SUPPLEMENTAL TESTIMONY

OF

CHARLES H. NORRIS, P.G.

Case No. EA-2012-0281

Q. Please state your name and **business address.**

A. My name is Charles H. Norris and my business address is Geo-Hydro, Inc., 1928 East 14th Avenue, Denver, Colorado 80206.

Q. Are you the same Charles H. Norris who previously filed cross-surrebuttal testimony in this case?

A. Yes.

Q. What is the purpose of your supplemental testimony?

A. My supplemental testimony responds to the supplemental testimony provided by Ameren witnesses Craig Giesmann, Tyler Gass, and Steven Putrich, and the supplemental schedule filed with Mr. Giesmann's testimony.

Q. What documents have you reviewed in connection with your supplemental testimony?

A. In addition to the pre-filed testimony, schedules, and data request responses previously filed in this case, and the documents I reviewed in preparing my cross-surrebuttal testimony, I also reviewed the supplemental testimony and schedule referenced above. I also reviewed the comments prepared by Andrews Engineering (Andrews), Franklin County's Independent

Registered Professional Engineer, on Ameren's previous versions of its construction permit application (CPA), and Ameren's responses to the comments prepared by Andrews. The comments by Andrews and subsequent responses by Ameren were referenced in the supplemental testimony of Ameren's witnesses, and are submitted herewith as Norris Schedules S1-S5.

I also reviewed previously-filed testimony and schedules that are pertinent to supplemental testimony by Tyler Gass related to contamination of groundwater by the existing ash ponds, including Schedule LNJB-S13, filed with the pre-filed surrebuttal testimony by Lisa Bradley. I also reviewed three of the references cited in Schedule LNJB-S13 -- the April 2012 Golder Associates report regarding temporary piezometers in bedrock near and above the Labadie plant, and the laboratory analyses of the first two rounds of baseline sampling performed in the monitoring system wells by Reitz & Jens, Inc., and Gredell Engineering Resources, Inc, in April and August 2013, respectively. I also reviewed a summary of results of the third round of baseline sampling performed in November 2013. Tables prepared by Lisa Bradley summarizing the first three baseline sampling events are submitted herewith as Norris Schedule S6.

Q. Have the opinions you stated in your prior testimony changed?

A. No.

Q. Are the opinions expressed in this testimony and your prior testimony based on a reasonable degree of certainty based on your education, training, and experience as a professional geologist specializing in hydrogeology and geochemistry?

A. Yes.

Q. To the extent that you relied on any documents, including in forming your opinions, do you consider such documents reasonably reliable and are those documents of the type reasonably relied upon by experts in the area of hydrogeology?

A. Yes, With respect to the documents submitted or referenced by Ameren's witnesses, I relied on the data within those documents but not the discussions or conclusions.

Q. Did Andrews Engineering, Franklin County's designated Independent Registered Professional Engineer, raise concerns about Ameren's groundwater detection monitoring system?

A. Yes, among the concerns raised by Andrews were concerns about Ameren's groundwater detection monitoring system.

Q. What concerns did Andrews Engineering raise regarding Ameren's groundwater detection monitoring system?

A. Andrews' concerns were based in part on the lack of sufficient information to design a scientifically and technically sufficient monitoring system. Andrews identified two foundational concerns with the proposed groundwater detection monitoring system. The first is that Ameren based its groundwater monitoring system on data obtained during what Ameren perceived to be a hydrogeologically atypical period. The second foundational concern was that the characterization of the hydrogeology of the proposed site was insufficient for the design of an adequate groundwater monitoring system. Andrews noted that the hydrogeologic characterization of the site was limited to two dimensions (horizontal flow), but that an aquifer needs characterization of flow in three dimensions, i.e., characterization of vertical as well as horizontal flow. Part of the characterization for vertical flow requires geologic and

hydrogeologic characterization of the aquifer from top to bottom and characterization of the rock layer at the base of the aquifer, across the entirety of the site.

These two foundational concerns generated a number of derivative concerns regarding the adequacy of the design for the groundwater monitoring system. Among those concerns were the following:

(1) A good design derived of data from a period of atypical conditions will be adequate for periods of comparable atypical conditions. Ameren did not demonstrate that the model it used would be adequate for other conditions.

