Table 1. Important Chemical and Physical Characteristics of Coal Fly Ashes

chemical	*physical*
CaO	particle shape
silicate	particle size
aluminate	loss on ignition
carbon	moisture

Table 2. Bulk Chemical Analyses of Low and High Lime Fly Ashes

	<10% CaO*	>20% CaO**
oxide	Wt % / STD	Wt % / STD
SiO_2	52.5±9.6	36.9±4.7
Al_2O_3	22.8±5.4	17.6±2.7
Fe_2O_3	7.5±4.3	6.2±1.1
CaO	4.9±2.9	25.2±2.8
MgO	1.3±0.7	5.1±1.0
Na_2O	1.0±1.0	1.7±1.2
K_2O	1.3±0.8	0.6±0.6
SO_3	0.6±0.5	2.9±1.8
moisture	0.11±0.14	0.06±0.06
LOI	2.6±2.4	0.33±0.35

- *based on n = 45 samples
- ** based on N = 97 samples.

Table 3. Phase Assemblages of Low and High Calcium Fly Ash

low CaO	*high-CaO*
glass	glass
quartz *(SiO_2)*	quartz *(SiO_2)*
mullite *($Al_6Si_2O_{13}$)*	mullite *($Al_6Si_2O_{13}$)*
Fe-spinel *($FeFe_2O_4$)*	Fe-spinel *($FeFe_2O_4$)*
	merwinite *($Ca_2Mg(SiO_4)_2$)*
	melilite *($Ca_2(Al,Mg)(Si,Al)_2O_7$)*
	dicalcium silicate *(Ca_2SiO_4)*
	sodalite *($Na_8[AlSiO_4]_6Cl_2$)*
	hematite *(Fe_2O_3)*
	tricalcium silicate *(Ca_3SiO_5)*
	lime *(CaO)*
	periclase *(MgO)*
	thenardite *(Na_2SO_4)*
	anhydrite *($CaSO_4$)*

Table 4. Typical Variations in the Bulk Chemical Compositions of Fluidized Bed Combustor Ashes

	High-BTU	**Refuse Burning**	
		Anthracite	***Bituminous***
oxide	**wt%**	**wt%**	**wt%**
SiO_2	24	58	34
Al_2O_3	6.05	20.4	2.15
Fe_2O_3	2.05	5.74	5.98
CaO	42	4.11	30
MgO	0.45	0.62	0.62
Na_2O	0.07	0.59	0.11
K_2O	0.51	2.56	1.49
SO_3	20.8	1.1	13.0
moisture	+0.25	+0.49	3.70
LOI	2.03	3.31	10.0

Table 5. Mineralogy of Various FBC Ashes

High-BTU	Refuse	Burning
	Anthracite	***Bituminous***
quartz *(SiO_2)*	quartz *(SiO_2)*	quartz *(SiO_2)*
anhydrite *($CaSO_4$)*		anhydrite *($CaSO_4$)*
calcite *($CaCO_3$)*		
portlandite *($Ca(OH)_2$)**		portlandite *($Ca(OH)_2$)**
ettringite *($Ca_6Al_2(SO_4)_3{\cdot}32H_2O$)***		
calcium sulfide *(CaS)*		

* formed from reaction with atmospheric moisture and CaO
** formed from reaction with anhydrite, moisture and calcium aluminate

Table 6. Sieve Analysis 60/40 Mix of Fly ash/Bottom ash from Anthracite Cogeneration Plant

Sieve size	% retained	sieve opening
1/4 inch	0	2540 μm
#4	2.08	4760 μm
#8	13.74	2360 μm
#16	14.75	1180 μm
#30	5.02	600 μm
#40	1.13	425 μm
#60	1.53	250 μm
#100	24.40	150 μm
#140	20.78	105 μm
#200	7.31	75 μm
#270	3.97	51 μm
#325	2.36	45 μm
pan	1.00	

