A Tier II application to modify a solid waste disposal facility permit (permit number FA3549012) was filed with the Department of Environmental Quality (DEQ) by the Grand River Dam Authority, PO Box 409, Vinita, Oklahoma 74301 on November 10, 2014.

The DEQ has tentatively found that the application meets the requirements of Title 27A of the Oklahoma Statutes, Section 2-1-101, et seq., Section 2-10-101, et seq., and rules of the DEQ, Oklahoma Administrative Code (OAC), Title 252, Chapters 4 and 515, and has prepared a draft permit modification for public review.

The draft permit modification and its conditions propose to allow the disposal of spent powdered activated carbon used to control flue gas mercury emissions at the GRDA coal combustion unit at the existing on-site GRDA non-hazardous industrial waste ash landfill. The landfill is currently authorized to dispose of only fly and bottom ash.

The landfill is located at their Grand River Energy Center facility, located in Sections 16, 20, 21, 28, and 29, Township 20N, Range 19E1W, Mayes County, Oklahoma, located 3 miles east of the town of Chouteau, at the northwest corner of the intersection of U.S. Highways 412 and 412B.

The draft permit may be reviewed at the Thomas J. Harrison Pryor Public Library, during normal business hours at 506 East Graham Street, Pryor, Oklahoma, or at the DEQ Central Records office (see address below). The draft permit is also available for review in the Land Protection Division Section of DEQ's Web Page: //www.deq.state.ok.us/

The public comment period ends 30 days after the date of publication of this notice. Any person may submit written comments concerning the draft permit to the DEQ contact listed below. A public meeting on the draft permit may also be requested in writing at the same address. Note that all public meetings are to be arranged and conducted by DEQ/CSD staff.

For additional information, contact the applicant's representative, Michael L. Bednar at (918) 256-0893 or PO Box 70, Langley, Oklahoma 74350-0070, or Hillary Young, Chief Engineer, Land Protection Division of the Department's central office, located at 707 N. Robinson, P.O. Box 1677, Oklahoma City, OK 73101-1677, (405) 702-5100.
DRAFT SOLID WASTE PERMIT MODIFICATION

The Department of Environmental Quality hereby approves the following modification:

Permit Number: 3549012
Permittee: Grand River Dam Authority (GRDA)
Facility: GRDA Ash Landfill
Facility Type: Non-hazardous Industrial Waste Landfill
County: Mayes

Modification:

Revise the existing permit to allow disposal of an additional waste stream at the on-site GRDA owned non-hazardous industrial waste landfill in Mayes County.

Conditions:

1) Only fly ash, bottom ash and spent powdered activated carbon used to control flue gas emissions, generated at the GRDA owned and operated coal combustion facility in Mayes County, may be disposed in the landfill.

2) Documentation that all waste disposed in the landfill has been fully characterized and documented to be non-hazardous must be maintained as part of the facility record. Documentation may consist of process knowledge.

The permittee is authorized to operate in conformity with the application described above. Commencing operations under this permit modification constitutes acceptance of, and consent to, the conditions contained herein.

Hillary Young, Chief Engineer
Land Protection Division

Date: ________________

Kelly Dixon, Director
Land Protection Division

Date: ________________
November 5, 2014

Patrick Riley
Solid Waste Permitting Unit
Waste Management Division
Oklahoma Department of Environmental Quality
707 N. Robinson (P.O. Box 1677)
Oklahoma City, OK 73101-1677

RE: Grand River Dam Authority, Permit No. FA 3549012
Tier II Modification of the Solid Waste Permit to include an Additional Solid Waste Stream
Response to Notice Of Deficiencies letter from ODEQ dated September 30, 2014

Dear Mr. Riley:

This letter is to address the three points brought out in your letter to GRDA referenced above.

The first point was a requirement to publish a notice of filing for the permit modification in a local newspaper. This occurred on September 23, 2014. A copy of the Affidavit of Publication is included with this letter.

