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May 19, 2016

Watts Enterprises
5200 South Highland Drive #101
Salt Lake City, Utah 84117
Attn: Mr. Rick Everson

IGES Project No. 01855-007

Subject: Reconnaissance-Level Geologic Hazards Assessment
Fairways at Wolf Creek Subdivision Phases 4 and 5
Eden, Utah

Mr. Everson:

At your request, IGES has performed a reconnaissance-level geologic hazard assessment for the Fairways at Wolf Creek Subdivision Phases 4 and 5, located in the city of Eden in Weber County, Utah (Figure A-1). This letter report identifies the nature and associated risk of the applicable geologic hazards associated with the property, based upon the results of the literature review and site reconnaissance conducted as part of this assessment.

INTRODUCTION

It is our understanding that the Fairways at Wolf Creek Subdivision Phases 4 and 5 project will involve the development of 40 conventionally-framed, one to two-story residences across an area covering approximately 15.8 acres in Eden, Utah. The property is located within the northwestern quarter of Section 22 of Township 7 North, Range 1 East, approximately 3 miles north-northwest of Pineview Reservoir. The property is bound on the east by the Wolf Creek Resort golf course, on the south by the Fairways Oaks at Wolf Creek Phase 1 development, and on the west and north by undeveloped privately owned lands.

PURPOSE AND SCOPE

This study was performed as a reconnaissance-level geologic hazards assessment to identify any surficial or subsurface geologic hazards that may be extant on the property or have the capability to adversely impact the property. Specifically, this study was conducted to:

- Assess the existing geologic conditions present on the property and relevant adjacent areas;

- Assess whether geologic hazards that could pose a risk to development are present on or have the potential to impact the property, and evaluate the associated risk for each hazard; and

- Identify the most significant geologic hazard risks, and provide recommendations for appropriate additional studies and/or mitigation practices, if necessary.

In order to achieve the purpose and scope outlined above, the following services were performed as part of this investigation:

- Review of available published geologic reports and maps for the subject property and surrounding areas;

- Stereoscopic review of aerial photographs and analysis of additional available aerial imagery, including LiDAR;

- Site reconnaissance by a geologist licensed in the state of Utah to map the surficial geology, evaluate site conditions, and assess the property for geologic hazards; and

- Preparation of this report, which is based upon the data reviewed and collected in this investigation.

REVIEW OF GEOLOGIC LITERATURE

A number of pertinent publications were reviewed as part of this assessment. Sorensen and Crittenden, Jr. (1979) provides the most recent published 1:24,000 scale geologic mapping that covers the area in which the property of interest is located. Coogan and King (2001) provide more recent geologic mapping of the area, but at a 1:100,000 scale. A United States Geological Survey (USGS) topographic map for the Huntsville Quadrangle (2014) provides physiographic and hydrologic data for the project area. A Federal Emergency Management Agency (FEMA) flood map (effective in 2015) that covers the project area was reviewed. Regional-scale geologic hazard maps pertaining to landslides (Elliott and Harty, 2010; Colton, 1991), faults (Christenson and Shaw, 2008a; USGS and Utah Geological Survey (UGS), 2006), debris-flows (Christenson and Shaw, 2008b), liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994), and radon (Solomon, 1996) that cover the project area were also reviewed. More site-specific, the EarthTec Engineering (EarthTec) geotechnical report (2016) for the subject property was also reviewed.

General Geologic Setting

The Fairways at Wolf Creek property is situated along the eastern margin of the northern part of the Ogden Valley, near the foothills of the Wasatch Mountains. Ogden Valley separates the western part of the Wasatch Range from the Bear River Range to the east, a subgroup of mountains that are part of the parent Wasatch Range. The Wasatch Mountains contain a broad depositional history of thick Precambrian and Paleozoic sediments that have been subsequently modified by various tectonic episodes that have included thrusting, folding, intrusion, and volcanics, as well as scouring by glacial and fluvial processes (Stokes, 1987). The uplift of the Wasatch Mountains occurred relatively recently during the Late Tertiary Period (Miocene Epoch) between 12 and 17 million years ago (Milligan, 2000). Since uplift, the Wasatch Front has seen substantial modification due to such occurrences as movement along the Wasatch Fault and associated spurs, the development of the numerous canyons that empty into the current Salt Lake Valley and Utah Valley and their associated alluvial fans, erosion and deposition from Lake Bonneville, and localized mass movement events (Hintze, 1988). The Wasatch Mountains, as part of the Middle Rocky Mountains Province (Milligan, 2000), were uplifted as a fault block along the Wasatch Fault (Hintze, 1988). Ogden Valley itself is a fault-bounded trough that was occupied by Lake Bonneville (Sorensen and Crittenden, Jr, 1979) before being cut through by the Ogden River and subsequently dammed to form the Pineview Reservoir.

Surficial Geology

According to Sorensen and Crittenden, Jr. (1979), the property is located entirely on Holocene-aged (~11,700 years ago to the present) colluvium and slopewash (Qcs) deposits (Figure A-2). This unit is adjacent to recent alluvium of the Wolf Creek drainage (Qal), and is likely underlain by various Precambrian rocks which both occupy the highlands and underlie the northern reaches of Ogden Valley. Coogan and King (2001; Figure A-3) denote the area underlying the subject property as Qac (alluvium and colluvium deposits), which are described as including "stream and fan alluvium, colluvium, and, locally, mass-movement deposits." In contrast to Sorensen and Crittenden, Jr. (1979), Coogan and King (2001) mapped the adjacent Wolf Creek drainage as Qafy, young (post-Lake Bonneville) alluvial fan deposits consisting largely of poorly bedded and poorly sorted sands, silts, and gravels. This Qafy unit encroaches upon the southeastern margin of the property. Neither of the aforementioned geologic maps show any faults on the property, though both display several older (inactive) faults that project onto the property. These older faults include both northwest-southeast trending normal faults approximately ½ mile southeast of the property on the east side of the Wolf Creek Drainage and northeast/southwest trending normal faults approximately 1.5 miles to the north and east of the property in the Precambrian rocks found in the highlands (see Figure A-2). Sorensen and Crittenden, Jr. (1979) identify these faults as "pre-Tertiary normal faults."

Hydrology

The USGS topographic map for the Huntsville Quadrangle (2014) shows that the Fairways at Wolf Creek project area is situated within the broad northwest-southeast trending Ogden Valley and near the northeast-southwest trending Wolf Creek drainage. Multiple generally north-south trending ephemeral stream drainages are found on the property, which were found to contain flowing water at least in part during the site visit. In the southern part of the property, the largest of these ephemeral stream drainages forms the boundary between the property and the golf course to the east. This drainage also passes generally north-south through the north-central portion of the property. One unnamed spring is noted on the topographic map just east of the southeastern margin of the property, and several named and unnamed springs are found within ½ mile of the property. It is possible that additional springs may occur on various parts of the property during peak runoff.