Table 7 - Chemical Analysis Parameters for Coal Ash, Leachate and Groundwater

Acceptable limits listed for leachate and ash
▨ - not tested

	ASH*		GROUNDWATER	
Parameters	Dry Weight	Leachate**	Annual	Quarterly
pH	7 - 12.5 units		▨	
Aluminum		5 ppm		▨
Antimony		0.15 ppm	▨	▨
Arsenic		1.25 ppm		▨
Barium		25 ppm		▨
Boron#		78.75 ppm	▨	▨
Cadmium		0.125 ppm	▨	▨
Calcium	▨	▨		▨
Chromium		2.5 ppm		▨
Cobalt			▨	▨
Copper		32.5 ppm		▨
Iron		7.5 ppm	▨	
Lead		1.25 ppm		▨
Manganese		1.25 ppm	▨	
Magnesium	▨	▨		▨
Mercury		0.05 ppm		▨
Molybdenum		4.375 ppm	▨	▨
Nickel		2.5 ppm		▨
Potassium			▨	▨
Selenium		1.25 ppm		▨
Silver		2.5 ppm		▨
Zinc		25 ppm		▨
Acid Neutr. Potent.#		▨	▨	▨
Phenolics	▨		▨	▨
Cyanide	▨	0.2 ppm	▨	▨
Total Org. Carbon	▨		▨	▨
Total Org. Halides	▨		▨	▨
Sulfate	▨	250 - 2500 ppm	▨	
Ammonia - (N)#	▨		▨	
Chloride	▨	250 - 2500 ppm	▨	
Nitrate - (N)	▨	10 ppm	▨	
Sodium	▨		▨	
Chem. Ox. Demand#	▨		▨	
Fluoride	▨	▨	▨	
Bicarbonate	▨	▨	▨	
Turbidity	▨	▨	▨	
Total Dissolved Solids	▨	▨	▨	
Total Suspended Solids	▨	▨	▨	
Specific Conductance	▨	▨	▨	
Alkalinity	▨	▨	▨	
Acidity	▨	▨	▨	

* EPA SW-846 method used exept for those 4 designated with # which uses Standard Methods or other EPA procedures.
** Using Synthetic Precipitation Leaching Procedure (SPLP)

Table 8. Pre- and Post-Grouting Mean Concentrations of Mine Drainage Constituants

Monitoring Well FF62 Mean Concentrations

Condition	Lab pH	TDS mg/L	SO_4 mg/L	Acid mg/L	Fe Tot mg/L	Fe^{+3} mg/L	Al mg/L	Mn mg/L	Cd ug/L	Cu ug/L	Cr ug/L	Ca mg/L	Temp deg C
Pre-Grout	2.3	7970	3477	4088	876	737	256	39.2	83.6	806	221	58.1	12.0
Post-Grout	2.5	5780	3110	2879	527	373	173	24.7	29.3	813	168	61.4	11.7
% Reduction	*-7%*	*27%*	11%	*30%*	*40%*	*49%*	*32%*	*37%*	*65%*	-1%	24%	-6%	3%

Monitoring Well S80D Mean Concentrations

Condition	Lab pH	TDS mg/L	SO_4 mg/L	Acid mg/L	Fe Tot mg/L	Fe^{+3} mg/L	Al mg/L	Mn mg/L	Cd ug/L	Cu ug/L	Cr ug/L	Ca mg/L	Temp deg C
Pre-Grout	2.4	9951	3500	5096	937	749	394	45.5	108.5	1542	394	66.4	12.7
Post-Grout	2.7	7222	3483	3230	530	254	282	32.4	24.9	771	232	58.7	12.7
% Reduction	*-9%*	*27%*	1%	*37%*	*43%*	*66%*	*28 %*	*28%*	*77%*	*50%*	*41%*	12%	0%

