Response To Community Comments On Ameren Missouri Corrective Measures Assessments For Rush Island, Labadie, Sioux And Meramec Energy Centers

Contents

SUMMARY OVERVIEW

In May 2019, Ameren Missouri held public meetings regarding Corrective Measures Assessment (CMA) Reports for the Rush Island, Labadie, Meramec and Sioux Energy Centers. At those meetings and afterwards in written comments, the public raised a variety of concerns regarding CCR basins located at the energy centers. This Response to Community Comments addresses those concerns. In addition, Ameren Missouri ("Ameren") has performed additional technical analysis which has been posted on Ameren's CCR website along with this Response. Ameren summarizes key response items below:

- *Groundwater Impacts are Limited and No Risk to Public Health Exists.* Groundwater impacts at Ameren's energy centers are limited and localized in nature. Drinking water supplies, whether residential wells or adjacent rivers, are not impacted by the energy centers. Suggestions that Ameren has somehow "skewed" or misrepresented the data are inaccurate. *See* Section 2 and 3 and Attachments 1 and 2.

- *Excavation Delays Compliance with Groundwater Standards*. Several commenters argue that the only way to comply with the CCR Rule is to excavate the ash. Not true. Concentration levels will diminish over time due to installation of a geomembrane cap, the water table lowers, and pH conditions stabilize. Excavation requires the basins to remain open to ongoing infiltration. To address such comments, Ameren performed additional modeling analysis to assess groundwater impact at Rush Island under both containment and excavation scenarios. Containment results in a predicted return to standards in 2027, approximately 6-7 years post-closure, as compared to 2057 under an excavation scenario. *See* Section 11 and in Attachments 6 and 7. Concerns relating to groundwater compliance are addressed more expeditiously by promply closing and capping the ash basins and cutting off infiltration.

- *Trucking is Less Burdensome than Rail but Neither is Fast.* The Lochmueller Extraction & Transportation Study (CMA, Appendix C) described the logistics behind hauling CCR from the energy centers to a commercial landfill. Certain commenters took issue with that analysis and instead contend that railroad carrier CSX provides such services. Connecting to the CSX railroad would require multiple carriers, installation of onsite storage yards, nine dedicated, 100-car unit trains, and commercial landfill unloading facilites. No Illinois or Missouri landfill was identified as having adequate rail facilities. *See* Section 4 and Attachment 3.

- *The CCR Basins are Structurally Sound, Built to Withstand Extreme Weather Events*. Several commenters expressed concerns regarding the risk of "wash out" or "liquefaction" of the stored material should a flood or seismic event occur. All of Ameren's CCR units are protected by massive embankments designed to prevent failure. The potential for extreme events has been specifically considered and we have provided a stability analysis summary chart. *See* Section 5.

GENERAL COMMENTS

To the extent a number of commenters raised identical or similar issues, such comments are grouped by subject matter.

1. The Public Meetings Facilitated One-on-One Discussions and Were Designed to Foster Collaboration

The public meetings provided a forum to define the community concerns; promote one-on-one communication between Ameren and the community; and to foster collaboration. Ameren and its experts presented information about the CMAs and made themselves available to discuss questions and concerns expressed by those in attendance. Importantly, the CCR Rule does not specify a format for the public meeting nor does the rule require that specific responses be provided. The rule simply states that the remedy selection by the owner should consider the "degree to which community concerns are addressed by a potential remedy(s)." Nevertheless, Ameren believes responses to the concerns are important.

Ameren organized the public meetings with much thought and consideration. The meetings featured technical experts located at discrete stations who were available to discuss a number of topics relevant to the corrective measures options; groundwater data collection; risk assessment analysis; modeling analysis; the corrective measures assessment process; and dam safety issues. The goal was to maximize for the community one-on-one time with company representatives and the experts so the community could provide their input and present questions.

A number of commenters expressed frustration with the meeting time, a perceived lack of notice and a perceived lack of time to review the CMAs. Ameren wishes to address these concerns. First, as to notice, Ameren placed notices of the meeting on its CCR website and in a variety of media outlets (***St. Louis Community News, Festus Jefferson Leader and the Washington Missourian***) during the weeks of May 1 and May 9, 2019. Second, as to the CMAs, Ameren posted the CMA reports on its CCR webpage starting on May 16, 2019, with printed copies available at the meetings.[1] We note that there is no requirement to make the CMAs available prior to the meeting but Ameren chose to do so regardless. Indeed, social media postings by the Labadie Environmental Organization (LEO) and Sierra Club clearly reflect that local environmental activists were not only well aware of the meeting dates and times, but also of the CMA posting. In fact, activist groups had members attend each of the meetings. Lastly, as to the time of day, Ameren selected the afternoon and all of the meetings were well attended. For those who could not attend, Ameren received comments through a dedicated email address box and, as requested, posted the exhibits used at the meetings to the Ameren website following the meetings. Again, all of this is more than is required by the CCR Rule.

[1] The CMA reports were removed temporarily from the website on May 30, 2019, during an IT system migration but were re-posted the next day.

While the format did not include or facilitate speechmaking, the format was informational and not a "public relations event." The amount of direct questioning and explanation clearly resonated with many members of the community. Again, Ameren chose the format to provide the greatest amount of direct contact with company representatives and the technical experts. Videos taken by the environmental activists during the meetings demonstrate that attendees effectively utilized the question and answer approach.

2. CCR Constituents Do Not Threaten Human Health or Drinking Water

Some commenters expressed concern that CCR constituents in groundwater at Ameren's energy centers present a risk to drinking water sources and to public health. **Public or private drinking water supplies are not at risk from Ameren's CCR units.** As depicted in the charts below and as presented in numerous technical reports including the CMAs, the CCR units have not affected the bedrock aquifer that serves as a water source to residences located within the general vicinity of the Labadie and Rush Island energy centers. To the extent impacts from coal ash exist on Ameren's property and immediately adjacent to surface impoundments, the public has no direct or indirect access to such groundwater. Further, as presented in numerous technical reports including the CMAs, sampling results demonstrate that public drinking water sources that draw from the Meramec, Mississippi and Missouri Rivers are not impacted by Ameren's CCR units. As made clear in published risk assessments, where there is no exposure, there can be no risk.

More specifically, in calendar years 2012-2014, going beyond then existing or current regulatory requirements, Ameren installed offsite monitoring well networks at both Labadie and Rush Island in an effort to provide the community with data to address concerns about the sites' impact on their drinking water wells. Through these monitoring networks, Ameren evaluated groundwater quality, flow direction and water column height within the bedrock aquifers. So that representative samples were taken, the monitoring wells mirrored the actual depths of the residential wells. Groundwater elevations in residential wells are at a higher elevation than groundwater levels near the ash basins. Groundwater moves from the bluffs to the river valleys and **no physical mechanism exists** through which groundwater from Ameren's coal ash basins could travel uphill to domestic water supplies. This is true even under an extreme flood; hypothetically assuming river levels match the highest flood of record for 55 straight days. *See Golder Technical Memorandum dated June 26, 2019* attached hereto as **Attachment 1**.

Labadie – No Impact to Bedrock Aquifer

Do values from offsite well network exceed CCR Rule GWPS (Yes or No)

Analyte	UNITS	GWPS	September/October 2014 Samples							
			TGP-A	TGP-B	TGP-C	TGP-D	TGP-E	TGP-F	TGP-G	BW-1
Sample Date			9/9/2014	9/8/2014	10/3/2014	10/6/2014	9/8/2014	9/30/2014	9/3/2014	9/9/2014
ARSENIC, TOTAL	µg/L	42.6	NO	NO	NO	NO	NO	NO	NO	NO
BARIUM, TOTAL	µg/L	2,000	NO	NO	NO	NO	NO	NO	NO	NO
BERYLLIUM, TOTAL	µg/L	4	NO	NO	NO	NO	NO	NO	NO	NO
CADMIUM, TOTAL	µg/L	5	NO	NO	NO	NO	NO	NO	NO	NO
CHROMIUM, TOTAL	µg/L	100	NO	NO	NO	NO	NO	NO	NO	NO
COBALT, TOTAL	µg/L	6	NO	NO	NO	NO	NO	NO	NO	NO
FLUORIDE, TOTAL	µg/L	4	NO	NO	NO	NO	NO	NO	NO	NO
LEAD, TOTAL	µg/L	15	NO	NO	NO	NO	NO	NO	NO	NO
MERCURY, TOTAL	µg/L	2	NO	NO	NO	NO	NO	NO	NO	NO
MOLYBDENUM, TOTAL	µg/L	100	NO	NO	NO	NO	NO	NO	NO	NO
SELENIUM, TOTAL	µg/L	50	NO	NO	NO	NO	NO	NO	NO	NO
THALLIUM, TOTAL	µg/L	2	NO	NO	NO	NO	NO	NO	NO	NO

Notes:
1) µg/L – micrograms per liter, mg/L – milligrams per liter,
2) GWPS – Site-specific Groundwater Protection Standard applicable to Labadie CCR units

Rush Island – No Impact to Bedrock Aquifer

Do values from offsite well network exceed CCR Rule GWPS (Yes or No)

Analyte	UNITS	GWPS	TBW-1	TBW-2	TBW-3
Samples Collected in 2014					
ARSENIC, TOTAL	µg/L	30	NO	NO	NO
BARIUM, TOTAL	µg/L	2,000	NO	NO	NO
BERYLLIUM, TOTAL	µg/L	4	NO	NO	NO
CADMIUM, TOTAL	µg/L	5	NO	NO	NO
CHROMIUM, TOTAL	µg/L	100	NO	NO	NO
COBALT, TOTAL	µg/L	6	NO	NO	NO
FLUORIDE, TOTAL	µg/L	4,000	NO	NO	NO
LEAD, TOTAL	µg/L	15	NO	NO	NO
MERCURY, TOTAL	µg/L	2	NO	NO	NO
MOLYBDENUM, TOTAL	µg/L	100	NO	NO	NO
SELENIUM, TOTAL	µg/L	50	NO	NO	NO
THALLIUM, TOTAL	µg/L	2	NO	NO	NO

Notes:
1) µg/L – micrograms per liter.
2) GWPS – Site Specific Groundwater Protection Standard applicable to Rush CCR Unit.

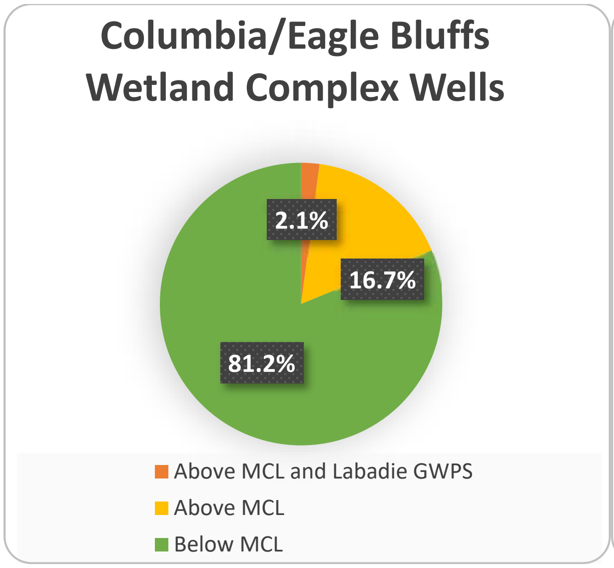
With respect to St. Charles and St. Louis County communities located near the Sioux and Meramec energy centers, all residences are connected to public water suppliers that draw from drinking water intakes located within the Missouri, Mississippi or Meramec Rivers and are miles away from the facilities. Extensive river sampling immediately adjacent, downstream and upstream from Ameren's facilities (again this sampling is over and above what is required by any rule), confirms that all such surface water samples (more than 250 sample locations and over 16,000 individual analyses) comply with federal and state drinking water standards. **Ameren's energy centers do not adversely impact those surface waterbodies.**

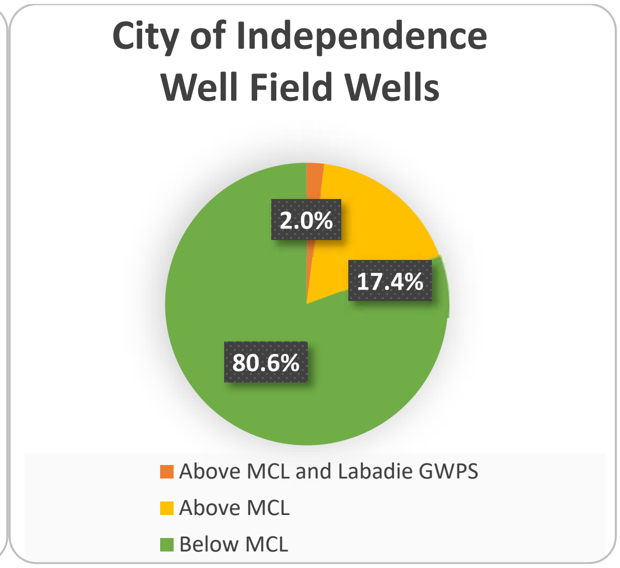
3. <u>The Groundwater Protection Standards Set by Ameren are Protective and Comply with the CCR Rule</u>

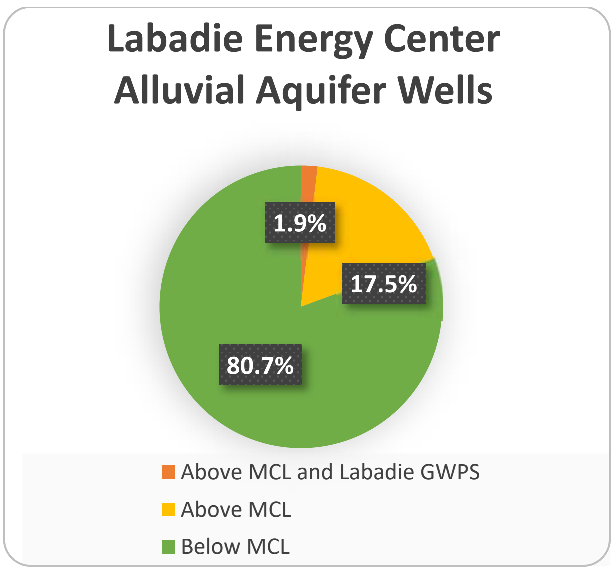
Groundwater impacts at Ameren's energy centers are limited in nature with more than 95% of assessment monitoring results statistically **below** site groundwater protection standards. This is good news. And yet, rather than being reassured by such results, activists instead argue in comments that Ameren "skewed" the data and calculated "abnormally high" background levels and, consequently, protection standards. Nothing could be further from the truth. The CCR Rule prescribes a specific process for the siting of wells, collecting data, and then statistically analyzing the results to calculate the Groundwater Protection Standards (GWPS) used in the CCR process. The CCR Rule requires that a licensed professional engineer certify all critical steps of the process and EPA has issued a Unified Guidance for determining the applicable statistical methodology, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*, (Unified Guidance) EPA-530-F-09-020 (March 2009). The GWPS calculated for each site fully comply with the CCR Rule and Unified Guidance. Ameren's independent licensed professional engineer and hydrogeologist who certified the standards prepared an additional technical memorandum to address comments received from the Washington University Environmental Law Clinic (WUELC), **<u>Attachment 2</u>** to this response document.

Ameren also responds to additional more specific comments received on two naturally occurring constituents, arsenic and molybdenum. Those comments relate to the setting of GWPS for those constituents at Labadie and Rush Island. As to arsenic, contrary to the WUELC's claims that arsenic present in background wells emanates from Ameren's CCR units, naturally occurring levels of arsenic with concentrations above EPA standards are widespread within the Missouri River alluvial aquifer. In fact, the National Water Quality Monitoring Council (NWQMC) reports in a publicly available database that approximately 20% of groundwater samples collected near groundwater municipal well fields in Missouri (Columbia and Independence), have ambient arsenic levels above the MCL. As the charts below reflect (prepared using the NWQMC data), the data closely align with sampling results collected in the alluvial aquifer at Labadie. In other words, naturally occurring levels of arsenic are found within various locations in Missouri and such levels are consistent with background conditions found upgradient from Ameren's sites. But putting aside data from other locations in Missouri, it is important to note that the background wells at Labadie are ***more than one-mile upgradient/cross-gradient*** from the facility and located in an agricultural field ***unimpacted*** by CCR. Additionally, background wells at Rush Island are located north of the power plant building and upgradient/cross-gradient of the CCR unit.

Naturally Occurring/Non-CCR Arsenic Exist At Labadie and Other Municipal Sites







Golder calculated the arsenic GWPS using sixteen (16) data points per site, consisting of eight (8) baseline samples from each of the two background wells. Due to the spatial variability in the arsenic samples between the background wells (one with high results and one with low results), Golder used a statistical method consistent with EPA's Unified Guidance to calculate the GWPS. The remainder of this paragraph describes the statistical test used to determine a single background level where measured results vary. The terms used are standard statistical language, perhaps not familiar to the reader. Where spatial variability exists, Golder performed statistical outlier analysis, removed any outliers and then calculated a tolerance level. Because the background data varied spatially at both sites, the resulting GWPS is equal to the highest background value in each data set. Because the background data were not normally distributed for either site, the concentrations of 42.6 µg/L (Labadie) and 30 µg/L (Rush Island), respectively, are from observed values, not outliers, and therefore are statistically part of the background population. In addition, it is clear from well logs that the selected background locations are not influenced by site operations due to their upgradient/cross-gradient locations and the limited groundwater concentrations of either boron or molybdenum, indicating the lack of CCR impact. As a result, and notwithstanding differences between the sample populations of the two wells at each site, the background data from the higher concentration wells must be considered. The higher concentrations in background wells at each site demonstrate that arsenic exists, unrelated to plant operations, representing a background condition that must be included in the statistical analysis of data.

As to molybdenum and based upon their comments, the Missouri Confluence Water-keeper (Waterkeeper) seems to have misunderstood the purpose behind the Molybdenum Fact Sheet provided by Ameren at the public meetings. Molybdenum, while naturally occurring, is not a commonly known element and Ameren thought it would be helpful to provide a separate background fact sheet with each of its CMA reports to provide context for the public. The fact sheet notes that the Institute of Medicine of the National Academy of Sciences (NAS) defines molybdenum as an essential nutrient for human health. In addition to developing a Recommended Daily Allowance (RDA) that defines the amount of molybdenum needed to maintain good health, the NAS also developed an Upper Tolerable Limit for molybdenum, a limit that equates to a safe drinking water level of 600 µg/L. The Fact Sheet presented this value purely as a point of context; **Ameren knows and acknowledges that it is the GWPS that is used as the basis of decision making under the CCR Rule.**

Further, in 2018, EPA revised its regulations to designate a specific protection standard for molybdenum and adopted 100 ug/L for molybdenum. 83 Fed. Reg. 36435,36444 (June 30, 2018) (Emphasis added.) Importantly, EPA went on to say:

> "These levels were derived using the same methodology that EPA proposed to require States to use to establish alternative GWPS (*See* 83 Fed. Reg. 11598–11599, 11613). The methodology follows Agency guidelines for assessment of human health risks of an environmental pollutant. This means that **these GWPSs are expected to be concentrations to which the human population could be exposed to on a daily basis without an appreciable risk of deleterious effects during a lifetime**." *Id.* (Emphasis added.)

Ameren used the GWPS of 100 µg/L for molybdenum at all four of its facilities. While we agree with the Waterkeeper that EPA included molybdenum on its 2009 Contaminant Candidate List, 74 Fed. Reg. 51850,51852 (Oct. 8, 2009), no regulatory action has occurred in the intervening ***10-year period*** and where the EPA may go with this rulemaking is unknown.

4. Railing or Barging CCR from Ameren's Energy Centers is Neither Reliable Nor Economical

WUELC argues, seemingly based on a CSX marketing brochure that it references, that rail transport would avoid local impacts to the community inherent in truck hauling and therefore rail is a viable option for transporting CCR for the offsite disposal. However, as the brochure notes, "CSX offers direct connections to numerous cement producers, fly ash and slag locations, and cement terminals **throughout the East Coast."** Ameren Missouri's energy centers are all located west of the Mississippi River.

Ameren receives coal via rail delivery and has extensive experience with the challenges associated with such transport mode. Ameren asked its transportation expert to expand its consideration of rail and barge in response to comments received. Set forth below are key considerations based on Ameren's experience and the Lochmueller Group review (**Attachment 3**):

- *Multiple Carriers.* Neither CSX nor its short-line rail partners have direct access to Ameren's energy centers. To connect to CSX at its Rose Lake Yard in East St. Louis, a unit train (a set of similar railcars that typically remain together in a dedicated train), would need to first transfer to the Terminal Railroad Association in St. Louis via the Burlington Northern (BNSF: Rush Island, Sioux) or Union Pacific railroads (UP: Meramec, Labadie).

- *Coal Trains Can't Be Repurposed.* Dedicated coal unit trains leave the the Powder River Coal Basin on a near-daily basis and travel directly to the energy centers via the UP or BN railroads, unload, and then return in a near-continuous loop. The train cars are specifically designed to carry and unload coal and are NOT designed to carry CCR.

- *Single Loop Rail Tracks Require Coal Delivery Prioritization.* The energy centers have single loop rail tracks that, in order to maintain reliable generating operations, must prioritize coal deliveries. The hauling of large volumes of CCR woud require separate onsite car storage areas known as "ladder tracks" and specialized, covered rail cars traveling in a "unit train". Sufficient or adequate property for ladder tracks may not be available at all locations such as Rush Island.

- *Carriers Control Haul Cycles, Not Shippers.* Unlike truck hauling, the carrier, not the shipper, controls the availability of locomotives and timing of shipments. In order to get to the CSX, the unit train would need to be staged on ladder tracks at the energy center until the originator carrier (UP or BNSF) is available to transport the unit train to a rail yard in St. Louis where a terminal railroad would then move the loaded unit train to CSX's Rose Lake yard located in East St. Louis. From there, the CSX would take possession of the unit cars and haul to a landfill with proper rail unloading facilities large enough to accommodate a unit train. Alternatively, the loaded unit train could be delivered to a train-to-truck transfer station located close to the disposal site where the CCR would be unloaded from rail cars and then hauled via truck to a landfill. Once emptied, the unit train cars would return via the reverse route (CSX, Terminal, and UP/BNSF railroads). The entire process entails multiple railroad crew exchanges.

- *Logistical Issues Impact Reliability of Rail*. Due to the haul cycles and load/unload times, a single unit, 100-car train is capable of transporting at most one load per week.

Nine (9) unit trains would be required to to maintain parity with trucking estimates of 5,000 tons per day. The cost of procuring such trainsets is approximately $90M ($100,000 per car x 9 unit trains). Interruptions with multiple railroad crews or service anywhere along the haul routes, rail yards or energy centers would disrupt shipments. Based on Ameren's experience with coal deliveries, it is highly unlikely that the rail carriers could consistently maintain such productivity.

