

US EPA ARCHIVE DOCUMENT

**EXHIBIT 16.  
COMPARISON OF LISTED WASTE AND  
MINERAL PROCESSING WASTE CONCENTRATION DATA (mg/l)**

Sector/Waste Stream	Constituent	TC Limits	Min	Mean	Max	Range of Listed Waste Concentrations		
						Mean	Max	
<b>Aluminum Cast House Dust</b>	Cadmium	1	3.5	3.5	3.5	<0.01 - 117.5	<0.01 - 268	
	Mercury	0.2	0.84	0.84	0.84			
<b>Coal Gas MEE Concentrate</b>	Arsenic	5	3	16	29			
	Selenium	1	15	30	44			
<b>Copper Acid Plant Blowdown</b>	Arsenic	5	0.04	884.3 5	12800			
	Cadmium	1	0.05	4.28	24.5	<0.01 - 117.5	<0.01 - 268	
	Chromium	5	0	0.41	5	6.03 - 273.23	12 - 4250	
	Lead	5	0.04	2.83	6.74	1.47 - 259.83	2.10 - 1550	
	Mercury	0.2	0.0001	0.042	0.31			
	Selenium	1	0.01	1.21	7.63			
	Silver	5	0.01	0.41	5			
	pH	2<pH>12	0.99	2.21	5			
<b>Elemental Phosphorous AFM Rinsate</b>	Cadmium	1	4.12	4.12	4.12	<0.01 - 117.5	<0.01 - 268	
	Selenium	1	1.03	1.03	1.03			
<b>Elemental Phosphorous Furnace Blowdown</b>	<b>Scrubber</b>	Cadmium	1	0.005	0.4	2.07	<0.01 - 117.5	<0.01 - 268

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Sector/Waste Stream	Constituent	TC Limits	Min	Mean	Max	Range of Listed Waste Concentrations	
						Mean	Max
<b>Lead Baghouse Incinerator Ash</b>	Cadmium	1	5.76	5.76	5.76	<0.01 - 117.5	<0.01 - 268
	Lead	5	19.2	19.2	19.2	1.47 - 259.83	2.10 - 1550
<b>Lead Slurried APC Dust</b>	Cadmium	1	22	22	22	<0.01 - 117.5	<0.01 - 268
	Lead	5	959	959	959	1.47 - 259.83	2.10 - 1550
<b>Lead Spent Furnace Brick</b>	Lead	5	63.3	647	1230	1.47 - 259.83	2.10 - 1550
<b>Lead Stockpile Miscellaneous Plant Waste</b>	Cadmium	1	29.4	29.4	29.4	<0.01 - 117.5	<0.01 - 268
	Lead	5	1380	1380	1380	1.47 - 259.83	2.10 - 1550
<b>Lead WWTP Liquid Effluent</b>	pH	2<pH>12	7	9.08	13		
<b>Lead WWTP Sludges/Solids</b>	pH	2<pH>12	7.5	9.06	13		
<b>Magnesium &amp; Magnesia Smut</b>	Barium	100	14.9	81.95	149		
<b>Rare Earths Spent Ammonium Nitrate Processing Solution</b>	pH	2<pH>12	0.1	7.07	9.59		
<b>Rare Earths Process Wastewater</b>	Lead	5	0.63	5.31	10	1.47 - 259.83	2.10 - 1550
<b>Selenium Plant Process Wastewater</b>	Lead	5	12	12	12	1.47 - 259.83	2.10 - 1550
	pH	2<pH>12	0.8	1.35	1.9		

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						Mean	Max
<b>Tantalum Process Wastewater</b>	pH	2<pH>12	3	8.4	12		
<b>Titanium and Titanium Dioxide Waste Acids (Sulfate Process)</b>	Arsenic	5	0.01	1.33	5		
	Chromium	5	0.08	31.12	83	6.03 - 273.23	12 - 4250
	Selenium	1	0.1	1.21	5		
	Silver	5	0.005	1.12	5		
	pH	2<pH>12	0	0.33	1		
<b>Titanium and Titanium Dioxide Leach Liquor &amp; Sponge Wash Water</b>	pH	2<pH>12	0	0.5	1		
<b>Zinc Acid Plant Blowdown</b>	Arsenic	5	1.1	2.12	5		
	Cadmium	1	0.83	8.58	19	<0.01 - 117.5	<0.01 - 268
	Chromium	5	0.03	1.81	5	6.03 - 273.23	12 - 4250
	Selenium	1	0.055	1.69	5		
	Silver	5	1.53	0.015	5		
	pH	2<pH>12	0.5	1.67	3.4		
<b>Zinc Process Wastewater</b>	Arsenic	5	0.02	1.59	10		
	Cadmium	1	0.023	123	589	<0.01 - 117.5	<0.01 - 268
	Chromium	5	0.005	1.13	10	6.03 - 273.23	12 - 4250
	Lead	5	0.025	1.27	5	1.47 - 259.83	2.10 - 1550
	Selenium	1	0.0025	1.13	10		
	Silver	5	0.0015	1.13	10		
	pH	2<pH>12	1	5.64	10.5		