Baseline groundwater depths for the Fairways at Wolf Creek property are currently unknown, but are anticipated to fluctuate both seasonally and annually. Groundwater was encountered in all six test pits excavated by EarthTec (2016) between the depths of 6 and 9.5 feet below existing ground level in late January and early February. Groundwater flow from snowmelt is dependent upon the nature of the surface and subsurface materials, including the degree and orientation of fracturing of the bedrock. Given that the topography slopes generally downhill to the south, groundwater flow paths are anticipated to be generally to the south. Daylighting of this groundwater can be expected in the various ephemeral drainages and generally flat, low-lying parts of the property, especially during times of peak runoff as was encountered during the site visit.

The FEMA flood map that covers the Fairways at Wolf Creek project area show that the Phase 4 and 5 areas are both outside of the 500-year flood floodplain for the Wolf Creek drainage (FEMA, 2015).

Geologic Hazards

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the Fairways at Wolf Creek project area have been produced for landslide, fault, debris-flow, liquefaction, and radon hazards. The following is a summary of the data presented in these regional geologic hazard maps.

Landslides
Two regional-scale landslide hazard maps have been produced that cover the project area. Neither Colton (1991) nor the more recent mapping of Elliott and Harty (2010) show any identified or suspected landslides on or adjacent to the Fairways at Wolf Creek Phase 4 and 5 properties.

Faults
Christensen and Shaw (2008a), the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006), and the Utah Quaternary Fault and Fold Database (UGS, 2016b) do not show any Quaternary-aged (~2.6 million years ago to the present) faults to be present on or projecting towards the subject property. The Ogden Valley Northeastern Margin Fault and the Ogden Valley North Fork Fault are the closest Quaternary-aged faults to the property, being northwest-southeast trending range-front faults located approximately 1.15 miles to the north and south of the property, respectively (USGS and UGS, 2006). The Weber County Natural Hazards Overlay Districts defines an active fault to be "a fault displaying evidence of greater than four inches of displacement along one or more of its traces during Holocene time (about 11,000 years ago to the present)" (Weber County, 2015). The closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 5.3 miles west of the western margin of the property (USGS and UGS, 2006).

Sorensen and Crittenden, Jr. (1979) show a series of northwest-southeast trending faults east of the Wolf Creek drainage and projecting onto the property to be cutting across (and therefore younger than) the Qcs surficial unit. It should be noted that Coogan and King (2001) do not show these faults, and the Quaternary Fault and Fold Database of the United States indicates that a 1988 U.S. Bureau of Reclamation (USBR) seismotectonic study for USBR dams in the Wasatch Mountains interpreted these faults as shallow landslide scarps (USGS and UGS, 2006).

Debris-Flows
Christensen and Shaw (2008b) do not show the project area to be located within a debris-flow hazard special study area.

Liquefaction
Anderson, et al (1994) and Christensen and Shaw (2008c) both show the project area to be located in an area designated as having a very low potential for liquefaction. The site-specific EarthTec geotechnical report (2016) in discussing liquefaction potential of the soils present on the property states "The soils encountered at this project do not appear liquefiable, but the liquefaction susceptibility of underlying soils (deeper than our explorations) is not known and would require deeper explorations to quantify."

Radon
Solomon (1996) has the project area located entirely in an area with high radon levels. This is due to the property being underlain by soil partially derived from the underlying Precambrian uranium-bearing metamorphic rocks, as well as the granular nature of the soils allowing for the ease of movement of radon.

REVIEW OF AERIAL IMAGERY

A series of aerial photographs that cover project area were taken from the UGS Aerial Imagery Collection (UGS, 2016a) and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1946 and 1963, which were all taken prior to the development of the nearby residences and their neighborhoods. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report.

No geologic lineaments, fault scarps, landslide headscarps, or landslide deposits were observed in the aerial photography on the subject property.

Google Earth imagery of the property from between the years of 1993 and 2015 were also reviewed. No landslide or other geological hazard features were noted in the imagery. The property was observed to contain abundant surficial gravel, cobbles, and boulders, as well as the several ephemeral drainages discussed above. Most of the project area was found to be covered in various forms of vegetation, with no bedrock exposures anywhere on the property.

Utah Geological Survey 1 meter LiDAR data (UGS, 2011) for the project area was reviewed. The northern half of the property was observed to be significantly gullied, while the southwestern part of the property exhibited minor shading. No landslide or other geologic hazard features were readily identified on the property.

SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on May 13, 2016. The site reconnaissance was conducted with the intent to assess the general geologic conditions present across the property, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas. Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area. Figure A-4 is a site-specific geologic map of the Fairways at Wolf Creek Phases 4 and 5 property and adjacent areas.

Variously-sized boulders and cobbles were found scattered across the property. These were typically subrounded to subangular, and were found to be as large as 5 feet in diameter. The rock clasts were found to be comprised of three distinct lithologies:

1. A medium gray to bluish gray to light gray quartzite; banded in places
2. An orange-brown to dark reddish brown well indurated sandstone gradational to quartzite; commonly contained calcite veining
3. Reddish orange to light gray pebbly conglomerate

In general, the proportion of these lithologies was fairly consistent across the property, with approximately 40% of the clasts comprised of quartzite, approximately 40% comprised of conglomerate, and approximately 20% comprised of sandstone. Rare dark reddish orange siltstone was also found in places. Clasts were commonly found to exhibit abundant desert varnish, and associated with the desert varnish was a weathered surface commonly exhibiting curvilinear fractures.

The presence or absence and setting within which these boulders were encountered provided the means by which the surficial geology was able to be mapped across the property. Three largely gradational geologic units were differentiated on the property. Each of these units are discussed in turn below.

Qac (Quaternary alluvium and colluvium)

This unit was mapped in generally low-lying areas and straddling the multiple ephemeral stream drainages where there was a significantly greater proportion of alluvial (running water-deposited) material present than colluvial (gravity-deposited with the aid of rain; slopewash) material. This unit underlies nearly all of the northern half of the property, and consists of both areas in which boulders are found in abundance and areas where few boulders are encountered. The northern half of the property was found have intermittent boulder fields and patches of fine sediment, having the appearance of intertwining braided stream deposits. Where present, boulders were typically found to be rounded to subrounded, and up to 5 feet in diameter.

Qca (Quaternary colluvium and alluvium)
This unit was generally mapped in areas with gentle slopes, and represents a transitional unit between the predominantly alluvial deposits of the Qac unit and the almost exclusive colluvial deposits of the Qc unit. The unit was gradational in terms of the proportion of alluvial and colluvial material, with some areas having slightly more alluvial material than colluvial material, and vice versa. Much of the area west and south of the property is underlain by the Qca unit.