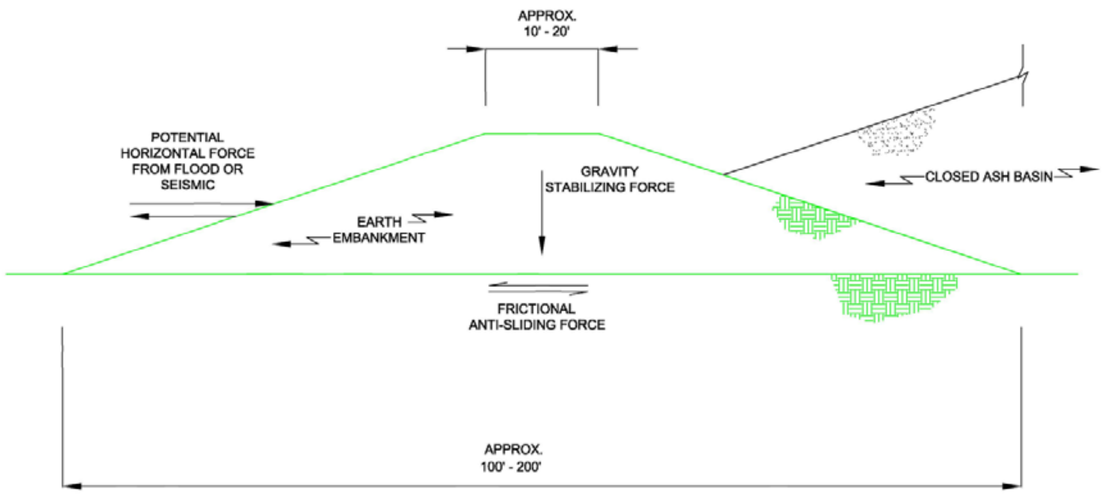
- Shipment via barge is not a viable option due to a lack of existing loading/unloading facilities and environmental concerns associated with large scale, long term shipments on unpredictable waterways.

5. Ameren Ash Basins: Sound Structural Integrity Even Under Flood Conditions

Several commenters expressed concerns that the in-place closure of CCR units could increase the risk of "wash out" or "liquefaction" of the stored material should a flood or seismic event occur. We understand these concerns. The CCR Rule specifically requires owners of ash basins and landfills to perform extensive structural and geotechnical analyses to verify the stability of such units during both normal operations and natural disasters. All of Ameren's CCR units have been inspected, evaluated and verified by third-party geotechnical engineering firms and are inspected weekly by specially-trained plant personnel and annually by Dam Safety specialists.

Ameren's coal ash basins are protected by massive embankments and designed to prevent failure. The potential for extreme events has been specifically considered. The embankment slopes have undergone rigorous evaluations as part of the CCR Rule's structural integrity requirements and are subject to weekly surveillance and monthly maintenance protocols. Engineering evaluations calculate the slope stability of the embankments and compare the driving forces within a cross-section of slope to the resisting forces and determining a factor of safety (FOS). Slope stability analysis includes multiple geotechnical borings and laboratory analysis to assess soil properties. Gravity forces tend to move the slope downward (driving force), while resisting forces derived from soil shear strength, tend to keep the slope in place. When the driving force on a slope is greater than the resisting force, sliding can occur. Ameren's embankments have broad foundations that are at least 4 to 6 times as wide as their height and narrow to a minimum of approximately 10 to 20 feet at their crests. This slope configuration functions as a solid pyramid designed to withstand flooding and seismic events. The diagram below depicts a typical configuration and illustrates the shear mass that would need to erode or otherwise be compromised before a "wash out" of compacted ash stored within the basin could occur.

EMBANKMENT SLOPES & FORCES



Lastly, the embankments surrounding the basins can withstand an estimated 7.0 to 8.0 magnitude earthquake. Both EPA and the Missouri Department of Natural Resources (MDNR) have published target safety factors for a variety of potential structural conditions and all of Ameren's CCR units meet or exceed those requirements.[2] The calculated FOS are expected to increase post-closure as surface waters are removed reducing internal force and pressures. In addition, an engineered cap and stormwater measures will prevent pooling on and within the basins.

SLOPE STABILITY ANALYSIS

	Condition	Target FOS	Minimum Calculated FOS
Labadie	Major Flood Event	1.40	1.52
	Steady State	1.50	1.64
	Liquefaction	1.20	1.27
	Slope with Seismic Forces	1.00	1.08

	Condition	Target FOS	Minimum Calculated FOS
Rush Island	Major Flood Event	1.40	1.42
	Steady State	1.50	1.51
	Liquefaction	1.20	1.29
	Slope with Seismic Forces	1.00	1.07

[2] 80 Fed. Reg. 214755-77

Sioux	Condition	Target FOS	Minimum Calculated FOS
	Major Flood Event	1.40	1.42
	Steady State	1.50	1.50
	Liquefaction	1.20	1.26
	Slope with Seismic Forces	1.00	1.12

Meramec	Condition	Target FOS	Minimum Calculated FOS
	Major Flood Event	1.4	1.62
	Steady State	1.5	1.71
	Liquefaction	1.2	1.62
	Slope with Seismic Forces	1.0	1.18

Lastly, closure design includes armoring the riverside of embankment slopes to mitigate erosion from floodwater rises and rapid draw down conditions. In addition to routine examinations, qualified Dam and Safety personnel inspect embankments before, during and after flood conditions to ensure proper ongoing maintenance. All of Ameren's ash pond embankments remain structurally sound following the recent 2019 floods crests.

6. <u>The WUELC Misconstrues the CCR Rule and Seeks to Create a New Standard</u>

WUELC's interpretation of the federal CCR rule as those rules relate to elimination of *"free liquids"* is simply misplaced. The requirement cited by WUELC is located within the closure provisions of the regulations that address the activity of drainage or dewatering, and subsequent stabilization of the CCR, to allow for the construction and installation of the final cover system. EPA specifically defined "f*ree liquids"* in relation to ambient pressure and temperature, a clear reference to removal of standing water as part of the draining/dewatering of a CCR basin in preparation for installation of a closure capping system in accordance with best engineering practices. Nowhere does the CCR Rule require draining or dewatering CCR impoundments at depth to meet the closure in place requirements.

The CCR rule requires that owners of CCR units meet two main performance criteria: contain the CCR waste mass in a covered, stabilized unit; and address impacted groundwater outside of the CCR unit boundaries. *See* 40 CFR §257.102 and §257.97, respectively. The rule does not require a compliance monitoring point *within* the waste that is contained in place. EPA specifically authorized two closure options: removal or closure in place and EPA does not select, or even prefer, one to the other.[3]

By conflating CCR Rule performance standards, WUELC attempts to create a *new* performance standard, one that does not exist in the rule and in effect would mandate excavation regardless of environmental impact. WUELC's position is also in direct contradiction to the actual language of the rule and RCRA's governing standards of *"no reasonable probability of adverse effect on health or the environment.*" EPA found that monitoring groundwater throughout the active and post-closure periods and requiring the owner to perform appropriate corrective measures adequately addresses any groundwater impacts.

7. <u>The Estimated Timeline for Excavation is Reasonable Given the Volumes and Complexity of an Excavation Project</u>

Estimated timelines contained in the Lochmueller report are based on a number of factors including transportation related factors. Using Rush Island as an example, such factors include: volume of stored material including soil amendments; travel time and distance to disposal site; maximum daily haul rate (5,000 tons); 8-hour daily operation and a range of 115-192 days per year of operation (adjusted for equipment breakdown, weather, holidays, vacation, imperfect execution, etc.). The daily haul rate assumes a fleet of trucks making multiple roundtrips per day and that the landfill has capacity, manpower, and authority to accept the maximum daily load of trucks (192). Haul trucks leaving the site every 2.5 minutes would still take decades upon decades to complete the project. Even assuming a constant stream of available trucks, there is simply a practical limitation on how quickly an excavator can load a truck even if there were multiple trucks and multiple excavators onsite.

Furthermore, in addition to the transportation challenges outlined by Lochmueller, there are a number of construction-related issues associated with excavating large volumes of material adjacent to large river systems in alluvial (i.e., river deposited) sands and up to depths of approzimately 100 feet. To further explain the timeline for excavation, Reitz & Jens, a geotechnical engineering firm, examined the construction related issues identified by Lochmueller and supplemented the analysis. Reitz & Jens prepared a white paper outlining its analysis found here in **<u>Attachment 4</u>**. In its *Study of Deep Excavation*, Reitz & Jens notes the following:

- *Excavation Methods.* There are two principal methods of removal or excavation of the CCRs from the basins: 1) excavation in the "dry" by first pumping out the water to some depth below the excavation; or 2) excavation in the "wet" by dredging. Other

[3] "In practice, EPA does not routinely require complete removal of all contamination (that is, cleanup to 'background') from a closing unit even for hazardous waste units. Requiring CCR units to clean up soils to levels before the site was contaminated, would be more stringent than current hazardous waste policies. There is no basis in the current record to impose provisions for the remediation of CCR units that are more stringent than those imposed on hazardous wastes." 80 Fed. Reg. 21302, 21412.

than at the top 20-30 feet, the location of the basins would preclude large-scale excavation via "dry" techniques and the use of conventional equipment.

- *Conventional Dredging has an Adverse Impact on Groundwater.* Dredging with an open bucket (i.e., backhoe, dragline or clamshell) could result in suspension of particles in the remaining groundwater, and an increase in the hydraulic conductivity of the remaining CCR, both potentially causing additional release of contaminants to groundwater.

- *Specially Designed Equipment*. Due to these concerns, the only viable method identified by Reitz & Jens for deep excavation is a cutter-head dredge that would need to be specifically designed and manufactured for Ameren's sites. The unique dredge may pump approximately 14,000 gallons per minute and could remove up to 650 cubic yards of CCR per hour. A suction dredge may be used for depths up to 20 to 30 feet.

- *Construction and Permitting of Settling Basins.* To use the specially designed dredge, a large volume of water would need to be routed from the CCR unit to multiple lined settling ponds. These ponds currently do not exist and would require permitting from MDNR. After CCR settles in the ponds, the dredged material is excavated and dried to allow for overland hauling to a commercial landfill. This double-handling and drying process takes substantial space and time, increasing the costs substantially as well. Remaining water would need to be monitored, potentially treated, and discharged in accordance with regulatory requirements.

- *Dredging Operations Could Take a Decade or More.* It would take more than a decade of full-time dredging operation to remove the CCRs from the largest of Ameren Missouri's CCR units—this time estimate does not take into account permitting, construction activities, drying, double-handling of CCR, weather, maintenance, transportation of the CCR for disposal off-site and handling of the water that remains in the settling ponds.

With all of these considerations taken into account, Reitz & Jens' conclusions are consistent with the time estimates determined by Lochmueller in its transportation study. In no sense are Ameren's basins (total system in-place volume 31M tons) similar to the City of Columbia's three year, 90,000 ton excavation from a single, four (4) acre former farmer's pond. WUELC erroneously relies on this example to demonstrate the ease by which such a project could be executed without disclosing the dissimilarities between that site and Ameren's sites.

8. <u>Closure Plans Posted on Ameren's Website Were Required by the CCR Rule and Do Not Indicate a Final Remedy has been Selected</u>

Several commenters suggested that Ameren is disingenuous in even requesting comments on the CMAs because Ameren has announced previously its plans to close the CCR basins. Such comments ignore the fact that the CCR Rule required Ameren to post on its CCR website closure and post-closure plans by October 2016, one year from the effective date of the CCR Rule. This federal requirement applied even though investigatory efforts were ongoing. (In fact, closure plans are required to be included with *applications* for *new* CCR units.)

Moreover, Ameren's approach continues to evolve through ongoing investigation and analysis, risk assessments and the corrective action options, including groundwater treatment, as outlined in the CMAs. The groundwater impacts observed at the CCR basins are few and localized in nature and do not pose a risk to human health even if the units were to remain open. Preliminary indications are that geochemical conditions within the alluvium are such that concentrations will reduce over time as pH levels stabilize.[4] In addition, Ameren is exploring a variety of treatment techniques that may reduce the amount of time needed to achieve groundwater protection standards at the designated compliance point (that is, the toe of the berm). That analysis will continue for several months.

In the meantime, Ameren has constructed wastewater treatment facilities at Rush Island and Labadie that isolate the ash basin systems and allow for the removal of surface waters from the basins. In fact, MDNR in a recently issued permit required Ameren to remove all standing surface water from the Rush Island CCR basin by this summer. The CCR Rule requires closure to commence shortly after the known final receipt of CCR. *40 CFR 257 §102.* For Labadie, Rush Island and Sioux, such "known final receipt" date is linked to the in-service dates for waste water treatment facilities. Even the most ardent environmental activist would have to concede that removing surface water reduces recharge into groundwater and that by eliminating the exposure of ponded ash to the elements, the environment benefits immensely. Having been very vocal about the ash basins for years, Ameren is surprised that activists now accuse it of moving too quickly.

SPECIFIC ISSUES RASIED BY COMMENTORS

9. "Litigation Risk" is not a CCR Rule Remedy Selection Factor

The first seven pages of the Waterkeeper's public comment contains a lengthy discussion on its view of legal issues that the United States Supreme Court may or may not entertain and the applicability or non-applicability of the Clean Water Act to CCR basins. None of that is relevant to CCR Rule requirements for remedy selection. No litigation has been brought by any person or entity regarding Ameren's CCR Units.

Furthermore, to the extent Waterkeeper suggests that Ameren should have solicited public comments before issuing its CMAs, they have clearly misread the CCR Rule requirements.

[4] A discussion of the behavior of metals in soil and groundwater can be found at **Attachment 5**.

10. <u>Closure of the CCR Basins Will Control Source Material and Mitigate Groundwater Impacts</u>

WUELC suggests that the only way Ameren can comply with the CCR Rule's closure performance standards is to excavate and remove all CCR, a positon rejected by EPA. In fact, EPA explicitly did not choose closure by removal over closure in place, indicating that both options, when done properly, are acceptable.

> *EPA did not propose to require clean closure nor to establish restrictions on the situations in which clean closure would be appropriate. As EPA acknowledged in the proposal, most facilities will likely not clean close their CCR units given the expense and difficulty of such an operation. Because <u>clean closure</u> is generally preferable <u>from the standpoint of land re-use and redevelopment</u>, EPA has explicitly identified this as an <u>acceptable means</u> of closing a CCR unit. However**, both methods** of closure (i.e., clean closure and closure with waste in place) can be **equally protective, provided they are conducted properly**. Thus, consistent with the proposal, the final rule **allows the owner or operator to determine** whether clean closure or closure with the waste in place is appropriate for their particular unit. EPA agrees that the RBCA [risk based corrective action] process, using recognized and generally accepted good engineering practices such as the ASTM Eco–RBCA process, can be a useful tool to evaluate whether waste removal is appropriate at the site. It is, however, not a prerequisite.*

80 Fed Reg at 21411-12 (emphasis added); *See also 80* Fed Reg at 21407.[5]

The CMAs step through the regulatory criteria for each of the considered remedial alternatives, all of which meets the requirements of 40 CFR §257.97. In addition, geochemical conditions across the sites indicate that concentration levels of the few parameters that exceed GWPS will reduce over time as infiltration is eliminated by installation of a cap, the water table lowers and pH conditions stabilize through a variety of natural in situ processes. [6] To optimize this process, Ameren is evaluating groundwater treatment options particularly for arsenic. Treatment methods for arsenic are well established.[7] While metals (unlike organics) cannot be destroyed, by changing the environmental conditions of the soil and groundwater, the leaching or dissolution of such metals can be reduced through the formation of stable minerals or by

[5] Contrary to WUELC assertions, the CCR Rule does not require returning CCR units to pre-construction conditions. EPA itself determined that was inappropriate, unnecessary, and would result in stricter standards than at hazardous waste sites. 80 Fed. Reg. 21302, 21412 **("There is no basis in the current record to impose provisions for the remediation of CCR units that are more stringent than those imposed on hazardous wastes.")**

[6] EPA specifically discussed that its lack of pH-specific data could impact its risk assessment. In its response to comments on the risk assessment, EPA indicates that pH-specific data, as well as other site-specific factors could yield site-specific remediation alternatives that cannot be addressed in a nationwide risk assessment. 80 Fed. Reg. 21302, 21434-37. Ameren is using site-specific data in the CMAs to make remedy comparisons that fit the unique nature of these surface impoundments.

[7] https://www.epa.gov/remedytech/arsenic-treatment-technologies-soil-waste-and-water.

binding such metals more strongly to other minerals. XDD has prepared a short description of this process, appended hereto as **Attachment 5**, *Behavior of Metals in Soil and Groundwater*.

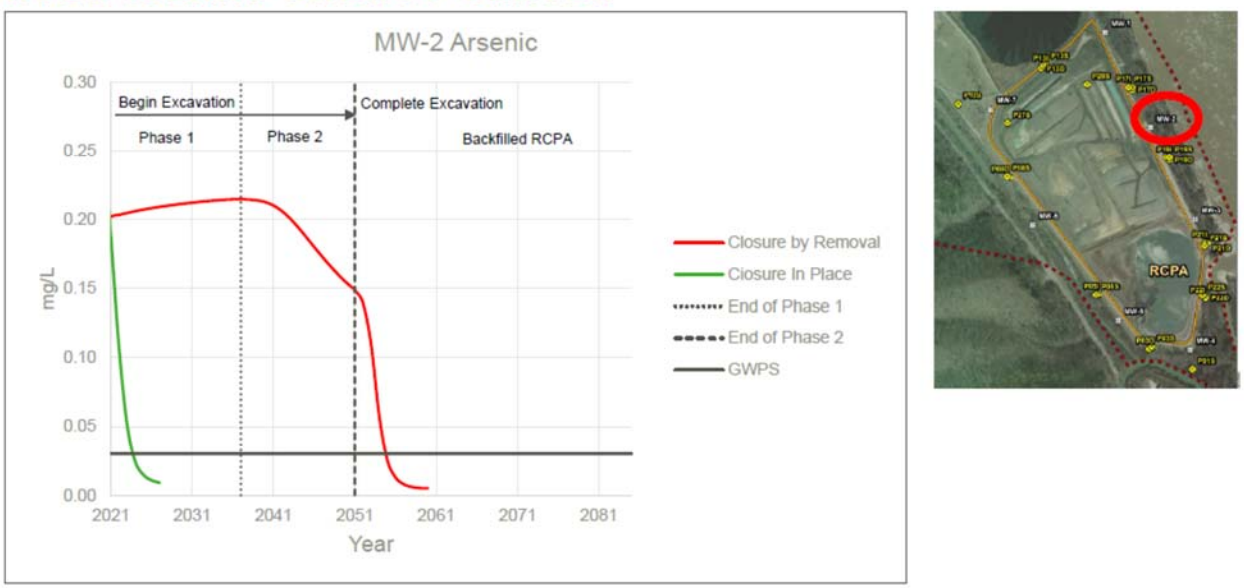
Predictive modeling also indicates that compliance with GWPS at the designated compliance point is achievable. Once that occurs and is confirmed by three years of groundwater monitoring, corrective actions are complete.

11. Excavation Would Delay Compliance Until After 2050

Several commenters believe that excavation is the only way to ensure compliance with GWPS. As the Lochmueller and Reitz & Jens reports make clear, excavation projects at these sites are complex, take decades to execute and will be a burden on local communities. During the entirety of the process, the ash basins remain open to weather, and recharge (contaminant loading due to infiltration from precipitation) to groundwater would continue during this entire period. Using Rush Island as an example, Ameren performed additional predictive modeling to illustrate the timeframe needed to come into compliance under an excavation scenario. (*See Golder Rush Island Closure by Removal Modeling,* **Attachment 6**). Under a containment/capping scenario, compliance with GWPS is predicted to occur in approximately 6-7 years post-closure (2027) as compared to thirty (30) or more years (2057) after beginning the excavation.

Modeling Results Indicate Excavation Delays Groundwater Compliance

RUSH ISLAND ENERGY CENTER



MW-2 (highest arsenic value in CCR Rule Well) is estimated to reach the GWPS 30 years sooner using closure in place vs closure by removal (Excavation)

12. Evaluation of Climate Change is Not Required by EPA

One commentor suggested that Ameren should have evaluated climate-related issues as part of its corrective measures assessment. EPA did not designate consideration of climate change as a requirement of the CCR Rule. However, to the extent precipitation events increase in severity or number as some climate models suggest, maintaining the proper Factors of Safety and structural stability of ash basins effectively counters those risks. Ameren addressed these issues in Section 5.

13. Transportation of Waste from Westlake Landfill has Less Impact on Community Due to Access Route and Volume

At the Westlake Landfill CERCLA Site in St. Louis, EPA recently ordered the **limited** excavation of **radioactive** material improperly sent to a sanitary landfill that due to its chemical composition set off subsurface fires. The proposed excavation is limited to approximately 1.5M in-place cubic yards (cy), located up to depths of 16 feet with deeper materials left in place at depths up to 89 feet below ground surface. EPA estimates the excavation will cost approximately $274M*. See Proposed Record of Decision Amendment Westlake Landfill Superfund Site (EPA, 2018).* The volumes proposed for excavation at Westlake are a fraction (5%) of the CCR material stored in Ameren's ash ponds (30M in-place cy; 41.3M with soil amendments) and would very likely also take the fraction of the time to transport off-site. Westlake Landfill is located in close proximity to interstate highways that function as major regional transportation arteries, thus minimizing disruption to local communities and neighborhoods. To Ameren's knowledge, specific transportation plans for Westlake have not been published.

