Outage Wash Wastewater Treatment Alternatives Under Revised CCR Regulatory Requirements

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INTRODUCTION

As stipulated by revised ELG/CCR regulations released in September of 2020, ash ponds or CCR impoundments are required to retire or to be upgraded to a compliant, lined sedimentation basin. In addition, using transport water to sluice ash to an impoundment or basin, whether compliant or not, is a process that will require closed loop operation by 2023. In response, the coal-fired electrical utility sector has been undergoing a long transformation with respect to the handling of coal combustion residuals (CCR) and the water associated with these materials. Some utilities have adopted continuous dewatering recirculation (CDR) systems to replace receiving ponds with above-grade mechanical equipment that separates conveying water from ash and then recycles the water for recirculation. Others have opted to upgrade or replace existing non-compliant CCR ponds with lined concrete or otherwise sedimentation basins that meet the new requirements under the CCR regulations. These compliance upgrades serve to meet the new requirements for bottom ash handling normal operations, but consideration for managing wastewater that results from periodic outage wash service events is also required. For decades the CCR ponds have served as the receiving bodies for wastewater that was generated by the maintenance activity of washing down various powerhouse systems, including the internals of the boiler, the backpass ductwork, air pre-heaters, economizers, and precipitators. Given the required implementation of wastewater flow cessation to close their surface impoundments, utilities are seeking alternatives to treat these periodic wastewaters sources.

Facilities that have brought new, compliant sedimentation basins online have the option to direct these wastewaters to the basins for treatment prior to discharge. Some facilities have opted to employ temporary, mobile wastewater treatment systems to pre-treat wash wastewater using traditional physical/chemical precipitation techniques. And facilities that have already installed bottom ash handling systems to manage the conveyance of bottom ash and to separate sluice water from the solid material efficiently can temporarily repurpose these systems for outage washwater treatment.

OUTAGE WASH WASTEWATER TYPES

The subsystems that are washed at coal fired utilities vary from site to site, based on site standard operating procedures. In general, the subsystems that are washed include:

- Internal Boiler
- Backpass ductwork
- Air Pre-Heaters
- Economizers
- Electrostatic Precipitators (ESPs)

WASHWATER CHARACTERISTICS

Contaminated outage wash wastewater presents challenging attributes for designing and implementing a treatment program. In general physical / chemical precipitation to remove contaminants is a process that works best with consistent contaminant loading and consistent flow. However, during outage washes there is tremendous variety in the flow and the contaminant loading throughout the duration of a wash event, especially when multiple subsystems are being addressed. Suspended solids can start out in the thousands of ppm range, with pH levels at 2.5 or even lower. Heavy metals concentrations can be high as well. There is variability between the different subsystems being washed, and even from one wash event to the next. As with all wastewater treatment applications, gathering as much upfront information as possible prior to design or execution of the water treatment and having a flexible solution is critical for success. Often however, the information is difficult to track down, and prior experiences are needed to inform future plans.

Factors that influence the characteristics of the outage wash wastewater include:

- Fuel type and mix and additives
- Time between washes
- Percentage unit utilization between washes
- Percentage load per unit

Fuel Type and Mix

It is important to develop an understanding of the type of fuel being burned at a coal fired power plant prior to conducting an outage wash. Characteristics such as sulfur content and ‘loss on ignition’ will result in lower or higher acidity content of the ash deposits being washed off, and also play into the specific gravity of the particles that eventually need to be settled in the wastewater treatment system.

Time Interval Between Washes

Most coal fired power plants are taken offline for outage maintenance in the spring and in the fall. Some or all of the units may be slated for washdown, but sometimes only a portion of the unit's offline subsystems are washed. Wash intervals can vary from yearly to 3 years or more. The longer the interval between washes, the more likely that contaminant loading will be higher.

Percentage Unit Utilization Between Washes

Many coal-fired plants are utilized to serve as 'peaking' plants, only supplying power when demand for electricity is highest. Hours of service directly play into the amount of contaminant material that will deposit on the air handling surfaces and boiler internals, and should be quantified prior to the wash.

Percentage Load Per Unit

In addition to utilization, percentage load per unit also influences the deposit of contaminants on air handling surfaces. Lower loading can result in less efficient combustion, which drives contaminant deposits higher. In addition, a unit may be forced to operate at sub-optimal load if an air handling system such as an air-preheater is partially plugged. Load restriction can be an indicator to how dirty the system is prior to wash.