Qc (Quaternary colluvium)
This unit was mapped in areas with steeper slopes with concentrated boulder fields and was characterized by a general absence or the minor presence of fine-grained soils (silts and clays). Typically, this unit comprised the higher elevation knobs encountered during the mapping exercise, including along the southwestern margin of the property and the small hills to the north of the property. Boulders in the boulder fields in this unit were commonly subangular to subrounded, could be as much as 3 feet in diameter, and exhibited extensive desert varnish, indicative of remaining stationary for an extended period of time.

Surface Water/Groundwater
At the time of the site visit, the ephemeral stream drainage that runs along the southeastern margin of the property was found to be flowing with water, with a larger volume of water and stronger current further to the south. The low-lying central portion of property contained several small gullies with flowing water and also ponded, marshy conditions (see Figure A-4). The EarthTec Test Pits 1 and 3 were completely filled with water. Approximately 415 feet north of the northern margin of the property, the main north-south ephemeral drainage was found to be moist but did not display any flowing water.

No springs were identified on the property, though a shallow water table was found to be present across much of the northern half of the property.

Geologic Hazards
No mass-movement deposits, faults, or any additional geologic hazards were observed on or adjacent to the property during the site reconnaissance.

GEOLOGIC HAZARD ASSESSMENT

Geologic hazard assessments are necessary to evaluate the potential risk associated with particular geologic hazards that are capable of adversely affecting a proposed development area. As such, they are essential in evaluating the suitability of an area for development and provide critical data in both the planning and design stages of a proposed development. The geologic hazard assessment discussion below is based upon a qualitative assessment of the risk associated with a particular geologic hazard, based upon the data reviewed and collected as part of this investigation.

A “low” hazard rating is an indication that the hazard is either absent, is present in such a remote possibility so as to pose limited or little risk, or is not anticipated to impact the project in an adverse way. Areas with a low-risk determination for a particular geologic hazard generally do not require additional site-specific studies or associated mitigation practices with regard to the geologic hazard in question. A “moderate” hazard rating is an indication that the hazard has the capability of adversely affecting the project at least in part, and that the conditions necessary for the geologic hazard are present in a significant, though not abundant, manner. Areas with a moderate-risk determination for a particular geologic hazard may require additional site-specific studies and associated mitigation practices in the areas that have been identified as the most prone to susceptibility to the particular geologic hazard. A “high” hazard rating is an indication that the hazard is very capable of adversely affecting the project, that the geologic conditions pertaining to the particular hazard are present in abundance, and/or that there is geologic evidence of the hazard having occurred at the area in the historic or geologic past. Areas with a high-risk determination generally always require additional site-specific hazard investigations and associated mitigation practices. For areas with a high-risk geologic hazard, simple avoidance is often considered.

The following are the results of the reconnaissance-level geologic hazard assessment for the Fairways at Wolf Creek Phases 4 and 5 properties.

Landslides/Mass Movement/Slope Stability

The property is not located on or adjacent to landslide deposits or headscarps, as determined by the geologic literature review, aerial imagery evaluation, and site reconnaissance. Additionally, the steepest slopes on the property are found to be greater than 5:1 (horizontal:vertical), which do not warrant site-specific slope stability analyses. As such, the risk associated with landslide and slope stability hazards on the property is considered to be low.

Rockfall

No bedrock is exposed upslope of the property, and it is more than ¼ mile to the north before there is a significant increase in slope. As such, the rockfall hazard associated with the property is considered to be low.

Surface-Fault-Rupture and Earthquake-Related Hazards

No faults are known to be present on the property, and the closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 5.3 miles to the west of the property (USGS and UGS, 2006). Though some nearby faults may project onto the property, there is no surficial evidence for their existence on the property. Additionally, these faults are pre-Tertiary-aged, have long been inactive, and are unassociated with the Wasatch Fault Zone, so the risk associated with their future activity is low. Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property is subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given the distance from the Wasatch Fault, the hazard associated with ground shaking is considered to be moderate. Proper building design according to appropriate building code and design parameters can assist in mitigating the hazard associated with earthquake ground shaking.

Liquefaction

Given the generally very coarse and likely relatively thin nature of the surficial materials, and consistent with the existing geologic literature for the area, the risk associated with earthquake-induced liquefaction is expected to be low. However, both shallow groundwater and granular soils are present on the property; therefore, we cannot preclude the possibility for liquefaction to occur onsite. A liquefaction study, which would include borings and/or CPT soundings to a depth of at least 50 feet, was not performed for this project and is not a part of our scope of work.

Debris-Flows and Flooding Hazards

Young alluvial fan deposits (Qafy) have been mapped adjacent to the property by Coogan and King (2001) in association with the Wolf Creek drainage. However, only the southeastern margin of the property is partially within this mapped alluvial fan deposit (and on the western edge of the mapped fan deposit), the Wolf Creek drainage is approximately 0.2 miles to the east of the property, and the property is not located on the Wolf Creek floodplain. Given this situation, the debris-flow hazard associated with the property is considered to be low.

Additionally, given the small size of the ephemeral drainages found on the property (generally 2 to 5 feet wide by a 1 to 3 feet deep), the distance away from the Wolf Creek drainage, and the elevated topography above the Wolf Creek floodplain, the flooding hazard for the property is considered to be low. This is consistent with the FEMA flood map that covers the area (FEMA, 2015).

Shallow Groundwater

Groundwater was encountered in all six tests geotechnical test pits excavated on the property between the depths of 6 and 9.5 feet below existing grade (EarthTec, 2016). These test pits were excavated in late January and early February, and the groundwater levels observed in the test pits are likely to be at or near seasonal lows. With the site reconnaissance occurring in mid-May near the expected peak runoff and seasonal high for groundwater, shallow groundwater was noted to be prevalent on the property. Extensive shallow groundwater was observed especially in the north-central part of the property in areas of gentle topography and near the multiple ephemeral stream drainages and gullies found in the area, though no springs were observed.

Given the existing data, it is expected that groundwater levels will fluctuate both seasonally and annually between approximately 9.5 feet below the existing ground surface and ground level. As such, the risk associated with shallow groundwater hazards is considered high. However, shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of residences with basements, or through the use of land-drains.

Radon

Limited data is available to address the radon hazard across the property. However, at least one study (Solomon, 1996) shows the site situated within an area designated as having a high radon hazard. To be conservative, the radon hazard associated with the property is considered to be high. A site-specific radon hazard assessment is recommended to adequately address radon concerns across the property.