Attachment List

1. **Golder Technical Memorandum dated June 26, 2019**
2. **Golder Response to CMA Public Comments Regarding Groundwater Protection Standards and Background Water Quality**
3. **Lochmueller Group Rail & Barge Transportation Assessment**
4. **Reitz & Jenz, Inc. Deep Excavation Analysis**
5. **XDD Behavior of Metals in Soil and Groundwater**
6. **Golder Rush Island Closure by Removal Groundwater Modeling**

TECHNICAL MEMORANDUM

DATE June 26, 2019 **Project No.** 153140601

TO Ameren Missouri

CC

FROM Mark Haddock, PE, RG **EMAIL mark_haddock@golder.com**

GROUNDWATER MODELING INDICATES NO IMPACT FROM LABADIE ENERGY CENTER CCR BASINS ON RESIDENTIAL WELLS EVEN UNDER EXTREME FLOOD CONDITIONS

Ameren Missouri (Ameren) recently held public meetings to discuss its Corrective Measures Assessment (CMA) as required under the United States Environmental Protection Agency's Coal Combustion Residual (CCR) Rule. In public comments raised either at these meetings or submitted to Ameren, members of the public questioned whether groundwater used by residential supply wells could be adversely impacted by CCR basins located at the Labadie Energy Center. The results of the modeling and testing conclude that bedrock groundwater quality in the residential areas of the bluffs is unaffected by CCR impacts to the alluvial aquifer based upon the following:

- The bedrock groundwater flow direction is consistently from high elevation areas (i.e. the bluffs) to low elevation areas (river bottoms).
- The closest community water supply well is located approximately two miles south of the LEC. Some individual wells are located within a mile of the LEC and all draw water from the bedrock aquifer in the bluffs area.
- Groundwater in the bedrock beneath the bluffs flows from the bluffs to the river valley areas, even under extreme river flood stage conditions. The higher groundwater levels in the bluffs prevent groundwater impacted by CCR on Ameren's property from travelling upgradient to residential water supplies.
- To assess groundwater flow under flood conditions, Golder modeled a worst case scenario (i.e. the 1993 flood of record (486.6 feet at the LEC), at a constant elevation and lasting for 55 straight days)[1]. The modeling results indicate that groundwater in the bluffs still flows in a northward direction, towards the Bottoms, and not vice versa.
- Multiple bedrock groundwater quality samples collected from wells in the bluffs area near the existing residential wells confirm that water quality is unaffected by CCR.

[1] In 1993, this peak elevation level lasted one day at Labadie.

Below is a reproduction of a technical memorandum originally produced on August 5, 2015 regarding Golder's groundwater modeling analysis.

August 5, 2015 Golder Technical Memorandum on flood conditions groundwater modeling at LEC

1.0 INTRODUCTION AND BACKGROUND

At the request of Ameren Missouri (Ameren), Golder performed limited groundwater modeling for the Labadie Bottoms area in the vicinity of the Labadie Energy Center (LEC) located in Labadie, Missouri. The modeling was primarily intended to investigate movement of groundwater near the LEC for a flood condition in the Missouri River. The intent of the modeling was to investigate the potential for reversal of groundwater hydraulic gradient from the alluvial aquifer toward the bedrock aquifer located in the Bluffs area south of the LEC during and following a significant flood event. Specifically, the intent was to investigate the potential that groundwater flow in the alluvial aquifer was significantly reversed toward the bedrock aquifer due to flood conditions.

1.1 Modeling Software

Groundwater modeling was accomplished using MODFLOW 2000, a finite-difference numerical modeling code developed by the United States Geological Survey, and the most widely accepted groundwater modeling platform. MODFLOW 2000 is an updated version of the original MODFLOW code and incorporates improved functionality. Model development was facilitated by Groundwater Vistas, a graphical user interface used to develop the model domain, grid, properties, and to visualize model results.

1.2 Conceptual Model, Domain and Grid

The model domain was intended to model conditions in the alluvial aquifer under and near the LEC and the adjacent limestone bedrock aquifer to the south. The domain was approximately 47,000 feet by 35,000 feet, and was developed roughly parallel to the Missouri River (Figure 1). The model domain was rotated such that the northern model boundary corresponded approximately to the Missouri River. The southern boundary was set in the bedrock aquifer a sufficient distance away from the river so as to minimize boundary effects to the model output. The direction of groundwater flow has been determined to be generally from the bedrock aquifer toward the alluvial aquifer.

The total model thickness for the alluvial aquifer was set at 100 feet based on subsurface drilling information. The individual grid cells were 500 feet by 500 feet, and the model was split into four layers, each 25 feet thick, for increased computational resolution. The model layers were sloped with the top of the model set to 600 feet at the southern model boundary and to approximately 454 feet at the Missouri River, based on general topographic trends in both areas. Initial modeling was conducted with the model layers both horizontal and sloped as a comparison. However, early model runs indicated that preliminary results for the sloped layer configuration were more conservative (i.e., greater effect at the area of interest).

1.3 Boundary Conditions

The eastern and western boundaries of the domain were treated as essentially parallel to groundwater flow and therefore were considered to be no-flow boundaries. The southern and northern boundaries of the model domain were considered to be constant head boundaries. The model boundaries are shown on Figure 2.

Groundwater elevations in the bedrock aquifer near the bluffs and the alluvial aquifer were used to extrapolate the hydraulic gradient throughout the model domain to the south. The intent was that the model emulate the approximate groundwater elevations determined in the installed bedrock wells. In order to do this, the southern constant head boundary was set to 590 feet. It is important to note that the actual groundwater elevations at the southern domain boundary are not expected to be 590 feet at all locations, but this was done as a convenience to generate the anticipated groundwater elevations in the middle of the model and avoid boundary effects.

The northern constant head boundary was set to 455.4 feet to represent a typical stage of the Missouri River. This constant head boundary was increased to 486.6 feet to represent the flood event, as observed during the flood event of 1993. This was a historic severe flood event with water in the Missouri River above flood stage for 55 days, primarily at modest elevations. The peak elevation of the flood near the LEC was 486.6 feet and only lasted one day. However, the intent was to model a worst case flood scenario so the peak elevation was extended for the entire 55-day flood event.

The alluvial aquifer was modeled as a single unit with a hydraulic conductivity of 70 feet per day (ft/d) based on a mean value for the alluvial aquifer from the Detailed Site Investigation (DSI) (GREDELL Engineering Resources and Reitz & Jens, Inc., 2011) for the LEC. The bedrock aquifer was modeled as a single unit with a hydraulic conductivity of 3 ft/d, based on a published value for limestone from Todd (1980). Specific yield for the alluvium and bedrock aquifers were set at 0.3 and 0.14, respectively, based on published estimates from Anderson and Woessner (1992), and were also used to approximate porosity. Specific storage for the alluvium and bedrock aquifers was set to 2.3E-04 ft^{-1} and 1.1E-05 ft^{-1}, respectively, based on published estimates from Anderson and Woessner (1992).

2.0 STEADY STATE GROUNDWATER MODELING RESULTS

The model was initially run in steady state to generate the typical groundwater gradient and movement from the bedrock aquifer to the alluvial aquifer toward the Missouri River, as observed from direct measurements. A general comparison was made between the model estimated groundwater elevations in the bedrock aquifer and the measured groundwater elevations in the area of the bluffs. The model estimated groundwater elevations at the edge of the bluffs were approximately 460 feet, which closely approximates the measured groundwater elevations in this area (Figure 3).

3.0 TRANSIENT GROUNDWATER MODELING RESULTS

Golder was asked to model the effects of a significant flood event, comparable to the 1993 flood event of the Missouri River, on the groundwater movement in the alluvial aquifer. The 1993 flood saw an increase in river flows and levels above flood stage for a period of 55 days. The maximum river stage in the Missouri River near the Labadie Plant during this flood was 486.6 feet, an increase of approximately 31 feet over typical flows in the Missouri River in this area. Use of the peak flood elevation for the entire length of the flood was conducted to represent an extreme worst case scenario.

A transient model run was conducted in which the southern constant head boundary, representing the Missouri River, was set to 486.6 feet for 55 days, then was returned to the same level as in the steady state model run (455.4 feet). Three stress periods were simulated in the model run: Period 1 is the steady state condition with the Missouri River set to 455.4 feet, Period 2 is a transient, 55-day period with the Missouri River set to 486.6 feet, and Period 3 is a transient, 100-year period with the Missouri River returned to 455.4 feet. Changes to water levels near a location of interest were monitored throughout the model run. This location of interest is a hypothetical monitoring well as shown on Figure 4.

Figure 4 shows the modeled groundwater level contours after the 55 day flood event. Modeled groundwater elevations near the limestone bluffs remained at approximately 460 feet at the end of the 55 day flood event, rising less than 0.5 foot (Figure 5). The groundwater divide, the area where the original hydraulic gradient from the bedrock aquifer and the hydraulic gradient from the alluvial aquifer meet, was located well north of the northern edge of the bluff area demonstrating no reversal of flow at the location of interest.

3.1 Particle Tracking

Particle tracking was conducted using the computer code MODPATH (Polluck, 1989). With this analysis, particles are placed in an area of the model to represent points in the groundwater system, and their flow paths through the groundwater system are traced by moving the particles along the vector of maximum velocity within each model cell. In this way, particle tracking can estimate the movement of groundwater under a simulated condition, in this case, a flood event on the Missouri River. Particles were started within the area of the Labadie Plant and tracked throughout the flood event and during the subsequent recovery period. The particles moved in toward the bedrock aquifer during the flood event, and for a period of about 100 days after the event, until the hydraulic gradient reversed again toward the Missouri River in response to the decrease in river stage. The total distance traveled in toward the bedrock aquifer is small (about 50 feet). This is consistent with independent calculations of the average groundwater flow velocity assuming the same parameters used in the model (Darcy’s law equation for advection, Fetter, 1988).

4.0 SENSITIVITY ANALYSIS

Numerical modeling always involves a certain level of uncertainty in assigning model parameters. A sensitivity analysis was conducted in which model parameters were systematically varied to determine the variability in the model estimated response to the flood event, as shown in Table 1. The structure of the model runs remained unchanged, only the parameters indicated in Table 1 were modified. The model presented above in this report, model 1, is the preferred model because the model parameters are considered the most likely for the aquifer systems near the LEC. Four sensitivity runs, models 2 through 5, were conducted in which the hydraulic conductivity, storage, and porosity were deliberately altered to facilitate greater movement of groundwater. The results for all of these sensitivity runs were not consistent with reversal of flow at the location of interest.

The particle tracking analysis was repeated for sensitivity model run 5 because this model had the largest response at the monitoring well location. Particles released in the area of the Labadie Plant travel toward the bedrock aquifer for approximately 60 days and travel approximately 235 feet before the hydraulic gradient is again reversed back toward the Missouri River.

5.0 CONCLUSIONS

Groundwater modeling was conducted for an extreme worst case flood event, using the maximum elevation of the 1993 flood and carrying this elevation for the entire 55 days of this flood. The results of groundwater modeling did not indicate any reversal of groundwater flow at the location of interest. Groundwater flow was consistently from the bedrock aquifer to the alluvial aquifer based on the results of this model.

Attachments or Enclosures:

Table 1 – Groundwater Model Parameters

Figure 1 – Groundwater Model Domain Boundary and Model Grid

Figure 2 – No-flow and Constant Head Boundaries

Figure 3 – Pre-flood Groundwater Elevations

Figure 4 – Groundwater Model Domain Boundary and Resulting Groundwater Elevations

Figure 5 – Water Level Changes at Point of Interest

References

Anderson, Mary P., and Woessner, William W., 1992. Applied Groundwater Modeling – Simulation of Flow and Advective Transport.

Fetter, C.W., 1988. Applied Hydrogeology, Second Edition.

GREDELL Engineering Resources and Reitz & Jens, Inc. 2011. Detailed Site Investigation. Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area. Franklin County, Missouri. February 4, 2011.

Todd, David Keith, 1980. Groundwater Hydrology, Second Edition.

USGS 2000, Modflow-2000, the U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process.

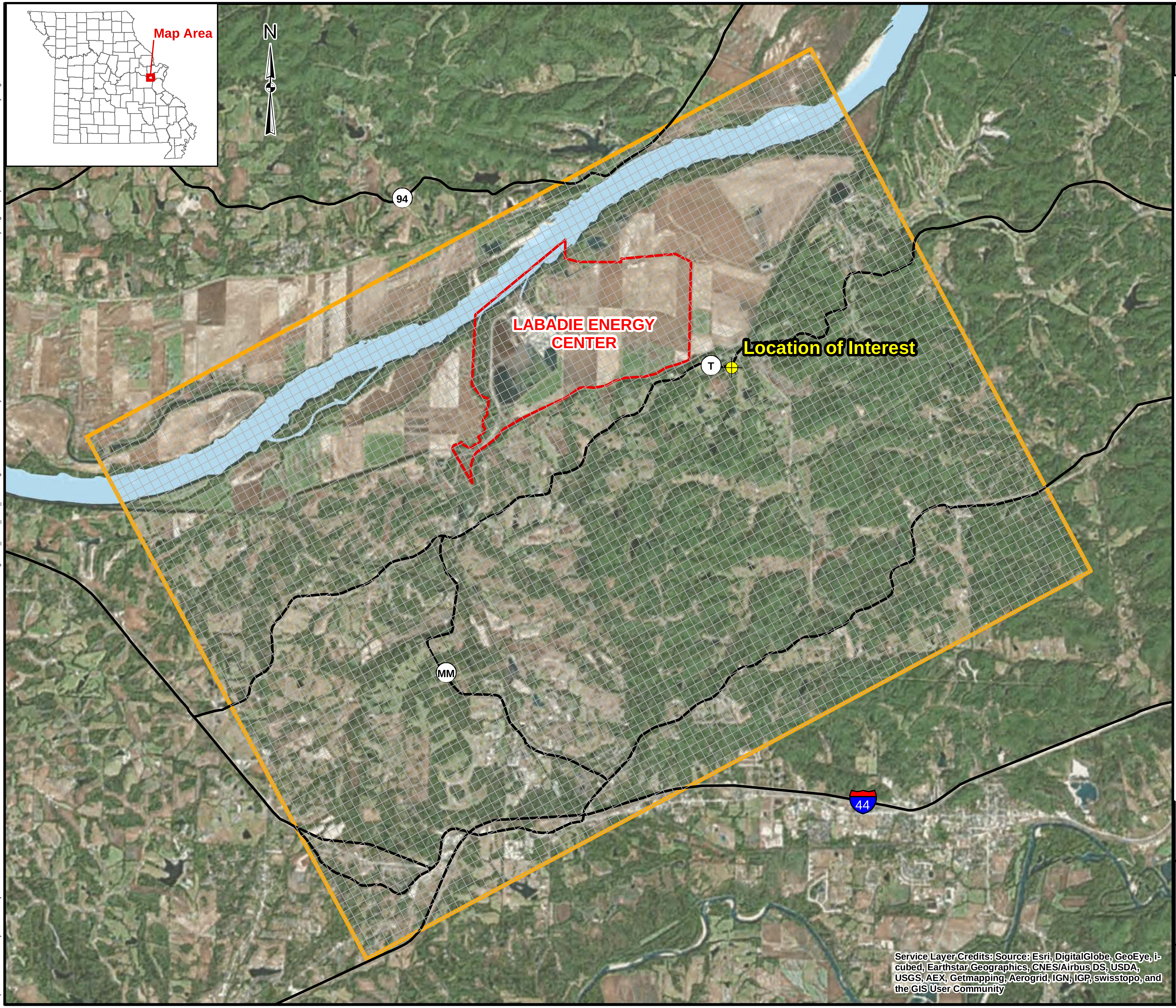
TABLES

Table 1
Groundwater Model Parameters
Labadie Energy Center, Franklin County, MO
Ameren Missouri

Model Number	Conductivity of Alluvium (feet/day)	Conductivity of Limestone (feet/day)	Specific Yield of Alluvium	Specific Yield of Limestone	Storativity of Alluvium ($feet^{-1}$)	Storativity of Limestone ($feet^{-1}$)	Model Results
1	70	3	0.3	0.14	2.30E-04	1.10E-05	Preferred
2	70	3	0.15	0.05	2.30E-04	1.10E-05	Sensitivity
3	70	10	0.15	0.05	2.30E-04	1.10E-05	Sensitivity
4	70	10	0.1	0.01	2.30E-04	1.10E-05	Sensitivity
5	120	10	0.1	0.01	2.30E-04	1.10E-05	Sensitivity

Prepared By: BS/JSI
Checked By: JS
Review By: JRS

FIGURES



TITLE

GROUNDWATER MODEL DOMAIN BOUNDARY AND MODEL GRID

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest

NOTES

1.) All boundaries and locations are approximate.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 1 - Domain Boundary and Model Grid.mxd	
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CHECK	JS	7/10/2015		
REVIEW	JRS	7/10/2015		

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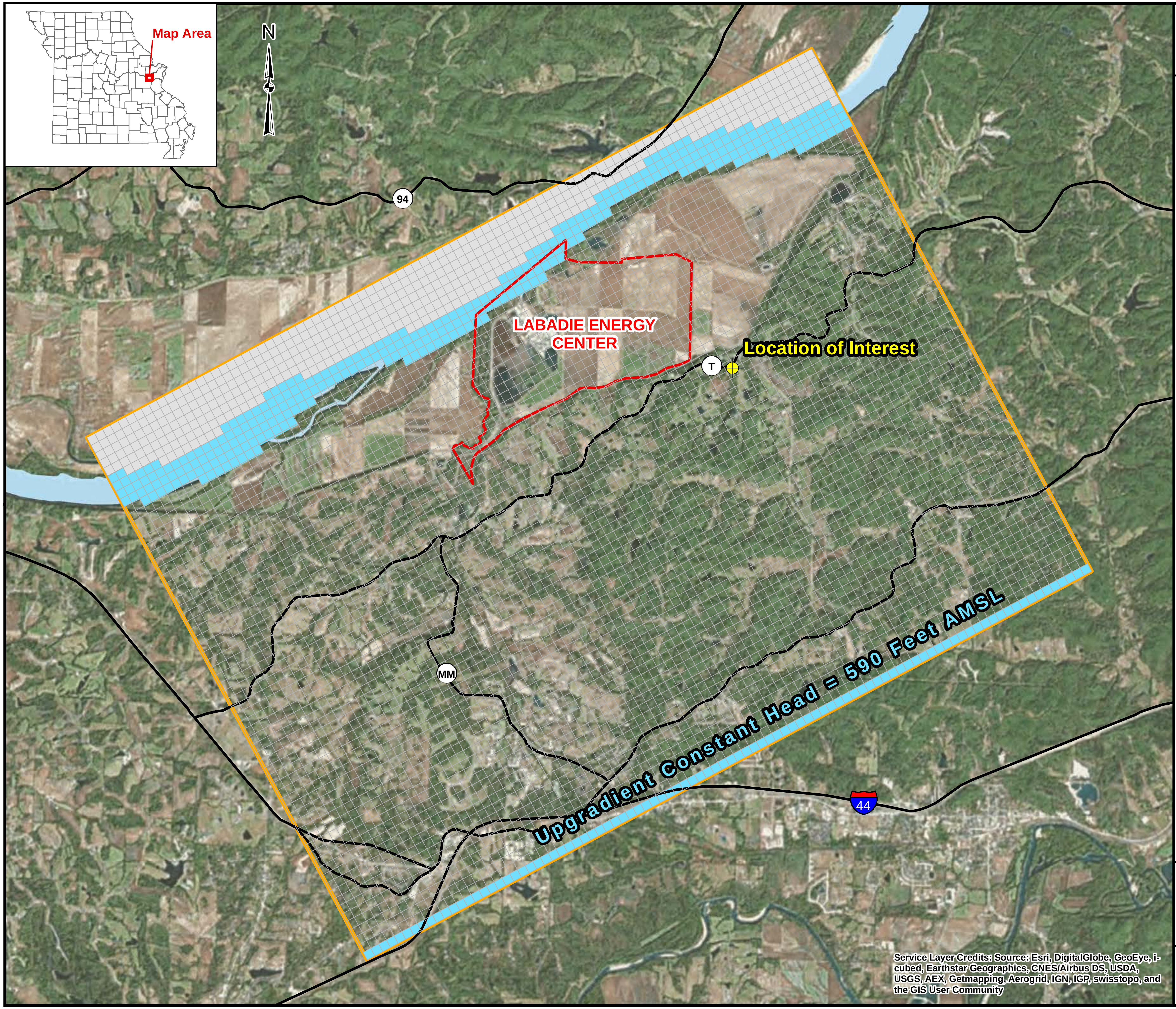

TITLE

NO-FLOW AND CONSTANT HEAD BOUNDARIES

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Constant Head Boundaries
- No-Flow Boundaries

NOTES

1.) All boundaries and locations are approximate.
2.) Constant Head Boundaries are 455.4 feet AMSL under average conditions, 486.6 ft AMSL under extreme flood conditons (peak of the 1993 flood), and are 590 feet AMSL upgradient.
3.) AMSL - Above Mean Sea Level.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 2 - Domain Boundary and Model Grid.mxd	
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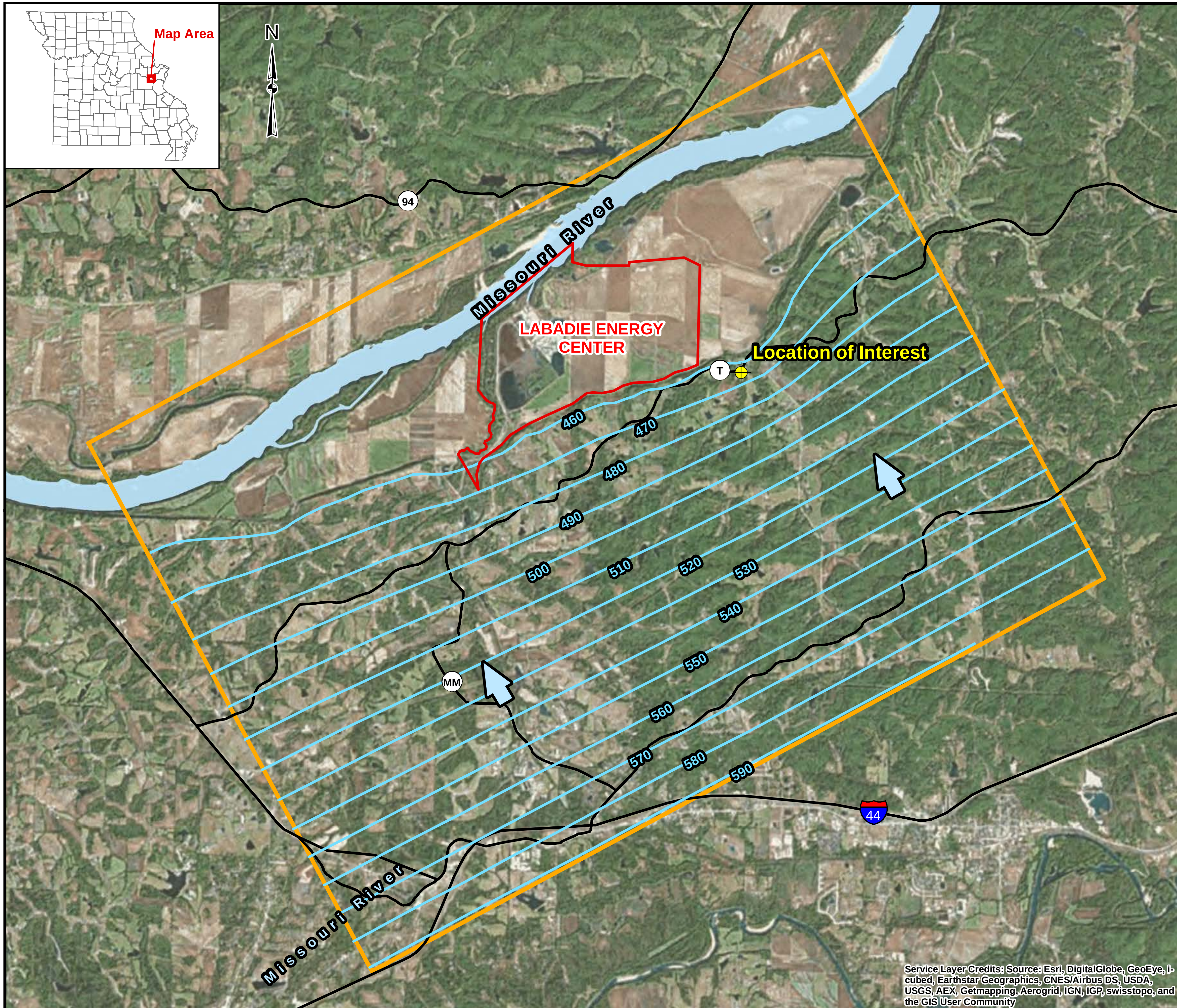

