Wastewater Treatment for FGD Purge Streams

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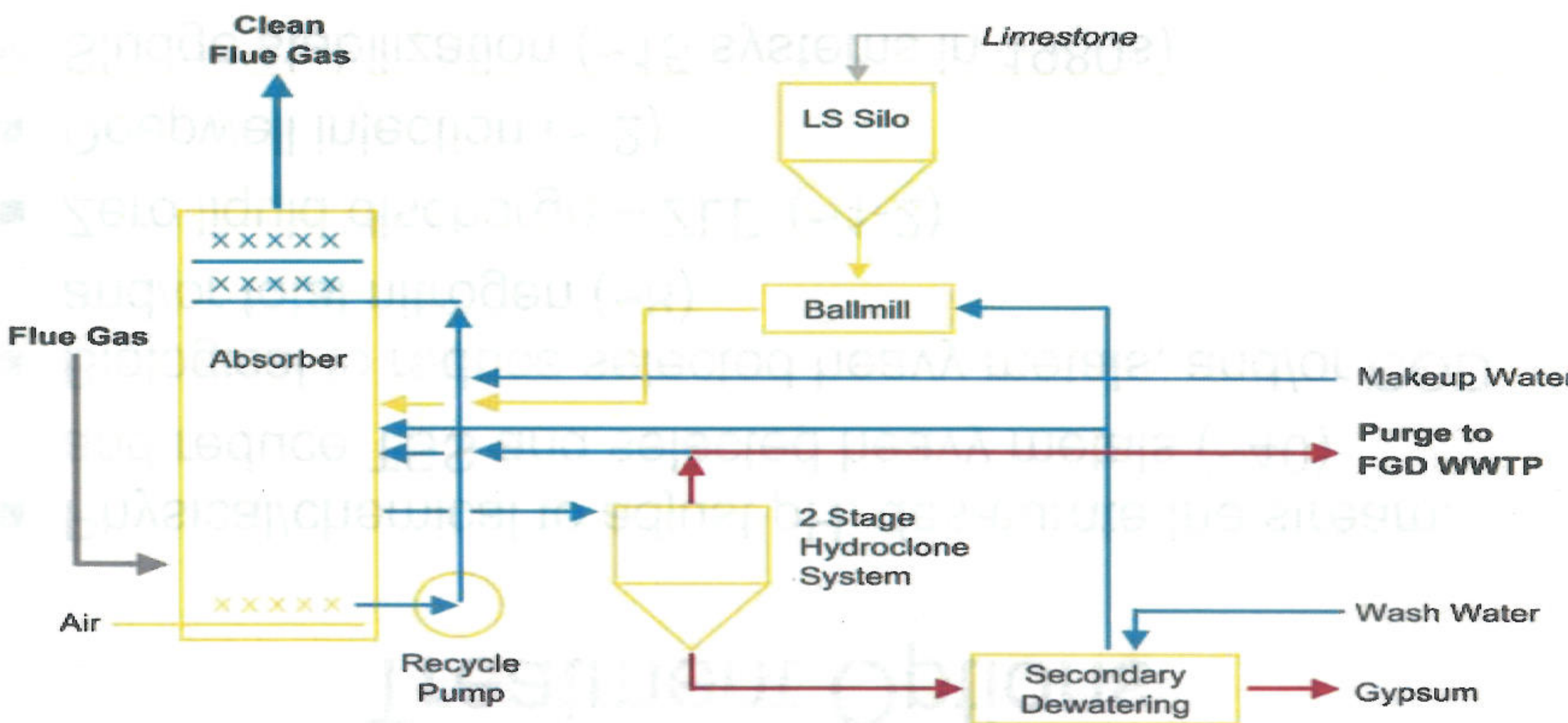
FGD Wastewater

- Wet LSFO FGD with gypsum by-product
  - Purge for fines and chloride control in scrubber
  - Ensure gypsum quality

