REINHOLD ENVIRONMENTAL Ltd.

2019 REINHOLD Round Table Presentation

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

Worley
energy | chemicals | resources

Treating Wastewater from Equipment Washes

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June 24, 2019

EcoNomics

Discussion Topics

1. Introduction
2. What is wash water
3. Characterizing wash waters
4. Management options
5. Wash water considerations in a post-ELG, post-CCR world

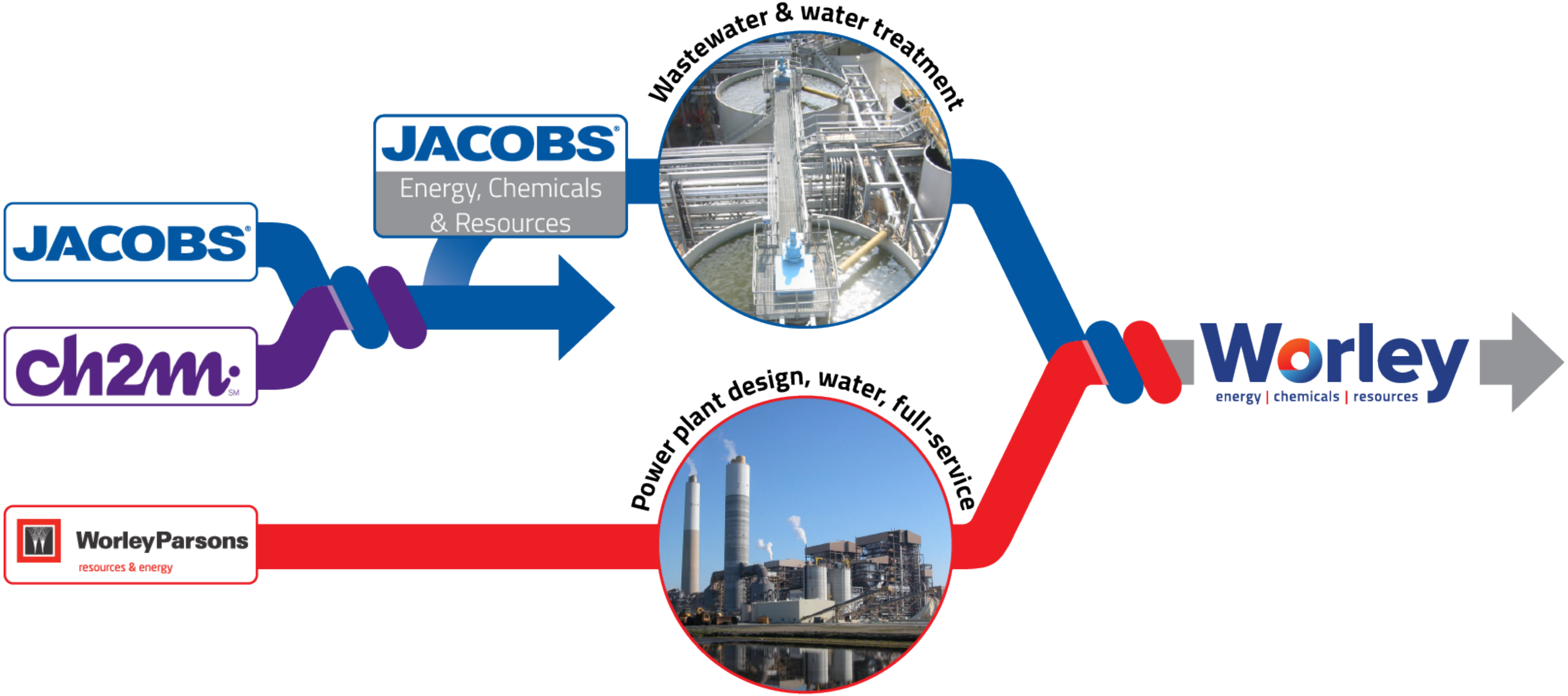
Thank You Co-Authors

- Jay Weist / Worley
- Paul Chu / Electric Power Research Institute
- Tom Higgins / Worley
- Laura Reid / Worley

01

Introduction

(Re-) Introduction



More offices. More countries. More people.
More to offer.

over
50
countries

almost
60,000
people

Together we are…

Acquired world-class expertise of CH2M with water and wastewater

Long successful record of delivering CCR/ELG projects

Fast adapting to the digital revolution

Self-performing construction of +2,500 craft

Market leader in Hydrocarbons; Chemicals; and Mining, Minerals, and Metals

Key player in the new energy transition

02

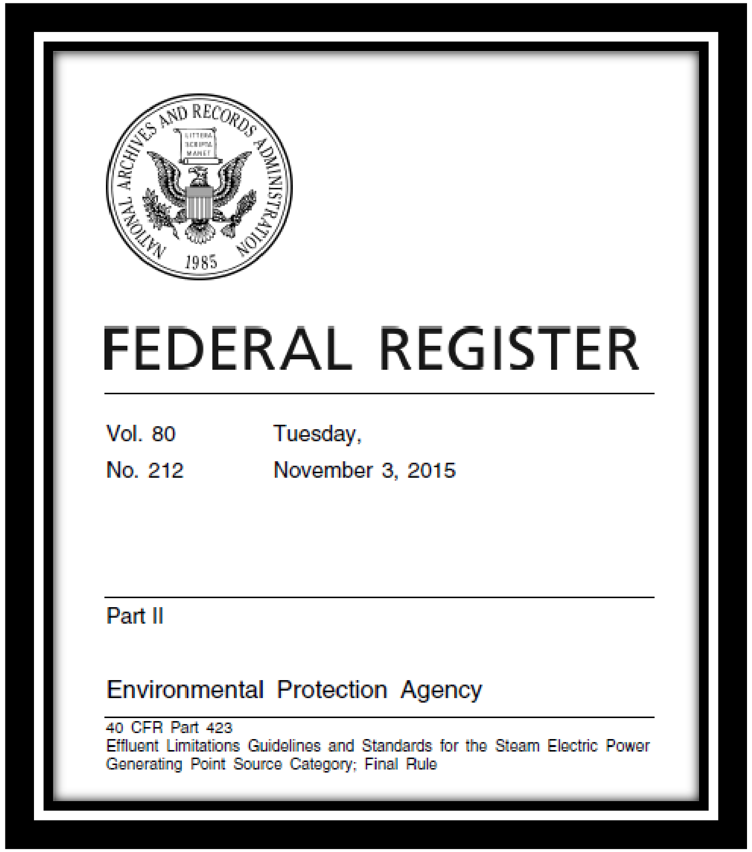
What is wash water?

What is wash water?

- Water after washing process equipment
- Wide variation in quality and quantity, can be up to several million gallons
- Relative to other (non-ash or FGD) water streams can be: acidic, high in suspended solids and some metals

Wash water in the 2015 ELG

- "Metal cleaning wastes: Any wastewater resulting from cleaning [with or without chemical cleaning compounds] any metal process equipment including, but not limited to, boiler tube cleaning, boiler fireside cleaning, and air preheater cleaning."
- Non-chemical metal cleaning wastes = wash without chemicals
- EPA continued to reserve BAT/NSPS/PSES/PSNS limits, as in earlier ELG
- EPA leaves states with discretion how to regulate, recommending to rely on BPJ and the permitting record


NATIONAL ARCHIVES AND RECORDS ADMINISTRATION 1985

FEDERAL REGISTER

Vol. 80 No. 212

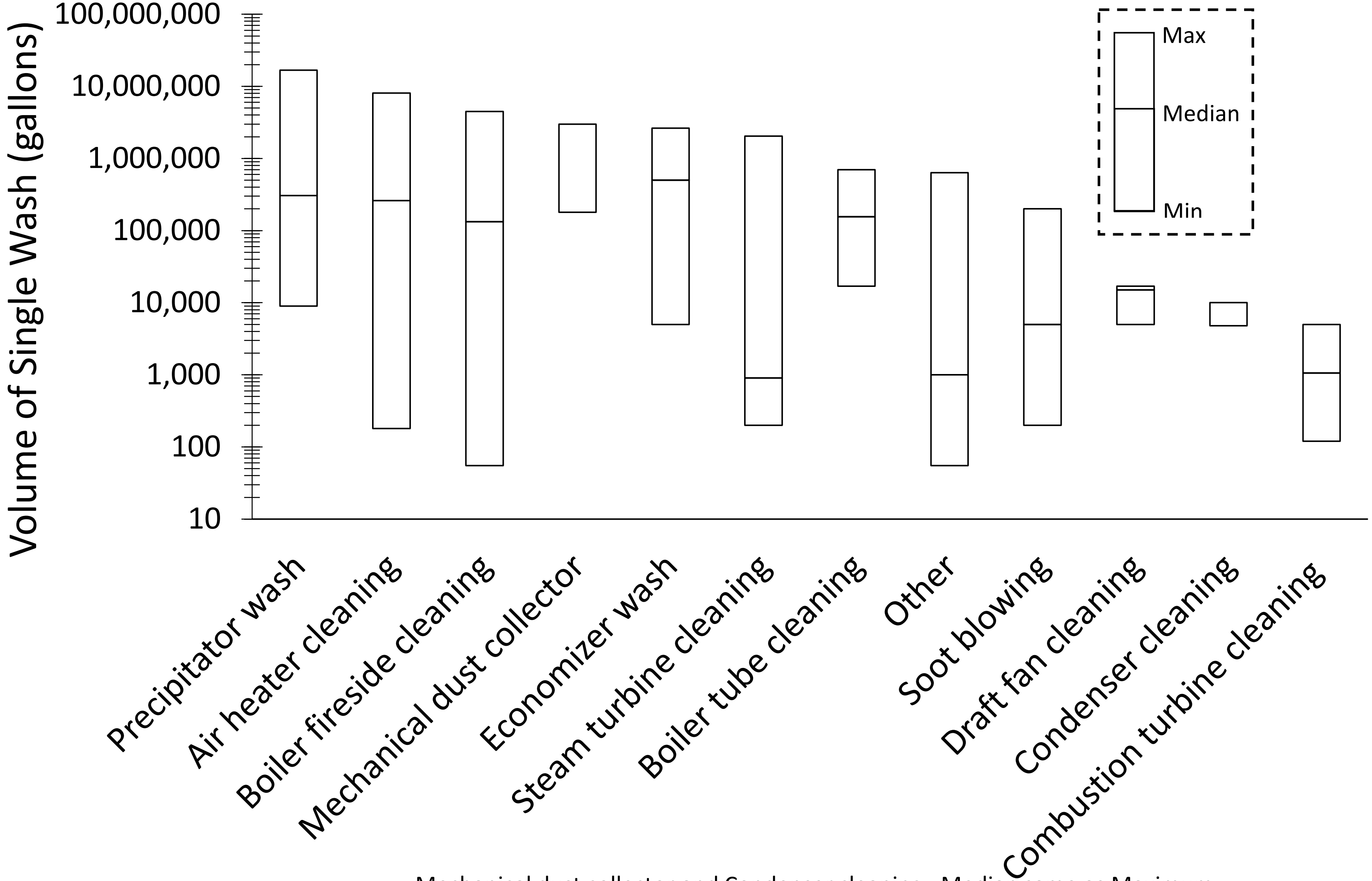
Tuesday, November 3, 2015

Part II

Environmental Protection Agency

40 CFR Part 423
Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category; Final Rule

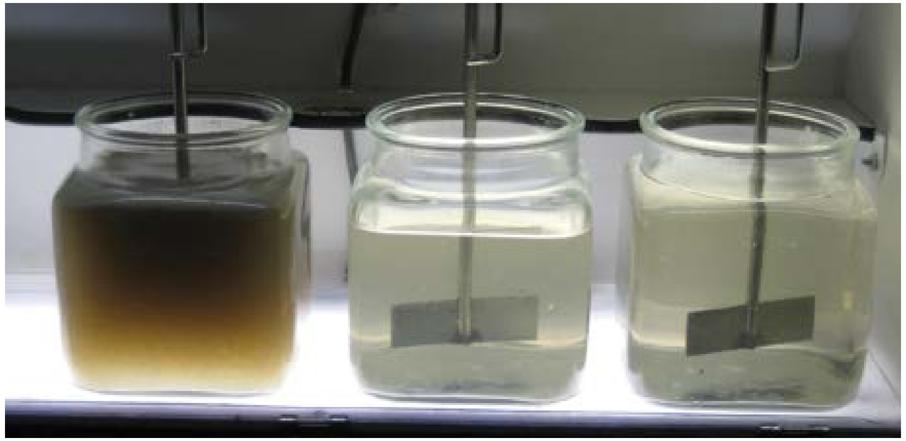
NCMCW Volumes



From ELG ICR Data

Mechanical dust collector and Condenser cleaning: Median same as Maximum.