TITLE

PRE-FLOOD GROUNDWATER ELEVATIONS

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Model Groundwater Elevation Contours
- Groundwater Flow Direction

NOTES

1.) All boundaries and locations are approximate.
2.) Model contour interval is 10 feet.
3.) Upgradient contours are used for generalized gradient and are not considered locally accurate.
4.) Model results reflect pre-flood river conditions.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 3 - Pre-flood groundwater elevations .mxd
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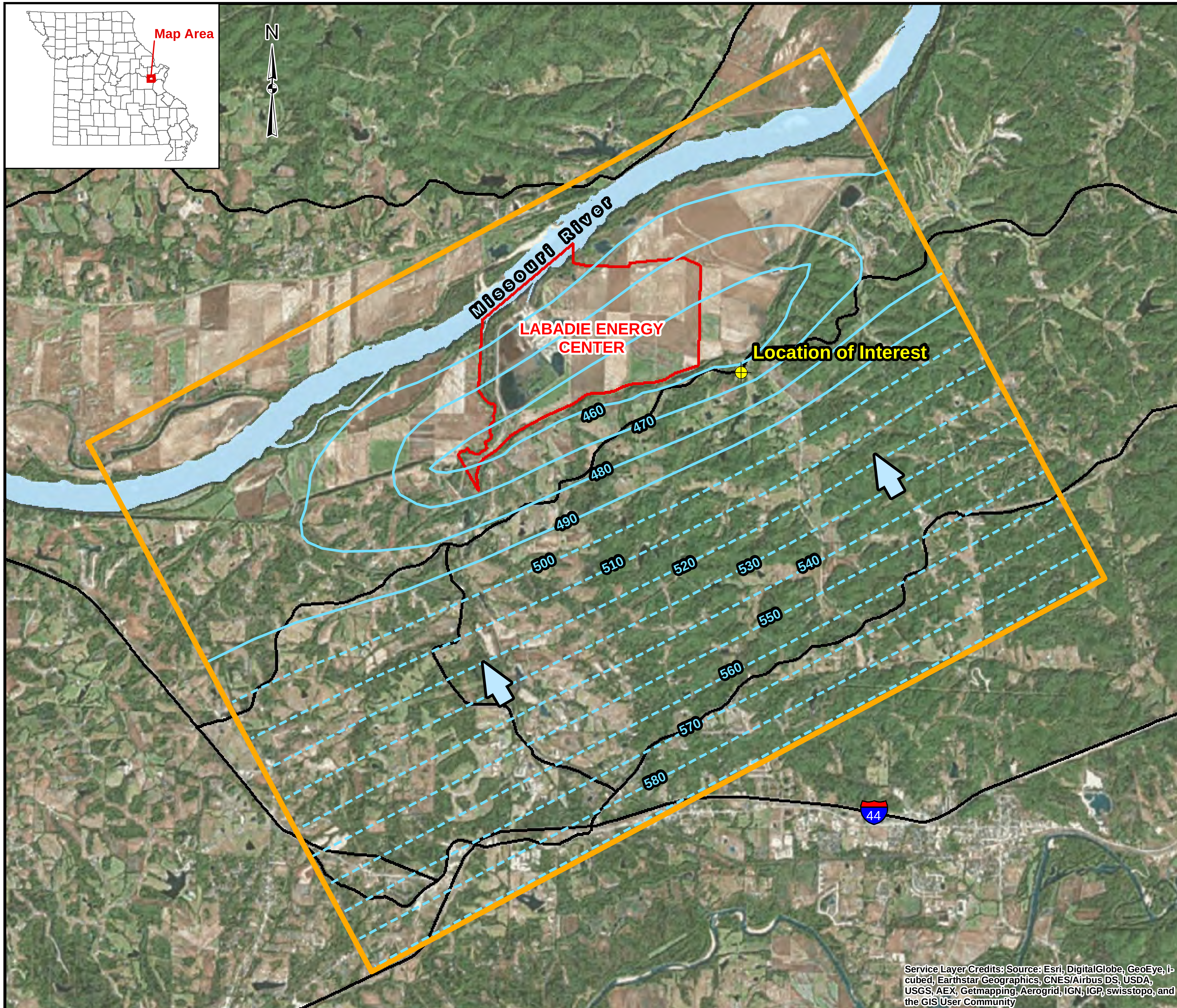

TITLE

GROUNDWATER MODEL DOMAIN BOUNDARY AND RESULTING GROUNDWATER ELEVATIONS DURING FLOOD

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Model Groundwater Elevation Contours
- Model Estimated Groundwater Elevation Contours
- Groundwater Flow Direction

NOTES

1.) All boundaries and locations are approximate.
2.) Model contour interval is 10 feet.
3.) Upgradient contours are used for generalized gradient and are not considered locally accurate.
4.) Model results reflect 55 continuous days of river level at 486.6 feet above mean sea level (peak level of the 1993 flood).

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560		Figure-4 - Groundwater Elevation after 55 days.mxd		
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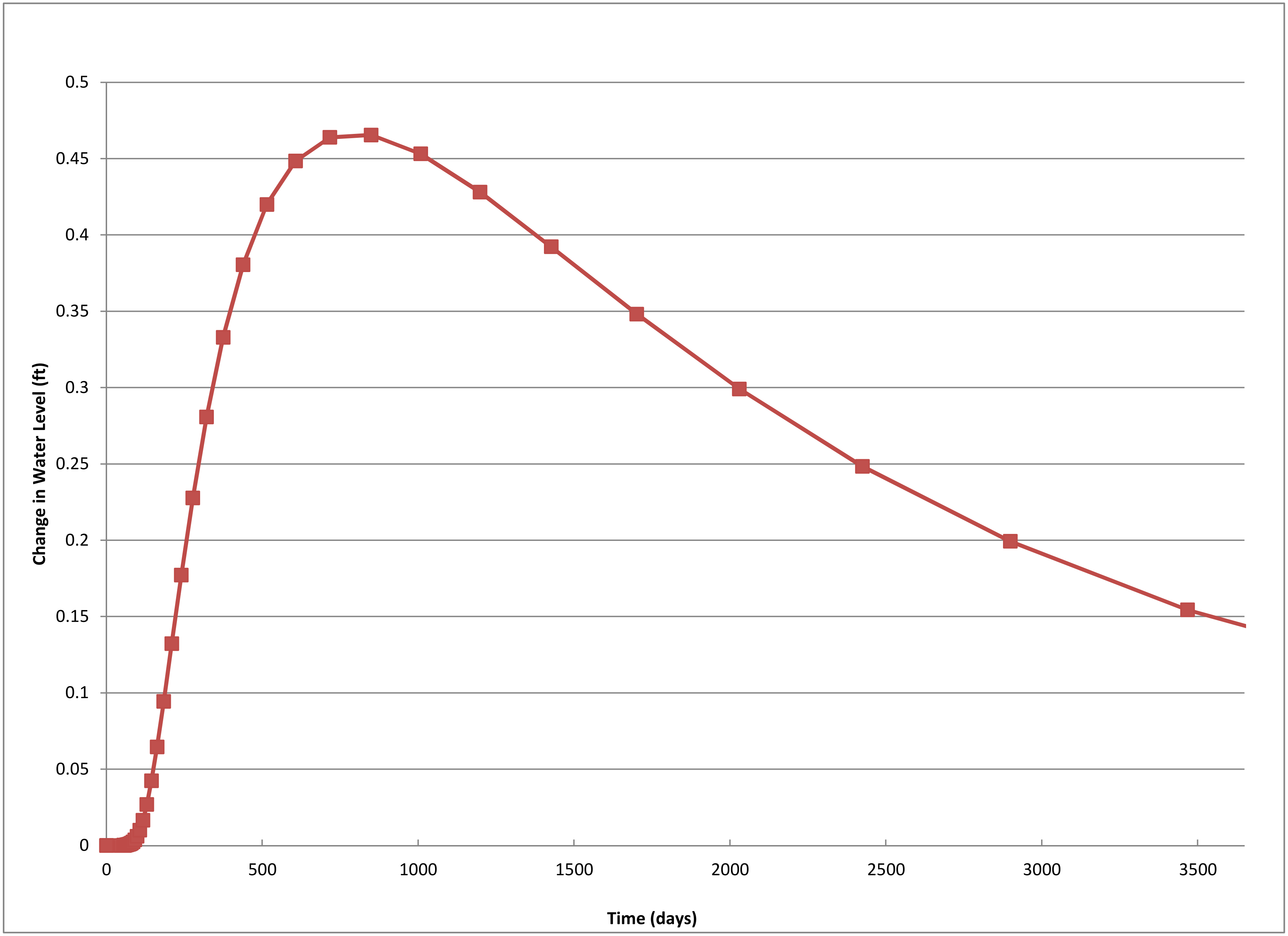
Figure 4

Figure 5
Water Level Changes at Point of Interest
Labadie Energy Center, Franklin County, MO
Ameren Missouri



TECHNICAL MEMORANDUM

DATE June 20, 2019 **Project No.** 1531410601

TO Ameren Missouri

CC

FROM Golder Associates Inc. **EMAIL Mhaddock@golder.com**

RESPONSE TO CMA PUBLIC COMMETNS REGARDING GROUNDWATER PROTECTION STANDARDS AND BACKGROUND WATER QUALITY

1.0 INTRODUCTION

This Technical Memorandum discusses the methods, procedures, and reasoning used to calculate the Groundwater Protection Standards (GWPS) at the Rush Island Energy Center (RIEC) and the Labadie Energy Center (LEC), as well as a brief review of publicly available data regarding arsenic in the alluvial aquifer of the Missouri River in Missouri. Recent public comments to the Corrective Measures Assessment reports (CMAs) have suggested that the calculation of the GWPS for arsenic have "skewed" the results of the monitoring evaluation and rendered the groundwater monitoring networks incapable of detecting arsenic contamination, biasing the CMAs against clean closure. This Technical Memorandum discusses the specific requirements of the CCR Rule that Golder has followed, the best practices for statistical evaluation as outlined in the United States Environmental Protection Agency's (USEPA) Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance), the locations of the background monitoring wells at the Labadie Energy Center (LEC) and Rush Island Energy Center (RIEC), and the presence of existing and naturally occurring arsenic in the alluvial aquifers of the Missouri and Mississippi River valleys.

2.0 LOCATION OF BACKGROUND MONITORING WELLS

The location of background wells is one of the most important factors in developing an effective monitoring well network. Section 257.91(a)(1) of the CCR Rule outlines the location requirements of background monitoring wells for a monitoring well network. The requirements are as follows:

(1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where: (i) Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or (ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells;

The CCR Rule requirements have been carefully followed and the locations selected for background monitoring wells accurately represent quality of background groundwater that has not been affected by a CCR unit.

2.1 Background Wells at the Labadie Energy Center

The background monitoring wells for the LCPA ash basin at the LEC are BMW-1D and BMW-2D and two other wells, BMW-1S and BMW-2S provide background monitoring for the LCPB ash basin. An aerial image with the

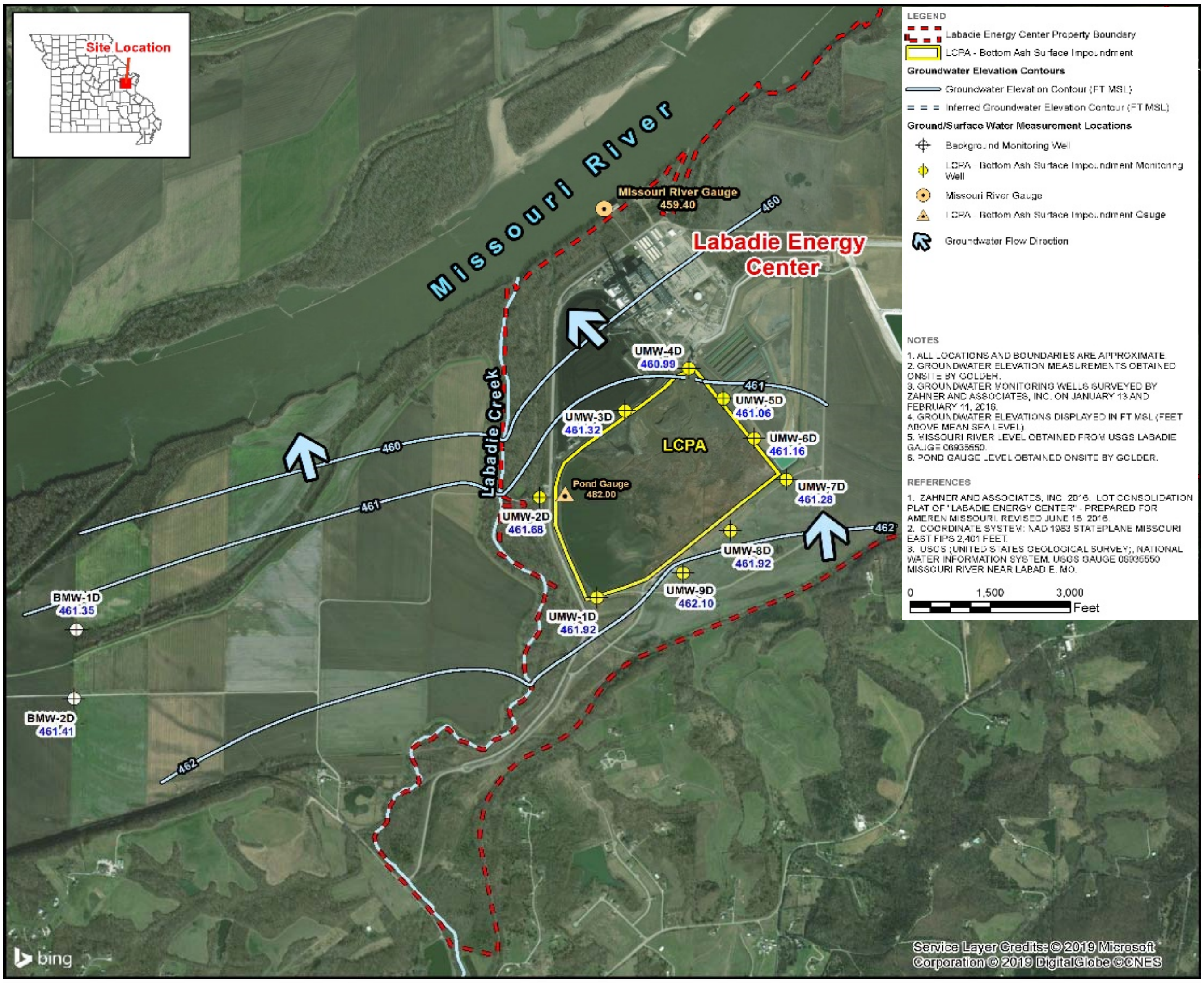


Figure 1: Labadie Monitoring Well Location and Groundwater Flow Map

location of the LCPA, the monitoring wells, and a representative groundwater flow map from 2018 is provided in Figure 1. The background monitoring wells are located approximately 1.5 miles west/southwest of the LCPA and 2,000 to 3,000 feet south of the Missouri River. These locations are upgradient and cross-gradient from the CCR at LCPA. Each of these two locations have shallow and deep zone wells (4 total) used for LCPB and LCPA monitoring purposes.

Groundwater flow within the alluvial aquifer is dynamic and can be influenced by seasonal changes in the water level of the Missouri River. Overall, as discussed in the annual reports (publicly available on Ameren website at https://www.ameren.com/company/environment-and-sustainability/managing-coal-combustion/ccr-compliance-reports), groundwater flows from the bluffs area toward the Missouri River at a rate of approximately 20 feet per year. Based on the upgradient/cross-gradient location of the background wells at LEC and the sampling results from these wells, there are no CCR impacts from the LCPA or the operation of the LEC in these wells and they are representative of un-impacted, background groundwater quality.

Background concentrations of arsenic in these wells have ranged from 0.12 µg/L to 42.6 µg/L and the spatial variability of concentrations is evident - at one location the deep well exhibits the highest concentration and at the other well-pair location the shallow well has the highest arsenic value. Spatial variability in these concentrations is the result of the heterogeneous makeup of the alluvial aquifer porous media and geochemical interactions of the aquifer media with groundwater. The alluvial aquifer is naturally composed of fine to coarse-grained sediments and clasts derived from soil and rock sources up the river basin that can contain arsenic and metallic minerals, as described in Section 4 below.

2.2 Background Wells at the Rush Island Energy Center

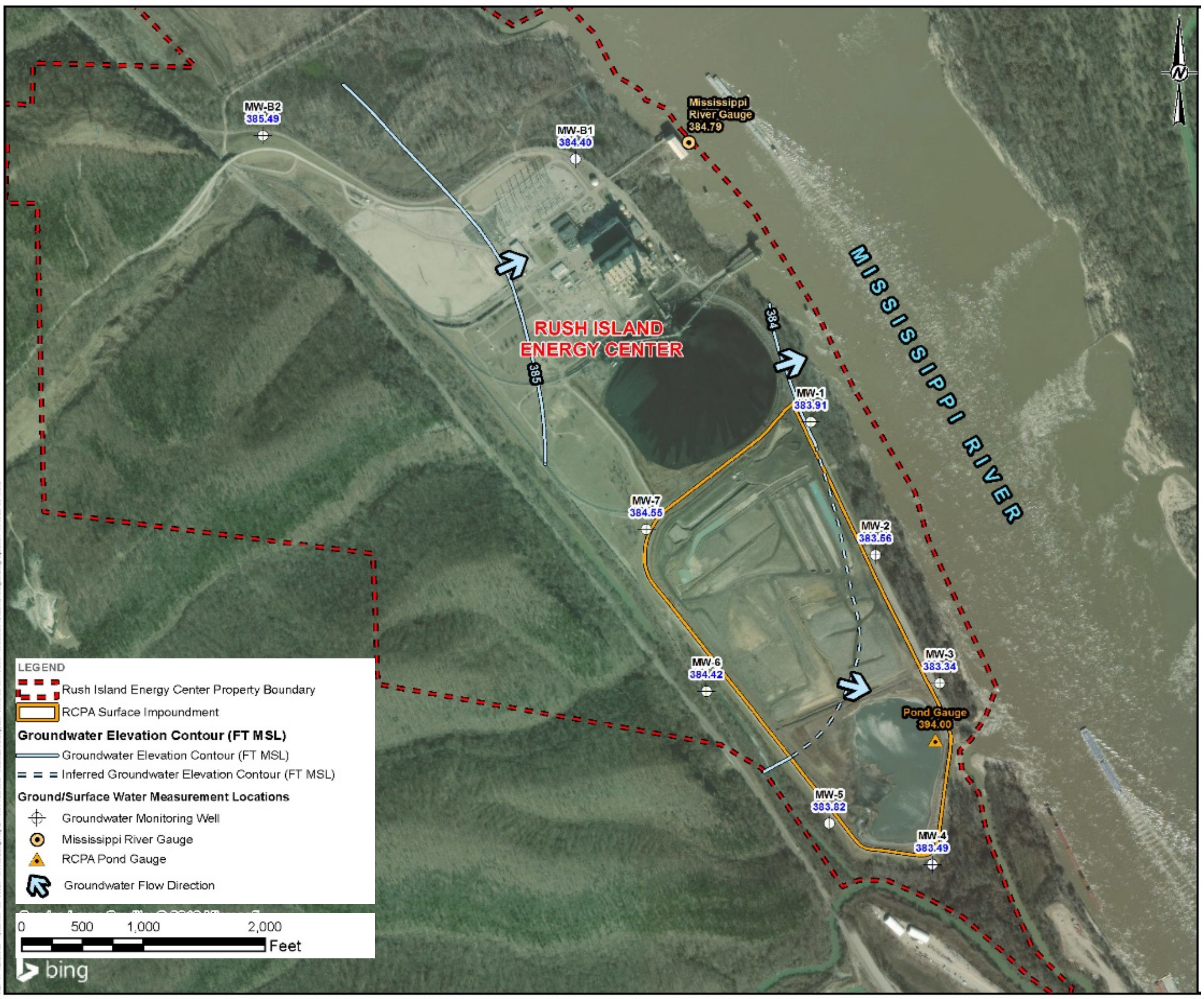


Figure 2: Rush Island Monitoring Well Location and Groundwater Flow Map

The background monitoring wells for the RCPA ash basin are MW-B1 and MW-B2. In addition, two monitoring wells from the 2014 Detailed Site Investigation (DSI) are present within 50 feet of MW-B2. These two wells include a shallow zone well (P29S) and a deep zone well (P29D). An aerial image of the location of the RCPA, the monitoring wells, and a representative groundwater flow map from 2018 are provided in Figure 2. The background monitoring wells are located approximately 2,500 to 4,500 feet north/northwest of the RCPA and 600 to 2,000 feet west of the Mississippi River. These wells are upgradient and cross-gradient from the CCR at RCPA.

Groundwater flow within the alluvial aquifer at the RIEC is also dynamic and can be influenced by seasonal changes in the water level of the Mississippi River. Overall, as discussed in the annual reports (publicly available on Ameren website at https://www.ameren.com/company/environment-and-sustainability/managing-coal-combustion/ccr-compliance-reports), groundwater flows easterly toward the Mississippi River. Based on the upgradient/cross-gradient location of the background wells at RIEC and the sampling results from these wells, there are no impacts from the RCPA or the operation of the RIEC in these wells and they are representative of un-impacted, background groundwater quality.

