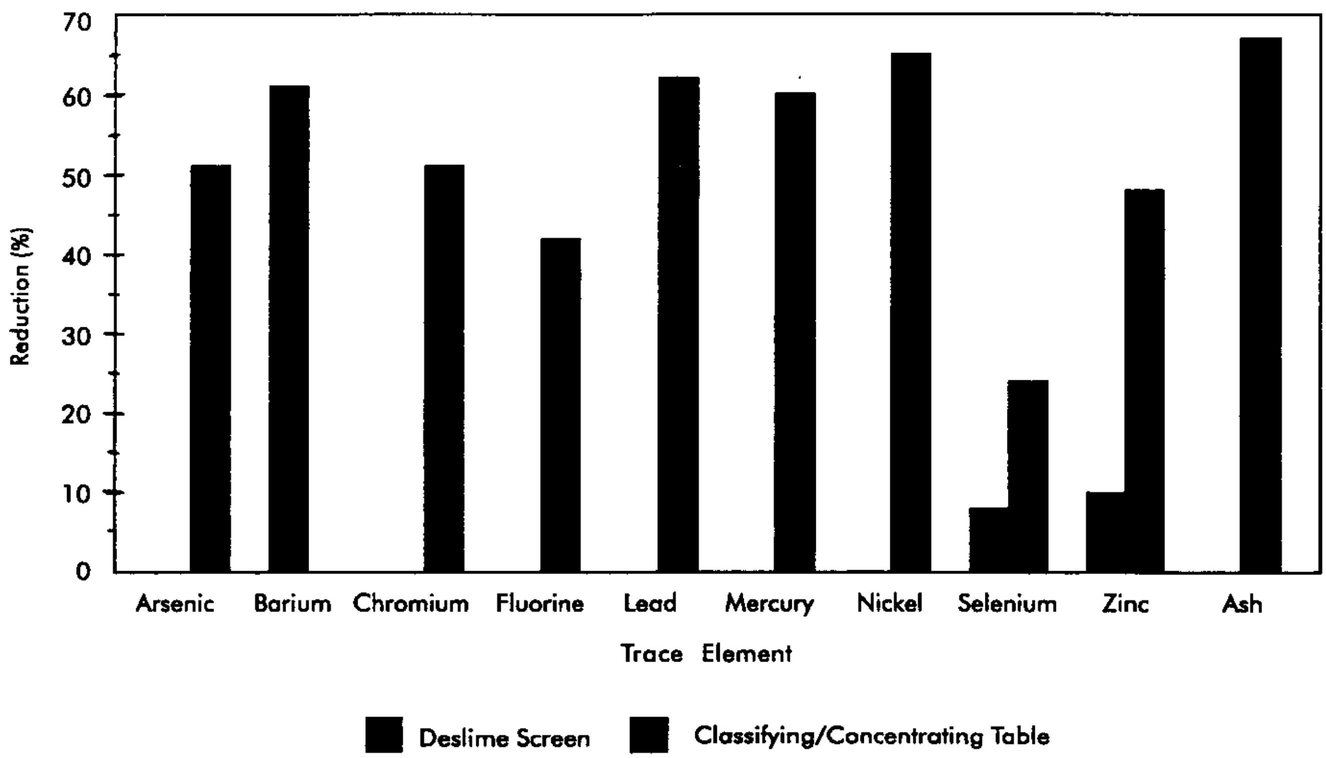
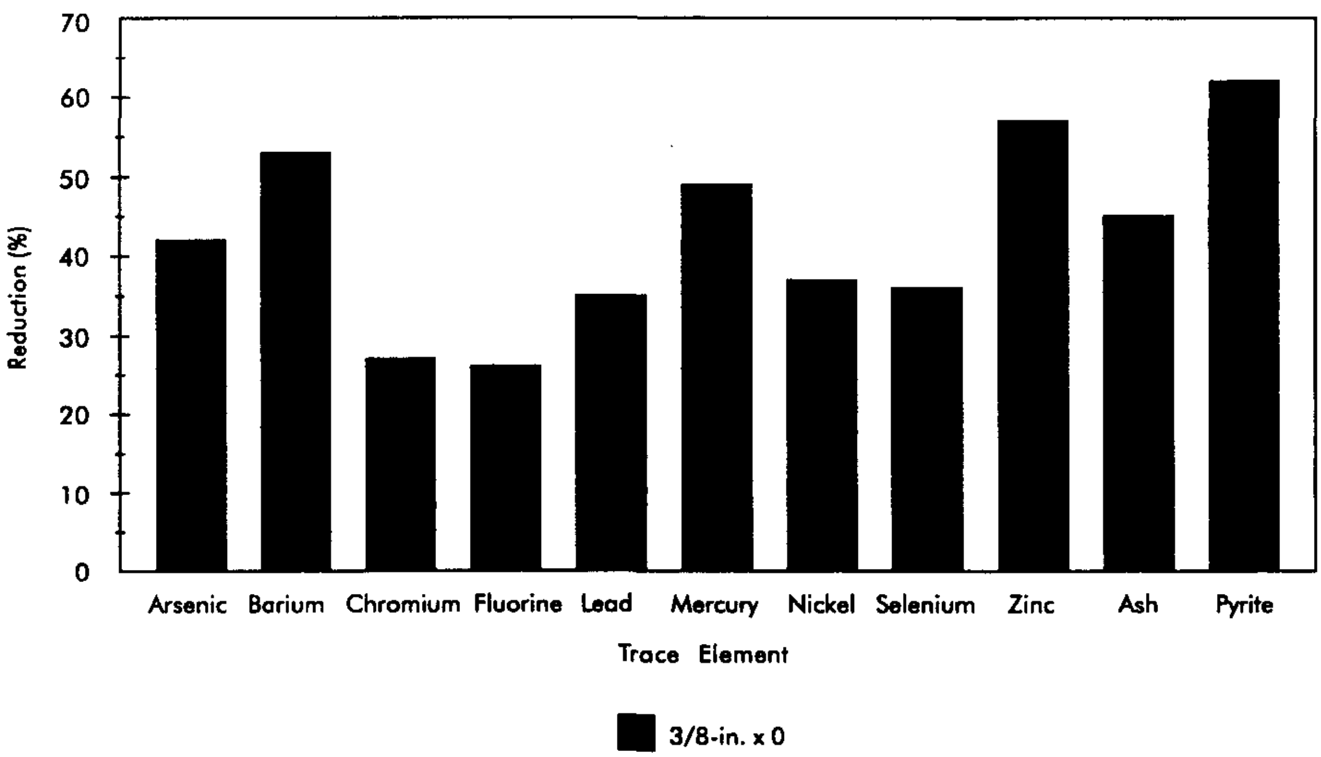


Figure 13. Flowsheet 3 Unit Operations. *Utley Coal Cleaning Characterization.*

In terms of reductions, Figure 14 does not show a strong correlation between pyrite reduction and the reductions of trace elements as a result of cleaning the Utley coal. However, there is an indication that there may be some relationship between the reductions of arsenic and ash-bearing mineral matter in this coal--suggesting that a cleaning method that is efficient in removing ash, should be equally as efficient in removing arsenic. The same relationship also appears to hold for ash and barium.



