United States Environmental Protection Agency

Industrial Environmental Research Laboratory Research Triangle Park NC 27711

Research and Development

EPA-600/S7-81-071b Dec. 1981

EPA

Project Summary

Environmental Assessment: Source Test and Evaluation Report — Coal Preparation Plant No. 2

J. Buroff, A. Jung, L. McGilvray, and J. Strauss

This Project Summary presents the results and conclusions of a Source Test and Evaluation Program conducted at a coal preparation facility. The major objective of the test program was to perform a screening Environmental Assessment (Level 1) on the discharge streams and fugitive emissions of the facility.

Results from the Source Analysis Model IA(SAM/IA) evaluation for the multimedia streams sampled indicated that all streams, except for fugitive particulates, contained some constituents which may have a potentially harmful health or ecological effect. For streams which showed potential for ecological effects, manganese was found to be of concern; for streams which showed a large health-related value, manganese and chromium were of prime concern. The leachate results showed high ammonia concentrations. Further investigation of the ammonia source is warranted.

The Ames assay test results for all fugitive particulates were negative. However, the health-related RAM assay produced moderate effects. The fine refuse sedimentation pond waters, and fine refuse slurry samples indicated a moderate biological effect. For leachates, all health-based bioassay tests showed a low or nondetectable effect; however, the coal and coarse refuse leachate composite and the pond sediment composite produced a moderate effect on the ecological-related algae test.

The results of this environmental assessment and future Level 1 Environmental Assessments performed on other coal preparation facilities will identify those substances in a given waste stream that are the most potentially harmful and will determine the need for further characterization of the discharge streams and development of control technology.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Versar, Inc., of Springfield, Virginia, under contract to the U.S. Environmental Protection Agency - Industrial Environmental Research Laboratory (EPA-IERL) at Research Triangle Park, North Carolina, is performing a comprehensive environmental assessment of coal preparation technologies. A significant part of this assessment involves Source