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Sector/Waste Stream	Constituent	TC Limits	Min	Mean	Max	Range of Listed Waste Concentrations	
						Mean	Max
<b>Zinc Spent Goethite &amp; Leach Cake Residues</b>	Arsenic	5	0.014	2.51	5		
	Cadmium	1	6.68	7.82	8.96	<0.01 - 117.5	<0.01 - 268
	Chromium	5	0.001	2.5	5	6.03 - 273.23	12 - 4250
	Selenium	1	0.001	2.5	5		
	Silver	5	0.015	2.51	5		
<b>Zinc Spent Surface Impoundment Liquids</b>	pH	2<pH>12	2	6.02	10		
<b>Zinc Spent Synthetic Gypsum</b>	Cadmium	1	0.52	5.81	11.1	<0.01 - 117.5	<0.01 - 268

unless the wastes are stored in tanks, containers, or containment buildings on-site solely for the purpose of the accumulation of such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal and the generator complies with the requirement in §262.34 and parts 264 and 265.

### 3. Comparison with Bevill feedstock

In the Supplemental Proposed Rule, the Agency raised the issue of whether to allow mineral processing secondary materials to be recycled in units generating Bevill-exempt wastes. The Agency has conducted further research on this issue, and found many cases in which environmental damages were caused by these Bevill-exempt wastes, including several cases in which non-Bevill feedstocks were being added to the unit generating the exempt waste (See Damage Cases and Environmental Releases, EPA, 1997). To assist in determining whether to allow alternative (non-virgin) feedstocks to be added to these “Bevill” units, the Agency has compared desirable and undesirable constituents of virgin Bevill unit feedstocks with those of secondary materials that might be used as alternative feedstocks to these units.

This section begins with a brief description of the minerals purification process. Typical concentrations of desired and undesirable constituents are then discussed. Next, an example from the copper sector is used to show how data from mineral processing operations could be compared with the virgin feedstocks. Finally, we present conclusions regarding the comparison.

#### *General Review of the Minerals Purification Process*

Several stages are involved in the production of valuable products from ore. First, overburden (the consolidated or unconsolidated material that overlies a deposit of useful ore) must be removed to expose the ore. The ores are then extracted (mined) by a variety of surface and underground procedures. Surface mining methods include open-pit mining, open-cut mining, open-cast mining, dredging, and strip mining. Underground mining creates adits (horizontal passages) or shafts by room-and-pillar, block caving, timbered stope, open stope, and other methods. Waste rock, the portion of the ore body that is barren or submarginal rock or ore that has been mined but is not of sufficient value to warrant treatment, must be separated from the ore containing value. The ore containing the value must then be beneficiated (concentrated or dressed).<sup>5</sup> As defined in 40 CFR 261.4(b)(7), beneficiation operations include: crushing; grinding; washing; dissolution; crystallization; filtration; sorting; sizing; drying; sintering; pelletizing; briquetting; calcining (to remove water and/or carbon

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<sup>5</sup> U.S. EPA, 1985, Report to Congress: Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale, pp. 2-10 - 2-12.

dioxide); roasting, autoclaving and/or chlorination in preparation for leaching<sup>6</sup>; gravity concentration; magnetic separation; electrostatic separation; flotation; ion exchange; solvent extraction; electrowinning; precipitation; amalgamation; and heap, dump, vat, tank, and *in situ* leaching. Beneficiation typically yields an intermediate product that often is further purified in mineral processing operations (such as smelting or refining) to produce pure metal and metal products.

*Concentrations of Desired Constituents*

Ores typically contain fairly low concentrations of the metal(s) of interest. Exhibit 17 presents estimates of indicates typical metal concentrations in ores. As ores move through extraction, beneficiation, and processing operations, the percentage of the metals of interest increases. For example, in pyrometallurgical processing of copper ores (sulfide ores), the ore (which has an initial concentration of less than one percent) is sent to milling and flotation. The concentrate from flotation has a copper concentration of 20 to 30 percent. The concentrate is then sent to smelting, which raises the copper concentration to 50 to 75 percent. The product of smelting (matte) is sent to the converter, which produces blister copper and further purifies the copper concentrations to 98 to 99 percent. The blister copper is sent to fire refining and then electrorefining to produce copper that is 99.99 percent pure.