Note: Percent reductions, heat unit basis (grams-per-billion Btus).

Figure 14. Flowsheet 3 Trace Element Reductions. *Utley Seam Coal Cleaning Characterization.*

Flowsheet 4 Trace Element Reduction Evaluation

Flowsheet 4--Trace Element Reductions.
(Percent)

Arsenic	28
Barium	83
Chromium	57
Fluorine	46
Lead	51
Mercury	9
Nickel	23
Selenium	32
Zinc	61
Ash	68
Pyrite	9

Flowsheet 4 was used to simulate a relatively simple flowsheet that incorporated inexpensive equipment--a concentrating table and spiral separator for cleaning Pratt Seam coal. Flowsheet 4 also provided the added ability of the spiral separator to remove previously liberated pyrite and fine-sized ash particles that had not been removed by the concentrating table. As with the previous tests, the raw Pratt coal was crushed and fed to the double-deck deslime screen that discarded the plus 3/8-in. size fraction while the 3/8-in. x 28 mesh size fraction was fed to the classifying cyclone/concentrating table circuit. The classifying cyclone made a 100 mesh separation with the minus 100 mesh fraction combined with the 100 mesh x 0 underflow from the deslime screen going to the flotation sump for further processing. In addition, the 28 mesh x 0 size fraction from the deslime screen was combined with the 28 mesh x 0 size fraction of the concentrating table clean coal and sent to thickening cyclones as feed to the spiral separator. The concentrating table made a separation near 1.70 specific gravity.

Flowsheet 4 produced a low weight yield (58 percent) and a moderate energy recovery (73 percent) with a moderate ash reduction of 68 percent. As with the previous flowsheet tests, all raw coal trace element concentrations were reduced by cleaning--in the range of nine percent for mercury to 83 percent for barium.

Table 16 lists the reductions of trace elements by size fraction and Figure 15 compares size fraction reductions with total flowsheet reductions (plus 3/8-in. x 0).

Table 16. Flowsheet 4 Trace Element Reductions. *Pratt Seam Coal (Percent).*

Element	+3/8-in.x 28M	28M x 100M	100M x 325M	325 M x 0
Arsenic	29	35	30	6
Barium	83	16	61	77
Chromium	56	48	48	61
Fluorine	44	24	-23	68
Lead	52	18	41	-41
Mercury	8	36	38	-18
Nickel	16	58	56	44
Selenium	34	27	-3	1
Zinc	53	40	-21	1
Ash	66	65	58	69

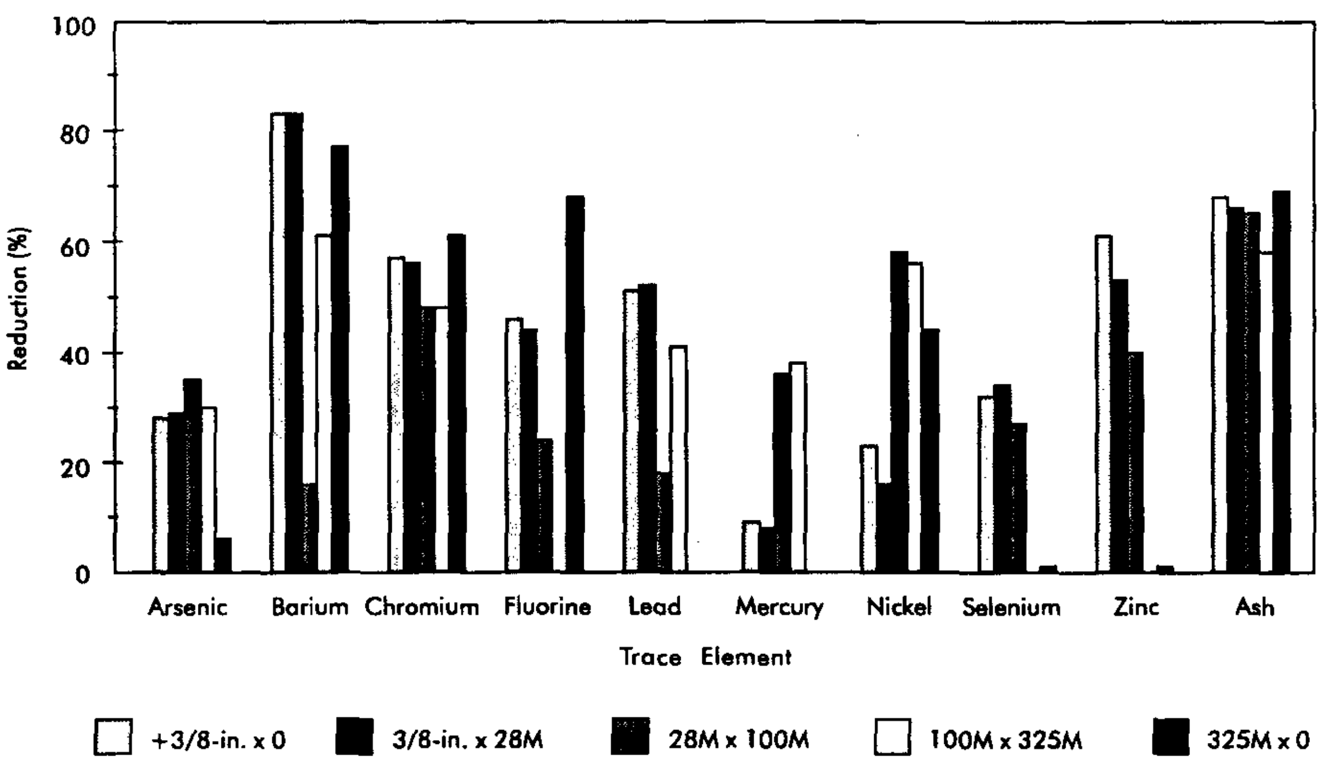


Figure 15. Flowsheet 4 Trace Element Reductions By Size Fraction. *Pratt Coal Cleaning Characterization.*

Figure 15 shows that, when comparing the plus 3/8-in. x 0 whole coal and the 3/8-in. x 28 mesh size fraction, cleaning the two smallest size fractions (100 mesh x 0 and 325 mesh x 0) had a positive effect on the overall removals of chromium, fluorine, zinc, and ash but may have caused a net decrease in the removals of arsenic, lead, mercury, nickel, and selenium. However, cleaning these two fractions did not appear to affect the net removal of barium. From the data, it appears that conventional coal cleaning will produce significant trace element reductions and that fine-sized cleaning by advanced technologies may provide enough additional reductions to be cost effective for trace element removals from the Pratt coal.