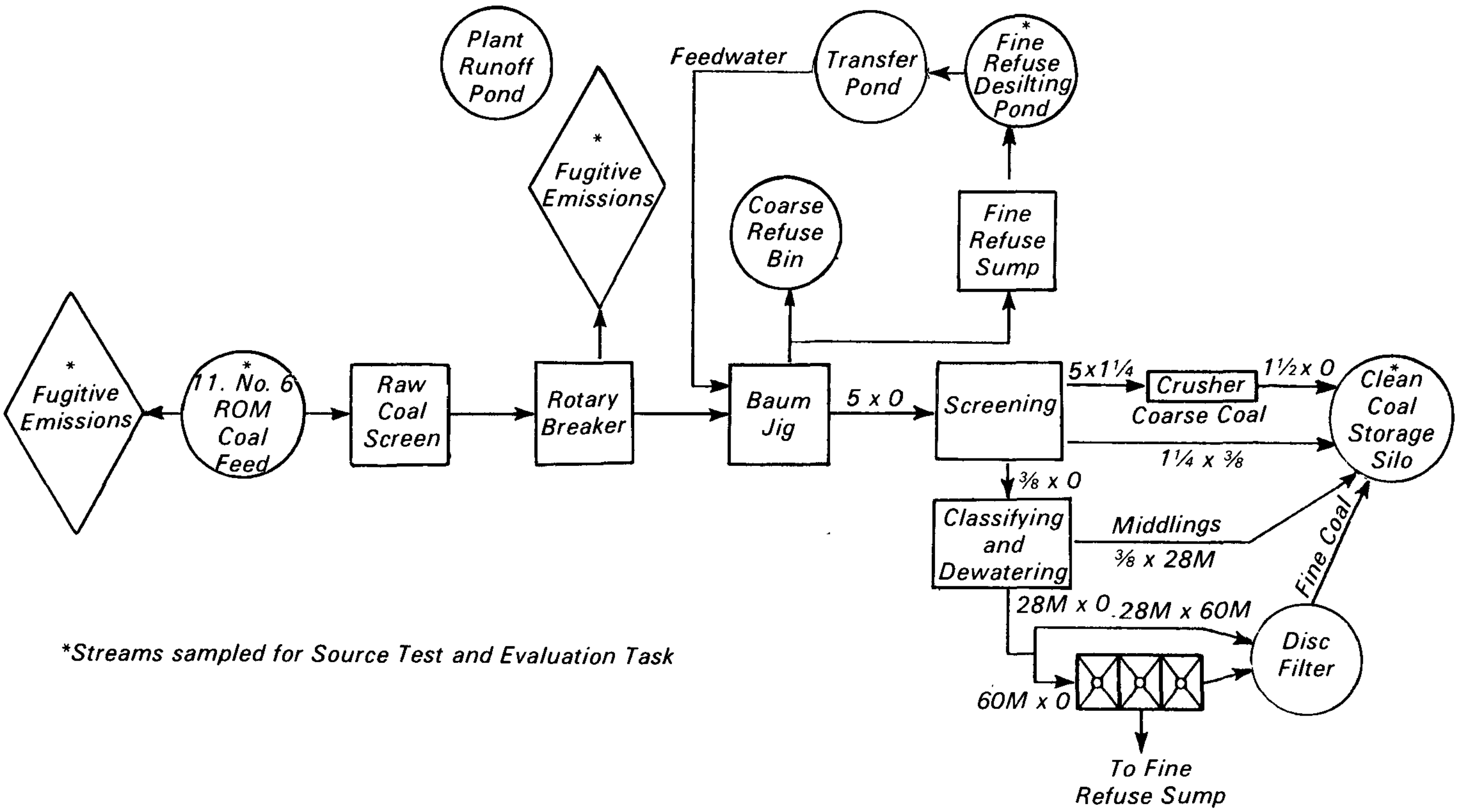

Figure 1. *Schematic flow diagram of coal preparation Plant No. 2.*

Test and Evaluation (STE) programs at operating coal cleaning facilities. The primary objective of each STE program is to perform a screening (Level 1) Environmental Assessment that characterizes multimedia emissions from the source, assesses the data on a health and ecological basis, and evaluates the effectiveness of pollution control systems.

The field testing program is designed to determine the physical, chemical, and relative toxicological characteristics of coal preparation plant effluent streams sampled at their respective sources. The results of the Level 1 testing and analysis provide the quantities of pollutants in process and effluent streams and identify those areas of the process needing additional control technology development. The field testing program is not designed to assess the environmental quality of the general vicinity of the cleaning plant. Therefore, results of the present testing program cannot be used to evaluate cause/effect relationships between discharge stream characteristics and ecological effects observed in the field.

General Plant Description

The coal cleaning plant chosen for the second assessment is representative of a group of cleaning plants that processes run-of-mine (ROM) coal with high pyritic sulfur (≥2 percent) content, uses high technology coal cleaning processes, operates in an environment with high rainfall [≥ 60 cm/yr (≥ 25 in./yr)], and has a low soil neutralization potential (pH ≥ 6.0). A schematic flow diagram of coal preparation plant No. 2 is shown in Figure 1.

Preparation plant No. 2 is a 1,088 Mg/h (1,200 tph) coal washing plant. Its yield is approximately 888 to 912 tph of clean coal (i.e., 74 to 76 percent yield). The plant cleans Illinois No. 6 coal to a yield product that has an average sulfur content of 2.7 percent (as received) and an energy content of about 27,000 kJ/kg (11,600 Btu/lb). Proximate and ultimate analyses for ROM coal, clean coal, and coarse refuse are shown in Table 1.

The plant processes the coal by first screening the stored ROM coal over a stationary primary screen. Everything above 5 in. is sent to the rotary breaker, and the underflow from the screen is blended with the product from the rotary breaker and placed on the incoming raw coal distribution belt. The 5 in. x 0 coal is then fed to a two-stage Baum Jig for primary washing. The clean coal from the Baum Jig is dewatered on a 3/16-in stationary screen, and the overflow goes through a double-deck washed coal screen. The product of the top screen is 5 x 1-¼ in. clean coal.The clean coal is fed to a crusher to produce a top size of 1-½ in. and then fed onto the clean coal load-out belt. The overflow from the bottom screen (1-½ x ⅜-in. coal) is dewatered in centrifuges and loaded onto the clean coal belt The underflow from the washed coal screens, which is predominantly ⅜-in. x 0 material, goes to the washed coal sumps.

