TECHNICAL REPORTS FOR 1999
APPLIED GEOLOGY PROGRAM

compiled by
Greg N. McDonald

Report of Investigation 244 **February 2000**
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

UTAH GEOLOGICAL SURVEY

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GREG N. McDONALD

Cover photos: Views of breached canal and backyards in the Pinebrook subdivision in Riverdale the morning after the July 11, 1999 Davis-Weber Canal failure. Photograph credits: Bill Black.

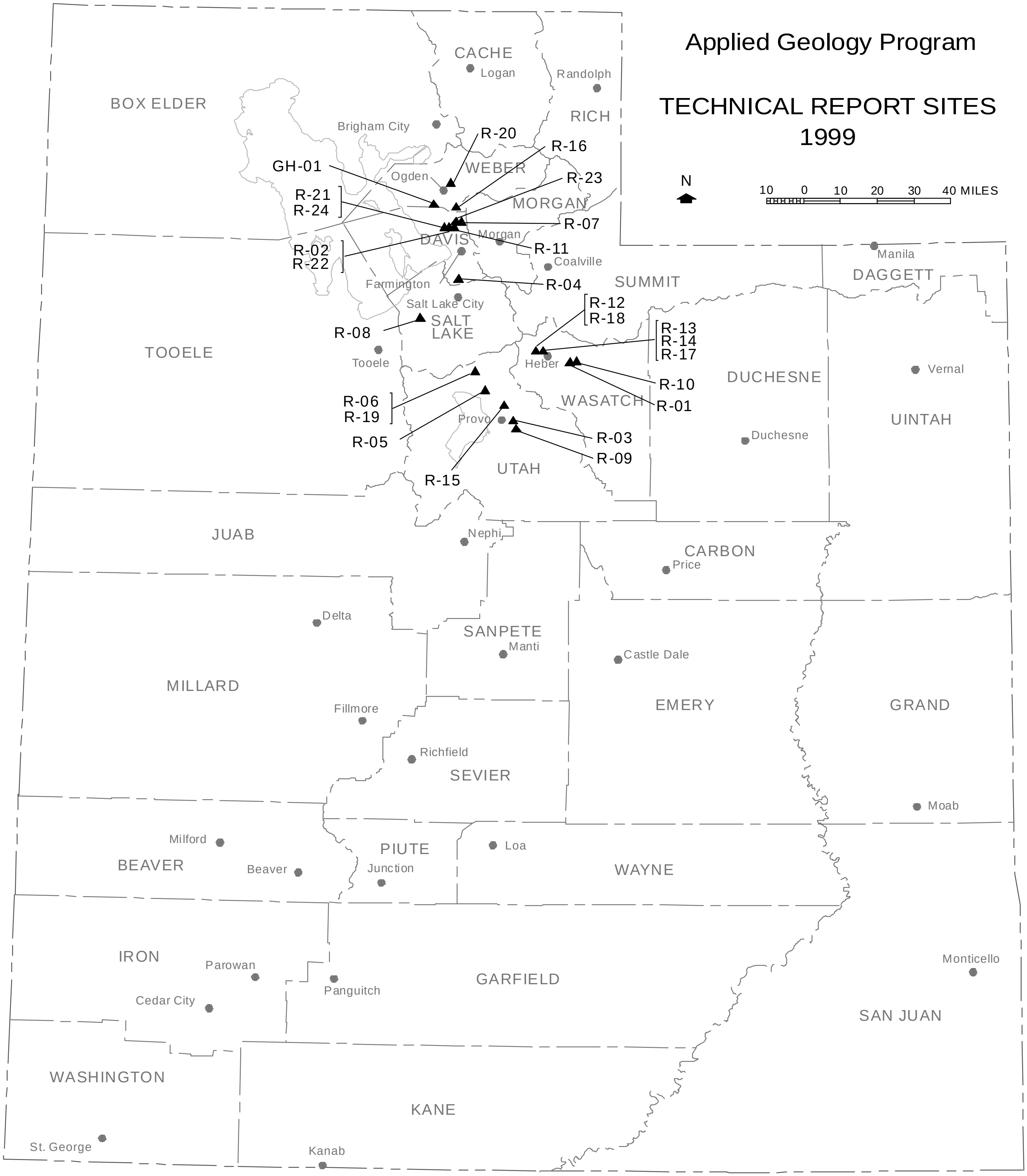
This Report of Investigation has undergone UGS review but may not necessarily conform to formal technical and editorial criteria. The material represents investigations limited in purpose.

PREFACE

The Applied Geology Program of the Utah Geological Survey (UGS) maps and defines geologic hazards and provides assistance to tax-supported entities (cities, towns, counties, and their engineers, planning commissions, or planning departments; associations of governments; state agencies; and school districts). We respond to emergencies such as earthquakes, landslides, and wildfires (where subsequent debris flows are a hazard) with a field investigation and a report of the geologic effects and potential hazards. We also conduct investigations to answer specific geologic questions from state and local government agencies, such as geologic investigations of slope stability, soil problems in developing areas, and hazards from debris flows, shallow ground water, rock falls, landslides, and earthquakes. We perform site evaluations of geologic-hazard potential for critical public facilities such as public-safety complexes, fire stations, waste-disposal facilities, water tanks, and schools. In addition to performing engineering-geologic studies, we review and comment on geologic reports by consultants for school sites, residential lots, subdivisions, and private waste-disposal facilities.

Dissemination of information is a major goal of the UGS. Studies of interest to the general public are published in several UGS formats. We present projects that address specific problems of interest to a limited audience in a technical-report format, which we distribute on an as-needed basis. We maintain copies of these reports and make them available for inspection upon request. This Report of Investigation presents, in a single document, the Applied Geology Program's 25 technical reports completed in 1999 (figure 1). The reports are grouped by topic, and each report identifies the author(s) and requesting agency. Minor editing has been performed for clarity and conformity, but I have made no attempt to upgrade the original graphics. This is the thirteenth year the Applied Program's technical reports have been compiled.

Greg N. McDonald
January 14, 2000



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GEOLOGIC HAZARDS

Project: Reconnaissance of flooding and sediment deposition from a breach of the Davis-Weber Canal near 1345 West 5300 South, Riverdale, Weber County, Utah.			Requesting Agency: Emergency Response
By: Bill D. Black Gary E. Christenson Greg N. McDonald	Date: 07-28-99	County: Weber	Job No: 99-15 (GH-01)
USGS Quadrangle: Roy (1346)		Number of attachments: 3	

INTRODUCTION

On July 12, 1999, the Utah Geological Survey (UGS) investigated flooding and sediment deposition from a breach in the Davis-Weber Canal in Riverdale, Utah, in the SE1/4 section 13, T. 5 N., R. 2 W., Salt Lake Base Line and Meridian (attachment 1). The breach occurred around noon on July 11, 1999, and was initially investigated that afternoon by Interagency Technical (IAT) Team coordinator Fred May (Utah Division of Comprehensive Emergency Management) and IAT Team member Scott Stoddard (U.S. Army Corps of Engineers). The purpose of our investigation was to document damage from flooding and sediment deposition, record evidence for possible geologic causes of the canal failure, and evaluate resulting potential hazards from slope failure and erosion. The IAT Team and representatives of the canal company were present during the July 12 investigation. The scope of our work included a literature review, interpretation of aerial photos, a second site visit with the IAT Team on July 20, and various meetings with Utah National Guard personnel, canal company representatives, and city officials.

DESCRIPTION OF THE EVENT

According to news accounts (Salt Lake Tribune, July 12, 1999; Ogden Standard Examiner, July 12, 1999), the canal breach began about noon on July 11, 1999. The canal was flowing at about 250 cubic feet per second (7,000 L/sec) (capacity of 300 cubic feet/second [8,500 L/sec]). Flow is diverted from the Weber River into the canal about 10 miles (16 km) upstream. Diversion of flow into the canal was stopped soon after the breach; an estimated 67 acre-feet (8.3 million L) of water in the canal drained in three to four hours (IAT Team, 1999). At least 300 people were evacuated, and flooding and sediment deposition damaged about 75 to 100 homes, 15 to 20 of them severely.

At the breach, water from the canal initially flowed downslope, eroded an outlet channel down the hillside, and began flooding the area at the base of the hill. Once the outlet was cut, continued flow as the canal drained caused headward erosion upstream, undercutting the canal and cutting a deep ravine along the canal parallel to the slope crest. Floodwater eroded 67,000 cubic yards (51,000 m3) of sediment to form the ravine, which is 390-foot- (120-m-) long, 60 foot- (18-m-) wide, 40-foot- (12-m-) deep (Utah National Guard, written communication, July 16, 1999) (attachment 2). Below the breach, floodwater deposited up to 5 feet (1.5 m) of sediment that buried streets, yards, and parked vehicles (attachment 3), and filled basements.

SITE DESCRIPTION

In the area of the breach, the canal follows the rim of a bluff with a steep east-facing slope. The bluff is a remnant of a delta deposited in Pleistocene Lake Bonneville by the Weber River. Since the retreat of Lake Bonneville, the river has cut down into the delta and left the bluff about 200 feet (60 m) above the present flood plain. A terrace on which newer (post-1996) homes of the Pinebrook subdivision have been built is about 125 feet (40 m) below the top of the bluff (attachment 1). The 110-year-old Davis-Weber Canal flows west from the mouth of Weber Canyon and is at the crest of the bluff above the subdivision. The canal is concrete-lined through the area, but the lining is cracked and deteriorated in places upstream from the breach. Underlying sediments are visible in some holes through the lining. Our inspection of pre-failure photos taken in 1993 by the Roy Water Conservancy District of the failed canal section indicates a deteriorated condition of the canal lining in this section as well. The canal lining north of the breach is in good condition and was emplaced in 1989 when the canal was rerouted (Harty, 1989).

Materials exposed in the post-failure erosional ravine are chiefly granular, non-cohesive, fine sand and silty sand (bedded and locally cross-bedded) capped by a discontinuous layer of rounded gravel and overlying loess or eolian sand. The ravine exposes few silt and clay layers, except near the downstream end below the canal where thin (1-2 inch [2-5 cm]) discontinuous layers of low-plasticity clay are present. A lower clay layer also formed a prominent erosion-resistant bench in the outlet. These clay layers showed evidence of seepage from perched ground water above them in our visit on July 20.

EVIDENCE FOR POSSIBLE GEOLOGIC CAUSES OF THE CANAL FAILURE

Detailed studies will be required to determine the cause of the canal failure. Both geologic and non-geologic causes must be considered, but unfortunately erosion following the breach has removed much of the evidence critical to determining the cause. Possible geologic causes of the canal breach include landsliding and/or collapse from subsurface erosion and piping. No significant earthquakes were recorded in the area on or near the time of the failure (University of Utah unpublished earthquake catalog).

Landslides are a hazard along the bluff that have caused problems and damaged the Davis-Weber Canal. Along much of its length, the canal traverses a slope characterized by prehistorical and historical landslides (Lowe, 1988). An area of landsliding was noted in the slope above the canal at the Craig-Dale subdivision south of the 1999 breach (Lowe, 1986). Landslides above the canal also occurred several miles to the southeast in 1998 (Black, 1998). However, at the breach, the canal is near the top of the bluff and little slope remains above it to be affected by slope instability. We observed no evidence of recent landsliding or instability in the part of the slope remaining below the canal to suggest that natural landsliding undercut the canal and caused the failure. No cracks or other evidence of landslides are apparent in the well-bedded flat-lying lake sediments exposed in the ravine. However, because of the general non-cohesive nature of materials in the slope, landslides may be characterized by sloughing due to saturation (a wet sand or rapid earth flow), rather than by rotational slumping, so little evidence may remain. We cannot rule out the possibility that a landslide occurred at the breach and was completely removed by the subsequent flood.

Landslides are most commonly caused by a rise in the water table. Sources of ground water in this area include infiltration of direct precipitation, canal leakage, and/or infiltration/leakage from retention ponds, water tanks, and buried water lines on the bluff. Regarding precipitation, the breach occurred in a dry mid-summer month when naturally occurring landslides are rare. The failure was not preceded by heavy precipitation and precipitation for the water year is nearly normal (103%), although it was well above normal in April and May (National Weather Service unpublished data). However, the timing makes the likelihood of a natural landslide low.

The deteriorated condition of the canal lining upstream from the breach indicates canal leakage is a possibility. Leakage from the canal produced several seeps and shallow landslides upstream along the canal in 1991 about 1.5 miles (2.5 km) to the southeast (Black and Lowe, 1991). We did not attempt to document seasonal seeps in the hillside below, but such seeps when the canal is flowing may indicate leakage.

Water from other sources also could have affected slope stability, such as leakage from the Riverdale City water tanks, and Roy Water Conservancy District and Hill Air Force Base storage and retention ponds on the bluff. Detailed studies, such as installing piezometers and compiling pre-failure piezometer data (if available) to construct water-table elevation maps, will be needed to determine if ground water from these sources is present and could have contributed to the canal failure.

Piping is a geologic process resulting from subsurface erosion by ground water moving through permeable, non-cohesive layers in unconsolidated materials. Removal of fine-grained sediment by this process creates voids (pipes) that channel water. Pipes eventually collapse as they enlarge, and may produce shallow landslides. Observations by Erickson and Wilson (1968) and us indicate the area is underlain by silty sand having moderate to rapid permeability. Low-cohesion silty sand layers exposed in the ravine are highly erodible and susceptible to piping. Collapse of a pipe may damage the canal lining or trigger a small slope failure that could remove downslope support for the canal bank, causing eventual canal collapse. We observed no direct evidence of piping (such as open pipes) in ravine exposures, but as with landsliding, little evidence may remain. The cause(s) of the failure remains uncertain pending detailed studies addressing both possible geologic and non-geologic causes.

HAZARD IMPLICATIONS

The erosional ravine poses several risks to people and homes below the breach. Collapse of the ravine walls poses a direct life-safety risk to anyone in the ravine or along the edge above, as well as a risk to utilities and structures along the slope crest as the walls wear back to achieve a stable slope angle. Runoff from precipitation could also collect in the canal along its length and further spill into the ravine, possibly causing additional erosion and flooding. The steep walls and overhanging concrete canal sections pose a hazard to workers or onlookers below.

RECOMMENDATIONS

Riverdale city officials and the Utah National Guard are considering immediate measures to repair slopes in and around the erosional ravine to improve slope stability and remove hanging debris. Any such measures must be designed and monitored by qualified geotechnical engineers. We recommend the canal company also consider measures to prevent water (such as seasonal spring flow or runoff collected along the canal length) from spilling from the canal breach. We further recommend maintaining free-flowing drainage through the area so that no water ponds on the slope, and regularly inspecting re-graded slopes for evidence of movement and seepage, particularly in wet seasons and after periods of increased precipitation.

Long-term measures for reducing the risk from future failures and flooding elsewhere along the canal should be taken prior to canal re-use. Such measures may include inspection and repair (as necessary) of the lining and embankment, geotechnical studies to identify sections of the canal vulnerable to hazards, stabilizing slopes, installing extra emergency structures to divert water from the canal to reduce flow reaching a breach, and/or taking flood-control measures to protect structures below the canal.

REFERENCES

Black, B.D., 1998, Reconnaissance of a landslide along the Davis-Weber Canal near 1250 East South Weber Drive, South Weber, Davis County, Utah, in McDonald, G.N., compiler, Technical reports for 1998, Applied Geology Program: Utah Geological Survey Report of Investigation 242, p. 36-41.

Black, B.D., and Lowe, Mike, 1991, Investigation of seeps and landslide potential in South Weber near 5939 South Weber Drive, Weber and Davis Counties, Utah, in Mayes, B.H., compiler, Technical reports for 1990-1991, Applied Geology Program: Utah Geological Survey Report of Investigation 222, p. 181-185.

Erickson, A.J., and Wilson, Lemoyne, 1968, Soil survey of the Davis-Weber area, Utah: U.S. Department of Agriculture Soil Conservation Service in cooperation with Utah Agricultural Experiment Station, 149 p.

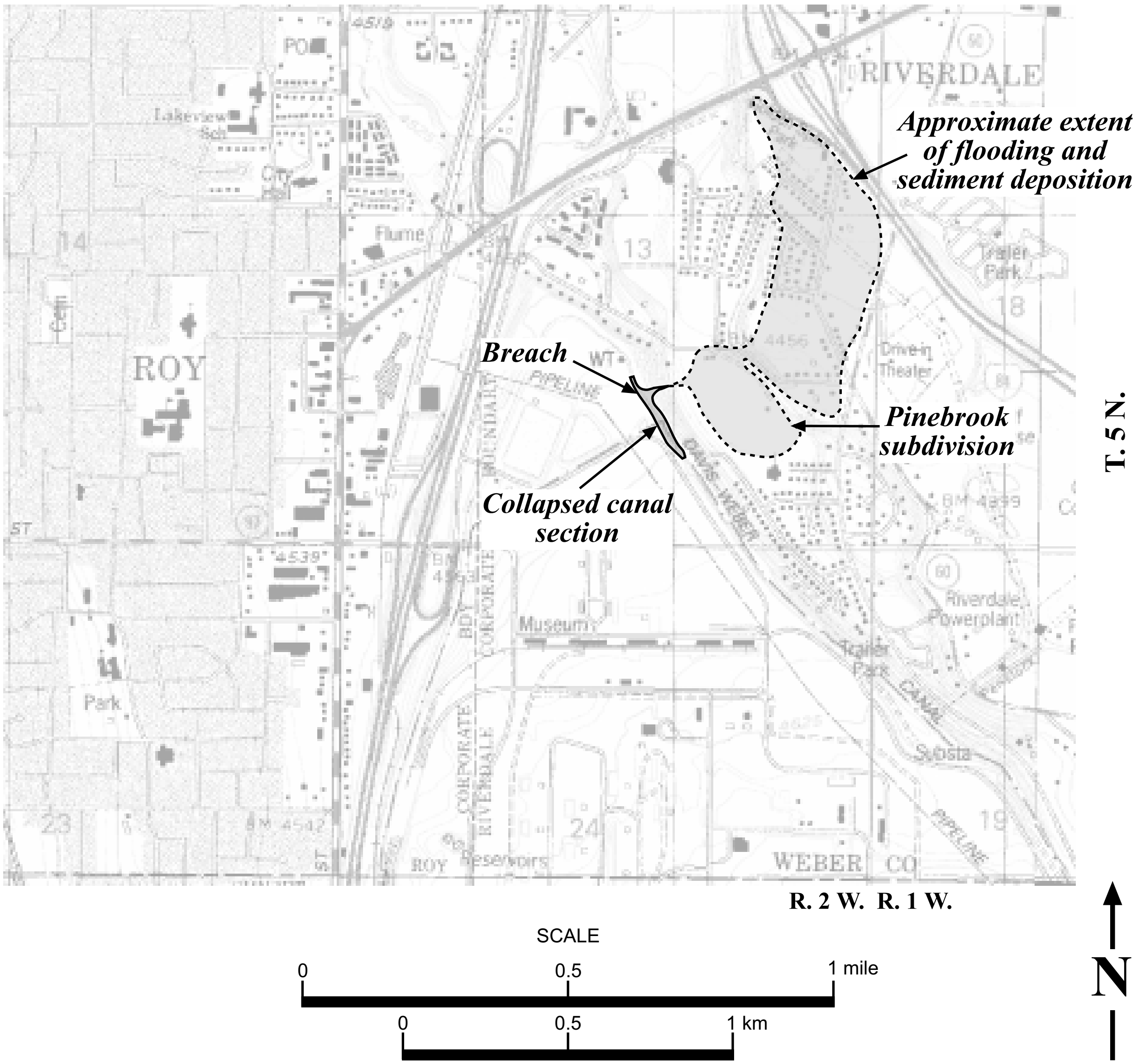
Harty, K.M., 1989, Geologic hazards investigation of a proposed 2-million-gallon water tank site, City of Riverdale, Weber County, Utah, in Black, B.D., compiler, Technical reports for 1988-1989, Applied Geology Program: Utah Geological and Mineral Survey Report of Investigation 220, p. 14-19.