Water quality of wash



- Can be high in suspended solids, acidity or alkalinity, metals (particulate and soluble)
- Wash water with fly ash – pH will be affected by coal type
- Example – air heater wash:
  - Removes deposited materials including sulfur oxides formed by coal combustion, and ferrous iron from oxidation of system metal
  - Sulfur oxides form sulfurous and sulfuric acid; these depress pH, resulting in low-pH, high soluble (ferrous) iron
  - High-Calcium coal (PRB) generates CaO, which raises the pH

03

Characterizing your wash water

To understand how to manage need flow and quality

- Identify types of NCMCW
  - Determine if wash will be generated when co-managed wastewaters will be produced. Impacts if have to increase size of treatment system.
  - Characterize wash with the largest flow / worst-case water quality
- Flow
  - Estimate the flow and frequency of largest washes
  - Often not known or metered
  - Can be estimated using operational insights

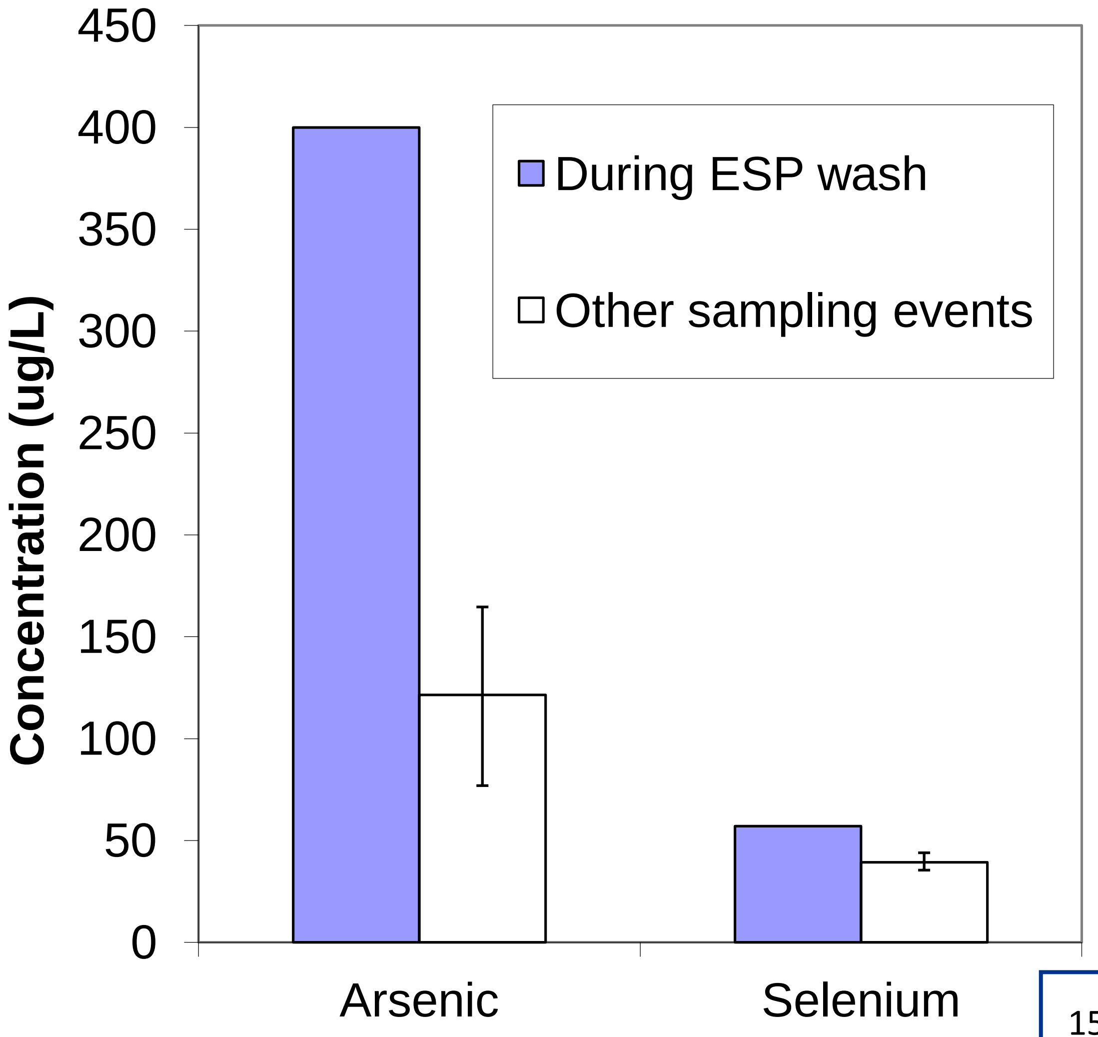
To understand how to manage need flow and quality

- Water quality
  - Can change by an order of magnitude during a wash so collect multiple samples
    - If spike will hit treatment - analyze separately
    - If will equalize before sent to treatment - analyze composited into a single sample
  - Challenging to develop sampling scheme to get data needed to understand treatment requirements
  - Analyze for iron, copper, TSS, O&G, pH; and parameters regulated in plant’s outfall
  - For sizing chemical feed and aeration systems also analyze: pH, acidity or alkalinity*, and ferrous iron
    - Rather than full acidity or alkalinity, instead do titration to determine amount of caustic needed to bring samples to neutral. If PRB, how much acid needed.
  - Plan ahead – may not get many chances at infrequent washes

Understanding impact on site-specific wastewater management

Case Study - Impact of wash on As and Se in Pond

- EPRI PISCES Site B – wet fly and bottom ash; no FGD
- Effect of ESP wash on ash pond water near discharge shows potential for WQBEL issues
- Single-unit plant so wash came when other streams not flowing to pond
- Impacts seen on Day 2; despite only 5 MG wash water into 60 acre pond



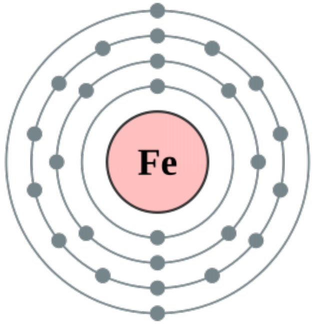
04

Wash water management examples and lessons

Wash water treatment overview

- If required to install separate treatment:
  - Size to handle large, intermittent volumes of water
  - Equalize flow to reduce size of treatment; use tank or lined pond
  - Consider trucking off-site, though big cost if high-flow
- If treated comingled with other water streams:
  - Size treatment system for NCMCW's flow surge, along with other consistent streams

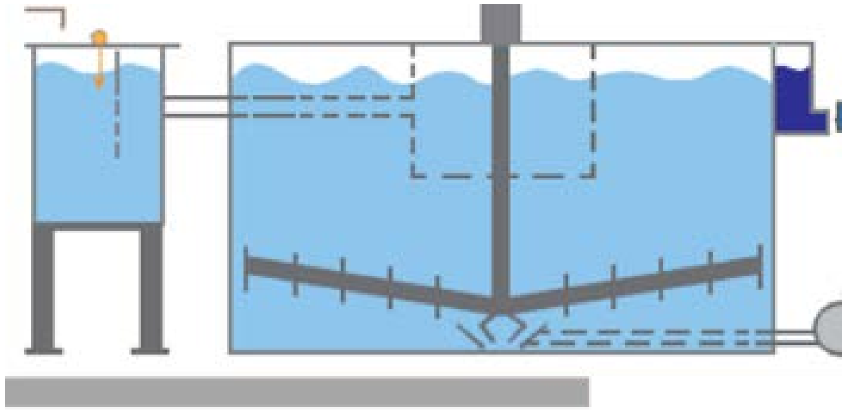
Case Study #1 – Pond-based treatment for Iron



- Pond outfall has 1 mg/L iron limit. Typically is met, but when not met has mostly been following an air heater wash.
- Characterized wash:
  - 1 MG over 2 days
  - Soluble iron in wash water: median is 900 mg/L (up to 1600 mg/L). Likely is ferrous iron.
  - pH 2 to 6
- Improved removal by:
  - Added aeration to oxidize ferrous (and provide chemical mixing)
  - Caustic to raise pH to neutral
  - Ensure sufficient time for settling
  - Also may need to provide polymer to help settling
  - Raising pH needed to speed oxidation of ferrous, which then precipitates and settles out

Case Study #2 – Design of tank-based

- Example: separate FGD treatment, dry fly ash, and closed-loop bottom ash. Left other wastewater (including wash water) to treat by: equalization, chemical mixing, and clarifier.
- Sized treatment for largest flows to this system under normal conditions - cooling tower blowdown: ~ 3,000 gpm
- Each air preheater wash: 1 MG over 2 days; ~350 gpm avg
- Management:
  - Increased capacity of new treatment system – including aeration, caustic feed
  - Sized treatment system equalization to equalize flow
  - Control operations to minimize or eliminate multiple simultaneous equipment washes

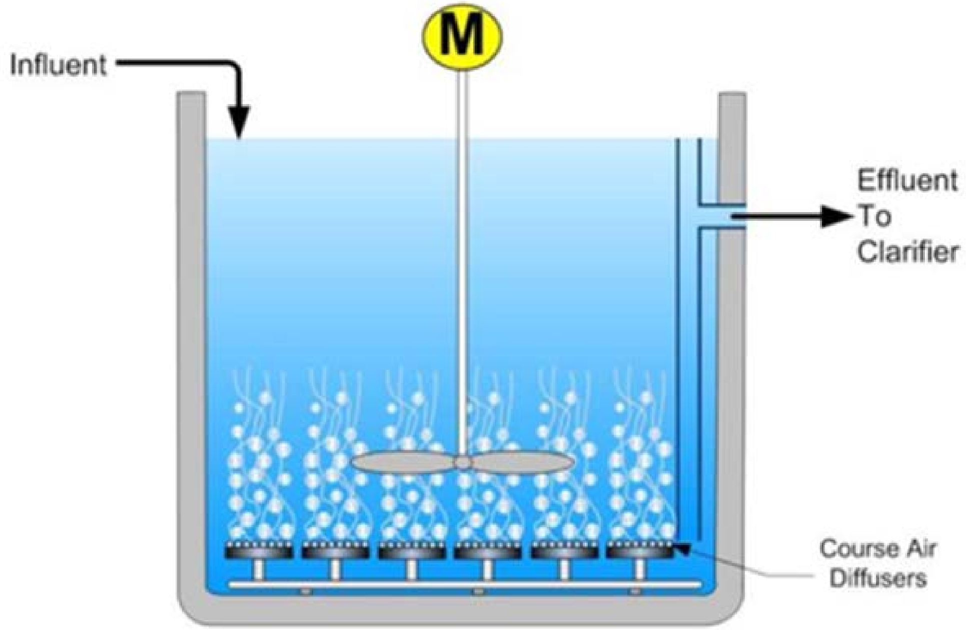


Case Study #3 – Design of tank-based

- Treatment system for bottom ash water and Other waters
- Issues – Air Heater Wash has:
  - Low pH and high acidity
  - Ferrous iron
- Design for wash by:
  - Neutralize this high acidity
  - Oxidize ferrous iron, precipitate and remove

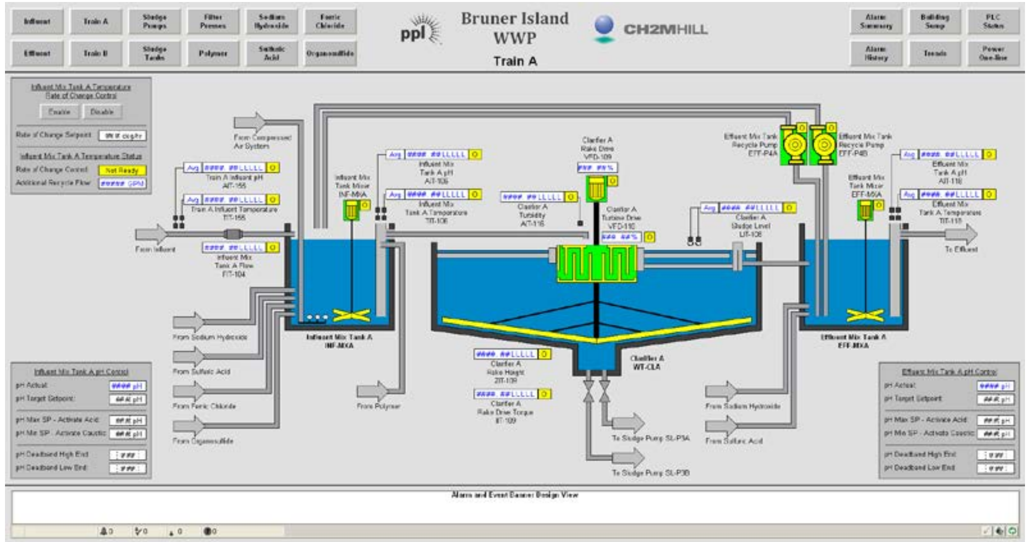
Ferrous Iron Oxidation

$$4\ Fe^{+2} + O_2 + 10\ H_2O \rightarrow 4\ Fe(OH)_3 + 8\ H^+$$



Case Study #3 – Design of tank-based

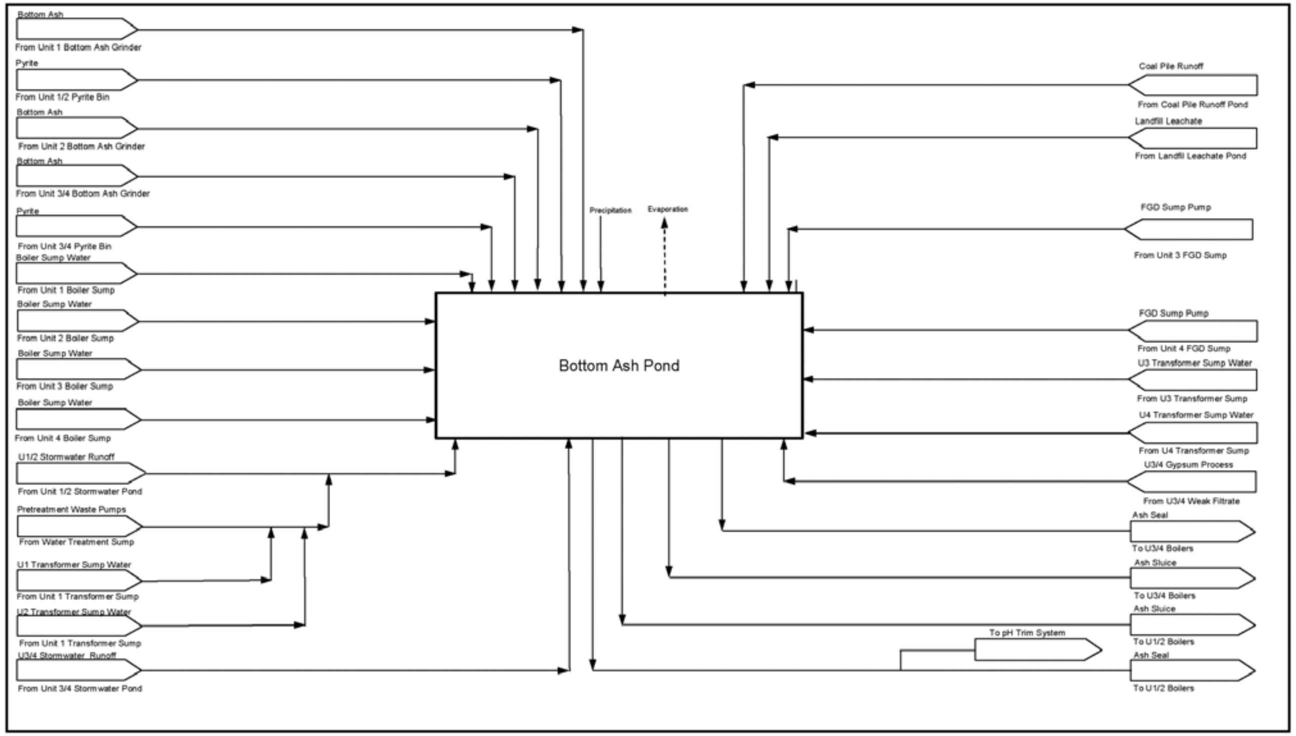
- Method
  - Pre-treat with 50 lb lime bags at conveyance sump
  - Monitor pH at EQ Pond
  - Increase caustic feed to Influent Mix Tanks
  - Aerate Influent Mix Tanks