The middlings product from the two-stage Baum Jig is sent to a middling screen for size separation. The overflow in the middling screen is fed to a crusher that reduces the material to 1-in. top size and then blends it back into the feed to the Baum Jig. The underflow in the middling screen, which is ½-in. x 0 coal, is then routed to the fine coal refuse slurry sump. The rejects from the two-stage Baum Jig are dewatered on a refuse screen and sent to a refuse bin container for load-out by truck. The underflow from the coarse refuse screens is combined with other fine coal refuse products of the plant and sent to the fine coal slurry sump.

The refuse streams in the plant consist of:

- Coarse refuse from the Baum Jig which is dewatered on screens and sent to the coarse refuse hopper.
- Fine refuse collected in a sump from the underflow of the polishing cyclones, froth flotation cells, and Baum Jig.

The fine refuse slurry collected in the fine coal sump is pumped to a desilting pond. The pond water overflows into a transfer pond from which water is recycled for makeup in the plant.

Test Program Description

Samples of 16 process and waste streams were obtained to meet the objective of this STE program. Because the pond waters and slurry streams were split into two samples (solid and liquid states) and non-fugitive solid samples were analyzed as the solid and a leachate of the solid, 30 samples were analyzed to characterize facility waste streams, raw materials, and product.

Samples collected at the coal preparation facility included:

- Fugitive particulates and gases from coal and coarse refuse storage areas.
- Fine refuse sedimentation ponds and a runoff pond
- Runoff from ROM coal storage area.
- ROM coal, clean coal, and coarse refuse.
- Fine refuse slurry.

These samples were selected based on their potential for pollution.

The following chemical analyses were performed:

- Spark Source/Mass Spectroscopy for inorganic element determinations (all streams).
- Inductively Coupled Argon Plasma for inorganic element determinations (liquid streams only).
- Total Chromatographable Organics and Gravimetric Analysis for assessing total organic content (all gaseous, liquid, and sediment streams).
- Atomic Absorption Spectroscopy for mercury (all streams).

The following tests were conducted:

- AMES test for mutagenesis (all streams).
- A second, suitable biological assessment test for cytotoxicity or toxicity, such as rabbit alveolar macrophage (solids), Chinese hamster ovary assay (liquids), rodent acute toxicity (liquids), or an aquatic bioassay on algal, daphnia, or the fathead minnow (all liquid streams and leachates).

In addition, classical water quality parameters were measured for each liquid stream: pH, conductivity, temperature, dissolved oxygen, hardness, alkalinity, acidity, ammonia, nitrates, nitrites, cyanide, phosphorus, sulfate, sulfite, fluoride, and chloride.

Methods for Characterizing Waste Streams

Three methods were used to evaluate the characteristics of the coal preparation plant samples:

Table 1. *Properties of Rom Coal, Clean Coal, and Coarse Refuse*

	Rom Coal		*Clean Coal*		*Coarse Refuse*	
Proximate Analysis	*As Received*	*Dry Basis*	*As Received*	*Dry Basis*	*As Received*	*Dry Basis*
(% Weight)						
Moisture	3.87	—	4.14	—	2.52	—
Ash	28.66	29.81	12.74	13.29	65.50	67.19
Volatile	31.68	31.96	36.62	38.20	19.77	20.28
Fixed Carbon	35.79	37.23	46.50	48.51	12.21	12.53
	100.00	100.00	100.00	100.00	100.00	100.00
Btu/lb	9,657	10,046	12,120	12,643	4,078	4,183
Sulfur	4.35	4.52	2.79	2.91	8.03	8.24
Ultimate Analysis						
Moisture	3.87	—	4.14	—	2.52	—
Carbon	53.93	56.10	67.61	70.53	22.84	23.43
Hydrogen	3.79	3.94	4.64	4.84	1.64	1.68
Nitrogen	1.23	1.28	1.28	1.34	0.56	0.57
Chlorine	0.08	0.08	0.08	0.08	0.03	0.03
Sulfur	4.35	4.52	2.79	2.91	8.03	8.24
Ash	28.66	29.81	12.74	13.29	65.50	67.19
Oxygen (by difference)	4.09	4.27	6.72	7.01	-1.12	-1.14
	100.00	100.00	100.00	100.00	100.00	100.00