The second point was a request for a summation of prior studies which GRDA referenced referencing the leaching potential of mercury from powdered activated carbon mixed with fly ash. A summary of these studies is attached with this letter.

Finally, you requested that we resubmit our application with an Oklahoma professional engineer stamp. This is also included with this letter.

I hope you find that this information provides the level of detail you require as you review our application. If you need any additional information, or would like to discuss this further by phone or in person, please do not hesitate to contact me.

Sincerely,

Michael L. Bednar
Superintendent of Environmental Compliance
GRDA
Ecosystems and Education Center
420 Hwy 28
PO Box 70
Langley, OK 74350-0070
(918) 256-0893

CC:
C. Barney, J. Burrow GRDA
P. Sadowski Black & Veatch
In the Court of Mayes County,
State of Oklahoma

GRDA

Cause No.: 
TIER II APPLICATION

Plaintiff,

vs.

Affidavit of Publication

Defendant,

STATE OF OKLAHOMA

COUNTY OF MAYES

Bailey Dabney, of lawful age, being duly sworn, upon oath depo[es and says that he/she is the Authoriz[ed Agent of The Times, a newspaper printed in Pryor, Mayes County, Oklahoma, and is a bona fide paid general circulation therein, printed in English language, and that the police by publication, a copy of which is hereto attached, was published in said newspaper for 1 consecutive times in its daily issue, first publication being on the 23rd day of September 2014, and the last day of publication begin on the 23rd day of September 2014, and that said newspaper has been continuously and uninterrupted published in said county during the period of One Hundred and Four (104) weeks consecutively prior to the first publication of said notice or advertisement as required by House Bill 99, (an act amending Section 54, Oklahoma Statutes 1931) passed by the Fifteenth Legislature and effective July 23, 1935, and thereafter.

The advertisement as referred to, a true and printed copy of which is hereto attached, was published in said newspaper on the following dates, to-wit:

Insertion: SEPTEMBER 23rd, 2014

2nd Insertion:

3rd Insertion:

4th Insertion:

5th Insertion:

Final Insertion:

Said notice was published in the regular edition of said newspaper and not in a supplement thereof. Affiant further states that said newspaper meets all the requirements of the laws of the State of Oklahoma with reference to legal publications.

Authorized Agent

Subscribed and sworn to by BAILEY DABNEY, Authorized Agent of said newspaper this 25 day of September, A.D. 2014

[Seal]

Notary Public

Commission expires: June 7, 2016 #04006124

Publishing Fee $57.75
MEMORANDUM

Grand River Dam Authority (GRDA)           B&V Project 177456
GREC Unit 2 AQC Upgrades                      B&V File 34.3000
Waste Characterization for permit Modification                  2 November 2014

To:        Mike Bednar, GRDA

From:      Paul Sadowski

Introduction
This memorandum is in response to the 20 Sept 2014 Notice of Deficiencies issued by the Oklahoma Department of Environmental Quality (DEQ) following submission of an Application to Modify a Solid Waste Disposal Facility Permit submitted by the Grand River Dam Authority (GRDA). One of the deficiencies cited was insufficient information on the proposed waste stream. During a telephone call with Patrick Riley (with DEQ) on 8 October 2014, it was learned that additional information is desired to determine how this waste might respond to long-term disposal in the high pH condition of the GRDA landfill.

Powdered activated carbon (PAC) will be introduced to the flue gas to reduce mercury emissions as required by regulations under the Mercury and Air Toxics Standards rule under the Clean Air Act Amendments. The PAC will be mixed with the fly ash, creating a new waste stream comprised of fly ash, PAC, and an increased concentration of mercury, produced by the GRDA Unit 2 Generating Station at the Grand River Energy Center (GREC) in Mayes County, Oklahoma. Using the maximum PAC injection rate, as much as 164 tons of PAC could be added to the fly ash placed in the landfill annually, beginning in January 2015.