- Lessons from Startup
  - Need frequent monitoring of influent pH and mix tank pH
  - Establish maximum allowable influent and tank pH differential (add additional lime bags if differential is exceeded)
  - Verify maximum flow settings are selected for chemical pumps
  - Clean sludge pump screens and create volume in sludge holding/storage tanks

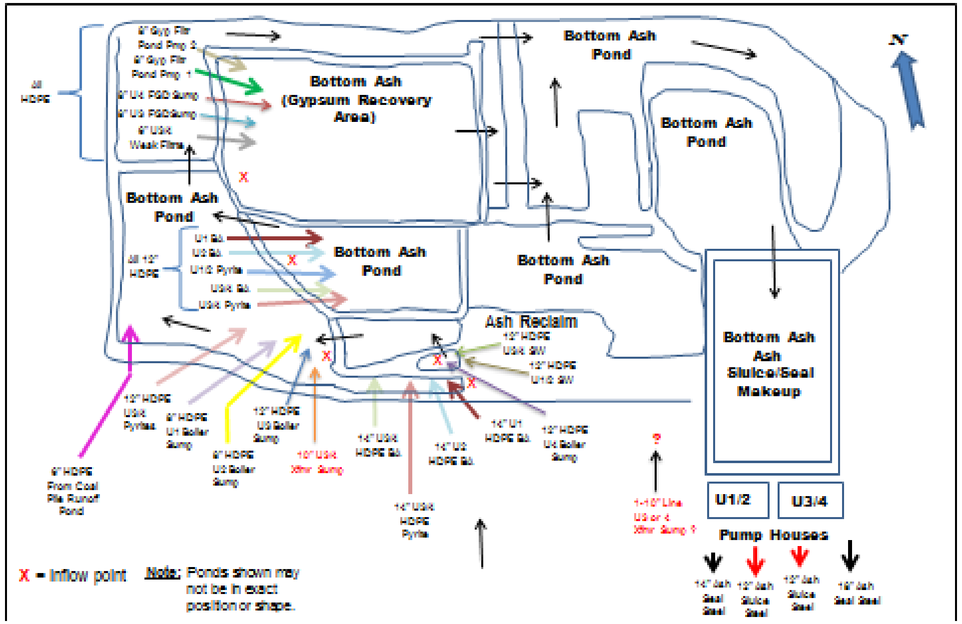
Case Study #4 – Treatment approach

- Consider existing site conditions
- Bottom ash pond discharge – single primary outfall
- NPDES permit review and future discharge scenarios
- Communication with permit authority/agency
- Categorize wastewater streams
  - Bottom Ash Transport Water
  - Pyrites/Economizer/SCR Ash Sluicing
  - Coal Pile Runoff
  - Low Volume Waste
  - FGD Blowdown
  - Non-chemical Metal Cleaning Waste
    - Air Pre-heater Wash water



Case Study #4 – Planning – Compliance plan approach

- Data Collection
  - Accurate water balance
    - Connectivity
    - Flow



Flow Meter	Weekly Average Flow Rate Location	Current Date 11/20/2015
FM-01	FGD Sump Unit 4	478.17
FM-02	FGD Sump Unit 3	363.66
FM-03	Sewage Plant	8.1
FM-04	Service Water to FGD Processing Unit 3 & 4	528.64
FM-05	Boiler Sump Unit 3 Pump A	0
FM-06	Boiler Sump Unit 3 Pump B	1406.03
FM-07	Formatted Site 7 Flow Data Boiler Sump Unit 4 Pump A	10.13
FM-08	Formatted Site 8 Flow Data Boiler Sump Unit 4 Pump B	1074.35
FM-09	Transformer Sump Unit 3	2.07
FM-10	Transformer Sump Unit 4	11.37
FM-11	Bottom Ash Unit 3	525.3
FM-12	Bottom Ash Unit 4	406.44
FM-13	Pyrites Unit 3	466.3
FM-14	Pyrites Unit 4	94.57
FM-15	(former FGD Sump Unit 1) Fines Transfer Pump	101.64
FM-16	FGD Sump Unit 2	28.37
FM-17	Transformer Sump Unit 1 & 2	121.95
FM-18	Gypson Filtrate Pond Unit 1 & 2 P1 Line	391.3
FM-19	Gypson Filtrate Pond Unit 1 & 2 P2 Line	255.5
FM-20	Pretreatment Sump	186.88
FM-21	Filtrate Overflow Sump Pump 174A Unit 1 & 2	62.92
FM-22	Filtrate Overflow Sump Pump 174B Unit 1 & 2	26.7
FM-23	Filtrate Tank 171 Pump Discharge Unit 1 & 2	20.89
FM-24	Filtrate Tank 172 Pump Discharge Unit 1 & 2	30.23
FM-25	Service Water to Unit 1 & 2 Gypsum Dewatering	70.37
FM-26	Boiler Sump Unit 1	9.54
FM-27	Firewater Unit 1 & 2	784.7
FM-28	Bottom Ash Unit 1	2072.2
FM-29	Pyrites Unit 1	327.1
FM-30	Firewater Unit 3 & 4	0
FM-31	FGD Gypsum W/L Filtrate Unit 3 & 4 (Blowdown Tank)	49.85
FM-32	Seal Water Return Sump Unit 3 & 4	100.19
FM-33	Wash Down Sump Unit 3 & 4	316.3
FM-34	Boiler Sump Unit 2	385.7
FM-35	Bottom Ash Unit 2	1485.8
FM-36	Pyrites Unit 2	17.0
FM-37	Boiler Sump Unit 1 Pump A	0

Case Study #4 – Planning – Compliance plan approach

- Analysis/Characterization of Streams
  - Chemical properties
    - Sampling
    - Analysis

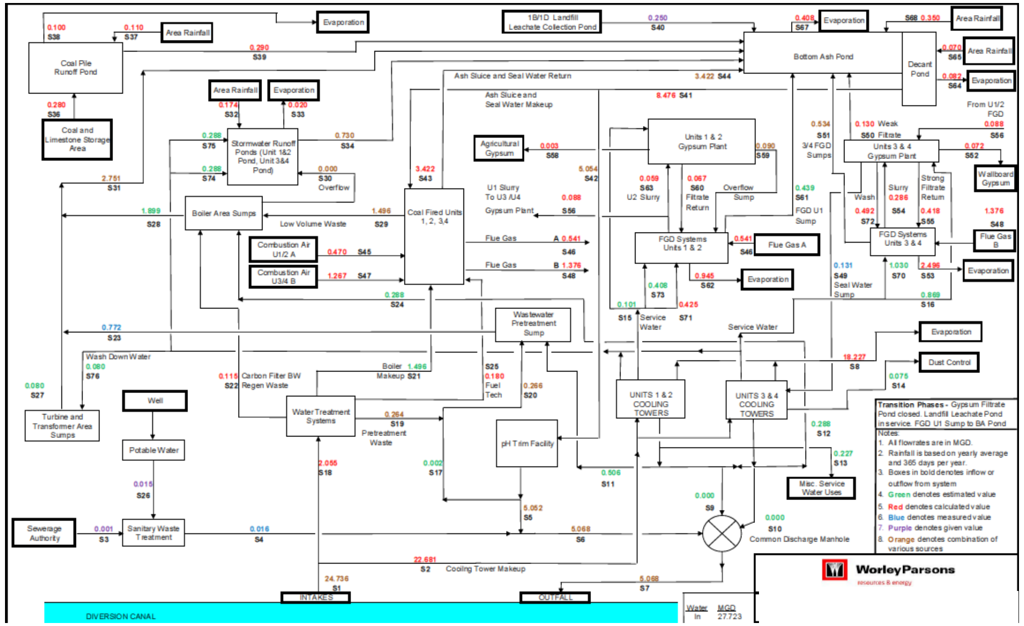
Stream	SAMPLES Description	Analysis Sheet	Sample
1	Makeup Water to Lake Juliette from Ocmulgee River	1	Y
3	Service Water (General Service Water)	1	Y
30	Gypsum Slurry Transfer Tank to Gypsum Stack	4	Y
31	Gypsum Stack Filtrate to Clear Water Pond	4	Y
32	Clear Water to Return Water Tanks	4	Y
33	Clear Water Pond Purge to Ash Pond	4	Y
45	Gypsum Slurry Transfer Tank Sump Discharge to Gypsum Slurry Transfer Tank	4	Y
50A	U1&2 Water Plants Waste to Waste Blending Sump	2	Y
50B	U3&4 Water Plants Waste to Waste Blending Sump	2	Y
53A	U1&2 Demin Waste to Waste Blending Sump	2	Y
53B	U3&4 Demin Waste to Waste Blending Sump	2	Y
56A	U1 Boiler Blowdown	2	Y - one unit represents all
56B	U2 Boiler Blowdown	2	N
57A	U3 Boiler Blowdown	2	N
57B	U4 Boiler Blowdown	2	N
64-1	U1&2 Power House Floor Drains Discharge to Wastewater Basins	3	Y Manhole
64-2	U3&4 Power House Floor Drains Discharge to Wastewater Basins	3	Y Manhole
65A	U1&2 Waste Blending Sump Discharge to Wastewater Basins	2	N
65B	U3&4 Waste Blending Sump Discharge to Wastewater Basins	2	N
66	Chemical Waste Basins Discharge to Wastewater Basins	2	N
68	No. 1 STP Discharge to Ash Pond	1	Y
69	No. 2 STP Discharge to Wastewater Basins	1	Y
70	No. 4 STP Discharge to Coal Pile Runoff Pond	1	Y
71	Wastewater Basins Discharge to Ash Pond	3	Y
74	Coal Pile Runoff Discharge to Ash Pond	3	Y
75A	U1 Precipitator Washdown Sump Discharge to Ash Pond	3	Y
75B	U2 Precipitator Washdown Sump Discharge to Ash Pond	3	Y
75C	U3 Precipitator Washdown Sump Discharge to Ash Pond	3	Y
75D	U4 Precipitator Washdown Sump Discharge to Ash Pond	3	Y
76	Ash Pond Discharge to Settling Pond	2	Y
77	Settling Pond Recycle to Ash System	2	Y
79	U1&2 Bottom Ash Sluice	3	Y
80	U3&4 Bottom Ash Sluice	3	Y
81	U1&2 Fly Ash Sluice	3	N
82	U3&4 Fly Ash Sluice	3	N
83	Ash System Bleedof to NPDES Basin	1	Y
84	NPDES Basin Discharge to Ocmulgee River	1	Y
90	Detention Pond Discharge to Ocmulgee River	1	N
70A-1	C transfer house sump eductor pump (Coal Pile Pond Stream)	3	Y
70A-2	A transfer house sump eductor pump (Coal Pile Pond Stream)	3	Y
70A-3	B transfer house sump eductor pump (Coal Pile Pond Stream)	3	Y
70A-4	Reclaim sump eductor pump (Coal Pile Pond Stream)	3	Y
70B	Oil Water Seperator (WW-OS-6001) to Wastewater Collection Manhole (Coal Pile Pond Stream)	2	Y
70A-5	C crusher house drain/ sump (lift station) (Coal Pile Pond Stream)	3	Y
70C	15 in corrugated pipe into south end of coal pile from Wastewater Collection Manhole (Coal Pile Pond Stream)	3	Y
64A-1	Pulverizer oil coolers (WW Basin) Unit 1 - 2 per unit	2	Y - one for unit 1 or 2
64A-2	Pulverizer oil coolers (WW Basin) Unit 2 - 2 per unit	2	N
64A-3	Pulverizer oil coolers (WW Basin) Unit 3 - 2 per unit	2	Y - one for unit 3 or 4
64A-4	Pulverizer oil coolers (WW Basin) Unit 4 - 2 per unit	2	N
64B-1	Plant air compressor motor coolers Unit 1 - 2 per unit	2	Y - one unit represents all
64B-2	Plant air compressor motor coolers Unit 2 - 2 per unit	2	N
64B-3	Plant air compressor motor coolers Unit 3 - 2 per unit	2	N
64B-4	Plant air compressor motor coolers Unit 4 - 2 per unit	2	N
64C-1	Condensate motor bearing coolers Unit 1 - 3 per unit	2	Y - one unit represents all
64C-2	Condensate motor bearing coolers Unit 2 - 3 per unit	2	N
64C-3	Condensate motor bearing coolers Unit 3 - 3 per unit	2	N