**Exhibit 17. Estimated Percentage Metal in Ore**

<b>Mining Industry Segment</b>	<b>Typical Percentage of Metal in Ore</b>
Copper	0.6000
Gold	0.0004
Iron	33.0000
Lead	5.0000
Molybdenum	0.2000
Silver	0.0300
Tungsten	0.5000
Zinc	3.7000

Source: Report to Congress: Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale, December 1985, p. 2-11.

*Concentrations of Impurities*

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<sup>6</sup> Except where the roasting (and/or autoclaving and/or chlorination)/leaching sequence produces a final or intermediate product that does not undergo further beneficiation or processing.

Tracking impurities as the ore moves through the production process is more difficult, because impurities are removed in almost every step of the purification process. Some of the impurities are removed early in the beneficiation operations, while others that are physically or chemically similar to or bound with the metal of interest may be carried along the production process for most of the processing steps.

The copper sector again provides an example of how the concentrations of impurities increase or decrease as the ore is purified. Because concentration levels of impurities in the intermediate products were not available, EPA evaluated constituent concentrations in wastes generated at various points along the production process. These concentrations are summarized in Exhibits 18 and 19. There are a number of limitations associated with these data, which were obtained from several facilities over a number of years. These factors add potential for error because concentrations of impurities vary greatly within and between ore deposits, each facility is likely to mine a different ore deposit and use a different production process. In addition, increasing environmental regulation in the last ten years and changing economic markets have also caused facilities to make changes in their production processes and ore selection.

Moreover, comparing the constituent concentrations of beneficiation *wastes* with mineral processing wastes may not adequately address EPA's underlying question about the appropriateness of using alternative feedstocks in Bevill units. EPA has examined the constituent concentrations of both beneficiation wastes and processing wastes in determining whether any of these wastes should retain their "Bevill" exempt status in two Reports to Congress. The comparison between extraction and beneficiation waste concentrations and mineral processing waste concentrations can yield only an insight into when in the process impurities are removed. For a complete understanding of how impurities are generated in the production process, waste volume should be considered in addition to concentration levels.

Several noteworthy trends can be discerned in Table 18, which compares concentrations in solid waste from beneficiation and mineral processing operations. The first trend is that concentrations of both the desired product and impurities are higher in the mineral processing wastes than in the beneficiation wastes. The next trend is that among the mineral processing wastes, constituent concentrations vary significantly from one waste to another. For example, the waste with the highest copper concentration (converter flue dust) has the lowest arsenic concentration. Table 19 displays contaminant concentrations for liquid wastes from beneficiation and mineral processing operations. As was seen in the data for solid waste, the mineral processing wastes have higher concentrations of almost all constituents than the beneficiation waste. The only exceptions are for chromium in WWTP liquid effluent and molybdenum in both WWTP liquid effluent and scrubber blowdown. The variability in constituent concentrations seen in the solid wastes is also seen in the liquid wastes. The highest levels of the 10 constituents are almost evenly divided between spent bleed electrolyte and acid plant blowdown. However, scrubber blowdown, which has the lowest concentration of copper has the highest concentration of mercury.



### *Findings*

Concentrations of metallic impurities are often higher in waste streams generated by mineral processing operations, than in waste streams generated by beneficiation operations. This trend is shown in Exhibits 18 and 19. Using these data as a basis, it is likely that the impurities in the secondary materials are also higher than in the corresponding virgin Bevill unit feedstocks. Therefore, reintroduction of mineral processing secondary materials as alternative feedstocks may increase contaminant concentrations in the wastes generated by the Bevill units. However, these results need to be understood in light of the following caveats:

- C Beneficiation and mineral processing steps often remove particular constituents preferentially; concentrations of specific constituents may therefore decline in wastes generated in later production stages;
- C Although concentrations may increase during the production process, waste volumes tend to decrease, such that the total mass of the hazardous constituent may be less than that of wastes generated earlier in the production process; and
- C Sector-specific and site-specific variability is significant.

Thus, while the Agency generally expects contaminants to become more concentrated in mineral processing wastes generated in later production stages, there may be cases where contaminant levels are reduced or stay the same.