Monitoring Well W70 Mean Concentrations

Condition	Lab pH	TDS mg/L	SO_4 mg/L	Acid mg/L	Fe Tot mg/L	Fe^{+3} mg/L	Al mg/L	Mn mg/L	Cd ug/L	Cu ug/L	Cr ug/L	Ca mg/L	Temp deg C
Pre-Grout	2.6	9689	3695	4611	735	606	397	49.4	60.2	985	221	81.9	11.3
Post-Grout	3.0	4795	3327	2348	268	185	180	21.8	17.3	635	156	56.3	10.9
% Reduction	*-17%*	*51%*	10%	*49%*	*63%*	*69%*	*55 %*	*56%*	*71%*	34%	30%	*31%*	4%

Monitoring Well V36 Mean Concentrations

Condition	Lab pH	TDS mg/L	SO_4 mg/L	Acid mg/L	Fe Tot mg/L	Fe^{+3} mg/L	Al mg/L	Mn mg/L	Cd ug/L	Cu ug/L	Cr ug/L	Ca mg/L	Temp deg C
Pre-Grout	2.7	6777	3568	3624	570	396	316	63.7	57.3	526	104	83.1	11.4
Post-Grout	3.1	5330	3111	2351	380	263	212	33.8	21.6	689	149	71.9	10.9
% Reduction	-13%	21%	13%	35%	33%	34%	33 %	*46%*	*62%*	-30%	-44%	13%	4%

Monitoring Well U32D Mean Concentrations

Condition	Lab pH	TDS mg/L	SO_4 mg/L	Acid mg/L	Fe Tot mg/L	Fe^{+3} mg/L	Al mg/L	Mn mg/L	Cd ug/L	Cu ug/L	Cr ug/L	Ca mg/L	Temp deg C
Pre-Grout	2.5	5163	1868	2840	649	602	222	24.3	59.4	1185	245	51.2	10.0
Post-Grout	2.7	4838	2852	2235	356	317	130	13.7	16.1	638	142	185.6	10.8
% Reduction	-6%	6%	-53%	21%	45%	47%	41 %	43%	*73%*	*46%*	42%	-262%	-8 %

Figure 1. Thermal Alterations of Coal Minerals in Pulverized Coal (PC) and Fluidized Bed Combustors (FBC)