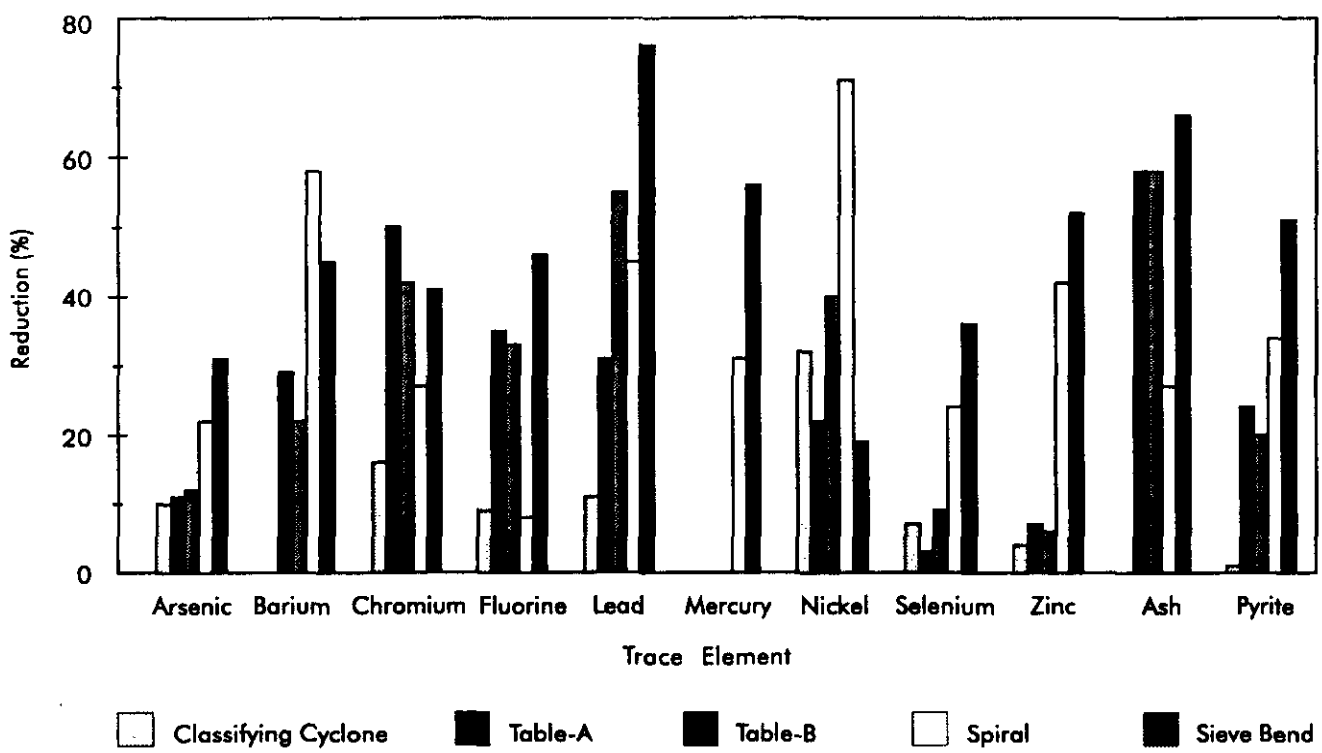
Table 17 contains the trace element removals of the deslime screen and classifying cyclone/concentrating table circuit, spiral concentrator, and sieve bends used in Flowsheet 4. A circuit upset midway through the flowsheet test required that two samples be collected for the concentrating table clean coal stream. Sample A was a sample of the clean coal prior to the plant upset and Sample B was clean coal taken under the second set of operating conditions. The analysis of these two samples give an indication of the variability of trace element reductions that can occur from the same piece of equipment operated under different conditions.

Table 17. Flowsheet 4 Unit Trace Element Reductions. *(Percent).*

Element	DSS	CC/CT-A	CC/CT-B	SC	SB
Arsenic	10	11	12	22	17
Barium	-33	28	22	58	52
Chromium	16	50	42	27	21
Fluorine	9	35	33	8	0
Lead	11	31	55	45	43
Mercury	-40	-21	-50	31	14
Nickel	32	22	40	71	44
Selenium	7	34	9	24	-2
Zinc	4	7	6	42	34
Ash	-6	58	58	27	24

DSS = Deslime Screen
CT-A = Classifying Cyclone/Concentrating Table "A" Sample
CT-B = Classifying Cyclone/Concentrating Table "B" Sample
SC = Spiral Concentrator
SB = Sieve Bends

As the data and Figure 16 show, the reductions of all trace elements and pyrite were affected by the plant upset, but reductions of ash were not. Although there was no change in the ash reductions, not all of the other tested parameters were effected in the same ways. For example, the reductions reported for barium, chromium, fluorine, zinc, and pyrite were greater under the operating conditions that produced Sample A but those reductions for arsenic, lead, nickel, and selenium were greater from Sample B than they were from Sample A. This is an indication that trace element reductions are very sensitive to coal cleaning operations.



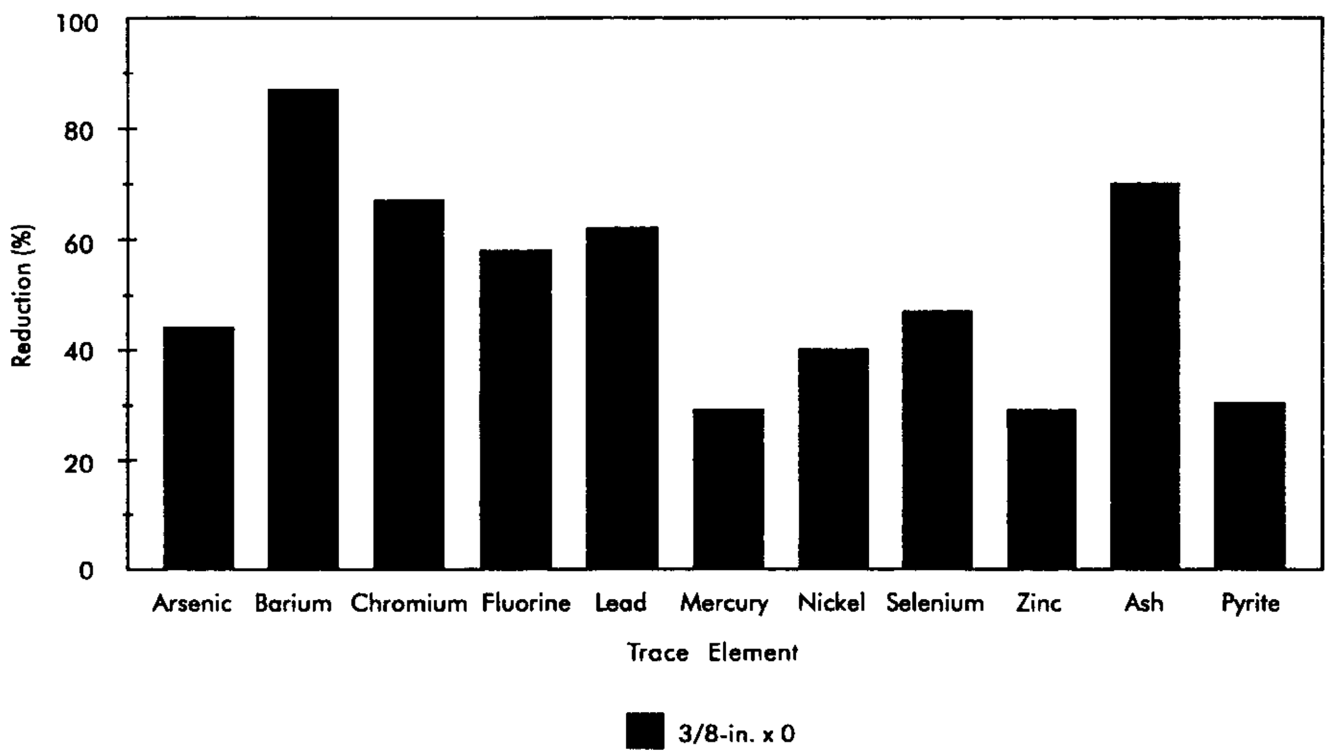
Note: Percent reductions, heat unit basis (grams-per-billion Btus).