Table 1. Typical Outage Wash Wastewater Contaminant Ranges

Outage Wash Water Influent Properties				
Parameter	Units	Boiler Wash	Air Pre-Heater Wash	Precipitator Wash
Total Suspended Solids	mg/L	100-20,000	100-20,000	100-65,000
pH	SU	3-8	2-8	2-7.5
Total Iron	mg/L	10-521	10-1680	10-49
Total Copper	mg/L	< 1.0	ND - 1.7	ND – 4.0

Table 2. Typical Effluent Quality Targets

Typical Treatment Targets (may vary from site to site)		
Parameter	Units	System Effluent
Total Suspended Solids	mg/L	100 daily max, 30 monthly average
pH	SU	6.0-9.0
Total Iron	mg/L	< 1.0
Total Copper	mg/L	< 1.0

Figure 1a and 1b. Typical 24-hour variability in inlet samples (Sampled every hour, on the hour)

WASTEWATER TREATMENT PRINCIPLES

The principle effort in treating washwater surrounds achieving the pH required to facilitate the precipitation of heavy metals and the optimization of the performance of the flocculant used to settle solids. For both goals, the required pH is between 8.0 and 9.0, with 8.5 being optimal. Targeting 8.5 also gives the operational staff a slight safety zone to avoid exceeding the upper pH discharge limit of 9.0.

Temporary Wastewater Treatment Systems

Some utilities have employed mobile, temporary treatment systems to treat outage wash wastewater. Typically, mobile equipment includes frac tanks or lake tanks for equalization, mobile clarifiers to give suspended solids a place to settle, mechanical dewatering equipment on a trailer bed such as a belt filter press or plate and frame press, and chemical injection skids. Advantages to this approach include avoidance of capital investment, no permanent changes to site footprint, and flexibility from wash to wash. Disadvantages include mobilization/demobilization management and site activities with each wash, challenges in managing large flows or flow variation, reliability concerns, and equipment availability.

Figure 2. Mobile Clarification Unit

Sedimentation Basins

Some utilities have opted to invest in compliant sedimentation basins that include design capacity above and beyond bottom ash sluice water and solids, to include washwater from outages. With these configurations, outage wash water is pH adjusted and flocculant is introduced prior to introduction into the basin to assure that the washwater contaminants settle in the basin prior to discharge. Advantages to this design include small additional incremental costs to accommodate the extra intermittent washwater flow, a forgiving design able to manage flow and contaminant variation, and relatively simple of operations. Disadvantages include large consumption of plant footprint, high capital cost, inefficient treatment as compared with clarification systems with lamellas, and large operating expenses associated with the increased rate of dewatering settled sludge that accumulates in the basin.

Figure 3. Sedimentation Basin System

Bottom Ash Handling Systems (CDRs, R-SFC)

Most facilities have already converted ash handling processes and procedures away from sluicing CCR to traditional surface impoundments. These systems tie into the sluice conveying piping in order to receive bottom ash, economizer ash and mill rejects/pyrites, and efficiently separate the ash from the sluicewater using a highly engineered flight conveying system. The remote SFC is designed to receive flow surges and a variety of ash loads. The water once separated from the ash is usually recirculated back to the powerhouse, while the ash dewaters passively in a bunker for eventual disposal or beneficial use.

Figure 4. Remote Submerged Flight Conveyor Bottom Ash Dewatering System

The design of the remote-SFC, given that it is capable of handling large and variable flows of water, as well as tons per hour of suspended solids, make it a logical option for treating outage wash wastewater. Chemical injection to facilitate pH adjustment and coagulation can be performed upstream near the powerhouse, employing the piping distances to allow mixing and reaction to occur. The SFC centerwell, which receives the sluicewater from the power house, provides a fast reaction zone to introduce flocculant and to trim the pH adjustment and coagulant dosing if needed. Finally, the body of the SFC provides a settling area to allow precipitated solids to settle, and either be conveyed up the ramp to the bunker, or pumped off for separate mechanical dewatering and eventual landfill disposal. Existing downstream clarifiers, temporary mobile clarifier solutions, or polishing basins can all provide additional clarification options if required.