Background concentrations of arsenic in these wells have ranged from 1.9 to 30 µg/L in CCR Rule wells (MW-B1 and MW-B2) and from 1.1 to 51.7 µg/L in the DSI wells (P29S and P29D). Spatial variability in these concentrations is evident as the highest and lowest concentrations are in nested wells (P29S, and P29D) located 4,500 feet north of the RCPA. This variability in background concentrations is the result of the heterogeneous makeup of the alluvial aquifer porous media and geochemical interactions of the aquifer media with groundwater. The alluvial aquifer is naturally composed of fine to coarse-grained sediments and clasts derived from soil and rock sources upriver that can contain arsenic and metallic minerals, as further described in Section 4 below.

3.0 STATISTICAL METHODS AND CALCULATION OF THE GWPS

As required by the CCR Rule, prior to October 17th, 2017 Ameren posted a Statistical Method Certification (SMC) to its publicly available website for each of its CCR Units. These SMC's describe the statistical methods to be used for each CCR Unit for Detection and Assessment Monitoring. The methods included in the SMCs were selected because they comply with the requirements of the CCR Rule and are consistent with methods recommended in the USEPA Unified Guidance, which is specifically referenced as a statistical guidance document in the CCR Rule.

As required by the CCR Rule, once assessment monitoring is triggered at a site, site-specific GWPS must be calculated for each of the detected Appendix IV parameters. Following standard practice, the CCR Rule also requires that the site-specific GWPS be derived from either: (1) the United States Environmental Protection Agency's (USEPA) maximum contaminant levels (MCL), (2) health-based standards which were adopted by USEPA in July 2018 for Cobalt, Lead, Lithium, and Molybdenum, or (3) un-impacted background concentrations, for situations where the un-impacted background concentrations are higher than the MCL. Using these methods, the GWPS for arsenic at the LCPA was set at 42.6 µg/L, while the arsenic GWPS for the RCPA is 30.0 µg/L.

As outlined in the SMCs for both the LCPA and the RCPA, following the establishment of the GWPS, assessment monitoring statistics were performed using an interwell confidence interval method to compare results from downgradient/compliance monitoring wells with the GWPS. The confidence interval method used to evaluate Appendix IV results from both the LCPA and RCPA are consistent with the methods recommended in the Unified Guidance.

In summary, the methods used for the calculation of the GWPS at the LEC and RIEC, as well as the resulting GWPS values, follow standard practice in groundwater monitoring and are consistent with the CCR Rule and the USEPA Unified Guidance.

4.0 EXAMPLES OF NATURALLY OCCURING ARSENIC IN MISSOURI

There are numerous reports and publications that discuss the presence of naturally occurring arsenic in Missouri. Arsenic has been reported to occur in groundwater in Missouri from both naturally occurring and anthropogenic sources (https://health.mo.gov/living/environment/ privatedrinkingwater /contaminants.php). Additionally, as provided in the risk assessment reports for Labadie and Rush Island, United States Geological Survey (USGS) soil and groundwater maps by the United States Geological Survey (USGS) for arsenic in the groundwater and soils shows that arsenic is naturally present in our environment (USGS Reports available at https://mrdata.usgs. gov/geochem/doc/ averages/ countydata.htm and http://water.usgs.gov/nawqa/trace/pubs/ geo_v46n11 /fig2.html, Ameren risk assessment report available at https://www.ameren. com/company/environment-and-sustainability/managing-coal-combustion/water-quality).

The National Water Quality Monitoring Council's (NWQMC) Water Quality Portal (available at https://www.waterqualitydata.us/) summarizes data from the USGS, the USEPA, and the NWQMC databases. The NWQMC database includes arsenic results from a total of 1,215 groundwater samples for wells located upgradient of the LEC within the Missouri River alluvial aquifer. These 1,215 samples are from wells located just upstream of the LEC to the confluence of the Kansas and Missouri River in Kansas City, Missouri. The 1,215 samples consist of: 351 samples from the Independence Well Field near Independence Missouri, 852 samples are from the Columbia/Eagle Bluffs Wetland Complex wells, and the remaining 12 samples from various locations in the identified area. This is an extensive dataset. A USGS report on the data for Independence Missouri is available at https://pubs.er.usgs.gov/publication/sir20105232 and USGS Reports for the Columbia/Eagle Bluffs Wetland Complex wells are available at https://pubs.er.usgs.gov/publication/wri024227. Arsenic values within these samples ranged from non-detect (<0.022 ug/L) to 72 µg/L, with an average concentration of 6.7 µg/L.

Figure 3: Comparison of Missouri River Alluvial Aquifer Groundwater Arsenic Concentrations – Public Data and Labadie Results

Figure 3 compares the publicly available groundwater arsenic data in upgradient Missouri River alluvial aquifer settings to the Labadie background and monitoring well results, which ranged from non-detect (<0.052 µg/L) to 69.5 µg/L in CCR Rule monitoring wells, with an average concentration of 6.6 µg/L. Overall, the results at the upgradient locations in Missouri are nearly identical to those at the LEC with around 80% of the samples being below the MCL and 20% above the MCL. These data demonstrate that arsenic concentrations above the MCL are not unusual in the Missouri River alluvial aquifer and are primarily from naturally occurring sources or, potentially, from anthropogenic sources that are unrelated to CCR and power plant operations.

Additionally, using the NWQMC Water Quality Portal (available at https://www.waterqualitydata.us/) from the confluence of the Mississippi and Missouri Rivers to the RIEC there are 99 arsenic groundwater sampling locations with published data from the alluvial aquifer of the Mississippi River. Arsenic test results from these published well samples range from non-detect (<1.0 µg/L) to 39 µg/L with 4 sampling locations reporting arsenic concentrations greater than the MCL and 2 locations with concentrations over the site-specific GWPS for the RIEC. These levels are similar to background arsenic concentrations at the RIEC and further support that the concentrations in background wells are derived from naturally occurring or non-CCR anthropogenic sources of arsenic in the Mississippi River alluvial aquifer.

Additional comments to the CMA's make note that boron is a clear indicator of CCR impacts, which is acknowledged by EPRI (2012) documentation that boron is "*Typically present in leachate, non-reactive and mobile in common hydrogeological environments, and not a common anthropogenic contaminant*." The public comments also attempt to draw a correlation between the arsenic concentrations present onsite and boron concentrations. Since boron is not detected in background groundwater wells, this absence further supports the case that the arsenic observed in background wells is not from a CCR source and is naturally occurring, likely derived from sulfide minerals present in the aquifer.

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LOCHMUELLER GROUP

ADDENDUM

Rush Island, Meramec, Labadie and Sioux Ash Pond Closure: Rail & Barge Transportation Assessment July 9, 2019

Lochmueller Group previously completed a planning-level assessment of the costs and logistics associated with extracting, stabilizing, and transporting coal combustion residuals (CCR) from existing ash ponds at the Rush Island, Meramec, Labadie, and Sioux Energy Centers to offsite landfills. Trucking is the most flexible and cost-effective mode of transporting CCR, given the relatively short distances (50 miles or less) between each energy center and the preferred landfill locations. The purpose of this addendum is to evaluate in detail the rail and barge transportation modes.

Rail and Barge Overview

Rail and barge typically become more cost-efficient than trucking over longer distances. In fact, the average barge trip length along the Mississippi River waterway system is 513 miles, which is indicative of the long distances that waterway freight commonly travels.

As compared to the highway network, the geographical reach of the rail and barge networks is limited. As such, payloads transported by rail and barge are commonly picked up by truck at the origin and delivered by truck to the destination, with intermediate transloads on and off trains and barges. Over short distances, the cost and time for these transloads renders rail and barge non-competitive with truck hauling.

To maintain parity with truck hauling, CCR transport by rail would require specialized rail cars fully lined with covers to prevent material escape (coal delivery trains are not suited for CCR removal). As such, these trains would be dedicated for CCR transportation and would run full to landfills and return empty. Such specialized rail cars are expensive and cost approximately $100,000 per car. Rail cars for each 100-car unit train are estimated to cost $10M.

CSX is a Class 1 railroad with acknowledged CCR transport capabilities. However, CSX does not directly serve any of Ameren's energy centers. For CSX to be a CCR hauler for Ameren, carrier transfers would be required involving the Class 1 serving each site (UP or BNSF). This would probably occur using the St. Louis Terminal Railroad (TRRA) as an intermediary to transfer train cars from UP and BNSF yards in Missouri to the CSX Rose Lake Yard in East St. Louis, Illinois. In total, the use of three separate carriers and multiple train yards would increase the complexity, cost, and haul cycle under the CSX option. Service disruptions would also be a concern, as Ameren would have little control over the means or methods of rail transport.

Given the carrier transfer process described above, a single 100-car unit train is assumed to be capable of transporting approximately one load every two weeks, although the actual timeframe depends on the landfill destination. To maintain the previously assumed CCR removal rates and assuming the 2-week roundtrip haul, unit trains would need to be loaded at each energy center one to four times per week dictating two to eight CCR unit trains in the cycle for each site. The capital expense to acquire a sufficient number of rail cars to support such haul cycles at Ameren's four energy centers would be approximately $90M.

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Rail and barge transportation is more susceptible to disruptions, particularly due to flooding events that can close rivers and rail lines for extended periods. In addition, congestion on rail lines and in rail yards and at lock and dams affects the reliability of these modes. Barges also present a unique environmental and safety concern. In 2018, 15 coal barges broke loose on the Monongahela River near Pittsburg with two of the barges sinking and at least one spilling coal into the river. The leakage or spillage of CCR into waterways would have environmental ramifications. Given the sensitivities surrounding CCR generally, barging is simply not a desirable transport mode.

Ameren Energy Centers

As previously noted, each energy center has the potential for direct rail and barge loading. However, there are site constraints at each location that would hamper rail or barge operations, as follows:

Rush Island

The site currently has a rail loop off the BNSF line for unloading coal trains. A full 12-hours is required to unload a coal train and the site receives about one train per day. Hence, the existing rail spur is fully utilized and does not have capacity to temporarily store or load CCR trains.

It would be necessary to construct dedicated tracks for loading CCR unit trains known as “ladder track”. The site does not have space for such a facility, so land would need to be acquired or leased from an adjacent property owner or from the BNSF itself to construct a loading area. Since the loading would occur off-site, CCR would need to be trucked to the rail loading area.

Additionally, the BNSF mainline consists of a flood-prone single track. The line has been inoperable due to multiple flooding events in 2019 alone. Due to the single track, northbound and southbound trains must pass at sidings to maintain two-way operation. This significantly diminishes the capacity of the line. It is uncertain if existing BNSF operations can accommodate additional train volume. The addition of CCR train operations could disrupt coal delivery, impacting power generation and ultimately service to customers.

Rush Island does not presently have barge loading capabilities. Ameren would need to construct barge-loading facilities in the Mississippi River along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. This section of the Mississippi River is very active and the ability to obtain regulatory approvals for CCR removal by barge is uncertain.

Meramec

Similar to Rush Island, Meramec is located along a single-track mainline, which is operated by the UP. It is uncertain if existing UP operations can accommodate additional train volume, as this line has the same challenges maintaining two-way operations as the BNSF line. This line is also prone to closure due to flooding.

Concerning barge transportation, Meramec has barge loading facilities in place. However, environmental and safety concerns with barge transportation persist, in terms of the potential for CCR to leak or spill from barges into waterways or for barges to break away.

Labadie

Both the UP (and BNSF via trackage rights) and Central Midland Railroad (CMR) – a short line railroad running between St. Louis and Union – operate in proximity to the Labadie site. However, CMR's line sale contract contains a service restriction prohibiting the CMR line from serving the Labadie facility. That restriction was upheld by the Surface Transportation Board (STB Dockets NOR 42126, FD 33508, FD 33537, served Feb. 27, 2013). The UP presently delivers two loaded coal trains per day to Labadie.

The site's existing rail infrastructure is fully committed to unloading coal trains and would not have capacity to temporarily store or load CCR trains. Therefore, it would be necessary to construct dedicated tracks for loading CCR unit trains on site. Given the site's location in the Missouri River flood plain, such a facility would be subject to permitting and approval from numerous regulatory authorities, which could delay or prohibit construction.

Barge transportation on the Missouri River is considerably less reliable than on the Mississippi River. There are no lock and dams along the Missouri River; water levels are highly susceptible to rainfall and spring snowpack melt in the Rocky Mountains; and the Army Corps of Engineers has not consistently maintained a navigation channel. In recent years, the barging "season" has been at most six months per year. Given these issues, barge transportation would not be a reliable mode for removing CCR from Labadie.

In addition, the Labadie site does not presently have barge loading capabilities. Ameren would need to construct docking facilities along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. With the river not being navigable for half of the year, pursuit of permits and capital expenditures for barge loading facilities would not be economically viable.

Sioux

The site is located along a single-track BNSF line, which is also prone to closure due to flooding and two-way volume constrained. Similar to the other sites, existing on-site rail infrastructure is dedicated to unloading coal trains. Dedicated tracks for loading a CCR unit train would need to be constructed to facilitate removal of CCR by rail.

The Sioux site does not presently have barge-loading capabilities and Ameren would need to construct docking facilities along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. The environmentally sensitive nature of this section of the Mississippi River – influenced by the presence of wetlands, recreation and parks along the river, and eagle habitats – would further encumber the permitting process.

Potential Landfill Destinations

To avoid the need to transload CCR from rail or barge to trucks to reach the final destination, Lochmueller reviewed landfills located in proximity to rail lines or waterways to determine if facilities are in place to enable direct unloading of CCR from rail or barge. Sites across Missouri and Illinois (excluding the Chicago area) were reviewed using location information provided by each state's environmental agency.

While several landfills were discovered along active rail lines, none appears to have active rail unloading capabilities in place. The Five Oaks Recycling and Disposal located near Taylorville, Illinois had a rail unloading spur at one time, although it seems to have fallen into disuse. Moreover, if reactivated, it would not have the ability to store long CCR unit trains and would need to be extended.

Similarly, no landfills were discovered with unloading capabilities along waterways. It is our understanding that such facilities may exist in other states. However, the increase in travel distance to access those facilities would likely render them cost-prohibitive for purposes of CCR removal from these four sites.

Study of Deep Excavation at Ameren Missouri Energy Centers

INTRODUCTION

In response to questions raised at recent public meetings held by Ameren Missouri (Ameren), Reitz & Jens was asked to prepare a white paper that discusses the methods and implications of deep excavation and removal of Coal Combustion Residuals (CCRs) from the surface impoundments ("basins") located at Ameren's four coal-fired energy centers. The technical review presented in this paper is applicable in general to a deep excavation below the water table at the Sioux, Labadie and Rush Island Energy Centers[1]; specific characteristics of each individual energy center or CCR unit are not addressed.

GENERAL DESCRIPTION OF CCR BASINS

The principal characteristics of the CCR basins at each of Ameren Missouri's energy centers are:

1. The basins are built both below and above grade (that is "partially-incised") in alluvial sands in close proximity to a major river (Mississippi River or Missouri River). The basins were created by dredging the sands in the vicinity of each plant to obtain fill material to raise the actual area of the power plant building and appurtenant facilities to above flood levels of the adjacent river. The excavation was then repurposed to manage CCRs generated from the plant. The CCRs were generally placed in the excavation by sluicing (deposited by flowing water). At some point in the history of each plant, large perimeter berms were constructed around the basins. This is illustrated below:

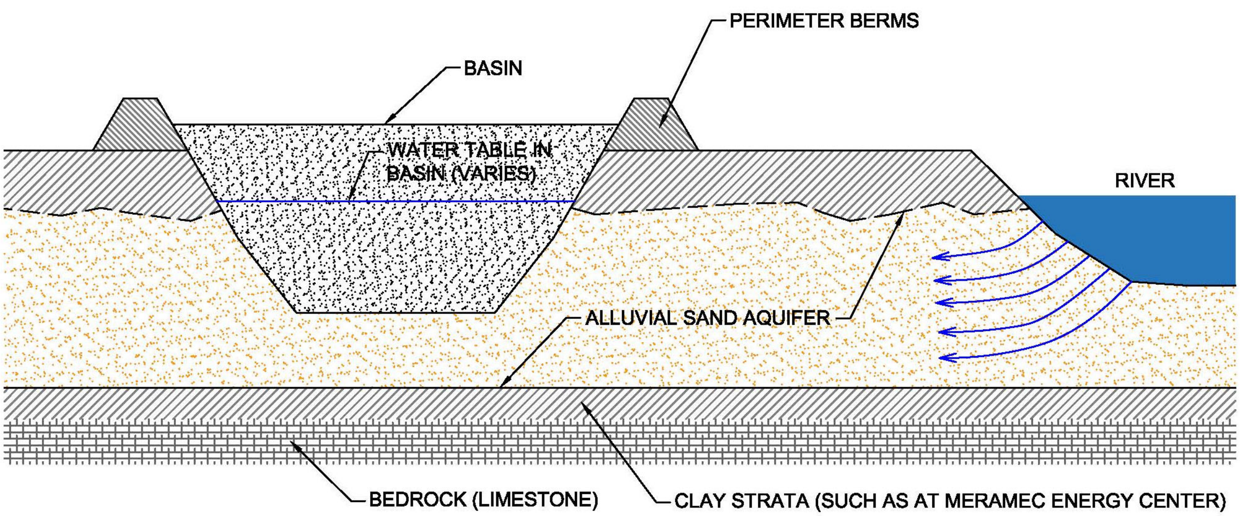


Figure 1 – Illustration of General Construction of CCR Basins (not to scale)

2. The size, depth and proximity to large rivers all impact the method of potential excavation. These basins are relatively large – up to 165 acres – compared to many CCR units at other power plants.

[1] At normal river levels, most of the CCR basins at the Meramec Energy Center are above the water table and are excluded from this description.

The basins are relatively deep – up to 100 feet. Some basins, such as at the Rush Island Energy Center, extend close to the underlying bedrock.

3. The removal process of the ponded CCR is more difficult than traditional soils and would require specialized equipment and management prior to transport to a landfill. The characteristics of the CCRs vary from plant to plant and also depend upon the nature of the CCR – fly ash, bottom ash, and other coal combustion byproducts. Fly ash tends to hold water and will not drain by gravity alone such as in a pile; it typically requires some mechanical grading or agitation. Bottom ash is more like sand and will drain more freely. In addition, CCRs are lighter in weight than soils and compressible. Near the surface of the basins CCRs are generally in a loose state due to their placement via sluicing. At greater depths within the basins, CCRs generally compress and become more dense due to settlement from the weight of the upper CCRs. CCRs become less permeable with increasing density, that is, limiting the volume and velocity of water that may move through the CCRs. Eventually, fly ash may become as impermeable as fine-grain soils.

The principal characteristics of the CCR basins listed above are the determining factors in the feasibility of excavation at Ameren's Energy Centers and could differ from that observed at other power plants which may have burned coal or built basins with different characteristics.

PRINCIPAL METHODS OF EXCAVATION

There are two principal methods of removal or excavation of the CCRs from the basins: 1) excavation in the “dry” by first pumping out the water (i.e. “dewatering”) to some depth below the excavation; or 2) excavation in the “wet” by dredging, which is how the basins were excavated originally. The “dredge” may be a backhoe with an extended arm and bucket, a crane with a dragline bucket, or a crane with a clam-shell bucket. Another type of dredge is the suction dredge which pumps the material and water to a disposal site. Small suction dredges have been used in CCR basins at other power plants, but they are limited to about 20 to 30 feet deep. Because of the greater depths, removing CCRs from Ameren’s basins would require a cutter-head dredge, such as pictured below.

Figure 2 – Illustration of Cutter-Head Suction Dredge

The cutter-head dredge is designed to break through and remove compacted or cemented CCRs and, due to the depths of Ameren's basins, would need to be specially manufactured. The dredge would pump approximately 14,000 gallons per minute and could remove up to about 650 cubic yards of CCR per hour.

EXCAVATION IN THE "DRY"

Complete removal of water from the CCR basin prior to excavation may not be practical or technically feasible using either deep wells or cutoff walls. The volume of water requiring handling would be tremendous because the basins are in a sand aquifer near a major river as illustrated in Figure 1.

To keep water from filling the excavation would require concentric rectangles or "rings" of deep wells installed at close spacings and completely encircling each basin, with each well pumping hundreds of gallons per minute. The use of a deep well system to dewater the basins creates a number of technical and environmental problems:

1. Space limitations around the basins could impede or preclude the installation of such a large system of concentric wells around each basin. Each concentric system of wells must be separated from the next system by 15 feet or more for equipment and maintenance. Also, a stable slope must be maintained in the sand between each system as the excavation progresses. Therefore, the outside limits of the wells and excavation would need to extend well beyond the existing limits of the basin. The basins are in close proximity to each plant and operational facilities, such as railroad tracks, tanks, and buildings.

2. The drawdown would pull CCR-impacted water from the basin; therefore, a tremendous volume of water would have to be managed and/or treated, requiring a large water treatment plant to be constructed on site[2].

3. Depending upon location, the drawdown of the groundwater table could potentially impact the surrounding environment, such as surrounding vegetation and crops, and potential settlement of the natural soils surrounding the basins. This could cause settlement of shallow foundations, roads, railroad tracks, adjacent river banks or levees, and utilities.

Therefore, in lieu of a concentric well system, a cutoff wall would need to be designed and constructed around each CCR basin to prevent the surrounding groundwater from flowing into the basin as it is pumped dry and excavated. For the Labadie Energy Center, the cutoff wall would have to be up to two (2) miles long and would extend to the bottom of the aquifer, up to 100 feet deep or deeper. Construction of the cutoff wall alone could take up to a year. The water removed during excavation of CCRs inside the cutoff wall would need to be treated.