Figure 16. Flowsheet 4 Unit Operations. *Pratt Seam Coal Cleaning Characterization.*

Screening also caused an increase in the product for barium (33 percent) and ash (six percent). Net reductions were produced by the spiral concentrating circuit for all elements, while the sieve bends produced net reductions of all trace elements except fluorine (zero percent net change) and selenium (two percent increase).

Flowsheet 4 produced reductions of all of the parameters tested and the use of the spiral concentrator in the circuit aided in additional reductions of trace elements making the use of spirals an inexpensive option that can be retrofitted to many coal cleaning operations to enhance trace element reductions.

Figure 17 shows a strong correlation between pyrite reduction and the reduction of mercury and zinc as well as a similar relationship among the reductions of lead, chromium, and fluorine and ash-bearing mineral matter.



Note: Percent reductions, heat unit basis (grams-per-billion Btus).

Figure 17. Flowsheet 4 Trace Element Reductions. *Pratt Seam Coal Cleaning Characterization.*

SUMMARY

The raw coal characterizations and the four flowsheet tests performed on the Pratt and Utley seam coals show that trace element concentrations in coals in general are specific to the individual coal. For all trace elements tested in the raw coals, the Utley Seam coal had lower concentrations except for arsenic and manganese, but the Pratt Seam coal was higher in ash, while the Utley Seam coal was about 1.6 times higher in sulfur. These tests have also shown that coal cleaning operations that remove trace elements from one coal might not necessarily remove trace elements from a different coal, and in fact can cause some trace elements to concentrate in the clean coal produced in a preparation plant. Moreover, these studies have shown that each individual piece of equipment used in a cleaning plant affects overall trace element removals differently. Finally, for many trace elements, it was shown that a direct relationship exists between the amounts of ash and pyrite removed and the amounts of certain trace elements removed.

Table 18 shows the variability of trace element removals using the same cleaning equipment, in this case a concentrating table, to clean two different coals.

Table 18. Flowsheets 2 and 3 Trace Element Reductions.
(Percent, Dry Basis).

Element	Pratt Seam Flowsheet 2	Utley Seam Flowsheet 3
Arsenic	15	36
Barium	38	48
Chromium	51	20
Fluorine	16	18
Lead	47	29
Mercury	10	44
Nickel	51	31
Selenium	37	30
Zinc	28	53
Ash	55	40
Pyrite	15	59

Generally, it would be logical to assume that if one raw coal is higher in trace elements than another, reductions from the first coal will be greater than the second if both coals are cleaned under similar conditions. However, this was not the case here. As the data show, although the Pratt Seam raw coal was higher in all trace elements except arsenic than the Utley Seam coal, cleaning the Utley coal in Flowsheet 3 produced higher reductions of barium, mercury, and zinc. Ash and sulfur reductions followed the norm as the higher ash Pratt had a higher reduction, while the higher sulfur Utley had a higher sulfur (pyrite) reduction.

The levels of trace element reductions can also be affected by the equipment used. Adding a particular piece of equipment to a flowsheet to provide specific additional cleaning of a particular portion of the coal stream can either enhance or in some cases hinder overall trace element reduction. Table 19 contains the data from flowsheet tests 2 and 4, each of which cleaned Pratt Seam coal on the concentrating table. They differ in the respect that a spiral concentrator was added to the circuitry of Flowsheet 4 in order to provide additional cleaning potential to remove previously liberated pyrite and fine-sized ash particles that had not been removed by the concentrating table.

Table 19. Flowsheets 2 and 4 Trace Element Reductions. *Pratt Seam Coal (Percent, Dry Basis).*

Element	Flowsheet 2	Flowsheet 4
Arsenic	15	28
Barium	38	83
Chromium	51	57
Fluorine	16	46
Lead	47	51
Mercury	10	9
Nickel	51	23
Selenium	37	32
Zinc	28	61
Ash	55	68
Pyrite	15	9

As the data show, the addition of the spiral to the circuit helped to significantly improve the reductions of arsenic, barium, chromium, fluorine, lead, and zinc as well as ash. However, its addition did not improve the reductions of nickel and selenium or pyrite. From this information, it might be concluded that the nickel and selenium in the Pratt coal are associated with the larger size fractions that were removed and discarded in Flowsheet 2. Conversely, the additional reductions produced in Flowsheet 4 probably are the result of increased reductions of fine-sized ash-forming mineral matter typically associated with spirals.

The benefits of deep cleaning are shown in the comparison of flowsheets 1, 2, and 4. These flowsheets essentially cleaned Pratt Seam coal, although Flowsheet 1 was a blend of 90 percent Pratt coal and ten percent Utley coal. It is assumed that the contributions to the feed coal quality of such a small proportion is negligible.

The data shown in Table 20 indicate that the deep cleaning in flowsheets 1 and 4 removed more arsenic, barium, chromium, fluorine, lead, zinc, and ash than the process of cleaning the coal with the concentrating table and discarding the 100 mesh size fraction. The deep cleaning in Flowsheet 1 used heavy-media and water-only cycloning along with froth flotation, while Flowsheet 4 featured the concentrating table and spiral concentrator. For comparison, flowsheets 2 and 4 produced similar reductions of mercury while Flowsheet 1 had no net reduction of mercury and flowsheets 1 and 2 were more efficient in reducing nickel and selenium than was Flowsheet 4.

Table 20. Flowsheets 1, 2, and 4 Trace Element Reductions.
Pratt Seam Coal (Percent, Dry Basis).

Element	Flowsheet 1	Flowsheet 2	Flowsheet 4
Arsenic	29	15	28
Barium	84	38	83
Chromium	57	51	57
Fluorine	50	16	46
Lead	60	47	51
Mercury	0	10	9
Nickel	46	51	23
Selenium	38	37	32
Zinc	65	28	61
Ash	69	55	68
Pyrite	11	15	9

As summarized by the data in Table 21, the trace element studies performed on the Pratt and Utley coals show that coal cleaning reduces significant amounts of trace elements, no matter how simple or complex the cleaning scenario.

Table 21. Flowsheets 1, 2, 3, and 4 Trace Element Reductions. *(Percent, Dry Basis).*

Element	Pratt Seam Flowsheet 1	Pratt Seam Flowsheet 2	Utley Seam Flowsheet 3	Pratt Seam Flowsheet 4
Arsenic	29	15	36	28
Barium	84	38	48	83
Chromium	57	51	20	57
Fluorine	50	16	18	46
Lead	60	47	29	51
Mercury	0	10	44	9
Nickel	46	51	31	23
Selenium	38	37	30	32
Zinc	65	28	53	61
Ash	69	55	40	68
Pyrite	11	15	59	9

The data also indicate that for a specific coal, a simple flowsheet configuration can achieve substantial removals of certain trace elements such as the arsenic and mercury reductions achieved for the Utley Seam coal in Flowsheet 3, which used only sizing and a concentrating table.