Interagency Technical Team, 1999, Onsite report–Riverdale, Weber County, Davis-Weber Canal flood, July 11, 1999: Unpublished Utah Department of Comprehensive Emergency Management report, 2 p.

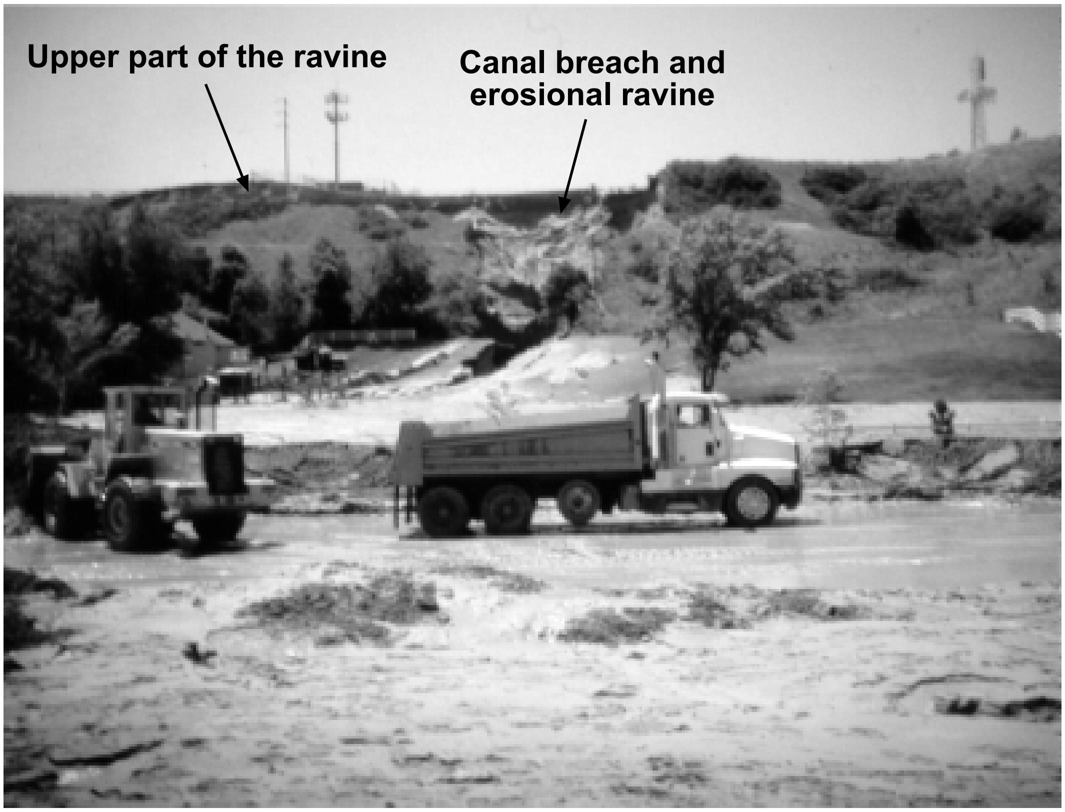
Lowe, Mike, 1986, Hazards evaluation of the Craig-Dale subdivision, Riverdale, Weber County, Utah: Unpublished Weber County Planning Commission Internal Memorandum, 1 p.

----1988, Slope failure inventory map--Roy quadrangle: Ogden, unpublished Weber County Planning Department Map, scale 1:24,000.

Base map from ROY, U.S.G.S.
7-1/2' topographic quadrangle.



Attachment 1. Location map.



Attachment 2. West view of the July 11, 1999, Davis-Weber Canal breach. An erosional ravine 390 feet long, 60 feet wide, and 40 feet deep is in the background. Headward erosion (to the south) during the flood produced the upper part of the ravine.

Attachment 3. East view of the outlet and sediment deposited in the Pinebrook subdivision from the July 11, 1999, Davis-Weber Canal breach.

REVIEWS

<table>
<tr><td colspan="3">Project:
Review of "Geologic reconnaissance of lot 1325, Timber Lakes subdivision, Heber, Utah."</td><td>Requesting Agency:
Wasatch County Planning Department</td></tr>
<tr><td>By:
Bill D. Black</td><td>Date:
01-07-99</td><td>County:
Wasatch</td><td rowspan="2">Job No:
99-01
(R-01)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
Center Creek (1126)</td><td>Number of attachments:
None</td></tr>
</table>

INTRODUCTION

This report is a review of a geologic reconnaissance report by Payton (1998) for lot 1325 in the Timber Lakes subdivision (NW1/4 SE1/4 section 8, T. 4 S., R. 6 E., Salt Lake Base Line and Meridian) in Wasatch County, Utah. Tony Kohler (Planner, Wasatch County Planning Department) requested the review. The Utah Geological Survey received the report on December 8, 1998, from Kip Barnes (Developer). The scope of work included a literature review and examination of 1:40,000- and 1:20,000-scale aerial photos (1987 and 1962, respectively). No field visit was made.

DISCUSSION AND COMMENTS

Payton (1998) evaluates potential hazards from earthquake ground shaking, surface faulting, and landslides at the site. I concur with his conclusions regarding ground shaking and faulting, but additional study of landslide hazards is needed. Slopes in the central and eastern parts of the property are moderately steep (up to 40 percent on Payton's topographic map), and aerial photos and an unpublished Timber Lakes special-study area map (Wasatch County Planning Department, 1998) show a landslide adjacent to the western end of the property. The flatter western part of the lot could be on this mapped landslide; the steep slopes on Payton's topographic map near the center of the lot may be part of the main slide scarp. However, Payton (1998) observed no evidence for landsliding on or adjacent to the property, and either did not recognize the landslide to the west or does not believe it exists. Payton (1998) believes the risk of landsliding is low and concludes site-specific studies addressing landslide hazards "may not be warranted."

The local steepness of slopes at the property and evidence for an adjacent landslide suggest to me that slopes at the site are potentially unstable and pose a landslide risk. I believe further evaluation of the landslide (or evidence showing its absence) and its impacts on the lot are needed. Also, I believe at least a preliminary geotechnical engineering evaluation should be conducted following guidelines in Hylland (1996), including quantitative slope-stability analyses based on presumed soil properties and estimated development-induced ground-water conditions at the site, to demonstrate slopes at the site are stable. As suggested by Payton (1998), soil properties can be determined when tests are conducted for assessing septic-tank soil-absorption (STSA) system suitability, and slope-stability analyses based on these properties may be performed to determine overall slope stability prior to construction.

RECOMMENDATIONS

Regarding lot 1325 in the Timber Lakes subdivision, I recommend:

- conducting further studies to evaluate the mapped landslide to the west and address its hazard implications, or present evidence that the landslide does not exist;

- performing a preliminary geotechnical evaluation to determine slope stability at the site, including quantitative slope-stability analyses based on site soil properties (which may be determined during tests for STSA system suitability) and estimated development-induced ground-water conditions; and

- disclosing the existence of Payton (1998), this review, and all subsequent reports and reviews regarding the site to future buyers.

REFERENCES

Hylland, M.D., editor, 1996, Guidelines for evaluating landslide hazards in Utah: Utah Geological Survey Circular 92, 16 p.

Payton, C.C., 1998, Geological reconnaissance of lot 1325, Timber Lakes subdivision, Heber, Utah: Provo, Utah, unpublished consultant's report, 3 p.

Wasatch County Planning Department, 1998, Timber Lakes lots within special study areas: Heber City, Utah, unpublished Wasatch County Planning Department Map, scale 1:24,000.

Project: Review of soils report and drawings, the Ponds at Oak Hills, Layton, Davis County, Utah			Requesting Agency: Layton City Community Development Dept.
By: Richard E. Giraud	Date: 02-16-99	County: Davis	Job No: 99-02 (R-02)
USGS Quadrangle: Kaysville (1320)		Number of attachments: None	

INTRODUCTION

This report is a review of a soils report and subdivision drawings for the proposed Ponds at Oak Hills subdivision, by Wilding Engineering, Inc. (Wilding, 1996, 1998). The subdivision is located at 2650 East Oak Hills Drive, Layton, Utah (NW1/4 SE1/4 section 23, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian). Doug Smith (Planner, Layton City) requested the review. The report was received by the Utah Geological Survey on January 20, 1999. The purpose of my review is to evaluate if geologic hazards at the subdivision are adequately addressed. The scope of my review included a literature review and interpretation of aerial photographs (1985; scale 1:24,000). No site visit was made. Wilding (1996) also provides geotechnical recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Wilding (1996) addresses possible hazards resulting from surface fault rupture, earthquake ground shaking, liquefaction, shallow ground water, and problem soils, and I concur with their recommendations. An additional concern at the site that was not addressed by Wilding (1996, 1998) is slope stability.

Lowe (1988) shows several active landslides in the drainage south of the subdivision and in other nearby drainages. The presence of these active landslides indicates that slopes in the area are susceptible to landsliding. The south portion of the subdivision is on and above a slope that extends down into the drainage with mapped active landslides (Lowe, 1988). The test-pit data indicate the soils are silty sands with interbedded clay lenses, which may cause perched ground-water conditions and promote slope instability. Wilding (1998) shows several planned cut and fill slopes in the subdivision. Slope gradients of 50 percent are planned for cuts and fills and fill will be placed on natural slopes with gradients of 20 to 30 percent. Because the slopes in this area are prone to landsliding, I recommend a geotechnical-engineering slope-stability analysis, as outlined in Hylland (1996), to determine if the slope modifications will affect the overall stability of the site. The stability analysis must also determine the effect of planned fills on stability of natural slopes. Any seepage from the subdivision ponds and landscape irrigation that may cause perched ground-water conditions must be considered in the stability analysis. Fill recommendations are made for pavements and footings but not for the placement of large fills that extend across the subdivision. Fill recommendations must be provided for these large fills to ensure proper placement and stability.

Wilding (1998) shows two retaining walls with maximum heights of 5 and 20 feet. No engineering design was provided for these retaining walls. The stability of the retaining walls is a serious concern because they are within 15 feet of house foundations. I recommend that an engineered design be provided for the retaining walls and that both static and earthquake ground shaking be incorporated in the design.

SUMMARY AND RECOMMENDATIONS

Regarding slope-stability concerns at the site, I recommend the following:

- Perform a slope-stability analysis to determine the effect of cuts and fills on the overall slope stability. Slope performance must be evaluated under appropriate earthquake ground-shaking and estimated development-induced (landscape irrigation) ground-water conditions.
- Provide recommendations for placing large fills across the subdivision. These recommendations should be reviewed by a geotechnical engineer.
- Provide an engineered design for the retaining walls and have the design reviewed by a qualified engineer. The retaining-wall design must consider static and earthquake ground-shaking conditions. A geotechnical engineer should also review foundation and pavement recommendations.
- Disclose the existence of the Wilding (1996, 1998) report and drawings, subsequent reports, and this review to future buyers.

Specific recommendations and restrictions pertaining to site building design and lot development should be included in subsequent reports. All conclusions and recommendations must be supported with evidence. I further recommend that Layton City provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consulting geologist and/or engineer indicating that their recommendations were followed.

REFERENCES

Hylland, M.D., editor, 1996, Guidelines for evaluating landslide hazards in Utah: Utah Geological Survey Circular 92, 16 p.

Lowe, Mike, 1988, Natural hazards overlay zone - slope failure inventory, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

Wilding Engineering Inc., 1996, The Ponds at Oak Hills soil report, 2650 East Oak Hills Drive, Layton, Utah: Draper, Utah, unpublished consultant’s report for Equus Limited, 5 p.

Wilding Engineering Inc., 1998, The Ponds at Oak Hills subdivision maps, 2650 East Oak Hills Drive, Layton, Utah: Draper, Utah, unpublished consultant's subdivision drawings, 7 sheets.

Project: Review of "Geotechnical study, Oakdale subdivision, plat A, Provo, Utah."			**Requesting Agency:** Provo Engineering Department
By: Bill D. Black	**Date:** 03-02-99	**County:** Utah	**Job No:** 99-03 (R-03)
USGS Quadrangle: Orem (1088)		**Number of attachments:** None	

INTRODUCTION

This report is a review of the geologic-hazards sections of a geotechnical report by Earthtec Testing & Engineering (Earthtec, 1998) for the Oakdale subdivision, plat A, in Provo (NW1/4SE1/4 section 32, T. 6 S., R. 3 E., Salt Lake Base Line and Meridian), Utah County, Utah. David Graves (Development and Project Engineer, Provo Engineering Department) requested the review. The Utah Geological Survey received the report on January 25, 1999. The purpose of my review is to assess if geologic hazards possibly present at the property are adequately identified and addressed. My review consisted of a literature search, and I made no field visit.

DISCUSSION AND COMMENTS

Earthtec (1998) discusses possible hazards from earthquake ground shaking, surface fault rupture, landsliding (slope instability), and moderately collapsible soils. I concur with their recommendations regarding ground shaking, but believe further work is needed to address surface-faulting and landslide hazards at the site; debris-flow and rock-fall hazards also must be considered. Earthtec (1998) provides geotechnical recommendations, particularly with respect to collapsible soil and site grading, that should be reviewed by a qualified geotechnical engineer.

- Surface fault rupture: Earthtec (1998) indicates observing no evidence for faulting at the property and published data show no active faults that traverse the site. Earthtec (1998) also indicates the nearest faults are a main trace of the Wasatch fault zone several hundred feet west of the property, and a branch of the fault to the east (uphill). Machette (1989) shows a similar pattern of faulting, and an unpublished Utah County Planning Department map (Robison, 1990a) indicates the property is in a special-study zone where trenching studies are needed to evaluate surface-faulting hazards. Earthtec (1998) conducted no trenching. Such studies are critical to evaluate possible faulting and deformation associated with surface fault rupture, and should be conducted in the vicinity of all mapped or suspected active faults. I suspect the steep slope at the property (discussed below) is the upper part of an eroded scarp produced by one or more surface-faulting earthquakes on the Wasatch fault. If so, trenching should be conducted in the western part of the property, and elsewhere, if other faults are identified.

- Landslides: Earthtec (1998) indicates the property slopes steeply to the northwest, with slope gradients ranging from 10 percent near the top at Terrace Drive (on the eastern edge of the site) to 80 percent near the western property boundary. Although Earthtec (1998) observed no evidence of slope instability at the property, Machette (1989) shows scarps and a failure in the slopes to the north; an unpublished Utah County Planning Department map (Robison, 1990b) also shows the site is in an area where studies are needed to assess potential landslide hazards. Earthtec (1998) conducted a preliminary computer slope-stability analysis of the steep slope, based on "conservative" estimated soil strengths (33 degree friction angle, 400 psf cohesion) and no ground water, and indicates factors of safety are 1.5 and 1.1 under static and dynamic (0.2 g earthquake horizontal acceleration) conditions, respectively. Based on this and a lack of evidence for instability, Earthtec (1998) believes the slope is stable and recommends buildings be set back 20 feet (6 m) from the slope crest.

Because Earthtec (1998) does not provide a detailed site topographic map, I cannot fully determine the adequacy of their slope-stability assessment. However, I do not concur with Earthtec's (1998) assessment that the slope is stable or that a 20-foot (6-m) setback is appropriate. I believe Earthtec's (1998) estimated soil strengths and ground-water conditions are not conservative, and a lack of evidence for past instability does not demonstrate that the slope will remain stable (particularly if ground-water conditions change). Measured strengths of similar soils along the Wasatch Front (Frank Ashland, Utah Geological Survey, written communication, 1998) are lower than Earthtec's estimates (particularly friction angles, which range from 26 to 33 degrees for silty clays). Also, development will likely induce rises in ground-water levels through landscape irrigation. Furthermore, Earthtec's input acceleration for dynamic analysis does not account for amplification of ground motions by soils at the site; the 1997 Uniform Building Code (table 16-Q) shows an acceleration-based seismic coefficient of 0.36 for building construction on SE soil types in seismic zone 3. Earthtec's (1998) factors of safety are minimum acceptable values, and will be lower if a lower friction angle, shallower water table, and higher earthquake ground acceleration are used, which suggests to me that the slope has marginal stability. Thus, I believe a detailed slope-stability evaluation following guidelines in Hylland (1996) is needed to evaluate slope stability and determine appropriate setbacks, using site-specific soil data, estimated development-induced ground-water conditions, and an appropriate earthquake acceleration. The evaluation should also consider potential impacts on stability from any planned site grading.

- Debris flows and rock falls: Although Machette (1989) does not show an active alluvial fan at the site, sand and gravel in the upper parts of test pits TP-1, TP-2, and TP-4 may be debris-flow/flood deposits. Machette (1989) shows an active alluvial fan west of the site, suggesting debris flows and floods may traverse the property and deposit material on lower slopes to the west. Robison (1990c) shows the property is in a special-study zone where debris-flow hazards should be evaluated. Although Earthtec (1998) does not provide a site topographic map, I believe the property may also be subject to rock falls from steep mountain slopes to the east; Robison (1990d) shows the site is in a special-study zone where rock-fall hazards should be evaluated. The mountain-front rock mass should also be evaluated (in terms of bedding and joint orientations) for evidence of rock-mass instability which could produce rock slides. Earthtec (1998) did not evaluate these hazards, and I believe further studies are needed to assess their risk and provide risk-reduction recommendations (where necessary).

- Collapsible soils: Earthtec (1998) indicates native silty clays and clayey silts at the site are moderately collapsible under light loads when wetted. Earthtec (1998) recommends structural fill be used below all foundations, and provides footing designs to reduce settlement. Earthtec's (1998) soil tests were performed on soils less than 6 feet (1.8 m) deep, but similar soils extend to greater depths at the site. If deeper soils are also collapsible, introduction of water accompanying development may cause additional settlement. I recommend Earthtec's (1998) collapsible soil and footing-design recommendations be reviewed by a qualified geotechnical engineer.

