ENVIRONMENTAL APPEALS BOARD
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C.

In Re:	)	
	)	
Four Corners Power Plant	)	**NPDES Appeal No. 19-06**
NPDES Renewal Permit: NN0000019	)	
Arizona Public Service Company (Permittee)	)	
	)	
	)	

ARIZONA PUBLIC SERVICE COMPANY'S RESPONSE TO PETITION FOR REVIEW

ATTACHMENT 23

DEVELOPMENT DOCUMENT

FOR FINAL

EFFLUENT LIMITATIONS GUIDELINES,

NEW SOURCE PERFORMANCE STANDARDS,

AND

PRETREATMENT STANDARDS

FOR THE

STEAM ELECTRIC

POINT SOURCE CATEGORY

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November 1982

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SECTION I

CONCLUSIONS

In revising effluent limitations guidelines, standards of performance for new sources, and pretreatment standards for the steam electric power generating industry, separate consideration has been given to heat and to chemical pollutants. In this regulation, only nonthermal-related pollutants were considered.

The analysis of pollutants and the technologies applicable to their control were based on specific waste streams of concern. These waste streams are primarily a function of fuels used, processes employed, plant site characteristics, and intake water quality. The major waste streams have been defined as direct or indirect products of the treatment system, power cycle system, ash handling system, air pollution control system, coal pile, yard and floor drainage, condenser cooling system and miscellaneous sources. Virtually all steam electric facilities have one or more waste streams associated with these systems and sources.

This review of effluent guidelines focused primarily on the 126 priority pollutants, although other pollutants were also considered. In general, very few of the organics in the list of 126 priority pollutants were detected in quantifiable amounts. Inorganic priority pollutants, however, are found in most waste streams. This review also disclosed that the chlorine (a nonconventional pollutant) limitations in the existing guidelines are not sufficiently stringent.

Treatment and control technologies currently in use by certain segments of the power industry could be applied to a greater number of power plants, reducing the discharge of pollutants. The best practicable control technology currently available (BPTCA) is not changed with exception to provisions relating to boiler blowdown and allowing concentration-based permit limitations to be established. The best available technology economically achievable (BATEA), new source performance standards (NSPS) and pretreatment standards for new (PSNS) and existing sources (PSES) are changed to reflect updated information on control technology, waste characterization and other factors.

In summary, the final regulations are as follows:

1. For once through cooling water, EPA is promulgating BAT and NSPS based upon a concentration of 0.2 mg/l total residual chlorine (TRC), applied at the final discharge point to the receiving body of water. Each individual generating unit is

not allowed to discharge chlorine for more than two hours per day, unless the discharger demonstrates to the permitting authority that a longer duration discharge is required for macroinvertebrate control. Simultaneous chlorination of more than one generating unit is allowed.

The above limitation does not apply to plants with a total rated generating capacity of less than 25 megawatts. BAT and NSPS are equal to BPT for those plants.

With the exception of a prohibition on the discharge of PCBs, there are no national pretreatment standards applicable to once-through cooling water.

2. For cooling tower blowdown, the Agency is retaining the existing BPT requirements for BAT and NSPS on free available chlorine. These limitations are 0.2 mg/l average concentration and 0.5 mg/l daily maximum concentration, with multi-unit chlorination prohibited. The final BAT, NSPS, and pretreatment standards also prohibit the discharge in detectable amounts of 124 priority pollutants contained in cooling tower maintenance chemicals, retain the existing limits on chromium and zinc discharges, and delete the limits on phosphorus.

3. For fly ash transport water, there are no BAT limits or PSES with the exception of a prohibition of PCB discharges. The existing BAT limits for conventional pollutants are withdrawn because they will be covered by Best Conventional Pollutant Control Technology (BCT) limitations. Final NSPS and PSNS for fly ash transport require no discharge of wastewater pollutants. This is based upon dry fly ash handling and disposal.

4. For bottom ash transport water, there are no BAT limits or pretreatment standards, with the exception of a prohibition on PCB discharges. NSPS is revised to equal BPT; the existing recycle requirement is withdrawn. The existing BAT limits for conventional pollutants are withdrawn because they will be covered by BCT.

5. For low volume wastes, the BAT limits for conventional pollutants are withdrawn because they will be covered by BCT. All other existing requirements are retained. Boiler blowdown is now regulated as a low volume waste, and no longer regulated separately.

6. For chemical metal cleaning wastes, the existing BAT and NSPS regulations are retained. The existing BAT limits for conventional pollutants are withdrawn because they will be covered by BCT. Final PSES and PSNS contain a maximum concentration limit of 1.0 mg/l for total copper.

7. BAT, NSPS, PSES, and PSNS for non-chemical metal cleaning wastes, wet air pollution control devices, chemical handling area runoff, and ash pile/construction area runoff are reserved for future rulemaking.

8. For coal pile runoff, the existing limits are retained, except that BAT is withdrawn for conventional pollutants.

9. BCT is reserved for all wastestreams.

Ash From Coal-Fired Plants

Coal Ash Formation

More than 90 percent of the coal currently used by electric utilities is burned in pulverized coal boilers. In such boilers, 65 to 80 percent of the ash is produced in the form of fly ash, which is carried out of the combustor in the flue gases and is separated from these gases by electrostatic precipitators and/or mechanical collectors. The remainder of the ash drops to the bottom of the furnace as bottom ash or slag The amounts of each type of ash produced in the United States during several recent years are listed in table V-24. The percentage of ash collected as fly ash has risen from 65 percent in 1971 to 71 percent in 1975.

The ash residue resulting from the combustion of coal is primarily derived from the inorganic matter in the coal Table V-25 provides a breakdown of several of the major ash constituents for different ranks of coal. The overall percent ash in the coal varies from 3 to approximately 30 percent. These major ash components can vary widely in concentrations within a particular rank as well as between ranks. Relatively significant concentrations of trace elements are also found in the coal ash Many of these elements are listed in table V-26 for various ranks of coal These elements can range from a barely detectable limit to almost 14,000 ppm as the maximum measured for barium in some lignites and subbituminous coals

During the combustion of coal, the products formed are partitioned into four categories· bottom ash, economizer ash, fly ash, and vapors. The bottom ash is that part of the residue which is fused into particles heavy enough to drop out of the furnace gas stream (air and combustion gases). These particles are collected in the bottom of the furnace The economizer ash particles are sized approximately between those of bottom and fly ash This ash is collected in economizer hoppers just beyond the boiler flue gas pass The fly ash is that part of the ash which is entrained in the combustion gas leaving the boiler While most of the fly ash is collected in mechanical collectors, baghouses, or electrostatic precipitators, a small quantity of this material may pass through the collectors and be discharged into the atmosphere The vapor is that part of the coal material which is volatilized during combustion. Some of these vapors are discharged into the atmosphere; others are condensed onto the surface of fly ash particles and may be collected in one of the fly ash collectors Certain of the trace elements are more volatile than others The more volatile elements, e g , mercury, fluorine, thallium, and antimony, will have a strong tendency to vaporize and perhaps condense on the fly ash particles Some of the vapors may also be trapped inside larger sized bottom ash particles resulting in condensation there as well

The distribution of the ash between the bottom ash and fly ash fractions is a function of the boiler type (firing method), the type of coal (ash fusion temperature), and the type of boiler bottom (wet

Table V-24

MEGATONS OF COAL ASH COLLECTED IN THE UNITED STATES (19)

Type	1971	1973	1974	1975	1980*	1985**
Fly ash	27.7	34.6	40.4	42.3	-	-
Bottom ash	10.1	10.7	14.3	13.1	-	-
Boiler slag	5.0	4.0	4.8	4.6	-	-
Total	42.8	49.3	59.5	60.0	75.0	120.0
Coal consumed	-	-	390	403	-	-
Calculated average ash content	-	-	15.3%	14.9%	-	-

*Projection by R. E. Morrison, American Electric Services Co.

**Projection based on expected doubling in coal-fired power generation, 1975 to 1985.

Table V-25

VARIATIONS IN COAL ASH COMPOSITION WITH RANK (19)

Component	Rank			
	Anthracite	Bituminous	Subbituminous	Lignite
SiO_2	48-68	7-68	17-58	6-40
Al_2O_3	25-44	4-39	4-35	4-26
Fe_2O_3	2-10	2-44	3-19	1-34
TiO_2	1-2	0.5-4	0.6-2	0-0.8
CaO	0.2-4	0.7-36	2.2-52	12.4-52
MgO	0.2-1	0.1-4	0.5-8	2.8-14
Na_2O	-	0.2-3	-	0.2-28
K_2O	-	0.2-4	-	0.1-1.3
SO_3	0.1-1	0.1-35	3-16	8.3-32

Table V-26

RANGE IN AMOUNT OF TRACE ELEMENTS PRESENT IN COAL ASHES (19)

(ppm)

	Anthracites			High volatile bituminous		
Element	Max.	Min.	Average	Max.	Min.	Average
Ag	1	1	*	3	1	*
B	130	63	90	2800	90	770
Ba	1340	540	866	4660	210	1253
Be	11	6	9	60	4	1253
Co	165	10	81	305	12	64
Cr	395	210	304	315	74	193
Cu	540	96	405	770	30	293
Ga	71	30	42	98	17	40
Ge	20	20	*	285	20	*
La	220	115	142	270	29	111
Mn	365	58	270	700	31	170
Ni	320	125	220	610	45	154
Pb	120	41	81	1500	32	183
Sc	82	50	61	78	7	32
Sn	4250	19	962	825	10	171
Sr	340	80	177	9600	170	1987
V	310	210	248	840	60	249
Y	120	70	106	285	29	102
Yb	12	5	8	15	3	10
Zn	350	155	*	1200	50	310
Zr	1200	370	688	1450	115	411

* = Insufficient data to compute an average value.

= Figures encircled indicate the number of samples used to compute average values.

Table V-26 (Continued)

RANGE IN AMOUNT OF TRACE ELEMENTS PRESENT IN COAL ASHES (19)

(ppm)

	Low volatile bituminous			Medium volatile bituminous		
Element	Max.	Min.	Average	Max.	Min.	Average
Ag	1.4	1	*	1	1	*
B	180	76	123	780	74	218
Ba	2700	96	740	1800	230	396
Be	40	6	16	31	4	13
Co	440	26	172	290	10	105
Cr	490	120	221	230	36	169
Cu	850	76	379	560	130	313
Ga	135	10	41	52	10	*
Ge	20	20	*	20	20	*
La	180	56	110	140	19	83
Mn	780	40	280	4400	125	1432
Ni	350	56		440	20	263
Pb	170	23	89	210	52	96
Sc	155	15	50	110	7	56
Sn	230	10	92	160	29	75
Sr	2500	66	818	1600	40	668
V	480	115	278	870	170	390
Y	460	37	152	340	37	151
Yb	23	4	10	13	4	9
Zn	550	62	231	460	50	195
Zr	620	220	458	540	180	326

* = Insufficient data to compute an average value.

= Figures encircled indicate the number of samples used to compute average values.

Table V-26 (Continued)

RANGE IN AMOUNT OF TRACE ELEMENTS PRESENT IN COAL ASHES (19)

(ppm)

Element	Lignites and Subbituminous Max.	Min.	Average
Ag	50	1	*
B	1900	320	1020
Ba	13900	550	5027
Be	28	1	6
Co	310	11	45
Cr	140	11	54
Cu	3020	58	655
Ga	30	10	23
Ge	100	20	*
La	90	34	62
Mn	1030	310	688
Ni	420	20	129
Pb	165	20	60
Sc	58	2	18
Sn	660	10	156
Sr	8000	230	4660
V	250	20	125
Y	120	21	51
Yb	10	2	4
Zn	320	50	*
Zr	490	100	245

* = Insufficient data to compute an average value.

= Figures encircled indicate the number of samples used to compute average values.

or dry) The first factor, boiler type, is significant in determining ash distribution The boiler types which are currently in use are pulverized coal, cyclone, and spreader stoker Most modern boilers are the pulverized coal type The different methods of firing pulverized-coal boilers are shown in figure V-11 Table V-27 shows the relative distributions of bottom ash and fly ash by boiler firing method. The smallest amount of fly ash, approximately 10 percent, is emitted by the cyclone furnace because the ash fusion temperature is exceeded and 80-85 percent of the ash is collected as slag in the bottom ash hopper.

A wet or dry bottom boiler influences the distribution of ash in pulverized coal-fired boilers Most of the modern pulverized units utilize a dry bottom design. This type of furnace allows the ash to remain in a dry, or non-molten, state and drop through a grate into water-filled hoppers used to collect the ash. Ash in a dry state may reflect either a relatively low boiler design combustion temperature or the ash may contain constituents which are characterized by relatively high melting points Since the dry ash does not fuse, it can be fairly easily entrained in the combustion gas stream resulting in higher fly ash/bottom ash ratios than in wet bottom boilers. The wet-bottom boiler collects bottom ash in a fused or molten state This furnace is referred to as a slagging furnace. The relative distributions of bottom ash and fly ash by type of boiler bottom are also shown in table V-27.

Chemical Characteristics of Coal Ash

The chemical compositions of both types of bottom ash, dry or slag, are quite similar The major species present in bottom ash are silica (20-60 weight percent as SiO_2), alumina (10-35 weight percent as Al_2O_3), ferric oxide (5-35 weight percent as Fe_2O_3), calcium oxide (1-20 weight percent as CaO), magnesium oxide (0 3-0 4 weight percent as MgO), and minor amounts of sodium and potassium oxides (1-4 weight percent). In most instances, the combustion of coal produces more fly ash than bottom ash. Fly ash generally consists of very fine spherical particles, ranging in diameter from 0.5 to 500 microns The major species present in fly ash are silica (30-50 weight percent as SiO_2), alumina (20-30 weight percent as Al_2O), and titanium dioxide (0.4-1.3 weight percent as TiO_2) Other species which may be present include sulfur trioxide, carbon, boron, phosphorous, uranium, and thorium. Tables V-28 and V-29 provide some ranges for these major species. Species concentration differences between fly ash and bottom ash can vary considerably from one site to another

In addition to these major components, a number of trace elements are also found in bottom ash and fly ash Tables V-29 and V-30 present data concerning concentrations of these trace elements for both bottom and fly ash for various utility plants The trace elemental concentrations can vary considerably within a particular ash or between ashes. Generally, higher trace element concentrations are found in the fly ash than bottom ash, however, there are several cases where bottom ash exceeds fly ash concentrations

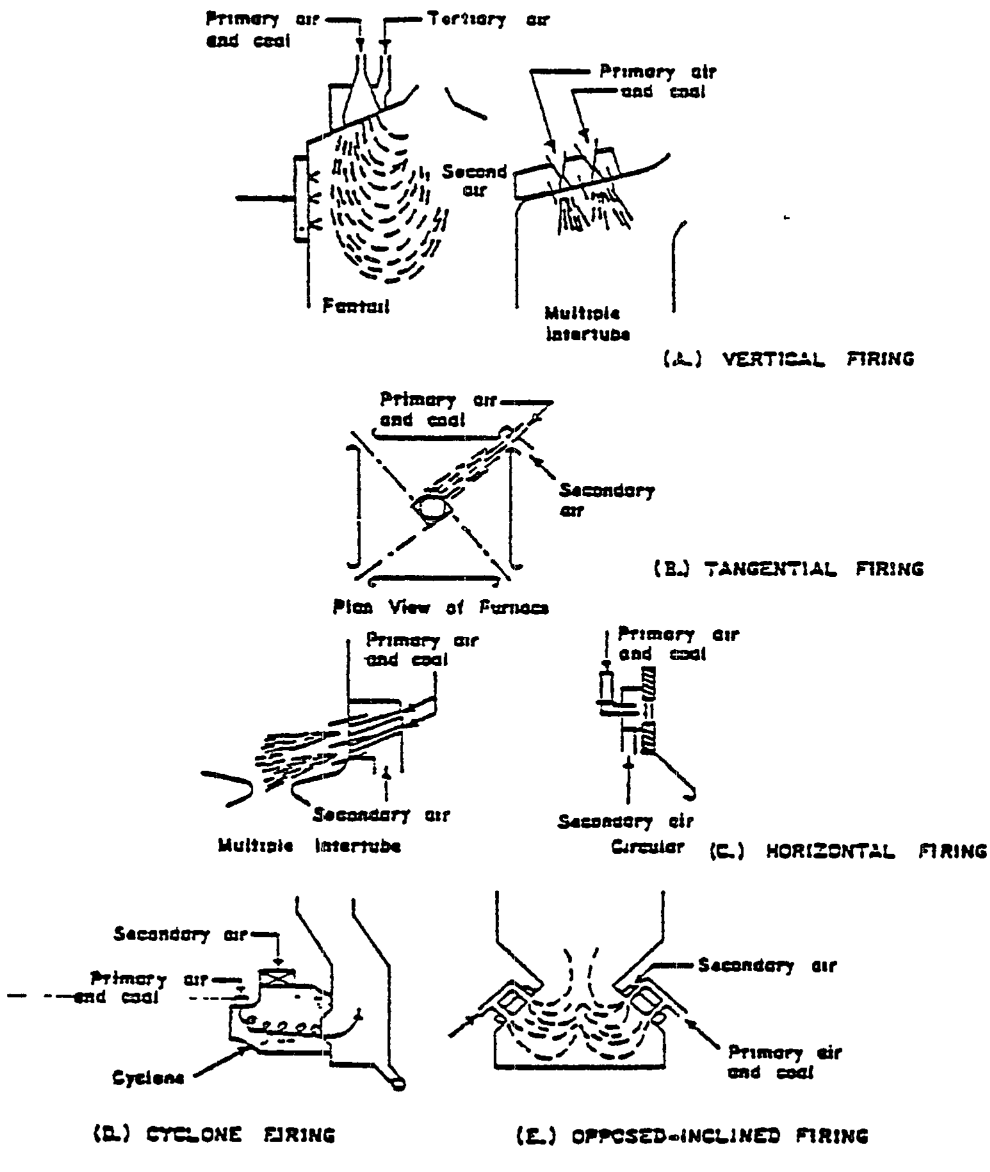

Figure V-11
PULVERIZED-COAL FIRING METHODS (19)

Table V-27

COMPARISON OF DISTRIBUTION BETWEEN BOTTOM ASH AND FLY ASH BY TYPE OF BOILERS AND METHOD OF FIRING (19)

Type of Firing*	Type of Boiler Bottom**	% Bottom Ash (typical%)	% Fly Ash (typical%)
PCFR	W	35	65
PCOP	W	35	65
PCTA	W	35	65
PCFR	D	15	85
PCOP	D	15	85
PCTA	D	15	85
CYCL	-	90	10
SPRE	-	35	65

*PCFR - Pulverized coal front firing
PCOP - Pulverized coal opposed firing
PCTA - Pulverized coal tagential firing
CYCL - Cyclone
SPRE - Spreader stoker

**W - wet bottom
D - dry bottom

Table V-28

MAJOR CHEMICAL CONSTITUENTS OF FLY ASH AND BOTTOM ASH FROM THE SOUTHWESTERN PENNSYLVANIA REGIONS (19)

Constituent	Fly Ash (% by weight)	Bottom ash (% by weight)
Sulfur trioxide	0.01-4.50	0.01-1.0
Phosphorus pentoxide	0.01-0.50	0.01-0.4
Silica	20.1-46.0	19.4-48.9
Iron oxide	7.6-32.9	11.7-40.0
Aluminum oxide	17.4-40.7	18.9-36.2
Calcium oxide	0.1-6.1	0.01-4.2
Magnesium oxide	0.4-1.2	0.5-0.9
Sodium oxide	0.3-0.8	0.2-0.8
Potassium oxide	1.2-2.4	1.7-2.8
Titanium oxide	1.3-2.0	1.3-1.8

Table V-29

COMPARISON OF FLY ASH AND BOTTOM ASH FROM VARIOUS UTILITY PLANTS (19)

Compound or Element	Plant 1		Plant 2		Plant 3		Plant 4		Plant 5		Plant 6	
	FA	BA	FA	BA	FA	BA	FA	BA	BA	BA	BA	BA
SiO_2, %	59	58	57	59	43	50	54	59	NR	NR	42	49
Al_2O_3, %	27	25	20	18.5	21	17	28	24	NR	NR	17	19
Fe_2O_3, %	3.8	4.0	5.8	9.0	5.6	5.5	3.4	3.3	20.4	30.4	17.3	16.0
CaO, %	3.8	4.3	5.7	4.8	17.0	13.0	3.7	3.5	3.2	4.9	3.5	6.4
SO_3, %	0.4	0.3	0.8	0.3	1.7	0.5	0.4	0.1	NR	0.4	NR	NR
MgO, %	0.96	0.88	1.15	0.92	2.23	1.61	1.29	1.17	NR	NR	1.76	2.06
Na_2O, %	1.88	1.77	1.61	1.01	0.4	0.5	1.5	1.5	NR	NR	1.36	0.67
K_2O, %	0.9	0.8	1.1	1.0	1.44	0.64	0.38	0.43	NR	NR	2.4	1.9
P_2O_5, %	0.13	0.06	0.04	0.05	0.70	0.30	1.00	0.75	NR	NR	NR	NR
TiO_2, %	0.43	0.62	1.17	0.67	1.17	0.50	0.83	0.50	NR	NR	1.00	0.68
As, ppm	12	1	8	1	15	3	6	2	8.4	5.8	110	18
Be, ppm	4.3	3	7	7	3	2	7	5	8.0	7.3	NR	NR
Cd, ppm	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	6.44	1.08	8.0	1.1
Cr, ppm	20	15	50	30	150	70	30	30	206	124	300	152
Cu, ppm	54	37	128	48	69	33	75	40	68	48	140	20
Mg, ppm	0.07	0.01	0.01	0.01	0.03	0.01	0.08	0.01	20.0	0.51	0.05	0.028

Table V-29 (Continued)

COMPARISON OF FLY ASH AND BOTTOM ASH FROM VARIOUS UTILITY PLANTS (19)

Compound or Element	Plant 1		Plant 2		Plant 3		Plant 4		Plant 5		Plant 6	
	FA	BA	FA	BA	FA	BA	FA	BA	BA	BA	BA	BA
Mn, ppm	267	366	150	700	150	150	100	100	249	229	298	295
Ni, ppm	10	10	50	22	70	15	20	10	134	62	207	85
Pb, ppm	70	27	30	30	30	20	70	30	32	8.1	8.0	6.2
Se, ppm	6.9	0.2	7.9	0.7	18.0	1.0	12.0	1.0	26.5	5.6	25	0.08
V, ppm	90	70	150	85	150	70	100	70	341	353	440	260
Zn, ppm	63	24	50	30	71	27	103	45	352	150	740	100
B, ppm	266	143	200	125	300	70	700	300	NR	NR	NR	NR
Co, ppm	7	7	20	12	15	7	15	7	6.0	3.6	39	20.8
F, ppm	140	50	100	50	610	100	250	85	624	10.6	NR	NR

KEY FA = Fly Ash
BA = Bottom Ash

Table V-30

CONCENTRATIONS OF SELECTED TRACE ELEMENTS
IN COAL AND ASH AT PLANT 4710 (19)

		Element Concentration		
Element	Coal[a]	Bottom ash	Inlet fly ash[b]	Outlet fly ash[c]
As	4.45	18	110	440
Ba	65	500	465	750
Br	3.7	2	4	
Cd	0.47	1.1	8.0	51
Ce	8.2	84	84	120
Cl	914	<100	<200	
Co	2.9	20.8	39	65
Cr	18	152	300	900
Cs	1.1	7.7	13	27
Cu	8.3	20	140	
Eu	0.1	1.1	1.3	1.3
Ga	4.5	5	81	
Hf	0.4	4.6	4.1	5.0
Hg	0.122	0.028	0.050	
La	3.8	42	40	42
Mn	33.8	295	298	430
Ni	16	85	207	
Pb	4.9	6.2	80	650
Rb	15.5	102	155	55
Sb	0.5	0.64	12	36
Sc	2.2	20.8	26	88
Se	2.2	0.08	25	36
Sm	1.0	8.2	10.5	9
Sr	23	170	250	
Ta	0.11	0.95	1.4	1.8
Tn	2.1	15	20	26
U	2.18	14.9	30.1	
V	28.5	260	440	1180
Zn	46	100	740	5900

[a]Mixture of coals from southern Illinois and western Kentucky. Ash content 12%.