CONCLUSIONS

In general, the data presented in these studies indicate that cleaning was effective in reducing the concentrations of most of the trace elements studied, more so in cases where trace elements were present in the raw coals in high concentrations. Not only were the reductions coal-specific, relating in part to the mineral association of the specific trace element and the degree of liberation of the trace element-bearing mineral, but also to the extent of removal controlled by the method of cleaning. The studies show that simple, cost-effective coal cleaning processes such as screening and concentrating tables that remove coarse particles and their associated trace elements can provide significant removals of many trace elements. Moreover, the studies show that more intense cleaning operations such as heavy-media cycloning or those that clean the smallest-size fractions can provide additional trace element removal opportunities.

In addition to reducing the concentration of many trace elements, coal cleaning improves utility boiler performance by increasing thermal efficiency while reducing ash loading. Removing potentially toxic trace elements from coal before it is burned reduces the amounts of these elements that enter a boiler, therefore reducing the amount that eventually volatilizes and either exits the boiler as hazardous air pollutants or condenses on the finest-sized fly ash particles. This increases the chance that they will not be collected by present particulate-capture systems such as scrubbers and electrostatic participators.

This concept can be illustrated by using the results of the Flowsheet 1 test as an example of the overall impacts of coal cleaning on potentially hazardous toxics emissions on a coal-fired electric generating station that burns one million tons of coal a year.

Based on the laboratory data given for this test, we can assume that the raw coal will contain approximately 351 tons of regulated trace elements for every million tons of coal. However, if the coal is cleaned and produces reductions similar to those in Flowsheet 1, the total amount of trace elements entering the boiler will be 125 tons for every million tons of coal--a reduction of 64 percent. Moreover, since coal cleaning increases the Btu content of the coal, less fuel will need to be purchased to meet power plant energy requirements.

The same power plant that burns one million tons of raw coal would only need to burn about 800,000 tons of the higher Btu clean coal to meet its energy requirements, meaning 20 percent less pollutants would enter the boiler. In addition, CQ Inc. engineers have found that improved quality coals increase boiler efficiencies and would undoubtedly result in lower toxics emissions, although it is difficult to quantify the amounts. Nevertheless, the total amount of trace element reductions attributable to coal cleaning would exceed 250 tons (71 percent).

Finally, the majority of the elements that enter a boiler do not escape out the stack of a power plant but rather become part of the boiler's ash component. Ash disposal is a concern since toxic elements may leach from power plant ash disposal sites and could potentially cause problems for groundwater sources. Equally important are the present regulatory limits of major sources of hazardous air pollutants to ten tons of any regulated pollutant or 25 tons total emissions, although it is uncertain at this time if the same regulations will apply to power plants. In any event, coal cleaning is a proven strategy for the reduction of many potentially hazardous air pollutants.

REFERENCES

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Zubovic, P. et al., "Geochemistry of Minor Elements in Coals of the Northern Great Plains Coal Province," Bulletin 1117-A, U.S. Geological Survey, 1961.

APPENDIX A

Pratt Raw Coal Characterization

GOULD ENERGY DIVISION
P.O. BOX 214
CRESSON, PA 16630
STANDARD LABORATORIES, INC.

CQ, INC.
ONE QUALITY CENTER
HOMER CITY, PA 15748

DATE: 05/25/93
SAMPLE NO: 144666

SAMPLE ID: RUN #91112100 PRATT SEAM
TOP X O

SAMPLED BY:

DATE SAMPLED:

DATE RECEIVED: 1/17/92

OTHER ID: RAW COAL CHARACTERIZATION PRIMARY SAMPLER REJECT SPLIT

CORRECTED REPORT - THIS REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH THE SAME LABORATORY NUMBER.

CERTIFICATE OF ANALYSIS

ANTIMONY	< 0.50	ppm
ARSENIC	8.28	ppm
BARIUM	188.4	ppm
CADMIUM	< 0.10	ppm
CHROMIUM	31.3	ppm
BERYLLIUM	< 0.50	ppm
LEAD	14.9	ppm
MERCURY	381.7	ppb
NICKEL	37.0	ppm
SELENIUM	2.01	ppm
MANGANESE	45.6	ppm
ZINC	70.8	ppm

APPROVED BY [signature]

APPROVED BY Thomas A. [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER 144666

SAMPLE ID:RUN# 91112100 PRATT SEAM COAL
RAW CHARACTERIZATION

OPERATING CO:PROJECT 90D0101 TASK 2.4
SAMPLED BY: CUSTOMER PROVIDED GROSS WEIGHT: 999.8
DATE SAMPLED: DATE RECEIVED:01/17/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
+3/4	37.94	< 0.50	6.76	237.50	< 0.10	34.70	< 0.50	17.70	381.70	38.60	1.67	50.10	81.80
3/4 X 28	51.51	< 0.50	8.19	172.70	< 0.10	28.90	< 0.50	14.70	283.60	38.10	2.12	40.90	62.10
28 X 100	3.76	< 0.50	13.10	110.00	< 0.10	22.80	< 0.50	12.50	272.00	32.00	2.83	108.85	57.00
100 X 0	6.79	< 0.50	10.30	278.45	< 0.10	44.80	< 0.50	21.90	432.60	45.90	4.04	132.50	152.75

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
+3/4	37.94	< 0.50	6.76	237.50	< 0.10	34.70	< 0.50	17.70	381.70	38.60	1.67	50.10	81.80
3/4 X 28	89.45	< 0.50	7.58	200.18	< 0.10	31.36	< 0.50	15.97	325.21	38.31	1.93	44.80	70.46
28 X 100	93.21	< 0.50	7.81	196.55	< 0.10	31.01	< 0.50	15.83	323.06	38.06	1.97	47.39	69.91
100 X 0	100.00	< 0.50	7.98	202.11	< 0.10	31.95	< 0.50	16.24	330.50	38.59	2.11	53.17	75.54

ALL TRACE ELEMENT RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED [signature]

APPROVED Thomas A. [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER # 156230

SAMPLE ID:RUN#91112100 PRATT SEAM COAL
RAW CHARACTERIZATION

OPERATING CO:PROJECT 90D0101 TASK 2.4
SAMPLED BY: CUSTOMER PROVIDED
GROSS WEIGHT: 999.8
DATE SAMPLED:
DATE RECEIVED: 01/17/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

+3/4

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	19.87	< 0.50	6.54	91.10	< 0.10	7.36	< 0.50	4.56	152.00	12.80	2.05	14.90	17.70
1.40	36.85	< 0.50	6.47	14.40	< 0.10	16.20	< 0.50	5.84	427.60	17.00	1.98	21.30	13.20
1.60	15.98	< 0.50	10.10	176.60	< 0.10	37.70	< 0.50	18.60	447.30	34.10	2.03	39.50	56.90
1.80	5.30	< 0.50	9.60	225.10	< 0.10	57.30	< 0.50	28.10	254.50	43.80	1.29	49.00	93.80
2.00	2.17	< 0.50	14.90	309.40	< 0.10	68.60	< 0.50	40.10	863.00	69.90	1.32	40.10	143.70
2.00 SK	19.83	< 0.50	13.20	690.90	< 0.10	94.20	< 0.50	49.20	410.90	94.20	1.89	124.10	207.70