CONCLUSIONS AND RECOMMENDATIONS

Based upon the data collected and reviewed as part of this assessment, IGES makes the following reconnaissance-level conclusions regarding the geological hazards present at the Fairways at Wolf Creek Phases 4 and 5 project area:

- **From a reconnaissance-level perspective, the Fairways at Wolf Creek Phases 4 and 5 project area does not appear to have major geological hazards that would adversely affect significant portions of the development as currently proposed. As such, no subsurface geologic hazards investigative methods are considered to be necessary for the property preceding development.**

- Earthquake ground shaking, shallow groundwater, and radon are the only hazards that may potentially affect all parts of the project area, while other hazards have the potential to affect only limited portions of the project area, or pose minimal risk.

- Landslide, rockfall, surface-fault-rupture, debris-flow, and flooding hazards are considered to be low for the property.

- Published literature and the site-specific geotechnical report (EarthTec, 2016) indicate that the liquefaction potential for the site is low. However, due to the presence of granular soils and shallow groundwater and the unknown character of the soils underlying those examined in the geotechnical report, the potential for liquefaction occurring at the site cannot be ruled out.

Given the conclusions listed above, IGES makes the following recommendations:

- The prevalence of shallow groundwater across the property makes necessary mitigation practices to adequately address this potential hazard. Appropriate grading measures in low-lying areas susceptible to near-surface groundwater conditions is recommended, as is the construction of the proposed residences without basements or with land-drains.

- To adequately address the radon hazard for the property, a site-specific radon assessment is recommended. This could be conducted either on a property-wide basis or a lot-by-lot basis.

LIMITATIONS

The conclusions and recommendations presented in this report are based on limited geologic literature review and site reconnaissance, and our understanding of the proposed construction. It should be noted that these conclusions are based solely upon the geological hazards investigated for this report, and do not pertain to other potential geologic hazards that may be present on the property. Additional geologic hazards may be present that may not be identified until construction activities expose adverse geologic conditions. Therefore, the geologic hazard classifications as denoted in this report are potentially subject to change with data collected from site-specific excavations across the property. This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

CLOSURE

We appreciate the opportunity to provide you with our services. If you have any questions, please contact the undersigned at your convenience at (801) 748-4044.

Respectfully Submitted,
IGES, Inc.

Peter E. Doumit, P.G., C.P.G.
Senior Geologist

David A. Glass, P.E.
Senior Geotechnical Engineer

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Utah Geological Survey, 2016a, Utah Geological Survey Aerial Imagery Collection https://geodata.geology.utah.gov/imagery/

AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
1947 AAJ	August 10, 1946	2B	46, 47, 48	1:20,000
1963 ELK	June 25, 1963	2	82, 169, 170	1:15,840

*https://geodata.geology.utah.gov/imagery/

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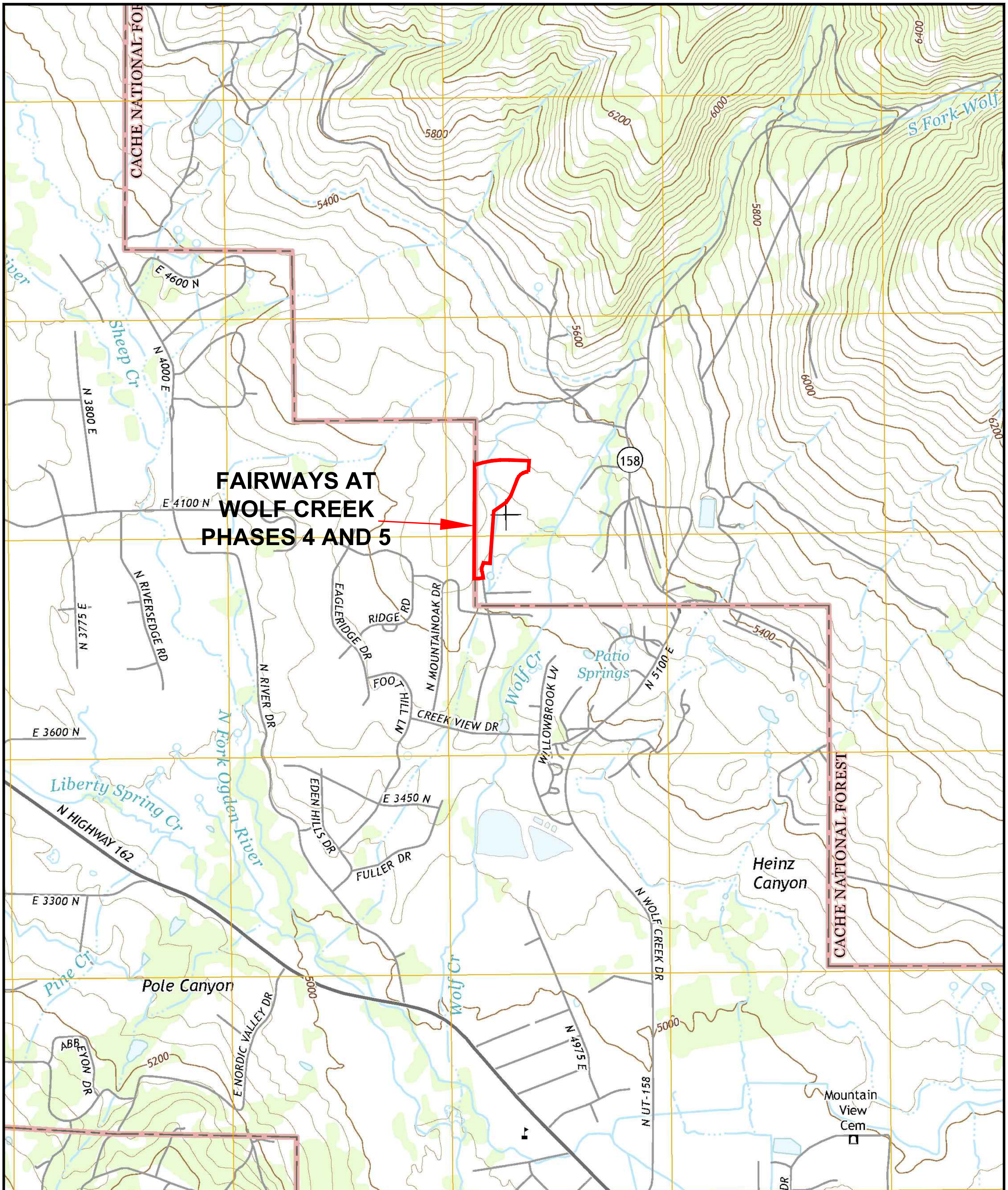
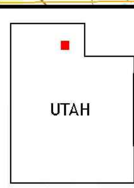
Weber County, 2015, Natural Hazards Overlay Districts, Chapter 27 of Title 104 of the Weber County Code of Ordinances, adopted on December 22, 2015.