[b]Collected upstream from electrostatic precipitator.

[c]Collected downstream from electrostatic precipitator.

Figure V-12 presents the size distribution curves for fly ash and bottom ash. The difference between the 50 percent grain sizes of bottom ash and fly ash is approximately two orders of magnitude with bottom ash being the larger Fly ash demonstrates various concentrations of trace elements in various size ranges of particles More specifically, there exists an increased concentration trend with decreasing particle sizes as shown in table V-31

Those data on the composition of ash particles demonstrate that priority pollutants are present in the dry ashes and therefore can dissolve into water when ash sluicing methods are used The next section addresses observed concentrations of these materials in ash handling waters. The purpose is to assess the extent to which these materials enter the ash sluicing waters and therefore are discharged from the plants.

Characterization of Ash Pond Overflows

Data From EPA Regional Offices

Table V-32 is a compilation of data obtained for ash pond overflows from various EPA regional offices These data summarize ash pond effluents where the total suspended solids values are less than 30 ppm. This data was studied to determine whether a correlation existed between TSS values and the corresponding heavy metal concentrations (20). The results from this study of five different metals, i e., arsenic, nickel, zinc, copper, and selenium, indicated that no correlation existed between these concentrations and TSS values Additional data on ash pond overflow are available in the 1974 Development Document (1).

Discharge monitoring report data for 17 plants from various EPA regional offices have been summarized Table V-33 lists metals concentrations for fly ash ponds, bottom ash ponds, and combined pond systems. These metal concentrations are discharge values only; they do not reflect a net discharge based on intake water metals concentrations.

Tennessee Valley Authority Data

Combined Ash Ponds. In 1973, the Tennessee Valley Authority (TVA) began collecting ash pond effluents and water intake samples quarterly for trace metals; calcium, chloride, and silica analyses. A summary of these data for 1973 through 1975 for plants with combined fly ash and bottom ash ponds appears in table V-34 The complete data from which the summary tables where prepared is presented in Appendix A. The summary consists of the average, maximum, and minimum concentrations for each element The average was calculated by substituting a value equal to the minimum quantifiable concentration (MQC) when the reported value was less than the MQC. Thus, the average may be biased upward if there is a significant number of values less than the MQC Those elements most likely affected are As, Ba, Be, Cd, Cr, Pb, Hg, Ni, and Se.

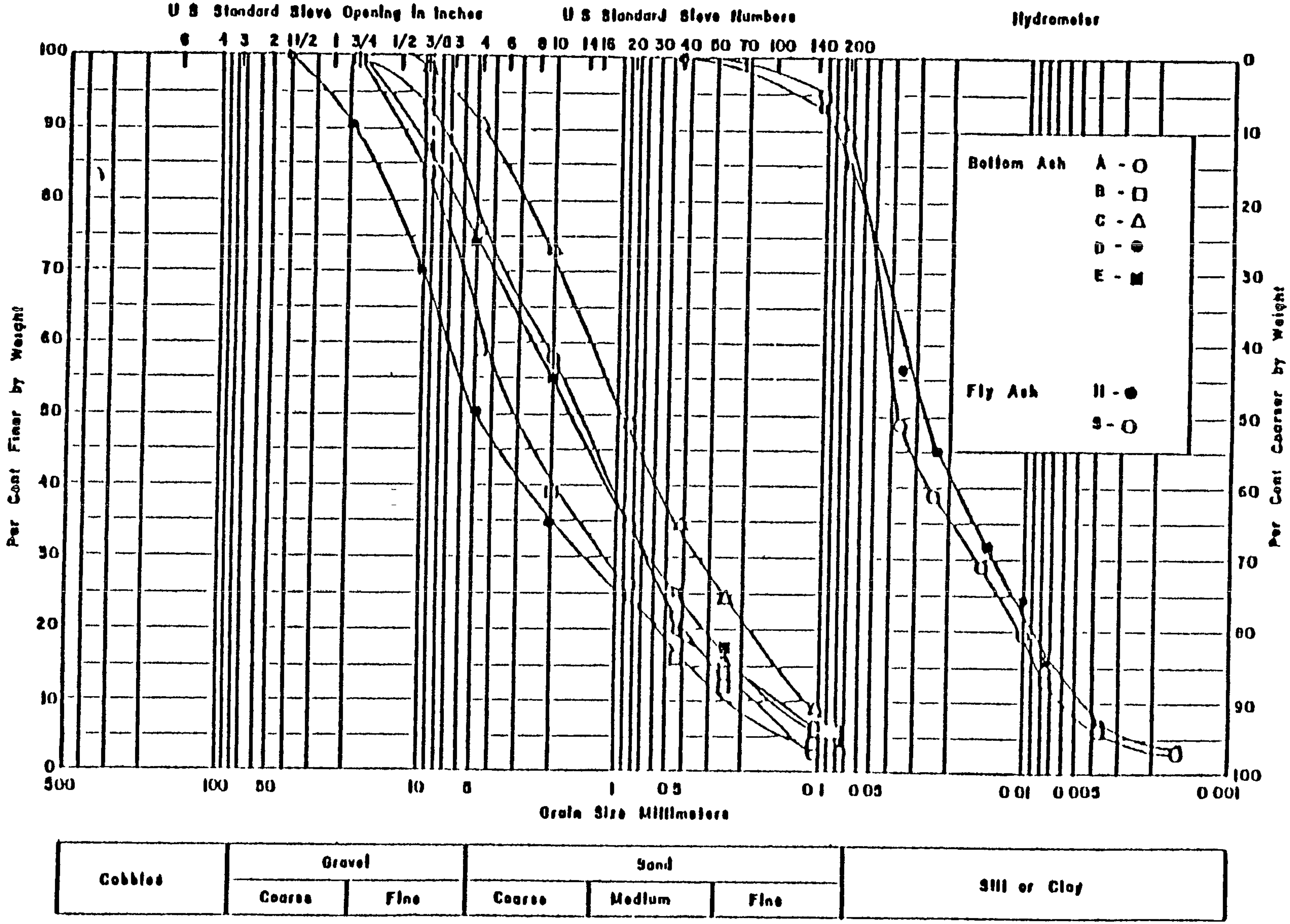

Figure V-12
GRAIN SIZE DISTRIBUTION CURVES FOR BOTTOM ASH AND FLY ASH (19)

Table V-31

ELEMENTS SHOWING PRONOUNCED CONCENTRATION TRENDS WITH DECREASING PARTICLE SIZE (19)

(ppm unless otherwise noted)

Particle Diameter (mm)	Pb	Tl	Sb	Cd	Se	As	Ni	Cr	Zn
A. Fly Ash Retained in Plant									
1. Sieved fractions									
74	140	7	1.5	10	12	180	100	100	500
44-74	160	9	7	10	20	500	140	90	411
2. Aerodynamically sized fractions									
40	90	5	8	10	15	120	300	70	730
30-40	300	5	9	10	15	160	130	140	570
20-30	430	9	8	10	15	200	160	150	480
15-20	520	12	19	10	30	300	200	170	720
10-15	430	15	12	10	30	400	210	170	770
5-10	820	20	25	10	50	800	230	160	1100
5	980	45	31	10	50	370	260	130	1400
3. Analytical method*	a	a	a	a	a	a	a	b	a
B. Airborne Fly Ash									
1. Data									
11.3	1100	29	17	13	13	680	460	740	8100
7.3-11.3	1200	40	27	15	11	800	400	290	9000
4.7-7.3	1500	62	34	18	16	1000	440	460	6600
3.3-4.7	1550	67	34	22	16	900	540	470	3800
2.1-3.3	1500	65	37	26	19	1200	900	1500	15000
1.1-2.1	1600	76	53	35	59	1700	1600	3300	13000
0.65-1.1	...	..	..	..	..	..	..	..	..
2. Analytical method*	d	a	a	d	d	d	d	d	a

* - (a) DC arc emission spectrometry.
(b) Atomic absorption spectrometry.
(c) X-ray fluorescence spectrometry.
(d) Spark source mass spectromety.

Table V-32

CHARACTERISTICS OF ASH POND OVERFLOWS WITH TOTAL SUSPENDED SOLIDS CONCENTRATIONS LESS THAN 30 mg/l (19)

(mg/l)

Plant Code	Capacity (MW)	Fuel*	No of Samples	TSS	Fe	Cu	Cd	Ni	A	Pb	Hg	Zn	Se	P	Cr	Oil & Grease
3711	781	c/o	18	24 5	0 36	0 1	0 02	0 1	0 06	0 1	0 002	0 14	0 007	-	0 05	0 23
3708	466	c/o	6	14 7	0 12	0 1	0 02	0 1	0 14	0 1	0 003	0 01	0 005	-	0 05	0 16
4234	598	c/o	1	6 0	0 38	0 01	-	0 0	0 011	0 05	-	0 03	-	-	-	1 71
0512	1,341	c	7	16 5	0 63	0 01	-	0 01	0 19	0 14	0 001	0 04	0 011	-	0 01	4 0
1226	1,229	c/g	22	9 4	0 92	0 03	-	-	0 02	0 01	0 0006	0 05	-	0 10	0 01	1 2
3713	2 000	c/o	9	5 2	0 20	0 1	02	0 1	0 03	0 1	0 002	0 08	0 03	-	0 ⁻05	0 17
3701	421	c/o	3	18 0	0 47	0 05	0 01	0 05	0 01	0 05	0 001	0 05	0 10	-	0 05	1 0
2105	511	c	5	4 4	0 11	0 006	0	0 0004	0 02	0 004	0	0 005	0 004	-	0 004	1 3
2102	132	c/o	2	10 9	0 2	0 009	-	0 0045	0 03	0 04	0 0004	0 06	0 018	-	0 003	0 26
3805	660	c	1	15	-	0 11	0 002	-	0 06	0 01	0 0001	0 04	-	-	0 02	-
2103	694	c	3	20	0 52	0 15	-	0 005	0 21	0 007	0 0001	0 02	0 01	-	0 005	0 79

* c - coal
o - oil
g - gas

Table V-33

SUMMARY OF ASH POND OVERFLOW DATA FROM DISCHARGE MONITORING REPORTS (21)

(ppb)

Trace Metal	Fly Ash Ponds[1]			Bottom Ash Ponds[2]			Combined Ponds[3]		
	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.
As	10	66	29.2	7	70	21.1	3.5	416	67
Cd	3.5	26.9	11.8	2	16.3	9.7	0	82	18.7
Cr	5	15.2	10.2	4	41.7	15.6	2.5	84.2	30.4
Cu	20	209	84.8	5	70	36.9	0	130	59
Fe	1055	8138	4011	657	10950	3410	80	2600	664.6
Pb	10	200	59.4	10	60	25.5	0	100	40.1
Hg	0.1	1.8	0.6	0.4	1.7	0.8	0	65	3.9
Ni	33	100	61.1	13.3	1345	191.4	0	100	49
Se	2	7.8	4.4	2	10	6.7	1.7	68.3	23.6
Zn	50	1139	358.4	10	302	131.9	10	293	94.9

[1]Data for 4 facilities

[2]Data for 9 facilities

[3]Data for 20 facilities

Table V-34

SUMMARY OF QUARTERLY TVA TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant C			Plant C			Plant D			Plant E		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Aluminum	EFF	0.3	1 5	3 8	0 5	3 4	8	<0 2	1 4	3 8	1 1	2 5	3 4
	RW	0 6	4 7	15	1 3	5 2	15	0 2	0 5	0 9	1 7	2 9	4 3
Ammonia as N	EFF	0 02	0 11	0 34	<0 02	0 09	0.22	<0 01	0 06	0 15	0 03	0 06	0 09
	RW	0 03	0 14	0 33	0 03	0 16	0 29	<0 01	0 04	0 13	0 04	0 07	0 10
Arsenic	EFF	<0 005	0 013	0 05	<0 005	0 022	0 035	<0 005	0 034	0 100	<0 005	0 028	0 13
	RW	<0 005	0 008	0 026	<0 005	0 009	0 026	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005
Barium	EFF	<0 1	0 2	0 4	<0 1	0 14	0 3	<0 1	0 2	0 3	<0 1	0 2	0 4
	RW	<0.1	0 1	0.2	<0 1	0 14	0 2	<0 1	0 1	0 2	<0.1	0 2	0 4
Beryllium	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Cadmium	EFF	0.002	0.006	0.013	<0 001	0 002	0 010	<0 001	0 001	0 002	<0 001	0 001	0 002
	RW	<0 001	0 001	0 002	<0 001	0 001	0 002	<0 001	<0 001	<0 001	<0 001	0 001	0 002
Calcium	EFF	45	78	100	19	37	89	26	31	37	68	126	170
	RW	15	29	45	15	33	43	23	28	31	14	17	20
Chloride	EFF	7	11	16	7	11	16	2	3	5	5	6	2
	RW	7	11	16	7	11	16	2	3	4	4	5	6
Chromium	EFF	<0 005	0 006	0 008	<0 005	0 009	0 024	<0 005	<0 005	0 008	<0 005	0 017	0 025
	RW	<0 005	0 012	0 041	<0 005	0 013	0 041	<0 005	0 005	<0.005	<0 005	<0 005	<0 005
Copper	EFF	<0 01	0 05	0 10	<0 01	0 06	0 18	<0 01	0 03	0 14	0 02	0 08	0 19
	RW	0 03	0 11	0 22	0 03	0 12	0 22	0 02	0 07	0 22	0 02	0 05	0 08
Cyanide	EFF	<0 01	0 01	<0 01	<0 01	0 01	0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	-	-	-	-	-	-	-	-	-	-	-	-
Iron	EFF	0 33	1 7	4 1	0 72	6 0	27	<0 05	0 32	0 67	0 05	0 16	0 39
	RW	1 0	6 5	14	1 4	7 2	14	0 25	0 51	1 00	0 45	1 0	1 6
Lead	EFF	<0 010	0 021	0 069	<0 010	0 017	0 033	<0 010	0 016	0 046	<0 01	0 017	0 036
	RW	<0 010	0 022	0 047	<0 010	0 024	0 047	<0 010	0 012	0 018	<0 01	0 015	0 028
Magnesium	EFF	1 4	10	16	6 3	10	16	7 5	8 3	9 8	0 1	0 3	0 3
	RW	6 5	9 5	14	6 5	6 6	14	7 1	8 0	9 1	3 0	3 4	4 1
Manganese	EFF	0 13	0 20	0 34	0 05	0 18	0 16	<0 01	0 02	0 05	<0 01	0 01	0 02
	RW	0 12	0 31	0 53	0 12	0 31	0 53	0 03	0 07	0 13	0 04	0 05	0 07
Mercury	EFF	<0 0002	0 0034	0 0074	<0 0002	0 0070	0 050	<0 0002	0 0002	0 0003	<0 0002	0 0002	0 0001
	RW	<0 0002	0 0004	0 0016	<0 0002	0 0003	0 0016	<0 0002	0 0002	0 0005	<0 0002	<0 0002	<0 0001
Nickel	EFF	<0 05	0 05	0 07	<0 05	0 06	0 17	<0 05	0 06	0 19	<0 05	<0 05	<0 05
	RW	<0 05	<0 05	<0 05	<0 05	0 05	0 05	<0 05	0 08	0 27	<0 05	<0 05	<0 05

Table V-34 (Continued)

SUMMARY OF QUARTERLY TVA TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant C			Plant C			Plant D			Plant E		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Selenium	EFF	<0 001	0 010	0.080	<0 001	0 003	0 004	<0 002	0 070	0 170	<0 002	0 007	0 014
	RW	<0 001	0 002	0 004	<0 002	0 002	0 004	<0 002	0 002	0 004	<0 002	<0 002	<0 002
Silica	EFF	4 7	7 4	11	1 5	6 7	14	3 2	4 0	6 2	5 9	7 0	8 4
	RW	5.5	6 1	7 9	5 4	6 2	7 9	3 8	5 2	9 5	4 5	4 7	5 0
Silver	EFF	<0 01	0 01	0 03	<0 01	0 01	0 02	<0 01	0 01	0 01	<0 01	0 01	0 02
	RW	<0.01	0 01	<0 01	<0 01	0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Dissolved Solids	EFF	260	345	460	170	239	420	100	156	200	240	368	420
	RW	160	205	240	160	197	220	110	126	140	80	93	100
Suspended Solids	EFF	3	18	37	4	31	98	3	15	45	2	4	6
	RW	11	46	150	17	51	150	1	14	55	8	18	38
Sulfate	EFF	110	158	200	35	99	280	16	57	84	100	147	210
	RW	0 07	23	52	34	49	68	13	16	20	15	20	25
Zinc	EFF	0 02	0 13	0 27	0 03	0 14	0 16	<0 01	0 03	0 07	<0 03	0 05	0 07
	RW	0 03	0 08	0 13	0 03	0 08	0 13	0 03	0 04	0 07	0 04	0 08	0 18

		Plant F			Plant G			Plant H			Plant I South		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Aluminum	EFF	0 8	1.7	3 1	0 4	1 7	2 9	0 8	1 6	2 9	0 6	1 5	2 6
	RW	<0 1	1 4	3 6	0.1	1 2	4 1	<0 2	1 0	1 6	0 8	1 6	3 0
Ammonia as N	EFF	0 03	0 17	42	<0 01	0 12	0 62	0 03	0 34	2 60	0 01	0 07	0 31
	RW	0 02	0 08	0 26	0 01	0 04	0 08	0 06	0 23	0 49	0 08	0 05	0 10
Arsenic	EFF	<0 005	0 008	0 040	<0.005	0 030	0 070	<0 005	0 123	0 360	<0 005	0 036	0 163
	RW	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	0 006	0 010	<0 005	<0 005	<0 005
Barium	EFF	<0 1	0 2	0 3	<0 1	0 2	0 4	<0 1	0 2	0 3	<0 1	0 2	0 5
	RW	<0 1	0 1	0 1	<0 1	0 1	0 1	<0 1	0 1	0 2	0 1	0 2	0 3
Beryllium	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Cadmium	EFF	<0 001	0 001	0 002	<0 001	<0 001	<0 001	<0 001	0 001	0 002	<0 001	<0 001	<0 001
	RW	<0 001	0 001	0 002	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001
Calcium	EFF	67	107	160	38	73	110	34	50	67	44	94	130
	RW	19	27	35	13	20	25	22	28	35	17	19	21
Chloride	EFF	4	5	6	2	4	8	8	14	22	4	6	12
	RW	3	4	4	3	4	5	7	14	28	4	6	8

Table V-34 (Continued)

SUMMARY OF QUARTERLY TVA TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant F			Plant G			Plant H			Plant I South		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Chromium	EFF	<0 005	0 033	0 072	<0 005	0 011	0 023	<0 005	0 006	0 01	<0 005	0 017	0 030
	RW	<0 005	0 006	0 012	<0 005	0 005	0 010	<0 005	0 005	0 007	<0 005	<0 005	<0 005
Copper	EFF	<0 01	0 03	0 08	<0 01	0 05	0 12	<0 01	0 04	0 14	<0 01	0 06	0 15
	RW	<0 01	0 05	0 08	<0 01	0 07	0 16	0 02	0 07	0 15	0 01	0 07	0 12
Cyanide	EFF	<0 01	<0 01	<0 01	<0 01	0 01	0 02	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	-	-	-	-	-	-	-	-	-	-	-	-
Iron	EFF	<0 05	0 22	1 1	0 26	0 53	1 4	0 18	0 56	1 4	<0 05	0 26	0 58
	RW	0 10	1 1	2 1	0 33	1 3	4 6	0 45	1 1	1 7	0 61	1 7	3 5
Lead	EFF	<0 010	0 013	0 040	<0 010	0 014	0 036	0 010	0 015	0 036	<0 01	0 012	0 038
	RW	<0 010	0 019	0 052	<0 010	0 019	0 04	0 010	0 019	0 033	0 01	0 15	0 221
Magnesium	EFF	0 3	1 57	7 2	1 1	2 4	3 1	6 2	7 4	9 7	0 2	1 2	3 7
	RW	3 5	4 2	4 9	3 4	4 0	4 6	5 7	7 4	13 0	2 6	3 3	4 3
Manganese	EFF	<0 01	0 01	0 04	<0 01	0 02	0 04	0 02	0 06	0 10	<0 01	0 05	0 3
	RW	0 06	0 07	0 011	0 05	0 10	0 23	0 10	0 14	0 18	0 01	0 01	0 2
Mercury	EFF	<0 0002	0 0003	0 0009	<0 0002	0 0024	0 014	<0 0002	0 0004	0 0016	<0 0002	0 0003	0 0032
	RW	<0 0002	0 0006	0 0033	<0 0002	0 0049	0 0031	<0 0002	0 0003	0 0008	<0 0002	0 0002	0 0003
Nickel	EFF	<0 05	0 05	<0 05	<0 05	<0 05	<0 05	<0 05	0 05	0 07	<0 05	0 05	0 05
	RW	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05
Selenium	EFF	0 006	0 014	0 028	<0 001	0 010	0 019	<0 002	0 017	0 034	<0 002	0 012	0 08
	RW	<0 002	<0 002	<0 002	<0 001	0 002	0 004	<0 001	0 002	0 006	<0 001	<0 002	<0 002
Silica	EFF	3 9	6 0	7 6	3 4	4 4	7 1	2 7	4 9	5 6	6 0	7 1	9 1
	RW	3 5	4 5	5 4	3 5	4 4	5 4	2 7	4 9	6 6	3 2	5 4	6 4
Silver	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Dissolved Solids	EFF	230	366	540	190	266	320	200	256	350	190	248	370
	RW	90	129	170	70	144	480	110	145	180	90	121	310
Suspended Solids	EFF	<1	4	20	8	19	45	4	10	19	<1	5	15
	RW	6	26	42	5	18	67	10	24	29	4	24	57
Sulfate	EFF	14	160	260	88	182	620	45	98	150	50	81	200
	RW	12	19	23	<1	17	23	16	19	22	10	21	80
Zinc	EFF	<0 01	0 05	0 14	<0 01	0 05	0 10	<0 01	0 05	0 15	<0 01	0 08	0 24
	RW	0 03	0 12	0 22	0 03	0 09	0 13	0 04	0 11	0 33	0 03	0 07	0 12

