MEMORANDUM

TO: Steam Electric Rulemaking Record

FROM: Deb Bartram, ERG
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DATE: June 15, 2020

SUBJECT: **Notes from Site Call with Duke Energy's Mayo Steam Station**

On March 31, 2020, EPA held a conference call with Duke Energy (Duke) to discuss their experience with implementing a thermal evaporator for flue gas desulfurization (FGD) wastewater treatment and a pneumatic vacuum system for bottom ash management at the Mayo Steam Station in North Carolina. Discussion topics also included how long the process took to examine options, select and build a system, and have the system operational. This conference call was conducted in place of an in-person visit to the site. See **Table 1** for a list of teleconference attendees. See Appendix A for a copy of slides Duke presented at the meeting.

Table 1. List of Attendees

Name	Affiliation	Contact Information
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Below is a summary of the topics discussed during the meeting.

Station Overview

- See slide 2 of Appendix A for an overview of Mayo Steam Station (Mayo).

- Although Duke reported to EIA that the 2017-2018 capacity factor for Mayo was 53%, they indicated that Mayo ran at a capacity factor of 22-24% in 2019. Duke indicated this is an ongoing trend.

- Duke has no plans to repower the Mayo to natural gas at this time.

- Duke plans to close Mayo in 2029 (and Roxboro Steam Station in 2028/2029) to meet its 2030 carbon goal. Closures are dependent on receiving approvals for accelerated depreciation and replacement generation.

FGD Wastewater Treatment

Overview and Study

- Mayo first began studying how FGD wastewater characteristics affect the receiving lake, Mayo Reservoir, in 2008 prior to installation of the FGD scrubbers. Mayo Reservoir is classified as a drinking water source because it was previously used for potable uses on site. Mayo stopped using lake water as a potable drinking water source for the site in 2006. When the FGD scrubbers were installed in 2009, Mayo also installed an FGD settling pond followed by the General Electric (GE) AbMet biotreatment system, targeting removal of arsenic and selenium before discharge to the lake.

- New water quality-based permit limits were imposed in the 2006 to 2007 timeframe as part of the initial permitting work for the FGD scrubber installation and associated scrubber blowdown discharge. Around 2009, Mayo experienced drought conditions which resulted in increased pollutants concentrations cycling up in the Mayo Reservoir and illustrated the effect of discharging dissolved solids. To comply with the more stringent water quality permit limits and reduce cycling up of constituents in the reservoir, Mayo determined that it would be best to reduce or eliminate discharge of FGD wastewater to the reservoir if possible. Following the call, Duke provided their 2008, 2009, and 2010 Environmental Monitoring Reports for the Mayo Steam Electric Plant (SE08917A1). These reports encompass the timeframe of the drought conditions occurring in the 2008 timeframe.

- In July 2011, Duke began exploring potential updates to their FGD wastewater treatment system. Duke noted the following FGD treatment alternatives:
    - Pipe FGD wastewater to Dan River for discharge.
    - Install electrocoagulation system (concerned there was limited experience with the technology and the bench-scale tests were not promising).

  - Add more stringent physical/chemical treatment.
  - Install thermal treatment.

- In Spring 2012, Duke entered into a Special Order of Consent (SOC) which established interim permit limitations for mercury, boron, thallium, manganese, and selenium and a plan and schedule to investigate and construct needed upgrades to the wastewater treatment system to comply with the more stringent water quality limits imposed in the NPDES permit. . (See Slide 13 of Appendix A)

- Duke evaluated thermal evaporation systems in 2011 and 2012, including visiting sites in Italy and the U.S. to see evaporators in person at steam electric power plants and other operations. In 2012, Duke decided to install a thermal evaporation system to treat FGD blowdown, after pretreatment with the FGD settling pond. At that time, they were the 3rd site in the US to install a thermal evaporator treating FGD blowdown and the largest such system on scrubber purge.

- The system design allows the brine from the thermal evaporator to be mixed with fly ash and disposed in the Mayo Monofill (on site landfill). Leachate from the monofill is sent back to the FGD settling pond. (See Slides 12, 14, and 15 of Appendix A)

- Duke brought the thermal evaporator system online in January 2015 and replaced the old FGD settling pond with a newly built settling pond in May 2019 that meets coal combustion residual (CCR) rule requirements.

Description of Thermal Technology

- The thermal evaporator system consists of a falling film evaporator and a forced circulation evaporator. This system concentrates the FGD blowdown from the pond into a concentrated brine and a distillate stream and is located near the fly ash silo. See Appendix A, Slide 16 for a list of key equipment and operating parameters and Appendix A, Slides 17-19 for depictions of the system.

- Following settling in the pond, Mayo adds chemicals -throughout the process to the thermal evaporator. They can feed acid antiscalent, antifoam, or caustic as required throughout different locations within the system. Because there is a fair amount of scaling that occurs in the evaporators, acid is used to reduce CO_2 to prevent $CaCO_3$ scaling. They can feed anti-foam to prevent foaming within certain vessels and caustic to the vapor scrubber to address the natural drop in pH that occurs (to protect the metallurgy). Following the call, Duke provided confidential data regarding the feed water chemistry design considerations for the Mayo thermal evaporator (SE08917A2).