SAMPLE LOCATION: 50A, 50B, 53A, 53B, (56A, 56B, or 57A), 57B, 65A, 65B, 66, 76, 77, 70B, (64A-1 or 64A-2), (64A-3 or 64A-4), (64B-1, 64B-2, 64B-3, or 64B-4), (64C-1, 64C-2, 64C-3, or 64C-4), (64E-1, 64E-2, 64E-3, or 64E-4)

Parameter	Units	USEPA / SM Method	Limits of Detection (MDL)	Analysis / Collection	Time
		If Blank - To Be Filled In By Bidder	If Blank - To Be Filled In By Bidder		If Blank - To Be Filled In By Bidder
Alkalinity, Total	mg/L	310.2	0.725	Required / Required	10 to 14 d
Aluminum	ug/L	200.8	15	Required / Required	10 to 14 d
Antimony	ug/L	200.8	1	Required / Required	10 to 14 d
Arsenic, Total	ug/L	200.8	1.7	Required / Required	10 to 14 d
Barium	ug/L	200.8	0.6	Required / Required	10 to 14 d
Biochemical Oxygen Demand (BOD5)	mg/L	5210 B	1	Required / Required	14 d TAT
Boron	ug/L	200.8	4	Required / Required	10 to 14 d
Cadmium, Total	ug/L	200.8	0.11	Required / Required	10 to 14 d
Calcium	mg/L	200.8	0.06	Required / Required	10 to 14 d
Chemical Oxygen Demand (COD)	mg/L	410.4	1	Required / Required	
Chloride (as Cl)	mg/L	300.0	0.067	Required / Required	10 to 14 d
Chromium, Hexavalent (dissolved)	ug/L	7196A	3	Required / Required	7 to 10 d
Chromium, Total	ug/L	200.8	2	Required / Required	10 to 14 d
Coliform	MPN/100ml	A-1 Broth MPN	2 (neat)/1,600	Not Required / Not Required	
Conductivity	mmhos/cm	Measured at source	0.001	Required / Required	
Copper, Total	ug/L	200.8	0.35	Required / Required	10 to 14 d
Hardness, Total (as CaCO3)	mg/L	130.1 or 2340B/C	1	Required / Required	10 to 14 d
Iron, Total	ug/L	200.8	33	Required / Required	10 to 14 d
Iron, Dissolved	ug/L	200.8	33	Required / Required	
Lead, Total	ug/L	200.8	0.5	Required / Required	10 to 14 d
Magnesium	mg/L	200.8	0.01	Required / Required	10 to 14 d
Manganese	ug/L	200.8	1	Required / Required	10 to 14 d
Mercury	ng/L	1631E	0.2	Required / Required	14 d to 21 d
Molybdenum	ug/L	200.8	0.165	Required / Required	10 to 14 d
Nickel	ug/L	200.8	0.5	Required / Required	10 to 14 d
Nitrate (as NO3)	mg/L	EPA 300.0	0.033	Required / Required	
Nitrogen, Ammonia	mg/L	EPA 350.1	0.017	Required / Required	10 to 14 d
Nitrogen, Kjeldahl (TKN)	mg/L	EPA 351.2	0.033	Not Required / Not Required	
Nitrogen, Total (Nitrite + Nitrate + TKN)	mg/L	EPA 353.2 / EPA 351.2	0.033	Not Required / Not Required	
Oil and Grease (hexane)	mg/L	(Hexane) 1664 A	1.4	Required / Required	10 to 14 d
pH	S.U	Measured at source	0.01	Required / Required	
Phosphate (as PO4) - ppm	mg/L	EPA 300.0	0.067	Required / Required	
Phosphorus, Total	mg/L	EPA 365.4	0.06	Required / Required	
Potassium (as K)	mg/L	200.8	0.08	Required / Required	
Selenium, Total	ug/L	200.8	1.5	Required / Required	10 to 14 d
Silica, Reactive (as SiO2)	mg/L	EPA 200.7	0.053	Not Required / Not Required	
Silica, Total (as SiO2)	mg/L	EPA 200.7	0.053	Required / Required	
Sodium	mg/L	200.8	0.08	Required / Required	10 to 14 d
Solids, Total Dissolved (TDS)	mg/L	2540 C	2.38	Required / Required	10 to 14 d
Solids, Total Suspended (TSS)	mg/L	2540 D	1.14	Required / Required	10 to 14 d
Sulfate (as SO4)	mg/L	EPA 300.0	0.133	Required / Required	
Thallium (as Tl)	ug/L	200.8	0.45	Required / Required	
Temperature	° F	Measured at source		Required / Required	
TOC - ppm	mg/L	SM 5310 D	0.33	Not Required / Not Required	
Turbidity	NTU	Measured at source	0.1	Required / Required	
Vanadium, Total	ug/L	200.7	1	Required / Required	10 to 14 d
Zinc, Total	ug/L	200.8	4	Required / Required	10 to 14 d

Case Study #4 – Planning – Compliance plan approach

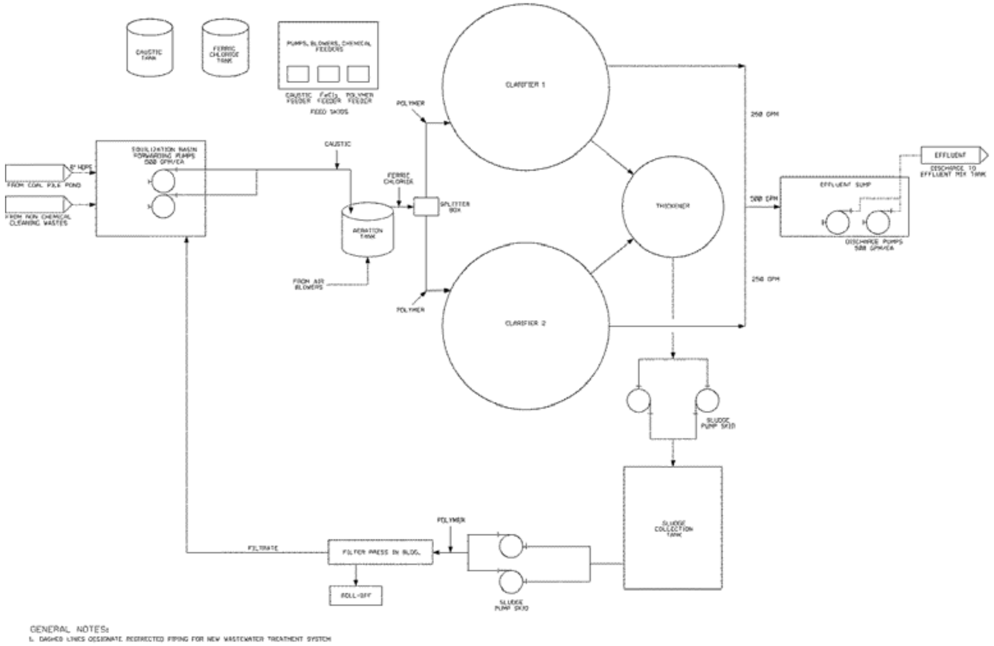
- Documentation
  - Create “As-Is” baseline water balance
  - Plant chemistry model
  - Supports “future scenario” planning



Boiler Sumps	Case Evaluated:	Case 1A GPM								
				Influent Flows to Process				Effluent Flows from Process		
Contaminant	Units	Conduct Conv	CaCO3 Conv Factors	S29 Water Into Boiler Sumps from Power Island	S24 U3/U4 CTBD Svc Water to Boiler Sumps	S22 Regeneration Waste	Total Influent	S30 Boiler Sump Overflow Into Stormwater Pond	S28 Water Out of Boiler Sumps	Boiler Sumps Reserved
Flow	GPM	0.00	0.00	1038.89	200.00	79.86	1318.75	0.00	1318.75	0.00
Alkalinity-Bicarbonate	mg/L	0.72	0.82	7.10	64.01	3554.67	230.57	7.10	7.10	7.10
Alkalinity-Carbonate	mg/L	2.82	1.67	0.00	0.05	0.00	0.01	0.00	0.00	0.00
Alkalinity-OH	mg/L	0.00	2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barium	mg/L	0.00	0.73	0.09	0.09	0.12	0.09	0.09	0.09	0.09
Chloride	mg/L	2.14	1.41	812.67	48.09	162.67	657.35	812.67	812.67	812.67
Fluoride	mg/L	0.00	2.66	0.00	0.51	0.00	0.08	0.00	0.00	0.00
Calcium	mg/L	2.6	2.50	580.67	14.70	9.62	460.25	580.67	580.67	580.67
Magnesium	mg/L	3.82	4.12	162.33	12.63	1.04	129.86	162.33	162.33	162.33
Iron	mg/L	0.00	1.79	2.38	0.29	0.00	1.92	2.38	2.38	2.38
Nitrate (as NO3)	mg/L	1.15	0.81	1.61	0.32	1.23	1.39	1.61	1.61	1.61
pH	s.u.	0.00	0.00	6.97	7.20	12.79	7.35	6.97	6.97	6.97
Phosphate	mg/L	0.00	1.58	0.00	7.00	0.00	1.06	0.00	0.00	0.00
Potassium	mg/L	1.84	1.28	12.00	15.75	53.53	15.08	12.00	12.00	12.00
Silica	mg/L	0.00	0.83	19.63	49.05	97.46	28.81	19.63	19.63	19.63
Sodium	mg/L	2.13	2.18	185.33	59.58	3372.50	359.27	185.33	185.33	185.33
Sulfate	mg/L	1.54	1.04	1196.67	78.13	2656.67	1115.45	1196.67	1196.67	1196.67
Other 1	Total Alkalinity		mg/l CaCO3	454.57	77.68	0.00	369.88	5.82	5.82	5.82
Other 2	Total Dissolved Solids		mg/l	3173.33	242.56	7910.00	3015.70	3173.33	3173.33	3173.33
Other 3	Field Conductivity		uS/cm	3643.33	483.26	16700.00	3954.77	3643.33	3643.33	3643.33
Other 4	Arsenic		ug/l	5.81	0.00	0.00	4.57	5.81	5.81	5.81
Other 5	Boron		ug/l	21666.67	201.48	507.75	17129.94	21666.67	21666.67	21666.67
Other 6	Mercury		nG/L	310.67	2.42	5.76	245.45	310.67	310.67	310.67
Other 7	Selenium		ug/l	40.40	0.00	0.00	31.83	40.40	40.40	40.40
Other 8	Cadmium		ug/l	6.16	0.00	0.00	4.86	6.16	6.16	6.16
Other 9	Copper		ug/l	17.07	6.67	1.95	14.57	17.07	17.07	17.07
Other 10	Lead		ug/l	1.01	0.00	0.00	0.80	1.01	1.01	1.01
Total Suspended Solids	mg/L			126.07	10.12	17.57	101.91	126.07	126.07	126.07
Total Dissolved Solids	mg/L			2980.48	350.20	9909.49	3001.18	2980.48	2980.48	2980.48
Specific Conductance	umhos/cm			6135.59	511.86	14293.27	5776.71	6135.59	6135.59	6135.59
Free CO2	mg/L			39.00	4.24	0.00	14.68	1.28	1.28	1.28
Total Cations	mg/L CaCO3			2544.18	239.41	7448.98	2491.67	2544.18	2544.18	2544.18
Total Anions	mg/L CaCO3			2846.27	239.41	2993.29	2459.82	2397.52	2397.52	2397.52
Total Hardness	mg/L CaCO3			2120.48	88.78	28.33	1685.66	2120.48	2120.48	2120.48