While a number of studies have been completed, this review is limited to information on the analysis of the potential for mercury to leach from the PAC once placed in the landfill. Mercury in coal varies and ranges from about 0.5 milligrams per kilogram (mg/kg) (parts per million or ppm) up to about 2 mg/kg (EPRI, 2009); however, the coal used at the GREC is primarily from the Powder River Basin (PRB). Based on 612 coal samples from the PRB, the mean concentration of mercury is 0.08 mg/kg (USGS, 2001). Over the past four years, approximately 100,000 tons of ash has been disposed in the landfill annually1. This figure is likely to increase if beneficial use of fly ash is reduced due to the addition of PAC and increased concentration of mercury in the ash.

The inlet mercury loading, ash content, and mercury capture rate in the PAC may also vary. Coal used in the design basis for the Unit 2 air quality control upgrade has a heating value of 8,400 British thermal units per pound (Btu/lb) and a mercury content of 0.1 ppm. The calculated mercury in the fly ash is 912 parts per billion (ppm), and the mercury removal efficiency will be approximately 90 percent.2

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1 GRDA Coal-Fired Complex information data request for design information for the emissions control project, 2009.
2 Based on the design basis used by Black & Veatch for the air quality control upgrades for Unit 2.
Properties and Analysis
Previous analysis of fly ash, leachate, and the use of PAC and other emissions control technologies has been conducted by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy, PAC manufacturers, universities, industry groups, and others. The amount of PAC required for this application was based on PAC vendor experience; physical testing has not been conducted on the projected GRDA waste stream.

Fly ash composition varies, but it typically produces a pozzolanic reaction in the presence of water, which is why it can replace a portion of the Portland cement in a concrete mix. Mineral analysis of the GRDA ash indicates that its composition (% by mass) is approximately as follows:

Silica (SiO₂) 33.8 %
Calcium Oxide (CaO) 22.2 %
Alumina (Al₂O₃) 15.9 %
Sulfur Trioxide (SO₃) 12.8 %
Iron Oxide (Fe₂O₃) 5.6 %
Magnesium Oxide (MgO) 4.8 %
Sodium Oxide (Na₂O) 1.5 %
Titania (TiO₂) 1.2 %
Phosphorus Pentoxide (P₂O₅) 0.8 %
Potassium Oxide (K₂O) 0.3 %

The GRDA ash would likely be classified as Type C in accordance with the American Society for Testing and Materials (ASTM) C618. The higher calcium oxide of this ash indicates this material is cementitious and will be self-hardening with the application of water.

Toxicity Characteristic Leaching Procedure
While the pozzolanic properties of fly ash make it a potentially desirable material and may promote beneficial reuse, it also has complicated testing to determine the potential of fly ash to leach contaminants, including mercury and other trace metals.

Flue gas emission control waste is considered exempt from classification as a hazardous waste by the Resource Conservation and Recovery Act. The regulations for coal combustion residuals (CCR) are presently under review by the EPA, with new rules anticipated to be issued in December 2014. The new rules are not anticipated to change the classification for CCR materials. The leaching procedure most commonly used to analyze the likelihood of contaminants in leachate, and required by the EPA to determine if a waste may release metals (and other constituents) in toxic concentrations, is the toxicity characteristic leaching procedure (TCLP). This test procedure is Method 1311, and is contained in Section 7.3 of EPA’s publication, “Test Methods for Evaluating Solid Waste (SW) Physical/Chemical Methods” (EPA publication SW-846). The TCLP produces a liquid extract from soil (or other solid waste) that is further analyzed and compared to regulatory limits provided in 40 CFR §261.24. The TCLP test was developed to assess the potential risk to groundwater from potentially toxic materials disposed with organic matter (garbage) in a landfill.

