# Combined License Application

## Part 11G: Site Area Paleoliquefaction And Surface Faulting Investigation Program

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# 1.0 PALEOLIQUEFACTION AND SURFACE FAULTING INVESTIGATION PROGRAM

To complement the references in the literature that consider paleoliquefaction and surface faulting in the area of the Callaway Plant Site, a specific field investigation program was conducted during the general field investigations as part of the overall development of the Callaway Plant Unit 2 COLA. The overall effort consisted of three Phases.

Consistent with USNRC Regulatory Guides and Standard Review Plans, this program focused on the area around the Callaway Site defined by a 5 mile (8 km) radius (Phase 1), and extending to cover the Site Vicinity (25 mile (40 km)) (Phases 2 and 3).

Phase 1 of the investigation program used remote imagery and topographic maps as the initial source of data for locating potentially anomalous features within the Site Area. Phase 1 consisted of a number of steps, including an on-the-ground inspection and reconnaissance (ground truthing) during late June-early July of 2007 of all areas where evidence suggested some type of anomaly which could not be interpreted directly. Each anomaly was visited, logged, photographed if questionable and documented to define the conditions at each anomaly, with an eye toward assessing the impact of the anomaly on the safety-related facilities of the Callaway Plant Unit 2.

Phase 2 of the program focused on paleoliquefaction features that are not discernible on remote imagery, but may be visible along stream banks and river banks in the Site Vicinity, that includes a short reach of the Missouri River and several small streams. Where possible, a small boat was used to view the stream banks and river banks from the water. For those streams where the water was too shallow for a boat, on-foot surveillance was undertaken.

Phase 3 consisted of an inspection of the surface expression of the 5 faults nearest the Site, to confirm their locations and to evaluate available exposures for indications of recent movement.

## 1.1 WORK PLAN DEVELOPMENT

Details of the investigations are provided below, including the scope, methodology, findings, and conclusions.

### 1.1.1 PHASE 1 WORK PLAN

The Phase 1 Work Plan implemented for this program consisted of a number of steps as outlined below:

1. Identified remote imagery, specifically aerial and satellite images and topographic maps, available for the area of the Site.

2. Analyzed and interpreted the maps and aerial and satellite images to identify features on the ground surface that are potentially anomalous and not explainable by observation on the remote imagery and could be postulated as being related to historic or prehistoric earthquakes or tectonic activity.

3. Created a remote image showing all of the anomalous features for use as a field location map and later as a basis for documentation purposes. The location map with the labeled anomalous features was used by the field geologists to find the anomalous features in the field.

4. Assigned a label and approximate longitude and latitude co-ordinates to the anomalous features using tools available from the imagery supplier.

5. Using the location map along with the labels and coordinates, a team of geologists visited each anomalous feature with the aid of a portable GPS unit to ground truth the anomaly.

6. During the visit to the anomalous feature, the team of geologists recorded electronically the actual location of the feature with the portable GPS unit.

7. The anomalous feature was observed, discussed by the team, logged with a written description, interpreted as (a) a non-geologic feature or (b) a geologic feature that is not associated with an earthquake or tectonics, e.g., a landslide or slump or (c) a feature that could be postulated as being derived from an earthquake (such as a paleoliquefaction feature) or (d) a tectonic feature such as fold, monocline or a fault. Photographs were taken to supplement the logs, if necessary, for future referencing.

8. In addition, the location of anomalous features observed during the field reconnaissance, but not observed previously on the remote imagery or maps, were also labelled and logged, as above.

9. The results of the ground truthing work were then re-interpreted in the office, together with the remote imagery and any literature available for the area of the feature. This step also involved a peer review of the interpretation of each anomaly.

10. The results were then analyzed with respect to the possibility that the features offer evidence for a geologic hazard that could affect the safety-related facilities of Callaway Plant Unit 2. If so, they were documented and discussed in the appropriate FSAR Sections 2.5.1 through 2.5.5.

### 1.1.2 PHASE 2 WORK PLAN

The Phase 2 Work Plan for this program consisted of a number of steps similar to those followed for Phase 1 as follows:

1. Using USGS quadrangle maps as well as electronic versions of topographic maps available from the National Geographic Society, waypoints were pre-established in the office along stream banks and river banks based on the plan view of the water course. For example, outside curves and other stream segments undergoing erosion were emphasized as these are zones on the banks of the watercourse where erosion under high water flow has the potential to expose paleoliquefaction features such as sand dikes and sills. Inside curves and zones of obvious deposition were not defined as waypoints. This step in the process defined where to look in the field for anomalies that might contain evidence of paleoliquefaction features.

2. Created a working map showing the waypoints (label, latitude and longitude) chosen in the office to be used as a field working document and later as a basis for documentation purposes. The map with the labeled features was used by the field geologists to find the features in the field.

3. Using the working map with the labels and co-ordinates, a team of geologists arranged a reconnaissance study of each feature with the aid of a portable GPS unit to ground

truth the feature. Visits were primarily accomplished with the use of a shallow draft boat, or when the water was too shallow, by foot working out of a utility vehicle.

4. During the visit to the feature, the team of geologists recorded electronically with the portable GPS unit, the actual location of the feature visited. This location may or may not be the precise location developed in the office during preparation of the working map.

5. The feature was observed, discussed by the team, logged with a written description, interpreted as (a) a non-geologic feature or (b) a geologic feature that is not associated with an earthquake or tectonics, e.g., a landslide or slump or (c) a feature that could be postulated as being derived from an earthquake (such as a paleoliquefaction feature). Photographs were taken to supplement the logs if necessary for future referencing.