- The secondary evaporator further concentrates the brine from ~8 gallons per minute (gpm) to ~4 gpm. Mayo only operates this evaporator when needed to reduce discharge. The secondary evaporator was installed to manage the brine generated during the 370 gpm feed flow scenario with predicted ash being generated. However, plant staff noted that, at the time of the design, the plant was operating at a lot higher capacity. Since then,

their capacity utilization factor has reduced significantly, which also reduces the need for flow reduction of brine. Because the secondary evaporator uses more caustic and steam to operate because it does not have latent heat available, it's no longer considered viable. Therefore, the plant has only operated it "a handful of times" and are evaluating if they will continue to operate it.

- Brine is mixed with fly ash and then landfilled on site. Previously some of the fly ash was sold for beneficial reuse. Ash sold was conditioned to 18% moisture. Duke found there was no longer much of a market for fly ash generated at the Mayo Station. Several other coal stations in the Duke fleet continue to market and sell its fly ash for beneficial use, such as for usage in concrete.

Maintenance

- Maintenance of the thermal evaporator is as expected. Some replacement parts have long lead times and high costs due to metallurgies.

- The two heat exchangers (per train) are designed to run 1-2 weeks between basic cleanings.

- Primary and secondary evaporator cleaning consists of mechanical cleaning, followed by chemical cleaning and various flushes. This type of cleaning occurs every 2-3 months. The system uses EDTA for chemical cleaning which requires heat to be effective. When the system is down, there is not a source of heat to facilitate cleaning. Installation of an auxiliary boiler has helped.

- See Appendix A, Slides 21-22 for a description of maintenance concerns and pictures of scaling on the heat exchanger and primary evaporator.

Cost Recovery and Other Considerations

- Regarding the time to recover the costs of installing a thermal evaporation system, Duke indicated that they have requested accelerated depreciation by 2029 (rather than a 20-year service life).

- EPA asked for input on the voluntary incentives program (VIP) program included in the proposed ELG and whether plants would voluntarily opt into such a program:
    - Duke believes its likely plants would investigate their options.
    - Plants are likely to consider a membrane system; this would be a site-specific decision (likely driven by flows).
    - The cost of thermal is typically not considered economically viable for plants with flows greater than 400gpm. These plants may likely find a membrane system more cost effective.

- Duke reported that they would have considered a membrane/encapsulation system if it had been available at the time. Interest in this system has been driven by development of encapsulation technology. In 2012, when Duke was selecting treatment alternatives,

membrane technology was showing promise, but there were still questions regarding long-term feasibility and full-scale operation. Duke staff felt that encapsulation technology was not as available or understood and Duke would still have to address the concentrated waste stream.

- Duke has considered leasing options for FGD treatment, Duke noted that it has quotes for leasing a biotreatment system for the Cliffside Power Station, and a comparison of the cost to purchase versus leasing. Duke indicated that the monthly rental cost of the treatment system with operating and maintenance (O&M) costs is approximately $270,000. Duke noted that capital upgrades will still be necessary to accommodate the rental equipment. Following the call, Duke provided confidential data on the costs to lease vs purchase a biological plus ultrafiltration treatment system for Rogers (Cliffside) Unit 5 (SE08917A2).

Bottom Ash Handling

Overview and Study

- As described under FGD Wastewater Treatment, Mayo first began studying the effect of wastewater discharge on the receiving lake, Mayo Reservoir, in 2008.
- More restrictive limits on thallium were imposed on the ash pond treatment system with the installation of the FGD scrubber. The effective date of the permit with these changes in the limits was 10/1/2006. The limits became effective two years after the commencement of FGD wastewater discharge. It was believed bottom ash sluice water may have been the primary source of thallium.
- Between 2008 and 2011, Mayo evaluated bottom ash handling options that would result in zero discharge of bottom ash transport water. Mayo selected a Pneumatic Vacuum System in 2011 because it has a low auxiliary load and would achieve zero discharge. For Mayo the pneumatic system was a viable option due to room (both below the boilers and for a silo) to install the system and a clear path from the boiler to the silo.
- Mayo selected a system, designed and installed by United Conveyor Corporation (UCC), the Pneumatic Ash Extractor (PAX) system. It became operational in 2013. See Appendix A, Slide 5 for operation details of the system.

Description of PAX System

- See Appendix A, Slides 6-8 for an overview of the system. Bottom ash is collected under the boiler where it is fed through a grinder and a screw feeder moves the ash out to the silo. The use of the grinders has minimized clinkers in the ash silo. Ash is transferred from the silo to the Mayo Monofill (on site landfill) for disposal.
- Some of the piping in the system is carbon steel with the majority of it being sections of lined pipe. There are several different types of ceramic liners utilized in the Mayo design. Mayo has been working with UCC on optimizing the systems required maintenance. Mayo has had to patch pipes regularly (every 8-9 months) due to excessive wear (see Appendix A, Slide 9). UCC has proposed other types of liners to increase life; Duke Energy is evaluating to see if use is warranted.

Effects of COVID-19 on Plant Operations

- The COVID-19 situation has slowed some part deliveries to date, but nothing considered excessive. It has resulted in longer project durations and increased vigilance, social distancing measures, and oversight.
- Most Duke projects are completed, except for Cliffside Power Station's Unit 5 installation of a bioreactor.
- The Roxboro Steam Station recently installed a new FGD wastewater treatment system that consists of physical/chemical treatment, biological treatment, and ultrafiltration. The bioreactor in the FGD treatment system supported by Suez. Because the Suez field personnel are in Canada, there has been some difficulty getting support due to travel restrictions.
- Some stations have delayed planned outages to prevent the spread of COVID-19 and avoid electrical supply and travel issues.
- Duke is still performing environmental compliance activities, including collecting and analyzing samples. Duke acknowledged this is still an evolving situation and actions company-wide are reassessed frequently.