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# State of Utah

## DEPARTMENT OF NATURAL RESOURCES

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September 4, 2007

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Reference: Review of *Geologic Hazard Investigation* for Leigh Hill reservoir in Cedar City, Iron County, Utah.

Dear Dave,

As per your request, the Utah Geological Survey (UGS) reviewed the report by GEM Engineering (GEM, 2007a) for Cedar City Corporation titled *Geologic Hazards Investigation, Leigh Hill Reservoir*. The report presents the results of a surface-fault-rupture-hazard investigation for the proposed reservoir site, which is at approximately 2000 West and 900 South in Cedar City (see attachment 1). The project site encompasses about 30 acres, of which the proposed 112-acre-foot reservoir and associated earth-fill embankment will occupy roughly 5 acres. The reservoir will provide storage for Cedar City Corporation's pressurized irrigation system. The purpose of our review was to determine whether the GEM Engineering report adequately addresses surface-fault-rupture hazards at the site. Our scope of work included a review of geologic literature (attachment 2) and aerial photographs, and three visits to the site with representatives of GEM Engineering and Cedar City Corporation; one visit was made prior to the start of the investigation, and two subsequent visits were made to inspect the nearly 1200-foot-long trench GEM Engineering excavated at the site.

An earlier UGS review (UGS, 2007), also made at your request, of the *Leigh Hill Storage Reservoir Project, Cedar City Corporation, Design Study Report* (Cedar City Corporation, 2007) determined that the Cedar City report and earlier geotechnical reports referenced therein (Kleinfelder, 1992; AGECE, 2005; GEM, 2007b) failed to address the proximity of the proposed reservoir and embankment to the Quaternary-age Cross Hollow Hills faults (Black and others, 2003) (see attachment 1). If present at the site, these faults could potentially rupture to the surface during an earthquake and compromise the integrity of the reservoir embankments and lining. Based on this earlier review, the UGS recommended that a site-specific surface-fault-rupture-hazard investigation be made of the Leigh Hill reservoir site to determine if potentially active faults cross onto or near the project site. The results of this recommended investigation are presented in the GEM Engineering report (GEM, 2007a).

To investigate the possibility of past surface faulting at the proposed reservoir site, GEM

Engineering excavated an east-west trending, 1180-foot-long trench on the property oriented at right angles to the trace of the north-trending Cross Hollow Hills faults. The trench extended across much of the 30-acre site and spanned the entire footprint of the reservoir and embankment. The GEM Engineering report (2007a) includes a line-drawing trench log at a scale of 1 inch = 20 feet. The report also includes a color photomosaic of one trench wall between stations 4+00 and 7+70. Like the trench log, the photomosaic requires several foldout pages in the report, and the scale of the photomosaic varies between pages from about 1 inch = 1.5 feet to about 1 inch = 3 feet. No geologic information (geologic strata or structure) is included on the photomosaic.

In their CONCLUSIONS section (p. 5-1), GEM Engineering (GEM, 2007a) states:

*From STA 5+00 to STA 9+00 is the proposed area of the reservoir site. Within the above stated reservoir stationing it was observed that 2 areas required further assessment, first STA 6+40 to STA 6+50 and STA 7+20 to 7+30 (see attached cross-section and trench photos).*

GEM Engineering goes on to state:

*In summary STA 6+40 to 6+50 was observed to have a vertical wedge of Bed A type alluvial fill gravels within Bed C type alluvial fill gravels. The north-side trench wall would suggest a thrust fault while the south-side trench wall showed a normal fault relationship (not possible). It is concluded that the continued cutting and deposition of alluvial channel deposits upon the basalt contact left, as a residue, a wedge of material (William Lund of the UGS was invited and accepted the opportunity to observe this area). The STA 7+20 to STA 7+30 area was also of interest. The uppermost portion of the basalt flow material had been removed during excavation revealing a thin, up to 5 feet thick, lense of alluvial/stream deposits containing some eroded basalt sand overlying another basalt flow deposit.*

Finally, GEM Engineering concludes that:

***In accordance with accepted standards, GEM Engineering Inc. is confident in the fact that within the locations studied there is no apparent evidence of surface fault rupture.*** (bold-face type from GEM Engineering report).