Table V-34 (Continued)

SUMMARY OF QUARTERLY TVA TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant J			Plant K			Plant L		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Aluminum	EFF	0 4	2 6	7 6	0 5	1 8	3 1	1 3	2 0	2 6
	RW	0 3	0 7	1 4	0 6	2 0	3.4	0 3	1 2	2 8
Ammonia as N	EFF	0 01	0 05	0 08	0 02	0 06	0 16	0 06	0 52	0.40
	RW	0 01	0 04	0 23	0 04	0 09	0 24	0 04	0 06	0 08
Arsenic	EFF	0 005	0 041	0 130	0 005	0 033	0 100	<0 005	0 032	0 070
	RW	0 005	0 018	0 110	0 005	0 009	0 024	<0 005	0 006	0 010
Barium	EFF	<0 1	0 2	0 3	<0 1	0 2	0 3	<0 1	0 1	0 2
	RW	<0 1	0 2	0 4	<0 1	0 1	0 3	<0 1	0 1	0 2
Beryllium	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Cadmium	EFF	<0 001	0 001	0 002	<0 001	0 001	0 002	<0 001	0 001	0 004
	RW	<0 001	0 001	0 002	<0 001	<0 001	<0 001	<0 001	<0 001	<0 001
Calcium	EFF	20	34	57	44	76	130	32	54	91
	RW	4	15	30	12	20	28	13	17	21
Chloride	EFF	2	5	21	6	10	19	4	6	9
	RW	2	2	4	4	7	10	4	6	8
Chromium	EFF	<0 005	0 005	0 007	<0 005	0 019	0 036	<0 005	0 009	0 018
	RW	<0 005	0 005	0 006	<0 005	0 009	0 027	<0 005	0 009	0 021
Copper	EFF	0 02	0 11	0 73	0 01	0 05	0 10	<0 01	0 06	0 14
	RW	<0 01	0 08	0 13	<0 01	0 07	0 12	<0 01	0.07	0 14
Cyanide	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	-	-	-	-	-	-	-	-	-
Iron	EFF	0 1	2 4	9 4	0 11	0 39	1 2	0 05	0 56	1 00
	RW	0 26	0 7	1 2	0 66	1 9	3 3	0 28	1 03	2 40
Lead	EFF	<0 010	0 015	0 038	0 010	0 017	0 048	0 010	0 017	0 043
	RW	<0 010	0 010	0 018	0 01	0 01	0 03	0 010	0 016	0 032
Magnesium	EFF	3 9	6 7	9 3	0 4	1 6	3 6	0 4	2 6	4 2
	RW	1 2	4 5	8 3	2 5	4 3	6 9	3 4	3 9	4 4
Manganese	EFF	0 05	0 38	0 79	0 01	0 02	0 04	0 01	0 03	0 13
	RW	0 03	0 07	0 18	0 07	0 10	0 18	0 03	0 07	0 12
Mercury	EFF	<0 0002	0 0003	0 0008	<0 0002	0 0003	0 0008	0 0002	0 0003	0 0009
	RW	<0 0002	0 0003	0 0009	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002
Nickel	EFF	<0 05	0 05	0 08	<0 05	0 06	0 22	<0 05	<0 05	<0 05
	RW	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05

Table V-34 (Continued)

SUMMARY OF QUARTERLY TVA TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant J			Plant K			Plant L		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Selenium	EFF	<0 001	0 004	0 008	<0 002	0.010	0 016	0 002	0 010	0 020
	RW	<0 001	0 003	0 008	<0 001	0 002	0 002	<0 001	0 002	0 002
Silica	EFF	3 5	6 4	8 7	4 0	6 7	8 8	4 5	5 7	9 1
	RW	1 0	3 9	5 0	2 5	4 6	5 9	3 6	5 1	5 8
Silver	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Dissolved Solids	EFF	140	202	250	180	240	310	140	211	260
	RW	30	89	210	80	106	150	70	88	100
Suspended Solids	EFF	1	15	81	3	8	26	3	12	50
	RW	5	13	35	17	29	60	4	14	43
Sulfate	EFF	56	119	180	54	83	110	6	80	110
	RW	9	22	80	12	20	31	9	13	16
Zinc	EFF	0 02	0 07	0 25	0 01	0 05	0 11	0 02	0 04	0 06
	RW	0 03	0 06	0 09	0 04	0 07	0 11	0 03	0 06	0 09

NOTE Effluent data based on years 1973-1975
Raw water intake data based on years 1974 and 1975

KEY EFF - effluent
RW - raw water (intakes)

The average concentrations of calcium, chloride, iron, magnesium, and manganese varied considerably from one effluent to another, while the average concentrations of aluminum, arsenic, silica, and sulfate varied only slightly. The average concentrations of barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc were approximately the same in all the ash pond effluents. The combined ash pond effluent at Plant D had a considerably higher concentration of selenium (70 ppb) than the rest of the effluents, while the ash pond effluent from Plant H had a considerably higher concentration of arsenic (123 ppb) than the others The plants, other than Plant H, had less than 50 ppb arsenic in the effluents.

TVA statistically compared the intake water characteristics to those of the effluents for Plants E, G, H, and J. Of particular importance was the evaluation of a potential relationship between priority pollutants (metals) and suspended solids. Essentially no correlation existed between suspended solids in the ash pond effluent and intake water quality characteristics

Relationships between the ash pond effluent and the plant operating conditions were also studied by TVA. Table V-35 provides a summary of the TVA plant operating conditions during collection of the ash pond effluent data No bottom ash characteristic data were available for this study Statistical correlations of the data show the pH of the ash pond effluent is influenced mainly by the calcium content of the fly ash and by the sulfur content of the coal As the percent CaO goes up, the alkalinity of the ash pond effluent increases The number of ash ponds in which the average concentration of each trace element shows a net increase from the ash pond influent to the overflow is presented in table V-36. More than half of the ash ponds increase the concentrations of Al, NH_3, As, Ba, Cd, Ca, Cl, Cr, Pb, Hg, Ni, Se, Si, SO_4 and Zn over that of the intake water. According to studies completed by TVA (22), the range over which the trace metals vary in the ash pond effluent appeared to be as great or greater than that in the intake water

<u>Separate Bottom Ash and Fly Ash Ponds</u> Certain utilities utilize separate fly ash and bottom ash ponds for handling the sluice water in their ash pond effluent systems. Table V-37 provides both ash pond effluent and raw water trace element and solids data for the separate fly ash and bottom ash ponds for two TVA plants The complete data from which the summary table was prepared is presented in Appendix A. Most of the elements appeared in greater concentrations in the fly ash effluent than in the bottom ash effluent for Plant A. On the average, the concentrations observed in Plant A fly ash effluents are at least several times as great as the observed bottom ash concentrations For Plant B, the fly ash and bottom ash effluent concentrations are approximately equal. Comparison of ash effluent concentrations to the raw water concentrations for Plant A reveals that the bottom ash concentrations are approximately equal to the raw water concentrations. The Plant A fly ash concentrations generally exceed the raw water concentrations For Plant B, the bottom ash and fly ash effluent concentrations generally exceed the raw water

Table V-35

SUMMARY OF PLANT OPERATION CONDITIONS AND ASH CHARACTERISTICS OF TVA COAL-FIRED POWER PLANTS (22)

Parameters	Plant C	Plant D	Plant E	Plant F	Plant G	Plant H	Plant I	Plant J	Plant K	Plant L
Method of Firing	Cyclone	Tangential	Circular Wall Burner	Opposed	Tangential	Tangential	Circular Wall Burner	Tangential	Circular Wall Burner	Circular Wall Burner
Coal Source	W Kentucky	E Kentucky	W Kentucky	W Kentucky S Illinois	W Kentucky	Virginia E Kentucky E Tennessee	W Kentucky	E Kentucky E Tennessee	S Illinois W Kentucky	W Kentucky N Alabama
Ash Content in Coal, %	11	15 5	15 3	16 3	15 7	15	14	19 1	15 6	16
Fly Ash of Total Ash, %	30	75	67	80	80	67	70	75	75	75
Bottom Ash of Total Ash, %	70	25	33	20	20	33	30	25	25	25
Sulfur Content in Coal, %	3 0	1 2	4 1	3 7	3 5	1 8	3 7	2 1	2 8	2 8
Coal Usage at Full Load (tons/day)	7848	8420	12897	24525	10503	8057	14460	16193	15304	17691
Number of Units	3	1	5	2	4	4	10	9	10	8
ESP Efficiency, %	-	99	74	99	60	-	75	70	60	60
Mechanical Ash Collector Efficiency, %	90-99	-	80	-	-	-	-	95	95	99
Overall Efficiency, %	-	99	95	-	98-99	99	75 5	98	98	70
Sluice Water to Ash Ratio (gal/ton)	23065	10770	9585	19490	12345	11425	42430	9520	17265	15370
pH of Intake Water	7 4	7 5	7 0	7 4	7 3	7 0	7 4	7 6	7 6	7 5
Suspended Solids Concentration of Intake Water (mg/l)	81	15	17	24	12	21	15	15	38	6
Alkalinity of Intake Water (mg/l as $CaCO_3$)	83	95	53	69	63	73	58	55	66	63
% SiO_2 in Fly Ash	47 6	NA	46 9	NA	53 7	52 5	58 7	50 4	NA	45 3
% CaO in Fly Ash	1 72	NA	4 66	NA	2 36	2,19	3 17	1 92	NA	4 91
% Fe_2O_3 in Fly Ash	11 3	NA	14 9	NA	9 6	10 2	10 7	11 6	NA	17 0
% Al_2O_3 in Fly Ash	22 7	NA	18 6	NA	26 4	25 5	23 9	25 2	NA	27 0
% H_3O in Fly Ash	0 93	NA	1 33	NA	1 12	1 42	1 24	1 29	NA	1 22
% SO_3 in Fly Ash	2 2	NA	1 5	NA	1 09	1 9	1 2	0 54	NA	1 16
% Moisture in Fly Ash	1 04	NA	0 32	NA	0 37	0 63	0 22	0 21	NA	0 87
pH of Fly Ash	2 9	NA	11 8	NA	4 5	3 6	4 6	4 0	NA	6 5
Ash Pond Effluent	7 1	8 4	11 1	11 1	9 5	8 7	11 0	7 5	10 8	10 1
Ash Pond Effluent Suspended Solids (mg/l)	30	19	<10	10	20	19	19	25	17	15

NOTE Intake water characteristics based on 1974 and 1975 weekly samples
Ash pond effluent characteristics based on 1970-1975 weekly samples
All plants use combined fly ash/bottom ash ponds

Table V-36

NUMBER OF ASH PONDS IN WHICH AVERAGE EFFLUENT CONCENTRATIONS OF SELECTED TRACE ELEMENTS EXCEED THOSE OF THE INTAKE WATER (22)

Element	No. Exceeding
Aluminum	10
Ammonia	9
Arsenic	15
Barium	7
Beryllium	1
Cadmium	7
Calcium	15
Chloride	8
Chromium	10
Copper	5
Cyanide	3
Iron	4
Lead	8
Magnesium	6
Manganese	5
Mercury	12
Nickel	10
Selenium	14
Silica	12
Silver	2
Sulfate	15
Zinc	7

NOTE. The total number of ash ponds is 15.

Table V-37

SUMMARY OF QUARTERLY TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant A Bottom Ash			Plant A Fly Ash			Plant B Bottom Ash			Plant B Fly Ash		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Aluminum	EFF	0 5	3 2	8 0	3 6	7 9	13	0 4	2 2	8 6	0 6	1 6	4 8
	RW	0 5	2 6	6 7	0 5	2 6	6 7	0 4	0 8	1 6	0 4	0 8	1 6
Ammonia as N	EFF	0 04	0 11	0 34	0 02	0 75	3 1	<0 01	0 07	0 31	<0 01	0 07	0 20
	RW	0 02	0 07	0 14	0 02	0 07	0 14	0 04	0 08	0 08	0 04	0 08	0 08
Arsenic	EFF	<0 005	0 007	0 015	0 005	0 011	0 035	<0 005	0 014	0 055	<0 005	0 029	0 070
	RW	<0 005	<0.005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005
Barium	EFF	<0 1	0 1	0 1	<0 1	0 2	0 4	<0 1	0 1	0 3	<0 1	0 1	0 2
	RW	<0 1	0 2	0 4	<0 1	0 2	0 4	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1
Beryllium	EFF	<0 01	<0 01	<0 01	<0 01	0 01	0 02	<0 01	<0.01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Cadmium	EFF	<0 001	0 001	0 002	0 023	0 038	0 052	<0 001	0 002	0 01	<0 001	0 001	0 002
	RW	<0 001	0 001	0 004	0 001	0 001	0 004	<0 001	0 004	0 01	<0 001	0 004	0 01
Calcium	EFF	23	38	67	88	126	180	17	50	200	27	152	430
	RW	21	35	48	21	35	48	17	19	20	17	19	20
Chloride	EFF	4	7	15	4	7	14	5	7	11	4	6	8
	RW	4	6	10	4	6	10	4	5	7	4	5	7
Chromium	EFF	<0 005	0 007	0 023	0 012	0 072	0.170	<0 005	0 009	0 026	<0 005	0 013	0 036
	RW	<0 005	0 010	0 024	0 005	0 010	0 024	<0 005	<0 005	<0 005	<0 005	<0 005	<0 005
Copper	EFF	0 01	0 07	0 14	0 16	0 33	0 45	<0 01	0 06	0 20	<0 01	0 03	0 10
	RW	0 04	0 09	0 19	0 04	0 09	0 19	<0 01	0 02	0 02	<0 01	0 02	0 02
Cyanide	EFF	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	-	-	-	-	-	-	-	-	-	-	-	-
Iron	EFF	1.7	5.2	11	0 33	2 3	8 6	0 26	4 7	30	0 14	1 4	7 1
	RW	1 1	2 7	6 7	1 1	2 7	6 7	0 32	0 57	0 90	0 32	0 57	0 90
Lead	EFF	<0 010	0 017	0 031	<0 010	0 066	0 200	<0 010	0 018	0 048	<0 01	0 015	0 030
	RW	<0 010	0 021	0 038	<0 010	0 021	0 038	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
Magnesium	EFF	0 3	6 0	9 3	9 4	14	20	4 1	6 2	21	0 2	3 6	6 8
	RW	4 1	6.1	8 0	4 1	6 1	8 0	3 6	4 3	4 7	3 6	4 3	4 7
Manganese	EFF	0 07	0 17	0 26	0 29	0 49	0 63	0 02	0 40	3 6	0 02	0 12	0 63
	RW	0 08	0 13	0 25	0 08	0 13	0 25	0 04	0 06	0 08	0 04	0 06	0 08
Mercury	EFF	<0 0002	0 0005	0 0026	<0 0002	0 0003	0 0006	<0 0002	0 0009	0 0042	<0 0002	0 0008	0 0056
	RW	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002	<0 0002
Nickel	EFF	<0 05	0 06	0 12	<0 05	0 08	0 13	<0 05	0 06	0 14	<0 05	0 05	0 03
	RW	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05	<0 05
Selenium	EFF	<0 001	0 002	0 004	<0 001	0 002	0 004	<0 001	0 007	0 056	0 001	0 015	0 064
	RW	<0 001	0 002	0 002	<0 001	<0 002	<0 002	<0 002	0 002	0 002	<0 002	<0 002	<0 002

Table V-37 (Continued)

SUMMARY OF QUARTERLY TRACE METAL DATA FOR ASH POND INTAKE AND EFFLUENT STREAMS (22)

		Plant A Bottom Ash			Plant A Fly Ash			Plant B Bottom Ash			Plant B Fly Ash		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Silica	EFF	5 6	7 4	9.3	9 3	13	20	3 7	6 4	22	3 1	7 1	22
	RW	1.7	5 6	8 0	1 7	5 6	8 0	3 2	5 4	7.2	3 2	5 4	7.2
Silver	EFF	<0.01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01
	RW	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	0 01	0 02	0 05	0 01	0 02	0 05
Dissolved Solids	EFF	140	185	260	470	593	700	110	229	710	40	458	1100
	RW	120	154	200	120	154	200	90	93	100	90	93	100
Suspended Solids	EFF	5	52	200	1	6	17	2	23	78	2	13	39
	RW	14	60	190	14	60	190	8	11	14	8	11	14
Sulfate	EFF	23	45	80	240	346	440	20	102	470	17	214	480
	RW	6	21	30	6	21	30	9	12	18	9	12	18
Zinc	EFF	0 02	0 08	0 16	0 82	1 4	2 7	0 02	0 13	0 55	0 01	0 05	0 13
	RW	0 06	0 09	0 14	0 06	0 09	0 14	0 01	0 02	0 04	0 01	0 02	0 04

NOTE Effluent data based on years 1973-1975
Raw water intake data based on years 1974 and 1975

KEY EFF - effluent
RW - raw water (intakes)

concentrations In both plants, iron was found in higher concentrations in the bottom ash than the fly ash Selenium, mercury, and cyanide were found in very low concentrations Arsenic was below 0.05 mg/l in all four ponds In both plants, the dissolved solids were higher in the fly ash ponds while the suspended solids were higher in the bottom ash ponds

Table V-38 provides plant operating information for Plants A and B. Plant A has a cyclone furnace that produces approximately 70 percent bottom ash and 30 percent fly ash, while Plant B has pulverized coal-fired boilers which produce 50 percent bottom ash and 50 percent fly ash

NUS Corporation Data. Table V-39 provides trace element information for separate fly ash and bottom ash ponds. These data were compiled by NUS Corporation (23). Nickel and manganese was evenly distributed between both types of ash ponds, zinc was slightly higher in the fly ash ponds, copper was slightly higher in the bottom ash ponds. The fly ash pond of southeastern Ohio was the only pond that demonstrated arsenic levels which exceeded 50 ppb

Sampling Program Results

Screening Phase The purpose of the screening phase of the sampling program was to identify the pollutants in the discharge streams The screening phase for the ash transport stream included the sampling of five ash pond overflows. Table V-40 presents the analytical results for sampling for the 129 priority pollutants

Verification Phase The verification phase involved the sampling of nine facilities for ash pond overflow to further quantify those effluent species identified in the screening program. The data reported as a result of this effort are summarized in table V-41. One of the plants (1226) was sampled by two laboratories and both sets of results are reported.

Arsenic Levels

Table V-42 presents data for plants in which arsenic concentrations in the ash pond discharge streams exceed the Interim Drinking Water Standard of 50 ppb The maximum arsenic level is 416 ppb Other data concerning arsenic levels in ash pond effluents are given in table V-43 Two plants exceed the 50 ppb level. Intake water concentrations for arsenic are provided in tables V-40, V-41, and V-43. The increases in arsenic concentrations, from the plant intake water to the ash pond overflow, range from no increase at all for a number of plants to a 300 ppb increase for plant 2603 in Table V-41 The range of arsenic levels in ash pond effluents is from less than 1 ppb to 416 ppb

Table V-38

SUMMARY OF PLANT OPERATING CONDITIONS AND ASH CHARACTERISTICS OF TVA COAL-FIRED POWER PLANTS

Parameters	Plant A	Plant B
Method of Firing	Cyclone	Circular Wall Burners
Coal Source	W. Kentucky	W. Kentucky
Ash Content in Coal, %	18.8	14.8
Fly Ash of Total Ash, %	30	50
Bottom Ash of Total Ash, %	70	50
Sulfur Content in Coal, %	4.1	-
Coal Usage at Full Load (tons/day)	22901	3314
Number of Units	3	4
ESP Efficiency, %	-	-
Mechanical Ash Collector Efficiency, %	98	-
Overall Efficiency, %	98	-
Sluice Water to Ash Ratio (gal/ton)	12380[f] 9810[b]	- -
pH of Intake Water	7.7	7.5
Suspended Solids Concentration of Intake Water (mg/l)	60	41
Alkalinity of Intake Water (mg/l as $CaCO_3$)	97	56
% SiO_2 in Fly Ash	NA	NA
% CaO in Fly Ash	NA	NA
% Fe_2O_3 in Fly Ash	NA	NA
% Al_2O_3 in Fly Ash	NA	NA
% MgO in Fly Ash	NA	NA

Table V-38 (Continued)

SUMMARY OF PLANT OPERATING CONDITIONS AND ASH CHARACTERISTICS OF TVA COAL-FIRED POWER PLANTS

Parameters	Plant A	Plant B
Ash Pond Effluent pH	4.4[f] 7.2[b]	9.8[f] 8.0[b]
Ash Pond Effluent Suspended Solids (mg/1)	25[f] 55[b]	85[f] 64[b]

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[f]Fly Ash Pond Only

[b]Bottom Ash Pond Only

NOTE. Intake water characteristics based on 1974 and 1975 weekly samples. Ash pond effluent characteristics based on 1970-1075 weekly samples.