BASE MAP:
USGS Huntsville 7.5-Minute Topographic Quadrangle Map (2014)



QUADRANGLE LOCATION

N

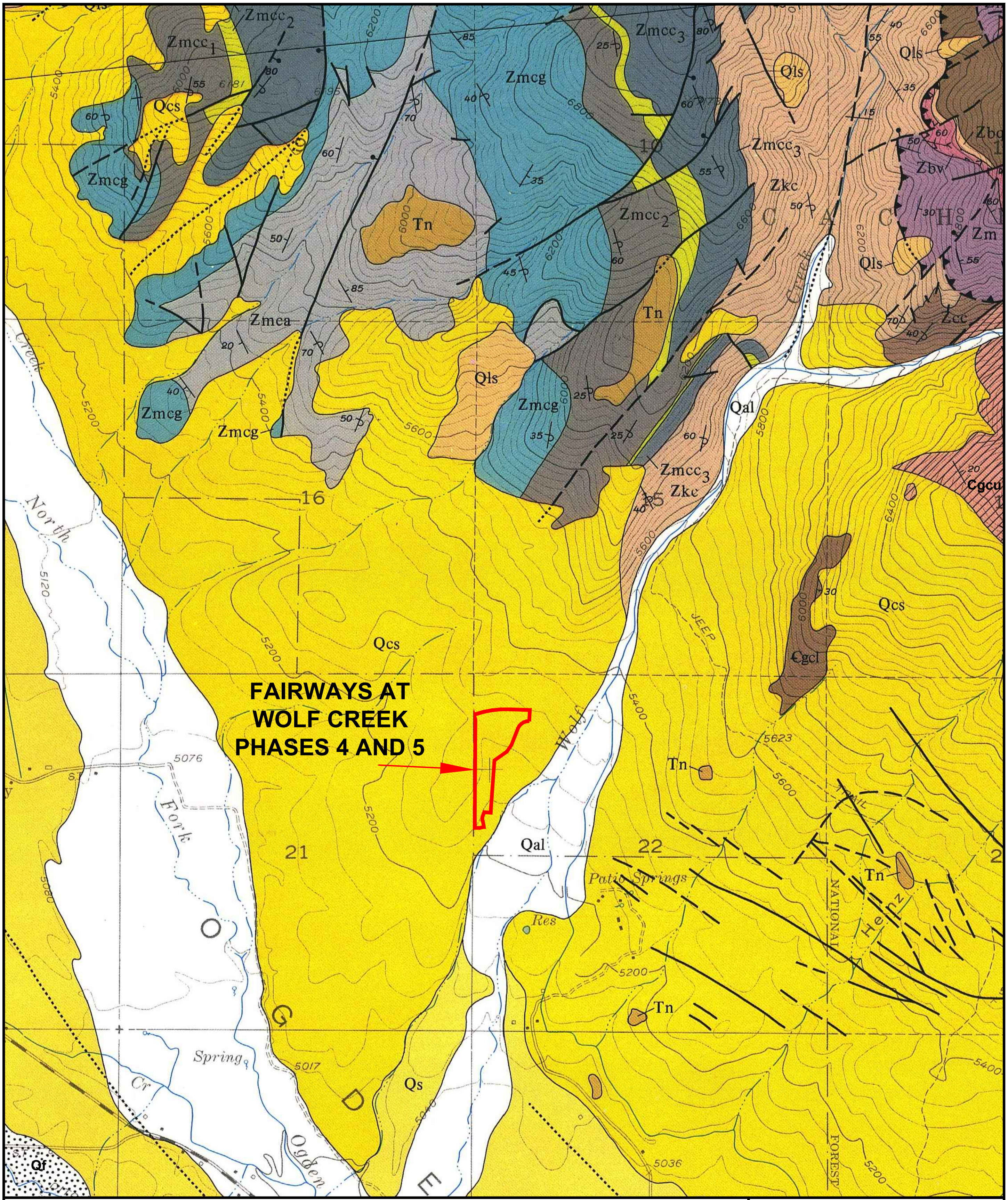
0 1000 2000 3000
FEET

FIGURE A-1

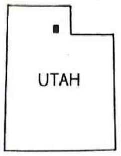
GENERAL LOCATION MAP

FAIRWAYS AT WOLF CREEK
SUBDIVISION PHASES 4 AND 5
GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016
PROJECT:01855-007
SCALE: 1"=2,000'
IGES



BASE MAP:
USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)



QUADRANGLE LOCATION

N

0 1000 2000 3000
FEET

FIGURE A-2a

REGIONAL GEOLOGY MAP 1

FAIRWAYS AT WOLF CREEK
SUBDIVISION PHASES 4 AND 5
GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016
PROJECT:01855-007
SCALE: 1"=2,000'
IGES

MAP LEGEND

Qal ALLUVIAL DEPOSITS, UNDIFFERENTIATED (Holocene) – Unconsolidated gravel, sand, and silt deposits in presently active stream channels and floodplains; thickness 0-6 m

Qcs COLLUVIUM AND SLOPEWASH (Holocene) – Bouldery colluvium and slopewash chiefly along eastern margin of Ogden Valley; in part, lag from Tertiary units; thickness 0-30 m

Qf ALLUVIAL FAN DEPOSITS (Holocene) – Alluvial fan deposits; postdate, at least in part, time of highest stand of former Lake Bonneville; thickness 0-30 m

Qls LANDSLIDE DEPOSITS (Holocene) – thickness 0-6 m

Qs SILT DEPOSITS (Pleistocene) – Tan silt and sand forming extensive flats in Ogden Valley; deposited during high stands of Lake Bonneville, but may include older alluvial units; thickness 0-60 m

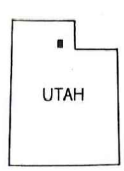
Tn NORWOOD TUFF (lower Oligocene and upper Eocene) – Fine- to medium-bedded, fine-grained, friable, white- to buff-weathering tuff and sandy tuff, probably waterlain and in part reworked; thickness 0-450+(?) m

BRIGHAM GROUP (Crittenden and others, 1971) – Includes:
GEERTSEN CANYON QUARTZITE (Lower Cambrian) – Includes:

€gcu Upper member – Pale-buff to white or flesh-pink quartzite, locally streaked with pale red or purple. Coarse-grained; small pebbles occur throughout unit and increase in abundance downward. Base marked by zone 30-60 m thick of cobble conglomerate in beds 30 cm to 2 m thick; clasts, 5-10 cm in diameter, are mainly reddish vein quartz or quartzite, sparse gray quartzite, or red jasper; thickness 730-820 m

€gcl Lower member – Pale-buff to white and tan quartzite with irregular streaks and lenses of cobble conglomerate decreasing in abundance downward. Lower 90-120 m strongly arkosic, streaked greenish or pinkish. Feldspar clasts increase in size to 0.6-1.3 cm in lower part of unit; thickness 490-520 m

BASE MAP:
USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)