As noted in the quotation above, the UGS (William Lund and Tyler Knudsen) was invited by GEM Engineering to inspect the Leigh Hill reservoir trench, and we did so on two different occasions. Based on our observations during our trench visits, we concur with GEM Engineering's conclusion that there was no evidence in the trench of Quaternary faulting. However, the GEM Engineering report (2007a) does not adequately document the evidence to support their conclusion that Quaternary faulting is absent. The 1 inch = 20-feet-scale trench log

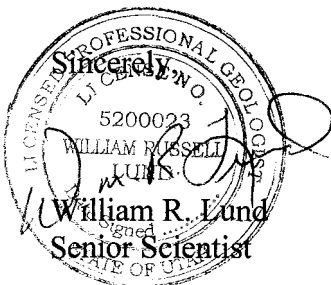
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does not provide sufficient detail of the two areas in question (STA 6+40 to 6+50 and STA 7+20 to STA 7+30) to preclude the presence of faulting and provide an alternate explanation for the stratigraphic relations observed in the trench at those locations. The geology depicted on the trench log between STA 6+40 and 6+50 does not correspond to the description of the geology of that area presented in the report text, leaving unresolved which interpretation (log or text) is correct. Likewise, the log from STA 7+20 to STA 7+30 lacks sufficient detail to show why this area was originally suspected as a possible area of Quaternary faulting, or why it was eventually concluded that faulting wasn't present. Also, because the basalt is the only age-dated unit in the trench, by inference from a nearby dated basalt flow, the evidence that the basalt is not displaced should be discussed in the report because it is not evident from the trench logs. If the lack of displacement in the overlying alluvium is part of the evidence that the basalt is not faulted, evidence for the age of the alluvium should be discussed further. Lacking geologic annotation, the photomosaics of the two areas of the trench in question likewise provide nothing of substance to support the report conclusion.

GEM Engineering states on p. 4-1 of their report that they made a brief review of aerial photographs, which gave evidence of "areas of lineal depression." The relation of these lineaments to the reservoir site is not stated, nor are they depicted on the map or air photo of the site in the report. It is unclear whether or not GEM Engineering considers the "lineal depressions" to be fault related. If not, the report should clearly state that conclusion and provide an alternate explanation. The report should include a site geologic map (preferably air-photo based) showing critical geologic relations, the lineaments, and the relation of the lineaments to the reservoir and embankment. If the lineaments through the area trenched, the report should include a discussion and detailed logs of the geologic relations exposed in the trench.