SUMMARY AND RECOMMENDATIONS

I believe Earthtec (1998) inadequately assesses geologic hazards at the site. Earthtec (1998) does not adequately evaluate the potential surface-fault rupture hazard, their preliminary slope-stability analyses use input parameters that overestimate stability, and they do not assess potential hazards from debris flows, rock falls, or rock slides. Therefore, I recommend:

- a detailed topographic map be made at a scale suitable for site planning;

- further studies to evaluate potential surface-fault-rupture hazards, including trenching near all mapped or suspected fault scarps, and provide risk-reduction recommendations as necessary;

- conducting a detailed slope-stability evaluation to determine static and dynamic stability of slopes and appropriate setbacks (following guidelines in Hylland [1996]), using site-specific soil-test data and estimated development-induced ground-water conditions and considering potential impacts of site grading on stability;

- conducting studies to evaluate potential debris-flow, rock-fall, and rock-slide hazards from slopes to the east, and provide risk-reduction recommendations as necessary;

- disclosing the existence of the Earthtec (1998) report, this review, and all subsequent reports and reviews to future buyers; and

- a qualified geotechnical engineer review Earthtec's (1998) geotechnical recommendations, particularly those regarding collapsible soils.

REFERENCES

Earthtec Testing & Engineering, 1998, Geotechnical study, Oakdale subdivision, plat A, Provo, Utah: Orem, Utah, unpublished consultant's report, 11 p.

Hylland, M.D., 1996, editor, Guidelines for evaluating landslide hazards in Utah: Utah Geological Survey Circular 92, 16 p.

Machette, M.N., 1989, Preliminary surficial geologic map of the Wasatch fault zone, eastern part of Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-2109, 30 p. pamphlet, scale 1:50,000.

Robison, R.M., 1990a, Utah County Natural Hazards Overlay (NHO) zone–Surface fault rupture: Provo, Utah, unpublished Utah County Planning Department Map, scale 1:50,000.

----1990b, Utah County Natural Hazards Overlay (NHO) zone–Landslide: Provo, Utah, unpublished Utah County Planning Department Map, scale 1:24,000.

----1990c, Utah County Natural Hazards Overlay (NHO) zone–Debris flow: Provo, Utah, unpublished Utah County Planning Department Map, scale 1:24,000.

----1990d, Utah County Natural Hazards Overlay (NHO) zone–Rock fall: Provo, Utah, unpublished Utah County Planning Department Map, scale 1:24,000.

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Review of "Geotechnical report, Springhill landslide, City of North Salt Lake, Davis County, Utah"</td><td>Requesting Agency:
City of North Salt Lake</td></tr>
<tr><td>By:
Richard E. Giraud</td><td>Date:
03-03-99</td><td>County:
Davis</td><td rowspan="2">Job No:
99-04
(R-04)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
Salt Lake City North (1254)</td><td>Number of attachments:
None</td></tr>
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INTRODUCTION

This report is a review of a geotechnical report for the Springhill landslide in North Salt Lake by Terracon Consulting Geotechnical Engineers (Terracon, 1998). The landslide is located in the area of Springhill Circle, Springhill Drive, 350 East, and Barry Circle in North Salt Lake, Davis County, Utah (SE1/4NW1/4 section 12, T. 1 N., R. 1 W., Salt Lake Base Line and Meridian). Rod Wood (Public Works Director, North Salt Lake City) requested the review. The report was received by the Utah Geological Survey on February 3, 1999. The purpose of my review is to evaluate if the landslide hazard has been adequately addressed and, where necessary, to provide additional comments and recommendations. Recommendations pertaining to the design of the interceptor trench and horizontal drains should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Terracon (1998) performed a geotechnical investigation of building distress in the Springhill area and concluded that the distress was caused primarily, if not entirely, by landsliding. Terracon (1998) recommends drainage of ground water from the landslide as the best approach to stabilizing it. I generally concur with Terracon's conclusions and with their recommendations regarding drainage, but I have a concern as to whether the clayey tuffaceous sediments, which make up most of the landslide mass, can be effectively dewatered. My comments regarding the landslide investigation and recommendations to characterize aquifer characteristics are outlined below.

Landslide Features

The Springhill landslide is similar to a landslide in a residential setting in Honolulu, Hawaii, described by Baum and others (1998). Both landslides are clay rich, highly plastic, weak, slow moving, perennially saturated, and irregular in shape, and damage to structures is greatest on the landslides margins. The landslide boundaries described by Baum and others (1998) were difficult to define in the early stages of movement, as are the boundaries of the Springhill landslide. The Springhill landslide rate of movement, indicated by inclinometer data, is slow to very slow (about 0.5 inch per year), which hopefully allows time for remedial measures to be implemented before substantial additional damage occurs. The clay-rich landslide studied by Baum and others (1998) had total lateral displacements of 11 to 14 feet over a 20-year period. Because the Springhill landslide has many similarities, similar displacements may also occur over the long term. Because the Springhill landslide is in the initial phase of movement, Terracon (1998) believes the shear strength along the slip surface is likely decreasing with continued movement and therefore, unless conditions change, the landslide will probably continue to move.

Possible Area of Incipient Landsliding

Terracon (1998) inferred boundaries of the landslide based on indications of surface and subsurface movement. I generally agree with their boundary locations, but believe there may also be incipient movement in the Barry Circle area to the southwest. I noted building distress in house foundations and retaining walls at 359, 367, and 360 Barry Circle (Giraud, 1998). The pattern of building distress indicates that some ground movement has taken place. An inclinometer installed in the Barry Circle cul-de-sac would help to determine whether landslide movement is occurring there.

Landslide Drainage

Terracon (1998) recommends landslide drainage to improve stability by lowering the water table within the landslide. Terracon (1998) recognizes that ground-water flow through landslides is erratic, irregular, and difficult to quantify, and I agree. This makes draining landslides a hit-or-miss proposition, with no guarantee of success. Hydrogeologic conditions must be understood in order to reduce the risk of failure and appropriately design an effective drain system. A conceptual hydrologic framework for the Springhill landslide likely includes lateral ground-water inflow into the head of the landslide from the slope east of Springhill Circle, ground-water flow through the landslide controlled by the hydraulic gradient and the highly variable hydraulic conductivity of the landslide materials (tuffaceous sediments and volcanic breccia), and ground-water discharge from the landslide as spring flow and lateral flow to downgradient areas. The drainage system design must account for the differing hydraulic conductivities of the geologic units, both laterally and vertically; the lateral ground-water inflow from upgradient areas; ground-water recharge from precipitation and irrigation sources; and ground-water discharge by springs and lateral flow downgradient.

Regarding Terracon's recommendations to drain the landslide, I have two main concerns: 1) the hydraulic conductivity of the geologic units in the landslide may be too low to drain effectively, and 2) the interceptor drain may be too shallow to intercept a significant volume of lateral ground-water inflow from the east. The two geologic units within the landslide probably have different water-yielding properties relative to drainage considerations. The clayey tuffaceous sediments will likely have a low hydraulic conductivity and be difficult to drain. Flow of ground water in the unit is probably controlled by permeable sandy layers, as noted by Terracon (1998). If such layers are not evident and cannot be targeted, the risk of installing an ineffective drain system is increased. A better understanding of the general aquifer characteristics of the tuffaceous sediments may be gained by aquifer testing of the monitoring wells at 410 East Springhill Circle. Even though monitoring-well aquifer tests have limitations, a general understanding of bulk aquifer parameters could be obtained and used in drainage-system design.

The ground water in the clayey volcanic breccia had a 2.6-foot drop over a 77-day period in piezometer P-4. As discussed by Terracon (1998), some of the decline may be attributed to sewer-line repair, but this water-level drop occurred during the fall when ground-water levels naturally decline and it occurred over a significant time period. This ground water likely discharges at springs along the crest of the Warm Springs fault scarp and by lateral ground-water flow to downgradient areas. The spring east of 131 South Springhill Drive (northeast of the landslide) was reported to have a flow of 20 to 50 gallons per minute in non-clayey volcanic breccia, and this discharge indicates substantial ground-water inflow from the east. The spring-flow rate and the decline of the ground-water level in the volcanic breccia indicates that this unit may yield water to a drain better than the tuffaceous sediments, but the bulk hydraulic conductivity has not been measured. Seasonal monitoring of spring flow and ground-water levels and subsequent analysis could provide a range of transmissivity and storage properties for ground water in the volcanic breccia.

Because of lateral ground-water inflow, an interceptor drain is proposed for the subdivision. However, given the steep hydraulic gradient in this area, the 12- to 20-foot-deep drain may not intercept a sufficient aquifer thickness to significantly affect the lateral recharge into the landslide from upgradient areas.

SUMMARY AND RECOMMENDATIONS

Terracon's recommendation to drain the landslide is probably the least expensive stabilization method with some likelihood of success. However, I caution that little is known about the aquifer characteristics of the geologic units, and drains, particularly in the clayey tuffaceous sediments, may be ineffective or may take years to lower ground-water levels. Also, the relatively shallow interceptor drain may have little success intercepting lateral recharge into the landslide mass. Damage to the drain system by additional landslide movement is also a concern noted by Terracon (1998). Regarding Terracon's (1998) assessment of the Springhill landslide and their recommendations to stabilize the landslide, I recommend the following:

- conduct an aquifer test at lot 410 Springhill Circle and consider aquifer characteristics in drainage-system feasibility and design;

- continually monitor inclinometers, spring flow, and piezometers to gain an improved understanding of landslide movement and aquifer characteristics to improve the assessment of the landslide hazard and the design and effectiveness of remedial measures;

- install an inclinometer and piezometer to assess landslide movement and ground-water conditions, if additional building distress occurs, in the Barry Circle area;

- provide designs for lateral drains, and have the designs reviewed by a qualified geotechnical engineer; and

- disclose the existence of the Terracon (1998) and subsequent reports and this review to homeowners and future buyers.

Finally, horizontal drains require long-term monitoring, maintenance, and repair, and the responsibility to perform and fund these activities must be assigned. Likewise, residents must understand that stabilization may take years, if the drain system is successful, and that the level of stability gained by the drain system may not be sufficient to preclude movement in a significant earthquake.

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Giraud, R.E., 1998, Reconnaissance of building distress and ground movement in the Springhill Circle area, North Salt Lake, Davis County, Utah: unpublished Utah Geological Survey Technical Report 98-29, 7 p.

Terracon, 1998, Geotechnical report, Springhill landslide, City of North Salt lake, Utah: Salt Lake City, Utah, unpublished consultant’s report for city of North Salt Lake, 23 p.

Project: Review of "Geotechnical report for proposed elementary school, 600 North 1300 West, Pleasant Grove, Utah County, Utah"			Requesting Agency: Alpine School District
By: Richard E. Giraud	Date: 03-09-99	County: Utah	Job No: 99-05 (R-05)
USGS Quadrangle: Orem (1088)		Number of attachments: None	

INTRODUCTION

This report is a review of a geotechnical report for a proposed elementary school at 600 North 1300 West in Pleasant Grove, Utah, by Delta Geotechnical Consultants, Inc. (Delta, 1999). The report incorporates a geologic-hazard assessment letter prepared by American Geological Services, Inc., dated December 2, 1998. The proposed school site is located in the E1/2 section 19, T. 5 S., R. 2 E., Salt Lake Base Line and Meridian. Dave Holdaway (Director of Physical Facilities, Alpine School District) requested the review. The report was received by the Utah Geological Survey on February 16, 1999. The purpose of my review is to evaluate if geologic hazards at the proposed school site are adequately addressed. Although the scope of this review did not include a field visit, my review of on-site work by others fulfills the intent of Utah State Office of Education (USOE) Rule R277-455 requiring inspection of new school sites by the Utah Geological Survey prior to approval by the USOE. Also, I previously conducted a preliminary geologic-hazards screening evaluation of this site, which is summarized in my letter dated June 29, 1998, to the Alpine School District. In addition to addressing geologic hazards, Delta (1999) also provides geotechnical-engineering recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND RECOMMENDATIONS

Delta (1999) addresses possible hazards resulting from earthquake ground shaking, liquefaction, tectonic subsidence, and shallow ground water. I concur with their recommendations regarding these hazards but provide additional comments below on earthquake ground shaking and tectonic subsidence. Delta (1999) also determined that surface fault rupture, slope failure, flooding, sensitive clays, rock falls, problem soils, erosion, and flooding of irrigation ditches have only a minimal potential to impact the site, and I agree. The Delta (1999) engineering recommendations pertaining to liquefaction, grading, drainage, foundations, backfill, and pavement should be reviewed by a qualified geotechnical engineer.

! Earthquake ground shaking: Delta (1999) states that at a minimum the building should be designed and constructed in accordance with the seismic zone 3 requirements of the Uniform Building Code (UBC). As discussed in my preliminary screening letter, I recommend that critical facilities such as schools along the Wasatch Front be designed to UBC seismic zone 4 standards to provide additional safety.

! Tectonic subsidence: Delta (1999) confuses American Geological Services' statement of the possibility of 4 to 5 feet of tectonic subsidence associated with surface fault rupture on the Provo segment of the Wasatch fault with subsidence resulting from liquefaction. As a result, the fault-related tectonic-subsidence hazard and how it affects the proposed building was not addressed. The American Geological Services report accurately summarizes the probability of occurrence of tectonic subsidence at the site and indicates it may result in a permanent lowering of the ground surface of 4 to 5 feet. The principal effect of such subsidence at this site would be possible foundation flooding or ponding by shallow ground water as the water table rises in response to surface downdropping. I recommend that Delta and building engineers determine if tectonic subsidence and related flooding pose a significant risk to the building and if necessary provide appropriate risk-reduction measures.

REFERENCE

Delta Geotechnical Consultants, Inc., 1999, Geotechnical study for proposed elementary school at 600 North 1300 West, Pleasant Grove, Utah: Salt Lake City, Utah, unpublished consultant's report for Alpine School District, 13 p.

<table>
<tr><td colspan="3">Project:
Review of “Geotechnical report for proposed elementary school, Ranch Drive, VanBurgress site, Alpine, Utah County, Utah”</td><td>Requesting Agency:
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(R-06)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
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INTRODUCTION

This report is a review of the geological hazards sections of a geotechnical report for a proposed elementary school in Alpine, Utah, by Delta Geotechnical Consultants, Inc. (Delta, 1999). The proposed school site is located in the SW1/4SW1/4 section 24, T. 5 S., R. 1 E., Salt Lake Base Line and Meridian. Dave Holdaway (Director of Physical Facilities, Alpine School District) requested the review. The report was received by the Utah Geological Survey on February 16, 1999. The purpose of my review is to evaluate if geologic hazards at the proposed school site are adequately addressed. Although the scope of this review did not include a field visit, my review of on-site work by others fulfills the intent of Utah State Office of Education (USOE) Rule R277-455 requiring inspection of new school sites by the Utah Geological Survey prior to approval by the USOE. I prepared a preliminary geologic-hazards screening evaluation of this site, which was included in my letter dated January 12, 1999, to the Alpine School District.

DISCUSSION AND RECOMMENDATIONS

Delta (1999) addresses possible hazards resulting from earthquake ground shaking, surface fault rupture, liquefaction, non-engineered fill, and radon gas. I concur with their recommendations regarding these hazards but provide additional comments below on earthquake ground shaking and radon gas. The Delta (1999) engineering recommendations pertaining to grading, drainage, foundations, backfill, pavement, and seismically induced subsidence (settlement) should be reviewed by a qualified geotechnical engineer.

! Earthquake ground shaking: Delta (1999) states that at a minimum the building should be designed and constructed in accordance with the seismic zone 3 requirements of the Uniform Building Code (UBC). As discussed in my preliminary screening letter, I recommend that critical facilities such as schools along the Wasatch Front be designed to UBC seismic zone 4 standards to provide additional safety.

! Radon Gas: Delta (1999) is inconclusive regarding an indoor-radon-gas hazard at the site. The site is in an area of high radon-hazard potential (Black, 1993) in which radon-resistant construction should be considered. I recommend that Delta and the building architects evaluate if radon gas may enter the building and present a significant hazard to building occupants and, if necessary, provide appropriate risk-reduction measures.

Delta (1999) appears to have only addressed hazards identified in my preliminary geologic-hazards screening. My preliminary screening was based principally on a literature review of the Utah County Natural-Hazards Overlay maps and was not a comprehensive site- specific field evaluation. The purpose of the preliminary screening is to identify major hazards to consider in property acquisition; it should not be used to narrow the scope of work for a comprehensive site-specific geologic-hazards evaluation, which must consider all hazards. Although I am not aware of other hazards at this site, the site-specific geologic-hazards report must identify all potential hazards, determine if the hazards present significant risks to the site, and present evidence that all hazards were considered or at least contain a statement that no hazards other than those identified in the report exist at the site.

REFERENCES

Black, B.D., 1993, The radon-hazard-potential map of Utah: Utah Geological Survey Map 149, 12 p. pamphlet, scale 1:1,000,000.

Delta Geotechnical Consultants, Inc., 1999, Geotechnical study for proposed elementary school, Ranch Drive, VanBurgress site, Alpine, Utah: Salt Lake City, Utah, unpublished consultant's report for Sandstrom Architects, 10 p.

Project: Review of geotechnical study, Jacobson P.R.U.D., Layton, Davis County, Utah			**Requesting Agency:** Layton City Community Development Dept.
By: Richard E. Giraud	**Date:** 03-22-99	**County:** Davis	**Job No:** 99-07 (R-07)
USGS Quadrangle: Kaysville (1320)		**Number of attachments:** None	

INTRODUCTION

This report is a review of a geotechnical study by Earthtec Engineering P.C. (Earthtec, 1999) for the proposed Jacobson subdivision. The Earthtec (1999) report includes an appendix by Charles Payton that addresses geologic hazards. The subdivision is located at 1850 North Valley View Drive, Layton, Utah (NW1/4NW1/4 section 13, T. 5 N., R. 1 W., Salt Lake Base Line and Meridian). Doug Smith (Planner, Layton City) requested the review. The Utah Geological Survey received the report on February 10, 1999. The purpose of my review is to evaluate if geologic hazards at the subdivision are adequately addressed. The scope of my review included a literature review and interpretation of aerial photographs (1985; scale 1:24,000). No site visit was made. Earthtec (1999) also provides geotechnical recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Earthtec (1999) addresses possible hazards resulting from earthquake ground shaking, surface fault rupture, shallow ground water, problem soils, landslides, rock falls, debris flows, and alluvial-fan floods. I concur with the recommendations regarding earthquake ground shaking, shallow ground water, problem soils, landsliding, and rock fall. My comments and recommendations regarding Earthtec's (1999) assessment of hazards from surface fault rupture, debris flows, and alluvial-fan flooding are outlined below. I also provide comments on the radon-gas hazard potential.

! Surface fault rupture: Earthtec (1999) states that the Wasatch fault zone is 600 feet east of the site. Lowe (1988a) and Nelson and Personius (1993) show the Weber segment of the Wasatch fault 350 to 500 feet east of the east subdivision boundary, placing at least the east portion of the subdivision within the county's designated surface-fault-rupture special-study area. Within the special-study area, a site-specific fault study is recommended to assess any impacts of faulting within the subdivision. The site-specific study should include detailed aerial-photo and field investigations to identify fault scarps or other evidence of faulting. If any evidence of faulting is found, trenching is necessary to locate faults and determine appropriate setbacks. Geologic logs of the trenches are required to show the type, extent, and amount of deformation in the fault zone and provide a basis for setback recommendations.