Table V-39

ASH POND EFFLUENT TRACE ELEMENT CONCENTRATIONS* (23)

(ppb)

Station Location	Ash Pond Type	Arsenic	Copper	Nickel	Zinc	Manganese
Western W. Virginia	Bottom	<5	<1	11	10	130
Eastern Ohio	Bottom	7	10	30	90	300
Southern Ohio	Bottom	<5	60	30	40	180
Eastern Michigan	Bottom	30	<1	20	270	70
Southeast Michigan	Fly	40	<1	20	240	5
Southeast Ohio	Fly	200	6	30	50	4
Eastern Missouri	Bottom	20	3	20	50	240
Central Utah	Bottom	<5	6	1	5	5
Western W. Virginia	Fly	8	5	30	40	550
Southern Ohio	Fly	10	4	<1	80	10

*Minimum Quantifiable Concentrations/Arsenic (5 ppb), Copper (1 ppb), Nickel (1 ppb), Zinc (1 ppb), Manganese (1 ppb).

Table V-40

SCREENING DATA FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
4222 (Combined Fly Ash and Bottom Ash)	Methylene Chloride	12	27
	Trichlorofluoromethane	ND<1/1	6/ND<1
	Phenol	2/<100	1/260
	Bis(2-Ethylhexyl) Phthalate	2	1
	Butyl Benzyl Phthalate	1	1
	Toluene	3/2	3/4
	Methylene Chloride	8	18
	Antimony, Total	<5	29
	Arsenic, Total	<5	160
	Beryllium, Total	<5	20
	Chromium, Total	<5	11
	Copper, Total	16	6
	Mercury, Total	0.26	0.21
	Nickel, Total	6	8
	Selenium, Total	<5	32
	Zinc, Total	14	10
2414 (Combined Fly Ash and Bottom Ash)	Benzene	6/13	3/2
	Chloroform	2	ND < 1
	Methylene Chloride	4/1	ND<1/2
	Phenol	45/<100	ND<1/31
	Bis(2-Ethylhexyl) Phthalate	12	40
	Diethyl Phthalate	3	ND < 1
	Toluene	21/1	11/70
	Cis 1,2-Dichloroethylene	ND<1/15	30/ND<1
	1,1,1-Trichloroethane	ND < 1	1
	1,4-Dichlorobenzene	ND < 1	1
	Ethylbenzene	1	2
	Arsenic, Total	5	50
	Asbestos (fibers/liter)	28,400	0
	Chromium, Total	<5	14
	Copper, Total	21	66
	Cyanide, Total	<20	80
	Lead, Total	7	8
	Mercury, Total	0.88	0.63
	Nickel, Total	8	144
	Selenium, Total	15	22
	Silver, Total	45	52
	Thallium, Total	6	8
	Zinc, Total	<5	41

Table V-40 (Continued)

SCREENING DATA FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
3805 (Combined Fly Ash and Bottom Ash)	Benzene	1/6	ND<1/2
	1,1,1-Trichloroethane	2	ND < 1
	Chloroform	1/3	2/4
	1,1-Dichloroethylene	ND<1/1	1/ND<1
	Ethylbenzene	20	ND < 1
	Methylene Chloride	22/10	8/15
	Trichlorofluoromethane	40	1
	Phenol	2	3
	Bis(2-Ethylhexyl) Phthalate	ND < 1	6
	Tetrachloroethylene	1	ND < 1
	Toluene	42/14	4/6
	Trichloroethylene	2	ND < 1
	Cis 1,2-Dichloroethylene	3	ND < 1
	Chromium, Total	39	<5
	Copper, Total	6	5
	Lead, Total	19	<5
	Mercury, Total	0.23	0.32
	Selenium, Total	11	<5
	Silver, Total	12	<5
	Zinc, Total	5	5
3404 (Bottom Ash)	Benzene	1	1
	Chloroform	3/1	ND<1/1
	1,1-Dichloroethylene	1/1	1/ND<1
	Methylene Chloride	20/1	4/ND<1
	Phenol	ND<1/36	1/20
	Bis(2-Ethylhexyl) Phthalate	11	9
	Di-N-Butyl Phthalate	4	1
	Toluene	3/3	3/2
	Antimony, Total	11	12
	Arsenic, Total	<5	14
	Cadmium, Total	15	13
	Chromium, Total	16	20
	Copper, Total	25	29
	Lead, Total	5	5
	Mercury, Total	0.34	0.32
	Nickel, Total	21	33
	Selenium, Total	55	42
	Silver, Total	40	19
	Zinc, Total	<5	8

Table V-40 (Continued)

SCREENING DATA FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
2512 (Fly Ash)	Benzene	ND<1/1	1/ND<1
	1,1,1-Trichloroethane	ND<1/ND<1	2/3
	Chloroform	2/3	1/ND<1
	1,1-Dichloroethylene	1/2	ND<1/2
	Ethylbenzene	ND<1/1	1/ND<1
	Methylene Chloride	23/12	35/5
	Bis(2-Ethylhexyl) Phthalate	1	27
	Di-N-Butyl Phthalate	ND < 1	1
	Toluene	2/7	4/3
	1,4-Dichlorobenzene	7	ND < 1
	Antimony, Total	<5	5
	Arsenic, Total	6	7
	Copper, Total	22	14
	Lead, Total	<5	12
	Mercury, Total	0.21	0.22
	Nickel, Total	7	1,500
	Selenium, Total	35	32
	Zinc, Total	<5	17

Table V-41

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
1742 (Combined Fly Ash and Bottom Ash Pond)	Cadmium, Total (Dissolved)	40(5)	10(9)
	Chromium, Total (Dissolved)	24/20*(ND/30)*	23/2000*(ND/30)*
	Copper, Total (Dissolved)	21/20*(ND/9)*	106/50*(54/7)*
	Lead, Total (Dissolved)	9/ND<20*(ND/90)*	9/ND<20*(3/100)*
	Mercury, Total (Dissolved)	ND < 0.5	1.5(1)
	Nickel, Total (Dissolved)	17/ND<5*(ND/40)*	39/900*(1/40)
	Zinc, Total (Dissolved)	ND/70*(30/ND<60)*	ND/ND<60*(20/ND<60)*
	Total Dissolved Solids	340,000	370,000
	Total Suspended Solids	100,000	15,000
	Total Organic Carbon	10,000	150,000
	Aluminum, Total	2,000	ND < 50
	Barium, Total (Dissolved)	60(30)	50(50)
	Boron, Total (Dissolved)	90(200)	200(400)
	Calcium, Total (Dissolved)	51,000(44,000)	51,000(53,000)
	Cobalt, Total (Dissolved)	10(7)	50(10)
	Manganese, Total (Dissolved)	200(10)	300(ND<5)
	Magnesium, Total (Dissolved)	23,000(22,000)	20,000(22,000)
	Molybdenum, Total (Dissolved)	9(40)	50(50)
	Phenolics, 4AAP	6	12
	Sodium, Total (Dissolved)	21,000(20,000)	26,000(25,000)
	Tin, Total (Dissolved)	30(60)	30(60)
	Titanium, Total	40	ND < 20
	Iron, Total	4,000	8,000
	Vanadium, Total (Dissolved)	ND/ND<10*(ND/20)	ND/20*(ND/30)*
	Silver (Dissolved)	(ND/10)*	(ND/10)*

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Concentration (ppb) Discharge
1741 (Bottom Ash)	Cadmium, Total (Dissolved)	ND < 2(3)	10(8)
	Chromium, Total (Dissolved)	ND/4,000*(ND/20)*	9/ND<5*(ND/20)*
	Copper, Total (Dissolved)	ND/90*(ND/9)*	35/10*(13/7)*
	Lead, Total (Dissolved)	ND/20*(ND/100)*	14/ND<20*(ND<4/100)*
	Mercury, Total	ND	1
	Nickel, Total (Dissolved)	ND/2000*(ND/20)*	15/ND<5*(ND/50)*
	Zinc, Total (Dissolved)	ND/ND<60*(20/ND<60)*	ND/70*(ND/100)*
	Total Dissolved Solids	130,000	4,000
	Total Suspended Solids	10,000	160,000
	Total Organic Carbon	5,000	17,000
	Aluminum, Total	200	ND < 50
	Barium, Total (Dissolved)	30(30)	60(60)
	Boron, Total (Dissolved)	70(ND<50)	80(100)
	Calcium, Total (Dissolved)	10,000(13,000)	21,000(24,000)
	Cobalt, Total (Dissolved)	40(6)	ND < 5 (8)
	Manganese, Total (Dissolved)	800(ND<5)	100(700)
	Magnesium, Total (Dissolved)	9,800(5,100)	5,600(5,800)
	Molybdenum, Total (Dissolved)	60(30)	8(30)
	Phenolics, 4AAP	ND	11
	Sodium, Total (Dissolved)	D<15,000(D<15,000)	D<15,000(D<15,000)
	Tin, Total (Dissolved)	ND < 5(30)	20(20)
	Titanium, Total	30	ND < 30
	Iron, Total	20,000	200
	Vanadium, Total (Dissolved)	ND/10(ND<10/ND)*	ND/ND<10(ND/10)
	Beryllium, Dissolved	(3)	(2)
	Silver, (Dissolved)	(ND/6)*	(ND/9)*

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake†	Concentration (ppb) Discharge
1741 (Fly Ash)	Cadmium, Total (Dissolved)		90(70)
	Chromium, Total (Dissolved)		12/6*(ND/20)*
	Copper, Total (Dissolved)		15/9*(4/7)*
	Lead, Total (Dissolved)		120/ND<20*(6/80)*
	Nickel, Total (Dissolved)		100/50*(58/90)*
	Zinc, Total (Disslved)		1400/1000*(ND/1000)*
	Total Dissolved Solids		790,000
	Total Suspended Solids		6,000
	Total Organic Carbon		18,000
	Barium, Total (Dissolved)		100(100)
	Boron, Total (Dissolved)		3,000(5,000)
	Calcium, Total (Dissolved)		140,000(160,000)
	Cobalt, Total (Dissolved)		10(20)
	Manganese, Total (Dissolved)		1,000(1000)
	Magnesium, Total (Dissolved)		9,500(10,000)
	Molybdenum, Total (Dissolved)		200(300)
	Phenolics, 4AAP		9
	Sodium, Total (Dissolved)		D<15,000(D<15,000)
	Tin, Total (Dissolved)		30(20)
	Titanium, Total		20
	Iron, Total		900
	Beryllium, (Dissolved)		2
	Silver (Dissolved)		(ND/10)*
	Vanadium (Dissolved)		(ND/20)*
	Yttrium (Dissolved)		(40)

†Same intake as for Plant 1741, Bottom Ash Pond.
*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Concentration (ppb) Discharge
1226 (Combined Fly Ash and Bottom Ash Pond)	Antimony, Total	ND/7*	ND/7*
	Arsenic, Total	ND/3*	ND/9*
	Cadmium, Total	2.1/ND<2*	2/ND<2*
	Chromium, Total	ND/7/7*	ND/6/10*
	Copper, Total (Dissolved)	10/12/10*(10)	18/14/10*(13/9)*
	Lead, Total (Dissolved)	12/10/ND<20*(7/ND<20)*	9/4*(4/ND<20)*
	Mercury, Total	ND<1/0.5*	ND<0.5/ND<0.2*
	Nickel, Total (Dissolved)	27/1.5/ND<5*(29/ND<5)*	ND/5.5/5*(ND/ND<5)*
	Selenium, Total	ND/ND<2*	ND/8*
	Silver, Total	ND/1.5/ND<1*	ND/0.5/ND<1*
	Zinc, Total (Dissolved)	ND/9/70*(50/ND<60)*	ND/7/ND<60*(ND/ND<60)*
	Total Dissolved Solids	190,000	2,350,000
	Total Suspended Solids	14,000	12,000
	Aluminum, Total (Dissolved)	700(100)	300(500)
	Barium, Total (Dissolved)	20(20)	60(60)
	Boron, Total (Dissolved)	ND < 50(70)	400(900)
	Calcium, Total (Dissolved)	6,900(D<5,000)	34,000(32,000)
	Cobalt, Total	7	ND < 5
	Manganese, Total (Dissolved)	200(200)	30(6)
	Magnesium, Total (Dissolved)	4,500(5,000)	7,300(7,500)
	Molybdenum, Total (Dissolved)	ND < 5(ND<5)	100(100)
	Phenolics, 4AAP	12	17
	Sodium, Total (Dissolved)	33,000(36,000)	66,000(72,000)
	Titanium, Total	20	ND < 20
	Iron, Total (Dissolved)	2,000(1,000)	600(ND<200)
	Vanadium, Total (Dissolved)	ND/40/ND<10*(ND/ND<10)*	ND/78/50*(ND/40)*

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
5409	Benzene	2.4	2
(Fly Ash)	Carbon Tetrachloride	D < 1	-----
	Chloroform	1.4	-----
	1,2-Dichlorobenzene	5.3	-----
	Ethylbenzene	-----	D < 1
	Toluene	2	3.5
	Trichloroethylene	D < 4	-----
	Antimony, Total	3	6
	Beryllium, Total	ND < 0.5	2.5
	Cadmium, Total	1.4	1.0
	Chromium, Total	ND < 2	4
	Copper, Total	27	80
	Cyanide, Totl	15,000	22
	Lead, Total	8	ND < 3
	Nickel, Total	1.7	9.5
	Selenium, Total	2.0	3.0
	Silver, Total	1.6	5.5
	Thallium, Total	1	ND < 1
	Zinc, Total	15	300
	Total Suspended Solids	5	15,000
	Total Organic Carbon	D < 20,000	7,600
	Chloride	-----	37,000
	Vanadium, Total	13	27
	1,3 and 1,4-Dichlorobenzene	2.4	2.4

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Concentration (ppb) Discharge
2603	Benzene	D < 10	D < 10
(Combined	Chloroform	D < 10	D < 10
Fly Ash	1,1-Dichloroethylene	ND	D < 10
and Bot-	Ethylbenzene	ND	D < 10
tom Ash	Methylene Chloride	D < 10	10
Pond)	Phenol (GC/MS)	ND/9*	ND/4*
	Bis(2-Ethylhexyl)Phthalate	D < 10	D < 10
	Butyl Benzyl Phthalate	D < 10	ND
	Di-N-Butyl Phthalate	D < 10	D < 10
	Diethyl Phthalate	50	10
	Dimethyl Phthalate	ND	D < 10
	Tetrachloroethylene	D < 10	ND
	Antimony, Total	ND < 2	10
	Arsenic, Total	ND < 20	300
	Cadmium, Total	ND < 2	3
	Chromium, Total	10	12
	Copper, Total	22	10
	Mercury, Total	0.2	-----
	Nickel, Total	8	10
	Selenium, Total	ND < 2	13
	Silver, Total	ND < 1	4
	Zinc, Total	88	ND < 60
	Total Dissolved Solids	292,000	455,000
	Total Suspended Solids	-----	D < 5000
	Oil and Grease	-----	1,000
	Total Organic Carbon	9,000	6,000
	Aluminum, Total	497	131

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
2603 (Cont'd)	Barium, Total	17	92
	Boron, Total	ND < 50	209
	Calcium, Total	48,700	62,100
	Manganese, Total	65	10
	Magnesium, Total	15,300	15,500
	Molybdenum, Total	ND < 5	143
	Sodium, Total	23,600	32,000
	Tin, Total	36	36
	Titanium, Total	18	ND < 15
	Iron, Total	842	170
	Vanadium, Total	-----	22
5604 (Combined Fly Ash)	Benzene	1.2	2.0
	Ethylbenzene	-----	D < 1
	Toluene	9.1	3.5
	Antimony, Total	4	6
	Beryllium, Total	ND < 0.5	2.5
	Cadmium, Total	ND < 0.5	1.0
	Chromium, Total	ND < 2	4
	Copper, Total	700	80
	Cyanide, Total	4	22
	Lead, Total	6	ND < 3
	Mercury, Total	ND < 0.2	0.2
	Nickel, Total	ND < 0.5	9.5
	Silver, Total	ND < 3	5.5
	Zinc, Total	53	300
	Total Suspended Solids	-----	15,000
	Total Organic Carbon	5,500	7,600
	Chloride	14,000	37,000
	Vanadium, Total	11	27

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb)	
		Intake	Discharge
3920	Beryllium, Total (Dissolved)	ND (ND)	2(2)
(Fly Ash)	Chromium, Total (Dissolved)	20/2*(10/ND<5)*	50/9*(41/8)*
	Copper, Total (Dissolved)	ND<6/8(4/ND<6)*	ND/30*(ND/40)*
	Lead, Total (Dissolved)	20/ND<20*(18/40)*	8/ND<20*(14/30)*
	Nickel, Total (Dissolved)	25/ND<3*(14/ND<5)*	16/20*(ND<9/40)*
	Zinc, Total (Dissolved)	ND/ND<60*(ND/ND<60)*	180/100*(ND/200)*
	Total Dissolved Solids	220,000	880,000
	Total Suspended Solids	12,000	73,000
	Total Organic Carbon	5,000	3,000
	Aluminum, Total (Dissolved)	ND<50(ND<50)	5,000(6,000)
	Barium, Total (Dissolved)	30(30)	60(ND<5)
	Boron, Total (Dissolved)	80(90)	1,000(5,000)
	Calcium, Total (Dissolved)	28,000(27,000)	120,000(120,000)
	Cobalt, Total (Dissolved)	ND<5(ND<5)	7(7)
	Manganese, Total (Dissolved)	50(50)	300(500)
	Magnesium, Total (Dissolved)	7,200(7,400)	6,700(9,700)
	Molybdenum, Total (Dissolved)	ND<5(6)	10(8)
	Phenolics, 4AAP	40	40
	Sodium, Total (Dissolved)	18,000(17,000)	35,000(47,000)
	Iron, Total	500	2,000
	Cadmium (Dissolved)	(ND<3)	(10)
	Silver (Dissolved0	(ND/ND)*	(ND/5)*
	Tin (Dissolved)	(20)	(20)

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
3924 (Fly Ash)	Chromium, Total (Dissolved)	7/ND<5*(ND/ND<5)*	27/70*(49/ND<5)*
	Copper, Total (Dissolved)	18/10*(16/9)*	32/ND<6*(42/ND<6)*
	Lead, Total (Dissolved)	10/ND<20*(5/ND<20)*	23/ND<20*(1/ND<20)*
	Nickel, Total (Dissolved)	18/ND<5*(ND/ND<5)*	23/40*(10/6)*
	Zinc, Total (Dissolved)	20/ND<60*(20/ND<60)*	20/ND<60*(ND/ND<60)*
	Total Dissolved Solids	480,000	670,000
	Total Suspended Solids	15,000	16,000
	Total Organic Carbon	21,000	16,000
	Barium, Total (Dissolved)	40(40)	200(200)
	Boron, Total (Dissolved)	100(100)	1,000(4,000)
	Calcium, Total (Dissolved)	57,000(55,000)	110,000(110,000)
	Manganese, Total (Dissolved)	100(50)	80(70)
	Magnesium, Total (Dissolved)	13,000(14,000)	14,000(14,000)
	Molybdenum, Total (Dissolved)	ND<5(ND<5)	300(300)
	Phenolics, 4AAP	38	35
	Sodium, Total (Dissolved)	43,000(44,000)	38,000(39,000)
	Iron, Total	500	300
	Aluminum (Dissolved)	ND < 50	60
	Tin (Dissolved)	(20)	(ND<5)
3001 (Combined Fly Ash and Bottom Ash Pond)	Chromium, Total (Dissolved)	ND/10*(ND/10)*	190/ND*(93/40)*
	Copper, Total (Dissolved)	ND/10*(22/ND<6)	ND/ND<6*(20/ND<6)*
	Lead, Total (Dissolved)	ND/ND<20*(ND/ND<20)*	3/ND<20*(4/ND<20)*
	Nickel, Total (Dissolved)	ND/6*(ND/ND<5)*	35/ND<5*(33/ND<5)*
	Total Dissolved Solids	532,000	490,000
	Total Suspended Solids	170,000	30,000
	Oil and Grease	25,000	24,000
	Aluminum, Total (Dissolved)	500(ND<50)	2,000(200)

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Concentration (ppb) Discharge
3001 (Cont'd)	Barium Total (Dissolved)	40(60)	200(80)
	Boron, Total (Dissolved)	60(200)	2,000(2,000)
	Calcium, Total (Dissolved)	38,000(48,000)	64,000(38,000)
	Manganese, Total	40	ND < 5
	Cadmium (Dissolved)	ND < 2	8
	Magnesium, Total (Dissolved)	23,000(27,000)	11,000(11,000)
	Molybdenum, Total (Dissolved)	ND < 5(ND<5)	30(20)
	Phenolics, 4AAP	-----	14
	Sodium, Total (Dissolved)	57,000(66,000)	70,000(69,000)
	Tin, Total (Dissolved)	ND < 5(20)	7(20)
	Iron, Total	200	ND < 200
	Vanadium, Total	ND/ND<10*	ND/20*
	1,1,2,2-Tetrachloroethane	24	-----
	Zinc (Dissolved)	(ND/ND<60)*	(20/ND<60)*
5410 (Combined Fly Ash and Bottom Ash Pond)	Cadmium, Total (Dissolved)	9(6)	4(ND<2)
	Chromium, Total (Dissolved)	7/70*(9/7)*	16/100*(ND/ND<5)*
	Copper, Total (Dissolved)	15/6*(9/ND<6)*	29/20*(61/10)*
	Lead, Total (Dissolved)	17/ND<20*(9/ND<20)*	ND/40(ND/ND<20)*
	Nickel, Total (Dissolved)	22/30*(9/6)*	66/100*(43/30)*
	Silver, Total (Dissolved)	ND/ND<1*(ND/2)*	ND/6*(ND/2)*
	Zinc, Total	20/ND<60*(ND/ND<60)*	40/ND<60*(30/ND<60)*
	Total Dissolved Solids	200,000	300,000
	Total Suspended Solids	9,000	20,000
	Total Organic Carbon	9,000	8,000
	Aluminum, Total	ND < 50	800
	Barium, Total (Dissolved)	30(30)	40(30)
	Boron, Total (Dissolved)	60(70)	100(300)

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-41 (Continued)

SUMMARY OF DATA FROM THE VERIFICATION PROGRAM AND EPA SURVEILLANCE AND ANALYSIS REPORTS FOR ASH POND OVERFLOW

Plant Code	Pollutant	Concentration (ppb) Intake	Discharge
5410 (Cont'd)	Calcium, Total (Dissolved)	27,000(27,000)	40,000(38,000)
	Cobalt, Total	ND < 5	20
	Manganese, Total (Dissolved)	40(ND<5)	100(200)
	Magnesium, Total (Dissolved)	7,700(7,300)	9,100(8,200)
	Molybdenum, Total	ND < 5	8
	Phenolics, 4AAP	9	6
	Sodium, Total (Dissolved)	18,000(17,000)	22,000(24,000)
	Tin, Total (Dissolved)	10(ND<5)	10(6)
	Titanium, Total	ND < 20	50
	Iron, Total	400	2,000
	Vanadium, Total	ND/ND<10*	ND/10*
	Yttrium, Total	ND < 20	20
	Arsenic (Dissolved)	ND	14
4203 (Combined Fly Ash and Bottom Ash Pond)	1,1,1-Trichloroethane	0.68	-----
	Chloroform	0.17	0.25
	Methylene Chloride	-----	32
	Pentachlorophenol	3.8	6.5
	Tetrachloroethylene	0.4	-----
	Trichloroethylene	0.57	-----
	4,4'-DDD (P.P'-TDE)	D < 0.1	-----
	Arsenic, Total	2	-----
	Cadmium, Total	4	ND < 2
	Chromium, Total	3	13
	Copper, Total	8	8
	Lead, Total	1.7	1.2
	Nickel, Total	18	24
	Selenium, Total	3	ND < 1
	Silver, Total	ND < 2	2
	Zinc, Total	32	15
	Iron, Total	1,100	1,200

*These multiple results represent analyses by multiple analytical labs.
()Values in parentheses indicate dissolved fractions.