QUADRANGLE LOCATION

N

0 1000 2000 3000
FEET

FIGURE A-2b

REGIONAL GEOLOGY MAP 1

FAIRWAYS AT WOLF CREEK SUBDIVISION PHASES 4 AND 5 GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016 | SCALE: 1"=2,000'
PROJECT:01855–007

IGES

MAP LEGEND

Zbq — BROWNS HOLE FORMATION (Precambrian Z) — Includes:
Quartzite member — Medium- to fine-grained, locally friable-weathering, well-rounded, well-sorted, terra-cotta-colored quartzite, with some small- to large-scale crossbedding; thickness 30-45 m

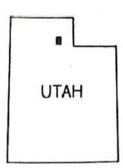
Zbv — Volcanic member — Unit comprises volcanic rocks ranging in composition from basalt or andesite to trachyte. Includes gray-weathering, fine-grained basaltic flows and a variety of black to red, scoriaceous to amygdaloidal volcanic breccias, all locally reworked as volcanic conglomerate. K/Ar age of hornblende from cobble of alkali trachyte is 570 ± 7 m.y. (Crittenden and Wallace, 1973); thickness 55-140 m

Zm — MUTUAL FORMATION (Precambrian Z) — Coarse- to medium-grained, commonly gritty, locally pebbly, grayish-red to pale-purple or pink quartzite and feldspathic quartzite with abundant cross-bedding; thickness 370 m

Zcc — CADDY CANYON QUARTZITE (Precambrian Z) — Medium-grained, vitreous, white to tan quartzite; unit is dominantly light-colored near top and tan- to pale-brown-weathering in lower part, with abundant intercalated red siltstone at base; thickness 460-600 m

Zkc ls — KELLEY CANYON FORMATION (Precambrian Z) — Upper part interbedded olive-drab siltstone and thin-bedded, tan- or brown-weathering quartzite, generally in wavy or contorted beds cut by small sandstone dikelets; contact with overlying unit may be marked by zone of thin-bedded quartzite (0.5-2-cm beds) with red-weathering wavy laminae of shale and siltstone. Middle part is gray to lavender argillite enclosing and intercalated with thin-bedded pinkish-gray silty limestone (at Middle Fork Ogden River, shown on map as ls). Lower part is lavender-gray, purple-gray, or olive-drab shale, with thin beds of greenish fine-grained sandstone at top. Base of unit marked by 3-m thin-bedded to laminated, tan-weathering, fine-grained dolomite; thickness 600 m

BASE MAP:
USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)



QUADRANGLE LOCATION

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0 1000 2000 3000
FEET

FIGURE A-2c

REGIONAL GEOLOGY MAP 1

FAIRWAYS AT WOLF CREEK
SUBDIVISION PHASES 4 AND 5
GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016
PROJECT:01855-007
SCALE: 1"=2,000'
IGES

MAP LEGEND

MAPLE CANYON FORMATION (Precambrian Z) – Includes:

Zmcc — Conglomerate member – Total thickness 30-150 m. Includes:

$Zmcc_3$ — Upper conglomerate – Coarse-grained, locally conglomeratic, white quartzite

$Zmcc_2$ — Argillite – Olive-drab to silvery-gray laminated argillite

$Zmcc_1$ — Lower conglomerate – White to pale-gray conglomeratic quartzite, with pebble- to cobble-size clasts of white quartz and white, gray, or pale-pink quartzite

Zmcg — Green arkose member – Massively bedded pale-green arkosic sandstone, with K-feldspar content locally to 40 percent. Zone of siliceous arkosic quartzite locally present approximately 60 m below top of unit; intercalated quartzitic conglomerates locally present near base of unit; thickness 150-300 m

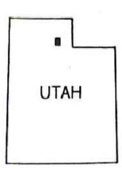
Zmca — Argillite member – Olive-drab, locally gray, thin-bedded siltstone and silty argillite, with a medial zone of greenish-gray arkosic sandstone. Argillite commonly shows small-scale folding and marked schistosity. May include rocks of Precambrian Y age near base of unit; thickness 150 m

Recently active normal fault – Dashed where inferred. Ticks on downthrown side

Pre-Tertiary normal fault – Dotted where concealed Bar and ball on downthrown side

Thrust fault – Dashed where inferred Sawteeth on upper plate

BASE MAP:
USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)



QUADRANGLE LOCATION

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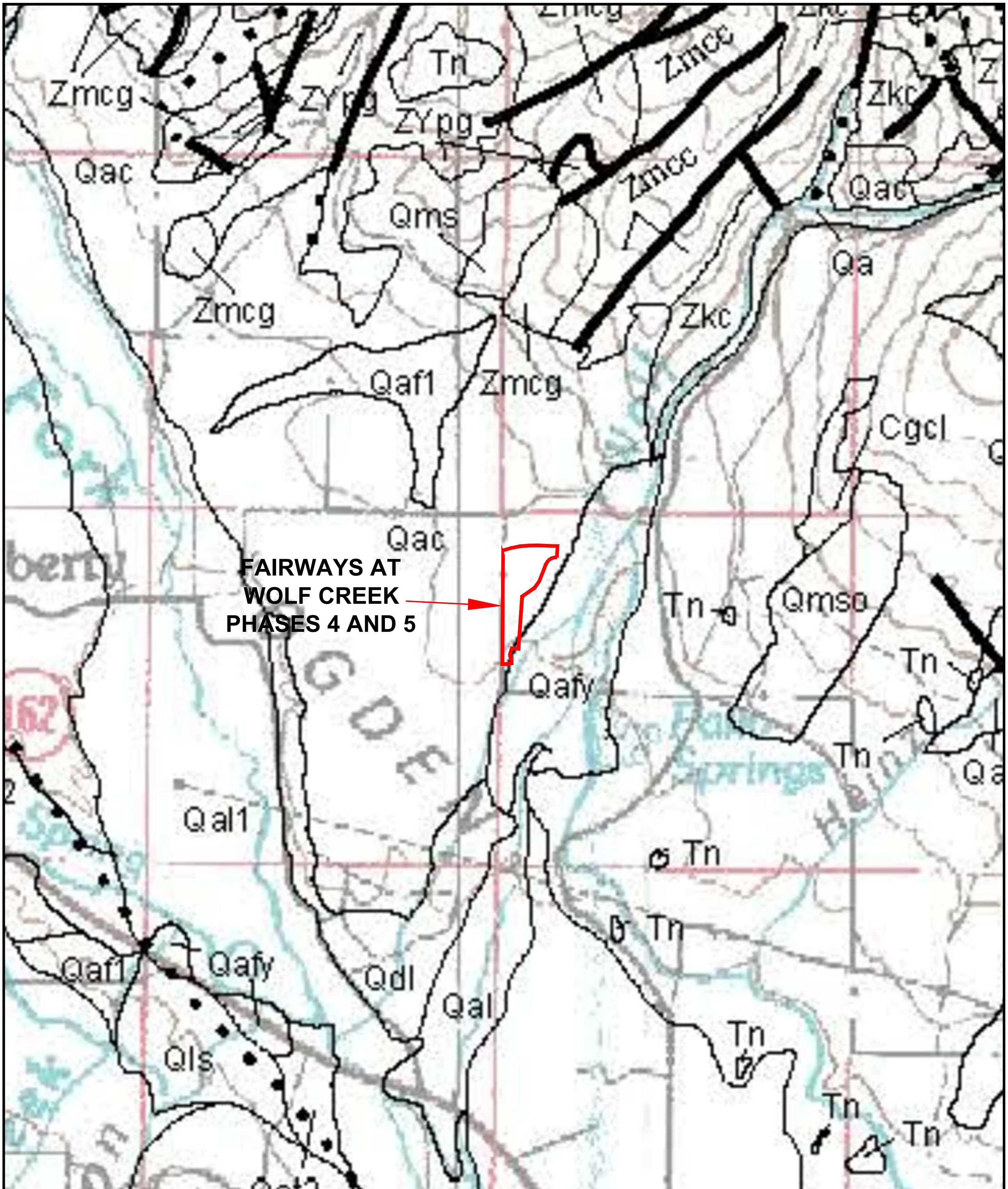
0 1000 2000 3000
FEET

