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Date: February 26, 2015
From: Dr. Lee Florea, P.G. & Dr. Scott Rice-Snow
To: Statement of Record
Re: Peer Review of Mounds Lake Reservoir Phase 2 Study

To Whom It May Concern:

This memo comprises a peer review of portions of the recently released Phase 2 study for the Mounds Lake Reservoir developed by DLZ Indiana under commission by the Anderson Corporation for Economic Development. For context Lee Florea is a licensed professional geologist in Indiana (License #2360) with proficiency in hydrogeology, geochemistry, and geophysics. Scott Rice Snow is a geomorphologist and hydrologist with research experience in river erosion modeling, watershed morphometry, and geoarchaeology. Our primary area of expertise, and the area in which we focus these comments, involves geotechnical and water resources issues. In particular, the below narrative concerns sections of the Phase 2 report that involve bedrock geology, cave and karst processes, groundwater, bank erosion, sedimentation, and flood routing.

<u>Bedrock Geology</u>:

Section 3, p. 41 of the Phase 2 report describes the bedrock underlying the proposed reservoir:

> "Bedrock, from shallowest/youngest in age to deepest/oldest in age…include: the Silurian Age Pleasant Mills Formation…; the lower portion of the Bainbridge group, which includes the Louisville Limestone, the Waldron Shale, and the Salamonie Dolomite; and the Brassfield Limestone. In the preglacial valley, the top of the Ordovician Age Maquoketa Group is the upper most bedrock unit, which underlies the younger Silurian units. The uppermost bedrock unit of the Maquoketa Group is the White Water Limestone Formation."

The above discussion does not accurately reflect the commonly used terminology of geologic units in the region and it does not correctly present the stratigraphic order of units. 1) The 'Bainbridge Group' is commonly applied to rocks in the Illinois Basin of southwestern Indiana. In East-Central Indiana, the term 'Salina Group' more correctly correlates observed rock units to Silurian-age depositional environments in the Michigan Basin. 2) Using the Salina Group terminology, the 'Louisville Limestone' and 'Waldron Shale' are more appropriately members of the 'Pleasant Mills Formation'. 3) The term 'Brassfield Limestone' is more appropriate to the southern part Indiana. In the vicinity of Madison and Delaware Counties, the Brassfield inter-tongues with the Cabot Head shale. Therefore the term 'Cataract Formation' is more appropriate and consistent with Michigan Basin terminologies. 4) The Brainard Shale, and not the Whitewater Limestone, is the upper most member of the Maquoketa Group. This shale is particularly important in separating groundwater into an upper and lower aquifer system with different chemical signatures and flow characteristics.

Caves and Karst:

Section 3, p. 42–43 of the Phase 2 report describes the probability of the caves and karst below the reservoir in the following way:

> "[T]he bedrock…at the proposed project site is not known to be as susceptible to dissolution as those rock types found in the southern portion of the state. Existing fractures and bedding plane surfaces with minor dissolution have been observed in bedrock cores from this investigation. This fracturing and limited dissolutioning contributed to the formation of the carbonate aquifers which underlies this region. Sinkholes, caves, sinking streams, and underground drainage systems are not identified with the rock formations at the subject site. Additionally, these formations are typically covered with a thick layer of glacial soils, which slows infiltrations rates and buffers acidic groundwater, thus resisting the formation of karst features in the rock."

The above statements display a clear lack of understanding about karst processes, available data, and the geologic history of East-Central Indiana. While it may be true that glacial materials now mantle the bedrock, reduce infiltration, and therefore de-activate some of the chemical processes that contribute to enhanced bedrock dissolution, these conditions only apply following the burial of the paleo-Anderson River drainage network. Prior to glaciation, it is likely that well-integrated karst aquifers conveyed groundwater through the bedrock. Evidence is difficult to detect using the number and density of borings presented in this report. However, at least one boring (B007-14) encountered a distinct terra rosa soil immediately above the bedrock contact. Such soils are typical of limestone weathering on karst landscapes, such as those found on the Mitchell Plain of southern Indiana.

Increased density of borings often presents a very different picture. For example, the drilling program for the geothermal system at Ball State University encountered evidence of caves in several borings (evidenced by 'bit drops' or 'loss of circulation'). Additionally, maps of the pre-glacial bedrock surface on the BSU campus strongly suggest the presence of sinkholes. Perhaps an even clearer example is archival records that document caves encountered during quarry operations near Muncie.

A lack of awareness of the potential for karst features may lead to geotechnical issues during dam construction. The example of Wolf Creek Dam in southern Kentucky is one high profile example where multiple mitigation efforts spanning several decades have been needed to buttress the integrity of the dam against karst features encountered during construction. If encountered below the projected dam location, karst features can contribute to additional below-dam seepage and cost overruns from the need to install more extensive grout curtains.