- Source Assessment Model (SAM)/IA evaluations for inorganic constituents.
- Water quality parameter comparisons with existing standards.
- Bioassay screening tests.

Source Assessment Models

The Energy Assessment and Control Division of the EPA's Industrial Environmental Research Laboratory at Research Triangle Park (EACD/IERL-RTP) has developed a standardized methodology for interpreting the results obtained from environmental assessment test programs. This methodology uses the Source Analysis Model which represents prototype approaches to multimedia, multipollutant problem identification and control effectiveness evaluation for complex effluents.

The simplest member of the Source Analysis Models, SAM/IA, was used for this STE program. SAM/IA provides a rapid screening technique for evaluating the pollution potential of gaseous, liquid, and solid waste streams. In performing a SAM/IA evaluation, an index, the Discharge Severity (DS), is determined for each substance in a discharge stream.

The DS is calculated by dividing the detected concentration of a compound, or class compounds, by its Discharge Multimedia Environmental Goal (DMEG) value (for both health and ecological effects) as reported in the Multimedia Environmental Goals for Environmental Assessment, Volume II (EPA-600/7-77-136b; NTIS PB 276920). The MEGs are concentration levels of contaminants in air, water, or solid waste effluents that will not evoke significant harmful responses in surrounding populations or ecosystems.

For example, the estimated concentration of aluminum in the fine waste slurry filtrate sample was 190 $\mu g/l$. The health-based DMEG value for aluminum in a liquid discharge is 8.0×10^4 $\mu g/l$. The discharge severity for aluminum is calculated to be:

$$DS = \frac{190\ \mu g/l}{8.0 \times 10^4\ \mu g/l} = 2.4 \times 10^{-3}\ \mu g/l$$

A DS value greater than 1.0 indicates a potential hazard, while a value less than 1.0 indicates little or no potential hazard. A total stream discharge severity (TDS) is calculated by summing the DS values for all constituents found in a sample.

The total concentration of organic extractables in each sample was given as the sum of the gravimetric (Grav) and total chromatographable organics (TCO) determinations. These results were not evaluated using the SAM/IA methodology because the MEG values are specific to individual organic compounds, which are not identified by Grav and TCO analyses, and most Grav and TCO values were at or below detection limits.

Water Quality Comparisons

Water quality tests were performed on the runoff and filtrate samples. The test concentrations were compared to the most stringent state effluent water regulations for eastern and midwestern states. The applicable water quality test concentrations for runoff and leachate samples were also compared to the Resource Conservation and Recovery Act (RCRA) Extraction Procedure-Toxicity Concentrations for determining hazardous wastes, although a neutral leachant procedure was used.

Bioassay Screening Tests

The use of biological assays in conjunction with physical and chemical analyses provides a comprehensive data base from which to prioritize streams relative to further study and/or control technology needs.

Biological test result evaluations are based on an interpretation of the data in terms of low, moderate, or high effects of each test. These interpretations are based on the biological responses of highly sensitive cellular and whole-organism cultures. Since highly-sensitive cells or organisms are tested, a positive response may not indicate actual field impacts. "Low or nondetectable effects" means that the material will not have any adverse health or ecological effects. "Moderate or high effects" means that the material may be potentially hazardous and more rigorour testing should be initiated.