**Exhibit 18. Comparison of Constituents in Solid Wastes in the Copper Sector**

	Beneficiation Wastes			Mineral Processing Wastes			
	Surface Mine Waste <sup>a</sup>	Tailings Pond Settled Solids <sup>a</sup>	Leaching Material <sup>a</sup>	Furnace Flue Dust <sup>b</sup>	Converter Flue Dust <sup>b</sup>	Acid Plant Blowdown Solids <sup>c</sup>	WWTP Solids <sup>d</sup>
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Arsenic	20.4	7.08	63.1	13,000	100	1,600	
Barium	572	408	453				
Cadmium	<10	10.2	<69.4				
Chromium	27.8	49.9	125			400	
Lead	159	120	157			316,000	
Mercury	0.14	0.16	0.17				
Selenium	7.51	4.86	5.9			100	
Copper	1,150	1,190	1,470	220,000	800,000	62,000	225,000
Molybdenum	209	157	210				
Zinc	123	137	207			4,800	

Sources:

- a - Pedco, Evaluation of Management Practices for Mine Solid Waste Storage, Disposal, and Treatment, 1984, pp. 4-36 - 4-37.
- b - Greenwald, Norman, Letter to Matthew Straus, US EPA, June 4, 1992.
- c - Rissman Report, 1992.
- d - US EPA, "Identification and Descriptions of Mineral Processing Sectors and Waste Streams," December 1995, p. 280.

**Exhibit 19. Constituents in Liquid Wastes in the Copper Sector**

	<b>Beneficiation Wastes<sup>a</sup></b>	<b>Mineral Processing Wastes<sup>b</sup></b>				
	<b>Tailings Pond Liquids</b>	<b>Spent Bleed Electrolyte</b>	<b>Acid Plant Blowdown</b>	<b>Process Wastewater</b>	<b>Scrubber Blowdown</b>	<b>WWTP Liquid Effluent</b>
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Arsenic	0.0869	2,219	856	14.9	13.98	
Barium	0.343	7.19	1.38		0.73	
Cadmium	0.045	0.52	62.93	1.26	3.75	0.151
Chromium	0.056	12.59	3.62	1.86	0.28	0.023
Lead	0.14	19.68	1,061	36.39	11.60	3.53
Mercury	<0.0002	0.005	0.32	0.001	0.49	
Selenium	0.184	4.25	78.97	0.55	7.20	
Copper	0.13	26,787	3,152	227	4.90	130
Molybdenum	1.53	62.58	70.68	14.77	0.90	0.11
Zinc	0.0472	25.84	1,737	8.72	6.24	0.6

Source:

- a - Pedco, Evaluation of Management Practices for Mine Solid Waste Storage, Disposal, and Treatment, 1984, pp. 4-36 - 4-37.
- b - US EPA, "Identification and Descriptions of Mineral Processing Sectors and Waste Streams," December 1995, pp. 273-279.

#### 4. Conclusions

Based on information received from commenters and further research and analysis conducted by the Agency, EPA has determined that certain assumptions it made in proposing the Supplemental LDR Rule in January 1996 may not have been valid, particularly assumptions concerning the volumes of wastes managed by the mineral processing industry and the need to manage these wastes in land-based units. Specifically, the Agency has determined that:

- C Generation rates for mineral processing wastes do not differ from rates for other listed hazardous wastes of similar type. In fact, in some cases, mineral processing waste generation rates were lower than for listed wastes. Generation rates for mineral processing wastes exceeded the Bevill high volume threshold in only three of 118 cases.
- C Contaminant concentrations found in mineral processing wastes are similar to concentrations found in listed wastes currently regulated under RCRA Subtitle C. In addition, the Agency has evidence that damages have resulted from the storage and disposal of these wastes.
- C As ore is processed, minerals of interest become more concentrated. At the same time, contaminants in the waste streams generated during processing steps also may become more concentrated.

As a consequence, the Agency no longer believes that land-based storage of secondary materials is essential to the mineral processing industry. Generated volumes of waste appear sufficiently small to allow them to be managed in a manner similar to RCRA Subtitle C hazardous wastes -- in tanks, containers, and buildings. Further, because the Agency has determined that contaminant concentrations in mineral processing wastes may be similar to concentrations found in RCRA hazardous wastes, the Agency believes that land-based storage of such materials may pose a significant threat to human health and the environment. The Agency therefore now believes that tanks, containers, and buildings should be used to store mineral processing secondary materials prior to recycling. Finally, due to the likelihood that mineral processing wastes may contain greater concentrations of contaminants than virgin feedstock, the Agency also believes that it would be inappropriate to allow these materials to be reintroduced into a Bevill unit while allowing the resulting waste to retain its Bevill-exempt status.