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	19.87	< 0.50	6.54	91.10	< 0.10	7.36	< 0.50	4.56	152.00	12.80	2.05	14.90	17.70
1.40	56.72	< 0.50	6.49	41.27	< 0.10	13.10	< 0.50	5.39	331.05	15.53	2.00	19.06	14.78
1.60	72.70	< 0.50	7.29	71.02	< 0.10	18.51	< 0.50	8.29	356.60	19.61	2.01	23.55	24.04
1.80	78.00	< 0.50	7.44	81.49	< 0.10	21.15	< 0.50	9.64	349.67	21.25	1.96	25.28	28.78
2.00	80.17	< 0.50	7.65	87.65	< 0.10	22.43	< 0.50	10.47	363.56	22.57	1.94	25.68	31.89
2.00 SK	100.00	< 0.50	8.75	207.28	< 0.10	36.66	< 0.50	18.15	372.95	36.78	1.93	45.20	66.75

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY

APPROVED BY

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER #156230

SAMPLE ID: RUN#91112100 PRATT SEAM COAL
RAW CHARACTERIZATION

OPERATING CO: PROJECT 90D0101 TASK 2.4
SAMPLED BY: CUSTOMER PROVIDED
DATE SAMPLED:

GROSS WEIGHT: 999.8
DATE RECEIVED: 01/17/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

3/4 X 28

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	40.61	< 0.50	5.19	131.00	< 0.10	8.65	< 0.50	4.06	196.10	12.20	1.60	12.30	18.90
1.40	28.39	< 0.50	5.81	123.90	< 0.10	18.70	< 0.50	8.83	249.30	24.50	1.65	20.90	32.30
1.60	10.42	< 0.50	9.13	126.30	< 0.10	40.30	< 0.50	24.50	421.30	45.00	1.67	39.20	76.00
1.80	3.79	< 0.50	8.57	208.30	< 0.10	58.70	< 0.50	23.05	555.80	76.10	1.64	68.80	121.40
2.00	2.05	< 0.50	13.20	252.80	< 0.10	69.10	< 0.50	27.40	768.70	77.40	1.36	84.30	161.60
2.00 SK	14.54	< 0.50	18.80	401.10	< 0.10	84.60	< 0.50	32.50	310.80	97.60	5.33	143.10	169.10

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	40.61	< 0.50	5.19	131.00	< 0.10	8.65	< 0.50	4.06	196.10	12.20	1.60	12.30	18.90
1.40	69.00	< 0.50	5.45	128.08	< 0.10	12.79	< 0.50	6.02	217.99	17.26	1.62	15.84	24.41
1.60	79.42	< 0.50	5.93	127.85	< 0.10	16.40	< 0.50	8.45	244.66	20.90	1.63	18.90	31.18
1.80	83.21	< 0.50	6.05	131.51	< 0.10	18.32	< 0.50	9.11	258.84	23.41	1.63	21.18	35.29
2.00	85.26	< 0.50	6.22	134.43	< 0.10	19.54	< 0.50	9.55	271.09	24.71	1.62	22.69	38.33
2.00 SK	99.80	< 0.50	8.05	173.28	< 0.10	29.02	< 0.50	12.90	276.88	35.33	2.16	40.24	57.38

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY

APPROVED BY

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER #156230

SAMPLE ID:RUN#91112100 PRATT SEAM COAL
RAW CHARACTERIZATION

OPERATING CO: PROJECT 90D0101 TASK 2.4
SAMPLED BY: CUSTOMER PROVIDED
DATE SAMPLED:

GROSS WEIGHT: 999.8
DATE RECEIVED: 01/17/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

28 X 100

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	46.27	< 0.50	6.08	49.40	< 0.10	8.88	< 0.50	1.78	132.40	6.33	1.60	7.26	10.40
1.40	23.51	< 0.50	7.13	63.10	< 0.10	18.50	< 0.50	6.83	237.70	16.80	2.01	12.10	24.40
1.60	8.08	< 0.50	9.40	112.70	< 0.10	32.10	< 0.50	20.10	442.40	36.50	2.48	29.70	60.00
1.80	3.02	< 0.50	12.30	190.40	< 0.10	59.90	< 0.50	30.80	692.90	73.10	1.65	59.00	131.30
2.00	1.80	< 0.50	15.40	187.25	< 0.10	68.80	< 0.50	35.10	801.30	88.95	2.17	81.80	180.50
2.00 SK	17.32	< 0.50	32.50	226.40	< 0.10	68.90	< 0.50	33.30	699.20	131.10	6.17	513.85	202.20

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	46.27	< 0.50	6.08	49.40	< 0.10	8.88	< 0.50	1.78	132.40	6.33	1.60	7.26	10.40
1.40	69.78	< 0.50	6.43	54.02	< 0.10	12.12	< 0.50	3.48	167.88	9.86	1.74	8.89	15.12
1.60	77.86	< 0.50	6.74	60.11	< 0.10	14.19	< 0.50	5.21	196.37	12.62	1.82	11.05	19.77
1.80	80.88	< 0.50	6.95	64.97	< 0.10	15.90	< 0.50	6.16	214.91	14.88	1.81	12.84	23.94
2.00	82.68	< 0.50	7.13	67.63	< 0.10	17.05	< 0.50	6.79	227.67	16.49	1.82	14.34	27.35
2.00 SK	100.00	< 0.50	11.53	95.13	< 0.10	26.03	< 0.50	11.38	309.34	36.34	2.57	100.86	57.63

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY [signature]

APPROVED BY Thomas A. [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER #156230

SAMPLE ID: RUN#91112100 PRATT SEAM COAL
RAW CHARACTERIZATION

OPERATING CO: PROJECT 90D0101 TASK 2.4
SAMPLED BY: CUSTOMER PROVIDED
GROSS WEIGHT: 999.8
DATE SAMPLED:
DATE RECEIVED: 01/17/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
WASHABILITY PERFORMED WITH CESIUM CHLORIDE AT PROCESS TECH
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

100 X 0

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	24.73	< 0.50	4.85	59.30	< 0.10	10.00	< 0.50	1.43	100.30	7.10	3.05	6.41	13.90
1.40	22.29	< 0.50	4.75	108.60	< 0.10	19.70	< 0.50	21.90	307.60	17.50	1.72	18.70	41.50
1.60	8.72	< 0.50	4.20	125.00	< 0.10	23.20	< 0.50	17.15	241.50	31.00	1.08	46.00	83.00
1.80	2.78	< 0.50	10.80	188.60	< 0.10	37.65	< 0.50	34.30	220.50	49.40	1.96	75.40	108.30
2.00	2.13	< 0.50	10.70	271.20	< 0.10	73.60	< 0.50	54.05	271.20	87.65	2.35	128.70	201.10
2.00 SK	39.36	< 0.50	22.60	422.00	< 0.10	100.60	< 0.50	30.60	875.60	89.60	8.36	268.90	274.75