(2) Andrews raised the concern that site characterization was performed only sufficiently to describe flow in a horizontal direction across the site Andrews recognized that for this aquifer in this setting, it is highly unlikely there is only two-dimensional, horizontal flow and recognized that potential impacts must be evaluated in all directions of flow. Andrews therefore proposed five deep borings surrounding the proposed waste disposal area, each to be drilled into the confining unit below the aquifer. The objective would be to characterize geologic and hydrogeologic conditions through the thickness of the aquifer and at its base at representative locations around the utility waste disposal area.

(3) Andrews was also concerned that the proposed monitoring system was collecting baseline water quality data only at the water table. Andrews recognized that for this aquifer at this setting, water quality would likely vary vertically and horizontally. Therefore, baseline water quality data must be collected throughout the aquifer, not just at the water table, to detect leakage from the landfill to the groundwater. Andrews therefore recommended that five deep characterization borings be completed as deep monitoring wells to establish baseline water

quality at the bottom of the aquifer, to collect head data to determine background local vertical gradients, and to serve as permanent wells in the monitoring system for head and water quality data.

(4) Andrews was also concerned that many of the input parameters to the computer program that was used in designing the monitoring system were generic or literature-based. Andrews established through sensitivity studies that these parameters substantially impact the geometry of any plume of utility waste leachate, and that using measurements taken specifically for this aquifer at this site or nearby sites would yield a more meaningful groundwater monitoring system. Where on-site or nearby hydrologic properties of the aquifer had not been measured, Andrews recommended that aquifer sediments be collected from the additional characterization borings. This would allow site-specific approximations of the properties to be calculated and would allow site-specific inputs to the computer program, designing a more effective monitoring system.

(5) Andrews was also concerned that the computer program PLUME, which cannot take into account vertical flow or vertical dispersion, was inappropriate for the design of an effective monitoring system. However, until the additional characterization and data collection were available to describe three-dimensional flow within the aquifer, Andrews could not recommend an alternative computer program to assist with additional design for the monitoring system.

Andrews was also concerned that the implementation of the computer program PLUME was flawed with respect to the use of hydrogeologic input parameters taken from literature; the input choices for the size, geometry, and orientation of hypothetical liner failures creating a plume; source term concentrations; and relevant plume boundary concentrations for determining an

adequate number and placement of monitoring points for the monitoring system. To demonstrate the sensitivity of the design by PLUME to variations of these inputs, Andrews used PLUME to generate an alternative monitoring system, accepting hypothetically that flow and contaminant migration are strictly two-dimensional. Andrews then recommended that, to appropriately implement PLUME at this site, nine additional monitoring wells should be installed at the water table.

Q. Do you have an opinion regarding the validity of Andrews' concerns as summarized above?

A. Yes. In my professional opinion, the concerns raised by Andrews are valid and significant.

Q. **Ameren subsequently made some changes to the monitoring system, as reflected in the revised Construction Permit Application (CPA) submitted to DNR in December 2013. To what extent do the changes in the monitoring system address the concerns raised by Andrews Engineering?**

A. The changes Ameren made to the monitoring system do not completely address any of the concerns raised by Andrews, although they partially address some of the concerns.

Ameren eventually agreed to add three deep characterization wells, rather than the five requested by Andrews. Whereas Andrews sought characterization of the full thickness of the aquifer, its contact with the underlying bedrock, and the nature of the bedrock contact entirely around the proposed landfill, the changes made by Ameren will provide new data only around the north half of Cell 2 and west of Cell 4. The bulk of the proposed landfill site will remain uncharacterized.

Each of the three deep characterization wells will be completed with a screened interval directly above the bedrock interface at the bottom of the alluvial aquifer. Except for measurements of heads, no direct hydrologic data collection, such as hydraulic conductivity testing or tracer testing, is proposed. The reduction from five deep alluvial wells around the facility (as recommended by Andrews) to three at only one end (as agreed to by Ameren in its revised application) significantly reduces the usefulness of this new data from the deep aquifer. The five wells proposed by Andrews around the circumference of the site would have likely provided sufficient data for heads deep in the aquifer to be integrated with those from the shallow aquifer. That would have enabled an analysis of vertical groundwater flow patterns and variations under the entire facility. By limiting the deep well data to the northwest corner of the proposed facility, little more is likely possible than assigning a planar gradient pattern to the deep aquifer under that corner.

Water quality data will be collected from the three deep wells both for purposes of determining baseline water quality at those three locations, and for conducting detection monitoring once the utility waste landfill is built. This is an improvement over the previous monitoring system and partially addresses concerns expressed by Andrews. However, as discussed above, the changes accepted by Ameren are limited to only a corner of the facility, whereas Andrews appropriately recommended obtaining this data from the whole facility.