- Flow from Hydroclones
- Acidic, warm, TSS, TDS, high Cl, heavy metals, organics
- TSS and metals reduction prior to discharge
- Flows from 20 gpm to 1200 gpm
- Existing power plant WWTS not suitable
- Discharge limits very site specific
- Future limits likely tighter

Source of the Wastewater



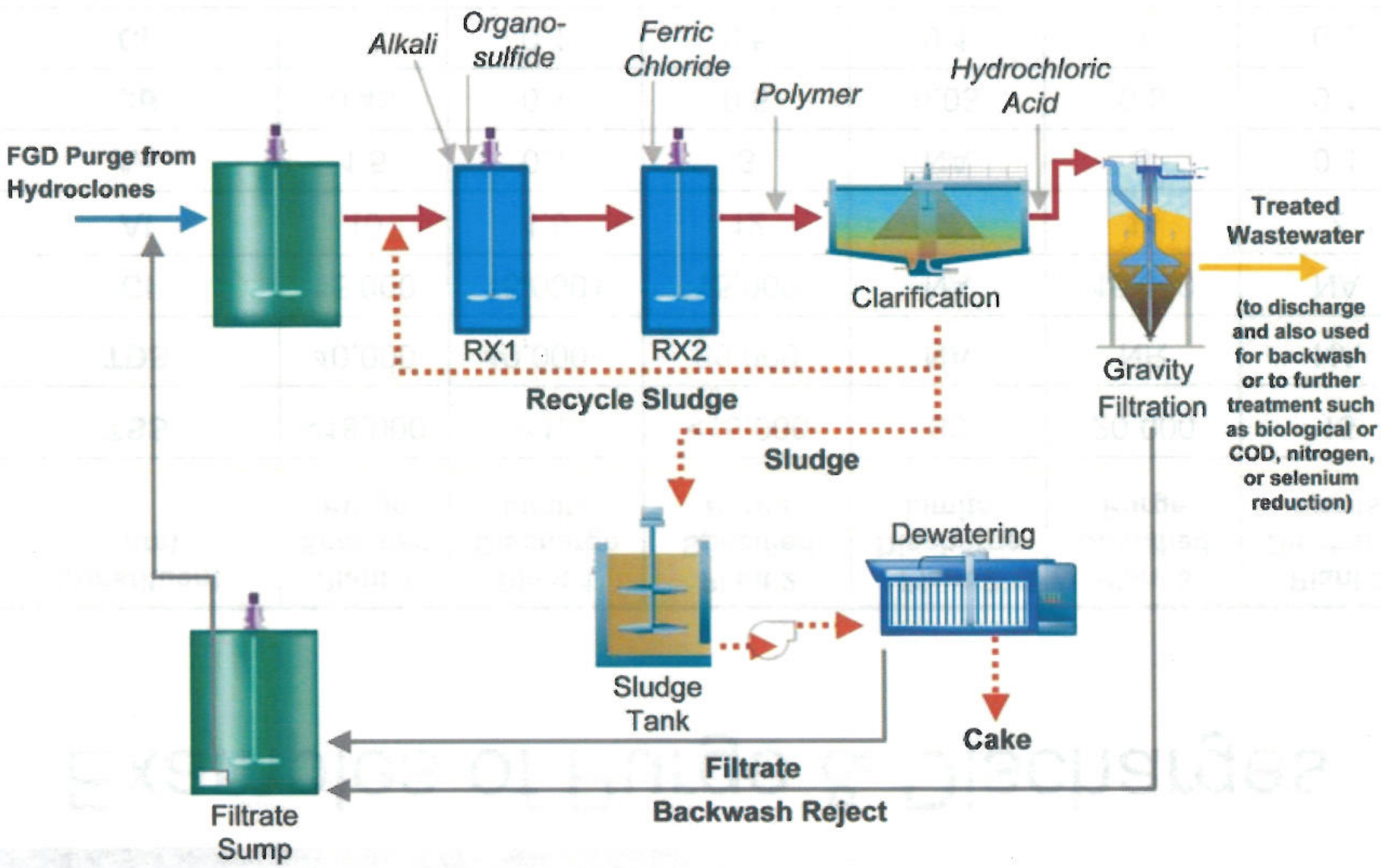
Treatment Options

- Physical/chemical to adjust pH, desaturate the stream, and reduce TSS and selected heavy metals (~40)
- Biological to reduce selected heavy metals, and/or COD, and/or total nitrogen (~8)
- Zero liquid discharge – ZLD (~1-2)
- Deepwell injection (~ 2)
- Sludge stabilization (~15 systems in 1980s)
- Gypsum stacking
- Constructed wetlands – biological (~3 systems)

Examples of Purge & Discharges

Constituent (ppm)	Plant 1 Specified Purge	Plant 1 Discharge Limits	Plant 2 Specified Purge	Plant 2 Discharge Limits	Plant 3 Specified Purge	Plant 3 Discharge Limits
TSS	<18,000	<10	<15,000	30	20,000	15
TDS	40,000	40,000+	30,000	NA	NR	NA
Cl	15,000	15,000+	15,000	NA	15,000	NA
Al	10	1.5	12	2	14	2
As	1.5	0.1	3	NA	3	0.1
Cd	0.45	0.1	0.5	0.03	0.5	0.1
Cr	0.3	0.1	0.5	0.1	1	0.1
Hg	0.5	0.002	0.8	0.001	0.8	0.001
Se	4.6	3	5	NA	5	2.835