Structural Stability: Cutoff Walls and Cofferdams

Slurry cutoffs, structural panel cutoffs or sheetpile walls alone would not be structurally adequate due to the tremendous hydrostatic pressure and lateral earth pressures that would occur on the outside of the cutoff wall as the interior CCRs are dewatered and excavated. Installation of deep wells around the outside of the

[2] Existing waste water treatment facilities are inadequate to manage the volume of water generated by a deep excavation project discussed here.

cutoff wall to reduce the hydrostatic pressure would create some of the same problems discussed above. A potential solution would be to install rows of tie-backs through the wall and into the underlying bedrock as the excavation progresses. This is illustrated in Figure 3 below:

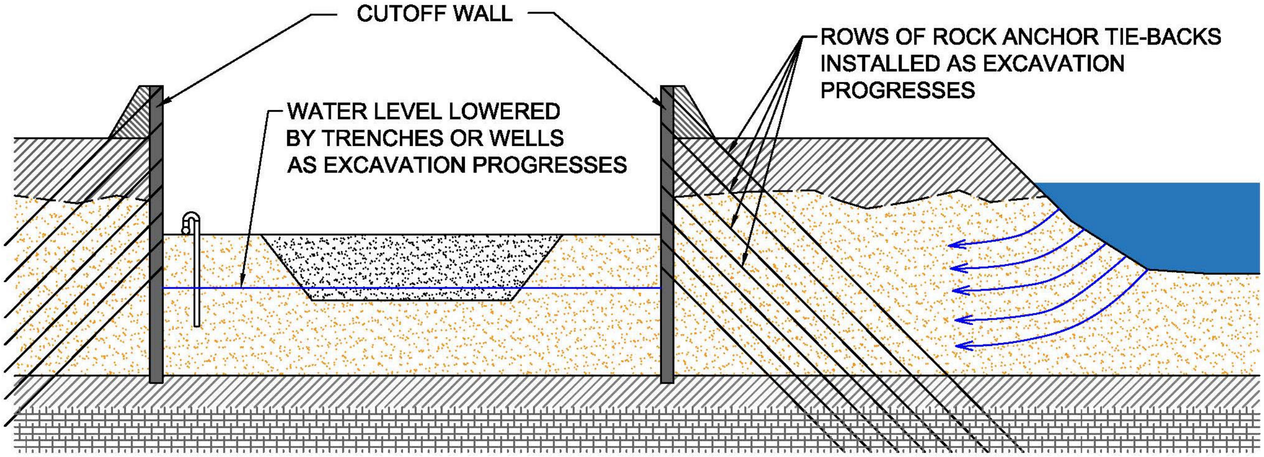


Figure 3 – Illustration of Cutoff Wall with Tie-Backs

There are several different methods of installing a structural concrete cutoff wall. One method is to excavate a deep trench, using a heavy mud slurry to keep the trench open in the sands. Reinforcing steel is then inserted into the trench, and the slurry is displaced by pumping concrete up from the bottom. An example is the structural concrete cutoff wall installed for the construction of the World Trade Center to hold back the water of the Hudson River.

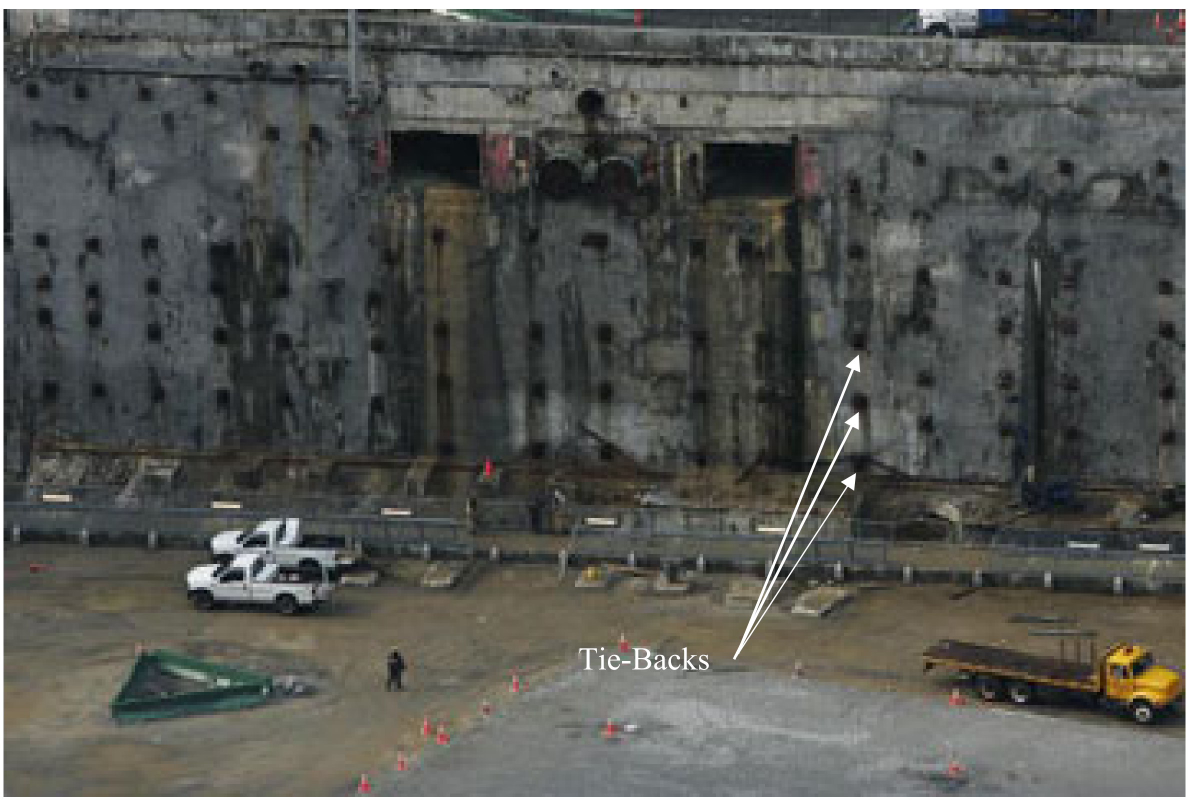


Figure 4 – Structural Concrete Cutoff Wall for the World Trade Center

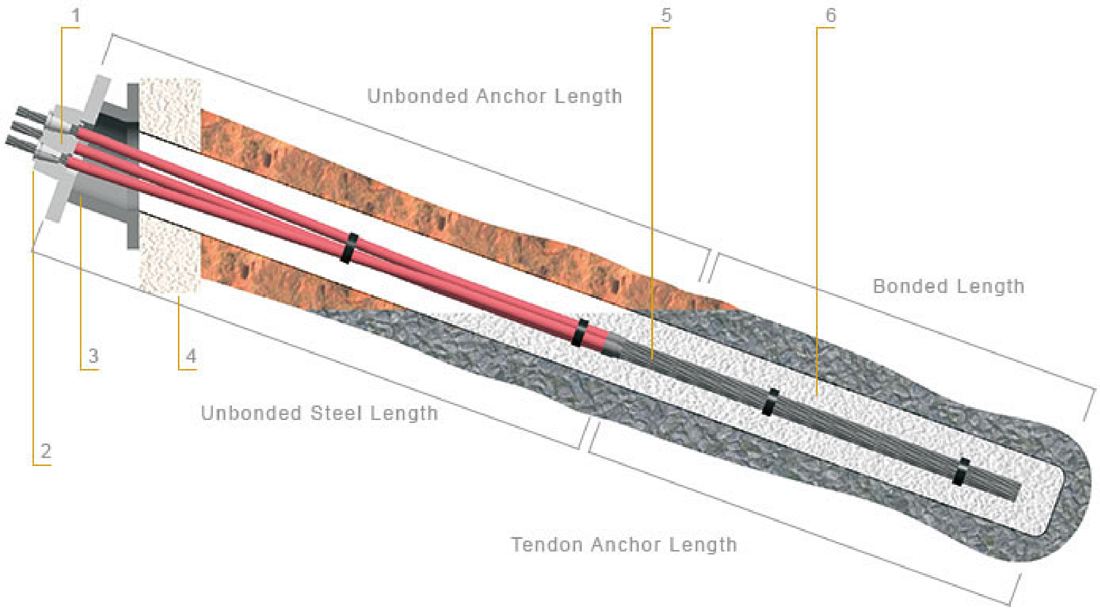


Figure 5 – Illustration of a Typical Rock Anchor Tie-Back

An illustration of a typical multi-stand rock anchor tie-back is shown in Figure 5. Tie-backs are installed by drilling in horizontal rows as the excavation progresses downward. Tie-backs ends can be seen in the photo of the cutoff wall in Figure 4. At some locations, the lengths of the upper tie-backs would need to be well over 100 feet to penetrate into the bedrock, such as at Labadie and Rush Island. The cost per tie-back could range from $10,000 to $40,000.

The construction of a structural concrete cutoff wall is problematic due to both the depths and the presence of large cobbles and boulders near the bedrock, such as at Labadie and Sioux Energy Centers. It is critical that the cutoff extend into the underlying clays where present, such as at Meramec, or into the bedrock, such as at Labadie and Rush Island. The cutoff has to be more than 90% sealed to have real effect at stopping the inflow of groundwater. Installation of hundreds to thousands of tie-backs as the excavation of the CCRs progresses would add years to the construction of the cutoff and the removal of the CCRs. The installation of the cutoff wall and tie-back rock anchors alone will add millions to tens of millions of dollars to the cost of removal of the CCRs by excavation in the dry.

Another type of cutoff sometimes used adjacent to a major river is a “cellular cofferdam.” This technique typically requires deep soil mixing, compaction grouting or drilled holes to make continuous lines of cylindrical columns to form a row of boxes or cells completely around each CCR basin. The width of the cells would have to be large to withstand the hydrostatic pressure and lateral earth pressures. This construction method requires a sufficient open area that may not exist at each energy center and is equally as expensive as a cutoff wall. The close proximity of the plant and appurtenances could be a limiting factor.

Treatment and Management of Water

As the excavation inside the cutoff walls progresses, water from the basin would need to be removed by temporary wells and trenches. This includes existing water and precipitation that falls over the years it would take to complete the project. The water would have to be evaluated to determine regulatory status before the pumped water could be discharged. Assuming such water exceeds regulatory standards, a water treatment plant would need to be constructed on site to handle the volume.

Summary

Since removal and treatment of sufficient volumes of water would be very problematic, extremely time consuming, and exceedingly costly, excavation of CCRs in the basins in the "dry" is not practically feasible.

EXCAVATION BY DREDGING

Excavation by dredging eliminates many issues associated with the removal of the water from an area of deep alluvial sands adjacent to a major river. There are, however, a number of technical challenges that remain with dredging. First, excavation by dredging is done blindly under water. Therefore, removal of CCRs from a basin with a bottom liner should not be done because there would be a very high probability that the bottom liner would be damaged, causing more environmental harm than if the basin were closed with the CCRs in place. Secondly, dredging with an open bucket – such as with a backhoe, dragline or clamshell – could result in suspension of contaminants and an increase in the hydraulic conductivity of the CCRs, resulting in an increase in release from the unlined basin. Because of these limitations, the only viable method is a suction dredge. As stated above, a cutter-head dredge would be necessary for the deep basins.

A suction dredge discharges a slurry of water and CCRs from the basin. The volume is tremendous – on the order of 14,000 gallons per minute for a large cutter-head dredge. Due to the volume, and to allow the CCRs to settle out, the slurry would be piped into one or more lined settling ponds constructed on site. The settling ponds would need to be located adjacent to the CCR basin so that the decanted water could flow by gravity or pumped back into the CCR basin. Excess water, such as from precipitation, would have to be tested and evaluated to determine the treatment that would be required before the water could be discharged. However, at all of the energy centers, space immediately adjacent to the basins is limited. Accordingly, settling basins would need to be located away from the CCR basins complicating ongoing excavation activities with delays inherent to the pumping and settling process.

The dredged material would need to be excavated and dried sufficiently to allow overland hauling to a commercial landfill. This double-handling and drying processes requires substantially more space and time, as well as cost, to complete. We estimate that it would take 10 years or more of a continuous dredging operation to remove the CCRs from the largest of Ameren Missouri's CCR basins. This time estimate does not take into account permitting and construction of the settling ponds which would further delay the completion schedule. Delays for weather, equipment maintenance, double-handing, drying, and transporting the CCRs to a landfill have the potential to further increase project duration.

Stability of Interior Slopes

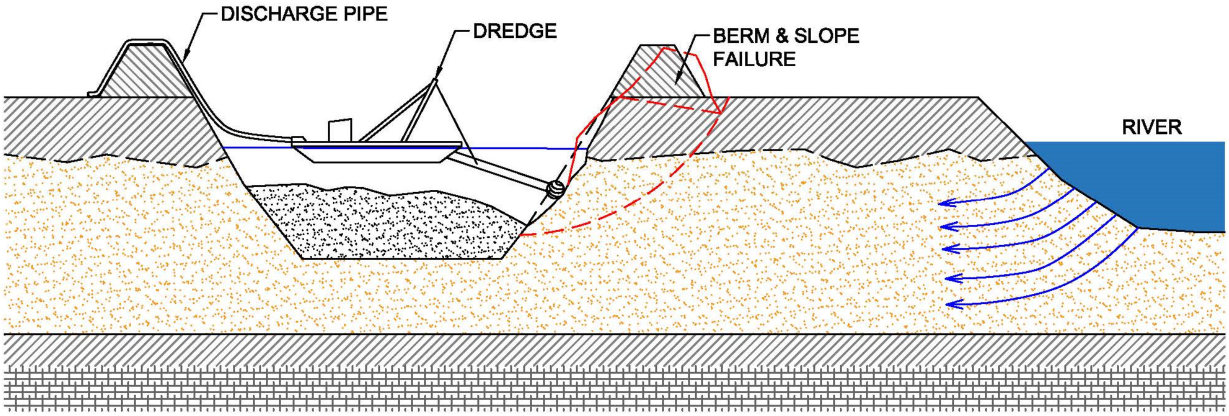


Figure 6 – Illustration of Problems with Stability of Interior Slopes

During an excavation project, the interior slopes of the basins have the potential to become unstable as illustrated in Figure 6. Instability is particularly problematic during a flood when water would be pushing on the perimeter berms. The basins were originally excavated by dredging, and the interior slopes were stable at that time. However, over time perimeter berms were constructed around the basins, in some cases after the deposition of the CCRs, to increase capacities and to protect against flooding. As excavation occurs, the interior slopes would become unstable unless the berms were removed. Removing the perimeter berms increases the risk that the basins would become flooded at high river stages. To prevent environmental risk associated with a flooded and unsecured CCR basin, new perimeter berms would need to be constructed far enough from the edge of the basin to prevent a slope failure and an uncontrolled release of CCR. Sufficient room may not exist at all energy centers to construct new temporary perimeter berms.

To ensure that all of the CCRs are removed, it is inevitable that some excavation will penetrate below the original bottom of the excavated basin and below the original interior side slopes. This would also cause instability of the interior side slopes. A failure of the perimeter of the partially-excavated basin has the potential to result in an uncontrolled release of CCR, particularly on the side adjacent to the river. An unstable slope would also be a major safety hazard for the construction and possibly for the adjacent energy center and operations. To mitigate such risks, temporary retaining walls with tie-backs may need to be constructed.

Completion of Project

Following completion of the excavation, the water remaining in each basin would have to be evaluated for compliance with regulatory water quality standards (GWPS) and some remedial clean-up activities would probably be required for each of the settling basins. After the water in each basin meets the required regulatory standards, the hole could be filled. Dredged sand from the adjacent river would likely be used for fill material because the excavation would contain water.

TECHNICAL MEMORANDUM

TO: AMEREN MISSOURI

FROM: XDD ENVIRONMENTAL, GOLDER ASSOCIATES INC.

SUBJECT: BEHAVIOR OF METALS IN SOIL AND GROUNDWATER

DATE: JULY 9, 2019

CC: SCHIFF HARDIN LLP

Metals are found naturally at varying concentrations in the minerals that make up our soil. As groundwater comes in contact with the soil, some metals leach from the soil, into the groundwater. The metals cannot be destroyed, but by changing environmental conditions of the soil and groundwater, the leaching (dissolution) can be reduced through the formation of more stable minerals or by being bound more strongly to other minerals.

Two major factors that affect the dissolved concentrations of metals in are the pH and the oxidation-reduction potential (ORP) of the water. pH is a measure of the acidic or alkaline nature of the water; strongly acidic water has a low pH (e.g., less than 4), while strong alkaline water has a pH typically greater than 10. ORP is a measurement of the tendency of a substance to oxidize or reduce another substance. Highly oxygenated water typically has a high ORP (greater than +200 millivolts), and highly reduced groundwater typically has an ORP less than 200 millivolts. The pH and ORP of the groundwater strongly influence the form of the metal present and the associated dissolution of the metals into groundwater.

Many metals increase in dissolved concentration when the groundwater is more acidic or more alkaline, because the minerals in the soils can dissolve under these conditions and the metals are released. Similarly, extremes in the ORP can also cause increases in dissolved metals due to the impact on the minerals. By optimizing pH and/or ORP levels, minerals within the groundwater and surrounding soils stabilize thereby reducing the dissolved concentrations of metals and creating more stable minerals that resist leaching / dissolution of the metals.

Groundwater conditions at Rush Island provide a useful illustration of this process. Upgradient of the ash basins, pH ranges from 6.0 to 8.5 in the shallow and deep groundwater zones to the north and west of the CCR unit (RCPA). On the downgradient side of the RCPA (eastern side), where pH is neutral, there are limited concentrations above the arsenic GWPS. However, as shown in Figures 1 and 2, on the downgradient side of the RCPA where the pH is higher than normal neutral conditions, arsenic concentrations are also present at elevated concentrations.

By optimizing natural processes, as one would do with a swimming pool, such as adjusting the pH level within the intermediate zone, a stabilization zone is created, and concentration levels are predicted to drop. Installation of an engineered cap system with a nearly impermeable geomembrane will effectively eliminate precipitation infiltration through the ash, which is a driving force behind the physical process that causes metal impacts to groundwater.

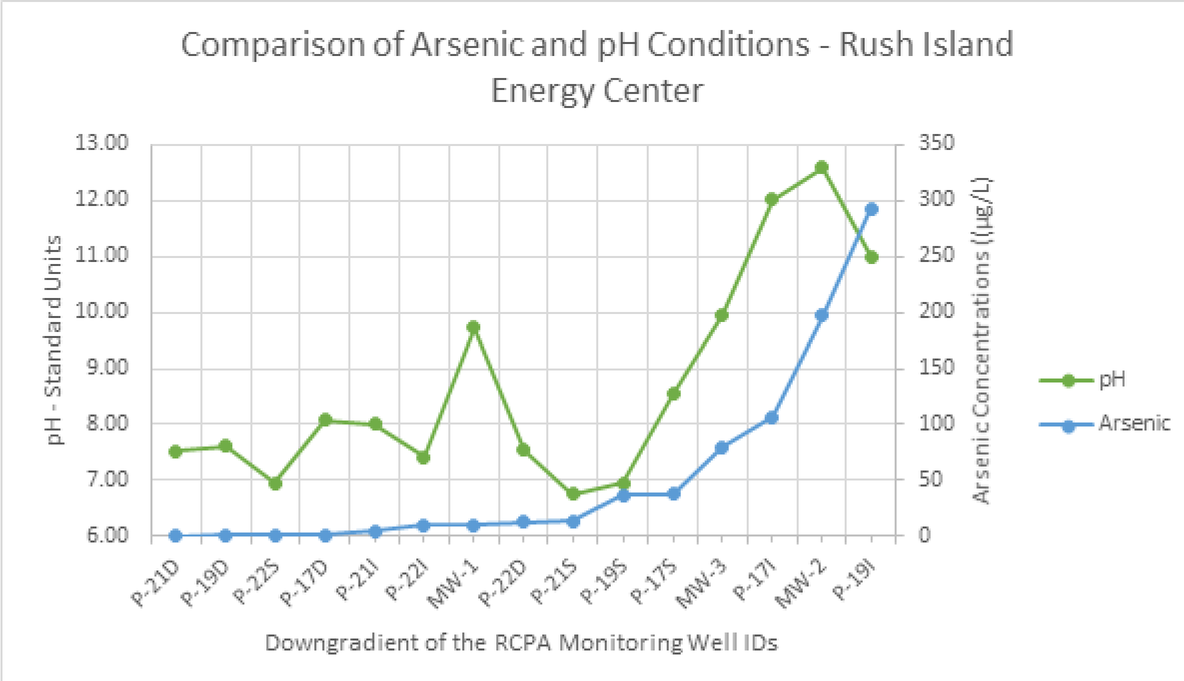
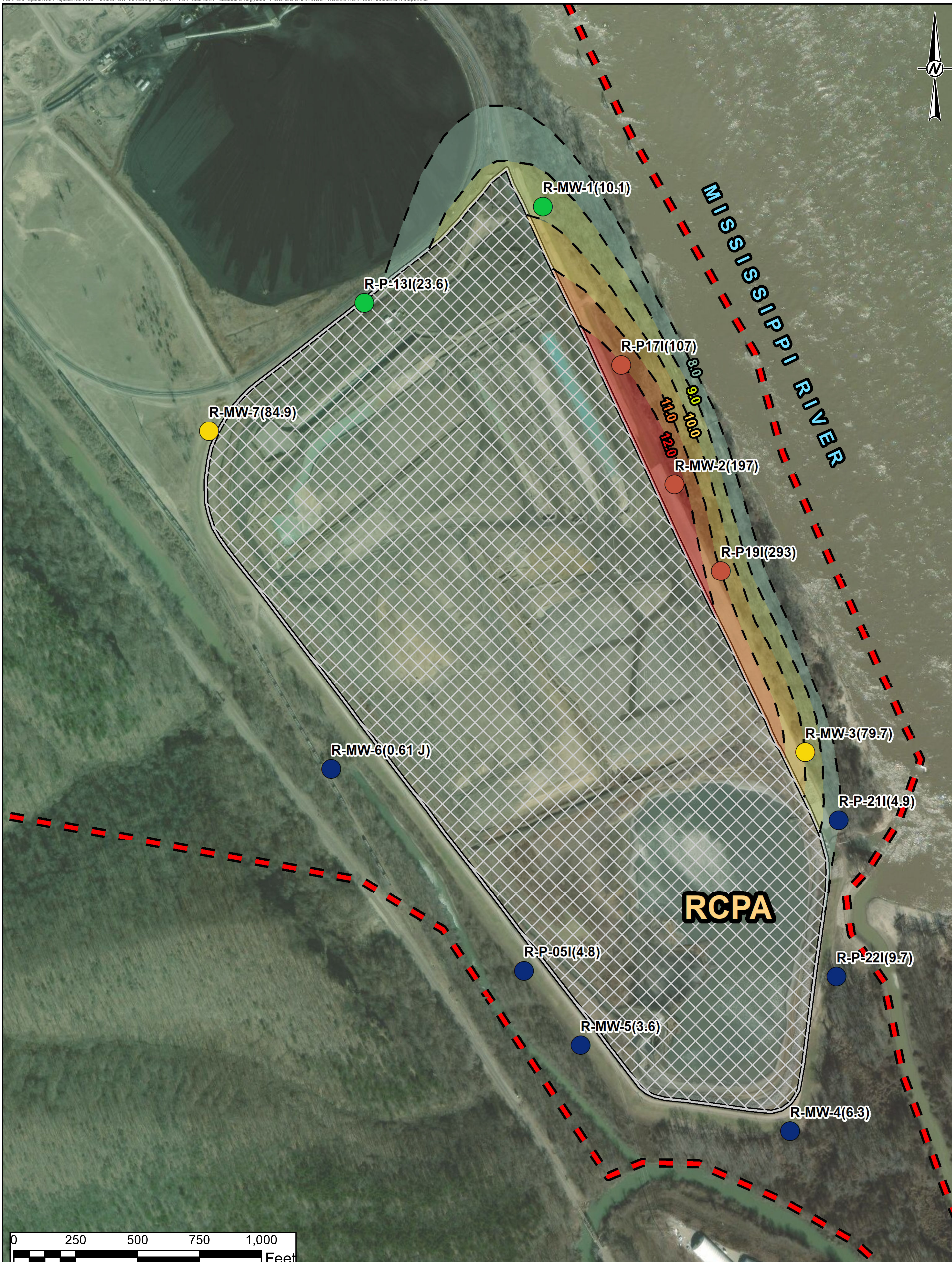


Figure 1 - Comparison of Arsenic and pH Conditions - Rush Island Energy Center



LEGEND

Rush Island Energy Center Property Boundary

RCPA Surface Impoundment

November 2018 Arsenic Concentrations (µg/L)

- Greater than 100 µg/L (Above Site GWPS)
- Greater than 30 µg/L (Above Site GWPS)
- Greater than 10 µg/L (Above MCL, Below GWPS)
- Less than 10 µg/L (Below MCL)

pH concentration Zones (Standard Units)

- pH values less than 8.0 are not colored
- pH between 8.0 - 9.0
- pH between 9.0 - 10.0
- pH between 10.0 - 11.0
- pH between 11.0 - 12.0
- pH above 12.0

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. J - ESTIMATED CONCENTRATION ABOVE THE ADJUSTED METHOD DETECTION LIMIT AND BELOW THE ADJUSTED REPORTING LIMIT.
3. GWPS - GROUND WATER PROTECTION STANDARD (SITE SPECIFIC).