Table V-42

CONDITIONS UNDER WHICH ARSENIC IN ASH POND OVERFLOW EXCEEDS 0.05 mg/l (19)

(mg/l)

Plant Code	Plant Capacity	Fuel*	pH	TSS	As	Cu	Cr	Cd	Ni	Fe	Pb	Hg	Zn	Se	Oil and Grease	No of Samples
3711	781	c/o	6 48	24 5	0 06	0 1	0 05	0 02	0 1	0 36	0 1	0 002	0 14	0 007	0 23	18
3708	466	c/o	8 48	14 7	0 14	0 1	0 05	0 02	0 1	0 14	0 1	0 003	0 01	0 005	0 16	6
0512	1341	c	8 29	16 5	0 19	0 01	0 01	-	0 01	0 63	0 14	0 001	0 04	0 011	4 0	7
3710	290	c/o	9 07	127	0 416	0 12	0 05	0 02	0 1	0 3	0 1	0 0023	0 11	0 05	0 13	3
4218	1163	c/o	6 63	36 8	0 131	0 075	0 002	-	0 038	0 74	0 002	0 0005	0 087	-	0 9	1
3701	421	c/o	-	18 0	0 09	0 05	0 05	0 01	0 05	0 47	0 05	0 001	0 05	0 10	1 0	3
2103	694	c	8 4	20	0 21	0 15	0 005	-	0 005	0 52	0 007	0 0001	0 02	0 01	0 79	3
3805	660	c	-	15	0 06	0 11	0 02	0 002	-	-	0 01	0 0001	0 04	-	-	1

*c - coal
o - oil

Table V-43

ARSENIC CONCENTRATIONS IN ASH POND EFFLUENTS (23, 24)

Station Location	Size (MW)	Ash Pond Type	Effluent Concentrations (ppb)[a]	Plant Water Intake Conc. (ppb)	Data Sources
Western W. Virginia	NA	Bottom	<5	NA	23
Eastern Ohio	NA	Bottom	7	NA	23
Southern Ohio	NA	Bottom	<5	NA	23
Eastern Michigan	NA	Bottom	30	NA	23
Southeast Michigan	NA	Fly	40	NA	23
Southeast Ohio	NA	Fly	200	NA	23
Eastern Missouri	NA	Bottom	20	NA	23
Central Utah	NA	Bottom	<5	NA	23
Western W. Virginia	NA	Fly	8	NA	23
Southern Ohio	NA	Fly	10	NA	23
Wyoming	750	Combined	<1	<1	24
Florida	948	Combined	9	3	24
Upper Appalachia	2900	Combined	74	<1	24

[a]Detection limit for NUS is 5 ppb/for Radian, 1 ppb.

NA - Not Available

the site, the ash should be wetted down after application to the landfill.

Bottom Ash

The technologies applicable to bottom ash handling systems are:

- o dry bottom ash handling,
- o Hydrobin/dewatering bin systems, and
- o ponding with recycle.

Dry Systems

Dry handling of bottom ash is generally typical of stoker-fired boilers. This method is used by 19 percent of those plants which reported a bottom ash system type in the 308 survey (including all types of plants). Stoker-fired boilers are generally used in relatively small capacity installations where small amounts of bottom ash are handled. Since this technology represents a small and more obsolete sector of the industry, it is not addressed in further detail in this section.

Complete Recycle Systems

The term "complete recycle" describes a system which returns all of the ash sluice water to the ash collecting hoppers for recurrent use in sluicing. The key concept of complete recycle is that there is no continuous discharge of sluice water from the system. Virtually no system is zero discharge from the standpoint of containing all ash handling water onsite because ash-laden water does leave the facility in a variety of ways. Water is occluded with the ash when trucked away to disposal. Under upset conditions, it is often necessary to discharge water. In some cases, small amounts of water from the ash handling system are needed elsewhere in the plant, typically for wetting fly ash handling trucks to prevent blowing of dry fly ash and for servicing the silo unloaders. Makeup water is required to maintain a steady water balance despite these inherent losses in the system. The magnitude of the makeup water requirement depends upon the major equipment in the ash handling system.

Technology Descriptions.

Dewatering/Hydrobin System (36). The various stages of a closed-loop recirculating system appear in figure VII-40. For the sake of clarity, some details have been omitted. Initially, as illustrated in figure VII-40a, the ash hopper is filled to its overflow line, and one dewatering bin (bin A) is partially

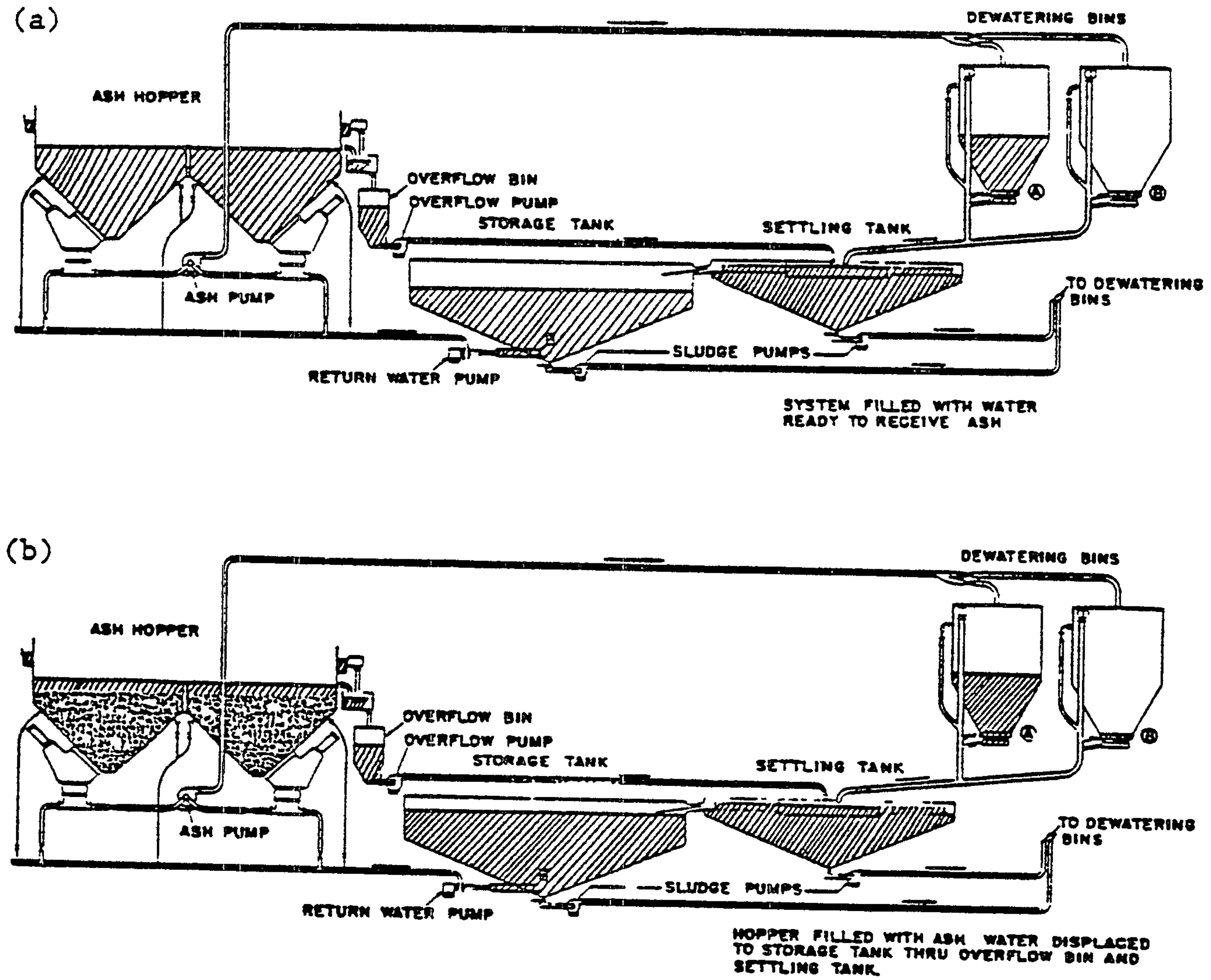
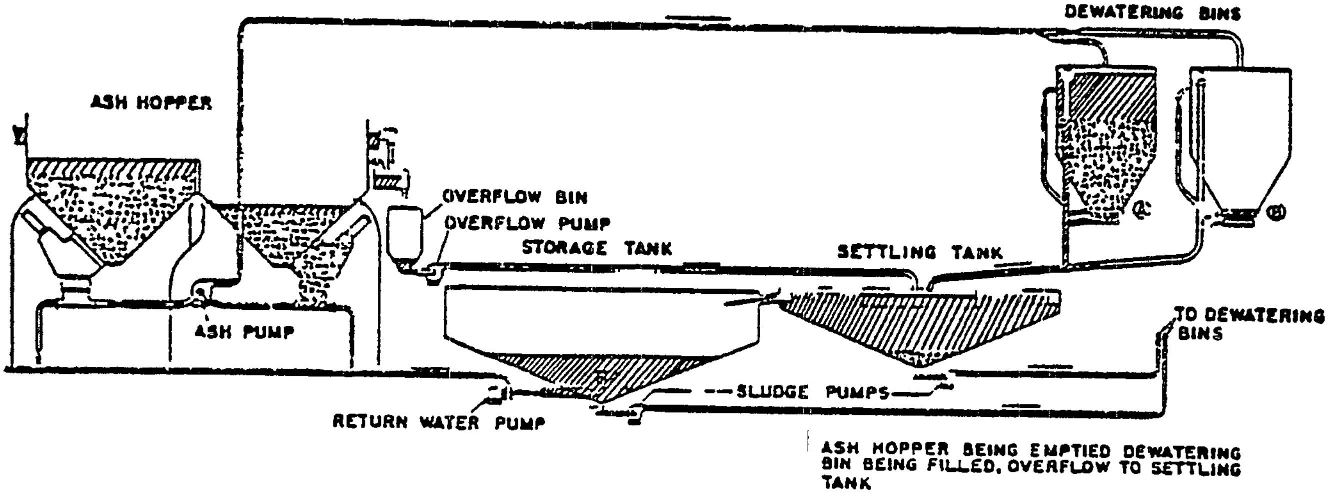


Figure VII-40
VARIOUS STAGES OF A CLOSED-LOOP RECIRCULATING SYSTEM (36)

(c)



(d)

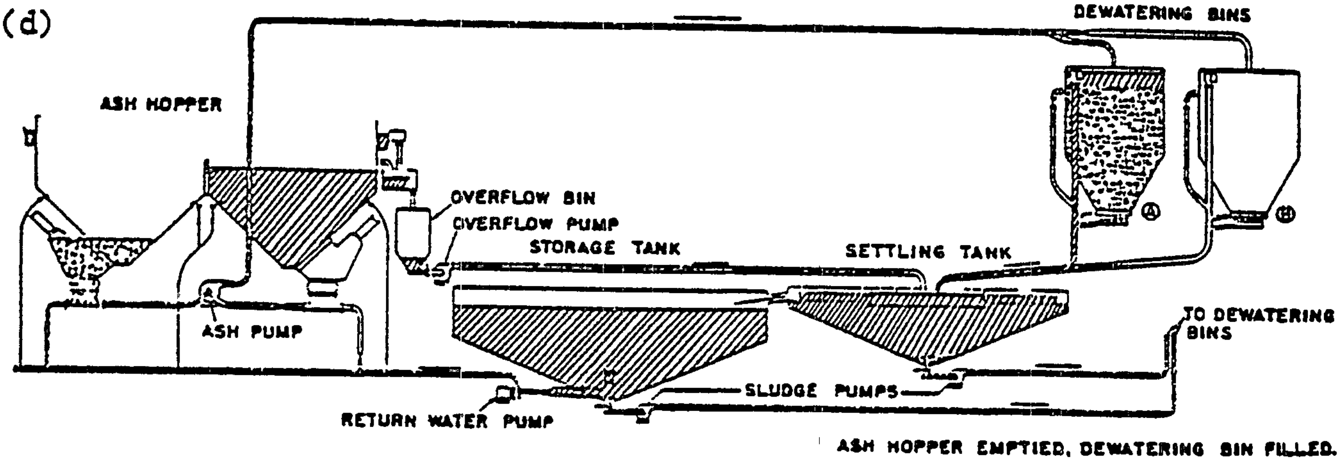
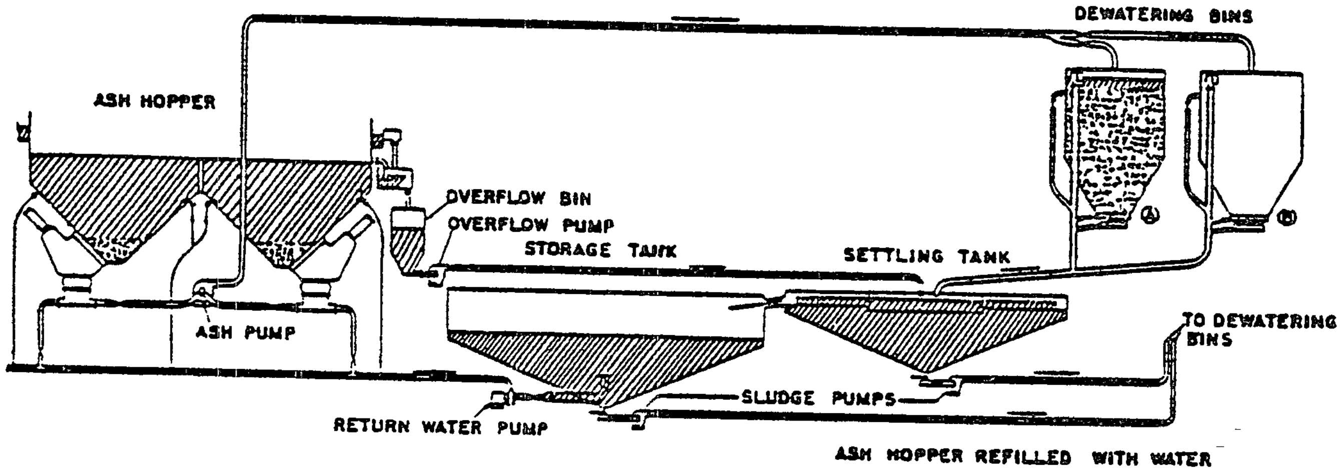


Figure VII-40 (Continued)
VARIOUS STAGES OF A CLOSED-LOOP RECIRCULATING SYSTEM (36)

(e)



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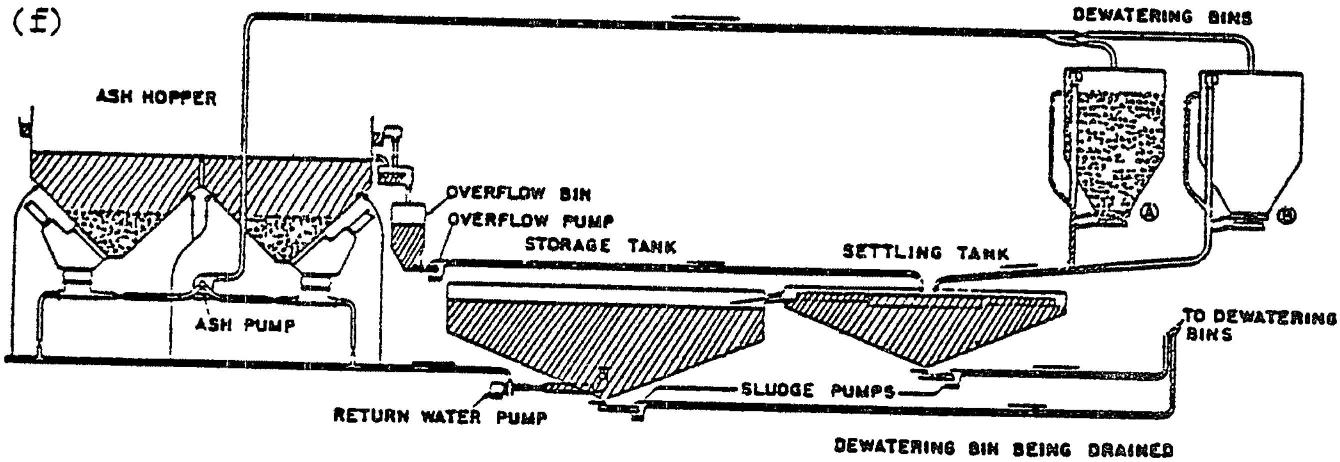


Figure VII-40 (Continued)
VARIOUS STAGES OF A CLOSED-LOOP RECIRCULATING SYSTEM (36)

(g)

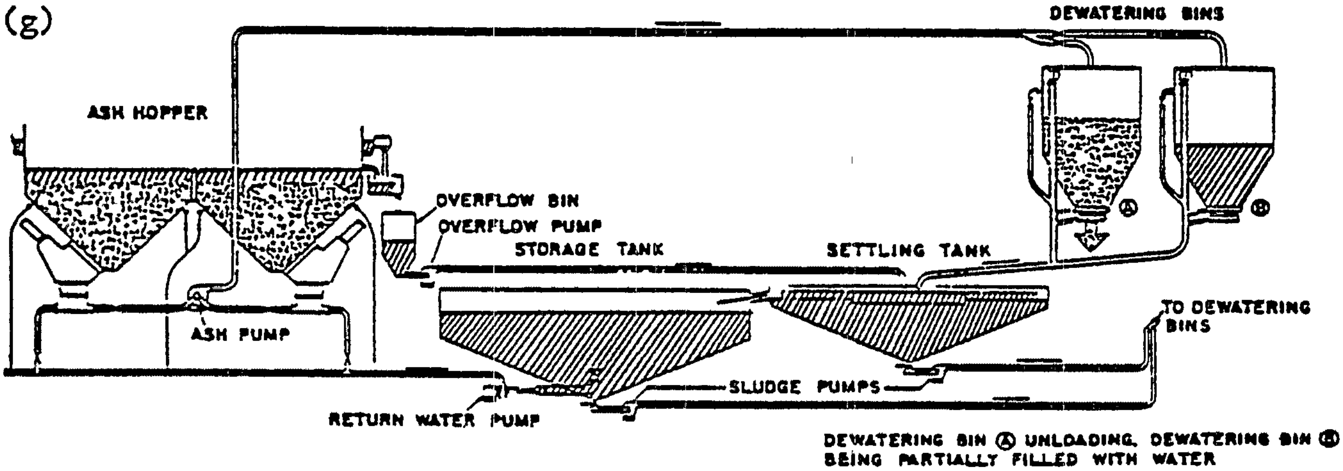


Figure VII-40 (Continued)
VARIOUS STAGES OF A CLOSED-LOOP RECIRCULATING SYSTEM (36)

filled with water. Enough water remains in the storage tank to start operating the system after the ash hopper is filled with ashes. In the next stage, illustrated in figure VII-40b, the ash hopper has been filled with ashes, and the water displaced by them has been pumped into the settling tank and overflowed into the storage tank. In the next step, shown in figure VII-40c, ash hopper cleaning is in progress in the right hand chamber. Ashes are pumped to the Dewatering Bin A. As ash-water slurry enters the dewatering bin, an equal amount of water overflows to the settling tank and then to the storage tank. In figure VII-40d, the ash hopper has been completely emptied. All of the water that had been in the ash hopper is now in the storage tank. The water in the storage tank is used to refill the ash hopper as shown in figure VII-40f. The water in the ash hopper is then available for filling Dewatering Bin B as shown in figure VII-40g. The water volume in the settling tank remains constant while the volume in all other vessels varies during different phases of operation.

Outside makeup water is necessary to restore the water lost with the bottom ash discharged from the dewatering bins as well as water lost through evaporation from the bottom ash hopper. Makeup usually is added at the storage tank. An emergency bypass can be installed between the settling tank and the storage tank to provide needed water in the event of temporary failure outside makeup.

In most cases, a closed-loop recirculating system shows a marked change in the pH of the recirculated water. This ph shift is tempered by the addition of makeup water if it is added in sufficient quantity and is of good quality. A monitoring system and chemical additives can maintain recirculated water at as neutral a level as possible in order to keep pipe scaling or corrosion to a minimum.

Cases where pH adjustment is not sufficient for scale prevention, such as very reactive bottom ash or poor intake water quality, may require side stream lime/soda ash treatment. The equipment for slip stream softening has been described in the section concerning physical/chemical treatment of ash pond overflows from wet once-through fly ash handling systems. The magnitude of the flow rate of the slip stream is estimated to be about 10 percent of the total sluice stream. The use of slip stream softening in a dewatering bin system would create an additional solid waste stream as well as an additional water loss source which would require more makeup water. Slip stream softening in a dewatering/hydrobin system is not a proven technology based on data from the 308 survey.