Physical/Chemical Treatment

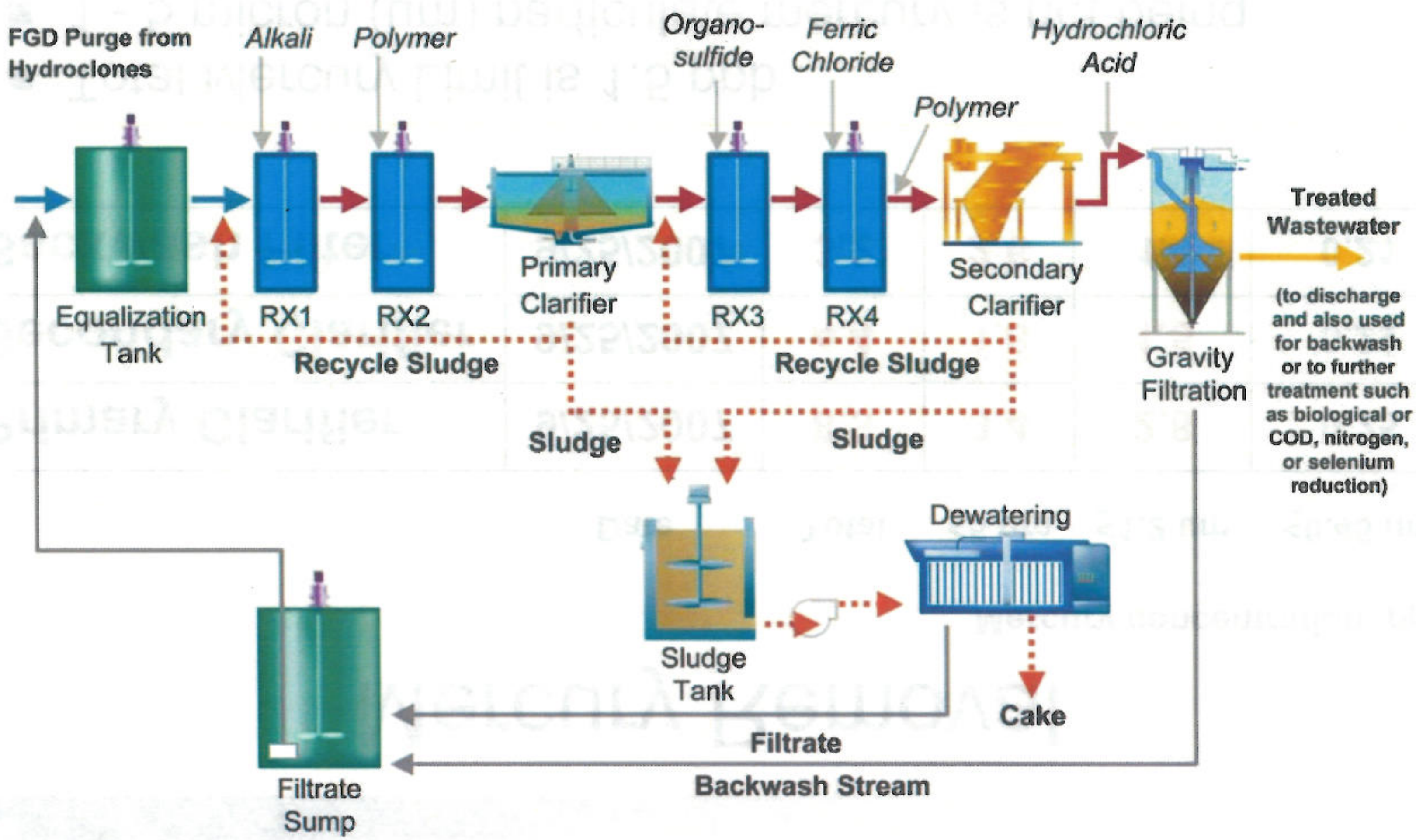


Case 1: We Energies' Pleasant Prairie Power Plant - Wisconsin

- Two Unit Site, 100% PRB sub-bituminous coal
- Unit 1 online 1980, Unit 2 online 1985
- Each Unit 650 MW (gross) / 617 MW (net) rated Riley turbo boilers
- Riley SCR with no bypass
- Siemens (Wheelabrator) Wet Limestone Forced Oxidation FGD Scrubbers
- Siemens (US Filter) FGD Alkali-Sulfide Wastewater Treatment System
- Treated effluent recycled to scrubber for 11 months

Courtesy of We Energies

PPPP FGD Wastewater System



Mercury Removal

Mercury concentration, ppb

	Date	Total	≤5 um	≤1.2 um	≤0.45 um
Primary Clarifier	9/25/2007	8.3	3.4	2.8	0.25
Secondary Clarifier	9/25/2007	4.4	1.8	1.5	0.29
Backwash Filter	9/25/2007	3.2	2.6	1.4	0.21

- Total Mercury Limit is 1.5 ppb
- 1 - 5 micron (um) particulate mercury is not being removed
- Mercury fines were recycled and concentrated
- Temporary filtration needed to meet limit

Courtesy of We Energies

New Wastewater Permit Limits

Parameter	Location	Limit	Frequency
Mercury	WWT effluent	1.5 µg/L (ppb)	2/Week grab
Mercury	WWT effluent	0.00135 lbs/day	2/Week calculated
Mercury	Lake Discharge	80 ng/L (ppt)	2/Week grab
Arsenic	Lake Discharge	Monitoring only	Monthly composite
Beryllium	Lake Discharge	0.084 µg/L (ppb)	Monthly composite
Chloride	Lake Discharge	1514 mg/L (ppm)	Monthly composite
Copper	Lake Discharge	117 µg/L (ppb)	Monthly composite

- Parameters identified from characterization of similar FGD wastewaters
- WWT Mercury limit (1.5 ppb) based on alkali-sulfide treatability studies
- Lake Mercury limit based on peak FGD WWT flow blended with 1500 gpm of cooling tower blowdown and other wastewater