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	24.73	< 0.50	4.85	59.30	< 0.10	10.00	< 0.50	1.43	100.30	7.10	3.05	6.41	13.90
1.40	47.02	< 0.50	4.80	82.67	< 0.10	14.60	< 0.50	11.13	198.57	12.03	2.42	12.24	26.98
1.60	55.74	< 0.50	4.71	89.29	< 0.10	15.94	< 0.50	12.08	205.29	15.00	2.21	17.52	35.75
1.80	58.52	< 0.50	5.00	94.01	< 0.10	16.98	< 0.50	13.13	206.01	16.63	2.20	20.27	39.19
2.00	60.65	< 0.50	5.20	100.23	< 0.10	18.96	< 0.50	14.57	208.30	19.13	2.20	24.08	44.88
2.00 SK	100.01	< 0.50	12.05	226.87	< 0.10	51.09	< 0.50	20.88	470.92	46.86	4.63	120.43	135.35

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY [signature]

APPROVED BY Thomas A. [signature]

APPENDIX B

Utley Raw Coal Characterization

GOULD ENERGY DIVISION
P.O. BOX 214
CRESSON, PA 16630
STANDARD LABORATORIES, INC.

CQ, INC.
ONE QUALITY CENTER
HOMER CITY, PA 15748

DATE: 05/25/93
SAMPLE NO: 146653

SAMPLE ID: RUN #91112101 TOP X O
UTLEY CHARACTERIZATION

SAMPLED BY:

DATE SAMPLED:

DATE RECEIVED: 1/28/92

OTHER ID: CORRECTED REPORT - THIS REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH THE SAME LABORATORY NUMBER.

CERTIFICATE OF ANALYSIS

ANTIMONY	< 0.50	ppm
ARSENIC	9.45	ppm
BARIUM	110.4	ppm
CADMIUM	< 0.10	ppm
CHROMIUM	17.9	ppm
BERYLLIUM	< 0.50	ppm
LEAD	10.7	ppm
MERCURY	356.8	ppb
NICKEL	26.6	ppm
SELENIUM	1.64	ppm
MANGANESE	51.6	ppm
ZINC	43.0	ppm

APPROVED BY [signature]

APPROVED BY Thomas A. [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER 146653

SAMPLE ID:RUN# 91112101 UTLEY SEAM COAL
RAW CHARACTERIZATION

OPERATING CO:PROJECT 9000101 TASK 2.3
SAMPLED BY: CUSTOMER PROVIDED
DATE SAMPLED:

GROSS WEIGHT: 916.5
DATE RECEIVED:01/28/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
+3/4	34.32	< 0.50	7.41	84.90	< 0.10	10.90	< 0.50	5.99	283.10	18.20	1.21	37.50	24.70
3/4 X 28	53.37	< 0.50	8.29	92.30	< 0.10	16.20	< 0.50	9.14	340.40	23.60	1.54	34.80	36.50
28 X 100	4.18	< 0.50	9.70	79.60	< 0.10	28.80	< 0.50	19.80	338.10	35.60	2.21	59.30	59.80
100 X 0	8.13	< 0.50	7.33	290.20	< 0.10	61.50	< 0.50	24.90	269.30	65.50	1.20	111.30	200.40

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
+3/4	34.32	< 0.50	7.41	84.90	< 0.10	10.90	< 0.50	5.99	283.10	18.20	1.21	37.50	24.70
3/4 X 28	87.69	< 0.50	7.95	89.40	< 0.10	14.13	< 0.50	7.91	317.97	21.49	1.41	35.86	31.88
28 X 100	91.87	< 0.50	8.03	88.96	< 0.10	14.79	< 0.50	8.45	318.89	22.13	1.45	36.92	33.15
100 X 0	100.00	< 0.50	7.97	105.32	< 0.10	18.59	< 0.50	9.79	314.86	25.65	1.43	42.97	46.75

ALL TRACE ELEMENT RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY [signature]

APPROVED BY Thomas A. [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER #156244

SAMPLE ID: RUN # 91112101 UTLEY SEAM COAL
RAW CHARACTERIZATION

OPERATING CO: PROJECT 90D0101 TASK 2.3
SAMPLED BY: CUSTOMER PROVIDED
GROSS WEIGHT: 916.5
DATE SAMPLED:
DATE RECEIVED: 01/28/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

+3/4

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	46.10	< 0.50	3.95	52.00	< 0.10	3.19	< 0.50	1.83	151.20	5.98	1.03	20.70	11.70
1.40	38.57	< 0.50	7.76	67.00	< 0.10	11.80	< 0.50	5.43	248.10	17.70	1.11	30.20	20.30
1.60	8.47	< 0.50	11.00	63.90	< 0.10	23.50	< 0.50	11.50	742.60	34.90	1.66	31.90	47.40
1.80	1.88	< 0.50	13.10	166.60	< 0.10	37.00	< 0.50	23.80	1159.20	59.90	1.46	52.00	75.80
2.00	0.49	< 0.50	15.30	94.10	< 0.10	24.70	< 0.50	13.30	1977.20	55.20	2.73	33.35	92.50
2.00 SK	4.48	< 0.50	21.30	255.00	< 0.10	50.30	< 0.50	35.40	1050.50	72.60	7.35	264.30	134.00

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	46.10	< 0.50	3.95	52.00	< 0.10	3.19	< 0.50	1.83	151.20	5.98	1.03	20.70	11.70
1.40	84.67	< 0.50	5.69	58.83	< 0.10	7.11	< 0.50	3.47	195.34	11.32	1.07	25.03	15.62
1.60	93.14	< 0.50	6.17	59.29	< 0.10	8.60	< 0.50	4.20	245.11	13.46	1.12	25.65	18.51
1.80	95.02	< 0.50	6.31	61.42	< 0.10	9.16	< 0.50	4.59	263.19	14.38	1.13	26.17	19.64
2.00	95.51	< 0.50	6.35	61.58	< 0.10	9.24	< 0.50	4.63	271.99	14.59	1.14	26.21	20.02
2.00 SK	99.99	< 0.50	7.02	70.25	< 0.10	11.08	< 0.50	6.01	306.87	17.19	1.41	36.88	25.12

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY [signature]

APPROVED BY [signature]

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER #156244

SAMPLE ID: RUN#91112101 UTLEY SEAM COAL
RAW CHARACTERIZATION

OPERATING CO PROJECT 90D0101 TSK. 2.3
SAMPLED BY: CUSTOMER PROVIDED — GROSS WEIGHT: 916.5
DATE SAMPLED — DATE RECEIVED: 01/29/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

3/4 X 28

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	50.50	< 0.50	8.10	55.60	< 0.10	4.62	< 0.50	2.94	200.40	7.56	1.20	22.70	12.50
1.40	31.72	< 0.50	6.27	61.10	< 0.10	15.80	< 0.50	8.11	316.70	21.60	1.33	29.70	28.00
1.60	9.31	< 0.50	12.00	104.50	< 0.10	32.90	< 0.50	16.90	806.80	50.80	1.83	31.90	71.10
1.80	1.78	< 0.50	11.50	183.20	< 0.10	49.60	< 0.50	31.60	967.00	83.00	2.27	54.10	129.90
2.00	0.86	< 0.50	12.50	255.60	< 0.10	54.30	< 0.50	31.20	937.30	90.40	2.81	80.80	145.90
2.00 SK	5.83	< 0.50	23.80	522.20	< 0.10	78.30	< 0.50	46.20	1227.70	94.40	7.09	186.80	172.70