Bottom ash obtained from dewatering bins is considered "commercially dry" by vendors of this equipment (36, 39), i.e., on the order of 20 percent moisture. This degree of moisture can vary widely depending on the installation as well as within a particular plant. The ash is wet enough for transport to a landfill site in an open truck without creating a fugitive dust problem, and at the landfill site, there is no need to wet the ash down. Some dust problems may occur with certain western coal ashes since these tend to contain relatively more fines than eastern coal ashes (39).

A dewatering/hydrobin system which contains a slip stream softening system produces a sludge waste stream which requires disposal. This waste is produced at a much lower rate than is the bottom ash and has a higher moisture content.

Ponding System. Approximately 81 percent of all plants which replied in the 308 survey designated ponding as their bottom ash handling method. Of these, approximately 9 percent designated either complete or partial recycle.

A ponding recycle system for bottom ash is illustrated in figure VII-41. The ash or slag collected in the bottom ash hopper which is filled with water is ground down to a sluiceable size range by clinker grinders at the bottom of the hopper. Depending on the size of the boiler, the bottom ash hopper may have two or three "pantlegs," or discharge points. At each pantleg there may be one or two clinker grinders. Larger facilities usually have three pantlegs and two clinker grinders at each pantleg (39). Smaller facilities have two pantlegs and one clinker grinder at each leg. Double roll clinker grinders can generally handle from 75 to 150 tons per hour of ash with drives from 5 hp to 25 hp depending on the material to be crushed and required system capacity. A smaller grinder that can handle 20 tons per hour or less uses a single roll with a stationary breaker plate.

After being crushed, the ash is fed into an adopter or sump from which it is pumped by one of two types of pumping devices, a centrifugal pump or a jet pump. Pumps and piping have already been discussed in the subsection on partial recirculating fly ash systems.

A series of ponds are usually used for bottom ash settling. A primary pond accumulates most of the sluiced bottom ash. The sluice water then flows by gravity to a secondary settling pond. Overflow from the secondary pond goes to a final or clear pond which is used as a holding basin for the recirculating water. Pond sizes cover a wide range depending on the plant size, the amount of bottom ash produced (boiler type), pond depth, required holding time (which is a function of the solids settling rate), and the amount of land available. Typically the primary and

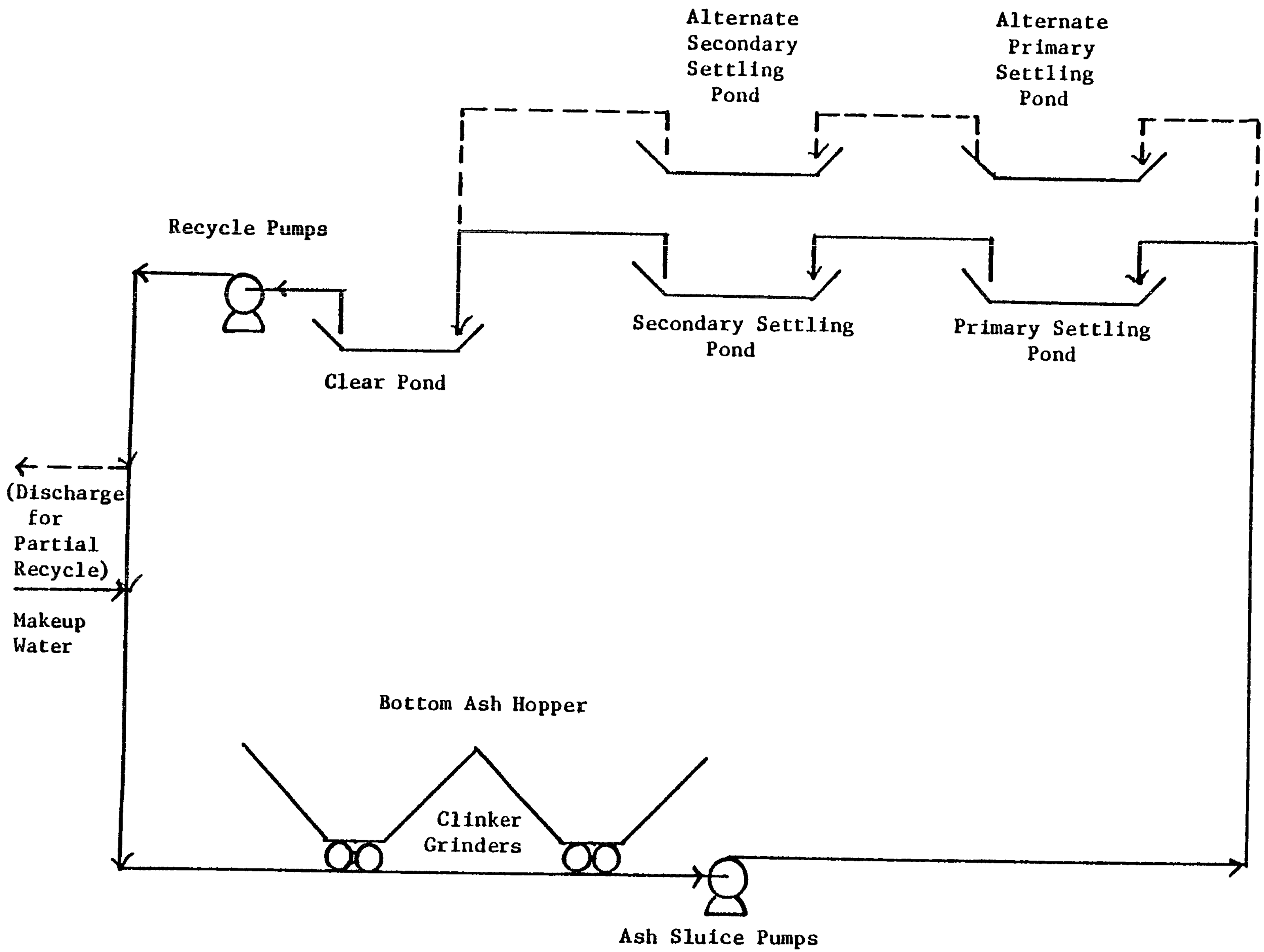


Figure VII-41
PONDING RECYCLE SYSTEM FOR BOTTOM ASH

secondary ponds are dual systems so that dredging does not interfere with operation. For instance, a plant may have two primary and secondary ponds. One primary and one secondary are dredged annually to remove the settled solids while the other two ponds are in operation.

Facilities may be made available to provide for a discharge of sluice water from the recycle line. A makeup water stream will be necessary due to water losses inherent in the system. The most significant water losses occur in percolation through the floor of unlined ponds and evaporation of pond water. A pond system maintained at a steady-state water balance without discharging is considered a zero discharge or complete recycle system. A partial recycle system maintains a discharge either on a continuous basis or for upset conditions.

Bottom ash recovered from ponds by dredging does not create fugitive dust problems because of the high moisture content of the ash. Disposal of bottom ash may be achieved by any of the conventional landfill methods discussed in the fly ash subsection.

Evaporation Ponds. In cases where pH adjustment can not adequately prevent scale, an alternative to slip stream softening is the release of some of the ash sluice water as a blowdown stream. In cases where it is difficult to maintain a steady water balance in a complete recycle system, occasional discharge of ash sluice water may be necessary. The use of evaporation ponds to contain blowdown streams from dewatering bin systems is an option for achieving zero discharge under these conditions. This option has been successfully exercised in the western part of the United States where high net evaporation rates are indigenous. Two of the plants visited attained zero discharge by using a blowdown to evaporation ponds from dewatering bin systems.

<u>Retrofitting</u>. The primary reasons for retrofitting complete recycle systems are:

- o A shortage of water requiring minimal consumption,
- o State or local regulations governing a reduction in wastewater pollutants, and
- o A market for dewatered slag.

Some of the piping from the old system is reusable in the retrofitted system, although difficulties may be encountered in rerouting old pipe. Of course, difficulty may be encountered in integrating any other system discharge with the bottom ash recycle loop, e.g., sump discharge and cooling tower blowdown. Plant downtime would be required for the hook-up of the retrofitted dewatering bin system, resulting in a temporary reduction in generating capacity. In addition, some downtime may occur during the debugging period. For some plants, debugging may last up to a year. The land required to retrofit a dewatering bin system is:

- Approximately 1 acre to contain the dewatering bins, settling tank, surge tank, and pump houses; and
- Landfill area for bottom ash disposal.

A plant that used a pond system prior to the retrofit of the dewatering bin system probably would have land available for disposal of the dewatered bottom ash.

Utilization of Complete Recycle Systems. Data from the 308 survey provided a list of plants which reported wet recirculating bottom ash handling systems and zero discharge of ash transport water. EPA teleponed each of these 14 plants to confirm the data submitted on the 1976 data form. The results of the telephone contacts appear in table VII-25. Specific details of plant designs are discussed below.

This information has not been positively confirmed for all 14 plants. The only method of positive confirmation is site inspection but time and budget constraints precluded visitation of all 14 plants. Four of the the most likely plants were visited.

Plants 4813, 3203, 1811 and 0822, handle and dispose of bottom ash completely separately from fly ash. The plants employ dry fly ash handling and complete recirculation of bottom ash transport water. The plants are located in Texas, Indiana, Nevada, and Colorado. The facilities in Nevada and Colorado make use of high evaporation rates in those locations to achieve zero discharge while allowing for some blowdown from the systems. The fuels burned at these plants include lignite and bituminous coals with the ash contents ranging from 9.7 percent to 11.5 percent. The boiler types include both pulverized coal boilers and cyclone boilers, giving a bottom ash to fly ash ratio from 20:80 to 90:10. These plants represent zero discharge designs; while the absolute number of plants identified as achieving zero discharge from this study is small, they do present a representative mix of location fuel type and boiler type.

Plants 4813, 3203, and 0822 use hydrobins or dewatering bins to separate the bottom ash particles from the sluice water. In each case, the sluice water overflows the weir at the top of the bin

Table VII-25

DATA SUMMARY OF PLANTS REPORTING ZERO DISCHARGE OF BOTTOM ASH TRANSPORT WATER

Plant Code	Location	Fuel	Boiler Type	Ash Handling Systems	Comments
2903	Missouri	Bituminous (13.8% ash)	Pulverized-Dry Bottom	- Fly Ash can be either dry transported to silo (for sale) or or sluiced to pond - Bottom Ash is sluiced to pond and water is recycled	Not all sluice water is recycled some is discharged to a river
2705	Minnesota	Subbituminous (9% ash)	Pulverized-Dry Bottom	- Fly Ash removed in wet scrubber - Bottom Ash is sluiced to pond and some of sluice water is recycled	The Bottom Ash Sluice water not recycled serves as scrubber makeup
2413	Maryland	Bituminous (14.6% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash sluiced to hydrobins overflow to surge tank and recycled	Not all the sluice water is recycled some reaches central treatment plant
4813	Texas	Lignite (10.4% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash sluiced either to hydrobins or primary settling ponds all sluice water is recycled	Zero discharge of bottom ash sluice water

Table VII-25 (Continued)

DATA SUMMARY OF PLANTS REPORTING ZERO DISCHARGE OF BOTTOM ASH TRANSPORT WATER

Plant Code	Location	Fuel	Boiler Type	Ash Handling Systems	Comments
5102	Virginia	Bituminous (17.8% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash is sluiced to a pond and all pond water is recycled	Drains carrying discharges from ash hoppers and pumps go to central treatment facility and are discharged
4229	Pennsylvania	Bituminous (11.5% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash is sluiced to a pond some of the water is recycled	Not a zero discharge facility
4230	Pennsylvania	Bituminous (10% ash)	Pulverized-Dry Bottom	- Wet Fly ash handling with recirculation of water - Bottom ash sluiced to a pond, some of the water is recylced	Not a zero discharge system facility, ash transport water goes to treatment facility
2901	Missouri	Subbituminous (25% ash)	Pulverized-Wet Bottom	- Fly ash is sluiced to settling pond water is recycled - Bottom ash is sluiced to settling pond and water is recycled	Combined ash pond, all water is recycled-zero discharge of ash transport water

Table VII-25 (Continued)

DATA SUMMARY OF PLANTS REPORTING ZERO DISCHARGE OF BOTTOM ASH TRANSPORT WATER

Plant Code	Location	Fuel	Boiler Type	Ash Handling Systems	Comments
3203	Nevada	Bituminous (9.69% ahs)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash is sluiced to dewatering bins and water is recycled	Blowdown from bottom ash sluicing system goes to evap. ponds
1811	Indiana	Bituminous (11.54% ash)	Cyclone-Wet Bottom	- Dry Fly ash handling - Bottom ash is sluiced to a pond, water is recycled recycled	Zero discharge design however blowdown is removed at times when water balance problems occur
1809	Indiana	Bituminous (13.72% ash)	Cyclone-Wet Bottom	- Fly ash is wet sluiced to ponds overflow goes to recycle - Bottom ash is wet sluiced to holding pond overflow to recycle	Recycle serves both fly ash and bottom ash sluicing operations, zero discharges except under upset conditions
3626	New York	Bituminous (17.7% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash wet sluiced to hydrobins, overflow to surge tank and recycled	Some water is discharged due to water balance problems

Table VII-25 (Continued)

DATA SUMMARY OF PLANTS REPORTING ZERO DISCHARGE OF
BOTTOM ASH TRANSPORT WATER

Plant Code	Location	Fuel	Boiler Type	Ash Handling Systems	Comments
2415	Maryland	Bituminous (14.58% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash wet sluiced some of water is recycled	Not a zero discharge plant, sluiced water is treated prior to discharge
0822	Colorado	Bituminous (10.66% ash)	Pulverized-Dry Bottom	- Dry Fly ash handling - Bottom ash is wet sluiced to hydrobins and overflow goes to recycle basin	Blowdown from sluice system is sent to evaporation pond

and gravity flows to a surge tank which supplies the suction side of the recycle or recirculation pumps. Makeup water to compensate for evaporation, water lost from pump seals, water lost from the ash hopper locks, water occluded with the bottom ash and other spills and leaks is added at some point in each system depending on the plant. Accurate control of makeup water is an important factor in achieving zero discharge. If the actual makeup rate exceeds the required makeup rate, a system upset occurs which causes discharge of ash transport water. Such upsets do occur in most systems from time to time, but do not constitute normal operating procedure. Plant 0153 has settling ponds backing up the hydrobins. Bottom ash can be sent to either system. One pond serves as a recycle tank from which recirculating sluice water is drawn.

Plant 1811 uses a ponding system to separate the bottom ash from the sluice water. Once side of the settling pond is wide and gradually inclined. The ash is sluiced to this open area where the heavy material forms a pile. The sluice water drains into a final settling pond at the base of the incline. The recirculation pumps draw suction from this pond. All system drains and leaks are sent to this pond.

Plants 2901 and 1809 sluice both fly ash and bottom ash. These two sluice waters are ponded prior to recycle. In both cases, the primary settling ponds for fly ash and bottom ash are separate ponds. The overflow from these ponds gravity flows to a final settling pond. Both plants are zero discharge designs. Only under upset conditions is ash handling water discharged. The plants are located in Missouri and Indiana and burn a subbituminous coal with 25 percent ash and a bituminous coal with 13.7 percent ash. Both plants have cyclone boilers which give a bottom ash to fly ash ratio of 90:10.

The remaining plants employ some continuous blowdown or discharge from the recirculating bottom ash sluicing systems. These plants have very low discharge rates but are not zero discharge facilities. Only one plant, 4429, was designed to be zero discharge but was unable to close the water balance due to problems in accurately monitoring the makeup water requirement. An additional plant, 2750, was not intended to be a closed-loop bottom ash system since the scrubber makeup is drawn from the recycle tank. If the scrubber loop can be operated in a closed-loop or zero discharge mode, this plant could be considered a zero discharge facility from the standpoint of ash handling. It could not, however, be representative of achievable complete recycle technology for bottom ash handling.

Each plant contact was asked if any scaling or corrosion problems had resulted from the recirculation mode of operations. Only one plant, 2750, indicated that scaling in the recirculation line might be a problem. No such problems have been encountered however. The plants in the survey produce both alkaline ash and acid ash covering the range of chemical properties of ash handling waters.

Trip Reports. Four plants were visited to confirm the bottom ash handling practices as zero discharge. Only two of the four plants were true zero discharge plants: 3203 and 0822. In both cases a blowdown from the bottom ash sluicing systems (with dewatering bins) was observed; however, this blowdown was directed to evaporation ponds on plant property. The purpose of the blowdown was primarily to maintain a steady-state water balance. The remaining two plants, 1811 and 1809, were confirmed as having discharges and were considered partial recycle plants.

Abridged versions of the trip reports for these plants are contained in this subsection. A description of the bottom ash handling system, a discussion of retrofitting problems, a discussion of operating and maintenance problems, and a presentation of sampling and analysis work are provided for each plant. Detailed information concerning the analytical techniques is presented in Appendix D.

Plant 3203. This plant is a 340-MW western bituminous coal-burning facility that uses a dewatering bin (United Conveyor Corporation) bottom ash sluice recycle system with a series of evaporation ponds. The plant fires a moderately low-sulfur coal (average 0.6 percent) with an average ash content of 12 percent and fluctuation to approximately 16 percent ash. The availability of the three boilers has historically averaged 86 percent annually. Water comes from two sources. During the summer, water is pumped from wells and during the winter, from a nearby river. The water is pumped to a reservoir for holding and then to the three cooling towers. Blowdown from the cooling towers accumulates in a storage tank. Water from this storage tank then feeds the three SO_2 scrubbers as well as the bottom ash sluicing system. The bottom ash storage tank receives water from the cooling tower blowdown storage tank and from the plant drain sump; the drain sump receives water from the area drains and boiler blowdown. A generalized flow diagram appears in figure VII-42, which shows the major equipment and associated typical flow rates.

The bottom ash sluicing system was designed and installed by United Conveyor Corporation. It was retrofitted to Units 1 and 2 and was installed along with Unit 3. The system was designed for 7 percent ash coal with capacity to handle a fourth unit, which was to be built at a later date. The bottom ash handling system is currently operating at a greater-than-rated capacity due to

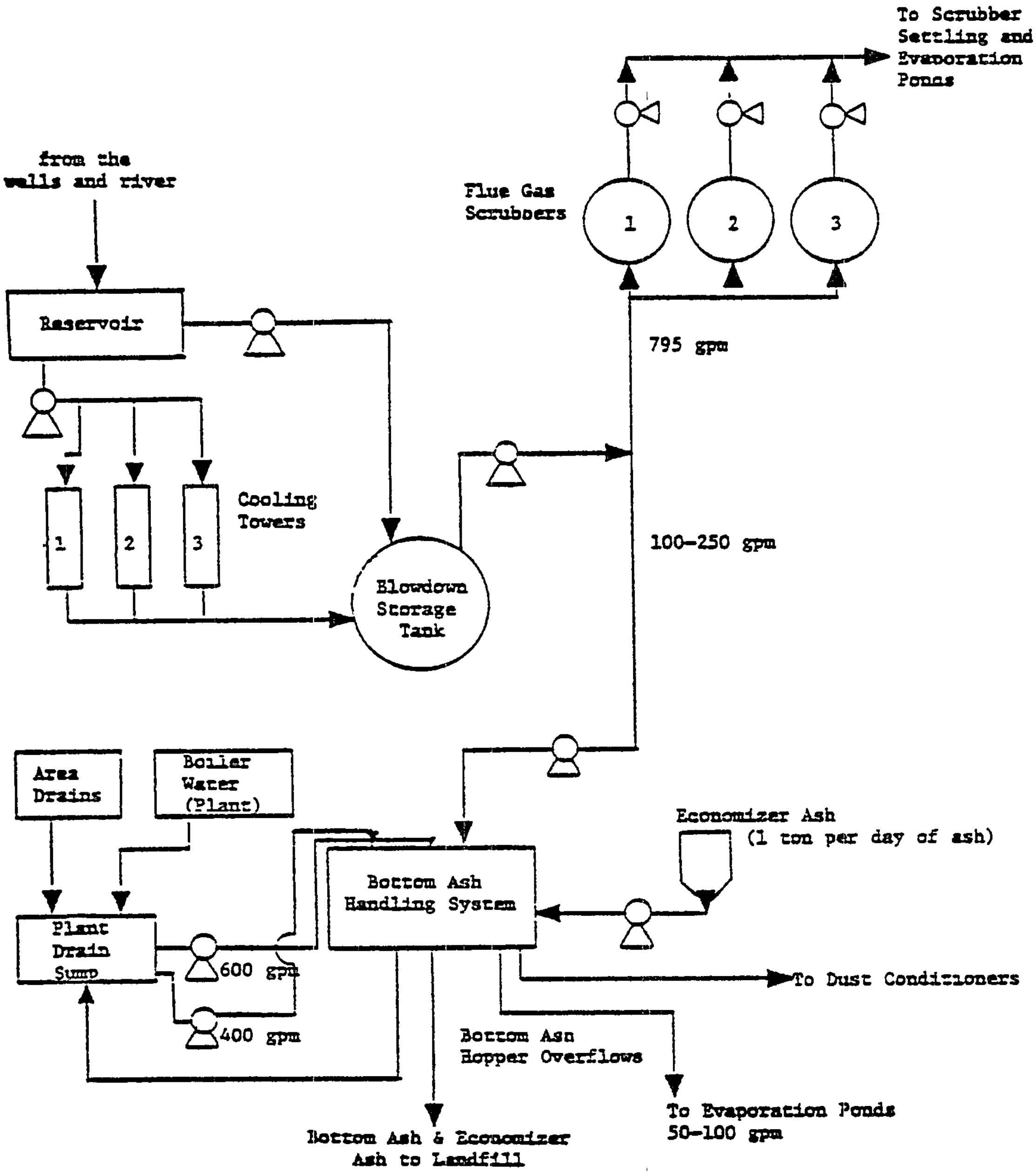


Figure VII-42
WATER FLOW DIAGRAM FOR PLANT 3203

the higher-than-average ash coal being burned in the three units. The general flow scheme for this bottom ash recycle system is shown in figure VII-43. The bottom ash handling system processes approximately 77 tons per day of bottom ash as well as 1 ton per day of economizer ash for all three units combined. The bottom ash is pumped from the hoppers to the dewatering bins for approximately 4 hours per day, the economizer ash for 1 hour each day. It takes approximately 6 hours to dewater the bottom ash in the bin to yield an ash moisture content of about 20 percent to 50 percent. Approximately one truckload of dewatered bottom ash is hauled to the onsite disposal area per day. The number of loads per month varies from 30 to 40. The disposal area is 1 mile from the plant. The hauling and placement of the ash is contracted to an outside firm.