Chemical Program

1. Site specific sampling and jar testing is required to determine the proper chemical program that will facilitate effective outage washwater treatment. Over the course of several dozen washes utilizing bottom ash handling systems, a variety of flocculant and coagulant combinations have proven effective. Interestingly, what proves effective at one site may be ineffective at a second site. As discussed, the variety of design basis inputs create unique circumstances for each site. Both cationic and anionic flocculants with varying charge density and molecular weight have proved effective, along with both iron based and aluminum based coagulants.
2. For pH adjustment, caustic soda is usually employed, as most contaminant streams carry a substantial acidic load. Caustic soda is available in 25% solution and 50% solution. Each has its own advantages and suitability for use, including:
    a. Strength of reaction – 50% caustic introduces a higher strength alkalinity to counteract strong acids found at the beginning of some of the washes. However, the high strength of 50% caustic can easily result in over-dosing, which will drive the pH above the discharge limit of 9.0. Careful application and diligent oversight is required.
    b. Freeze point – 50% caustic soda has a freeze point of 55 degrees Fahrenheit, which can cause operational problems even in early fall. Freeze protection measures such as tote blankets, heated storage tents and heat-tracing need to be in place for its use.
    c. Cost and availability. More dilute caustic soda carries a higher $ per 'unit of alkalinity delivered.' Global market conditions and manufacturing constraints can pose difficulties in acquiring either caustic product; working with a vendor with up-to-date knowledge of availabilities and willingness to inventory material is an advantage.
3. Chemical injection skids need to be sized appropriately to deliver adequate volumes of chemical for effective treatment. Caustic soda addition is controlled by pH readings. Coagulant and flocculant addition are indicated by flow and contaminant load.
4. Auxiliary mechanical dewatering equipment is deployed to manage the wastewater treatment sludge generated by the physical / chemical reaction process. As sludge settles and accumulates in the bottom of the clarifier system, it can periodically be pumped out or drained to a sludge thickening tank, and then directed to a mechanical dewatering device such as a belt filter press. In addition, Geo-Membranes have been successfully deployed in certain circumstances to passively dewater sludge and prepare it for disposal in a dry landfill.

Figure 5. Belt Filter Press Dewatered Sludge

Figure 6. Geo Membrane Dewatered Sludge

PERFORMANCE RESULTS

Results from the repurposing of R-SFC bottom ash dewatering systems have been favorable so far and indicative of a positive solution for the outage wash wastewater treatment challenge. Some key performance indicators and performance data are shown below.