- ! Debris Flows and Alluvial-Fan Flooding: The site is located on an alluvial fan at the canyon mouths of Middle Fork and South Fork Kays Creek. Earthtec (1999) states that a hydrologic analysis of South Fork Kays Creek should be considered although "it appears that the risk of debris flows, debris floods, and flooding is low." The surficial geologic map of Nelson and Personius (1993) shows upper Holocene alluvial-fan deposits at the site from intermittent stream flows, debris flows, and debris floods. Lowe (1988b) shows the subdivision within a debris-flow hazard special-study zone, and a historical debris-flow deposit is mapped on the northern portion of the subdivision (debris flow 460 [Lowe, 1988c]). Keaton and Lowe (1998) document two historical sedimentation-flood events from Middle Fork Kays Creek (1947 and 1983) and seven from South Fork Kays Creek (1912, 1923, 1927, 1930, 1945, 1947, and 1983). Therefore, I disagree with Earthtec's (1999) statement that the risk of debris flows and debris floods is low. Based on the geologic evidence for debris flows at the site and the documented historical debris flows, I recommend the debris-flow hazard from Middle and South Fork Kays Creek be re-evaluated. The evaluation should define areas of active deposition and estimate the frequency and volume of flows, travel paths, flow depths, and velocities to determine appropriate hazard-reduction measures as outlined in Lowe (1993).

  Surface-water runoff from Middle Fork and South Fork Kays Creek, associated with rapid snowmelt or intense rainfall, may cause alluvial-fan flooding. Based on the above history of flooding, as well as debris flows, I disagree with Earthtec's conclusion that the flood hazard is low and recommend that the flooding potential from Middle and South Forks Kays Creek be evaluated. Erickson and others (1968) indicate moderately to highly erodible soils on site, so soil erosion by floodwaters should also be addressed.

- ! Radon Gas: The subdivision is in an area of moderate to high radon-hazard potential (Black and Solomon, 1996). Radon gas represents a possible health hazard where structures intended for human occupancy are planned. Radon-resistant construction techniques should be considered for incorporation into residential structures.

SUMMARY AND RECOMMENDATIONS

Regarding Earthtec's (1999) assessment of hazards at the site, I recommend the following:

- ! Evaluate the surface-fault-rupture hazard associated with the Wasatch fault by performing a site-specific study that includes detailed aerial-photo and field investigations to identify possible fault scarps or other evidence of faulting, and trenching of possible faults identified, to locate them and determine appropriate setbacks.

- ! Evaluate the debris-flow and alluvial-fan flooding hazards from Middle Fork and South Fork Kays Creek and provide hazard-reduction measures.

- ! Consider radon-resistant construction techniques in the residential structures.

- ! Have a qualified geotechnical engineer review the geotechnical recommendations.

- ! Disclose the Earthtec (1999) report, subsequent reports, and this review to future buyers.

I recommend that setbacks, hazard areas, and protective structures, determined from the above hazard evaluations, be shown on the subdivision plat map to delineate buildable areas. Specific recommendations and restrictions pertaining to site building design and lot development should be included in the report. All conclusions and recommendations must be supported with evidence. The hazard evaluations should be performed by a qualified engineering geologist, hydrologist, and/or geotechnical engineer, as appropriate. Also, Layton City should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Black, B.D., and Solomon, B.J., 1996, Radon-hazard potential of the lower Weber River area, Tooele Valley, and southeastern Cache Valley, Cache, Davis, Tooele, and Weber Counties, Utah: Utah Geological Survey Special Study 90, 56 p.

Earthtec Engineering P.C., 1999, Geotechnical study Jacobson P.R.U.D., 1850 North Valley View Drive, Layton, Utah: Ogden, Utah, unpublished consultant's report for Steve Brandley, Creekside Development, 14 p.

Erickson, A.J., Wilson, Lemoyne, Hughie, V.K., Nielson, Woodrow, and Chadwick, R.S., 1968, Soil survey, Davis-Weber area, Utah: U.S. Department of Agriculture Soil Conservation Service, 149 p.

Keaton, J.R., and Lowe, Mike, 1998, Evaluating debris-flow hazards in Davis County, Utah - engineering versus geological approaches, in Welby, C.W., and Gowan, M.E., editors, A paradox of power - voices of warning and reason in the geosciences: Geological Society of America, Reviews in Engineering Geology, Volume XII, p. 97-121.

Lowe, Mike, 1988a, Natural hazards overlay zone - surface fault rupture, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

--- 1988b, Natural hazards overlay zone - debris flow hazard, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

--- 1988c, Natural hazards overlay zone - slope failure inventory map, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

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Survey Professional Paper 1519, p. 143-150.

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<table>
<tr><td colspan="3">Project:
Review of geotechnical study for proposed junior high school, 3570 South 7755 West, Magna, Salt Lake County, Utah</td><td>Requesting Agency:
Granite School District</td></tr>
<tr><td>By:
Richard E. Giraud</td><td>Date:
04-08-99</td><td>County:
Salt Lake</td><td rowspan="2">Job No:
99-08
(R-08)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
Magna (1214)</td><td>Number of attachments:
None</td></tr>
</table>

INTRODUCTION

This report is a review of a geotechnical report for a proposed junior high school at 3570 South 7755 West in Magna, Utah, by Delta Geotechnical Consultants, Inc. (Delta, 1999). The proposed school site is located in the E1/2W1/2 NW1/4 section 33, T. 1 S., R. 2 W., Salt Lake Base Line and Meridian. Oscar Anderson (Granite School District) requested the review. The report was received by the Utah Geological Survey on March 11, 1999. The purpose of my review is to evaluate if geologic hazards at the proposed school site are adequately addressed under State Office of Education Rule (USOE) R277-455 which requires public-education building sites to be inspected for geologic hazards by the Utah Geological Survey prior to approval by the USOE. Although I did not perform a field visit, my review of this site investigation by Delta (1999) fulfills the intent of USOE Rule R277-455. I previously conducted a preliminary geologic-hazards screening evaluation of this site, which is summarized in my letter dated April 15, 1998, to the Granite School District. In addition to addressing geologic hazards, Delta (1999) also provides geotechnical-engineering recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND RECOMMENDATIONS

Delta (1999) addresses possible hazards resulting from earthquake ground shaking, liquefaction, problem soils, and shallow ground water. I concur with their recommendations regarding these hazards but provide an additional comment below on earthquake ground shaking.

! Earthquake ground shaking: Delta (1999) states that at a minimum the building should be designed and constructed in accordance with the seismic zone 3 requirements of the Uniform Building Code (UBC). As discussed in my preliminary screening letter, I recommend that critical facilities such as schools along the Wasatch Front be designed to UBC seismic zone 4 standards to provide additional safety.

It is unclear if Delta (1999) considered all geologic hazards that could potentially affect the site because they do not mention other geologic hazards or state that all hazards were considered. Although, I am unaware of any additional hazards that could affect the site and I believe Delta (1999) addressed the hazards of concern, in future geologic-hazard studies for new school sites I recommend that the consultant clearly state that all hazards were considered.

REFERENCE

Delta Geotechnical Consultants, Inc., 1999, Geotechnical study for proposed Granite School District new junior high school, 3570 South 7755 West, Magna, Utah: Salt Lake City, Utah, unpublished consultant's report for Jeff Pinegar, 9 p.

<table>
<tr><td colspan="3">Project:
Review of “Geological hazards study phase 1, Alpine Brook Town Homes at Sunridge Hills, Provo, Utah County, Utah”</td><td>Requesting Agency:
City of Provo Engineering Department</td></tr>
<tr><td>By:
Richard E. Giraud</td><td>Date:
04-13-99</td><td>County:
Utah</td><td rowspan="2">Job No:
99-09
(R-09)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
Provo (1047), Springville (1046)</td><td>Number of attachments:
None</td></tr>
</table>

INTRODUCTION

This report is a review of a geologic-hazards study for the proposed Alpine Brook Town Homes at Sunridge Hills, by RB&G Engineering Inc. (RB&G, 1999). The subdivision is located at approximately 1200 South Slate Canyon Drive in the NW1/4 NE1/4 section 17, T. 7 S., R. 3 E., Salt Lake Base Line and Meridian. Nick Jones (City Engineer, Provo City) requested the review. The Utah Geological Survey received the report on March 8, 1999. The purpose of my review is to evaluate if geologic hazards at the subdivision are adequately addressed. The scope of my review includes review and inspection of aerial photographs, geologic maps, and Utah County natural-hazard overlay maps, as well as a previous review (Giraud, 1998) of an earlier geotechnical report for this property by RB&G (1995) addressing problem soils, shallow ground water, faulting, and slope stability. I did not conduct a field inspection of the subdivision or trenches. The RB&G (1999) report does not contain a general location map and the location map in the 1995 RB&G report appears to be in error. An accurate location map must be included with subsequent submittals.

DISCUSSION AND COMMENTS

RB&G (1999) addresses earthquake ground shaking, surface fault rupture, slope stability, debris flows, alluvial-fan flooding, and rock falls. I concur with their recommendations regarding earthquake ground shaking, surface fault rupture, and rock-fall hazards. My comments and recommendations regarding surface fault rupture, slope stability, debris flows, alluvial-fan flooding, and rock falls are outlined below.

! Surface fault rupture: RB&G (1999) identified areas of active faulting and provided setbacks from active faults. I concur with their setback recommendations. RB&G (1999) states that buildings may be built in the deformation zone with fault displacements of less than 4 inches (figure 1, green shaded area) if they are designed to withstand 4 inches of displacement. For buildings in this deformation zone, I recommend a qualified structural engineer provide a design (including an appropriate factor of safety) for these buildings to account for displacements of up to 4 inches, and provide conclusions regarding the effects of anticipated displacements in the buildings.

! Slope Stability: RB&G (1999) evaluated both dry and saturated slope conditions, using reduced estimated shear strength values (decreased cohesion) to model saturated conditions, rather than using a shallow water table in the computer model to account for the pore pressure effects. Because these effects are often the cause of slope instability (Duncan, 1996), I recommend further evaluation to reflect the pore pressure effects of a shallow water table in slopes where such water tables may develop from landscape irrigation. Under development-induced ground-water conditions, water will likely perch on and eventually saturate the relatively less permeable, weak Lake Bonneville silt and clay layers identified in trenches and boring logs. Seismic slope stability should also be evaluated for the subdivision (Giraud, 1998) to determine slope stability during earthquake ground shaking.

RB&G (1999) recommends that a lower factor of safety (1.2 rather than 1.5) is acceptable for saturated slopes, but they do not indicate their basis for this recommendation. I believe this factor of safety is too low, particularly when using estimated soil strengths in the slope-stability analysis where the recommended static factor of safety is $ 1.5 (Hylland, 1996). Also, the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, Section 3312) does not allow cut slopes steeper than 2H:1V (50 percent), unless the soil engineer or engineering geologist indicates that they are stable. The preliminary RB&G analysis does not indicate stability for steeper slopes (1.5H:1V, 67 percent), and therefore I agree with RB&G that site-specific soil-test data are needed, particularly for slopes in clayey soils where development-induced shallow water tables can be expected.

! Debris Flows and Alluvial-Fan Flooding: RB&G (1999) concludes that debris flows and alluvial-fan flooding are not a concern because drainage channels direct flow away from the subdivision. RB&G (1999) states that debris-flow deposits were not observed at the site, although the origin of the post-Lake Bonneville sand and gravel deposits described in trenches and boreholes is not discussed. No surficial geologic map is presented and copies of site topographic maps are too poor to identify alluvial fans. The topographic contours on the Provo City geologic-hazard maps (International Engineering Company Inc., 1984), however, indicate at least one drainage on the range-front facet with a small fan at the base of the facet. Based on the topographic and geologic setting, geologic-unit descriptions, stratigraphic relationships, trench photographs, and aerial photographs, I believe the post-Lake Bonneville deposits are likely alluvial-fan sediments. Machette (1992) maps Holocene and uppermost Pleistocene alluvial-fan sediments on the south portion of the subdivision and I believe they may also be found north of the fault scarp in the northern portion. The post-Lake Bonneville sediments may have been deposited by hyperconcentrated flows or stream flows, the other two more dilute flow types in the sediment-water flow continuum (Pierson and Costa, 1987), rather than debris flows. The origin of the post-Lake Bonneville deposits must be determined to help evaluate if future sedimentation events are a hazard for the subdivision. The National Research Council (1996) provides field criteria for distinguishing deposits indicative of the various flows in the sediment-water continuum.

RB&G must either provide quantitative support for their statement that channels are sufficient to direct flow away from the subdivision or show hazard areas (feeder channels and flood/depositional areas) on a map relative to the subdivision. When drainage channel capacity is used to evaluate hazard potential, the channel capacity must be compared to the estimated peak flow of the flood/sedimentation event to determine if overbank flooding/sedimentation could occur. As previously recommended (Giraud, 1998), the debris-flow and alluvial-fan flooding hazard evaluation should define areas of active deposition (post-Bonneville alluvial fans); estimate the frequency, volume, and types of flows; define travel paths; and estimate flow depths. I recommend the debris-flow and alluvial-fan flooding hazard be re-evaluated. The channels must be shown to contain at least a 100-year clear-water flood and a sedimentation event for these drainages, or mitigation measures must be recommended.

The flow depths and debris volumes likely to affect an alluvial fan can be estimated by determining the thickness and extent of existing individual depositional events on the alluvial fan or by estimating the volume of debris that could be produced from the drainage basin and feeder channel. On the alluvial fan, trenches and test pits can be excavated to determine flow types, thicknesses, lateral extent, and approximate volume (Mulvey, 1993). In the drainage basin, sediment is typically eroded from the feeder channel by progressive sediment bulking during an intense rainfall or snowmelt event (Keaton and Lowe, 1998). Available sediment in mountain channels can be estimated based on the extent of bedrock exposure in the channel and thickness of channel sediments. Debris production and accumulation in alluvial-fan feeder channels and methods to estimate future debris volumes are discussed by Williams and Lowe (1990). The possibility of feeder-channel plugging and diversion of flow to other distributary fan channels by a sedimentation event (Costa, 1984) must also be considered in the evaluation. Also, human alterations to channel courses and obstructions to flow must be considered.

- Rock Fall: RB&G (1999) considers the rock-fall hazard “minimal to modest” and recommends a flat bench be designed and constructed with a chain-link fence or catchment ditch to reduce the risk from rock falls. I recommend that a design be provided for the catchment structure and the structure’s location be shown on the site plan.

SUMMARY AND RECOMMENDATIONS

Regarding RB&G’s (1999) assessment of hazards at the site, I recommend the following:

- Submittal of an accurate location map on a 7 ½-minute topographic base and a site surficial geologic map showing alluvial-fan deposits, lacustrine silts and clays, and lacustrine beach sands and gravels.

- For buildings planned in the surface fault rupture zone with fault displacements of 4 inches or less, a qualified structural engineer should evaluate and design the buildings with an adequate factor of safety, and indicate the effects of the anticipated displacements on the building. I also recommend that a structural engineer review the design.

- ! Slope stability should be re-evaluated using laboratory soil-strength test data and accounting for pore pressure effects caused by a shallow development-induced water table and earthquake ground-shaking conditions. As recommended by RB&G, additional subsurface investigations are needed at critical locations to collect samples for shear strength tests, particularly in areas of proposed cuts in silt and clay soils below building sites where shallow water-table conditions may result from landscape irrigation.

- ! Re-evaluate the debris-flow (sedimentation) and alluvial-fan flooding hazards to define areas of active deposition (post-Bonneville alluvial fans) and flooding, to estimate the type, frequency, and volume of flows, travel paths, and flow depths in relation to channel capacities.

- ! Provide a design and show the location of the rock-fall catchment structure.

- ! Disclose the existence of the RB&G (1999) report and this review, and any previous and subsequent reports and reviews, to future buyers.

I recommend that hazard areas and protective structures, determined from the above hazard evaluations, be shown on the site map. Specific recommendations and restrictions pertaining to site design and lot development should be included in the report. All conclusions and recommendations must be supported with evidence. The hazard evaluations should be performed by a qualified engineering geologist, hydrologist, and/or geotechnical engineer, as appropriate. Also, Provo City should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

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RB&G Engineering, 1995, Geotechnical investigation, Town Homes at Sunridge Hills, Provo, Utah: Provo, Utah, unpublished consultant's report for Steve Stewart, Sun Ridge Development, 10 p.

---1999, Geological hazards study phase 1, Alpine Brook Town Homes at Sunridge Hills, Provo, Utah: Provo, Utah, unpublished consultant's report for Steve Stewart, Sun Ridge Development, 11 p.

Williams, S.R., and Lowe, Mike, 1990, Process-based debris-flow prediction method, in French, R.H., editor, Hydraulics/hydrology of arid lands: New York, American Society of Civil Engineers Special Publication, p. 66-71.

Project: Review of “Engineering geologic/geotechnical reconnaissance, lot 262, Timber Lakes subdivision, Heber City area, Utah”			Requesting Agency: Wasatch County
By: Barry J. Solomon	Date: 05-06-99	County: Wasatch	Job No: 99-10 (R-10)
USGS Quadrangle: Center Creek (1126)		Number of attachments: None	

In response to a request from Anthony Kohler, Wasatch County Planning Assistant, I reviewed the geotechnical report for Timber Lakes lot 262 by Delta Geotechnical Consultants, Inc. (Delta, 1997). I received the report on April 23, 1999. Lot 262 is in the NW1/4 section 9, T. 4 S., R. 6 E., Salt Lake Base Line and Meridian. The purpose of my review is to assess whether Delta (1997) adequately addressed the potential for landslides on the lot. My scope of work included a review of published geologic-hazards maps (Hylland and Lowe, 1995), examination of aerial photos (1:20,000 scale, 1962; 1:40,000 scale, 1987), and inspection of the property on April 28, 1999, with Richard Giraud and Gary Christenson, Utah Geological Survey (UGS). Recommendations pertaining to foundation design and site grading in Delta (1997) should be reviewed by a qualified geotechnical engineer.

Delta (1997, p. 5) states that “no evidence of slope instability or landslides were observed on the site or adjacent properties.” I believe that such evidence exists. Lot 262 lies on the southern edge of one of several deep-seated landslides in the Timber Lakes subdivision (Utah Geological Survey unpublished mapping). The landslide was first identified in a geotechnical report (Klauber, 1996) for lot 223, upslope and adjacent to lot 262. Although Delta’s review of aerial photos indicated to them that the landslide did not extend onto lot 262, I found the Klauber (1996) landslide clearly visible on aerial photos, with a west-facing arcuate main scarp east of Lake Pines Drive and landslide debris extending westward across Lake Pines Drive to the drainage at the base of the slope. The landslide debris underlies at least part of lot 262, as well as nearby lots.