Results

Fugitive Particulates and Vapors

The ambient Total Suspended Particulates (TSP) concentrations and the concentration of particles less than 15 $\mu g/m^3$ were highest adjacent to the ROM coal storage pile and the rotary breaker. This was expected because of the continual coal handling activity in those areas. The contribution of plant fugitive emissions to the ambient air quality can be measured as the downwind TSP value minus the upwind TSP value. When the high ambient air TSP value is subtracted from the downwind results, the contribution to the ambient air 600 m downwind from the preparation plant was found to be 70 $\mu g/m^3$. Although 600 m downwind is still within the plant boundary, this value is significantly less than the 24-hour primary ambient air quality standard of 260 $\mu g/m^3$ for TSP and also considerably less than the secondary ambient air quality standard of 150 $\mu g/m^3$. Particulate morphology tests showed that downwind particulates were primarily quartz-like material rather than coal particles. However, downwind particulates show a slightly higher concentration of coal dust than the upwind sample.

The TCO + GRAV analyses of the fugitive vapors were determined to be 40 $\mu g/m^3$ after subtracting the upwind contribution. It can be concluded that the preparation plant and specific coal and refuse piles contribute little or no organic vapors to the environment. The TDS values for organic vapors were less than 10 for health criteria and less than 1.0 for ecological criteria. Chromium and nickel were the only elements with a DS greater than 1.0; however, for two of the chromium concentrations and two of the nickel concentrations, the DS value can be attributed to contamination in the XAD-2 resin blank.

The fugitive particulate sample results indicate a low potential for hazard according to the low TDS values; however, the results show a potential hazard based on health-related bioassay test results (RAM test results showed moderate effects). The bioassay test results for the organic vapor samples were negative (i.e., low or nondetectable effect)

Liquids

The filtrate sample from the fine waste slurry had health- and ecological-based TDS values greater than 1.0. The health-based TDS of 2 and the ecological-based TDS of 10 is largely due to selenium. The low total extractable organic concentration shows that there was very little dissolved organic material in the fine coal waste slurry filtrate.

The waters from the desilting, transfer, and runoff ponds exhibited low potential for effect based on the health-based TDS value and a relatively higher potential for hazard based on the ecological-based TDS value. There were no chromatographic organics detected; however, gravimetrically determined organic concentrations were 300, 400, and 300 μg/l for the desilting, transfer, and runoff ponds, respectively. The bioassay test results for the desilting pond water were mixed. The Chinese hamster ovary clonal assay and the aquatic bioassay with algae produced moderate effects. However, the Ames assay, the rodent acute *in vivo* test, and the aquatic bioassays with fish and invertebrates indicated low or nondetectable effects.

The ROM coal storage pile runoff sample is similar to the pond water results; i.e., low potential for hazard on a health-related basis and a greater potential on an ecological-related basis. The total extractable organic concentrations were relatively low (200 μg/l). The biological tests (Ames and CHO clonal assays) showed negative results for both samples.

Solids and Leachates

The inorganic analyses for the fine refuse waste solids had a health-based TDS value of approximately 500 and an ecological-based TDS value of 10,000. The high ecological-based TDS value was primarily due to a high phosphorus DS value. The results for the health and ecological bioassays were mixed The Ames assay, rodent acute *in vivo* test, and the aquatic bioassays with fish and invertebrates all produced negative effects. However, the Chinese hamster ovary clonal assay produced a high effect, and the aquatic bioassay with algae produced a moderate effect.

The ecological-based TDS values for the coarse refuse solids sample were of the same magnitude as those for the fine refuse (i.e., 10,000). However, the health-based TDS was an order of magnitude greater (i.e., 2,000). The health-related bioassays, however, produced low or nondetectable effects. The coarse refuse leachate had a health-based TDS of 10 and an ecological-based TDS of 200. The coarse refuse leachate also produced negative results for the health-related bioassays.

The TDS values for the ROM coal and clean coal leachate are of the same order of magnitude. The health-based TDS for ROM and clean coal leachates are 4 and 2, respectively. The ecological-based TDS values of 67 and 35, respectively, indicate a relatively higher potential for hazard. The extractable organic concentrations for both ROM and clean coal leachate samples were below the detection limit. The results of the health-related bioassays were negative for both the ROM and clean coal leachate samples.