Courtesy of We Energies

Lessons Learned

- Mercury limit (1.5 ppb) not met initially
  - Initial recycle to FGD caused Hg fines to be recycled also
  - Installed temporary cartridge filters to remove mercury fines passing through Secondary Clarifier or Sand Filters.
  - Changed process chemistry in Reaction Tanks
    - Lower pH ~6.4
    - Higher Ferric Chloride dose, 200 ppm
- Process piping pluggage from ferric chloride floc
  - Horizontal piping replaced with sloped pipe and flush connection
- Gypsum scaling
  - Caused by high magnesium in limestone (~2% $MgCO_3$)
  - Fouled Sand and Cartridge Filters. Removed from service.
  - Secondary Clarifier effluent requires manual cleaning

Courtesy of We Energies

Summary – Pleasant Prairie

- System performance
  - Discharging 20-30 gpm since Nov 2007
  - Tested to full design flow
- Mercury performance
  - WWT effluent: 0.4 to 1.0 ppb (limit 1.5 ppb)
  - Discharge to lake: 5 to 20 ppt (limit 80 ppt)
- Additional system tuning and evaluation of other mercury removal technologies will continue

Case 2: Metals & Total Nitrogen Reduction - Maryland

- Two Unit Site, burns mostly eastern coal
- Unit 1 online 1984, Unit 2 online 1991
- Each Unit 690 MW (gross) / 650 MW (net)
- Overfire air, low NOx burners, hotside ESP, and SCR
- Siemens (Wheelabrator) Wet Limestone Forced Oxidation FGD Scrubbers
- Siemens (US Filter) FGD Alkali-Sulfide Wastewater Treatment System with periodic additional fines purge treatment and with biological sequencing batch reactors for total nitrogen reduction. Also, municipal grey water to be treated for FGD limestone slurry makeup.

Case 2: Metals and Total Nitrogen Reduction - Maryland

Consituent (ppm)	Specified Purge	Discharge Requirement
TSS	≤16,000	30
TDS	≤75,000	NA
Cl	≤30,000	NA
Al	12	NA
As	1.8	0.1
Cd	0.5	0.01
Cr	0.1	0.1
Hg	0.77	0.002
Se	6.5	NA
Total Nitrogen	**290**	**4**
BOD5	20	20

Case 2: Lessons to be Learned

- System operational 2009
- Will determine following:
  - Accuracy of wastewater design basis (chemistry and flowrate) compared to actual
  - Use of treated grey water as makeup to FGD limestone slurry system
  - Capacity of periodic fines purge clarification and recycle
  - Flexibility of SBR biological treatment for total nitrogen