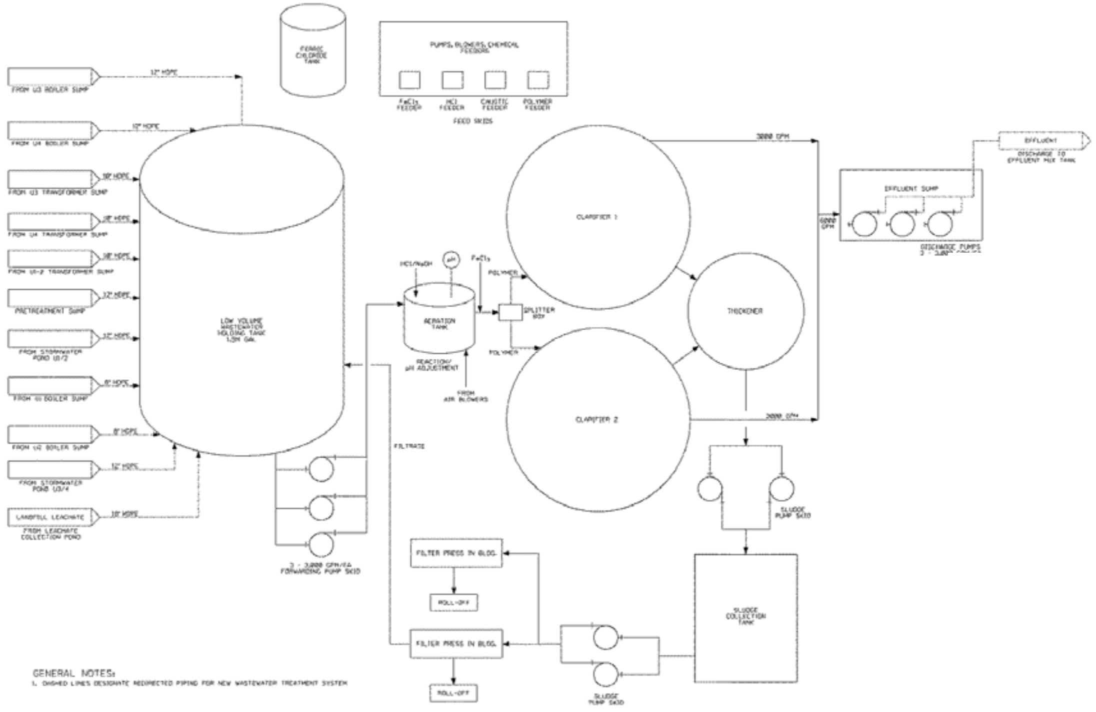
Case Study #4 – Treatment Approach

- Develop treatment plan
  - Coal pile runoff treatment
    - Co-treat NCMCW, air pre-heater wash water
      - similar treatment characteristics (acidity, iron, suspended solids, pH adjustment, oxidation, metal hydroxides precipitation, solids separation, dewatering)
    - Capacity - use coal pile pond surge during high runoff to forward to sized equalization basin for week duration of batch operation
    - 500 gpm, not continuous, intermittent operation
    - Physical/chemistry treatment



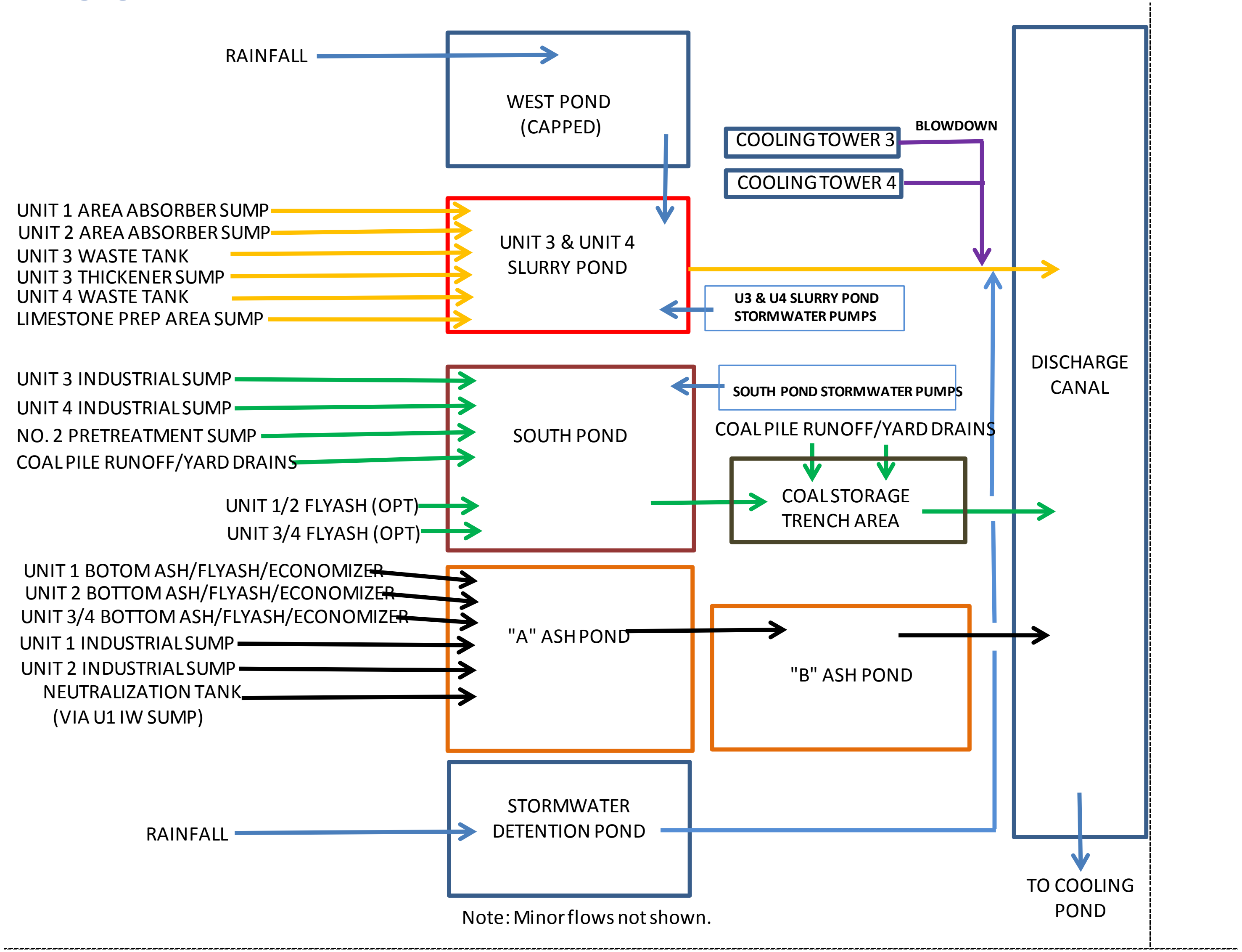
Case Study #4 – Treatment Approach

- Develop treatment plan
  - Low volume waste treatment
    - Wastewater from the Boiler Sumps, Transformer Sumps, Pretreatment Sump, and Stormwater Ponds
    - Co-treat Landfill Leachate
    - Capacity – document flows from historical data capturing operating range, use surge pond for outage support, and equipment redundancy for high availability
    - 6,000 gpm, continuous operation
  - Physical/chemistry treatment
    - Primary treatment (pH adjustment, oxidation, solids separation, dewatering)



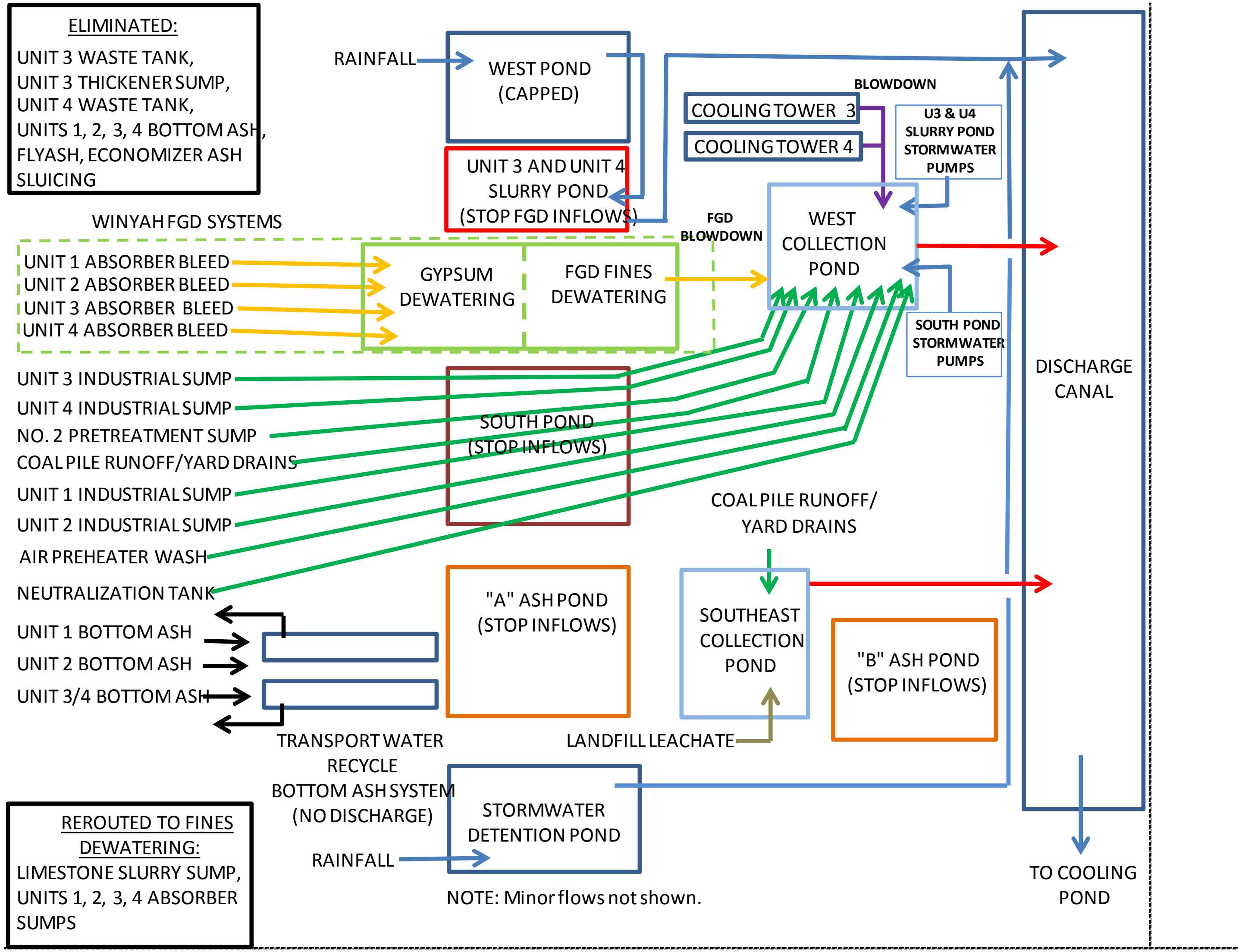
Case Study #5 – Treatment Approach

- Consider existing site conditions
- Cooling pond discharge – single primary outfall
- NPDES permit review and future discharge scenarios
- Communication with permit authority/agency



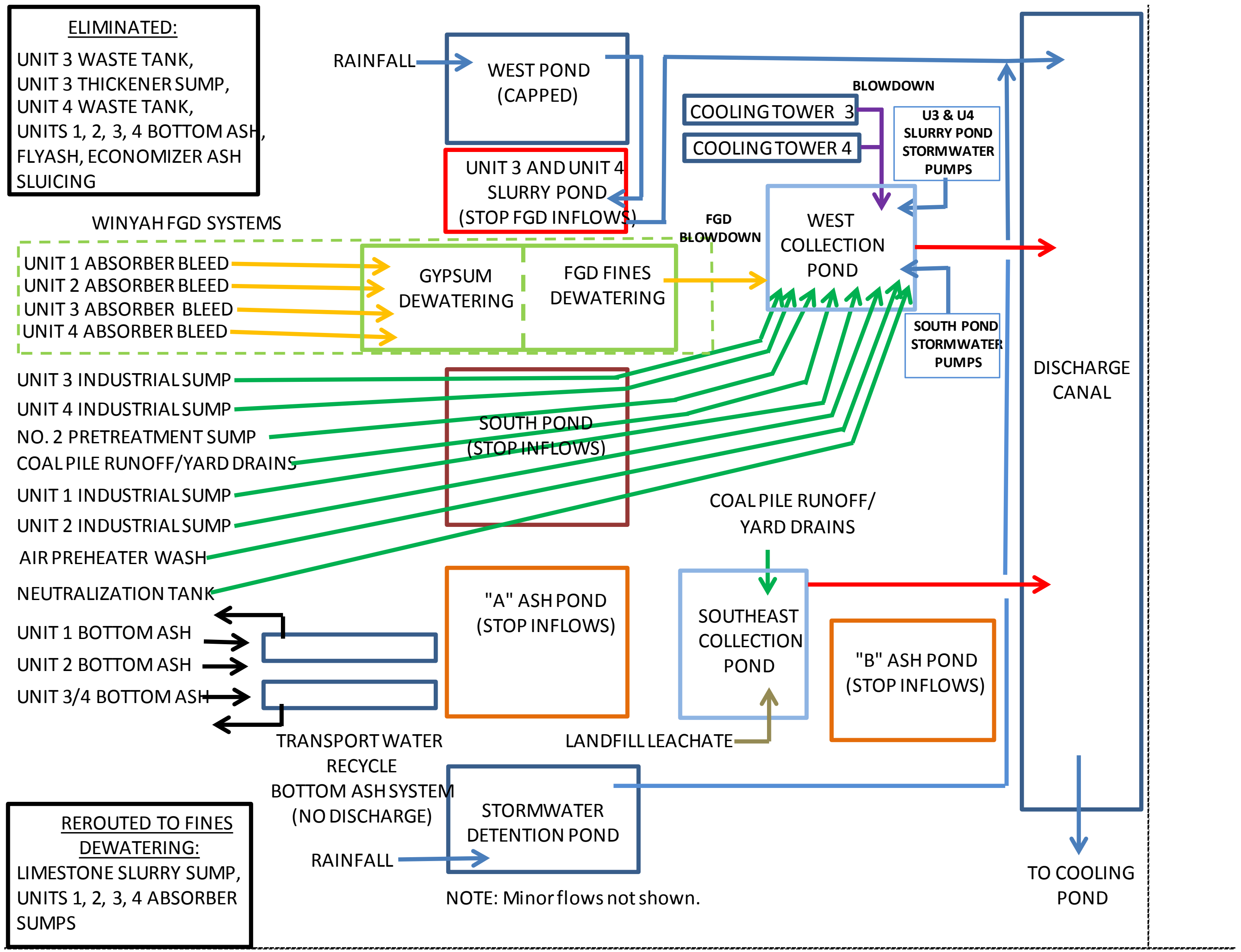
Case Study #5 – Treatment Approach

- Categorize wastewater streams
  - Bottom Ash/Economizer Sluicing
  - Low Volume Wastewater
  - Non-chemical Metal Cleaning Waste
    - Air Pre-heater Wash water