REFERENCE

1. AMEREN MISSOURI RUSH ISLAND ENERGY CENTER, RUSH ISLAND PROPERTY CONTROL MAP, JANUARY 2012.

CLIENT
AMEREN MISSOURI
RUSH ISLAND ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
NOVEMBER 2018 ARSENIC VS PH CONCENTRATION MAP
INTERMEDIATE ZONE OF THE ALLUVIAL AQUIFER

CONSULTANT
GOLDER

YYYY-MM-DD	2019-07-02
PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

PROJECT No. 153-140601
PHASE 0002
FIGURE 2

Rush Island Closure by Removal Groundwater Modeling

June 27, 2019

AGENDA

Objective of the Model

RUSH ISLAND ENERGY CENTER

This modeling effort compared the estimated time to achieve groundwater concentrations below the Groundwater Protection Standard (GWPS) at monitoring wells around the RCPA. Modeling included updating the previous model(s) to simulate the effects of Closure by Removal (CBR) on the groundwater quality around the RCPA. These results were then compared with Closure in Place (CIP) to compare how long it would take to achieve GWPS at compliance wells in both scenarios.

Closure by Removal Modeling - Phases

Rush Island Energy Center

Phase 1 – Active Conditions	Active conditions were modeled the same way as previously reported. Assumed constant slurry recharge to the RCPA
Phase 2 – Dry CCR Removal	Removal of the top portion of the RCPA that would be above the static groundwater level after dewatering to static conditions.
Phase 3 – Wet CCR Removal	Removal of deeper portions of the RCPA were the CCRs are fully submerged.
Phase 4 – All CCR Removed and Backfilled	Modeling conditions after all CCR has been removed from the RCPA. Assumes fluvial sands/silts from the Mississippi River are to be used as backfill.

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Phase – 1 Active Conditions

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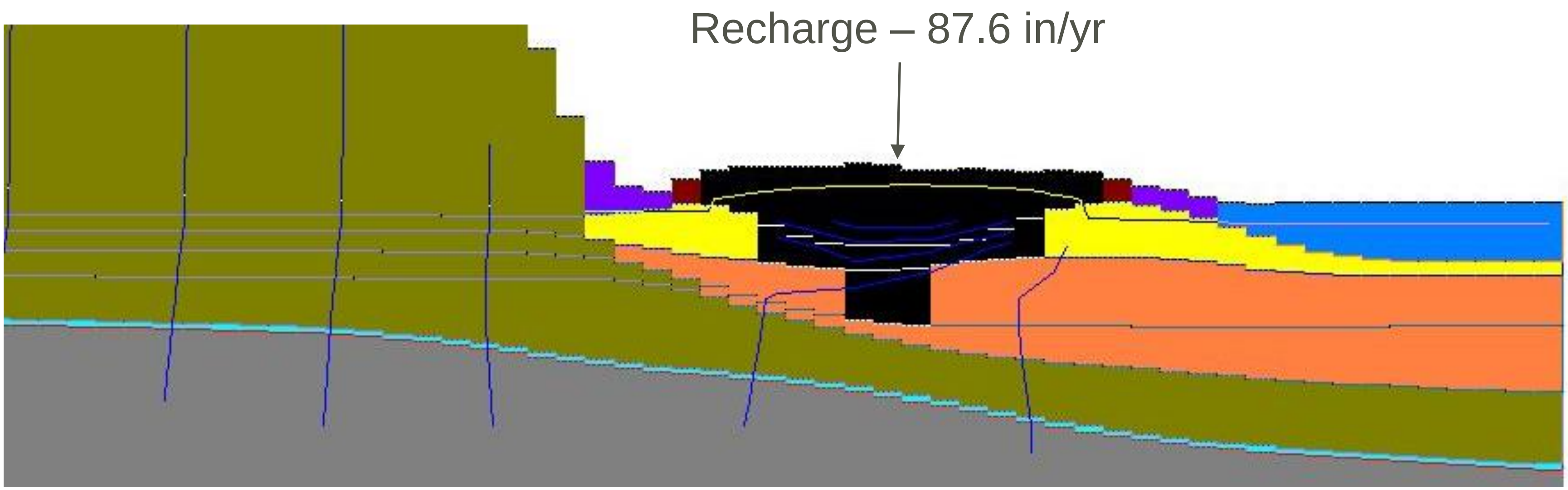

Active Conditions Assumptions

1. Same model(s) used as described in previous modeling report.
2. Recharge into RCPA 87.6 inches per year (i.e. Active Conditions).
3. Results in predicted mound in RCPA as measured in present conditions.

Phase 1 – 3D Model Design

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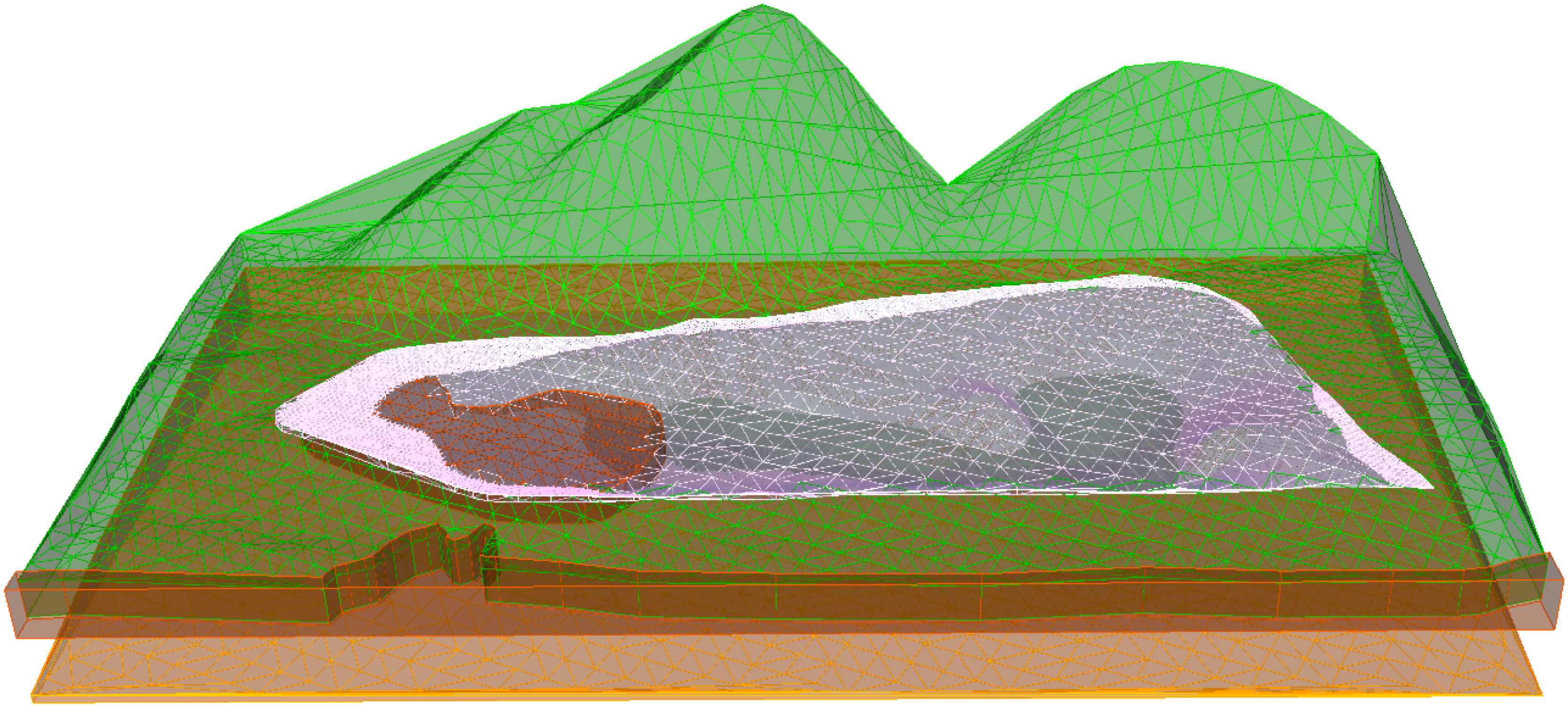

Phase 2 – Dry CCR Removal

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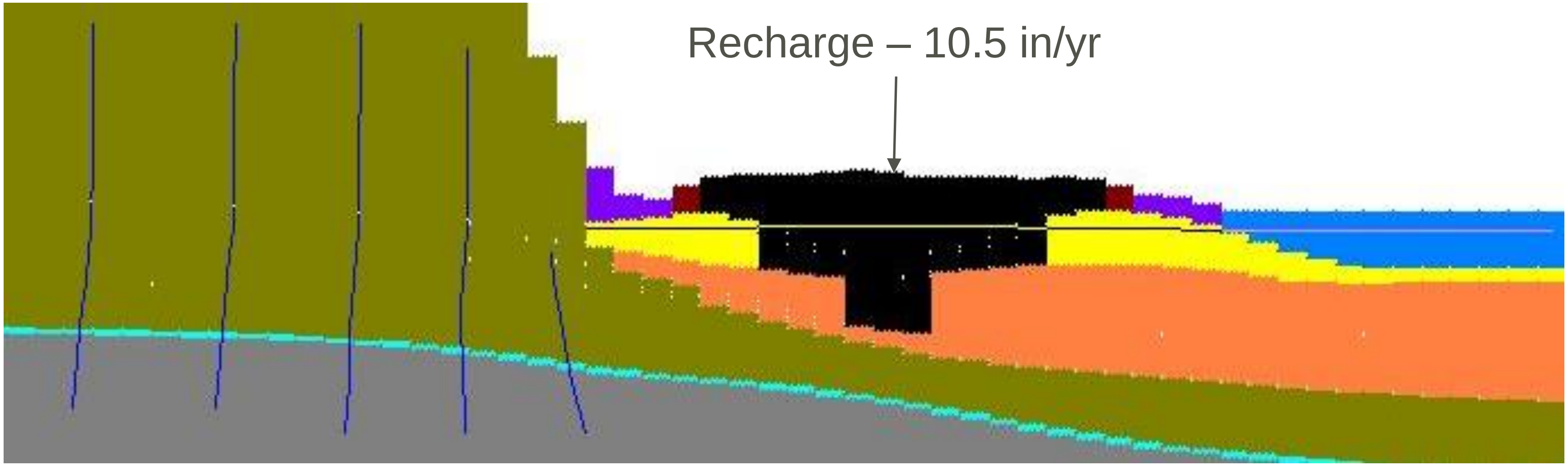

Dry CCR Removal Assumptions

1) Based on volume of CCR, it will take 16 years to excavate down the top 28 feet (dry excavation and partially wet excavation, based on Iochmuller (2019) report).

2) Recharge into the pond will be less than active conditions, but higher than cap and closed conditions. The vertical conductivity (Kz) of the ash is estimated to be $1x10^{-5}$ cm/sec, so for a conservative approach, the value calculated in the help model for a $1x10^{-5}$ cm/s cap was used for recharge (10.5 in/yr) during this stage. This recharge rate causes a small mound in the RCPA of ~1-3 feet during this phase.

3) Removed polishing pond from southern portion of the RCPA.

Phase 2 – Model Design

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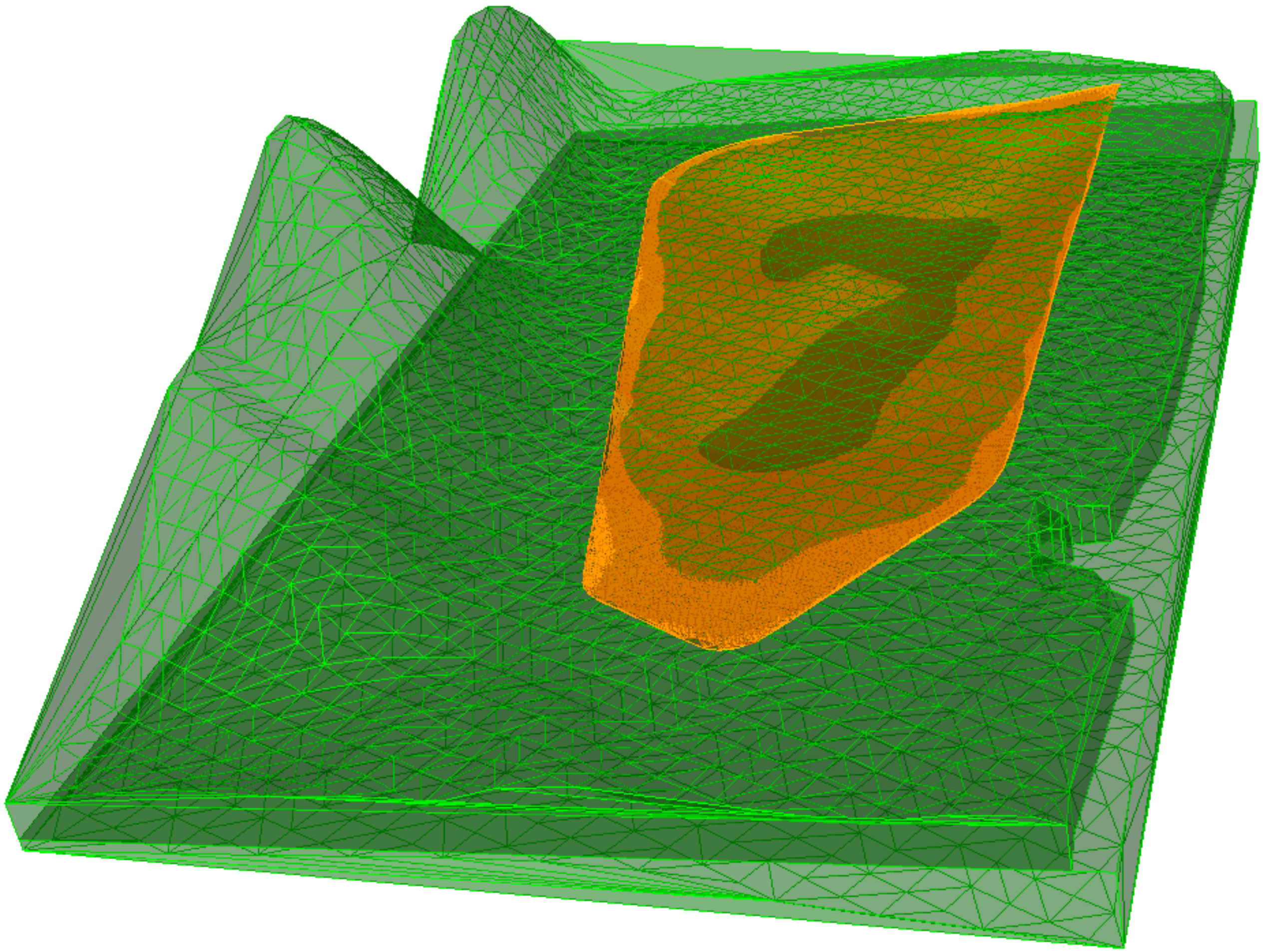

Phase 3 – Wet CCR Removal

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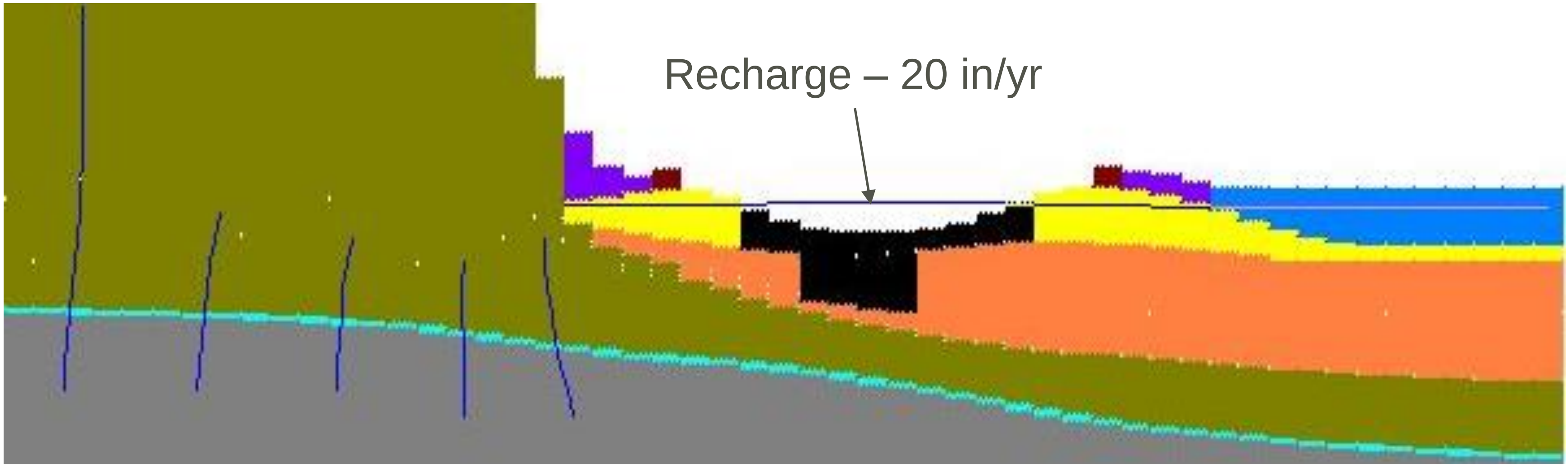

Wet CCR Removal Assumptions

1) Removed the upper portion of the CCR and treated resulting pit as an open hole.

2) Recharge was higher than the dry excavation stage, but less than the active conditions. It was assumed that there would be 43 in/year of rainfall (U.S. Climate Data, Festus). It was also assumed that the RCPA would evaporate similar to a lake, which according to U.S. Department of Commerce report, *Evaporation From Pans and Lakes*, a lake in Missouri can have ~23 inches a year in evaporation. Therefore, net annual recharge is expected to be ~20 inches/year. The rest of the water used for hydraulic dredging is assumed to be in a "closed" loop, and water used to pump the CCR out of the pond will be directed back to the RCPA after the materials are extracted.