FIGURE A-2d

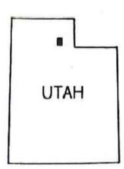
REGIONAL GEOLOGY MAP 1

FAIRWAYS AT WOLF CREEK SUBDIVISION PHASES 4 AND 5 GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016	SCALE:	IGES
PROJECT:01855-007	1"=2,000'	



BASE MAP:
UGS Ogden 30' x 60' Progress Report Geologic Quadrangle Map (OFR-380), Coogan and King (2001)



QUADRANGLE LOCATION

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0 1000 2000 3000
FEET

FIGURE A-3a

REGIONAL GEOLOGY MAP 2

FAIRWAYS AT WOLF CREEK
SUBDIVISION PHASES 4 AND 5
GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016
PROJECT:01855-007
SCALE: 1"=2,000'

IGES

MAP LEGEND

OGDEN 30' x 60' PRELIMINARY MAP UNITS

QUATERNARY (number suffixes show local levels/relative age, with "1" the youngest; other common suffixes are: o = older and y = younger; see correlation chart for unit suffixes)

Qa1, Qa2, Qa[p], Qab, Qay, Qao Stream and fan alluvium -- Sand, silt, clay, and gravel. Alluvium labeled Qa[p] and Qab are graded to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively. Near former Lake Bonneville, units labeled 1 and 2 are younger than Lake Bonneville; elsewhere relative-age numbers only apply to local drainages.

Qal1, Qal2 Stream alluvium, Holocene -- Sand, silt, clay, and gravel in channels and floodplains; composition depends on source area; suffixes 1 and 2 indicate ages where they can be separated in the area of former Lake Bonneville, with 2 including low terraces.

Qat2, Qat3, Qatp, Qaty, Qato, Qat4-7 Stream-terrace deposits -- Sand, silt, clay, and gravel in terraces above floodplains. Terraces labeled Qatp are graded to the Provo and slightly lower shorelines of late Pleistocene Lake Bonneville and are only present in Morgan and Mantua Valleys. Near former Lake Bonneville, units with suffixes 2 and 3 are younger than Lake Bonneville; elsewhere relative-age numbers only apply to local drainages and the lowest terraces are labeled 2.

Qaf1, Qaf2, Qafy, Qafp, Qafb, Qaf3, Qafo Alluvial-fan deposits -- Mostly sand, silt, and gravel that is poorly bedded and poorly sorted. Fans labeled Qafp and Qafb are graded to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively; unit Qaf3 is used where these fans can't be separated. Near former Lake Bonneville, units with suffixes 1 and 2 are younger than Lake Bonneville and are shown as Qafy where they can't be separated; here, unit Qafo is older than Lake Bonneville. Elsewhere relative-age numbers and letters only apply to local drainages.

QafO Lower and middle Pleistocene alluvial-fan deposits – Fans located above pre-Lake Bonneville older alluvial-fan deposits (Qafo) near Mountain Green; contain mostly sand, silt, and gravel that is poorly bedded and poorly sorted.

Qap Pediment-mantle deposits (also labeled as Qs = erosion surface with uncertain mantle thickness) -- Gravel, sand, silt, and clay alluvium and colluvium capping erosional surfaces.

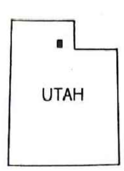
Qac Alluvium and colluvium -- Includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits.

Qc Colluvium -- Includes slopewash and soil creep; composition depends on local bedrock.

Qcg Colluvial and residual gravel deposits – Includes Quaternary gravel-armored

BASE MAP:

UGS Ogden 30' x 60' Progress Report Geologic Quadrangle Map (OFR-380), Coogan and King (2001)



QUADRANGLE LOCATION

N

0 1000 2000 3000

FEET

FIGURE A-3b

REGIONAL GEOLOGY MAP 2

FAIRWAYS AT WOLF CREEK SUBDIVISION PHASES 4 AND 5 GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016 | PROJECT:01855–007 | SCALE: 1"=2,000' | IGES

MAP LEGEND (cont.)

surfaces that don't resemble pediments; previously included in Huntsville fanglomerate.

Qmc Colluvium and mass-movement deposits, undivided – Includes landslide, slump, slopewash, and soil creep with subdued morphology on steep slopes.

Qm, Qmo Mass-movement deposits, undivided – Includes slides, slumps, and flows, as well as colluvium, talus, and alluvial fans that are mostly debris flows; composition depends on local sources. Qmo locally used where younger mass-movements (including landslides and slumps) are mapped.

Qms, Qms1, Qms2, Qms3, Qmsy, Qms4, Qmso Landslide and slump deposits (locally, unit involved is shown in parentheses) – Poorly sorted clay to boulder-sized material; locally includes flow deposits. Near former Lake Bonneville units with relative-age number suffixes were: 1) emplaced in the last 80 to 100 years; 2) are post Lake Bonneville in age; 3) were emplaced during or shortly after Lake Bonneville regression; and 4) were emplaced before Lake Bonneville transgression; extensive deposits in Lake Bonneville sediments in North Ogden and Kaysville quadrangles include earthquake liquefaction features. Suffixes y (as well as 1&2) and o (as well as 3&4) indicate probable Holocene and Pleistocene ages, respectively.

Qmt Talus, and lesser colluvium -- Angular debris at the base of and on steep slopes. Includes rock glaciers that form lobate mounds in cirques in the Wasatch Range; probably inactive.