Case Study #5 – Treatment Approach

- Categorize wastewater streams
  - Bottom Ash Transport
  - Economizer Dry Handling
  - Low Volume Wastewater
  - Non-chemical Metal Cleaning Waste
    - Air Pre-heater Wash water
- LVW Collection System
  - Collect and treat LVW and NCMCW
  - Solids separation, settling



Case Study #6 – Treatment approach

- Coal Pile
  - PRB Coal
- Coal Pile Runoff Pond
- Rainfall Data
- Additional Process Flow
  - 2,800 gpm (8 hrs in every 24 hours)
- Precip Wash Water
  - Outage Maintenance – Non-chemical Metal Cleaning Waste (NCMCW)

Case Study #6 – Project description

- Coal Pile Runoff
  - Discharge to Ash Pond
  - Need to redirect flow
  - 6,000 gpm
  - 24 hour 25-year storm event
  - Peak runoff flow during 8 hour period
- Nonchemical Metal Cleaning Waste (NCMCW)
  - Precip Wash Water
  - Discharge to Ash Pond
  - Need to redirect flow
  - 400 gpm (6 continuous days – 24 hours per day operation)

Case Study #6 – Project description

- Not a NPDES permitted facility for outfall discharge
- Internal process treatment only
- Alternative processing to the ash pond
- Develop pilot test plan
- Parametric testing
- Sampling/analysis
- Jar testing
- Design basis

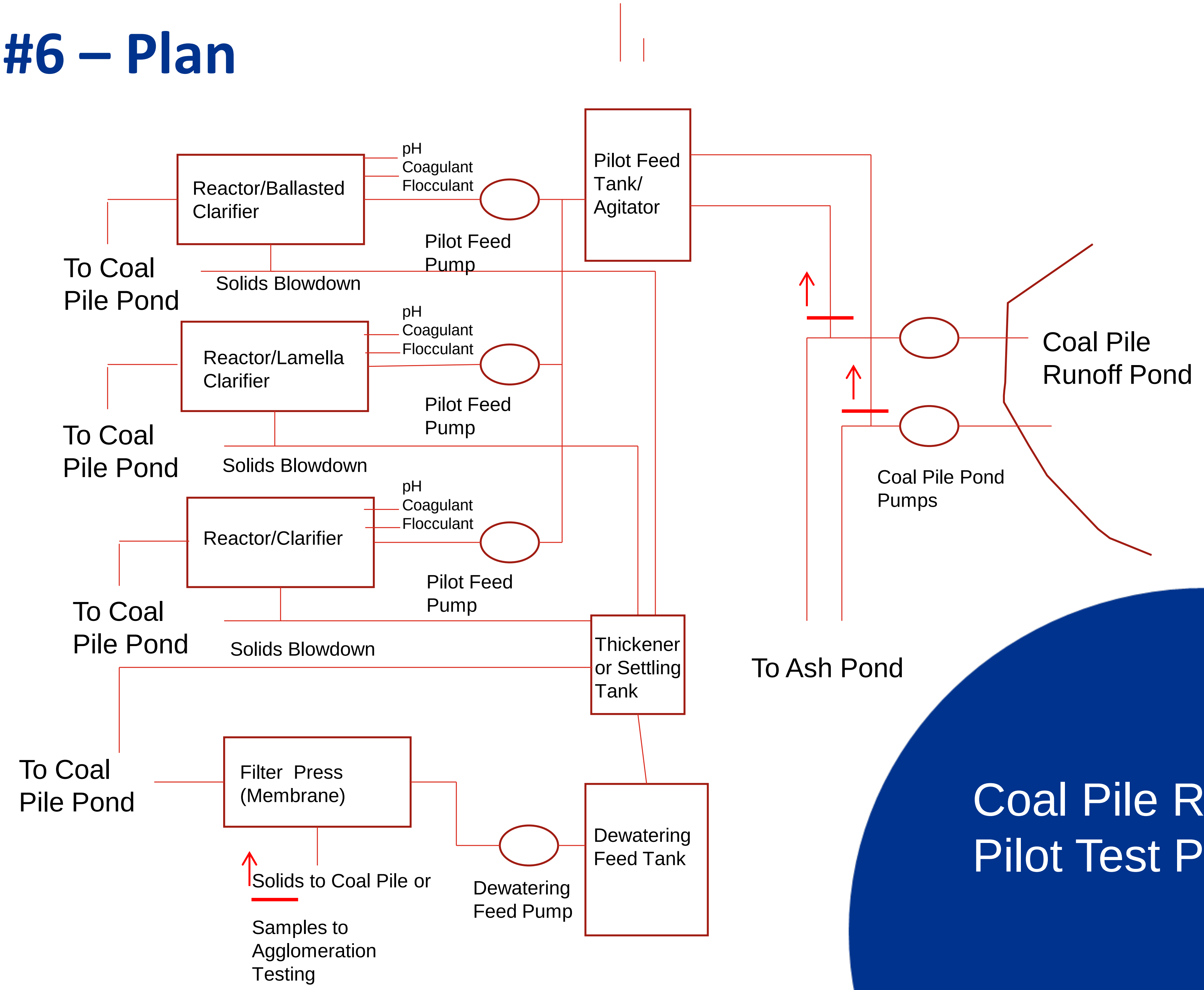
Case Study #6 – Pilot test plan

- Liquid solids separation equipment
  - Sludge blanket clarifier
  - Lamella clarifier
  - Ballasted clarifier
  - Thickener/settling
- Chemicals
  - pH Adjustment, if required
  - Coagulant/flocculant
- Operations (Process)
  - Ballast loading
  - Sludge recirculation rates

Case Study #6 – Plan

- Pilot Test Plan
  - Dewatering equipment
    - Filter press
    - Membrane filter press
  - Chemicals
    - Flocculant
  - Operations (Process)
    - Slurry feed pressure
    - Membrane squeeze pressure
    - Membrane squeeze duration
    - Membrane cycles

Case Study #6 – Plan



Coal Pile Runoff Pilot Test Program

Case Study #6 – Data collection

- Sampling / analysis
  - PRB coal pile runoffcoal pile runoff
  - Bituminous
  - Coal pile runoff wastewater not the same

ANALYTE	UNITS	PRB Coal Pile Runoff	Bituminous Coal Pile Runoff
Alkalinity, Total	mg/l	35	0.00
Aluminum	ug/L	300	74866.67
Antimony	ug/L	<0.85	0.00
Arsenic	ug/L	1.4	12.03
Barium	mg/l	0.14	0.00
Boron	ug/L	1300	936.33
Cadmium	ug/L	<0.085	11.67
Calcium	mg/l	53	641.67
Chloride	mg/l	22	659.00
Chromium	ug/L	1.1	21.50
Copper	ug/L	<2.1	62.27
Field pH	SU	7.48	2.16
Fluoride	mg/l		
Hardness as calcium carbonate	mg/l	190	2290.00
Hexavalent chromium	mg/l	<0.0065	0.00
Iron, Dissolved	mg/l	0	638.43
Lead	ug/L	<0.33	0.83
Magnesium	mg/l	15	166.67
Manganese	ug/L	8.1	11933.33
Mercury	ng/L	27	4.85
Molybdenum	ug/l	22	0.27
Nickel	ug/l	<0.70	994.00
Nitrate as N	mg/l	0.091	0.04
Phosphorus, Total	mg/l	0.1	0.06
Potassium	mg/l	8.4	1.97
Selenium	ug/l	4.8	13.07
SiO2, Silica	mg/l	6.9	50.33
Sodium	ug/l	95	535.00
Specific Conductance	umhos/cm	0.547	6216.67
Sulfate	mg/l	330	5443.33
Thallium	ug/l	<0.026	1.60
Total Dissolved Solids	mg/l	520	7060.00
Total Suspended Solids	mg/l	1000	10.10
Vanadium	ug/l	8.7	8.31
Zinc	ug/l	7.9	2806.67

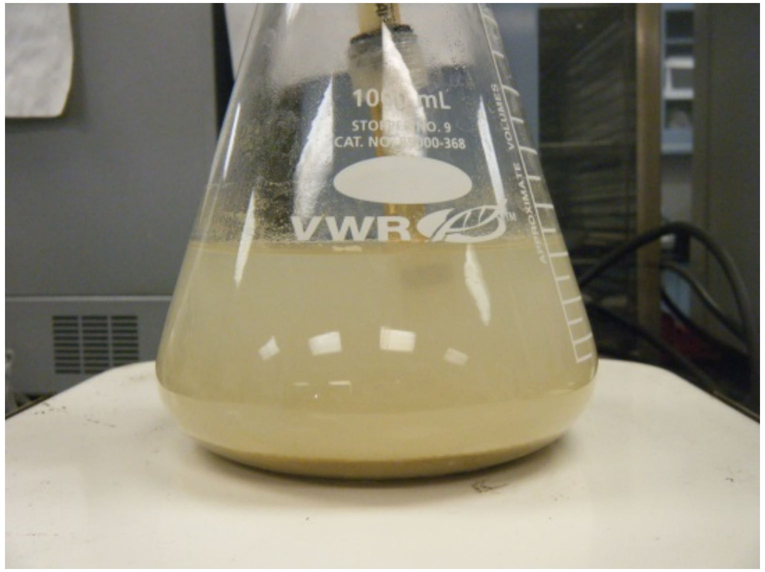
Case Study #6 – Data collection

- Sampling / analysis
  - Precip wash water

ANALYTE	UNITS	
Alkalinity, Total	mg/l	2500
Aluminum	mg/l	2000
Ammonia	mg/l	3.6
Antimony	ug/L	20
Arsenic	ug/L	730
Barium	ug/L	3900
Boron	mg/l	17000
Cadmium	ug/L	39
Calcium	mg/l	4600
Chloride	mg/l	26
Chromium	ug/L	1700
Copper	mg/l	4.8
Field pH	SU	10.55
Fluoride	mg/l	
Hardness as calcium carbonate	mg/l	15000
Hexavalent chromium	mg/l	0.17
Iron	mg/l	730
Iron, Dissolved	ug/L	<25
Lead	ug/L	390
Magnesium	mg/l	800
Manganese	mg/l	5
Mercury	ng/L	820
Molybdenum	ug/l	290
Nickel	ug/l	1300
Nitrate as N	mg/l	1.4
Oil & Grease (HEM)	mg/l	1.6
Orthophosphate as P	mg/l	<0.10
Percent Solids	%	5.60
pH	SU	11.2
Phosphorus, Total	mg/l	2.1
Potassium	mg/l	33
Selenium	ug/l	560
SiO2, Silica	mg/l	130
Sodium	mg/l	200
Specific Conductance	umhos/cm	1.58
Sulfate	mg/l	370
Thallium	ug/l	20
Total Dissolved Solids	mg/l	740
Total Suspended Solids	mg/l	56000
Vanadium	ug/l	6200
Zinc	ug/l	4400

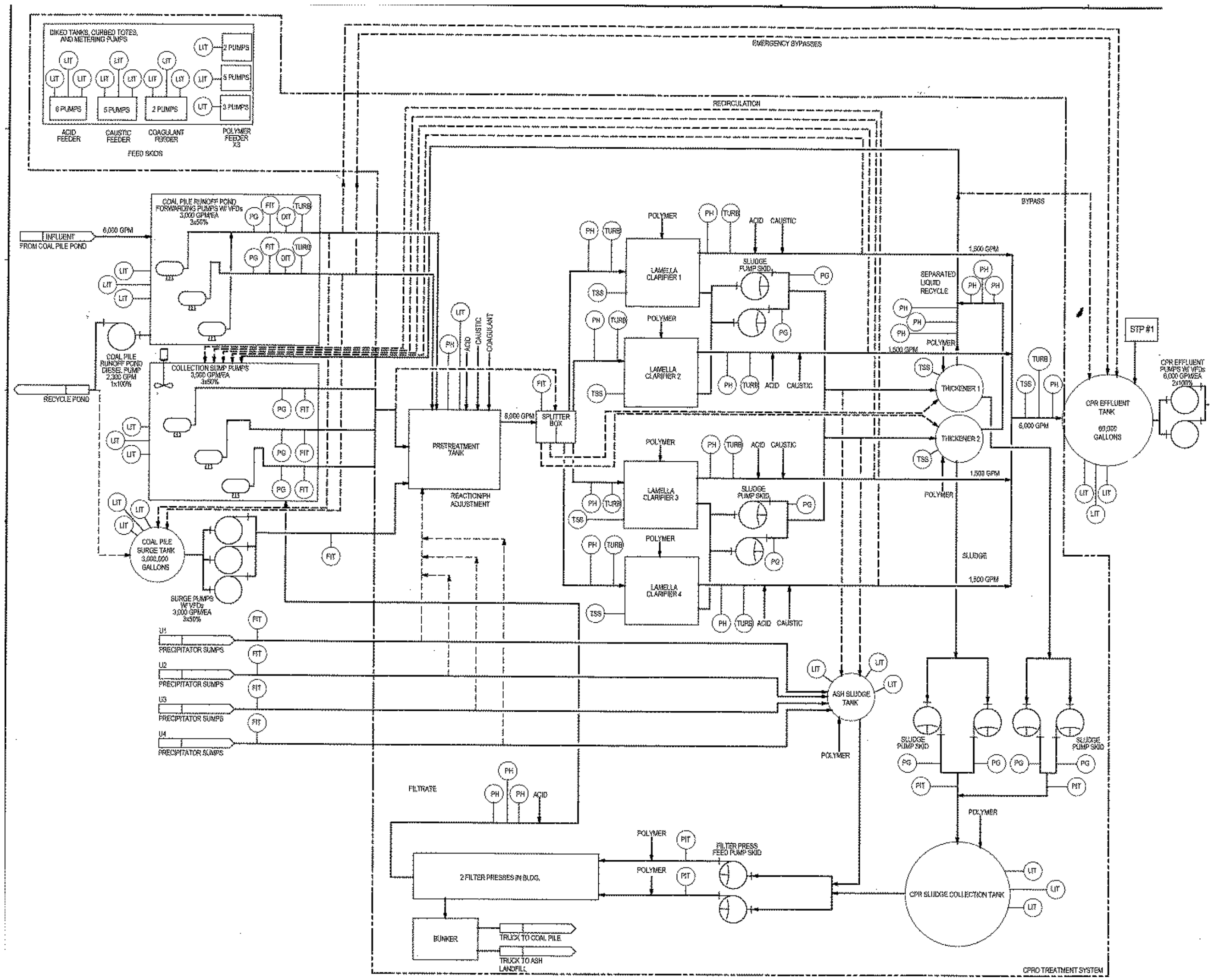
Case Study #6 – Data collection

- Jar testing
  - pH adjustment
  - Coagulant
  - Flocculant



Case Study #6 – Design basis

- Process flow diagram
- Plot plan
- Plant integration
- Operations
  - Shift schedule
  - Staffing
  - Automation
  - Controls
- Sparing
- Redundancy