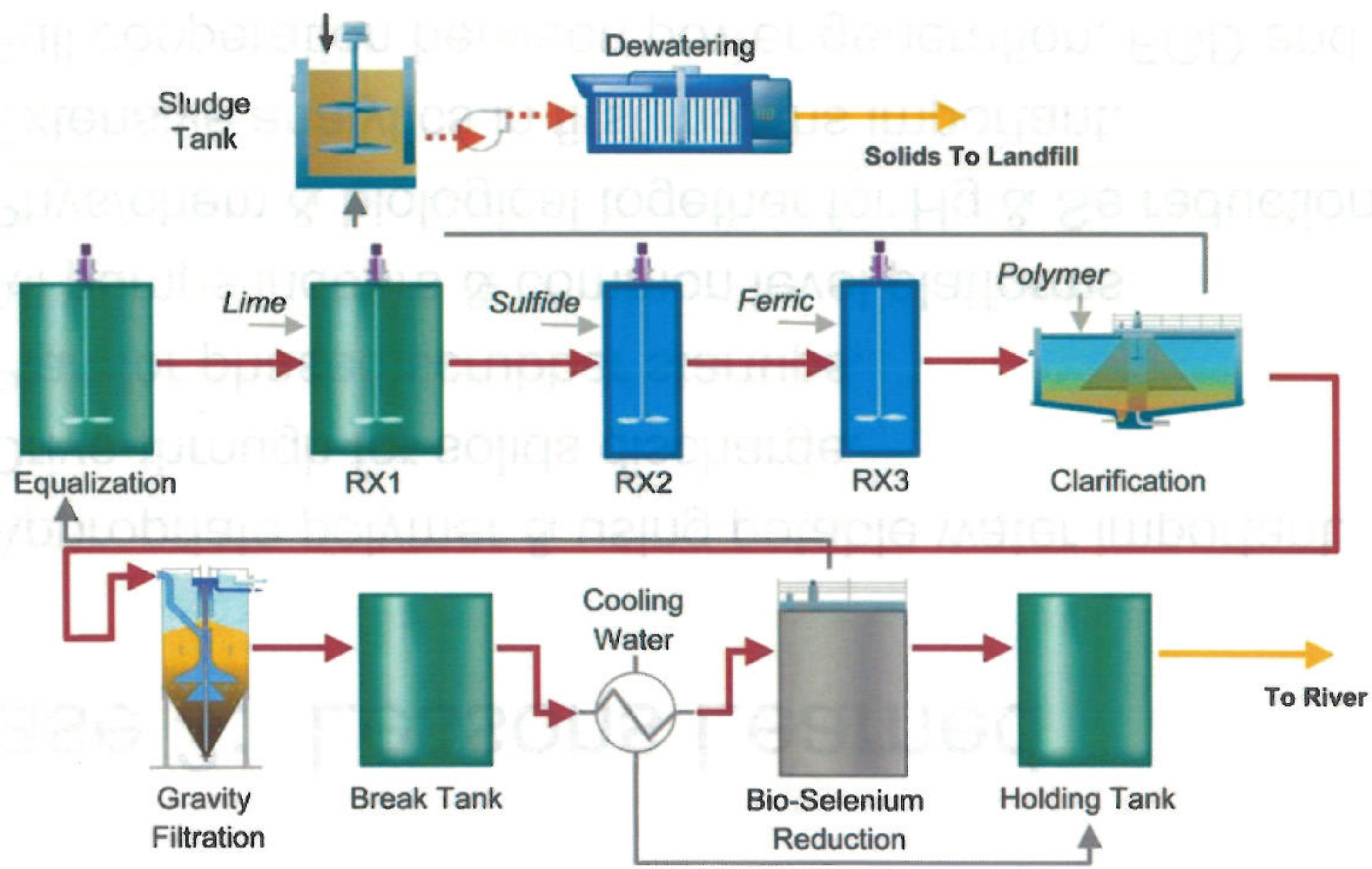
Case 3: Metals Reduction, including Selenium

- Two Unit Site, burns eastern coal
- Unit 1 online 1974, Unit 2 online 1975
- Each Unit rated 1120 MW (gross), super critical boilers
- SCR installed
- Alstom Wet Limestone Forced Oxidation FGD Scrubbers
- Siemens (US Filter) FGD Alkali-Sulfide Wastewater Treatment System with biological treatment system for selenium reduction

Case 3: Metals, including Selenium Reduction

Consituents (ppm)	Specified Purge	Discharge Requirement
TSS	≤16,000	≤50
TDS	≤25,000	NA
Cl	≤12,000	12,100
Al	NR	NA
As	0.49	NA
Cd	0.10	NA
Cr	0.36	NA
Hg	0.30	0.001
Se	**4.0**	**0.100**
Total Nitrogen	≤14	NA
BOD5	NR	NA

Case 3: FGD Wastewater System



Case 3: Lessons Learned

- Appropriate polymer & using potable water important.
- Drive-through for solids discharge.
- Plan for phased scrubber startups.
- All pumps indoors & common level platforms.
- Phys/chem & biological together for Hg & Se reduction.
- Extensive analytics in first months important.
- Full cooperation between power generation, FGD and FGD WWTS mandatory for success.

Summary

- Proper treatment of FGD purge by a dedicated WWTS is essential, unless direct or mixed discharge is allowed.
- Design must account for variations in coal, limestone, water, and scrubber operation.
- Selected treatment processes integrated properly into a system can meet the challenge for FGD purge.
- Lessons learned from earlier projects can make real impact on future projects, especially as limits vary and/or tighten.

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