3 GRDA, op cit.
Use of the TCLP for analysis of fly ash has been criticized since ash is rarely co-disposed with garbage, and the buffered acetic acid solution used as the leaching medium would not mimic conditions in a typical ash landfill. Another potential drawback to the TCLP is the requirement to prepare the sample (soil or other materials) for the procedure. The substance to be tested must pass a 9.5 millimeter (mm) sieve. Grinding or crushing a sample of ash to prepare the material for the leaching phase physically alters the ash, and produces a sample that would not be equivalent to the fly ash found in a landfill (compacted and probably altered by chemical reactions following contact with precipitation). Since the particle size is reduced and contact between the acid and the ash may be increased, the constituents found in the resulting extraction may contain concentrations of metals that are significantly different from, and potentially greater than, those likely to occur in leachate from the landfilled fly ash.

**Analysis of Leachate and Landfills**

The U.S. Department of Energy's (DOE's) National Energy Technology Laboratory has conducted a lengthy multi-year research program on coal combustion, including testing leaching potential of metals from fly ash using various leaching fluids.

Testing the mercury content of 31 pulverized coal fly ash samples as part of a leaching study was summarized in a report titled, *Comparison of Leaching Results for Three High Mercury Fly Ash Samples* (Kazanic et al., 2005). Five leaching fluids were used, including 0.1 “normal” (N) solutions of sulfuric acid, acetic acid, and sodium carbonate, as well as deionized water and synthetic precipitation (deionized water with a mixture of sulfuric and nitric acid added) in the research. In this study, both ash with and without activated carbon was tested.

The total mercury concentrations in the three ash samples were 1.614 ppm in sample FA51, 8.93 ppm in sample FA52, and 1.091 ppm in sample FA53. The DOE report noted that the concentration of mercury in ash sample FA52 was “about 1000 times more than most PC (powdered coal) fly ash” however, the resulting leachate from all three samples was less than 80 nanograms per liter (ng/L) or parts per trillion. Leaching times lasted as little as three months (when mercury concentrations in leachate in some samples had decreased to below the detection limit of 0.5 of ng/L), to as long as one year. The cumulative amount of mercury reported from all leaching ranged from 0.01 percent in sample FA51 to 0.10 percent of the total mercury samples FA52 and FA53. Two results are worth noting -- while the waste stream to be disposed from the GRDA will have PAC and be in a basic (high pH) environment, the samples producing the greatest concentrations of mercury in the previously mentioned study were those that did not have the activated carbon and were from an acidic (low pH) environment, the acetic acid leachant, which ranged between 20 and 50 ng/L for nearly a year.

The EPA issued a report titled, *Characterization of Mercury-Enriched Coal Combustion Residuals for Electric Utilities Using Enhanced Sorbents for Mercury Control* (EPA, 2006). This research was conducted for EPA's Office of Research and Development, and focused on the potential for leaching to groundwater of mercury, arsenic, and selenium during storage, beneficial use, and disposal of coal combustion residuals (CCR). During this fly ash study, leaching of mercury as a function of pH and liquid-to-solid ratios (milliliter of water per gram [ml/g] of CCR) was also tested. The laboratory test results were used to assess a variety of field management scenarios to develop estimates of constituent release. Laboratory results and field observations of leaching were compared, and
MEMORANDUM

constituent release estimates projected to occur over a 100-year period were also developed for three hypothetical landfill scenarios with and without activated carbon injection. This study concluded that mercury is strongly retained by the CCR and unlikely to be leached at levels of environmental concern. In this study, leaching did not correlate to the total mercury content in the CCR, the pH of the leaching medium, or the liquid-to-solid ratios.

The multi-year study supported by the DOE also evaluated samples of fly ash both with and without mercury control technologies in place (DOE, 2007). As expected, the total mercury content in the fly ash increased with the use of activated carbon control technology; however, as described in EPA's study above, both short- and long-term leaching studies did not correlate total mercury with the concentrations of mercury in leachate. This DOE study concluded that current management options will continue to be sufficiently protective of the environment.

This DOE study also noted that fly ash with high pH levels (pH > 10) has the potential to undergo hydration reactions and form ettringite (a hydrated calcium aluminum sulfate hydroxide mineral) that can change the leaching profile over time; however, the authors noted that mercury is not affected by the formation of ettringite, so the chemical changes over time would be unlikely to affect the leaching rate of mercury. They also noted that mercury was not released in the vapor phase below 250°C, while 100 percent of the mercury was released by the time 750°C was reached. Therefore, release of mercury in the vapor form would not occur from CCR landfills.