A composite of coarse refuse, ROM, and clean coal leachates was used for the aquatic bioassays. The results showed low or nondetectable effects on fish and invertebrates and moderate effects on algae.

The TDS values for the pond sediments were fairly high (health TDS values >100 and ecological TDS values >1,000), with the highest health TDS for desilting pond sediment (2.1E3) and the highest ecological TDS for runoff pond sediment (1.0E4). The TDS values for the pond sediment leachates were significantly lower (health TDS >1.0; ecological TDS >10). The concentrations of chromatographable and gravimetric organics in the sediments were all 20 mg/g. The extractable organic concentrations for the sediment leachates were below the detection limit.

The pond sediments and sediment leachates produced negative effects when evaluated by the Ames assay. However, a composite of desilting and transfer pond sediments, and the runoff pond sediment sample produced a high effect when evaluated by the rabbit alveolar macrophage assay. The aquatic bioassays performed on a composite of the leachate samples showed no effect on fish and invertebrates and a moderate effect on algae.

Summary and Conclusions

A summary of the multimedia chemical and biological stream characteristics and control strategy recommendations is provided in Table 2.

Table 2. *Summary of Environmental Results*

	Total Discharge Severity		*Major Contributors (Discharge Severity >10)*		*Biological Results*			
Waste Stream	*Health*	*Ecological*	*Health*	*Ecological*	*Health*	*Ecological*	*Conclusions*	*Recommendations*
ROM Coal Storage Pile Fugitive Particulates	*1.3E-2*	*2 0E-3*	—	—	*M*	*N C*	● *Low potential for hazard according to TDS values; however, potentially hazardous based on health-related bioassay test results.*	● *Improve techniques for control of fugitive emissions.*
Rotary Breaker Fugitive Particulates	*1 1E-2*	*6.0E-3*	—	—	*M*	*N.C*		
Upwind Fugitive Particulates	*1.2E-2*	*2.0E-2*	—	—	*M*	*N C.*	● *Particulate morphology shows coal in all but upwind samples.*	
Downwind Fugitive Particulates	*1.1E-2*	*3 0E-3*	—	—	*M*	*N C.*	● *TSP values for fugitives below primary standard, except rotary breaker*	
ROM Coal Storage Pile Vapors	*7.9E0*	*3.0E-1*	—	—	*L/N*	*N C*	● *Low potential for hazard according to TDS values and bioassay test results.*	
Rotary Breaker Vapors	*6 7E0*	*1 0E-1*	—	—	*L/N*	*N.C*		
Upwind Vapors	*7 7E0*	*3 1E-1*	—	—	*L/N*	*N C.*		
Downwind Vapors	*1.2E1*	*9.0E-1*	—	—	*L/N*	*N.C.*		