This landslide was not mapped in an earlier assessment of landslide hazards by Hylland and Lowe (1995), but they assign a high relative landslide hazard to the lot based on slope inclination and the lot’s location within an older landslide complex. According to Delta (1997), the lot consists of an upper segment descending from Lake Pines Drive with an approximate slope of 28 percent, and a lower segment descending to the drainage at about 40 percent. Our measurements at the site indicate the lower segment locally exceeds a slope of 50 percent. Slopes of both segments exceed the critical slope inclination (25 percent), defined by Hylland and Lowe (1997) as the slope inclination above which late Holocene landsliding has typically occurred in similar geologic materials.

The presence of a landslide partly on lot 262, and steep slopes with inclinations exceeding critical values, warrants further study of the landslide hazard on lot 262. I therefore recommend:

- at least a preliminary geotechnical-engineering evaluation of local steep slopes and the deep-seated landslide identified by Klauber (1996), consistent with the recommendations of Hylland (1996);

- evaluation of the cumulative affect of development, particularly increases in ground-water levels from septic-tank soil-absorption (STSA) systems, on the stability of local steep slopes on the lot as well as the overall stability of the Klauber (1996) landslide; and

- inclusion of a topographic map at a scale suitable for site planning, created by a qualified surveyor, showing recommended building setbacks, non-buildable areas, the house and STSA-system locations, and any site-design features to reduce hazards.

The long-term stability of the Klauber (1996) landslide, and cumulative effects of development on stability, are difficult to assess in a lot-specific study such as this. I recommend that landslide stability be addressed before permitting additional development on the landslide.

REFERENCES

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Klauber, William, 1996, Landslide reconnaissance of lot 223, Timber Lakes Estates, Wasatch County, Utah: West Jordan, Utah, unpublished consultant's report, 10 p.

Project: Review of geologic-hazards investigation, proposed Canyon Creek Estates, Layton, Davis County, Utah			Requesting Agency: Layton City Community Development Dept.
By: Richard E. Giraud	Date: 05-21-99	County: Davis	Job No: 99-11 (R-11)
USGS Quadrangle: Kaysville (1320)		Number of attachments: None	

INTRODUCTION

This report is a review of a geologic-hazards investigation for the proposed Canyon Creek Estates subdivision, by LGS and Associates Inc. (LGS, 1999). The subdivision is located on the east side of U.S. Highway 89 at 438 North, Layton, Utah (NW1/4 SW1/4 section 24, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian). Doug Smith (Planner, Layton City) requested the review. The report was received by the Utah Geological Survey on April 19, 1999. The purpose of my review is to evaluate if geologic hazards at the subdivision are adequately addressed. The scope of my review included a literature review and a site visit on March 26, 1999. I performed an earlier review of a soils and ground-water report (Giraud, 1998) by George Toland Consulting Geotechnical Engineers (Toland, 1998).

DISCUSSION AND COMMENTS

LGS (1999) addresses possible hazards resulting from surface fault rupture, slope instability, debris flows, and alluvial-fan flooding. I provide comments and recommendations on these hazards below. I concur with their recommendations regarding erosion control and channel maintenance of North Fork Holmes Creek.

! Surface Fault Rupture: LGS (1999) identified northwest-trending aerial photo lineaments, and excavated trenches to evaluate possible faulting associated with these lineaments. LGS (1999) found no evidence of surface fault rupture in their trenches. However, the trench logs do not indicate the age(s) of the geologic units exposed in the trenches. Because the geologic units are part of an active alluvial fan, they may be much younger than 10,000 years and may even post-date the most recent surface-faulting earthquake on the Weber segment of the Wasatch fault. An estimate of the age(s) of the geologic units must be given to evaluate the extent to which the investigation addresses the surface-fault-rupture hazard within the past 10,000 years. Also, the untrenched areas between trenches 1 through 6 are not evaluated (LGS, 1999, figures 2, 4, and 5). In order to adequately evaluate surface fault rupture hazard trenches must be continuous across the area of concern (McCalpin, 1996). In the untrenched areas between trenches 1 through 6, LGS must provide supporting evidence to demonstrate that there is no evidence of faulting.

! Slope Stability: LGS (1999) concludes that the steep fault scarp on and above lots 11 and 12 is stable but only if site grading does not impinge on the slope toe areas. I have previously indicated (Giraud, 1998) that Nelson and Personius (1993) show landslide scarps in steep slopes along the Wasatch fault scarp in deposits similar to those northeast of lots 11 and 12, and I recommended that a slope-stability analysis of this scarp be performed. LGS (1999) recommends that the stability of any cuts and excavations within lots 11 and 12 be evaluated by a geotechnical engineer or engineering geologist and I agree. I believe the stability of the steep fault scarp, as well as planned cuts and excavations, should be evaluated prior to subdivision approval to determine if setbacks or other risk-reduction measures are needed. Slope performance must be evaluated under appropriate earthquake ground-shaking and estimated development-induced (landscape irrigation) ground-water conditions.

! Debris Flows: LGS (1999) concludes that the debris-flow hazard is low to very low, but does not define a low to very low hazard relative to debris-flow size and frequency. LGS (1999) recognizes young debris-flow deposits on the alluvial fan but does not discuss the implications of these deposits to the debris-flow hazard. I believe the young debris flow on the upper part of the alluvial fan indicates a significant debris-flow hazard at the site.

I disagree that the waterfalls upstream would serve as effective check dams and that the drainage is quite free of debris. The young debris-flow deposit on the alluvial fan is evidence that the waterfalls have not prevented debris flows from reaching the area of the proposed subdivision in the past. Lowe (1988) maps a historical debris flow (Dfa 490) in Adams Canyon that did not reach the alluvial fan. Because sediment associated with debris flow Dfa 490 was deposited in the North Fork Holmes Creek channel, this sediment could be remobilized in a subsequent debris-flow event. Because of this I believe Adams Canyon has the potential to produce future large debris flows and recommend that the debris-flow hazard be re-evaluated. As previously recommended (Giraud, 1998), the debris-flow-hazard evaluation should define areas of active deposition (post-Bonneville alluvial fans); estimate the frequency, volume, and types of flows; define travel paths; and estimate flow depths.

LGS (1999) also provides an opinion that the present channel will contain debris flows or minimize overbank flow. When channel capacity is used to evaluate hazard potential, the calculated channel capacity must be compared to the estimated peak flow of the sedimentation event to determine if overbank sedimentation could occur. LGS must either provide quantitative support for their opinion or show hazard areas (feeder channel, channel-fan intersection point, and debris/sediment depositional areas) on a map relative to the subdivision and provide appropriate setbacks and/or other risk-reduction measures.

The flow depths and debris volumes likely to affect an alluvial fan can be estimated by determining the thickness and extent of existing individual depositional events on the alluvial fan or by estimating the volume of debris that could be produced from the drainage basin and feeder channel. On the alluvial fan, trenches and test pits can be excavated to determine flow types, thicknesses, lateral extent, and approximate volume (Mulvey, 1993). In the drainage basin, sediment is typically eroded from the feeder channel by progressive sediment bulking during an intense rainfall or snowmelt event (Keaton and Lowe, 1998). Available sediment in drainage-basin channels can be estimated based on the extent of bedrock exposure in the channel and thickness of channel sediments. Debris production and accumulation in alluvial-fan feeder channels and methods to estimate future debris volumes are discussed by Williams and Lowe (1990). The possibility of feeder-channel plugging and diversion of flow to other distributary fan channels by a sedimentation event (Costa, 1984) must also be considered in the evaluation. Many of the historical debris flows in Davis County have not been contained by the alluvial-fan channel. Also, human alterations to channel courses and obstructions to flow such as culverts must be considered.

! Alluvial-Fan Flooding: LGS (1999) states that flooding is not a concern to the proposed development. The Federal Emergency Management Agency (FEMA) has mapped a 100-year flood inundation area (zone A3; FEMA, 1982) along North Fork Holmes Creek west of Highway 89. FEMA did not map the subdivision area and North Fork Holmes Creek east of Highway 89. However, based on FEMA mapping west of Highway 89 I believe a 100-year flood inundation zone may also exist along North Fork Holmes Creek in the subdivision. LGS (1999) gives an opinion, although not based on hydrologic data, that the channel will accommodate future high-runoff flows. As mentioned above, the channel capacity must be compared to the estimated peak flow of the flood event to determine if alluvial-fan flooding will occur in the proposed subdivision. I recommend the alluvial-fan flooding hazard be re-evaluated and that conclusions and recommendations be based on quantified data. I also recommend that subdivision design comply with the Davis County Flood Control Ordinance. I concur with the LGS recommendation to keep the channel free and unobstructed, however no discussion of who is responsible for performing this duty is included. For this recommendation to be effective, a mechanism must be in place to ensure the inspections are performed and, if a channel obstruction persists, that it is removed.

RECOMMENDATIONS

Regarding LGS's (1999) assessment of geologic hazards at the site, I recommend the following:

! Provide age estimates for the geologic units described in trenches to demonstrate the extent to which the trench exposures evaluate faulting within the past 10,000 years. Supporting evidence must be provided to demonstrate faulting is not present in areas between trenches 1-6.

! Evaluate the stability of the steep slope above lots 11 and 12. The stability analysis must consider any planned cuts, excavations, earthquake ground-shaking conditions, and development-induced (landscape irrigation) ground-water conditions.

! Re-evaluate the debris-flow and alluvial-fan flooding hazards and define areas of active deposition/inundation; estimate the frequency, volume, and types of flows; define travel paths; estimate flow depths; and recommended risk-reduction measures.

! Disclose the LGS (1999) report, the previous report (Toland, 1998) and review (Giraud, 1998), subsequent reports, and this review to future buyers.

I recommend that setbacks, hazard areas, and protective structures, determined from the above hazard evaluations, be shown on the subdivision plat map to delineate buildable areas. Specific recommendations and restrictions pertaining to site building design and lot development should be included in the report. All conclusions and recommendations must be supported with quantified data. The hazard evaluations should be performed by a qualified engineering geologist, hydrologist, and/or geotechnical engineer, as appropriate. Also, Layton City should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consulting geologist, hydrologist, or engineer indicating that their recommendations have been followed.

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Williams, S.R., and Lowe, Mike, 1990, Process-based debris-flow prediction method, in French, R.H., editor, Hydraulics/hydrology of arid lands: New York, American Society of Civil Engineers Special Publication, p. 66-71.

Project: Review of geotechnical and geologic reports, Lot 120 Interlaken Estates, Midway, Wasatch County, Utah			Requesting Agency: Wasatch County Planning Department
By: Richard E. Giraud	Date: 05-26-99	County: Wasatch	Job No: 99-12 (R-12)
USGS Quadrangle: Heber City (1168)		Number of attachments: None	

INTRODUCTION

This report is a review of a geotechnical study by Earthtec Testing and Engineering, P.C. (Earthtec, 1999) and a geologic reconnaissance report by American Geological Services, Inc. (AGS, 1999) for lot 120 in Interlaken Estates, 335 Bern Way, Midway (SE1/4 section 22, T. 3 S., R. 4 E., Salt Lake Base Line and Meridian). A letter addressing slope stability under saturated conditions and slope-stability computer-output plots were also submitted for review. The report, letter, and computer plots were received by the Utah Geological Survey on April 12, April 23, and May 5, 1999, respectively. Anthony Kohler (Wasatch County Planner) requested the review. The purpose of my review is to evaluate if geologic hazards at the lot are adequately addressed. The scope of work consisted of a literature review and a site visit on April 28, 1999. Earthtec (1999) also provides geotechnical recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Earthtec (1999) and AGS (1999) address possible hazards resulting from surface fault rupture, ground shaking, landslides, problem soils, and debris flows. This appears to be a complete list of possible geologic hazards at the subdivision. I concur with their recommendations regarding surface fault rupture, ground shaking, and debris flows. I also concur with their drainage recommendations to divert runoff and prevent infiltration at the lot, line the irrigation ditch (if it is still used), inspect the sewer line to prevent leakage, and divert runoff from the proposed house and other runoff from adjacent properties offsite. I provide comments and recommendations below regarding slope stability, retaining walls, and slope cuts.

The initial Earthtec (1999) report evaluates static and seismic slope stability under unsaturated conditions, assuming a deep water table and using estimated soil strength parameters that are reduced to account for moist conditions. The approach taken in the April 23 letter uses higher strengths and saturated conditions with three different water-table depths to account for possible development-induced ground water. I believe the latter approach is most representative of actual conditions because pore-pressure effects of the water table within the slope are considered. Earthtec indicates the factor of safety is marginal for water-table depths 1 to 2 feet and 5 to 8 feet below the ground surface, and acceptable for water-table depths 19 to 25 feet below the ground surface.

Earthtec (1999) indicates no ground water is present in soils above bedrock in the hole drilled in March 1999, so under natural conditions soils are unsaturated. Because of the negative effects of ground water on slope stability, landscape irrigation must be minimized and drainage recommendations to inhibit water infiltration into the slope must be followed. Also, water and sewer lines must be inspected for leakage and repaired.

Earthtec (1999) mentions that retaining walls will be constructed throughout the site, but they do not describe the location or design of the retaining walls. I recommend that an engineered design be provided for the retaining walls and that both static and earthquake ground shaking conditions and appropriate drainage be incorporated in the wall design. A site plan and slope profile showing cuts, fills and retaining walls should be submitted with the retaining-wall design. A vertical road cut is present on the site; the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, Section 3312) does not allow permanent cut slopes steeper than 2H:1V (50 percent) unless the soil engineer or engineering geologist indicates the slopes are stable. If the road cut or any other permanent cuts having slopes steeper than 2H:1V (50 percent) are not supported by retaining walls, the cut-slope stability must be addressed.

RECOMMENDATIONS

Regarding the Earthtec and AGS assessment of hazards at the site I recommend the following:

- Minimize landscape irrigation, follow all drainage recommendations, and monitor water and sewer lines for leakage to prevent water infiltration into the slope. To ensure stability, a shallow water table must not be permitted to develop in the slope. Monitoring for evidence of shallow ground water is advisable to ensure that development has not altered ground-water conditions. Also, all drains must be maintained to ensure their effectiveness.

- Provide an engineered design for the retaining walls and have the design reviewed by a qualified engineer. The design must include a site map and slope profile showing cuts, fills, and retaining walls. The retaining-wall design must consider static and earthquake ground-shaking conditions and incorporate pertinent drainage recommendations. A geotechnical engineer should also review foundation and site grading recommendations.

- Address the stability of the road cut and any other permanent cuts greater than 2H:1V (50 percent) not supported by retaining walls.

- Disclose the existence of the Earthtec (1999) and AGS (1999) reports and letters, subsequent reports, and this review to all future buyers.

Wasatch County should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

American Geological Services, Inc., 1999, Geologic reconnaissance lot 120 Interlaken Estates, Midway, Utah: Provo, Utah, unpublished consultant's report for Earthtec Testing and Engineering, P.C., 4 p.

Earthtec Testing and Engineering, P.C., 1999, Geotechnical study lot 120 Interlaken Estates, Midway, Utah: Orem, Utah, unpublished consultant's report for Bob Davis, 23 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, International Conference of Building Officials, Volume 1, Appendix Chapter 33, p. 407-411.

Project: Review of "Geotechnical study, lot 167, Interlaken development, Midway, Utah"			Requesting Agency: Wasatch County
By: Barry J. Solomon	Date: 06-23-99	County: Wasatch	Job No: 99-13 (R-13)
USGS Quadrangle: Heber City (1168)		Number of attachments: None	

INTRODUCTION

In response to a request from Anthony Kohler, Wasatch County Planning Assistant, I reviewed the geotechnical report for Interlaken Estates lot 167 by Earthtec Testing & Engineering, P.C. (Earthtec, 1999). I received the report on June 14, 1999. The geotechnical report includes an addendum by American Geological Services, Inc., describing the results of a geological reconnaissance of the lot. Lot 167 is in the SW1/4 section 23, T. 3 S., R. 4 E., Salt Lake Base Line and Meridian. The purpose of my review is to assess whether Earthtec (1999) adequately addressed the potential for geologic hazards on the lot. My scope of work included a review of published geologic mapping (Bromfield and others, 1970), but I did not inspect the property. Recommendations pertaining to foundation design and site grading in Earthtec (1999) should be reviewed by a qualified geotechnical engineer.

DISCUSSION

Earthtec (1999) lists earthquake ground shaking, rock falls, debris flows, liquefaction, and subsidence as potential geologic hazards on the property. The report recommends that proposed structures on the property be designed in accordance with the requirements of Uniform Building Code seismic zone 3 to minimize the risk from earthquake ground shaking, and I concur. The report acknowledges the potential for rock fall to impact the site because of its location on mountain slopes, but considers the hazard to be low because of the presence of an upslope roadway acting as a deterrent, and I agree. The report also considers the potential for debris flows, subsidence, and liquefaction to be low. I agree with this conclusion; the site is not located on or near a significant drainage (minimizing the potential for debris flows), soluble minerals are not significant components of soil and rock underlying the lot (reducing the potential for subsidence), and site soils are dry and clayey (not susceptible to liquefaction). Earthtec (1999) did not encounter expansive or collapsible soils during its investigation. However, Earthtec (1999, p. 20) makes prudent recommendations regarding site grading, runoff, irrigation, and compaction to minimize the impacts of problem soils should they be encountered.

The report finds no evidence of recent landslide or slope movement on the lot, but because of the steep slope (17 to 30 percent) Earthtec (1999) includes slope-stability analyses conducted with the computer program PCSTABL6. The analyses address potential landsliding from shallow, circular failure surfaces, but do not address potential failures along rock discontinuities (joints, bedding, and small shears). Earthtec (1999) documents the orientation of major rock discontinuities (northeast-striking beds and vertical joints) and believes that they will not contribute to slope failure (on the northwest-trending slope); I agree. The analyses model the slope with stratigraphy (including, from top to bottom, clay, weathered bedrock, and competent bedrock) determined from a borehole near the north (upslope) end of the lot. Soil-strength parameters for the clay (cohesion 250 pounds per square foot [psf], friction angle 28 degrees) were determined by laboratory testing of a split-spoon sample from the borehole; parameters for the weathered and competent bedrock (respectively, 1,000 psf and 34 degrees, 4,000 psf and 36 degrees) were estimated. Although Earthtec (1999) found no ground water in its investigation of lot 167, they analyzed slope stability under both static and pseudo-static conditions with both dry soils and a shallow water table (4-foot depth). In all cases, factors of safety exceeded the acceptable levels of 1.5 under static conditions and 1.0 under pseudo-static conditions, indicating that site slopes are stable. To increase stability, Earthtec (1999) recommends (1) supporting the proposed home on footings founded entirely on competent bedrock, (2) setting the foundation back a minimum of 15 feet from the slope face, (3) properly designing retaining walls and designing subgrade walls to act as retaining structures, (4) installing a drainage system adjacent to all retaining and subgrade walls to reduce pore pressures, and (5) implementing design features noted above to minimize the impacts of problem soils. However, Earthtec (1999) does not describe the location or design of the retaining walls.

RECOMMENDATIONS

I believe Earthtec (1999) adequately addresses geologic hazards on Interlaken Estates lot 167 and agree with the report's conclusions that the potential for geologic hazards is low. The potential for landslides may be further reduced by implementing site-design features suggested in the report. I therefore recommend that:

- recommendations pertaining to foundation design and site grading in Earthtec (1999) and any subsequent studies be reviewed by a qualified geotechnical engineer.