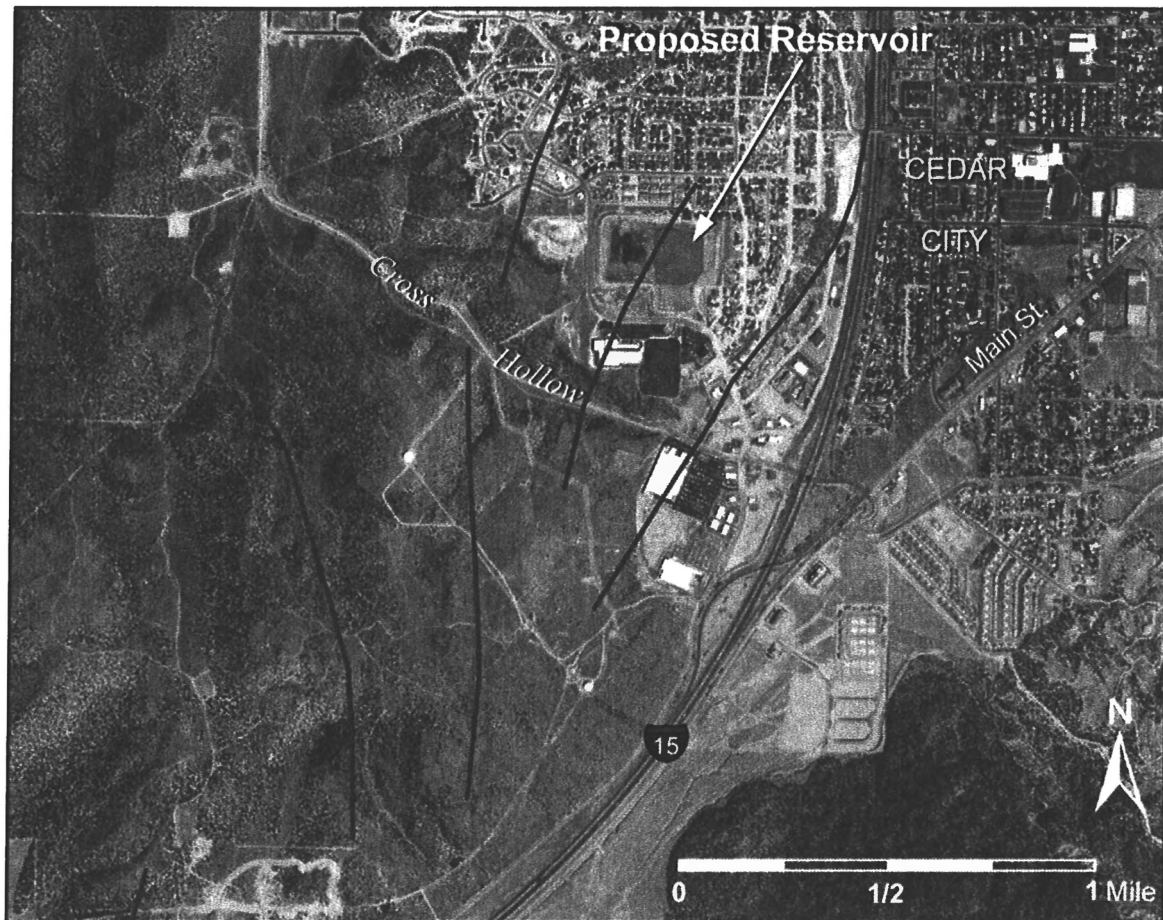
In summary, because we reviewed the Leigh Hill reservoir trench in the field, we can state that we saw no clear evidence for Quaternary faulting in the trench. However, lacking an adequate geologic map of the site and detailed trench logs (1" = 2.5' minimum) of both walls in questionable areas, the GEM Engineering report fails to adequately support their conclusion that Quaternary faulting is absent at the site. The UGS believes this additional information should be provided to document this site's suitability if the GEM Engineering (2007a) report is to be the document of record for the site. Hopefully, these data are available from the original investigation so that this documentation need not involve additional field investigations.



2 Attachments



Tyler R. Knudsen  
Geologist



Attachment 1. Map showing the general proximity of the Cross Hollow Hills faults (red lines) to the proposed reservoir site. Fault locations are from the 1:500,000-scale *Quaternary Fault and Fold Database and Map of Utah* (Black and others, 2003) and should be considered approximate.

Attachment 2. References Cited

- AGEC, 2005, Geotechnical investigation, Leigh Hill Reservoir, 2000 West 900 South, Cedar City, Utah: Draper, Utah, unpublished consultant's report for Gilson Engineering, 12 p.
- Black, B.D., Hecker, Suzanne, Jarva, J.L., Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003, Quaternary fault and fold database and map of Utah: Utah Geological Survey Map 193DM, scale 1:500,000, compact disk; available online at <http://geology.utah.gov/maps/geohazmap/qfaults/imagemap2/index.html>
- Cedar City Corporation, 2007, Leigh Hill Storage Reservoir Project, Cedar City Corporation, design study report: Cedar City, Utah, unpublished report prepared by the Cedar City Engineering Department, variously paginated.
- GEM Engineering, 2007a, Geologic hazards investigation, Leigh Hill reservoir, approximately 2000 West 900 South, Cedar City, Iron County, Utah: Cedar City, Utah, unpublished consultant's report for Cedar City Corporation, variously paginated.
- GEM Engineering, 2007b, Geotechnical investigation, Leigh Hill Reservoir, 2000 West 900 South, Cedar City, Iron County, Utah: Cedar City, Utah, unpublished consultant's report for Cedar City Corporation, variously paginated.
- Kleinfelder, 1992, Geotechnical investigation for an existing water storage reservoir, Cedar City, Utah: St. George, Utah, unpublished consultant's report for Cedar City Corporation, 8 p.
- Utah Geological Survey, 2007, Review of geotechnical reports for the Leigh Hill Storage Reservoir in Cedar City, Iron County: Cedar City, Utah, unpublished letter to the Utah Division of Water Rights – Dam Safety, 5 p.