Qg, Qgw Glacial till and outwash -- Mostly Pinedale (~15,000 to 30,000 yrs old) but probably includes Little Ice Age (1500 to 1800 A.D.) and may include Bull Lake (~130,000 to 150,000 yrs old) deposits; locally includes rock glaciers. Unit Qgw is outwash and, possibly, alluvially reworked outwash that obscures older deposits and bedrock.

Qly Lacustrine deposits other than those in Lake Bonneville – Fine-grained material and locally marsh deposits in lakes outside the Great Salt Lake basin; typically younger than Lake Bonneville deposits.

Qla Lake Bonneville deposits; and post- and pre-Lake Bonneville alluvial-fan deposits, undivided -- Mostly poorly sorted and poorly bedded sand, silt, and gravel.

Ql Lake Bonneville deposits, undivided.

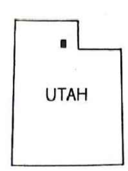
Qlf Fine-grained lacustrine deposits -- Mostly clay, silt, and fine sand deposited offshore in Lake Bonneville. In the Kaysville quadrangle, deposits below the Gilbert shoreline are the same age as the shoreline, while deposits below the historic-highstand shoreline (4,213 feet [1,284.5 m]) of Great Salt Lake are recent.

Qls Lake Bonneville sand -- Mostly sand with some silt and gravel deposited nearshore; grades downslope into unit Qlf with decreasing sand content. Typically sand in the Ogden and Morgan Valleys.

Qlg Lake Bonneville gravel -- Mostly interbedded gravel and sand deposited along

BASE MAP:

UGS Ogden 30' x 60' Progress Report Geologic Quadrangle Map (OFR-380), Coogan and King (2001)



QUADRANGLE LOCATION

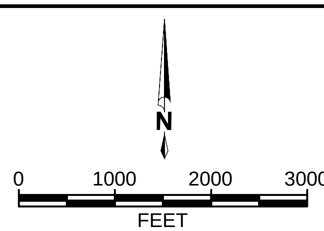
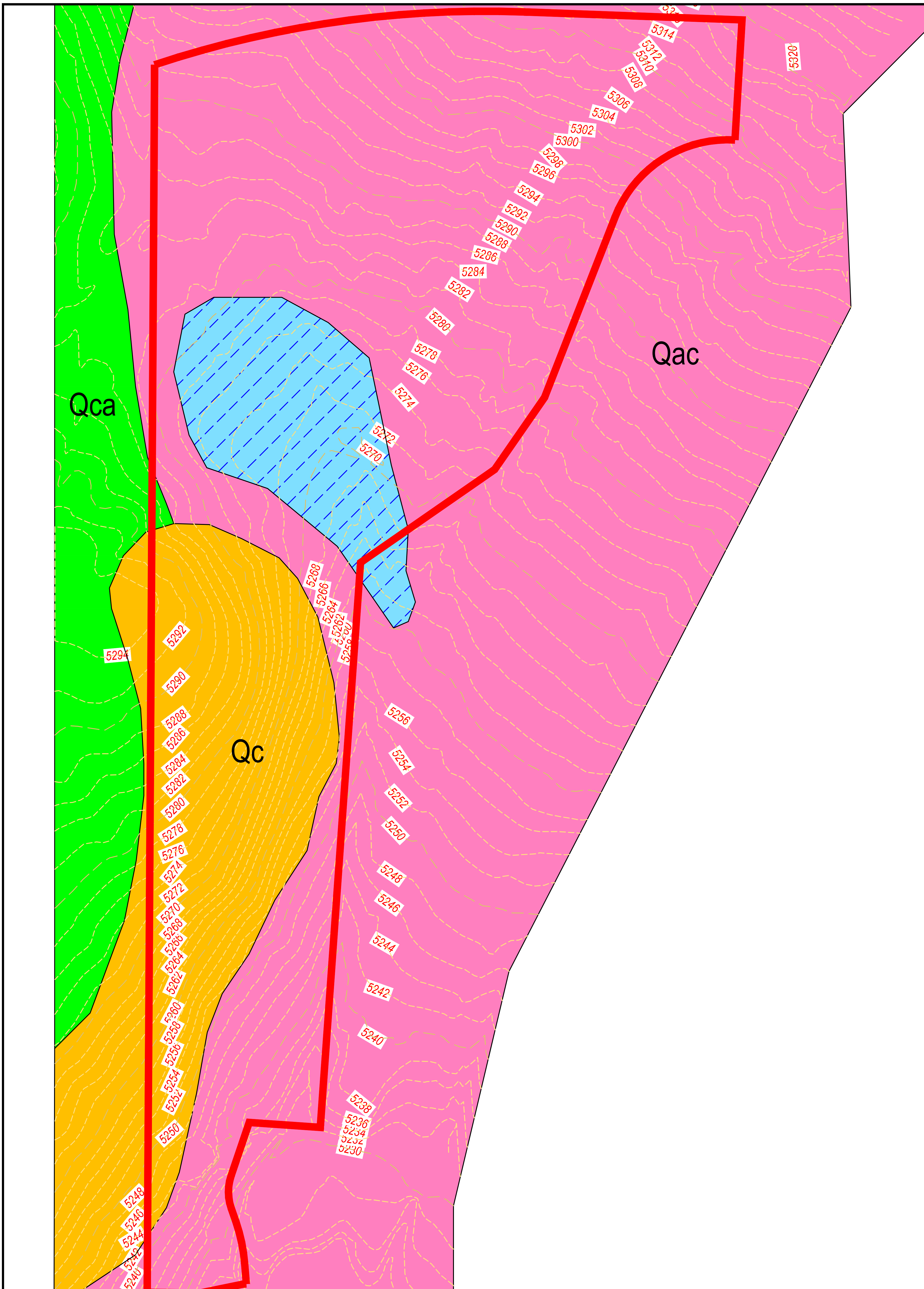


FIGURE A-3c

REGIONAL GEOLOGY MAP 2

FAIRWAYS AT WOLF CREEK SUBDIVISION PHASES 4 AND 5 GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016 | PROJECT:01855-007 | SCALE: 1"=2,000' | IGES



LEGEND

- Qac — PREDOMINANTLY ALLUVIUM AND SOME COLLUVIUM
- Qca — COLLUVIUM AND ALLUVIUM; GRADATIONAL
- Qc — BOULDERY COLLUVIUM
- AREA OF STANDING WATER/MARSHY CONDITIONS
- PROPERTY BOUNDARY

N

0 200

FEET

FIGURE A-4

LOCAL GEOLOGY MAP

FAIRWAYS AT WOLF CREEK
SUBDIVISION PHASES 4 AND 5
GEOLOGIC HAZARDS ASSESSMENT

DATE: 05/17/2016
FILE: 01855-007
SCALE: 1"=200'

IGES