I further recommend that the developer:

- provide an engineered design for retaining walls and have the design reviewed by a qualified engineer; the design must include a site map and slope profile showing cuts, fills, and retaining walls; the retaining-wall design must consider static and earthquake ground-shaking conditions and incorporate pertinent drainage recommendations; and

- if permanent cuts have slopes steeper than 2H:1V (50 percent) and are not supported by retaining walls, cut-slope stability must be addressed in accordance with the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, section 3312).

Wasatch County should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Bromfield, C.S., Baker, A.A., and Crittendon, M.D., Jr., 1970, Geologic quadrangle map of the Heber quadrangle, Utah: U.S. Geological Survey Map GQ-864, scale 1:24,000.

Earthtec Testing & Engineering, P.C., 1999, Geotechnical study, lot 167, Interlaken development, Midway, Utah: Orem, Utah, unpublished consultant’s report for Duane S. Carling, 21 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, California, International Conference of Building Officials, Volume 1, Appendix Chapter 33, p. 407-411.

<table>
<tr><td colspan="3">Project:
Review of "Geotechnical study, lot 216, Interlaken development, Midway, Utah"</td><td>Requesting Agency:
Wasatch County Planning</td></tr>
<tr><td>By:
Barry J. Solomon</td><td>Date:
07-21-99</td><td>County:
Wasatch</td><td rowspan="2">Job No:
99-14
(R-14)</td></tr>
<tr><td colspan="2">USGS Quadrangle:
Heber City (1168)</td><td>Number of attachments:
None</td></tr>
</table>

In response to a request from Anthony Kohler, Wasatch County Planning Assistant, I reviewed the geotechnical report for Interlaken Estates lot 216 by Earthtec Testing & Engineering, P.C. (Earthtec, 1999). I received the report on July 13, 1999. The geotechnical report includes an addendum by American Geological Services, Inc., describing the results of a geological reconnaissance of the lot. Lot 216 is in the SW1/4 section 23, T. 3 S., R. 4 E., Salt Lake Base Line and Meridian. The purpose of my review is to assess whether Earthtec (1999) adequately addressed the potential for geologic hazards on the lot. My scope of work included a review of published geologic mapping (Bromfield and others, 1970), but I did not inspect the property. Recommendations pertaining to foundation design and site grading in Earthtec (1999) should be reviewed by a qualified geotechnical engineer.

Earthtec (1999) lists landslides, earthquake ground shaking, rock falls, debris flows, liquefaction, and subsidence as potential geologic hazards on the property. I believe Earthtec (1999) adequately addresses geologic hazards on Interlaken Estates lot 216 and I agree with the report's conclusions that the potential for geologic hazards is low. The potential for landslides may be further reduced by implementing site-design features recommended in the report. To ensure slope stability, I recommend that the developer:

- provide an engineered design for retaining walls and have the design reviewed by a qualified engineer; the design must include a site map and slope profile showing cuts, fills, and retaining walls; the retaining-wall design must consider static and earthquake ground-shaking conditions and incorporate pertinent drainage recommendations; and

- address cut-slope stability in accordance with the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, section 3312) for any proposed permanent cuts with slopes steeper than 2H:1V (50 percent) that are not supported by retaining walls.

Wasatch County should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Bromfield, C.S., Baker, A.A., and Crittenden, M.D., Jr., 1970, Geologic map of the Heber quadrangle, Wasatch and Summit Counties, Utah: U.S. Geological Survey Map GQ-864, scale 1:24,000.

Earthtec Testing & Engineering, P.C., 1999, Geotechnical study, lot 216, Interlaken development, Midway, Utah: Orem, Utah, unpublished consultant's report for Stephan and Sandra Dembinsky, 22 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, California, International Conference of Building Officials, Volume 1, Appendix Chapter 33, p. 407-411.

Project: Review of geotechnical investigation, Rhodes Condominium building, Provo, Utah County, Utah			Requesting Agency: City of Provo
By: Richard E. Giraud	Date: 08-06-99	County: Utah	Job No: 99-16 (R-15)
USGS Quadrangle: Orem (1088)		Number of attachments: None	

INTRODUCTION

At the request of Dave Graves, Provo City Project Engineer, I reviewed a geotechnical report by RB&G Engineering, Inc. (RB&G, 1999) for the Rhodes Condominium building. The site is located at 5600 North Canyon Road in Provo, Utah, in the SW 1/4 SW1/4 section 7, T. 6 S., R. 3 E., Salt Lake Base Line and Meridian. I received the report on June 30, 1999. The purpose of this review is to evaluate if geologic hazards were adequately addressed. The scope of work for the review included a literature review and inspection of soil and geologic maps, Utah County natural-hazard overlay maps, and Provo City geologic-hazard maps. I visited the site on August 3, 1999 with Gary Christenson of the Utah Geological Survey. Recommendations pertaining to foundation design and site grading should be reviewed by a qualified geotechnical engineer.

RB&G (1999) addresses problem soils, shallow ground water, surface fault rupture, and slope stability. The report recommendations concerning these hazards are adequate. However as I interpret the site plan and slope profiles, to have enough space at the base of the slope for the building and parking lot, the final cut slope will need to be steeper than the evaluated slope. If this is the case, additional slope stability study may be necessary depending on final slope grade. In addition, debris-flow, alluvial-fan-flooding, and rock-fall hazards may exist at the site but were not addressed.

SURFACE FAULT RUPTURE

RB&G (1999) inspected a fault trench across the building's footprint that was excavated because a fault is shown on the Provo City geologic-hazard maps (International Engineering Company Inc. [IEC], 1984). No trench log was included, and RB&G states that, although no evidence of faulting was found, their study was not conclusive in discounting faulting at the site. Although IEC (1984) shows a fault at the site, the most recent mapping by Machette (1992) shows the nearest trace of the Wasatch fault approximately 4,500 feet east of the site, placing the site outside of the Utah County fault-rupture overlay zone (Robison, 1990). Based on this and the apparent lack of faulting in the trench, I do not believe further fault investigations are necessary.

SLOPE STABILITY

The site is within Utah County's landslide-hazard overlay zone (Robison, 1990) and a potential landslide area on the Provo City geologic-hazard maps (IEC, 1984). The RB&G (1999) investigation shows soils at the site to be thick unstratified gravel with no silt or clay beds. RB&G states that, based on their experience with gravel soils, a slope of 2.2H:1V will be stable under normal wetting conditions with a factor of safety greater than 1.5. I agree, and only add that allowance must also be made for raveling of the slope if it is not vegetated. However, to accommodate the proposed building and parking lot footprints shown on the site plan (figure 1), the final cut slope (figure 3) would need to be steeper than 2.2H:1V. I recommend showing the building and parking lot on the final cut slope drawing. If the final cut slope is steeper than 2.2H:1V, a slope-stability evaluation may be necessary depending on final grade of the gravel slope.

DEBRIS FLOWS AND ALLUVIAL-FAN FLOODING

The site is within the Utah County debris-flow hazard overlay zone (Robison, 1990). Machette (1992) maps young fan alluvium (Holocene to uppermost Pleistocene) upslope of the site, consisting of pebble and cobble gravel in a matrix of sand and minor clay. The fan alluvium is deposited by intermittent stream flow, debris floods, and debris flows. RB&G (1999) does not discuss the geologic origin of gravels at the site (for example, whether they are debris-flow/alluvial-fan deposits, hillslope colluvium, or Lake Bonneville deposits), so I do not know if recent sedimentation events have affected the site in the geologic past. Also, there is no discussion drainages east of the site and their potential to produce debris flows or flooding during rapid snowmelt or intense rainfall. If debris-flow/alluvial-fan deposits are present at the site, I recommend the debris-flow and alluvial-fan-flooding potential from drainages and slopes east of the site be evaluated and mitigation measures, if necessary, be incorporated into site drainage design. Site drainage design must consider runoff from the hillslope and drainages east of the site. Swenson and others (1972) indicate that site soils are erodible, so soil erosion by floodwaters particularly during site preparation and construction should also be addressed.

ROCK FALL

The site is within a rock-fall hazard overlay zone (Robison, 1990) and rock-fall clasts were observed east of the site, indicating a potential for rock fall from the slopes east of the site. No comments are made regarding the presence of rock-fall sources or clasts east of the site. I recommend that the rock-fall hazard be evaluated in terms of identifying potential rock-fall sources, travel paths, and runout areas.

SUMMARY AND RECOMMENDATIONS

RB&G's (1999) recommendations for problem soils, shallow ground water, and surface fault rupture are adequate; however, additional evaluation of slope stability may be necessary, and the

potential debris-flow, alluvial-fan-flooding, and rock-fall hazards must be addressed. I recommend the following:

- ! If final cut slope is steeper than 2.2H:1V, a slope stability evaluation may be necessary depending on final slope grade. Also, raveling of gravel slopes must also be considered if they are not vegetated.

- ! Define the origin of gravel deposits at the site and, if debris-flow/alluvial-fan deposits are present, assess the hazard by estimating the frequency and volume of flows, travel paths, and flow depths. These data must be incorporated into site drainage design or other hazard-reduction measures, where pertinent. The drainage design must consider runoff from the hillslope and drainages east of the site. Potential erosion from floodwaters, particularly during site preparation and construction, should also be addressed.

- ! Evaluate the rock-fall potential from slopes east of the site and provide recommendations for hazard-reduction measures, if necessary.

I recommend that setbacks, hazard areas, and protective structures, determined from the above hazard evaluations, be shown on the site map. Specific recommendations and restrictions pertaining to site design should be included in the report. All conclusions and recommendations must be supported with evidence. The hazard evaluations should be performed by a qualified engineering geologist, hydrologist, and/or geotechnical engineer, as appropriate. I also recommend that the RB&G (1999) report, this review, and any subsequent geologic-hazards reports and reviews for this site be disclosed to future condominium lot and/or home buyers.

REFERENCES

International Engineering Company Inc., 1984, Provo geological hazard study: San Francisco, California, unpublished consultant's geological hazard maps for Provo City, 24 p. pamphlet, scale 1:1,200.

Machette, M.N., 1992, Surficial geologic map of the Wasatch fault zone, eastern part of Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2095, 26 p. pamphlet, scale 1:50,000.

RB&G Engineering, 1999, Geotechnical investigation, Rhodes Condominium building, 5600 North Canyon Road, Provo, Utah County, Utah: Provo, Utah, unpublished consultant's report for Jack Rhodes, Real Properties, L.C., 9 p.

Robison, R.M., 1990, Utah County natural hazards overlay (NHO) zone, southern Utah County: unpublished Utah County Planning Department maps, scale 1:50,000.

Swenson, J.L., Jr., Archer, W.M., Donaldson, K.M., Shiozaki, J.J., Broderick, J.H., and Woodward, Lowell, 1972, Soil survey of Utah County, Utah, central part: U.S. Department of Agriculture Soil Conservation Service, 161 p.

Project: Review of geotechnical study for lot 1 of the Haugen subdivision, Ogden, Weber County, Utah			**Requesting Agency:** Weber County
By: Richard E. Giraud	**Date:** 08-20-99	**County:** Weber	**Job No:** 99-17 (R-16)
USGS Quadrangle: Ogden (1345)		**Number of attachments:** None	

INTRODUCTION

At the request of Jim Gentry, Weber County Planner, I reviewed a geotechnical report by Earthtec Testing and Engineering, P.C. (Earthtec, 1999) and a geologic reconnaissance report by American Geological Services, Inc. (AGS, 1999) for lot 1 of the Haugen subdivision, 6464 South Bybee Drive, Ogden, Utah (SE1/4 section 24, NW 1/4 section 25, T. 5 N., R. 1 W., Salt Lake Base Line and Meridian). I received the report on July 28, 1999. The purpose of this review is to evaluate if geologic hazards were adequately addressed. The scope of work for the review included a literature review and inspection of published geologic maps and Weber County geologic-hazard maps. I did not conduct a field inspection of the property. Recommendations pertaining to foundation design and site grading should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Earthtec (1999) and AGS (1999) address possible hazards resulting from problem soils, shallow ground water, slope instability, surface fault rupture, debris flows, flooding, and rock fall. I generally concur with their recommendations but provide additional comments on slope stability, rock-fall hazards, and the recommended hydrologic study for site drainage design.

Earthtec (1999) provides recommendations for the access-road cut and fill slopes. Earthtec (1999) states that no ground water was observed in the access-road cuts, and that they should be notified immediately if water is encountered during construction. In conflict with Earthtech's observations, AGS (1999) observed "moisture does seep to the surface within bedded sands within bedded sands exposed in the access road," which indicates perched ground water. Because moisture can influence slope stability this conflict must be resolved. If perched water is present in slopes, Earthtec must re-evaluate slope stability in observed and expected areas of perched ground water.

AGS (1999) identified rock-fall sources and clasts at the site. AGS (1999) recommends that the rock-fall source outcrops be regularly inspected and that loose boulder-sized rocks be removed to prevent them from rolling downhill. AGS provides no discussion of who is responsible for inspections and rock removal or how frequently inspections should be performed. Such details must be defined to carry out the AGS (1999) recommendation. I recommend also considering other alternatives to reduce the hazard such as an appropriately designed catchment structure, particularly if the developer does not own the land in the rock-fall source area.

AGS (1999) recommends a hydrologic study for the Broad Hollow drainage to determine the discharge for future runoff events to design road crossings and protect property downstream. A hydrologic study was not included or discussed in the geotechnical study. I concur with the AGS recommendation that a hydrologic study be completed.

RECOMMENDATIONS

Regarding the Earthtec and AGS assessment of geologic hazards at the site, I recommend the following:

- Resolve the conflict between the Earthtec and AGS reports regarding perched ground water along the access road, and re-evaluate the stability of cuts and fills in areas where perched ground water is observed or may be expected.
- Establish a mechanism to regularly inspect and remove rocks to reduce the rock-fall hazard or consider other alternatives such as an appropriately sized rock-fall-catchment structure.
- Complete the hydrologic study recommended by AGS.
- Disclose the existence of the Earthtec and AGS (1999) reports, subsequent reports, and this review to future buyers.

Specific recommendations and restrictions pertaining to site and building design should be included in subsequent reports. All conclusions and recommendations must be supported with evidence. I further recommend that Weber County provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consulting geologist and/or engineer indicating that their recommendations were followed.

REFERENCES

American Geological Services, Inc., 1999, Geologic reconnaissance Rasmussen Property, Uintah, Utah: Provo, Utah, unpublished consultant's report for Earthtec Testing and Engineering, P.C., 4 p.

Earthtec Testing and Engineering, P.C., 1999, Geotechnical study lot 1 Haugen Subdivision 6464 South Bybee Drive, Ogden, Utah: Ogden, Utah, unpublished consultant's report for Matt Rasmussen, 11 p.

Project: Review of "Geotechnical investigation, proposed residence, lot 163 - Interlaken Estates, Midway, Utah"			**Requesting Agency:** Wasatch County Planning
By: Barry J. Solomon	**Date:** 08-20-99	**County:** Wasatch	**Job No:** 99-18 (R-17)
USGS Quadrangle: Heber City (1168)		**Number of attachments:** None	

In response to a request from Anthony Kohler, Wasatch County Planning Assistant, I reviewed the geotechnical report for Interlaken Estates lot 163 by Applied Geotechnical Engineering Consultants, Inc. (AGEC, 1999). I received the report on August 16, 1999. Lot 163 is in the SW1/4 section 23, T. 3 S., R. 4 E., Salt Lake Base Line and Meridian. The purpose of my review is to assess whether AGEC (1999) adequately addressed the potential for geologic hazards on the lot. My scope of work included a review of published geologic mapping (Bromfield and others, 1970), but I did not inspect the property. Recommendations pertaining to foundation design and site grading in AGEC (1999) should be reviewed by a qualified geotechnical engineer.

With the exception of earthquake ground shaking, AGEC (1999) did not identify any geologic hazards that would affect development on the site. AGEC (1999) recommends that ground shaking be considered in design of the proposed structure and states that the site is suitable for the proposed development. I agree with the AGEC (1999) assessment of site suitability. This assessment is supported by geotechnical investigations of nearby lots 167 and 216 (Earthtec Testing & Engineering, P.C., 1999a, 1999b; reviewed in Solomon, 1999a, 1999b), which include slope-stability analyses for geologic conditions similar to those on lot 163. These analyses indicate that such slopes are stable, with factors of safety exceeding minimum acceptable levels under both static and earthquake ground-shaking conditions. The potential for landslides will be further reduced by implementing site-design features recommended in the AGEC report. To ensure slope stability, I recommend that the developer:

- provide an engineered design for retaining walls and have the design reviewed by a qualified engineer; the design must include a site map and slope profile showing cuts, fills, and retaining walls; the retaining-wall design must consider static and earthquake ground-shaking conditions and incorporate pertinent drainage recommendations; and

- address cut-slope stability in accordance with the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, section 3312) for any proposed permanent cuts with slopes steeper than 2H:1V (50 percent) that are not supported by retaining walls.

Wasatch County should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Applied Geotechnical Engineering Consultants, Inc., 1999, Geotechnical investigation, proposed residence, lot 216 - Interlaken Estates, Midway, Utah: Sandy, Utah, unpublished consultant's report for Tim Wolfgram, 14 p.

Bromfield, C.S., Baker, A.A., and Crittenden, M.D., Jr., 1970, Geologic map of the Heber quadrangle, Wasatch and Summit Counties, Utah: U.S. Geological Survey Map GQ-864, scale 1:24,000.

Earthtec Testing & Engineering, P.C., 1999a, Geotechnical study, lot 167, Interlaken development, Midway, Utah: Orem, Utah, unpublished consultant's report for Duane S. Carling, 21 p.

Earthtec Testing & Engineering, P.C., 1999b, Geotechnical study, lot 216, Interlaken development, Midway, Utah: Orem, Utah, unpublished consultant's report for Stephan and Sandra Dembinsky, 22 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, California, International Conference of Building Officials, Volume 1, Appendix Chapter 33, p. 407-411.

Solomon, B.J., 1999a, Review of "Geotechnical study, lot 167, Interlaken development, Midway, Utah": Utah Geological Survey Technical Report 99-13, 3 p.

Solomon, B.J., 1999b, Review of "Geotechnical study, lot 216, Interlaken development, Midway, Utah": Utah Geological Survey Technical Report 99-14, 2 p.

Project: Review of "Geotechnical study, lot 64, Interlaken development, Midway, Utah"			Requesting Agency: Wasatch County Planning
By: Barry J. Solomon	Date: 08-24-99	County: Wasatch	Job No: 99-19 (R-18)
USGS Quadrangle: Heber City (1168)		Number of attachments: None	

In response to a request from Anthony Kohler, Wasatch County Planning Assistant, I reviewed the geotechnical report for Interlaken Estates lot 64 by Earthtec Testing & Engineering, P.C. (Earthtec, 1999). I received the report on August 16, 1999. The geotechnical report includes an addendum by American Geological Services, Inc., describing the results of a geological reconnaissance of the lot. Lot 64 is in the SE1/4 section 22, T. 3 S., R. 4 E., Salt Lake Base Line and Meridian. The purpose of my review is to assess whether Earthtec (1999) adequately addressed the potential for geologic hazards on the lot. My scope of work included a review of published geologic mapping (Bromfield and others, 1970), but I did not inspect the property. Recommendations pertaining to foundation design and site grading in Earthtec (1999) should be reviewed by a qualified geotechnical engineer.