The major equipment for the bottom ash recycle system was bought from and installed by United Conveyor Corporation. The dewatering bins are 30 feet in diameter, with 5,000 cubic feet per bin. Two bins are used: one dewaters ash, while the other fills with ash. The drained-off water from the bins flows by gravity to a settling tank of 50 feet in diameter and a capacity of 145,000 gallons. Sludge pumps are provided beneath the settling tank to pump any settled solids back into the top of the settling tank. Overflow from the settling tank drains into the surge (or storage) tank, which is of the same diameter and capacity as the settling tank. The surge tank is operated, however, at 19,108 cubic feet, or 135,000 gallons. Sludge pumps beneath the surge tank pump any settled solids back into the settling tank. From the surge tank, water is pumped back to the bottom ash hoppers for subsequent sluicing. A jet pump provides the pressure for transporting the ash to the dewatering bins. The length of pipe from the bottom ash hopper to the dewatering bin is approximately 500 feet for Unit 3 and 100 feet from Units 1 and 2. The pipe diameter for this system is typically 10 inches with a discharge pressure of 200 psi. The land area devoted to the dewatering bins, settling tank, and surge tank is approximately one acre; this does not include the pump house or pipe rack. The bottom ash is trucked to a 200-acre, onsite landfill area. Side streams are taken from the bottom ash sluice lines which feed the fly ash dust conditioning nozzles and from a purge stream to the evaporator ponds. The purge flow rate is continuous and varies from approximately 50 to 100 gpm.

The maintenance of the sluicing system has been nominal since installation in 1975. No chemical testing for scaling species has been done and no scaling has been observed to the extent of producing a malfunction in equipment or line pluggage. Some minor corrosion on valves has occurred and some pump repair has been needed due to minor erosion.

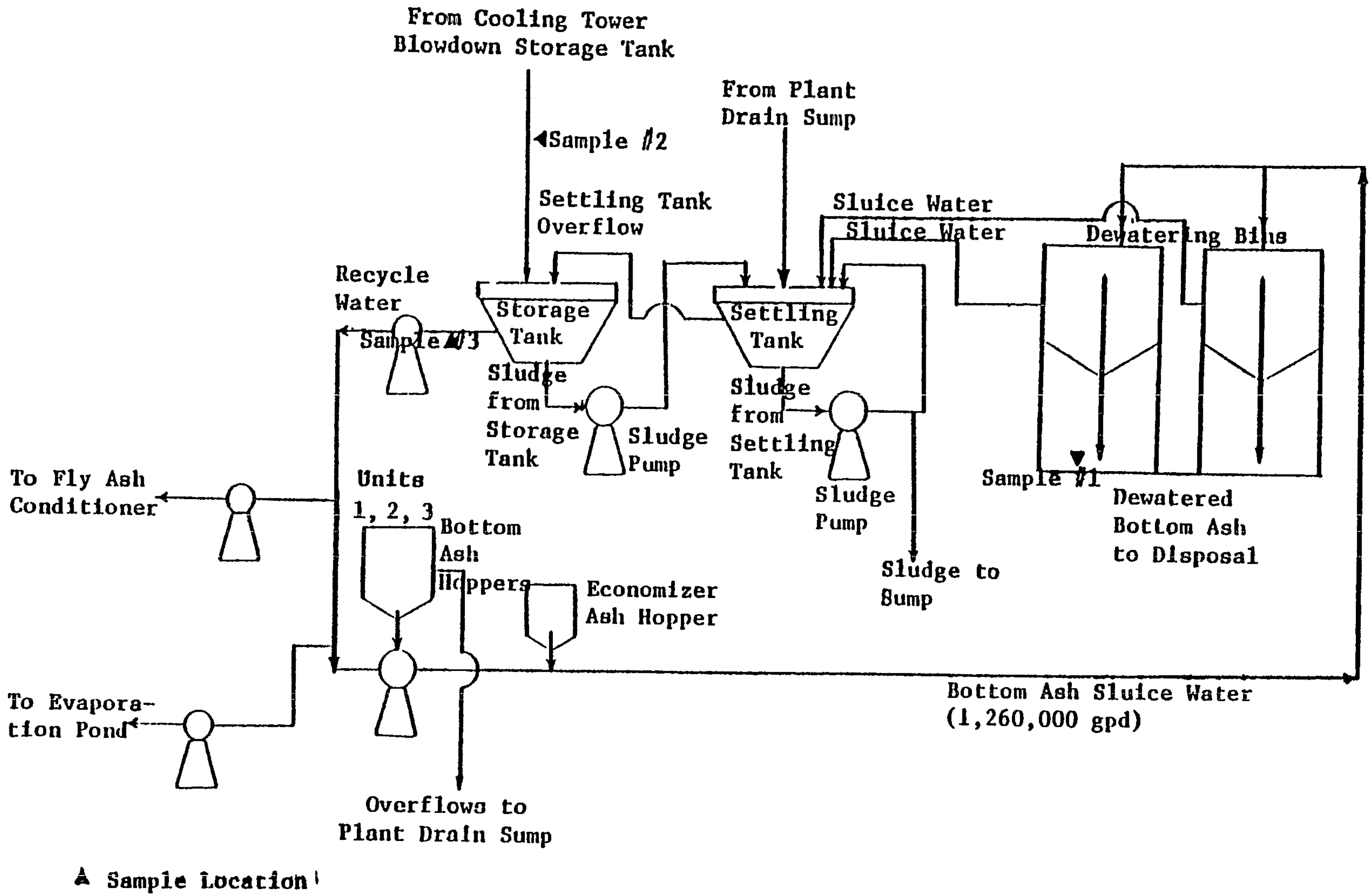


Figure VII-43
BOTTOM ASH RECYCLE SYSTEM AT PLANT 3203

There is a problem with solids pluggage in the bottom of the settling tank. This is due to several inherent design aspects of the system. The settling tank is not designed to remove large amounts of sludge. In this system, the plant drain sump discharges to the settling tank as well as the sludge from the surge tank. Adding to the problem is the fact that the system was designed to remove less ash than is currently being generated. Generation of fines is indigenous to western bituminous coal ash. These fines can plug the dewatering bin screens and overflow into the settling tank. A platform has been built over the settling tank to provide access for air lancing the solids in order to prevent sludge pump plugging. The settling tank sludge pumping capacity is to be doubled in the future to help reduce the load on the current pumps.

The entire bottom ash system requires two men per day for maintenance and one man per shift each day for operation of the system.

The motivation for retrofitting the bottom ash recycle system was a general water shortage problem associated with both wet once-through bottom ash and fly ash handling systems. At the time the bottom ash recycle system was installed, a pressure dry fly ash handling system and a third unit were also installed. Scaling problems tended to be more prevalent in the wet once-through system than in the current bottom ash sluice recycle system. Some of the wet once-through system piping was reused in the installation of the new bottom ash system. A 2-week outage for Units 1 and 2 occurred when the retrofit systems were installed and major pipe rerouting was done. It took approximately a year to debug the fly ash and bottom ash systems as well as the new Unit 3.

Samples were taken at three different locations in the bottom ash sluicing system. These locations are shown in the bottom ash sluicing system diagram in figure VII-43 and are described as follows:

- A sample was taken of a stream of water leaking through the slide gate at the bottom of the dewatering bins,
- A sample was taken of the recycle system makeup water from the cooling tower blowdown tank, and
- A sample was taken at the recirculation pump which pumps the ash transport water back to the bottom ash hoppers.

These samples provide an indication of the trace elements, major species, and carbon dioxide content of transport streams before and after dewatering of the bottom ash and of the makeup water to the system. The trace elements which were quantified include silver, arsenic, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, and zinc. Other metal elements (major species) were magnesium, calcium, and sodium. The non-metal major species quantified were phosphate, sulfate, chloride, silicate, and carbon dioxide. The results of the analyses are presented in tables VII-26 and VII-27.

Of the three samples taken, the cooling tower blowdown had the highest concentrations in arsenic, magnesium, sulfates, and silicates. The pH of this stream was 8.2, and the temperature was 96°F. Dilution of this stream in the surge tank with the plant drain sump effluent resulted in lower concentrations of these species. Species which had the highest concentrations at the recirculation pump, i.e., downstream from the surge tank, were phosphates, chlorides, carbon dioxide, zinc, and sodium. The pH of this stream was 8.2, and the temperature was 126°F. The third sample was taken from a leak beneath the dewatering bin during an ash dewatering mode of operation. The pH of this water was 10.4, and the temperature was ambient, 106°F. The significant species in this sample relative to the other two samples were copper, lead, and calcium.

On the basis of the sampling results and the subsequent analyses, EPA assessed the potential for precipitation of certain species by using an aqueous equilibrium computer program. The results from this assessment indicated that the calcium carbonate species has the greatest potential for precipitation in the leakage from the dewatering bin sample. The next greatest potential for the same species was in the cooling tower blowdown. The lowest potential was in the recycle stream prior to the recirculation pump. In this case, the maximum precipitation potential occurred in the stream in contact with the coal ash for the greatest period of time.

In conclusion, a closed-loop bottom ash system is feasible at Plant 7281 by using discharge to evaporation pond. The technical problems associated with the equipment in the closed-loop system were of a reconciliable design nature. The only significant equipment problem exists because the settling tank was designed to handle all the overflow fines from the dewatering bins. More modern systems pipe these overflow fines back to dewatering bins. Chemically, there seemed to be no major cycling of trace elements and major species concentrations as a result of the closed-loop operation. It appears, however, that the concentration of copper increases as a consequence of sluice water being in contact with the coal ash. Contact with the coal ash also increased the concentrations of calcium and sodium. The potential for precipitation of $CaCO_3$ exists in all three sample streams based on scaling tendency calculations. The greatest potential exists in the sluice water in the dewatering bin. This means that

Table VII-26

TRACE ELEMENTS/PRIORITY POLLUTANTS[1]
CONCENTRATIONS AT PLANT 3203

(ug/l)

	Cooling Tower Blowdown	Leakage from Dewatering Bin	Recirculation Pump
pH	8.20	10.40	8.20
Temp. (°F)	96	--	96
Silver	<0.1	<0.1	<0.1
Arsenic	71	4	26
Beryllium	<0.5[2]	<0.5	<0.5
Cadmium	<0.5	<0.5	<0.5
Chromium	15	24	19
Copper	21	49	5
Mercury	<2	<2	<2
Nickel	<0.5	<0.5	<0.5
Lead	<3	4	<3
Antimony	8	<1	5
Selenium	5	<2	<2
Thallium	<1	<1	<1
Zinc	160	40	40

[1] Two analyses were done for each sample species, the results are given as the average for each element.

[2] <.5 refers to the fact that the measured concentration was less than 0.5 g/l, which is the detection limit for this species.

NOTE. All concentrations reflect dissolved as opposed to total concentrations.

Table VII-27

MAJOR SPECIES CONCENTRATION[1] AT PLANT 3203

(mg/l)

	Cooling Tower Blowdown	Leakage from Dewatering Bin	Recirculation Pump
Calcium	395	505	310
Magnesium	190	1	105
Sodium	645	780	770
Phosphate[2]	0.40	0.06	2.30
Sulfate	2546	1773	1786
Chloride	394	601	622
Silicate	181	27	92
Carbonate	2520	60	2760

[1]Two analyses were done for each sample for Ca, Mg, Na, the results are given as an aveage of the two values.

[2]All species except Ca, Mg, Na, were analyzed only once, one number is reported for each sample species.

NOTE: All concentrations reflect dissolved as opposed to total concentrations.

increased recycle or continuous operation of the current system can cause scale formation on pipes thereby reducing the flow rate in the pipes.

Plant 0822. This plant is a 447 MW coal-fired powerplant located in northwestern Colorado. The plant consists of two units: Unit 1 completed in 1965 and Unit 2 in 1976. The facility is a base-load plant using cooling towers for condenser heat dissipation, dry fly ash transport, and a zero discharge bottom ash sluicing system. The plant burns a bituminous coal from USBM Coal District 17. The plant is sufficiently close to the coal mine (nine miles) to be considered a mine-mouth operation. Plant water is drawn from a nearby river. The facility utilizes an RCC vapor compression distillation unit to recover recycleable water from cooling tower blowdown. All final wastewaters are ultimately handled by an evaporation pond. A general description along with a flow diagram (figure VII-23) of this plant has been provided in the fly ash subsection.

The flow scheme for the bottom ash sluice system is illustrated in figure VII-44. Bottom ash from the boiler is jetted to one of two United Conveyor dewatering bins (one bin is in operation while the other is being drained). The overflow from the dewatering bin flows by gravity to a solids settling tank. Sludge from the settled ash material is pumped back to the hydro-bin. The overflow from the settling tank flows to the surge tank and then to the two centrifugal pumps which supply water to the ash jet pumps. Makeup water, which consists of cooling tower blowdown and some plant raw water, is added to two ash water storage tanks. The makeup water is directed either to the surge tank or to the high- and low-pressure ash water pump suction headers. Under normal operation, the ash water makeup equals the water retained by the bottom ash after dewatering, the water used for wetting fly ash prior to unloading and small losses from evaporation in the bottom ash hopper. Any solids which settle to the bottom of the surge tank are pumped as sludge back to the dewatering bins.

Once the dewatering bin fills with bottom ash, the bottom ash sluice is switched to the other bin. The filled bin is then drained of the sluice water. When the bottom ash is sufficiently dewatered (after about 8 hours), it is dumped into an open truck and hauled to the mine for disposal. The sluice water makeup from the cooling tower blowdown is treated with a scale inhibitor (NALCO). The cooling towers operate between 8 and 10 cycles of concentration with a dissolved solids level of 1,200 mg/l.

The current bottom ash sluice system was designed as a part of Unit 2. Thus, for Unit 2, the system is an original design while for Unit 1, it is a retrofit. Prior to the construction of the

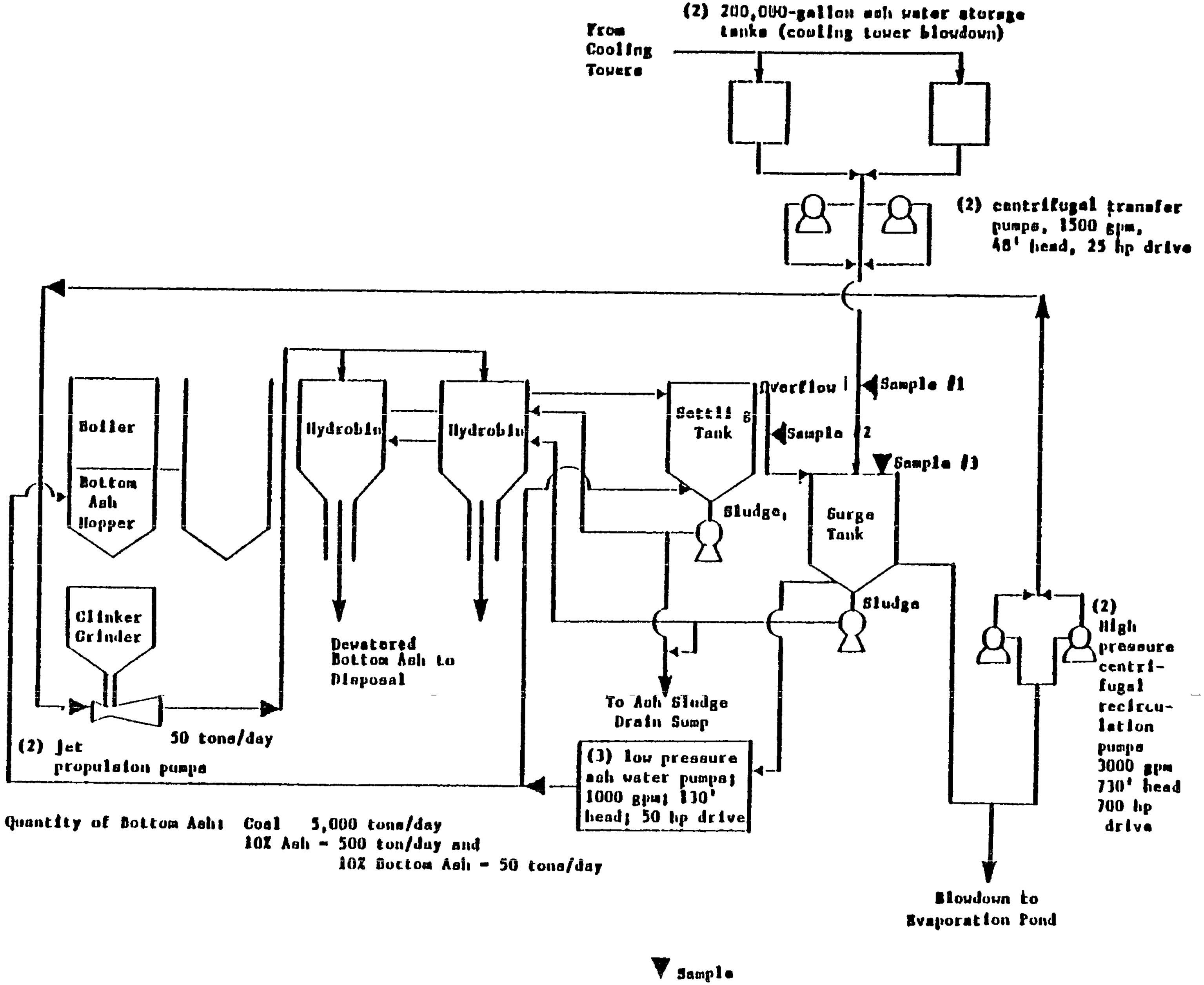


Figure VII-44
BOTTOM ASH HANDLING SYSTEM FOR PLANT 0822

current system in 1975, the plant used a once-through sluice operation in which both fly ash and bottom ash were sluiced to a pond. The solids resulting from these operations have since been removed and disposed of at the mine. The pond now serves as a water storage pond to be used in the event of drought conditions.

The bottom ash handling system supplier for plant 0822 is United Conveyor Corporation. The following discussion provides specific information concerning the major equipment for the bottom ash handling system.

Two ash water storage tanks hold the makeup water to the ash handling system. These tanks have volumes of 200,000 gallons each. High and low water level switches are used to control the water level in these tanks.

Two Bingham horizontal end suction, back pullout, centrifugal pumps each rated at 150 gpm, 48 feet head are driven by 25 HP, 1,200 rpm Westinghouse motors. These pumps supply water to the surge tank from the ash water storage tanks and are automatically controlled by surge tank hi-low level switches.

Two high pressure pumps supply recirculation water to the jet pumps at the bototm ash hoppers from the surge tank. These pumps are Bingham horizontal, single stage, axially split, double suction centrifugal pumps each rated at 3,000 gpm, 730 feet head and are driven by 700 hp, 3,600 rpm Reliance motors. Start-stop control switches are located on the bottom ash panel.

Three low pressure ash water pumps supply ash water from the surge tank at a pressure of approximately 50 psig to the surge and settling tanks for sludge removal and flushing, and to the bottom ash hopper for fill, seals, flushing, and overflow supply. These pumps are Bingham horizontal end suction, back pullout, single stage centrifugal pumps each rated at 1,000 gpm, 130 feet head and are driven by 50 hp, 1,800 rpm Westinghouse motors. Automatic controls are located on the bottom ash panel and manual controls are locally placed.

The "jetpulsion" pumps are jet pumps located beneath the cylinder grinders. These pumps create the force necessary to convey the ash and water to the dewatering bins. Water for the "jetpulsion" pumps is supplied by the high pressure ash water pumps. These jet pumps are controlled on and off by associated two-way rotary sluice gates located in the discharge line of each pump. The sluice gates are solenoid operated from the bottom ash control panel by OPEN-CLOSE switches.

Each of the two dewatering bins is designed to provide a net storage volume of 12,700 cubic feet or approximately 48 hours bottom ash storage capacity with both Unit 1 and 2 at full load. Also, each bin is fitted with a 12 kw chromolox electric heater and an ash level detector which activates an alarm and a light on the control room panel when maximum ash level is reached. At this point the conveyor is stopped, the diverting gates are switched, and the conveying operation is then restarted by an operator.

Separate settling and water surge tanks are provided to recover the ash water used in the handling of bottom ash and pyrites. The settling tank is sized to provide flow-through water velocities sufficiently low to precipitate most particulate matter larger than 100 microns. Sufficient volume is provided in the surge tank to absorb the severe imbalance between input and output flows that occur when the system progresses through the ash transport and dewatering cycle.

The manpower increase due to the retrofitted ash handling systems is 15. This number includes both fly ash and bottom ash systems for both maintenance and operation.

The maintenance problems with the bottom ash handling system are nominal. The most frequently recurring problem is the erosion of the impellers and casings of the high pressure recirculation pumps. There are no problems with fines in the operation of the dewatering bins, e.g., screen plugging or overflow into the settling tank causing plugging of the sludge pumps. Some problems arose in retrofitting the bottom ash system; the usual pipe rerouting, use of old pipe, and outage time were required for the system installation.

Samples were taken at three different locations in the bottom ash sluicing system. These locations were:

- A sample was taken of the system makeup stream from the cooling tower blowdown water,
- A sample was taken of the settling tank overflow to the surge tank, and
- A sample was taken from the surge tank.

These samples provide an indication of the trace elements, major species, and carbon dioxide content of transport streams before and after the surge tank, and of makeup water to the system. The trace elements which were analysed include silver, arsenic, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, and zinc. The major species analyzed were magnesium, calcium, sodium, phosphate, sulfate, chloride, silicate, and carbon dioxide. The results of these analyses are reported in tables VII-28 and VII-29.