Table 2. *(Continued)*

Waste Stream	Total Discharge Severity		Major Contributors (Discharge Severity >10)		Biological Results		Conclusions	Recommendations
	Health	Ecological	Health	Ecological	Health	Ecological		
Fine Waste Slurry Filtrate (bio. tests conducted on raw slurry)	2.0E0	1.0E1	—	—	H	M	● Uncertain potential hazard according to ecological-based SAM/IA evaluation. Potentially hazardous based on bioassay test results	● Should not discharge directly to offsite surface waters, should be treated onsite.
Desilting Pond Water Filtrate (bio. tests conducted on raw pond water)	1.4E0	8.0E0	—	—	M	M		
Transfer Pond Water Filtrate (bio tests conducted on raw pond water)	1.4E0	1.5E1	—	—	L/N	N.C.	● Low potential for hazard according to health-based criteria. ● Uncertain hazard potential according to ecological TDS values.	● Should not discharge directly to offsite surface waters; should be treated onsite.
Runoff Pond Water Filtrate (bio. tests conducted on raw pond water)	2 6E0	1.8E1	—	—	L/N			
ROM Coal Storage Pile Runoff	2.0E0	1.6E1	—	—	L/N	N.C	● Low potential for hazard according to health-based criteria. ● Uncertain hazard potential according to ecological TDS values.	● Collect runoff for treatment
Clean Coal Leachate	2.2E0	3.5E1	—	NH_3-N	L/N	M	● Uncertain hazard potential according to ecological-based criteria ● Chemical constituents are more leachable in the coarse refuse than other solids. ● Coarse refuse already stored in closed system.	● Use RCRA's EP Method for leachability to investigate leaching potential under acid conditions. ● Should not discharge pond waters directly to offsite surface waters. ● If discharged, treat for trace metals control ● Check origin of nitrogen compound in samples
ROM Coal Leachate	4.0E0	6.7E1	—	NH_3-N	L/N	M		
Coarse Refuse Leachate	1.0E1	2.0E-2	—	NH_3N, Mn, Ni	L/N	M		
Desilting Pond Sediment Leachate	4.1E0	2.0E1	—	—	L/N	M		
Transfer Pond Sediment Leachate	8.4E-1	1.2E1	—	—	L/N	M		
Runoff Pond Sediment Leachate	9.2E0	3 3E1	—	Mn	L/N	M		
Desilting Pond Water Filtered Solids	6.5E1	4.1E1	Mn,Hg	P	M	N.C.	● Uncertain hazard potential according to SAM/IA evaluation and health-based bioassay test results.	● Retain material onsite via sedimentation. ● Check forms of phosphorus
Transfer Pond Water Filtered Solids	4.1E2	6.1E1	Hg	P	L/N	N.C.	● Moderate potential for hazard based on SAM/IA evaluation. No or low hazard based on health-related bioassay test results.	● Retain material onsite via sedimentation ● Check forms of phosphorus
Runoff Pond Water Filtered Solids	4.2E1	3.1E1	Mn,Hg	P	L/N	N.C.		
Desilting Pond Sediment	1.6E3	3.1E3	Mn,Ba,As, Cr,Pb,Li, Ni,P,V	P,Mn,V	H	N.C.	● High potential for hazard based on SAM/IA evaluation and health-related bio-assay test results	● Retain material onsite ● Check forms of phosphorus ● Further characterization during level 2 testing
Transfer Pond Sediment	1.2E3	8.1E3	Cr,Mn,As, Ba,Cd,Pb, Li,Ni,P,V	P,Mn	H	N.C		
Runoff Pond Sediment	4.3E2	1.0E4	Ba,As,Cd, Pb,Li,Ni, P,V	P,Cd,Ni	H	N.C.		
Coarse Refuse	2.1E3	1 0E4	Mn,Pb,Se, As,Ba,Cd, Cr,Li,Ni, P,V	P,Pb,Mn	L/N	N.C.	● High potential for hazard based on SAM/IA evaluation. Low or no hazard based on health-related bioassay results.	● Store coarse refuse in a closed system. ● Check forms of phosphorus.

N.C. = Not conducted.
L/N = Low or nondetectable effect.
M = Moderate effect.
H = High effect.

For air samples there is a low potential for hazard from both the fugitive particulates and fugitive vapors. Improved dust control measures are recommended to decrease fugitive particulate emissions.

For liquid streams the major constituents of concern were manganese and nickel. These two metals would require control if the pond waters were discharged or runoff water was collected and then discharged.

The solid samples showed the highest potential for hazard. However, the leachates from the solids had considerably lower discharge severity values than the solids themselves. The recommendation is to retain solids onsite via sedimentation or filtration.

J. Buroff, A. Jung, L. McGilvray, and J. Strauss are with Versar, Inc., Springfield, VA 22151.

***David A. Kirchgessner** is the EPA Project Officer (see below).*

The complete report, entitled "Environmental Assessment: Source Test and Evaluation Report — Coal Preparation Plant No. 2," (Order No. PB 82-103 573; Cost: $23.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆U. S. GOVERNMENT PRINTING OFFICE: 1982/559-092/3369

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

Official Business
Penalty for Private Use $300

PS 0000329
U S ENVIR PROTECTION AGENCY
REGION 5 LIBRARY
230 S DEARBORN STREET
CHICAGO IL 60604