Earthtec (1999) lists landslides, earthquake ground shaking, debris flows, liquefaction, and subsidence as potential geologic hazards on the property. I believe Earthtec (1999) adequately addresses these geologic hazards on Interlaken Estates lot 64 and I agree with the report's conclusions that the potential for them is low.

Earthtec (1999) also addresses the rock-fall hazard. Although the report initially characterizes the rock-fall hazard as low (Earthtec, 1999, p. 3), the report later states that "mountain slopes...pose a general potential rock fall hazard to the site" (Earthtec, 1999, p. 10). Downslope properties are afforded some protection from this hazard by upslope roads and home sites which are often graded flat and may impede rock-fall debris. However, lot 64 is downslope from Wasatch Mountain State Park. The undeveloped slope within the park contains fractured quartzite outcrops and boulder-sized rock fragments. Earthtec (1999) recommends that the park slope be periodically inspected to identify and remove loose rocks. This action may reduce the rock-fall hazard, but such techniques require a mechanism to identify responsible parties, set inspection schedules, and provide funding to ensure that inspections are performed. In addition, land-ownership issues may preclude any alterations to slopes above the lot not owned by the developer. Earthtec (1999) also recommends a 15-foot setback from the slope, site grading, and/or possible construction of a fence or wall near the toe of the slope to deflect or impede rock-fall debris. If properly designed, these passive techniques will likely be more practical and effective than slope monitoring. I therefore recommend that:

- the final design for rock-fall mitigation measures be submitted for review, along with data supporting design setback distances or wall heights.

The potential for landslides will be reduced by implementing site-design features recommended in the Earthtec report. To ensure slope stability, I recommend that the developer:

- provide an engineered design for retaining walls and have the design reviewed by a qualified geotechnical engineer; the design must include a site map and slope profile showing cuts, fills, and retaining walls, consider static and earthquake ground-shaking conditions, and incorporate pertinent drainage recommendations; and

- address cut-slope stability in accordance with the Uniform Building Code (International Conference of Building Officials, 1997, Appendix Chapter 33, section 3312) for any proposed permanent cuts with slopes steeper than 2H:1V (50 percent) that are not supported by retaining walls.

Wasatch County should provide a means to ensure that final recommendations are followed. To accomplish this, the County should require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Bromfield, C.S., Baker, A.A., and Crittenden, M.D., Jr., 1970, Geologic map of the Heber quadrangle, Wasatch and Summit Counties, Utah: U.S. Geological Survey Map GQ-864, scale 1:24,000.

Earthtec Testing & Engineering, P.C., 1999, Geotechnical study, lot 64, Interlaken development, Midway, Utah: Orem, Utah, unpublished consultant's report for Glen Roser, 23 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, California, International Conference of Building Officials, Volume 1, Appendix Chapter 33, p. 407-411.

Project:			Requesting Agency:
Review of “Geotechnical study, West Lehi Elementary School, 7900 North 9150 West, Lehi, Utah County, Utah”			Alpine School District
By: Richard E. Giraud	Date: 08-30-99	County: Utah	Job No: 99-20 (R-19)
USGS Quadrangle: Lehi (1130)		Number of attachments: None	

INTRODUCTION

This report is a review of the geological hazards sections of a geotechnical study for a proposed elementary school in west Lehi, Utah, by Earthtec Testing and Engineering, P.C. (Earthtec, 1999). The proposed school site is located in the SW1/4SW1/4 section 24, T. 5 S., R. 1 E., Salt Lake Base Line and Meridian. Dave Holdaway (Director of Physical Facilities, Alpine School District) requested the review. The report was received by the Utah Geological Survey on August 9, 1999. The purpose of my review is to evaluate if geologic hazards at the proposed school site are adequately addressed. Although the scope of this review did not include a site visit, my review of this on-site work fulfills the intent of Utah State Office of Education (USOE) Rule R277-455 requiring inspection of new school sites by the Utah Geological Survey prior to approval by the USOE. I prepared a preliminary geologic-hazards screening evaluation of this site, which was included in my letter to the Alpine School District dated June 16, 1999.

DISCUSSION AND RECOMMENDATIONS

In their geotechnical study, Earthtec (1999) addressed possible hazards resulting from earthquake ground shaking, liquefaction, non-engineered fill, and shallow ground water. I concur with their recommendations regarding these hazards and provide additional comments below. The Earthtec (1999) engineering recommendations pertaining to grading, drainage, foundations, excavations, backfill, pavement, and liquefaction should be reviewed by a qualified geotechnical engineer.

- Earthquake Ground Shaking: Earthtec (1999) states that at a minimum the building should be designed and constructed in accordance with the seismic zone 3 requirements of the Uniform Building Code (UBC). As discussed in my preliminary screening letter, I recommend that critical facilities such as schools along the Wasatch Front be designed to UBC seismic zone 4 standards to provide additional safety.

- Liquefaction: Earthtec (1999) determined that the sand units under the site have a moderate to high risk of liquefying during an earthquake. The maximum depth of geotechnical boreholes was 21.5 feet; typically liquefaction investigations extend to greater depths.

Martin and Lew (1999) recommend a minimum depth for subsurface exploration of 50 feet below the existing ground surface or lowest proposed finish grade (whichever is lower). Because Earthtec identifies a moderate to high liquefaction potential and recommend engineering measures to reduce the risk, I recommend a qualified geotechnical engineer review the liquefaction analysis and foundation recommendations for liquefaction-induced settlement to ensure the investigation and recommendations are adequate.

! Tectonic Subsidence: In the preliminary screening I identified a possible tectonic-subsidence hazard associated with surface fault rupture on the Provo segment of the Wasatch fault (Keaton, 1987). The principal effect of such subsidence at this site would be possible foundation flooding by shallow ground water as the water table rises in response to surface downdropping of 1 to 2 feet (Keaton, 1987). I recommend that Earthtec and building engineers determine if a permanent rise in the water table of 1 to 2 feet poses a significant risk to the building and, if necessary, provide appropriate risk-reduction measures.

! Radon Gas: In my preliminary screening I identified a possible radon gas hazard and recommended consideration of radon-resistant building construction. The site is in an area of moderate radon-hazard potential (Black, 1993). I recommend that the building architects evaluate if radon gas may enter the building and present a significant hazard to building occupants and, if necessary, provide appropriate risk-reduction measures.

REFERENCES

Black, B.D., 1993, The radon-hazard-potential map of Utah: Utah Geological Survey Map 149, 12 p. pamphlet, scale 1:1,000,000.

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Martin, G.R., and Lew, M., editors, 1999, Recommended procedures for implementation of Division of Mines and Geology (DMG) Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction Hazards in California: Los Angeles, Southern California Earthquake Center, University of California, 63 p.

Project: Review of surface-fault-rupture and debris-flow hazard study for a residential development east of Sheridan Drive, Ogden, Weber County, Utah			Requesting Agency: Ogden City
By: Richard E. Giraud	Date: 09-10-99	County: Weber	Job No: 99-21 (R-20)
USGS Quadrangle: North Ogden (1370)		Number of attachments: None	

INTRODUCTION

At the request of John Mayer, Ogden City Planner, I reviewed a surface-fault-rupture and debris-flow hazard evaluation by Dames and Moore (1999) for a proposed 12-acre subdivision east of Sheridan Drive in Ogden, Utah (SE1/4NW1/4 section 15, T. 6 N., R. 1 W., Salt Lake Base Line and Meridian). I received the report on August 17, 1999. The purpose of this review is to evaluate if geologic hazards were adequately addressed. The scope of work for the review included a literature review and inspection of published geologic maps, Weber County geologic-hazard maps, and aerial photographs. I did not conduct a field inspection of the property.

DISCUSSION AND COMMENTS

Dames and Moore (1999) addresses possible hazards resulting from surface fault rupture and debris flows. I generally concur with their recommendations but provide additional comments on these hazards and alluvial-fan flooding.

Dames and Moore (1999) used data from their trench 1 as well as previous trench information to define active faults and recommend setbacks. To utilize the previous trench information, either a report from the geologist performing the work (Bruce Kaliser) or evidence (photographs, trench logs, maps) supporting the conclusions derived from the study must be provided. Without such documentation, this information cannot be considered conclusive. In particular, evidence confirming reports from the landowner that faults were absent in trenches C, D, and E is needed. If this information is provided, specifically for trenches C and D, the recommended setbacks in the north part of the subdivision are adequate.

Dames and Moore (1999, figures 2 and 5) identifies two faults in trench 1 and projects them to the south subdivision boundary parallel to the main fault scarp trace. Setbacks are based on the projected locations of the faults rather than subsurface data in the south part of the subdivision. Gilbert (1928) and Nelson and Personius (1993) identify as many as six parallel fault scarps west of the main scarp north of the site at Jumpoff Canyon, and parallel faults were also exposed in trenches A, B, and 1. Given the presence of parallel faults along this portion of the fault zone, I believe potential exists for faults in the untrenched area east of trench E and west of the fault setback shown on Dames and Moore figure 2. Therefore, if building footprints on lots 14 through16 extend into the area between trench E and the setback zone, this area must be trenched. Additionally, evidence confirming the lack of faulting in trench E must be provided. If such evidence is not available, the area will need to be retrenched.

Dames and Moore (1999) addresses the debris-flow hazard and gives hazard-reduction recommendations. Although termed a debris-flow hazard, assessment of this hazard must consider all alluvial-fan type sedimentation processes (debris flows, hyperconcentrated flows, streamflows) from the drainages along the mountain front. To reduce this hazard, Dames and Moore (1999) recommends houses be constructed with upslope windows and doors no closer than 4 feet above final grade. For this design to be effective, flow depths must not exceed 4 feet and the houses must be able to withstand the impact pressure exerted by a debris flow. Therefore, an evaluation of anticipated debris-flow impact pressures and flow depths is needed to ensure that houses are adequately designed. This evaluation must consider the runup of debris on the upslope side of houses oriented perpendicular to the flow direction. Deng and others (1992) outline methods for estimating debris-flow impact pressures based on damage to houses during the 1983 Rudd Canyon debris flow in Farmington. A debris flow similar to what may be expected at the proposed subdivision occurred approximately 5 miles north of the site in North Ogden on September 7, 1991, where seven houses were damaged by a debris flow in the Cameron Cove subdivision (Mulvey and Lowe, 1991). A debris flow also occurred in the spring of 1983 at Coldwater Canyon 3 miles north of the site (Wieczorek and others, 1983).

The Dames and Moore (1999) recommendation for a minimum 4-foot height above final grade for doors and windows only pertains to the upslope side of houses; water and sediment may still flow into houses from the sides or back, depending on the elevation of other windows and doors and the inundation depth of water and debris. As an alternative, Dames and Moore (1999) recommends protective berms to route debris flows around structures. If debris flows can be routed safely to designated collection area(s) without impacting existing properties, this is a preferred alternative because a higher level of hazard reduction and greater life-safety protection would be achieved. Routing debris flows and other sediment-laden water flows to a designated sediment collection area would also prevent the cleanup of sediment from properties and city streets following a debris flow (although collection areas may require cleaning), and the routing design could be incorporated into the drainage plan for the subdivision. To implement this alternative, plans showing an engineered berm design and configuration must be submitted.

The Dames and Moore (1999) report did not address the alluvial-fan-flooding potential from drainages north and east of the site. Federal Emergency Management Agency (FEMA) maps indicate the subdivision is in an area of minimal flooding (zone C; FEMA, 1983), although FEMA does not show alluvial-fan-flooding areas on these maps. FEMA (1989) states only that buildings in this zone could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Flood insurance is available in participating communities but is not a requirement by regulation in this zone. FEMA does not impose any building restrictions in zone C.

In general, steps taken to reduce debris-flow and sedimentation hazards can also reduce the alluvial-fan-flooding hazards to acceptable levels. I recommend evaluating the alluvial-fan- flooding potential from drainages north and east of the site to ensure that the subdivision drainage and debris-flow-hazard design are sufficient to control surface-water runoff from the north and east.

RECOMMENDATIONS

Regarding the Dames and Moore assessment of geologic hazards at the site, I recommend the following:

- Provide trench logs, photos, or written documentation from the previous investigation confirming that no faults are present in trenches C, D, and E.

- If the building footprints on lots 14 through16 extend east of trench E, the area between trench E and the setback zone must be trenched.

- As a preferred alternative to the house design recommendation, consider building protective berms to route debris flows and other sediment-laden water flows to designated receiving areas. This may prevent direct impact of debris flows on houses, prevent the cleanup of sediment and debris following a sedimentation event, provide a higher level of risk reduction, and provide greater life-safety protection.

- If the design of houses to withstand debris flows is acceptable to Ogden City, evaluate the anticipated debris-flow impact pressures and runup on houses to ensure they are adequately designed to withstand the pressures.

- Evaluate whether the chosen debris-flow-hazard reduction measures are sufficient to reduce the alluvial-fan-flooding hazard from drainages north and east of the site, and if not, provide a drainage plan to ensure that surface-water flows are controlled and routed to appropriate receiving areas.

- Disclose the existence of the Dames and Moore (1999) report, subsequent reports, and this review to future buyers.

Specific recommendations and restrictions pertaining to site and building design should be included in subsequent reports. All conclusions and recommendations must be supported with evidence. I further recommend that Ogden City provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Dames and Moore, 1999, Surface-fault-rupture and debris-flow hazard study for a proposed 12-acre residential development, Ogden, Utah: Salt Lake City, Utah, unpublished consultant's report for Roy Harris, 7 p.

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Federal Emergency Management Agency, 1983, Flood insurance maps for City of Ogden, Utah: scale 1:6,000.

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Project: Review of "Geotechnical study, PRUD condominium complex, 1700 East Ponderosa, Layton, Utah"			Requesting Agency: Layton City Community Development Dept.
By: Richard E. Giraud	Date: 10-01-99	County: Davis	Job No: 99-22 (R-21)
USGS Quadrangle: Kaysville (1320)		Number of attachments: None	

INTRODUCTION

At the request of Doug Smith, Layton City Planner, I reviewed a geotechnical study by Earthtec Testing and Engineering, P.C. (Earthtec, 1999) for the PRUD condominium complex located between Ponderosa Street and Oak Hills Drive from 1700 to 1800 East in Layton, Utah (E1/2SE1/4 section 22, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian). I received the report on September 10, 1999. The purpose of this review is to evaluate if geologic hazards were adequately addressed. The scope of work for the review included a literature review; inspection of published geologic maps, Davis County geologic-hazard maps, and aerial photographs; and a site visit on September 17, 1999.

The North Fork of Holmes Creek flows through the middle of the site. Access roads, garages, and condominiums are planned on both the north and south sides of Holmes Creek. A siphon associated with the Davis-Weber Canal crosses the site diagonally from northwest to southeast.

DISCUSSION AND COMMENTS

Earthtec (1999) addresses possible hazards resulting from problem soils, shallow ground water, liquefaction, earthquake ground shaking, and slope instability. I generally concur with their recommendations but provide additional comments on these hazards and stream flooding.

In their description of site conditions, Earthtec (1999) does not discuss the wetlands on the west and north portions of the site. Based on the site plan (Earthtec, 1999, figure 2), some buildings and roads will be constructed over wetland areas and the siphon. The wetlands consist mostly of cattails and standing water and may contain compressible organic soils. Earthtec (1999) recommends removal of topsoil but there is no discussion of organic soils associated with wetlands. If organic soils are present, their possible impacts on development must be addressed. I also recommend that a drainage plan be developed for these areas to ensure proper drainage.

Earthtec (1999) recommends that a soil-profile type SD be used in seismic design of buildings. An SD soil-profile type is defined in the Uniform Building Code (International Conference of Building Officials, 1997) as a soil having average standard penetration test blow counts in the upper 100 feet of 15 to 50 blows per foot. The highest blow count recorded on the drill logs was 11 blows per foot in B-1, which suggests that the shallow soils would be classified as SE (< 15 blows per foot). Because of the low blow counts in shallow soils at the site, Earthtec must justify why they recommend an SD soil-profile type.

Earthtec (1999) provides an opinion that the site slopes are stable in their present condition and the steeper slopes adjacent to the site may become unstable when saturated. Earthtec recommends a setback of 30 feet from the property line adjacent to the steeper slopes, but does not show the property line or the location of the steeper slopes of concern where the setback recommendation applies or state how the setback distance was determined. Lowe (1988) maps the entire north portion of the site (north of Holmes Creek) as an active landslide (LSa 474) and an older landslide to the west (LS 471). During my field visit I noticed a fence line, near the northeast corner of the site, that was displaced 15 feet downslope by landslide movement. Condominiums 23 through 26 may be on the toe of this movement area. Because of recent landslide movement I recommend the extent and nature of recent and older sliding be defined, and appropriate slope-stabilization measures be recommended for the affected areas. Geotechnical-engineering slope-stability analyses, as outlined in Hylland (1996), will be needed to assess the effectiveness of proposed slope-stabilization techniques, and may be required to assess the stability of adjacent areas as well. Slope performance must be evaluated under appropriate earthquake ground-shaking and estimated development-induced (landscape irrigation) ground-water conditions.

The Earthtec (1999) report does not address the stream flooding potential along the North Fork of Holmes Creek. Federal Emergency Management Agency (FEMA) maps show that parts of the subdivision are in an inundation area along the creek associated with the 100-year flood (zone A18; FEMA, 1982). FEMA (1989) states that this inundation area is a Special Flood Hazard Area (SFHA) subject to inundation by the 100-year flood and that mandatory flood insurance purchase requirements apply. The proposed development within the SFHA may change the base flood elevation of the 100-year flood in this area. As a participant in the National Flood Insurance Program (NFIP), Layton City must ensure that this development conforms to NFIP requirements for construction in an SFHA. This includes evaluating the stream-flooding impacts on the proposed development and determining whether the development will change the base flood elevation along the creek. The development must also comply with the Davis County Flood Control Ordinance.

RECOMMENDATIONS

Regarding Earthtec's assessment of geologic hazards at the site, I recommend the following:

! Where development is planned in wetlands, determine the extent and thickness of organic soils, evaluate their possible impacts on development, recommend hazard-reduction measures if necessary, and develop a site drainage plan to ensure proper drainage in areas of shallow ground water.

! Earthtec must justify the recommended SD soil-profile type, given the low blow counts in shallow soils at the site.

- ! The extent and nature of recent and older landsliding in the north part of the site must be defined, and appropriate stabilization measures recommended. Geotechnical-engineering slope-stability analyses must be performed to assess the effectiveness of recommended stabilization measures and assess the stability of adjacent slopes as necessary. Slope stability must be evaluated under appropriate earthquake ground-shaking and estimated development-induced (landscape irrigation) ground-water conditions.