Case Study #6 – Design basis

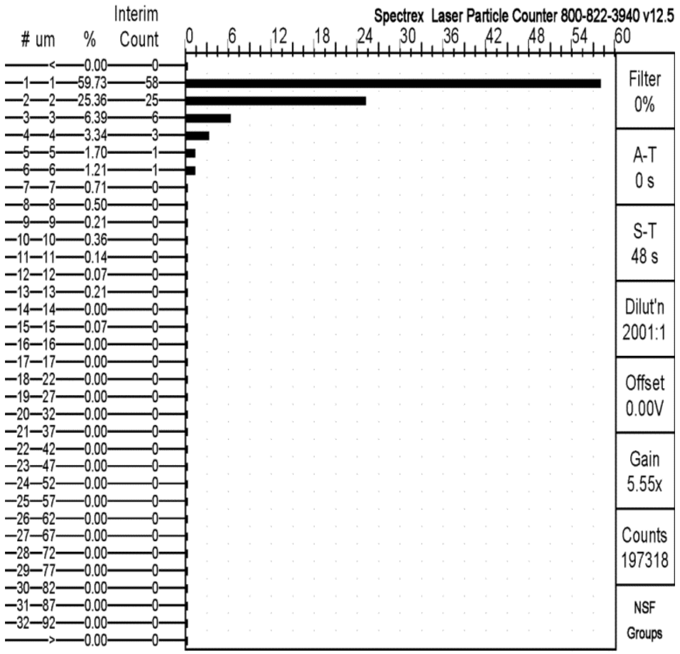
- Coal pile runoff
  - Analysis

Constituent / Parameter	Average Value	Low Value	High Value	Units
Alkalinity, Total as CaCO3	35			mg/l
Aluminum, as Al	692	300	889	µg/l
Ammonia	0.06	0.02	0.11	mg/l
Antimony, as Sb	52.5	51.9	53	µg/l
Arsenic	53.6	53.4	53.8	µg/l
Barium, as Ba	184	140	208	µg/l
Biological Oxygen Demand	<2.0			Mg/l
Boron, as B	1,527	1,300	1,790	µg/l
Cadmium, as Cd	51.2	50.9	51.5	µg/l
Calcium, as Ca	61	60.9	61.4	mg/l
Chemical Oxygen Demand	48			mg/l
Chloride, as Cl	22			mg/l
Chromium, as Cr	49.6	49.3	49.9	µg/l
Chromium, Hexavalent	0.0065			mg/l
Conductance, Specific	0.547			µS/cm
Copper, as Cu	52.5	52.4	52.5	µg/l
Hardness as CaCO3	153	152	153	mg/l
Hardness, Magnesium	86.1	86	86.2	mg/l
Iron	215	190	240	µg/l
Iron, Dissolved	5,625	5,610	5,640	µg/l
Lead, as Pb	44	39.2	48.7	µg/l
Magnesium, as Mg	17,925	15,000	20,900	µg/l
Manganese, as Mn	504	502	505	µg/l
Mercury	27			ng/l
Molybdenum, as Mo	72.6	71.6	73.5	µg/l

Constituent / Parameter	Average Value	Low Value	High Value	Units
Nitrate, as N	0.09			mg/l
Nitrate Nitrate, as N	0.09			mg/l
Nitrite, as N	0.021			mg/l
Oil & Grease (HEM)	1.6			mg/l
Oxidation Reduction Potential	41			mV
Orthophosphate as P	0.10			mg/l
Oxygen, Dissolved	7.61			mg/l
pH	6.9	6.9	6.9	SU
pH, Field	7.48			SU
Phosphorus, Total as P	0.1			mg/l
Potassium	14,500	14,500	14,500	µg/l
Selenium	56.5	56.1	56.8	µg/l
Silica, Total	6.9			mg/l
Sodium, as Na	104,000	104,000	104,000	µg/l
Sulfate, as SO_4	330			mg/l
Temperature	21.1			°C
Temperature, Field	31.41			°C
Thallium, as Tl	11.9	10.6	13.2	µg/l
Total Dissolved Solids	520			mg/l
Total Organic Carbon	3.6			mg/l
Total Suspended Solids	1,000	200	15,000	mg/l
Vanadium, as V	59.4	59.4	59.4	µg/l
Zinc, as Zn	55.8	55.4	56.2	µg/l

Case Study #6 – Design basis

- Coal pile runoff
  - PSD



Bin	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
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	< 1	0.00	0.00%	0.00%	0.00%	0.0000
1	1-5	187,087.47	94.82%	48.85%	26.28%	0.5295
2	5-15	10,090.11	5.11%	48.28%	67.48%	1.3595
3	15-30	140.14	0.07%	2.87%	6.25%	0.1258
4	30-50	0.00	0.00%	0.00%	0.00%	0.0000
	50-100	0.00	0.00%	0.00%	0.00%	0.0000

Total counts: 197,317.72/cc
Total suspended solids: 2.01ppm (mg/liter)
Dilution factor: 2001.00:1
Spec. gravity: 1.00
Mean size: 1.79um
Standard dev: 1.53um

Bin	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
---	--------	---------	---------	---------	---------	----------
	<	0.00	0.00%	0.00%	0.00%	0.0000
1	1um	117,858.10	59.73%	10.72%	3.06%	0.0617
2	2um	50,030.13	25.36%	18.21%	8.75%	0.1762
3	3um	12,612.64	6.39%	10.33%	6.72%	0.1355
4	4um	6,586.60	3.34%	9.59%	7.75%	0.1561
5	5um	3,363.37	1.70%	7.65%	7.31%	0.1472
6	6um	2,382.39	1.21%	7.80%	8.54%	0.1722
7	7um	1,401.40	0.71%	6.25%	7.68%	0.1547
8	8um	980.98	0.50%	5.71%	7.76%	0.1564
9	9um	420.42	0.21%	3.10%	4.60%	0.0927
10	10um	700.70	0.36%	6.38%	10.24%	0.2063
11	11um	280.28	0.14%	3.09%	5.32%	0.1073
12	12um	140.14	0.07%	1.84%	3.38%	0.0681
13	13um	420.42	0.21%	6.47%	12.64%	0.2547
14	14um	0.00	0.00%	0.00%	0.00%	0.0000
15	15um	140.14	0.07%	2.87%	6.25%	0.1258
16	16um	0.00	0.00%	0.00%	0.00%	0.0000
17	17um	0.00	0.00%	0.00%	0.00%	0.0000
18	22um	0.00	0.00%	0.00%	0.00%	0.0000
19	27um	0.00	0.00%	0.00%	0.00%	0.0000
20	32um	0.00	0.00%	0.00%	0.00%	0.0000
21	37um	0.00	0.00%	0.00%	0.00%	0.0000
22	42um	0.00	0.00%	0.00%	0.00%	0.0000
23	47um	0.00	0.00%	0.00%	0.00%	0.0000
24	52um	0.00	0.00%	0.00%	0.00%	0.0000
25	57um	0.00	0.00%	0.00%	0.00%	0.0000
26	62um	0.00	0.00%	0.00%	0.00%	0.0000
27	67um	0.00	0.00%	0.00%	0.00%	0.0000
28	72um	0.00	0.00%	0.00%	0.00%	0.0000
29	77um	0.00	0.00%	0.00%	0.00%	0.0000
30	82um	0.00	0.00%	0.00%	0.00%	0.0000
31	87um	0.00	0.00%	0.00%	0.00%	0.0000
32	92um	0.00	0.00%	0.00%	0.00%	0.0000
	>	0.00	0.00%	0.00%	0.00%	0.0000
		---------	----------	----------	---------	----------
	TOTALS	197,317.72	100.00%	100.00%	100.00%	2.0148

Case Study #6 – Design basis

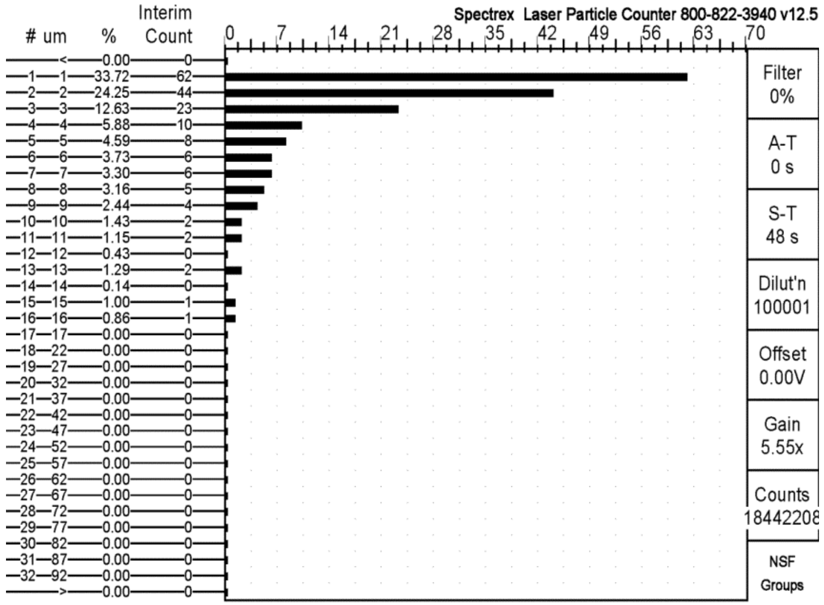
- Precip wash water
  - Analysis

Constituent / Parameter	Average Value	Units
Alkalinity, Total as CaCO3	2,500	mg/l
Aluminum, as Al	2,000,000	µg/l
Ammonia	3.6	mg/l
Antimony, as Sb	20	µg/l
Arsenic	730	µg/l
Barium, as Ba	3,900	µg/l
Biological Oxygen Demand	<2.0	mg/l
Boron, as B	17,000	µg/l
Cadmium, as Cd	39	µg/l
Calcium, as Ca	4,600,000	µg/l
Chemical Oxygen Demand	76	mg/l
Chloride, as Cl	26	mg/l
Chromium, as Cr	1,700	µg/l
Chromium, Hexavalent	0.17	mg/l
Conductance, Specific	1.58	µS/cm
Copper, as Cu	4,800	µg/l
Hardness as CaCO3	15,000	mg/l
Iron	730,000	µg/l
Iron, Dissolved	<25	µg/l
Lead, as Pb	390	µg/l
Magnesium, as Mg	800,000	µg/l
Manganese, as Mn	5,000	µg/l
Mercury	820	ng/l
Molybdenum, as Mo	290	µg/l
Nickel, as Ni	1,300	µg/l

Constituent / Parameter	Average Value	Units
Nitrate, as N	1.4	mg/l
Nitrate Nitrate, as N	1.8	mg/l
Nitrite, as N	0.39	mg/l
Oil & Grease (HEM)	1.74	mg/l
Oxygen Reduction Potential	140	mV
Ortho-phosphate as P	<0.10	mg/l
Oxygen, Dissolved	6.03	mg/l
pH	11.2	SU
pH, Field	10.55	SU
Phosphorus, Total	2.1	mg/l
Potassium	33,000	µg/l
Selenium	560	µg/l
Silica, as SiO_2	130	mg/l
Sodium, as Na	200,000	µg/l
Sulfate, as SO_4	370	mg/l
Temperature	20.9	°C
Temperature, Field	21.7	°C
Thallium, as Tl	20	µg/l
Total Dissolved Solids	540	mg/l
Total Organic Carbon	6.7	mg/l
Total Suspended Solids	56,000	mg/l
Vanadium, as V	6,200	µg/l
Zinc, as Zn	4,400	µg/l