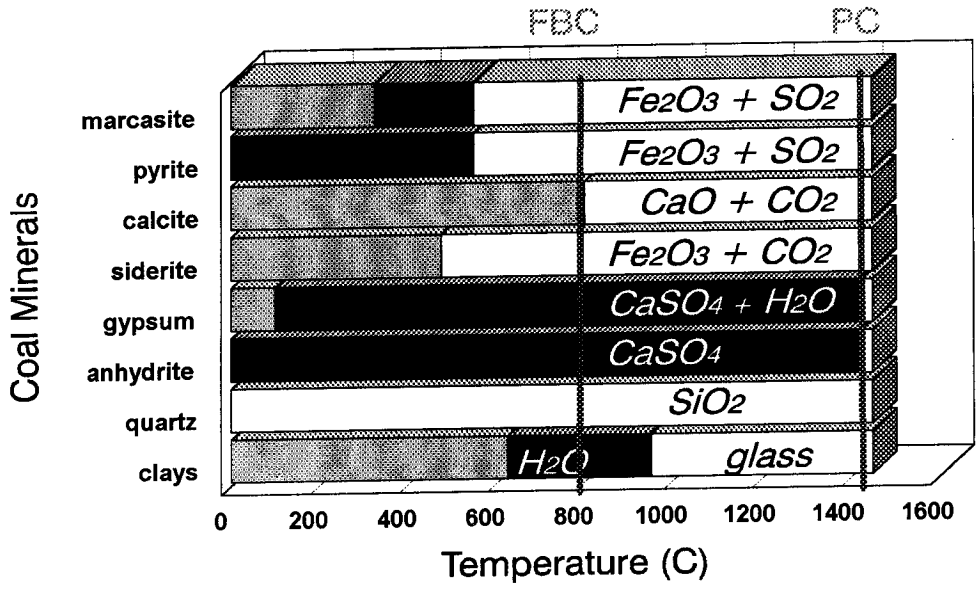

Figure 2. Calcium Oxide Variations in Coals

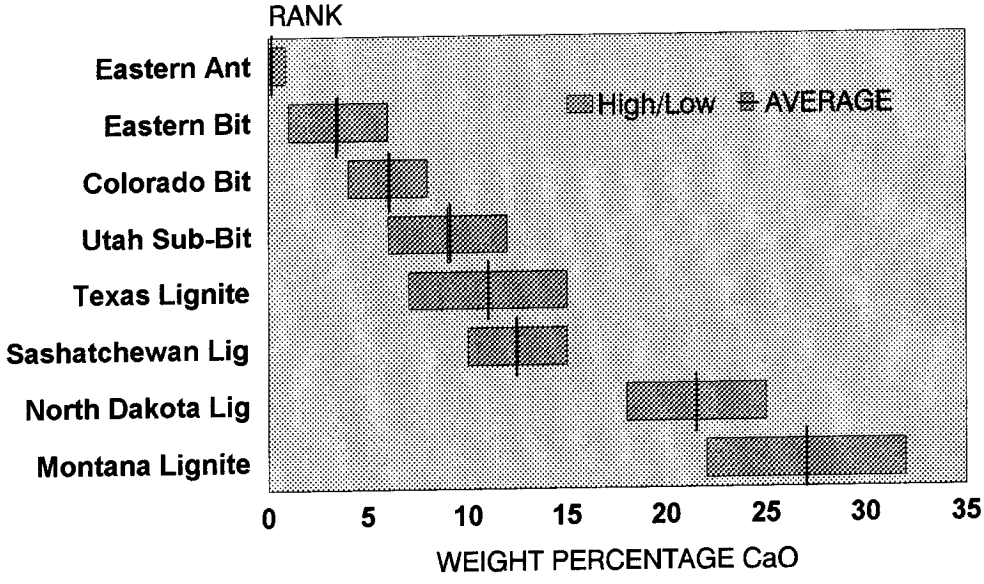

Figure 3. Compaction Test Data from Wheelabrator Frackville Energy Co. Co-Generation Plant

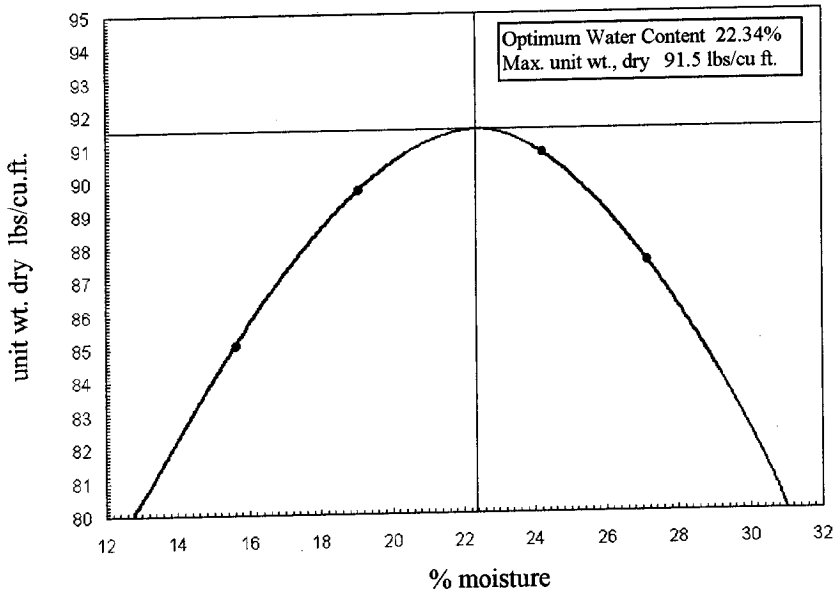

Figure 4. Locations of Magnetic Anomalies, Pyritic Materials, Fly Ash Grout Injection and Capping Sites, and Monitoring Wells at the Fran Mine Site