A paper titled, "Leaching Behavior of Elements from Coal Combustion Fly Ash: An Overview" (Izquierdo and Querol, 2011) compared several studies (including the EPA study described in the previous paragraph) and presented the results of studies for several constituents. This report notes that leachate studies of Australian and U.S. fly ash samples show extremely low concentrations of mercury (below 0.2 micrograms per liter [µg/L] or parts per billion [ppb]), and often below 0.02 µg/L) across the 4.5 to 13 pH range, and also show no pH dependence. The report states that testing also indicates that there was a consistent lack of correlation between total mercury concentration and leachable mercury in studies, with little differences between short- and long-term leaching studies.

A study conducted in Ontario, Canada titled "Chemical and Mineralogical Transformations of Coal Fly Ash after Landfilling" (Yeheyis et al., 2009), reported that secondary minerals were produced after landfilling due to the hydration, carbonation, and pozzolanic reactions within the landfill. Samples of fly ash were obtained from both the capped (a geomembrane and soil cover) and uncapped areas of the landfill. Fly ash from the uncapped portion of the landfill was continuously exposed to weathering and other natural processes. While the purpose of the Ontario study was to determine if the "fresh and disposed fly ashes" were amenable to recycling and reuse, the materials were also subjected to tests that assessed changes in leachability. In this study, fly ash was tested using both an 18-hour reaction time (as specified by the TCLP) and a more rigorous 48-hour mixing, as required by the generalized acid neutralization capacity (GANC) test. The study reported that the metals concentrations in the leachate reached equilibrium during the 18-hour study, and that neither the fresh nor the disposed ash samples exceeded the maximum concentrations of the TCLP or the Ontario Regulation 558 Leachate criteria.

Studies at three coal-fired power plants using various activated carbons reported leachate concentrations in the range of 0.01 to 0.07 µg/L, with the amounts of mercury frequently also
reported below the detection limit of 0.01 µg/L (Senior et al, 2003). In a study using the TCLP as well as testing over a broad pH range funded by the Chinese Special Funds for High Tech Research, the maximum concentration of approximately 0.55 µg/L was reported (Lao et al, 2006). The prior studies were laboratory studies; however, field samplings of leachate from CCR landfills in Wisconsin showed that concentrations of mercury were usually less than 50 ng/L, with the concentration of methyl mercury less than 1 ng/L (EPRI, 2005). The Wisconsin study noted that the total mercury content in the landfill ash increased with use of activated carbon injection, but the leaching concentrations continued to be very low, particularly at the alkaline pH ranges in the landfill and groundwater in Wisconsin.

Studies of fly ash using the TCLP and other synthetic groundwater leaching tests conclude that mercury release is stable on activated carbon, and research conducted by the EPA (EPA, 2006), DOE (Kazonic, 2005; DOE, 2007), and private researchers reports leaching concentrations below the TCLP regulatory limit of 0.2 milligrams per liter (mg/L).

**Stability of Mercury on Activated Carbon**

As noted, while studies of leachate with enhanced mercury-absorbing media has concluded that mercury is retained by activated carbon, the studies described previously used fly ash, which presents challenges to the TCLP and other leaching procedures. In a study conducted at the University of Toronto, mercury was directly loaded onto activated carbon — eliminating problems associated with grinding and crushing needed by other leaching procedures (Graydon et al., 2009). This study also used TCLP as well as sequential extractions to allow identification of the phases of mercury involved.

Although their loading of mercury exceeded the amount used in a prior study (e.g., 224 micrograms per gram (µg/g) vs. 0.66 µg/g in the study by Liu et al., 2000), the TCLP results were generally less than the detection limit of 0.02 ppm, with the exception of a non-sulfur impregnated carbon, which reported leachate at 0.05 ppm. The total quantity of mercury leached was less than 0.5 percent of the total mercury loaded on the activated carbon. The study concluded that mercury was retained both chemically and physically, and that both forms of binding “provide permanent stabilization of the mercury in activated carbon sorbents after disposal.”