Case Study #6 – Design basis

- Precip wash water
  - PSD



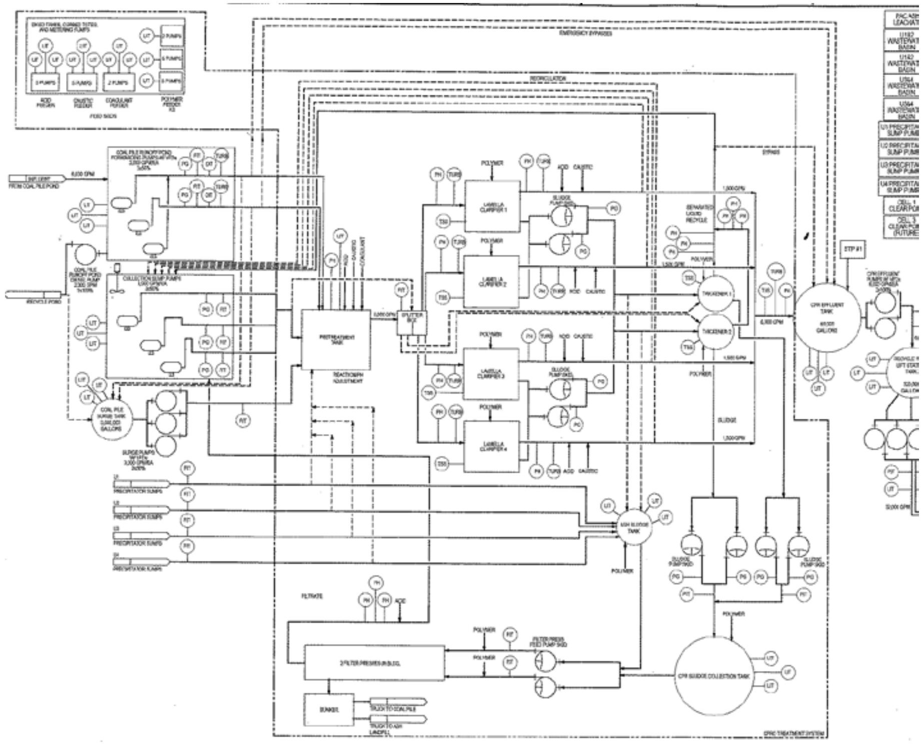
Bin	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
	< 1	0.00	0.00%	0.00%	0.00%	0.0000
1	1-5	14,102,864.76	76.47%	15.48%	6.26%	69.7237
2	5-15	3,995,370.69	21.66%	64.10%	63.52%	707.2996
3	15-30	343,972.31	1.87%	20.42%	30.22%	336.5529
4	30-50	0.00	0.00%	0.00%	0.00%	0.0000
	50-100	0.00	0.00%	0.00%	0.00%	0.0000

Total counts: 18,442,207.77/cc
Total suspended solids: 1113.58ppm (mg/liter)
Dilution factor: 100001.00:1
Spec. gravity: 1.00
Mean size: 3.39um
Standard dev: 3.22um

Bin	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
	<	0.00	0.00%	0.00%	0.00%	0.0000
1	1um	6,217,961.01	33.72%	1.54%	0.29%	3.2557
2	2um	4,471,640.05	24.25%	4.44%	1.41%	15.7506
3	3um	2,328,427.95	12.63%	5.20%	2.25%	25.0118
4	4um	1,084,835.75	5.88%	4.31%	2.31%	25.7056
5	5um	846,701.07	4.59%	5.25%	3.33%	37.0592
6	6um	687,944.62	3.73%	6.14%	4.46%	49.7128
7	7um	608,566.40	3.30%	7.40%	6.03%	67.1933
8	8um	582,106.99	3.16%	9.24%	8.33%	92.7895
9	9um	449,809.95	2.44%	9.04%	8.90%	99.1276
10	10um	264,594.09	1.43%	6.56%	7.00%	77.9074
11	11um	211,675.27	1.15%	6.35%	7.27%	81.0025
12	12um	79,378.23	0.43%	2.84%	3.47%	38.5877
13	13um	238,134.68	1.29%	9.98%	12.96%	144.2665
14	14um	26,459.41	0.14%	1.29%	1.76%	19.6531
15	15um	185,215.86	1.00%	10.34%	14.94%	166.3136
16	16um	158,756.45	0.86%	10.08%	15.29%	170.2393
17	17um	0.00	0.00%	0.00%	0.00%	0.0000
18	22um	0.00	0.00%	0.00%	0.00%	0.0000
19	27um	0.00	0.00%	0.00%	0.00%	0.0000
20	32um	0.00	0.00%	0.00%	0.00%	0.0000
21	37um	0.00	0.00%	0.00%	0.00%	0.0000
22	42um	0.00	0.00%	0.00%	0.00%	0.0000
23	47um	0.00	0.00%	0.00%	0.00%	0.0000
24	52um	0.00	0.00%	0.00%	0.00%	0.0000
25	57um	0.00	0.00%	0.00%	0.00%	0.0000
26	62um	0.00	0.00%	0.00%	0.00%	0.0000
27	67um	0.00	0.00%	0.00%	0.00%	0.0000
28	72um	0.00	0.00%	0.00%	0.00%	0.0000
29	77um	0.00	0.00%	0.00%	0.00%	0.0000
30	82um	0.00	0.00%	0.00%	0.00%	0.0000
31	87um	0.00	0.00%	0.00%	0.00%	0.0000
32	92um	0.00	0.00%	0.00%	0.00%	0.0000
	>	0.00	0.00%	0.00%	0.00%	0.0000
	TOTALS	18,442,207.77	100.00%	100.00%	100.00%	1113.5763

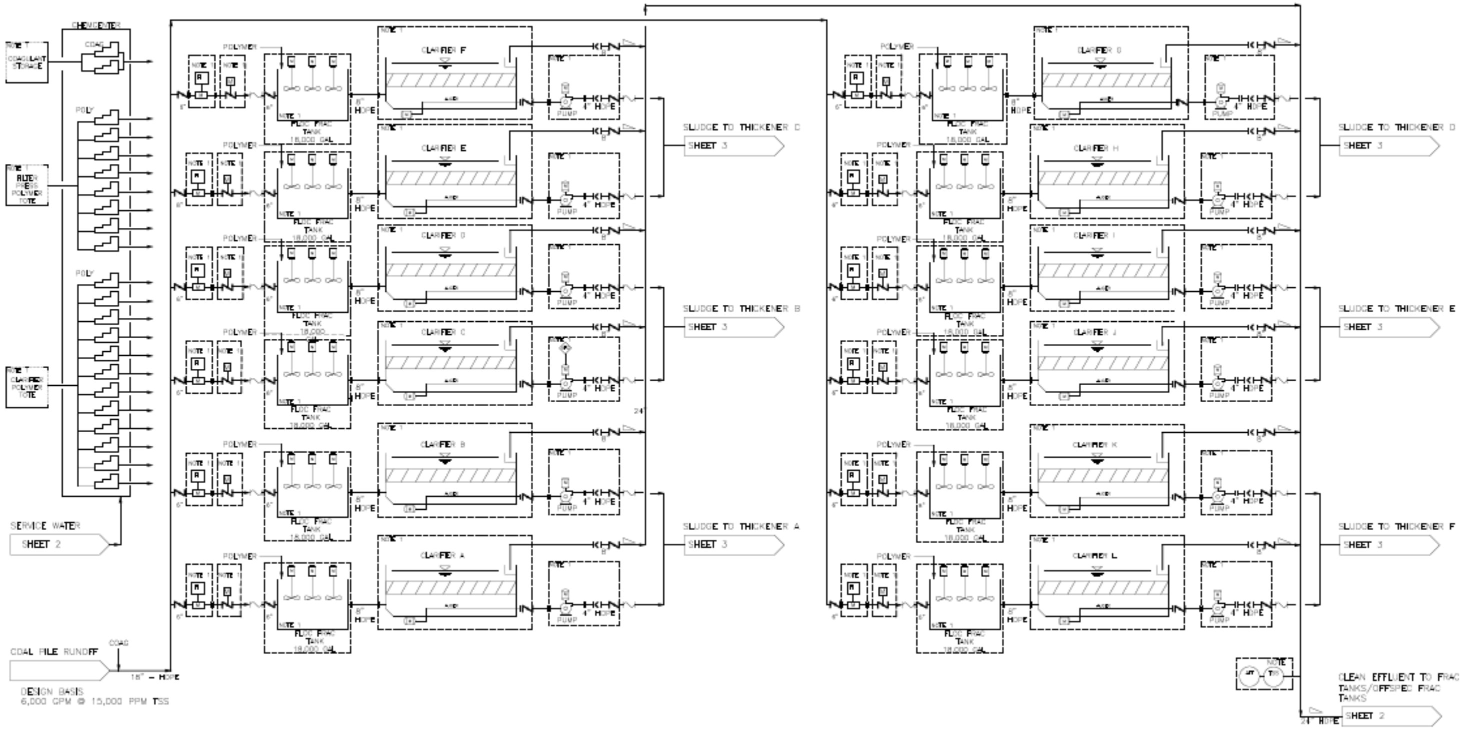
Case Study #6 – Design basis

- Process Flow Diagram
  - Flow
    - Coal Pile Runoff – 6,000 gpm
    - Precip Wash Water – 400 gpm
  - TSS
    - Coal Pile Runoff
    - Precip Wash Water
  - pH
    - Coal Pile Runoff - 7.48
    - Precip Wash Water - 11.2
- Equipment Sizing
  - Pre-Treatment Tank
  - Lamella Clarifier
  - Thickener
  - Filter Press

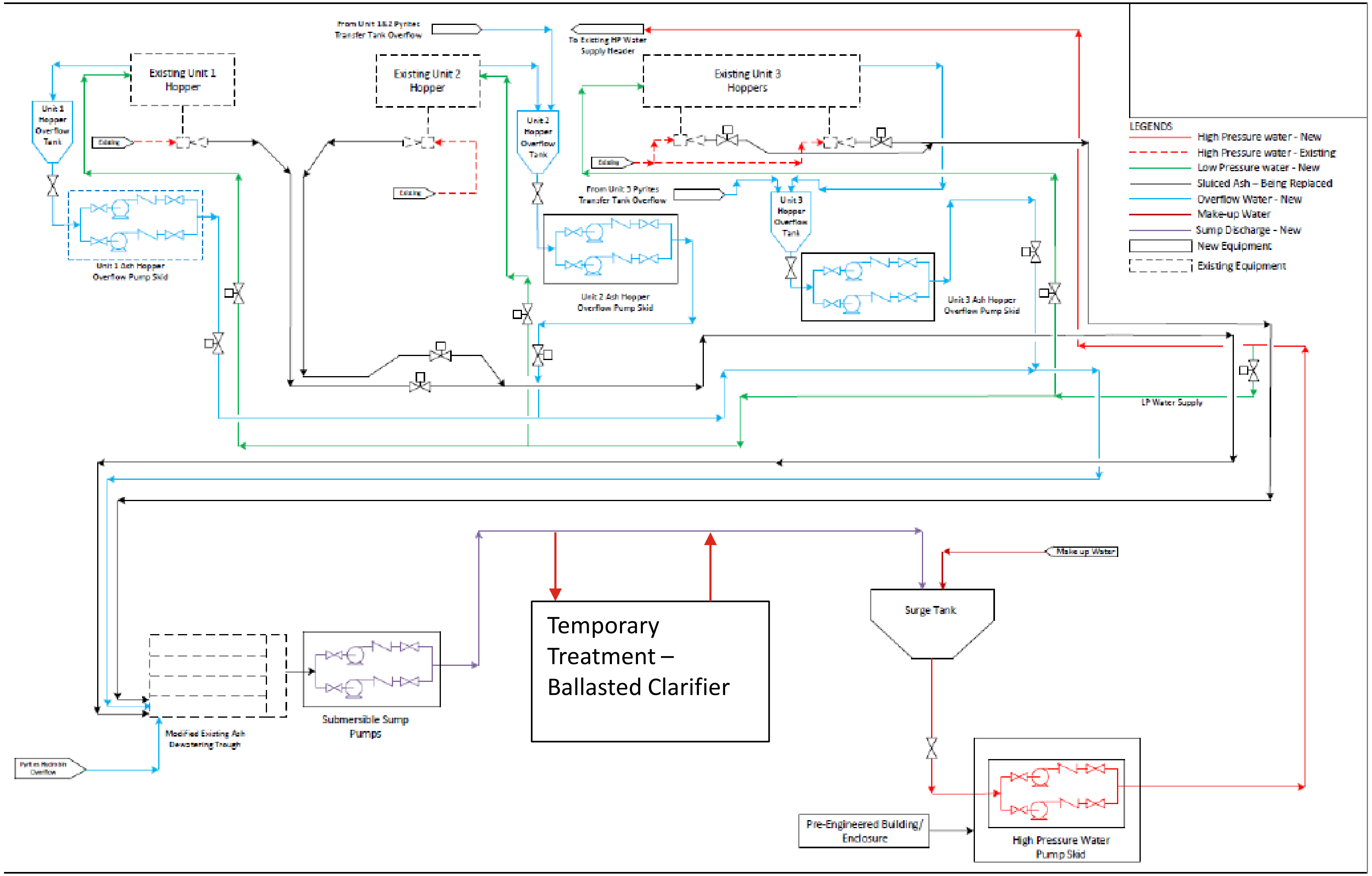


Case Study #7 – Use of Temporary Treatment

- Timing for permanent system and start up
- Outage support treatment
- Temporary Treatment Systems
- Plot plan
- Capacity
- Consider technologies with high capacity and smaller footprint
- Integrate with wastewater source and discharge treated water
- Solids handling and disposal
- Ballasted clarifiers



Case Study #7 – Use of Temporary Treatment



05

Wash water considerations in a post-ELG, post-CCR world

Managing Wash Water – Special Considerations in Post-ELG / Post-CCR World

- If closing large ash pond that had received wash → lose equalization and mixing
- If stopping bottom ash discharge → lose mixing

In Conclusion

- Need to understand wash water at site (even if rarely done)
- Design for wash with the largest flow / worst-case water quality
- Planning and communication with wastewater operators
- Impact on outfall vs WQBELs

Q&A

Thank you for your time and interest

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