Table VII-28

TRACE ELEMENTS PRIORITY POLLUTANTS CONCENTRATIONS[1,2] AT PLANT 0822

(ug/l)

	Cooling Tower Blowdown	Settling Tank Overflow	Surge Tank
pH	8.0	6.3	6.7
Temp. (°F)	89.0	130.0	126.0
Silver	<0.1	0.4	<0.1
Arsenic	49.0	3.0	3.0
Beryllium	<0.5[3]	<0.5	<0.5
Cadmium	<0.5	2.0	<0.5
Chromium	<2.0	10.0	<2.0
Copper	47.0	8.0	15.0
Mercury	<0.2	<0.2	<0.2
Nickel	<0.5	<0.5	<0.5
Lead	<3.0	<3.0	<3.0
Antimony	<1.0	<1.0	5.0
Selenium	<2.0	5.0	6.0
Thallium	<1.0	<1.0	<1.0
Zinc	95	145	410

[1] All trace element analyses were done in duplicate, the two values were averaged.

[2] All concentrations are for the dissolved, not total, concentration.

[3] The value <0.5 indicates that the concentration was below the detection limit which in this case is 0.5 ppb for beryllium.

Table VII-29

MAJOR SPECIES CONCENTRATIONS[1,2]
AT PLANT 0822

(mg/l)

	Cooling Tower Blowdown	Settling Tank Overflow	Surge Tank
Calcium	365	365	370
Magnesium	120	92	90
Sodium	210	145	150
Phosphate (PO_4)	3.3	0.17	0.09
Sulfate (SO_4)	1215	1203	1165
Chloride (Cl-)	211	112	125
Silicate (SiO_2)	57	36	35
Carbonate (CO_3=)	60	120	360

[1]Ca, Mg, Na were analyzed in duplicate, values are averages.

[2]All values reflect dissolved, not total, concentrations.

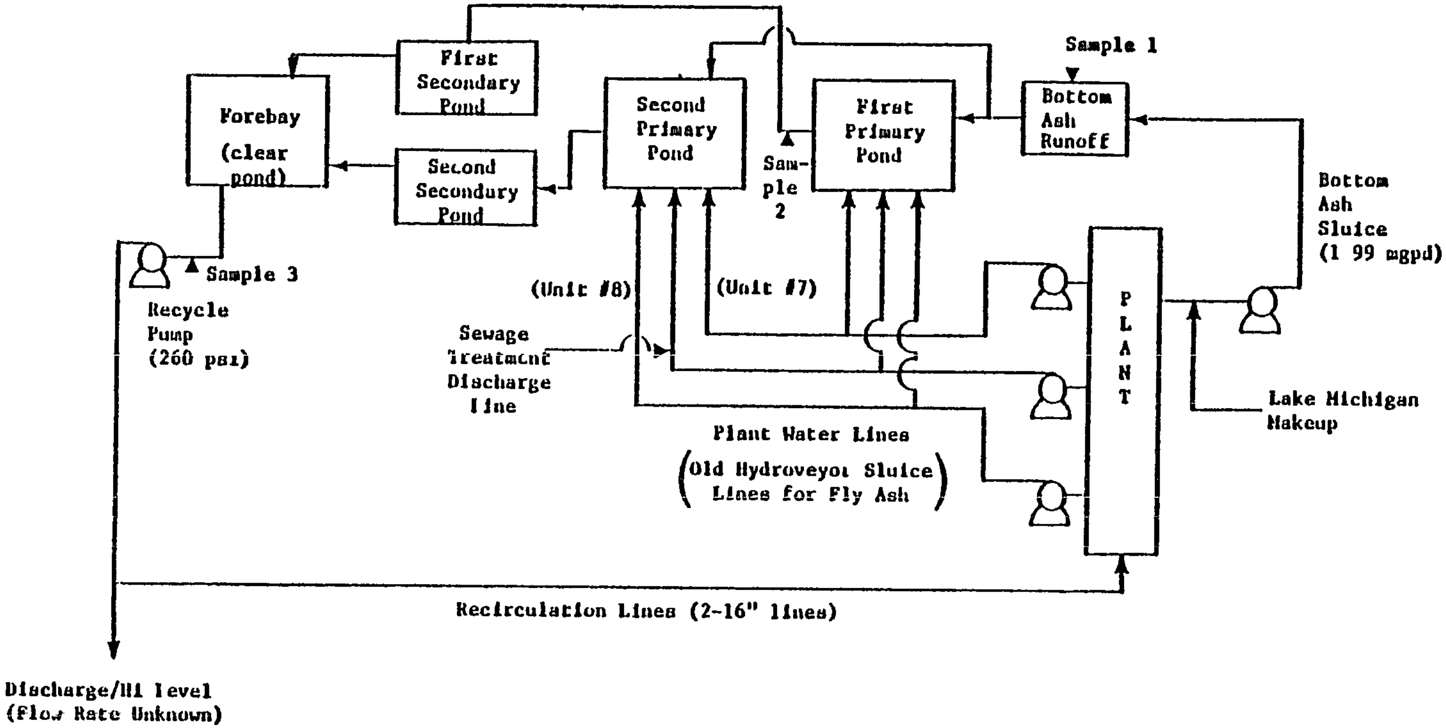
The sampling results indicate that the contact of the sluice water with the bottom ash, as reflected in the settling tank overflow species values relative to the other two streams, raises the concentrations of some species. The trace elements, which increased due to ash contact are silver, cadmium, chromium, selenium, and zinc. For the major species, an increase in carbonate concentration is reflected in the carbon dioxide values. Decreases in concentration from the makeup source to the recycle loop are observed for arsenic and copper and for magnesium, sodium, chloride, and silicate, which indicates that a cycling effect does not exist in this system for these species.

On the basis of the sampling analyses, the Agency determined the tendencies for scaling for various species in the makeup and recycle streams by using an aqueous equilibrium program. The amount of scaling which may actually exist is contingent upon the amount of the species present and any other inhibitor additives which may be present. Only one sample species represented any driving force for precipitation. This species was $CaCO_3$ for the cooling tower blowdown makeup water stream.

In summary, this plant has achieved zero discharge by using evaporation ponds. No significant mechanical problems have occurred since the installation of this bottom ash system in 1974, and no significant problems arose during the retrofitting procedure. Chemically, some increase in trace element priority pollutants and major species concentrations has been observed due to contact with the ash. The potential exists for scaling $CaCO_3$ in the makeup water stream. However, neither scaling nor corrosion has been a problem in the operation of this system.

Plant 1811. This plant is a 615-MW electric power generating station located in Northern Indiana. The plant uses a wet recirculating ponding system to handle bottom ash. This ash is generated by two cyclone-type boilers of 194 and 422 MW each. The coal ash content is 10 to 12 percent with 11 percent as the average. This bituminous coal is obtained from Bureau of Mines Coal Districts 10 and 11. The bottom ash sluicing recycle system was retrofitted in the early 1970's. The dry fly ash handling system was retrofitted early in 1979. Both of these systems were designed and installed by United Conveyor Corporation.

The bottom ash sluicing system is characterized by a bottom ash storage area, a series of settling ponds, and a recirculation or final pond. Figure VII-45 presents the sluice system flow diagram for the plant. Only one primary and one secondary pond is used during operation of the sluicing system. The sluice lines shown, other than the bottom ash sluice, are used to transport sump water to the ponds. Also, the discharge from a package sewage treatment facility is sent to the primary settling pond.



▲ Sample location

Figure VII-45

PLANT 1811 FLOW DIAGRAM FOR BOTTOM ASH HANDLING

The hydroveyor line, which was used to sluice fly ash to the ponds, is used as a backup to the normal ash sluice pipes. The main sluice pumps for the bottom ash are jet pumps which discharge at a pressure of 230 psig at the runoff area. The larger unit 8 has two 10 inch sluice lines (including one spare) which transport the ash one-quarter of a mile to the slag runoff area. The smaller unit 7 has one 10 inch sluice line. The flow rate used to transport the bottom ash to the runoff area is approximately 2.0 x 10^6 gpd. The ash is sluiced for 1 to 2 hours each shift (depending on the load) with 10 minutes of flushing before and 15 to 20 minutes afterwards. The surface areas of the two primary settling ponds are 4.2 acres (182,900 $feet^2$) and 4.4 acres (192,200 $feet^2$). The areas of the two secondary ponds are 2.09 acres and 3.66 acres. The forebay or final pond has an area of 0.1 acres (5,188 $feet^2$). Three centrifugal pumps are located at the forebay which are used to recirculate the sluice water back to the bottom ash pump (a distance of 1/2 mile) as well as the general plant water system through one of two existing lines (16 inches diameter). These recirculation pumps supply sluice water to the bottom ash pump at a discharge pressure of 260 psig. A single pipe exists downstream of the forebay recirculation pumps which allows for the discharge of sluice water from the recirculating system. This discharge is initiated during upset conditions but is under complete control of the plant operators. This discharge is estimated to occur 2 days out of 7. The water is transported to Lake Michigan. Since this occurs intermittently, the flow rate was difficult to quantify. Makeup water to the bottom ash sluicing system enters the system at the sluice pumps from Lake Michigan. Makeup water is required because of pond evaporation, pond percolation, and water losses by removal of wet bottom ash. The amount of ash handled by the bottom ash sluicing system was estimated by 1978 FPC figures given by Plant 1811 personnel.

In 1978, the amount of bottom ash collected was 72,200 tons. The operating and maintenance cost associated with the sluicing operation was $67,300 for 1978. The hauling and disposal of the bottom ash at the landfill site was contracted out and cost $86,900 in 1978. Some of the bottom ash was sold which yielded $11,400.

Operating problems associated with the sluice system are nominal. Occasional broken lines and ruptured slag pumps require periodic maintenance, but this is considered normal. One major operating problem is pond sluice water percolation. The ponds are located at a higher elevation than a nearby plant and national park. These ponds are not sealed and the sluice water seeps into offsite water systems. The amount of percolation increases during periods of high water levels in the pond. Future plants are expecting to build a lined pond to prevent this percolation.

The operating manpower required to run the sluicing system is one man part-time in the control room each shift and one man part-time monitoring the slag sluicing operation. This requirement totals to one man full-time for equipment maintenance. Most heavy maintenance work is done during planned outages.

The recycle portion of the sluice system, i.e., the forebay and recycle line, was retrofitted in the early 1970's as a result of a decision to collect all process waters at one location. No problems were incurred due to the retrofit of the system.

Samples were taken at three different locations in the bottom ash sluicing system. These locations, which are designated in figure VII-45, are:

- o the bottom ash discharge point,
- o the primary pond overflow, and
- o the forebay outfall.

These samples were taken to provide an indication of the levels of trace elements and major species in the recirculating/sluicing system. The trace elements assayed were silver, arsenic, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, and zinc. The major species assayed were magnesium, calcium, sodium, phosphate, sulfate, chloride, silicate, and carbon dioxide. The results of these analyses are reported in tables VII-30 and VII-31.

The sampling results are inconclusive. Most of the concentrations are low, except for the sulfate and zinc. There is essentially no indication of an effect on trace metal concentrations due to contact of the sluice water with the ash.

On the basis of sampling results, EPA determined the tendencies for scaling for various species in the recycle streams by using an aqueous equilibrium program. The results of this analysis indicated that the potential for scaling of four major species was very low in all three sample streams.

The feasibility of zero discharge using complete recycle with ponding for bottom ash cannot be confirmed by the system used at this plant because it requires intermittent discharge to maintain a steady-state water balance in the system; however there were no mechanical or chemical problems related to the recycle operation. The problem with percolation could be alleviated by lining the existing ponds.

Table VII-30

TRACE ELEMENTS PRIORITY POLLUTANTS CONCENTRATIONS[1,2]
AT PLANT 1811

(ug/l)

	Forebay Outfall	Primary Pond Overflow	Bottom Ash Discharge
pH	6.5	6.7	6.3
Temp. (°F)	77	79	85
Silver	<0.1[3]	<0.1	<0.1
Arsenic	<1.0	2	6
Beryllium	<0.5	<0.5	<0.5
Cadmium	6.0	5.0	8.0
Chromium	<2	<2	<2
Copper	14	3	10
Mercury	<1	<1	<1
Nickel	27	16	17
Lead	<2	<2	<2
Antimony	<3	<3	<3
Selenium	<2	<2	<2
Thallium	10	10	25
Zinc	270	180	90

[1]All trace elements analyses were done in duplicate, and the two values were averaged.

[2]All concentrations are for the dissolved, not total, concentration.

[3]The value <.1 indicates that the concentration was below the detection limit which in this case is .1 ppb for silver.

Table VII-31

MAJOR SPECIES POLLUTANTS CONCENTRATIONS[1,2]
AT PLANT 1811

(mg/l)

	Forebay Outfall	Primary Pond Overflow	Bottom Ash Discharge
Calcium	69	54	74
Magnesium	14	11	19
Sodium	40	43	36
Phosphate (PO_4)	<0.06	<0.06	<0.06
Sulfate (SO_4)	273	241	250
Chloride (Cl)	8	8	8
Silicate (SiO_2)	5	<3	4
Carbonate (CO_3)	60	300	600

[1] Ca, Mg, Na were analyzed in duplicate, the values are averaged.

[2] All values reflect dissolved, not total, concentrations.

Plant 1809. This plant is a 736-MW electric power generating station. Four boilers currently in operation burn bituminous coal which has an ash content of 10 to 12 percent. The boilers are of the wet bottom cyclone type and produce a relatively large amount of bottom ash slag. The plant utilizes a wet recirculating ponding system to handle both fly ash and bottom ash. Water is obtained from a nearby creek for use in the sluicing operation. A flow diagram of the ash handling system appears in figure VII-35.

The bottom ash sluicing system was retrofitted in 1974 along with the fly ash sluicing system and Unit 12, the largest of the steam generators (520 MW). All systems were designed and installed by Allen-Sherman-Hoff, retrofitted for Units 4, 5, and 6, and new for Unit 12. The principal reasons for installing the ash sluicing recycle system were the requirements of discharge regulations and the decision to collect and handle all process waters at one location. The fly ash and bottom ash is produced at a ratio of 26 percent fly ash to 74 percent bottom ash. In 1978, approximately 48,600 tons of fly ash were collected and 136,000 tons of bottom ash were collected.

A jet pump sluices the bottom ash from the slag tanks to the bottom ash runoff area. Two 12-inch diameter pipes are used to sluice the bottom ash; one from the Boiler 12 slag tank and one from Boilers 4, 5, and 6 slag tanks. The bottom ash sluice water flow rate is approximately 3×10^6 gpd. At the bottom ash runoff area, the bottom ash slag is bulldozed into piles and is sold for use as a road bed aggregate. The runoff area is composed of two primary ponds, 11,536,000 and 14,198,000 gallons capacity, and one small secondary pond. Only one primary pond operates at a time. The bottom ash is sluiced every 4 hours for 30 to 45 minutes. The piping used for conveying the bottom ash is cast iron in the plant area and cast basalt (Sch. 80) outside the plant area. From the secondary pond, the sluice water overflows into the final pond for recirculation back to the jet pumps.

At the final pond, facilities are available for a discharge to Lake Michigan. These facilities consist of two pipes from the main conveying lines to Lake Michigan for intermittent and upset conditions. The discharge is actuated by gravity overflow. A discharge condition prevails when Unit 12 is operating. Usually when Units 4, 5, and 6 are operating and Unit 12 is down, the discharge condition does not exist. The final pond also receives a large amount of water from the miscellaneous sump system; thus, during heavy rainfall periods, a discharge condition often exists. Thus, Plant 1505 is not strictly a zero discharge plant. It does provide for a discharge under fairly consistent conditions when Unit 12 is operating. This discharge stream was not quantified by plant personnel. The discharge is not used to prevent scaling of the ash handling components, but is used solely to remove the surplus water which accumulates. This surplus water is being considered for use as makeup to the cooling tower.

Operating problems associated with the sluice system are nominal. Occasional instances of low pH have caused some pipe corrosion; however, lime addition for pH adjustment has alleviated m ch of this problem. Scaling has historically not been a maintenance problem. Suspended solids have caused pump erosion problems on an intermittent basis. Currently, the creek is used as the makeup water source. High flow situations, e.g., after heavy rainfall, result in a poor quality makeup water; also, incomplete bottom ash settling caused some wear on pumps. Control of final pond water flow and installation of surface booms for floating material collection has mitigated much of the solids problem. The piping is rolled to maintain even wear on all inside sluicing surfaces. This procedure is not unusual. One area which requires significant maintenance is the sluicing jets and recirculation pumps. These pumps do not have spares and therefore must be frequently checked and maintained so as not to cause a shutdown of the sluicing operation.

The primary ponds are cleaned annually and only one primary pond is cleaned per year. Ash hauling is contracted to an outside trucking firm.

The bottom ash is sold for commercial use, which provides a credit for the ash. According to the 1978 FPC data provided by the plant personnel, the cost for collection and disposal of the bottom ash was $79,200 and the sale of the bottom ash provided a $29,900 credit.

The bottom ash ponding recycle sluicing system for plant 1505 was installed in 1974. At the same time the fly ash sluice water recycle system and unit 12 was installed. Thus, the recycle portion of the pond system is a retrofit system for units 4, 5, and 6. The reason for retrofitting a recycle system, i.e., a final pond and return line, was in part due to discharge regulations since the plant is bounded by a National Park, a town, and Lake Michigan. An additional motive was to collect all discharge streams in the final pond for common treatment, if needed.

The retrofit of the recycle line did not enable the plant to achieve zero discharge because of water balance problems. Water is accumulated especially when unit 12 is operating. The plant is in a low net evaporation climate. When the plant installed the recirculation system, the already-existing main sluicing jet pumps and the new recirculation pumps were not spared. This has presented a maintenance problem and a need for redundancy by the plant is recognized.

The plant claims that it is difficult to achieve zero discharge by retrofitting a recycle loop on a ponding system for two reasons: it is difficult to tie up all the streams into one collection point, and it can be done only if the already-existing systems can be totally segregated. There is also the effect on electricity generation to be considered; higher auxiliary power requirements reflect lower net power generation. Plant 1809 personnel indicate that the technology to retrofit bottom ash systems is more available than that for retrofitting fly ash recycle systems. Cyclone boilers produce mostly bottom ash; however, cyclones are no longer available as a technology, primarily because of NO_x emissions. According to plant personnel, the only way for plant 1809 to meet a zero discharge requirement is to install evaporators which would increase the auxiliary power requirements.

Any new expansion of generating capabilities would have to be met with pulverized coal boilers. No market for bottom ash from these boilers has been found by plant 1809 personnel, so the bottom ash handling systems would have to be segregated. Also, facilities to handle a larger percentage of fly ash would be installed with a pulverized unit.

Samples were taken at three different locations in the bottom asn sluicing system. These locations are shown in the bottom ash sluicing system diagram in figure VII-35 and are de cribed as follows:

- A sample was taken of the miscellaneous sump water,
- A sample was taken of the bottom ash pond overflow, and
- A sample was taken of the recirculating water from the final pond.

These samples provide data on the trace element, major species, and carbon dioxide content of transport streams at the settling ponds and of the sump water before the ponds. The trace elements analyzed for were silver, arsenic, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, and zinc. The major species assayed were calcium, magnesium, sodium, phosphate, sulfate, chloride, silicate, and carbon dioxide. The results of these analyses are presented in tables VII-32 and VII-33.

Table VII-32

TRACE ELEMENTS/PRIORITY POLLUTANTS CONCENTRATIONS[1,2]
AT PLANT 1809

(ug/l)[1]

	Sluice Water from Recirculation Pond	Bottom Ash Pond Overflow	Miscellaneous Sump
pH	7.9	7.9	7.7
Temp (°F)	80	85	80
Silver	<0.1[3]	<0.1	<0.1
Arsenic	66	12	12
Beryllium	<0.5	<0.5	<0.5
Cadmium	0.7	1.0	1.0
Chromium	3	<2	3
Copper	5	3	16
Mercury	<1.0	<1.0	4.0
Nickel	17	29	<3
Lead	<2	<2	3
Antimony	9	8	<3
Selenium	4	<2	<2
Thallium	62	56	6
Zinc	70	50	100

[1]All samples were analyzed in duplicate, the values were averaged.

[2]All analytical values are for dissolved concentrations, the samples were filtered initially.

[3]The value <.1 indicates that the concentration was below the detection limit which is 0.1 g/l.

Table VII-33

MAJOR SPECIES CONCENTRATIONS[1,2]
AT PLANT 1809

(mg/l)

	Sluice Water from Recirculation Pond	Bottom Ash Pond Overflow	Miscellaneous Sump
Calcium	125	115	63
Magnesium	60	58	24
Sodium	50	48	19
Phosphate (PO_4)	0.06	<0.06[3]	0.11
Sulfate (SO_4)	633	650	149
Chloride (Cl)	16	18	14
Silicate (SiO_2)	6	5	5
Carbonate (CO_3)	1080	1020	1800

[1] Ca, Mg, Na samples were analyzed in duplicate, the results were averaged.

[2] These concentrations reflect dissolved, not total, concentration.

[3] The value <.06 reflects a concentration below the detection limit which in this case is 0.06 mg/l.

Results from the sampling of trace elements indicate that only one concentration increased due to exposure to the bottom ash. The concentration of nickel in the bottom ash pond overflow is higher than in the final pond effluent which serves as the makeup water to the bottom ash sluicing system.

On the basis of this sampling and analysis, the tendencies for scaling in the sluice streams were determined through an aqueous equilibrium program. Based on the aqueous equilibrium results, of calcium carbonate theoretically has the greatest potential for precipitation in the sluice water from the final pond; next greatest in the bottom ash pond overflow, and the least potential in the miscellaneous sump stream. None of the streams indicated a high scaling potential.

The feasibility of a closed-loop zero discharge operation cannot be established based on the information available from this plant since there is fairly continous discharge. This discharge is due to an inherent accumulation of water in the recyle loop under certain operating conditions.

LOW-VOLUME WASTES

One treatment technology applicable for the treatment of low-volume waste streams is vapor-compression evaporation (VCE). Although this method of waste treatment is energy intensive, it yields a high-purity treated water stream and significantly reduces the wastewater effluent flow. A number of the low-volume waste streams described in Section V are suitable for VCE treatment. These streams are:

- Water Treatment
  - Clarifier blowdown (underflow)
  - Make-up filter backwash
  - Lime softener blowdown
  - Ion exchange softener regenerant
  - Demineralizer regenerant
  - Reverse osmosis brine
  - Evaporator bottoms
- Boiler blowdown
- Floor and laboratory drains.

The VCE process concentrates non-volatile effluents from these sources. This produces a concentrated brine which is usually ponded in arid regions or sent to a pond or treated in a spray dryer in non-arid regions (49).