**Closure**

Ash is placed in the GRDA landfill in a dry condition, so no free water is present during disposal. Water is used to minimize dust formation during working of the surface, so the cementitious reaction of the ash with water is used to an advantage. Analysis of the natural clay liner underlying the adjacent permitted (but not used) cell was performed and the coefficient of vertical permeability for two samples was reported as 9.45 E-07 centimeters per second (cm/sec) (Bentley, 1995).

At the end of its useful life, the landfill would be capped and closed in accordance with the DEQ-approved closure plan. A post-closure program, including continuation of runoff controls to prevent ponding and monitoring of the cap, would be performed to maintain the integrity of the closed landfill. The current closure requirements include placement of clay and a vegetated erosion control
layer. While closure requirements may change with the proposed new rules, current closure standards would further reduce the quantity of future leachate.

Summary and Conclusions
This review was prepared to provide additional information on the proposed waste stream, as well as additional information on the potential impact of the waste stream on the landfill and surrounding environment. Studies of mercury leaching from fly ash by the EPA, DOE, and others confirm that the PAC retains mercury effectively. Research confirms that leaching of mercury should be expected; however, various leachate procedures (TCLP and other leaching methods at different pH ranges) show that mercury concentrations in leachate are significantly below the TCLP regulatory levels (200 ppb) as well as the primary drinking water standard of 2 ppb.

Limited information was found discussing the long-term changes to dry landfills used for fly ash disposal. It is likely that construction methods used for older landfills have varied, and comparative landfill studies were not found. Studies indicate that mercury concentrations in fly ash are low, and suggest that concentrations of mercury in leachate decline over time. Capping the GRDA landfill in accordance with the DEQ-approved closure plan would be expected to reduce infiltration into the landfill and weathering of the material, as well as the potential for leachate formation and mercury release from the landfill.

References


APPLICATION TO MODIFY A SOLID WASTE DISPOSAL FACILITY PERMIT

Date: 11/5/2014  County: Mayes

Send to:
Solid Waste Permitting Unit
Waste Management Division
Dept. of Environmental Quality
707 N. Robinson (PO Box 1677)
Oklahoma City, OK. 73101-1677

FOR DEQ USE
DEQ Log No. 
No. Copies 
Date Received:

Grand River Dam Authority proposes to modify the permit of 
(Applicant's Name)
the Grand River Energy Center, located at SW/4 of the NE/4, and the SE/4 of the NW/4, and 
(Facility Name)
the N/2 of the NE/4 of the SW/4, Section 26, T20N, R 19E, I.M.
(Exact legal description:
metes & bounds, platted lot, or land survey. Append extra sheets if necessary)
in Mayes County, Oklahoma. We hereby make application for a modification of existing permit number FA3549012 as required by the Oklahoma Solid Waste Management Act and the Rules pursuant thereto.

Remarks & brief description of proposed modification:
Modification of the Coal Ash Disposal Site to allow placement of powdered activated carbon in this landfill. Based on the maximum injection rate, up to 154 tons of this waste stream will be disposed annually, while an average of 100,000 tons of ash was disposed annually from 2010 to 2013.

Applicant or Authorized Agent: Michael Badnar 
Typed Name
Address: GRDA, 420 Highway 28, PO Box 70 
City: Langley State: OK 74350 

Preparation Engineer: Monty E. Hintz 
Typed Name
Address: Black & Veatch, 11401 Lamar Avenue 
City: Overland Park State: KS 66213 

Date signed: 11/5/2014 Phone: 918-256-0893

Date signed: 9/19/2014 Phone: 913-459-2464

Facility Address (if any):
Grand River Energy Center 
8142 Highway 4128 (PO Box 609) 
Chouteau, OK 75337-0609

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