Phase 3 – Wet CCR Removal

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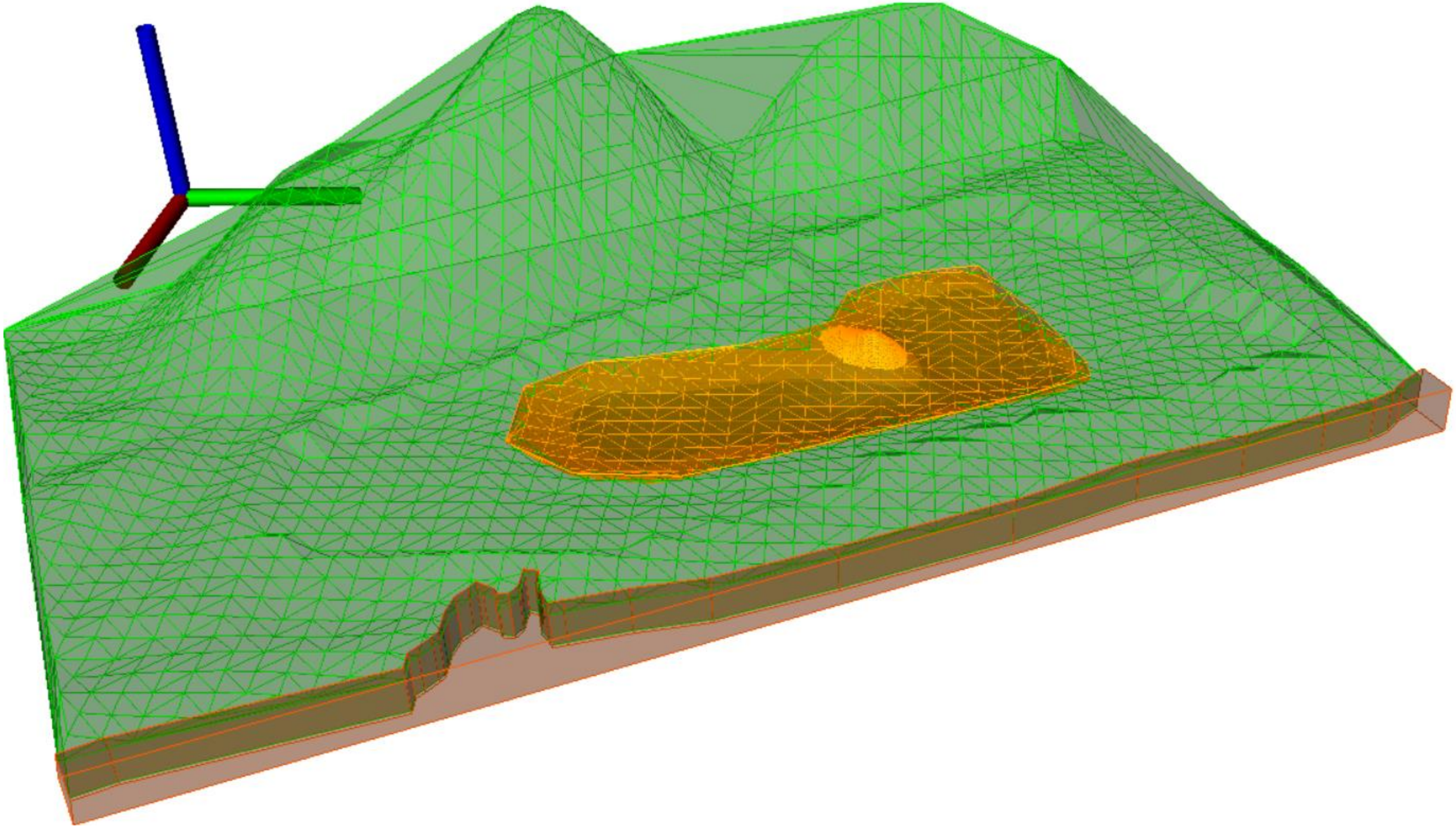

Phase 3 – Wet CCR Removal

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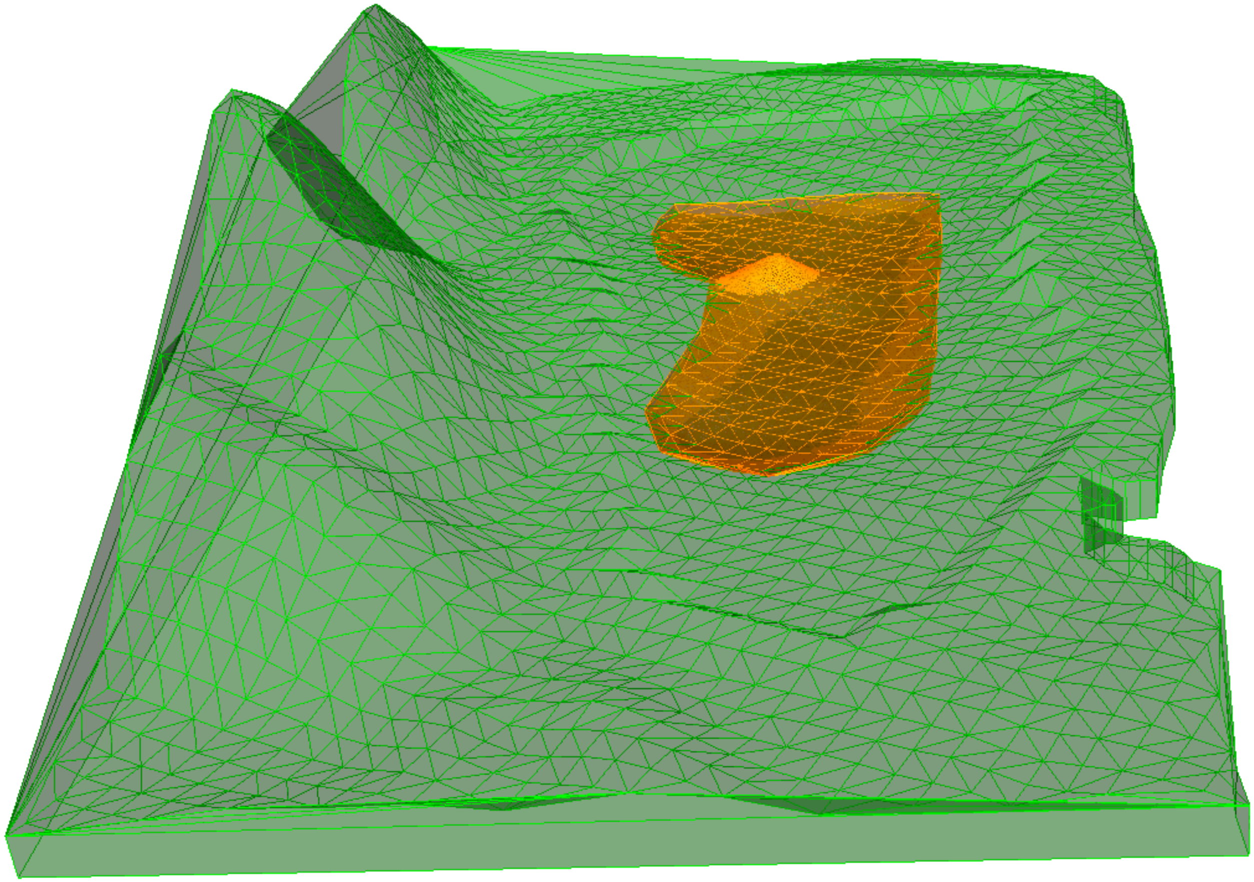

Phase 4 – Backfilled RCPA

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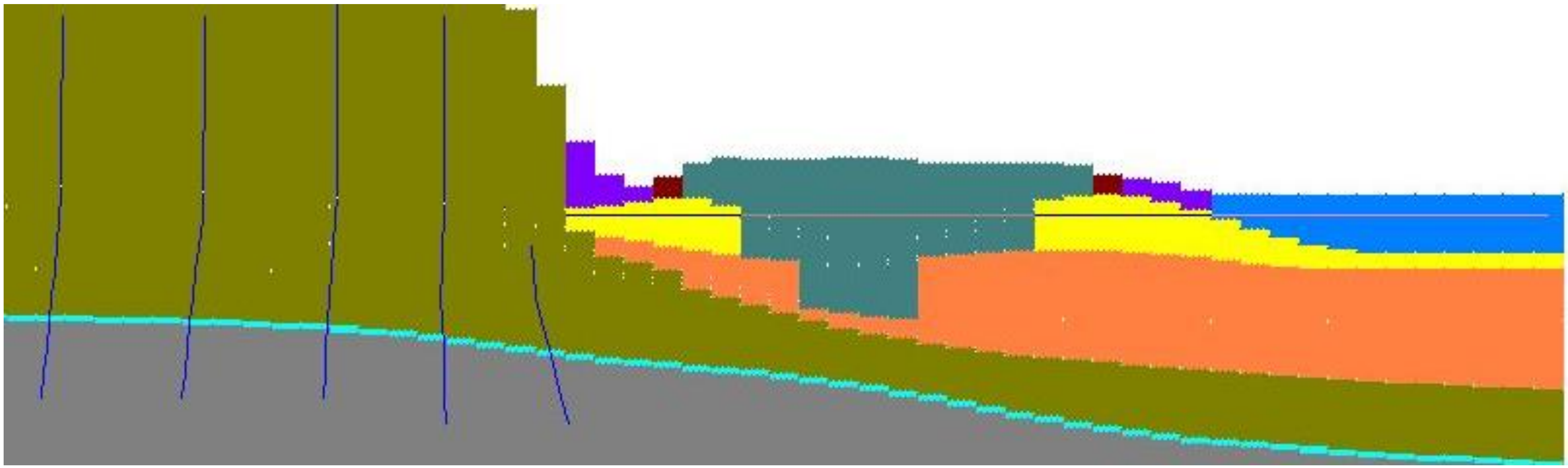

Backfilled RCPA Assumptions

1) Entire former RCPA backfilled with materials similar to the shallow alluvium onsite from dredging the Mississippi River (Lochmueller 2019). Material assumed to have a conductivity of 2.1 x 10^{-3} cm/sec (6 feet/day).

2) Recharge into the backfilled area was set equal to that estimated for the surrounding alluvial aquifer.

Phase 4 – Backfilled RCPA

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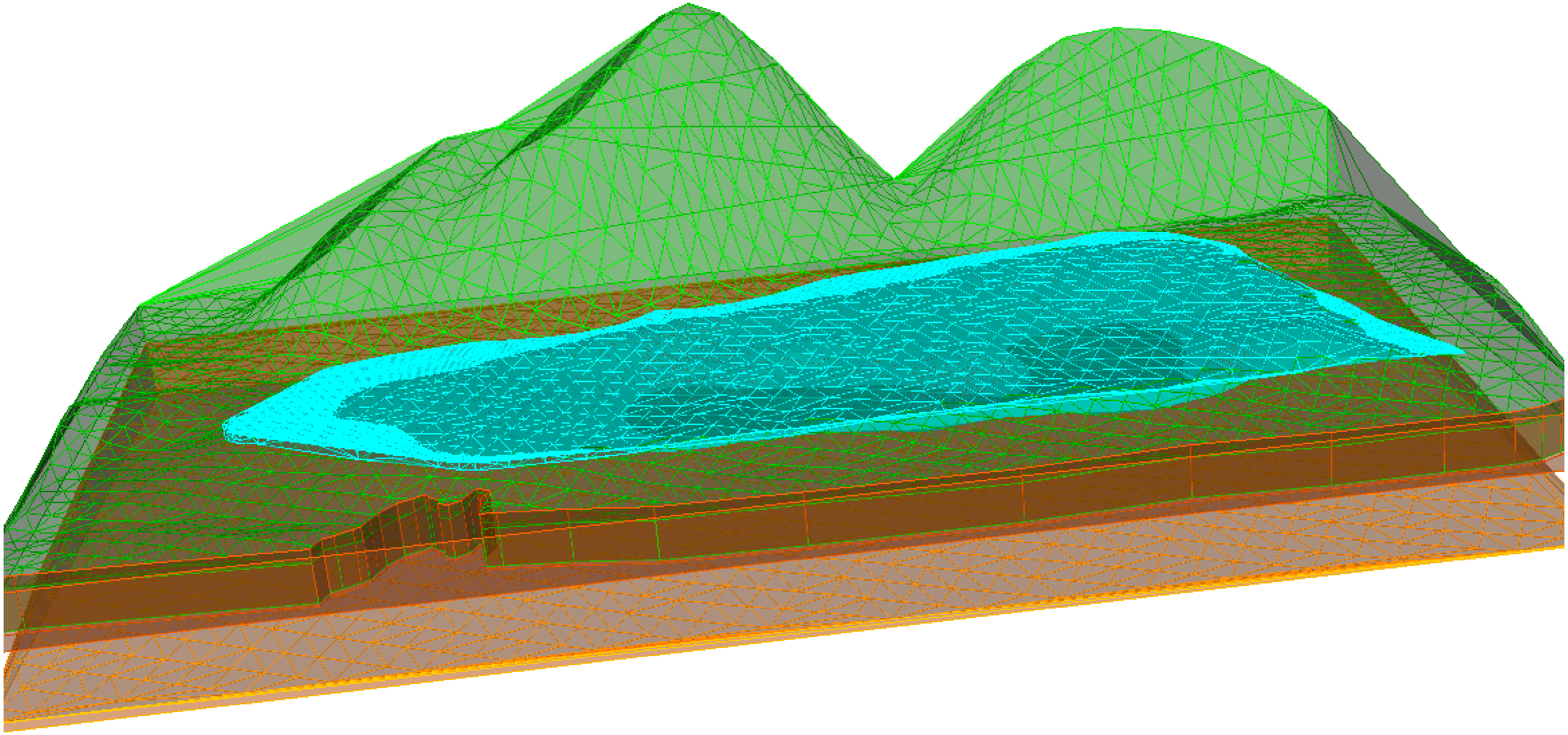

Phases of the Model

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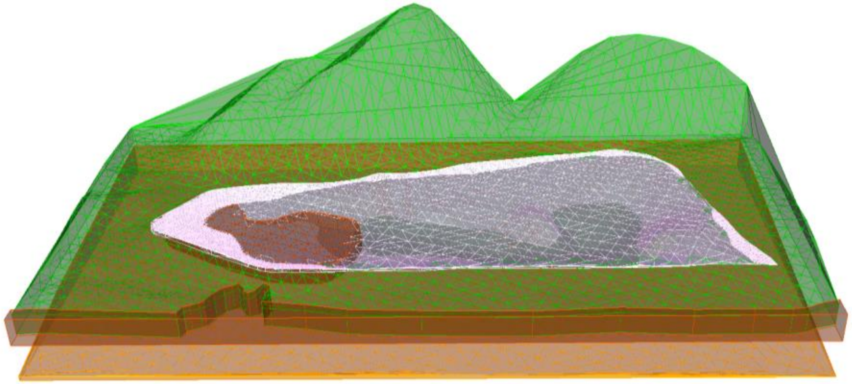
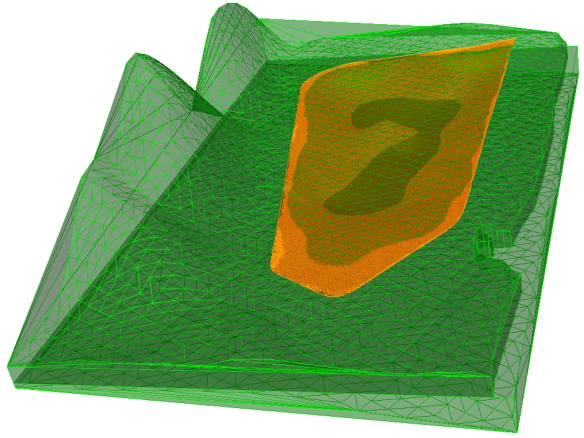
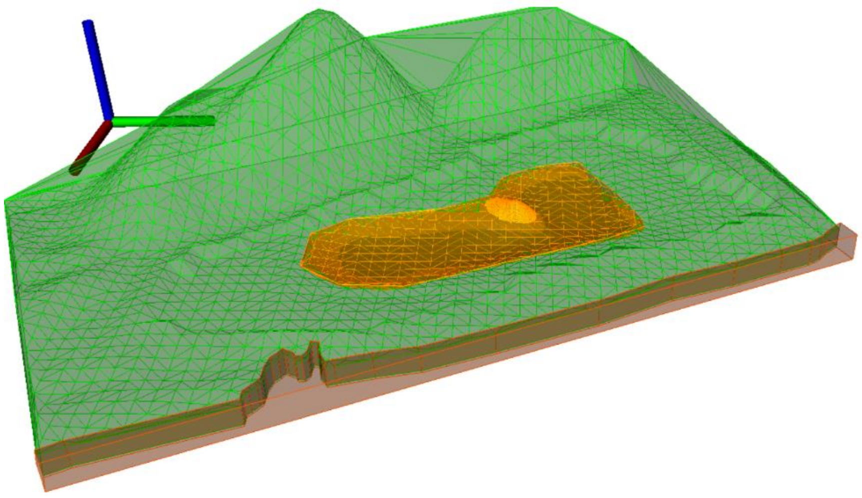
Phase 1 - Active



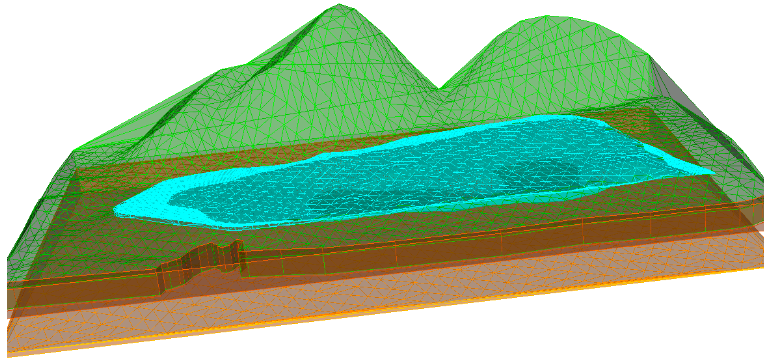
Phase 2 – Dry Removal



Phase 3 – Wet Removal



Phase 4 – Backfilled



Modeling Results Indicate Excavation Delays Groundwater Compliance

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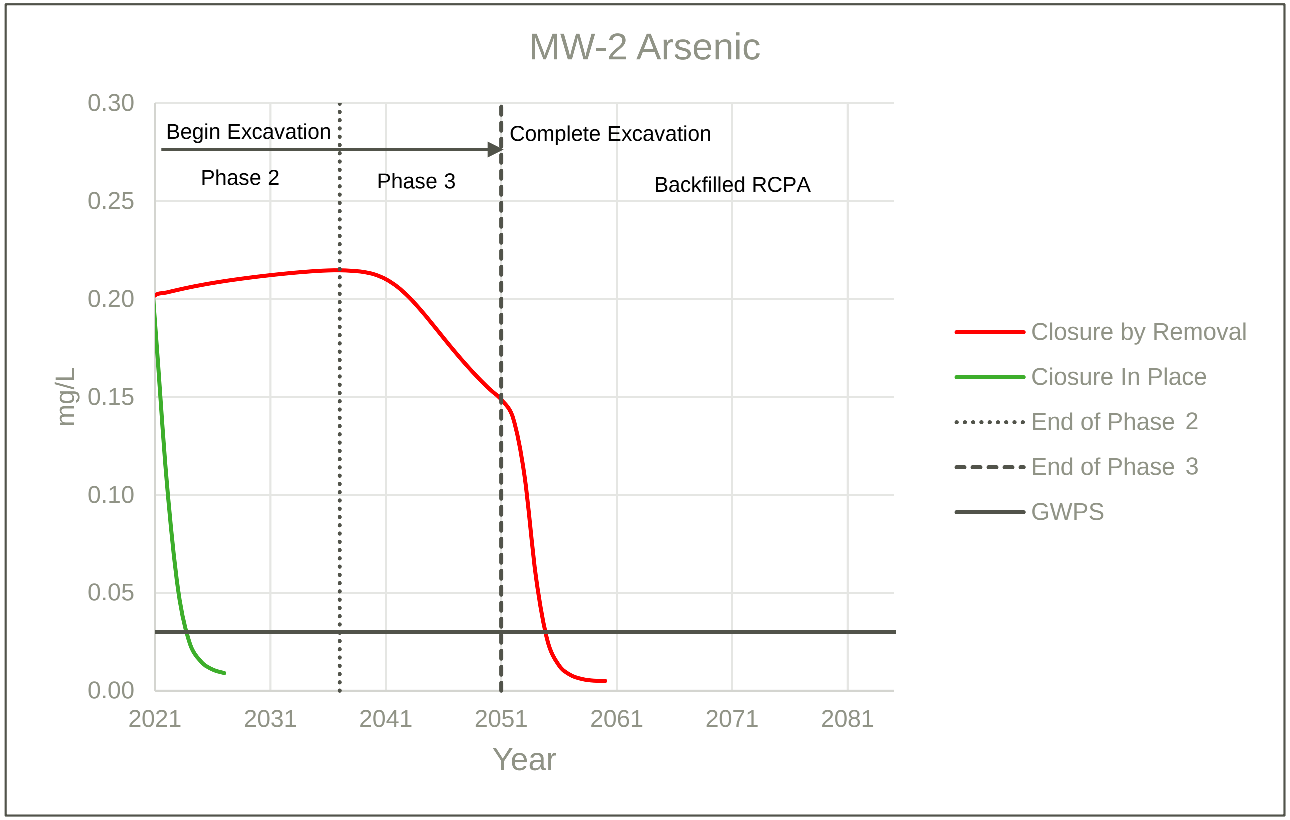

MW-2 (highest arsenic value in CCR Rule Well) is estimated to reach the GWPS 30 years sooner using closure in place vs closure by removal (Excavation)

Information on the closure by removal process is available in the Lochmueller (2019) and the Reitz & Jens (2019) reports

Modeling Results Indicate Excavation Delays Groundwater Compliance

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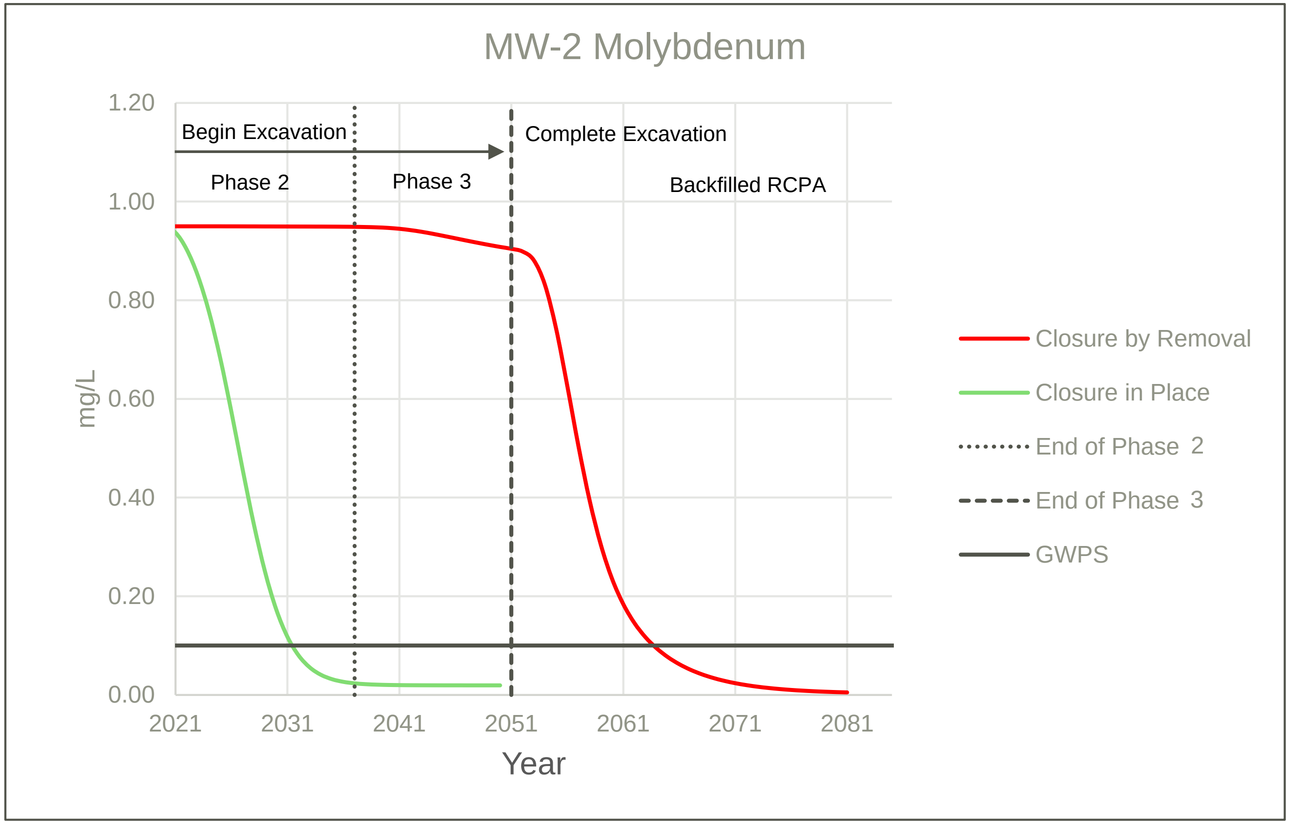

MW-2 is estimated to reach the GWPS 31 years sooner using closure in place vs closure by removal (Excavation)

GOLDER

Information on the closure by removal process is available in the Lochmueller (2019) and the Reitz & Jens (2019) reports

Explanation of Results

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Closure in Place reduces downgradient concentrations faster than Closure by Removal because:

- The 31-year time for CBR ash removal, during which rainfall drives outward migration of CCR impacts, adds contaminant loading and delays groundwater cleanup