Groundwater:

Section 2, p. 29 of the Phase 2 discuss the occurrence of groundwater in the proposed reservoir area and concludes with:

> "No impacts are expected to sole source aquifers or wellhead protection areas since there are none within the project area vicinity."

Yet, in the section on Drinking Water that immediately follows, they establish that 33 water wells would be impacted and the following statement is made:

> "Numerous groundwater wells are also present that supply domestic water for individual properties within the project area."

While these wells may not tap into a designated sole-source aquifer, it is clear that this does constitute an impact even if the proposed mitigation is to properly close these wells prior to inundation.

Considerably more alarming are statements that suggest a lack of understanding about hydrogeology and available groundwater resources, likely from an absence of any direct study. The discussion in Section 3, p. 42 provides boiler plate language on yields from wells completed in the glacial till, but provides no mention on groundwater flow direction, potentiometric surfaces, geochemical conditions, or points of groundwater discharge. For example, seepage of groundwater along the banks of the White River is an important point of groundwater discharge—several sizeable springs emerge near river level at Mounds State Park alone. How impoundment will impact groundwater discharge, and as a result the potentiometric surface, is not even a consideration of this report.

Subsurface borings identify a number of zones of high-permeability material within the glacial deposits. In this region, some such zones are predictable in shape, extent, and connection, but many are not. The data presented represent only a small first step in the level of investigation that will be needed to identify routes of groundwater flow in the vicinity of the dam. Attention to this concern must be kept active when new excavations occur throughout the dam construction phase, should the project proceed.

In our region, the water table naturally lies close to the surface, commonly requiring artificial drainage for agricultural and residential uses. Creation of the reservoir would set a much higher base level for groundwater flow beneath nearby lands, significantly altering subsurface flow gradients. This reasonably raises the following stakeholder concerns, which should be investigated by detailed 2-D or 3-D modeling of dam-related alterations in the area's water tables, and be included in mitigation projections. Diminished depth of unsaturated ground beneath residential and industrial properties could affect basement, sewer and septic system integrity, and standing water and saturated ground surfaces become more common in wet seasons. Groundwater flow directions in near-surface aquifers would permanently change, altering well source areas and affecting subsurface transport of pollutants. Areas of permanently saturated ground (active groundwater seepage) would increase within the White River valley just west of the dam, potentially reducing slope stability and reducing land use options.

<u>Bank Erosion, Sedimentation, and Flood Routing</u>:

<u>Erosion</u>: The Executive Summary of the report surprisingly states that slope erosion in Mounds State Park will, if anything, be reduced by creation of the reservoir. This is presumably based on the following statement in the Cultural Resources narrative in Section 2 on the report

> "The lowest mound construction is located approximately 30 feet above Mounds Lake. Mounds Park has historically flooded in the lower lands on the average of three events per year. These fast current flood events have played a major role in creating the current river valley. It can be expected that once Mounds Lake is established, erosion of the side walls of the valley would greatly diminish."

In actuality, there would be a trade-off: elimination of localized flood erosion low on the valley floor, but initiation of wave erosion and seepage erosion focused at reservoir water surface level high on the valley walls, with potential for slope erosion well above water line by sapping and slumping. In contrast to current conditions that have demonstrably preserved the bluff-edge earthworks from erosion for many centuries, reservoir creation would redirect erosion to be most active at a level near the earthworks, and near to other bluff-crest properties outside the Park. To that end, the report acknowledges that possibility and states:

> "Preservation of resources of constructed mounds within Mounds State Park, which are located 30 to 35 feet above the proposed pool height, may need to be protected by an engineered barrier to address long-term erosion concerns and ensure that erosion does not encroach on the mounds."

Monetary and cultural/aesthetic costs of such mitigation, at all appropriate locations, warrant consideration in early stages of project feasibility assessment.

Sedimentation: The White River and tributaries have a long established record of problems with turbidity derived from erosion of riparian zones. Excess sedimentation can lead to shorted reservoir life spans and costly remediation strategies. Earlier in the section on water quality, the report makes the following claim on p. 28 about mitigation measures for sedimentation:

> "The design of the reservoir is likely to include an innovative maintenance plan with an expansive headwater wetland at the upper end of the reservoir that would allow for sediments to be trapped and nutrients to be filtered by the vegetation."

Neither the nature of this 'innovative' mitigation strategy nor the methods of upkeep are explained in the report. These are potential points where costs estimates are greatly under represented.

Flood routing: Backwater calculation follows recognized procedures; however stakeholders should receive clear demonstration that the projections are robust within the 1-ft margin of error suggested by the I-69 bridge clearance constraint, for decades of reservoir life in which altered urban drainage systems and climate change will impact river hydrology.

It is our hope that these comments are useful and provide additional conversation on this controversial topic. Please do not hesitate to contact us if you have additional questions.

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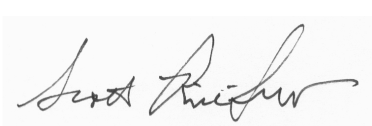

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