Figure 7. TSS Comparison Influent and Effluent

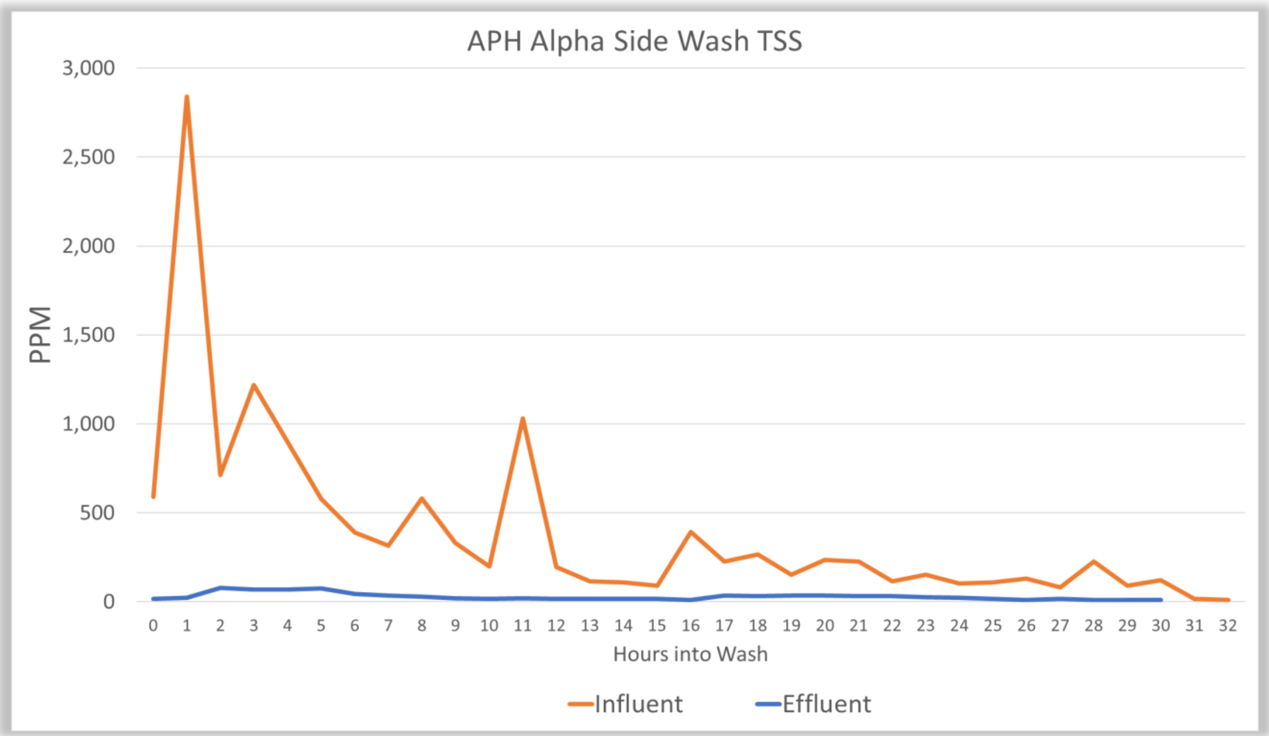


Figure 8. Total Iron Influent and Effluent Comparison

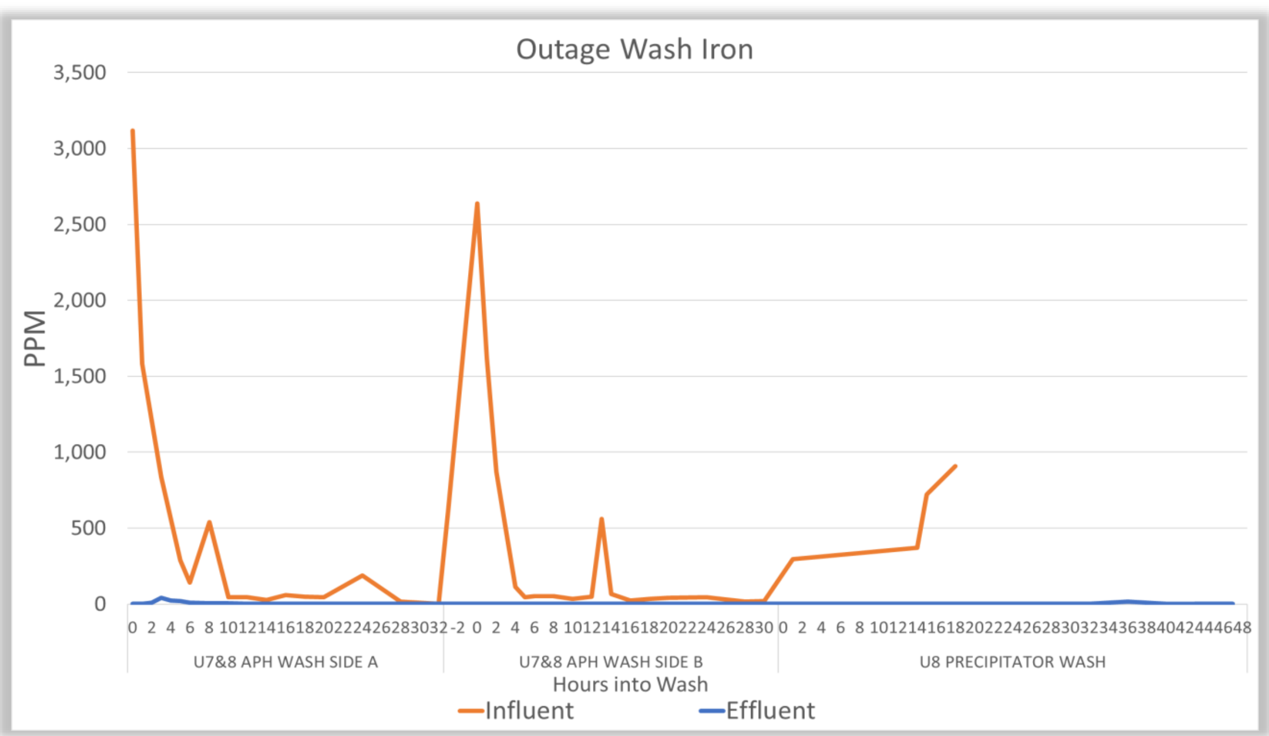
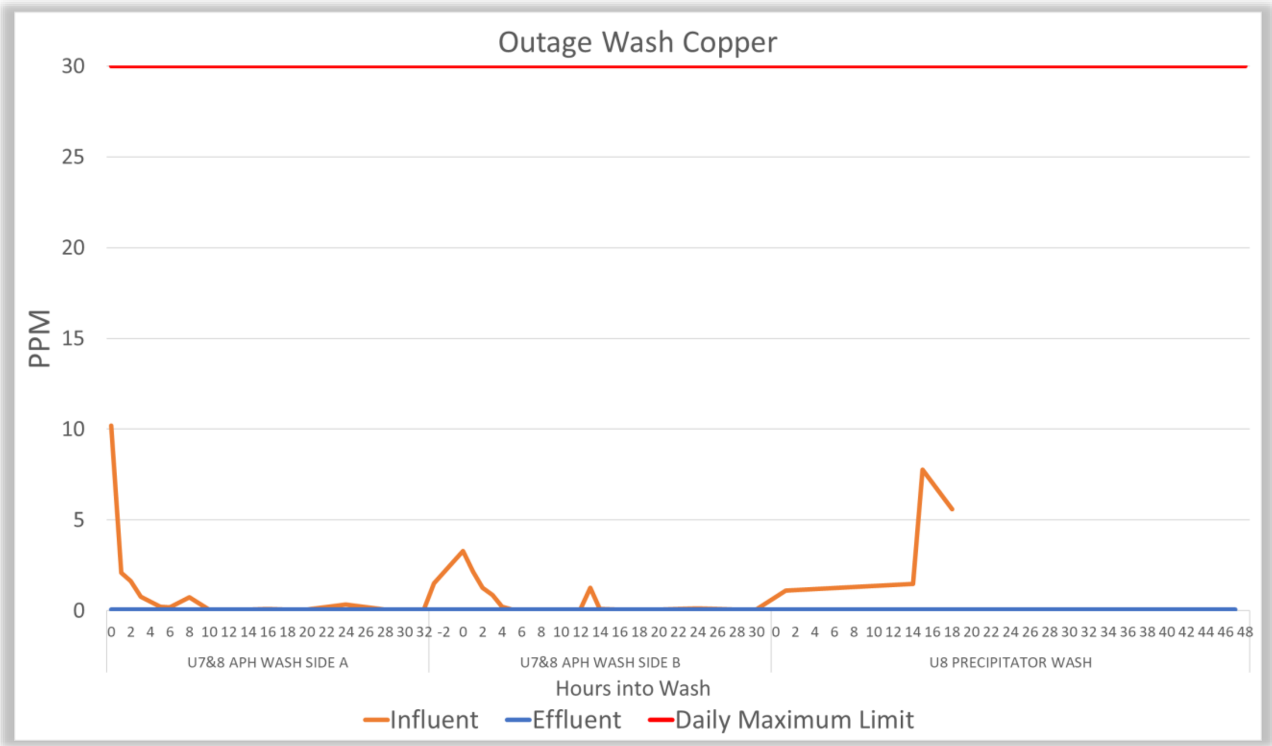


Figure 9. Total Copper Influent and Effluent Comparison



CONCLUSION

A variety of options are available to coal fired utilities to manage the treatment and discharge of outage wash wastewaters. Future focus of UCC Environmental will be the retrofit and temporary repurposing of bottom ash handling systems, as they offer an efficient and economical solution, both with respect to capital investment and operating costs. Retrofitting different types of bottom ash dewatering systems, such as under-boiler submerged flight conveyors and dewatering bin systems are being studied and assessed for performance as wastewater treatment systems as well. Much remains to be learned in order to fully understand the variances in the outage washwater quality and characteristics so that better predictive designs can be implemented to assure effluent compliance during outage wash events.