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	50.50	< 0.50	8.10	55.60	< 0.10	4.62	< 0.50	2.94	200.40	7.56	1.20	22.70	12.50
1.40	82.22	< 0.50	7.39	57.72	< 0.10	8.93	< 0.50	4.93	245.27	12.98	1.25	25.40	18.48
1.60	91.53	< 0.50	7.86	62.48	< 0.10	11.37	< 0.50	6.15	302.38	16.82	1.31	26.06	23.83
1.80	93.31	< 0.50	7.93	64.78	< 0.10	12.10	< 0.50	6.64	315.06	18.09	1.33	26.60	25.86
2.00	94.17	< 0.50	7.97	66.53	< 0.10	12.49	< 0.50	6.86	320.75	18.75	1.34	27.09	26.95
2.00 SK	100.00	< 0.50	8.90	93.09	< 0.10	16.32	< 0.50	9.15	373.62	23.16	1.68	36.40	35.45

ALL TRACE ELEMENTS RESULTS ARE STATED IN ppm EXCEPT THOSE INDICATED BY * WHICH ARE IN ppb

ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

APPROVED BY Lori Patney

APPROVED BY Thomas A. Right

STANDARD LABORATORIES, INC.

C.Q., INC.
1 QUALITY CENTER BOX 280
HOMER CITY, PA 15748

DATE: 05/25/93
MASTER WARNER #156244

SAMPLE ID: RUN #91112101 UTLEY SEAM COAL
RAW CHARACTERIZATION

OPERATING CO: PROJECT 9000101 TASK 2.3
SAMPLED BY: CUSTOMER PROVIDED — GROSS WEIGHT: 916.5
DATE SAMPLED — DATE RECEIVED: 01/28/92

OTHER ID: TOP X 0 AS RECEIVED COAL PRIMARY SAMPLER REJECT SPLIT
(NORTH RIVER #1 MINE SITE)
THIS CORRECTED REPORT SUPERCEDES ALL PRIOR REPORTS IDENTIFIED WITH SAME LAB NUMBER

CERTIFICATE OF ANALYSIS

28 X 100

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	43.63	< 0.50	5.56	5.29	< 0.10	7.66	< 0.50	2.24	180.80	6.10	1.35	17.10	14.50
1.40	19.73	< 0.50	5.52	18.10	< 0.10	17.70	< 0.50	6.85	231.20	16.40	1.42	18.50	27.40
1.60	10.59	< 0.50	6.21	66.20	< 0.10	19.90	< 0.50	16.30	437.20	36.70	1.46	32.30	52.60
1.80	4.16	< 0.50	8.28	80.15	< 0.10	64.20	< 0.50	27.80	638.10	67.30	1.63	45.60	99.70
2.00	2.61	< 0.50	8.67	63.00	< 0.10	75.60	< 0.50	51.70	442.90	84.50	1.98	56.70	100.80
2.00 SK	19.29	< 0.50	19.90	274.50	< 0.10	102.40	< 0.50	73.70	743.00	96.30	7.66	180.20	153.60

CUMULATIVE RESULTS

SCREEN SIZE OR GRAVITY	WEIGHT %	ANTIMONY	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
1.30	43.63	< 0.50	5.56	5.29	< 0.10	7.66	< 0.50	2.24	180.80	6.10	1.35	17.10	14.50
1.40	63.36	< 0.50	5.55	9.28	< 0.10	10.79	< 0.50	3.68	196.49	9.31	1.37	17.54	18.52
1.60	73.95	< 0.50	5.64	17.43	< 0.10	12.09	< 0.50	5.48	230.96	13.23	1.38	19.65	23.40
1.80	78.11	< 0.50	5.78	20.77	< 0.10	14.87	< 0.50	6.67	252.65	16.11	1.40	21.03	27.46
2.00	80.72	< 0.50	5.88	22.14	< 0.10	16.83	< 0.50	8.13	258.80	18.32	1.42	22.19	29.83
2.00 SK	100.01	< 0.50	8.58	70.81	< 0.10	33.34	< 0.50	20.78	352.19	33.36	2.62	52.66	53.71

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ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

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STANDARD LABORATORIES, INC.

, INC.
ALITY CENTER BOX 280
R CITY, PA 15748

DATE: 08/03/92
MASTER WARNER NO. 146661

SAMPLE ID: RUN# 91112101 UTTLEY SEAM

ATING CO: PROJECT #90D0101 TSK. 2.3
LED BY: BOB DOSPOY
SAMPLED:

GROSS WEIGHT: 916.5
DATE RECEIVED: 1/28/92

R ID: RAW COAL CHARACTERIZATION PRIMARY SAMPLER REJECT SPLIT (NORTH RIVER #1 MINE SITE)
NOTE: ANALYSIS PERFORMED ON MATERIAL RETURNED FROM PROCESS TECH (CESIUM CHLORIDE)

CERTIFICATE OF ANALYSIS

100 X 0

EN SIZE RAVITY	WEIGHT %	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
	15.72	2.61	21.50	< 0.10	4.77	<0.50	0.94	251.10	2.70	0.86	6.34	8.28
	12.49	2.25	26.70	< 0.10	17.00	<0.50	7.11	465.30	7.38	0.71	12.50	32.50
	11.81	1.87	53.90	< 0.10	14.90	<0.50	11.10	243.10	13.30	0.36	39.90	45.00
	3.37	3.28	104.20	< 0.10	43.00	<0.50	21.80	251.80	38.70	0.34	64.20	107.90
	2.01	4.51	219.00	< 0.10	68.10	<0.50	37.70	157.50	73.00	1.30	74.20	204.40
SK	54.59	9.26	409.50	< 0.10	98.50	<0.50	42.50	153.60	112.00	2.02	147.70	270.80

CUMULATIVE RESULTS

EN SIZE RAVITY	WEIGHT %	ARSENIC	BARIUM	CADMIUM	CHROMIUM	BERYLLIUM	LEAD	MERCURY (*)	NICKEL	SELENIUM	MANGANESE	ZINC
	15.72	2.61	21.50	< 0.10	4.77	<0.50	0.94	251.10	2.70	0.86	6.34	8.28
	28.21	2.45	23.80	< 0.10	10.18	<0.50	3.67	345.94	4.77	0.79	9.07	19.00
	40.02	2.28	32.68	< 0.10	11.58	<0.50	5.86	315.59	7.29	0.67	18.17	26.68
	43.39	2.36	38.24	< 0.10	14.02	<0.50	7.10	310.64	9.73	0.64	21.74	32.98
	45.40	2.45	46.24	< 0.10	16.41	<0.50	8.46	303.86	12.53	0.67	24.06	40.57
SK	99.99	6.17	244.56	< 0.10	61.23	<0.50	27.04	221.82	66.84	1.41	91.56	166.27

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ANALYTICAL RESULTS ARE STATED ON A DRY BASIS

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