These three deep wells have very limited utility for detecting groundwater contamination due to their locations. There is likely no upgradient/downgradient relationship among the wells. The two “downgradient” wells are located north and northeast of Cell 2 of the proposed landfill, where the river-side flow regime is north 32.6 degrees east. Water passing these wells is not water that passed through the area monitored by the “upgradient” deep well. The “upgradient”

deep well is located in the southern, bluff-side water regime, where the depicted flow direction averages north 66.6 degrees east. Water passing the "upgradient" well moves under Cells 3 and 4 of the proposed landfill, but is not monitored on the downgradient side.

The monitoring proposed by Andrews for the base of the aquifer would have monitored both upgradient and downgradient locations for both the river-side and bluff-side regimes of flow, thereby allowing common statistical techniques to be used to compare water qualities to determine impacts. In contrast, the limited additional monitoring in Ameren's revised application is not sufficient to support meaningful comparison between the "upgradient" and "downgradient" locations. As a result, the revised groundwater monitoring plan is unlikely to detect impacts of the proposed landfill on the deep aquifer.

Finally, as discussed by Andrews in its comments, the monitoring of the deep aquifer for baseline water quality may demonstrate that groundwater at the proposed landfill site is already contaminated by leachate from the existing ash ponds at the power plant site. That would significantly complicate the challenge of determining whether contaminants detected at the landfill site are coming from the landfill, the ash ponds, or both. If the plume from the ash ponds were of appropriate composition and sufficient concentration, identification of significant leakage from the utility waste landfill may be impossible. The revised monitoring system could identify an existing plume of contamination under only the northwest corner of the utility waste landfill, leaving the rest of the facility without this crucial information.

Q. To what extent do the changes in the monitoring system address the concerns you raised in your cross-surrebuttal testimony?

A. To almost no extent. The only concern it partially addresses is the need to identify an existing plume from the ash ponds. The addition of the three deep monitoring wells may allow one to identify such a plume in the northwest corner of the facility, but will do nothing to detect any such plume throughout the rest of the proposed landfill site.

Q. In your opinion, is the revised monitoring system contained in the December 2013 CPA adequate to detect groundwater contamination originating from the proposed landfill?

A. No.

Q. Why not?

A. The revised shallow monitoring system remains designed based upon the unrealistic assumption that that all migration from any liner failure will migrate at, and solely at, the water table and that the migration will occur in directions and rates determined without benefit of any water table measurements. Under pre-construction hydrologic conditions, water-table contamination will migrate downward, away from the water table. Under post-construction hydrologic conditions, that downward movement will be accentuated. Except under exceptional and unusual situations, contamination from the proposed facility will pass below – and undetected by – the water table monitoring system. The three deep wells that have been added do not form an upgradient/downgradient package and do not cover a significant portion of the facility.

Q. Did you review the opinion expressed by Tyler Gass in his supplemental testimony that the existing ash ponds "have never been found to have caused any groundwater contamination during the past 40 years of operation"?

A. Yes.

Q. Do you have a response to that opinion?

A. Yes. That statement is misleading. The failure to find contamination does not confirm that no such contamination exists. In this case, it likely reflects the failure to look for it.

Q. On what is your response based?

A. I found no evidence that Ameren has sought to determine any existence and extent of contamination from the ash ponds. I looked through all available sources I could find related to this proceeding or written by Ameren and publicly available that might indicate any effort to determine the existence and extent of groundwater contamination caused by the existing ash ponds. These sources included the 1992 construction permit application and associated specification form for the lined waste impoundment, the Detailed Site Investigation (DSI) for the proposed landfill, the first three rounds of baseline water sampling performed in the groundwater detection monitoring system for the proposed landfill, available NPDES permit applications for the Labadie plant, the CPA for the proposed landfill, and water quality and head data obtained from piezometers/wells installed and sampled by Golder Associates in the bluffs south of the Labadie plant.

Q. What did your review determine?

A. There has been no documentation of any attempt to look for potential contamination that could be attributed to the existing ash ponds. It is not the case that thorough investigations have established there is no contamination caused by the waste impoundments. To the contrary, there

has been no attempt to investigate groundwater quality in the vicinity of the ash ponds. With respect to the documents I reviewed, I found the following:

1. The 1992 construction permit application and specification form for the lined ash pond discussed wells/piezometers that were located appropriately and at appropriate depths to have been used to obtain information regarding groundwater quality related to the pre-existing, unlined ash pond. However, there is no indication in those documents that the wells were ever sampled for that purpose.