- ! The development must meet FEMA's requirements for construction in an SFHA and comply with the Davis County Flood Control Ordinance.

- ! Disclose the existence of the Earthtec (1999) report, subsequent reports, and this review to future buyers.

Any setbacks, hazard areas, and slope stabilization structures determined from the above hazard evaluations must be shown on the site map to delineate buildable areas. Specific recommendations and restrictions pertaining to the site and building should be included in the report. All conclusions and recommendations must be supported with quantified data. The hazard evaluations should be performed by a qualified engineering geologist, hydrologist, and/or geotechnical engineer, as appropriate. Also, Layton City should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consulting geologist, hydrologist, or engineer indicating that their recommendations have been followed.

REFERENCES

Earthtec Testing and Engineering, P.C., 1999, Geotechnical study, PRUD condominium complex, 1700 East Ponderosa, Layton, Utah: Ogden, Utah, unpublished consultant's report for Max Feiz, 11 p.

Federal Emergency Management Agency, 1982, Flood insurance maps for City of Layton, Utah: scale 1:6,000.

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Hylland, M.D., editor, 1996, Guidelines for evaluating landslide hazards in Utah: Utah Geological Survey Circular 92, 16 p.

International Conference of Building Officials, 1997, Uniform Building Code: Whittier, California, International Conference of Building Officials, variously paginated.

Lowe, Mike, 1988, Natural hazards overlay zone - slope failure inventory, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

Project: Review of "Geotechnical engineering report, proposed Ponds at Oak Hills development, 2650 East Oak Hills Drive, Layton, Utah"			Requesting Agency: Layton City Community Development Dept.
By: Richard E. Giraud	Date: 10-29-99	County: Davis	Job No: 99-23 (R-22)
USGS Quadrangle: Center Creek (1126)		Number of attachments: None	

INTRODUCTION

At the request of Doug Smith, Layton City Planner, I reviewed the geologic-hazard portions of a geotechnical engineering report by Terracon (Terracon, 1999) for the proposed Ponds at Oak Hills development located at 2650 East Oak Hills Drive in Layton, Utah (NW1/4 SE1/4 section 23, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian). I received the report on October 12, 1999. The purpose of this review is to evaluate if geologic hazards were adequately addressed. The scope of work for my review included a literature review, interpretation of aerial photographs (1985; scale 1:24,000), and a previous review (Giraud, 1999) of a soils report (Wilding Engineering, 1996) and subdivision drawings (Wilding Engineering, 1998) for the development. Terracon (1999) provides foundation and other geotechnical-engineering recommendations that should be reviewed by a qualified geotechnical engineer.

DISCUSSION AND COMMENTS

Terracon (1999) addresses possible hazards resulting from slope instability, earthquake ground shaking, and liquefaction. Recommendations are provided for cuts, fills, drainage, and retaining-wall design. I concur with Terracon's recommendations to reduce the risk of the above hazards and provide additional comments below.

Terracon (1999) recommends backdrains under fill slopes to reduce the risk of landsliding and liquefaction, and states that positive drainage should be provided during construction and maintained throughout the life of the proposed project. However, Terracon (1999) does not discuss who will be responsible for maintaining the drainage system. For this recommendation to be effective, a mechanism must be in place to ensure the monitoring, cleaning, operation, maintenance, and repair or eventual replacement of the drain system for the life of the project.

Terracon (1999) determined that an unacceptable static factor of safety exists for the proposed 20-foot-high retaining wall and recommends eliminating the wall or reducing the height. Terracon (1999) obtained acceptable static factors of safety using tie-back anchors for the 20-foot retaining wall but did not determine a seismic factor of safety for the tie-back design. If the retaining wall is not eliminated, I recommend the design consider seismic as well as static conditions.

RECOMMENDATIONS

Regarding Terracon's assessment of geologic hazards at the site, I recommend the following:

- ! A mechanism must be outlined and implemented to ensure the monitoring, cleaning, operation, maintenance, and repair or eventual replacement of the fill-slope drainage system for the life of the project.
- ! If the 20-foot-high retaining wall is not eliminated, the wall design must consider both static and seismic conditions.
- ! The foundation and other geotechnical-engineering recommendations should be reviewed by a qualified geotechnical engineer.
- ! Disclose the existence of the Wilding (1996, 1998), Giraud (1999), and Terracon (1999) reports, subsequent reports, and this review to future buyers.

Layton City should provide a means to ensure that recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations were followed.

REFERENCES

Giraud, R.E., 1999, Review of soils report and drawings, the Ponds at Oak Hills, Layton, Davis County, Utah: unpublished Utah Geological Survey Technical Report 99-02, 3 p.

Terracon, 1999, Geotechnical engineering report, proposed Ponds at Oak Hills development, 2650 East Oak Hills Drive, Layton, Utah: Salt Lake City, Utah, unpublished consultant's report for Layton Ponds I, L.L.C., 16 p.

Wilding Engineering Inc., 1996, The Ponds at Oak Hills soil report, 2650 East Oak Hills Drive, Layton, Utah: Draper, Utah, unpublished consultant's report for Equus Limited, 5 p.

Wilding Engineering Inc., 1998, The Ponds at Oak Hills subdivision maps, 2650 East Oak Hills Drive, Layton, Utah: Draper, Utah, unpublished consultant's subdivision drawings, 7 sheets.

Project:			Requesting Agency:
Review of "Geotechnical investigation, proposed Country Oaks condominiums, approximately 2550 East 1850 North, Layton, Utah"			Layton City Community Development Dept.
By: Francis X. Ashland	Date: 11-02-99	County: Davis	Job No: 99-24 (R-23)
USGS Quadrangle: Kaysville (1320)		Number of attachments: None	

INTRODUCTION

At the request of Doug Smith, Layton Planning Department, I reviewed the geologic-hazard aspects of a geotechnical report by AGRA Earth & Environmental (AGRA) (1995) for the proposed Country Oaks condominiums in Layton, Utah. The proposed subdivision is in the NE1/4 section 14, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian. The site is divided into two parts. The northern part is on a south- and west-facing bluff of the Middle Fork of Kays Creek. The southern part is located in a west-trending tributary drainage to the Middle Fork. The purpose of this review is to determine if geologic hazards have been adequately addressed to support proposed development at the site. The scope of my evaluation consisted of a review of available engineering-geologic reports and maps, but did not include a site reconnaissance. The report was received on October 15, 1999.

GEOLOGIC HAZARDS AND ADVERSE SITE CONDITIONS

The AGRA (1995) report identifies the following geologic hazards and adverse site conditions as having potential impacts on the proposed development.

1. Non-engineered fill, from 3 to 10 feet thick near the crest of the slope in the northern part of the site.

2. Moderate to steep slopes, ranging between 20 and 50 percent.

3. Collapsible soils, including one sample demonstrating about 2.5 percent collapse, in the southern part of the site.

4. Perched ground water, possibly resulting from excess landscape irrigation on abutting properties, in the northern part of the site.

In addition, the AGRA (1995) report concludes that two other hazards, surface fault rupture and liquefaction, are not present or significant, respectively, at the site. Based on my review of Nelson and Personius (1993), I concur that no known active faults cross the site. AGRA does not anticipate liquefaction at the site based on an inferred depth of ground water in excess of 30 feet. However, the depth estimate is based on unreferenced data, and is thus unsupported. This inferred depth to ground water is also inconsistent with AGRA's observations of shallow ground water ("seeping free moisture") in the fill above the buried topsoil and the potential for additional shallow perched ground water from landscape irrigation at this subdivision and abutting developed areas to the east and upslope. AGRA's opinion on the potential for liquefaction should be supported by actual on-site ground-water depth information obtained during the wettest part of the year and estimates for development-induced perched ground-water levels, standard penetration resistance data, and other geotechnical information.

The adverse conditions at the site, particularly the presence of non-engineered fill, collapsible soils, and steeps slopes concern AGRA, and thus they recommend that geotechnical professionals be onsite to:

1. assist in identifying problem areas,

2. ensure proper implementation of design recommendations contained in the AGRA (1995) report, and

3. conduct additional engineering evaluation and design, particularly for slopes, as necessary.

I strongly concur with the need for geotechnical professionals to be on-site during all site grading, excavation, and foundation construction work. I make some specific recommendations regarding their scope of services in the last section of this review. I also strongly believe that additional pre-development slope-stability analyses are needed to support final site grading plans and design.

CRITICAL DESIGN CONSIDERATIONS

The list of geologic hazards and adverse site conditions can be separated into two categories:

1. those that could result in differential settlement and cause building and pavement distress, and

2. those that could result in slope instability or landsliding.

Differential building and pavement settlement could be caused by non-engineered fill and collapsible soils at the site. The recommendations made in the AGRA (1995) report, including removal and replacement with structural fill, appear adequate to reduce the potential for significant settlement, but would be difficult, if not impossible, to properly implement in the absence of geotechnical professionals at the site during construction.

The AGRA (1995) report also indicates that existing and proposed modifications to the site, including surcharge fills at the crest of the slope, excavations at the toe of the slope, and excess soil moisture from infiltration of surface runoff or landscape irrigation, could cause slope instability. At present, many conditions at the site are similar to those at the Sunset Drive landslide (Terracon, 1998) and other Kays Creek bluff area landslides. Although mapped prehistorical landslides do not underlie this specific site, two active landslides occur on the same bluff directly to the southwest (Lowe, 1989), indicating the susceptibility of the slope soils to landsliding.

RECOMMENDATIONS

Given AGRA's slope-stability concerns and the results of the analyses of similar slopes in Layton (Terracon, 1998), I believe that a final site design with grading plans showing proposed cuts, fills, and building locations must be submitted to the city prior to approval. The final site design should be supported by additional geotechnical studies, including subsurface geotechnical boreholes, ground-water monitoring wells, laboratory soil-strength tests, and computer-assisted slope-stability analyses. In my opinion, the geotechnical studies should include the following.

1. At least one borehole completed in the crest of the slope in the northern part of the site to a minimum depth of 30 feet.

2. A ground-water monitoring well, or piezometer, installed in the deep borehole. Ideally, the well/piezometer in the northern part of the site should be located so that it survives later construction and can be used for subsequent ground-water-level monitoring.

3. Laboratory soil-strength testing that includes tests on all distinct soil types present in the upper 30 feet of the bluff.

4. Slope-stability analyses that evaluate the stability of proposed final slope configurations, retaining structures, and natural undisturbed slopes and include the entire slope below the site boundaries on the west side of the northern part of the site. The slope-stability analyses should consider reasonable long-term development-induced rises in ground-water levels including perched ground water.

Development-induced ground-water levels and conditions should also be used to evaluate liquefaction potential at the site. If necessary, setbacks from the crests or toes of slopes should be incorporated into the final site design plans.

I recommend that the city require the owner/developer to have geotechnical professionals present at the site during all site grading, excavation, and foundation construction work. The scope of services that the geotechnical professionals should be responsible for includes, but should not be limited to, the following.

1. Excavation inspection and identification of non-engineered fill, topsoil (including buried topsoil), deleterious material, and collapsible soils.

2. Field control during emplacement of structural fill including design and construction

monitoring of benches in sloped areas exceeding 10 percent as indicated in the AGRA (1995) report.

3. Engineering re-evaluation of maximum surcharge heights in the crest of slopes and slope design as excavation proceeds, particularly if designs are modified during construction.

4. Design and construction monitoring of all retaining structures including upslope basement walls, in conjunction with a structural engineer as necessary.

5. Design and construction monitoring of subsurface drains and surface drainage, including connection of downspouts to storm drains, as indicated in the AGRA (1995) report.

6. Installation of long-term monitoring instrumentation, as considered necessary by the responsible geotechnical professional, including piezometers and surface monitoring benchmarks, to ensure that designs perform adequately.

Upon completion of this work, the city should require the responsible geotechnical professional to notify it, in writing, that the site modifications were completed in accordance with design recommendations and were constructed in a manner that minimizes the likelihood of future slope instability or building distress.

Based on my review of the AGRA (1995) report, I believe that conditions at the site preclude successful and safe development without the involvement of geotechnical professionals during construction.

REFERENCES

AGRA Earth & Environmental, 1995, Geotechnical investigation, proposed Country Oaks condominiums, approximately 2550 East 1850 North, Layton, Utah: Salt Lake City, unpublished consultant's report, 16 p.

Lowe, Mike, 1989, Slope-failure inventory map, Kaysville quadrangle: Davis County Planning Division unpublished map, scale 1:24,000.

Nelson, A.R., and Personius, S.F., 1993, Surficial geologic map of the Weber segment, Wasatch fault zone, Weber and Davis Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2199, scale 1:50,000, 22 p. pamphlet.

Terracon, 1998, Geotechnical report, Sunset Drive landslide, Layton, Utah: Salt Lake City, unpublished consultant's report for Layton City, 11 p.

Project: Review of "Geotechnical study, Joe Morgan lots, 275 North 1700 East, Layton, Utah"			Requesting Agency: Layton City Community Development Dept.
By: Richard E. Giraud	Date: 11-09-99	County: Davis	Job No: 99-26 (R-24)
USGS Quadrangle: Kaysville (1320)		Number of attachments: None	

INTRODUCTION

At the request of Doug Smith, Layton City Planner, I reviewed the geologic-hazards portions of a geotechnical study by Earthtec Testing and Engineering, P.C. (Earthtec, 1999b) for two residential lots located at 275 North 1700 East in Layton, Utah (E1/2SE1/4 section 22, T. 4 N., R. 1 W., Salt Lake Base Line and Meridian). I received the report on October 12, 1999. The purpose of this review is to evaluate if geologic hazards are adequately addressed. The scope of work for the review included a literature review and inspection of published geologic maps, Davis County geologic-hazard maps, and aerial photographs. I reviewed a previous geotechnical study (Giraud, 1999) by Earthtec (Earthtec, 1999a) for a proposed condominium complex immediately southeast of the two lots. I did not perform a site visit of these lots but visited the proposed condominium complex on September 17, 1999 (Giraud, 1999).

DISCUSSION AND COMMENTS

Earthtec (1999b) addresses possible hazards resulting from problem soils, non-engineered fill, shallow ground water, liquefaction, earthquake ground shaking, and slope instability. I generally concur with their recommendations except for those concerning slope instability. I provide additional comments on slope stability and subsurface drainage below.

Earthtec (1999b) concludes the slope at the site is stable. However, several conditions illustrate the existence of slope instability that could impact the lots. First, Lowe (1988) maps an active landslide (LSa 474) and an older landslide (LS 471) west of the active landslide in the area of the proposed development. From the site and lot locations shown in Earthtec (1999b) figures 1 and 2, respectively, I cannot determine if these landslides are within or immediately south of the proposed development. In their analysis of slope stability, Earthtec (1999b) did not discuss these landslides. Second, three lots east of the proposed development, a house experienced slope-instability problems during construction and a subsurface drain was installed (Scott Carter, verbal communication, November 1, 1999). Third, I noticed a fence, 200 feet southeast of the development, that was displaced 15 feet downslope by landslide movement (Giraud, 1999). Therefore, I recommend further investigation to identify and characterize these landslides and determine if they directly or indirectly impact the lots through reactivation and/or enlargement, or if they have other implications for slope stability at the site.

Earthtec (1999b) recommends a subsurface drain approximately two thirds of the way down the steepest portion of the slope to prevent saturation of the slope. However, no discussion of drain maintenance or outlet location is included. For this recommendation to be effective, a mechanism must be in place to ensure the monitoring, cleaning, operation, maintenance, and repair or eventual replacement of the drain. Also, discharge of water from drains onto a landslide downslope mapped by Lowe (1988) may promote landslide movement.

RECOMMENDATIONS

Regarding Earthtec's assessment of geologic hazards at the site, I recommend the following:

- Evaluation of mapped landslides at or near the site, considering the extent and nature of the landslides to determine if they directly or indirectly impact the lots through reactivation and/or enlargement, or whether they have other implications for slope stability at the site. Appropriate slope-stabilization measures should be recommended if necessary.

- Development and implementation of a mechanism to ensure the monitoring, cleaning, operation, maintenance, and repair or eventual replacement of the fill-slope drainage system for the life of the project.

- Review of the foundation and other geotechnical-engineering recommendations by a qualified geotechnical engineer.

- Disclosure of the existence of the Earthtec (1999b) report, subsequent reports, and this review to future buyers.

Any setbacks, hazard areas, and slope-stabilization structures determined from the above hazard evaluations must be shown on the site map to delineate buildable areas. Specific recommendations and restrictions pertaining to the site and buildings should be included in the report. All conclusions and recommendations must be supported by quantified data. Also, Layton City should provide a means to ensure that final recommendations are followed; one way to do this is to require the developer to submit written documentation from the consultant indicating that their recommendations have been followed.

REFERENCES

Earthtec Testing and Engineering, P.C., 1999a, Geotechnical study, PRUD condominium complex, 1700 East Ponderosa, Layton, Utah: Ogden, Utah, unpublished consultant's report for Max Feiz, 11 p.

Earthtec Testing and Engineering, P.C., 1999b, Geotechnical study, Joe Morgan lots, 275 North 1700 East, Layton, Utah: Ogden, Utah, unpublished consultant's report for Joe Morgan, 13 p.

Giraud, R.E., 1999, Review of geotechnical study, PRUD condominium complex, 1700 East Ponderosa, Layton, Utah: unpublished Utah Geological Survey Technical Report 99-22, 4 p.

Lowe, Mike, 1988, Natural hazards overlay zone - slope failure inventory, Kaysville quadrangle: Weber County Planning Department unpublished map, scale 1:24,000.

APPENDIX

1999 Publications of the Applied Geology Program

Maps

Solomon, B.J., Surficial geologic map of the West Cache fault zone and nearby faults, Box Elder and Cache Counties, Utah: Utah Geological Survey Map 172, 20 p. pamphlet, 2 pl., scale 1:50,000.

Reports of Investigation

McDonald, G.N., compiler, 1999, Technical reports for 1998, Applied Geology Program: Utah Geological Survey Report of Investigation 242, 219 p.

Special Studies

Black, B.D., Solomon, B.J., and Harty, K.M., 1999, Geology and geologic hazards of Tooele Valley and the West Desert Hazardous Industry Area, Tooele County, Utah: Utah Geological Survey Special Study 96, 65 p., 6 pl., scale 1:100,000.

Final Technical Reports for Grants

Ashland, F.X., and Rollins, K.M., 1999, Seismic zonation using geotechnical site-response mapping, Salt Lake Valley, Utah: unpublished Final Technical Report to the U.S. Geological Survey, 33 p., 1 plate, scale 1:50,000.

Pearthree, P.A., Lund, W.R., Stenner, H.D., and Everitt, B.L., 1999, Paleoseismic investigations of the Hurricane fault in southwestern Utah and northwestern Arizona: unpublished Final Project Report, National Earthquake Hazards Reduction Program, External Research, 132 p.

Survey Notes

Lund, W.R., 1999, Utah Geological Survey participates in 1998 Bulnay fault expedition: Utah Geological Survey, Survey Notes, v. 31, no. 2, p. 6-7.