2. The 100+ piezometers installed and monitored for the DSI investigation were located in an area apparently downgradient of the ash ponds. The piezometers were completed within the alluvial aquifer at some distance below the water table, where impoundment-related contamination might be found, were there a plume in the area. However, there is no indication in the DSI that any of these piezometers were sampled for water quality.

3. The 1992 and 2011 NPDES permit applications describe leakage of coal ash wastewater from the unlined ash pond. One of the leaks was estimated at up to 30 gallons per minute and was described as soaking into the ground. There is no indication that Ameren conducted any groundwater investigation to determine the impact of this leakage on groundwater quality. Ameren submitted its 2011 application in response to Staff Data Request 14.2. Attachment A of the 1992 application is submitted herewith as Norris Schedule S7.

4. The bedrock piezometers installed for Ameren by Golder Associates on the bluffs south of the Labadie plant sampled groundwater that was determined to be upgradient of both the plant and the ash ponds. Therefore, these groundwater sampling points shed no light on whether the ash ponds are causing groundwater contamination.

5. The baseline monitoring for the groundwater detection monitoring system for the proposed landfill, like the earlier DSI piezometers, is favorably located with respect to possible migration of contaminated groundwater from the waste impoundments. To date, the monitoring system has sampled only water table wells. Because these wells are completed at the water table, evidence of any underlying plume would be subtle.

Q. Is there any evidence that is suggestive of groundwater contamination that might be attributable to the existing ash ponds?

A. Yes. The first such evidence is the NPDES permit applications' discussion of leakage from the unlined ash pond. Ameren stated that "the location and chemical make up of the seeps indicate that their source is the ash pond." Ameren also stated that one of the seeps was soaking into the ground. Yet Ameren made no effort to test the groundwater for contamination.

Additional evidence is found in comparing the groundwater data collected from the wells drilled in the bluffs south of and upgradient from the plant with the groundwater data from the monitoring wells at the proposed landfill site, which are downgradient from the plant and the ash ponds. The first three sampling events to develop baseline water quality from the monitoring wells have been completed. If the ash ponds were not affecting groundwater quality, then the water quality immediately downgradient from the plant site should closely resemble the water quality immediately upgradient from the site. This is not the case; the downgradient groundwater at the proposed landfill site is substantially degraded relative to the upgradient water. At the proposed landfill site, averages of specific conductance (indicative of total dissolved solids) and sulfate are each 166% that of the upgradient groundwater. Boron concentrations at the proposed landfill site average more than 300% that of the upgradient

groundwater. Arsenic concentrations at the proposed landfill site average more than 220% that of the upgradient groundwater. Barium at the monitoring systems averages 250% that at the upgradient piezometers. All of these constituents are associated with coal ash.

Q. In your opinion, if Ameren had conducted groundwater monitoring at the existing ash ponds at the plant site, would contamination likely have been detected?

A. Yes.

Q. Does this conclude your Supplemental Testimony?

A. Yes.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of the Application of Union Electric Company d/b/a Ameren Missouri for Permission and Approval and a Certificate of Public Convenience and Necessity Authorizing it to Construct, Install, Own, Operate, Maintain and Otherwise Control and Manage A Utility Waste Landfill and Related Facilities at its Labadie Energy Center	)	File No. EA-2012-0281

AFFIDAVIT OF CHARLES H. NORRIS, P.G.

STATE OF COLORADO)
) ss
CITY OF DENVER)

Charles H. Norris, being first duly sworn on his oath, states:

1. My name is Charles H. Norris. I work in Denver, Colorado and am employed by Geo-Hydro, Inc. as a professional geologist and a hydrogeologist.
2. Attached hereto and made a part hereof is my Supplemental Testimony on behalf of Intervenors Labadie Environmental Organization and Sierra Club. The testimony consists of 13 pages and has been prepared for introduction into evidence in the above-referenced matter.
3. I hereby swear and affirm that my answers contained in the attached testimony are true and correct to the best of my knowledge and belief.

Charles H. Norris

Subscribed and sworn to before me this 19 day of February, 2014.

Notary Public

My Commission expires:

Ryan Dravitz
NOTARY ID #20144002250
NOTARY PUBLIC
STATE OF COLORADO
My Commission expires Jan 15, 2018