6. Where practical, the bank of the watercourse was excavated with hand tools, to check the depth of the feature, and whether it has "roots" in liquefiable soils. On the basis of the observations and/or the shallow excavations, a judgment was made regarding the feature in terms of one of the following:

    a. The feature at the defined waypoint does not exhibit characteristics of a paleoliquefaction feature.

    b. The feature is not of interest from a paleoliquefaction perspective as it is not associated with earthquake response.

    c. The feature could not be adequately assessed at this time as, for example, the depth of the water in the water course precluded excavation or the stream bank was not accessible. In such a case, the waypoint was so noted.

    d. The feature was noted as having a high probability of being caused by an earthquake and the feature was noted and described as a paleoliquefaction feature.

    e. For those features classified above as "c" or "d", a diligent effort was made to obtain samples of material suitable for dating the feature, for example by radiocarbon dating. The samples were logged and manifested to a suitable laboratory with an acceptable Quality Assurance Program for age dating.

7. The locations of features observed during the field reconnaissance, but not defined on the working map prepared beforehand in the office were identified and logged as in Step 6.

8. The results of the field work were then compiled and re-interpreted in the office together with the age dating results and any literature that is available for the area of the feature.

9. The feature was then analyzed with respect to the location(s) and magnitude(s) of the likely causative events, taking into account the likely date (or range of dates) of the events, and the alternate scenarios that could lead to the development of the paleoliquefaction feature.

10. The results were then analyzed with respect to the possibility that the causative event is within the range of events and parameters considered in the Probabilistic Seismic Hazard Analysis (PSHA). If the causative event is covered by the PSHA, the event is so noted and no other work is carried out. If the causative event is not covered by the PSHA, the results of the PSHA are re-considered, either in terms of a sensitivity analysis or a re-run of all or part of the analysis, to account for the causative event,
11. The results are then documented in the appropriate sections of the FSAR.

### 1.1.3 PHASE 3 WORK PLAN

The Phase 3 investigation was conducted in two stages, a Literature Review followed by a Field Inspection.

- The Literature Review was undertaken to identify the current level of understanding of each fault, and its location.
- The Field Inspection involved a visit to each locality where the field team traversed the fault trace at multiple locations. The inspection was designed to locate new road cuts or other exposures where new observations could be made. The visits were recorded with digital photographs and GPS coordinates for each location visited.
- At the end of the Field Inspection the data (maps, GPS coordinates and photographs) were compiled to create a record of the effort for inclusion in the FSAR.

## 1.2 SUMMARY OF THE GEOLOGY OF THE SITE AREA

The geology of the Site Area is fully described in Section 2.5.1.2 and the stratigraphy and lithology of rock formations observed are described in Section 2.5.1.2.3.3. The following descriptions are provided to establish a broad overview of the local geologic features within which to interpret the results of these investigations.

In general, the Site can be characterized as occupying the crest of a small plateau, that has developed a radial drainage pattern to the surrounding streams. These streams are the Auxvasse Creek to the west, Mud Creek to the south, and Logan Creek to the east. All of these drain to the Missouri River, running 5 miles (8 km) to the south. The top of the plateau rises approximately 330 ft (100 m) above the run of the Missouri River, providing access to several exposed geologic formations between the crest and the runs of the surrounding rivers. The top of the plateau is covered by unconsolidated glacial deposits of principally clay and silt. Beneath these glacial deposits are several lithified formations of principally limestone, dolomite, and sandstone. Along the courses of the rivers and creeks are unconsolidated sediments forming flood plain and terrace deposits.

The surface materials on the high ground of the plateau are dominantly windblown loess (rock flour) underlain by paleosol. The paleosol is commonly underlain by either glacial till or cherty bedrock of the Pennsylvanian Age Graydon Chert Conglomerate. Loess thickness is highly variable but tends to be thicker at higher elevations due to less disturbance by fluvial environments.

The lithified rock outcrops investigated during this program include the stratigraphic profile between the St. Peter Formation and the Roubidoux Formation. The rocks are of Ordovician age, including the St. Peter Formation, the underlying Cotter-Jefferson City Dolomite and the underlying Roubidoux and Gasconade Formations, all of Ordovician Age. These are principally limestone, dolomite, and sandstone that form the valley walls.

The soils found along the watercourses, such as the banks of the Missouri River, are unconsolidated alluvial in nature, consisting of reworked loess deposits, mixed with glacial till, and usually capped with modern silty flood deposits. A typical exposure along a sizeable river would consist of interbedded sand, silt, and clay with modern flood deposits near water level and a 2-3 foot (~1 m) thick layer of floodplain deposits with abundant plant material at the surface. The rivers and creeks of Callaway County are floored by either glacial till or limestone bedrock. The large floodplains of the Missouri River and the major tributaries such as the Osage River and Auxvasse Creek consist of fining outward (away from river) sequences of sandy alluvium to silty and clayey alluvium.

## 1.3 WORK PLAN IMPLEMENTATION

The following sections describe the level of effort used in each phase of this investigation program.

### 1.3.1 PHASE 1 WORK PLAN IMPLEMENTATION

Recognizing the stratigraphy in the area of the Site, the Phase 1 Work Plan was implemented initially with remote imagery and map work in the office, secondly with field work, and finally with office work to finish the effort over the course of several months.

The field work activities defined in the Work Plan were performed in late June and early July 2007, by a team of geologists. The work was accomplished in the field using a combination of four-wheel drive vehicles and hiking. USGS Quadrangle Maps, the satellite imagery and the portable GPS Units were used for determining locations. Log books and digital cameras were used for logging and documenting the anomalous features.

The initial remote imagery work culminated with the production of Figure No. 27 which is an aerial image showing the area around the Site, overlaid with all of the anomalous features located remotely as well as those added during the field work. The anomalous features are classified as either a Potential Paleoliquefaction Feature (L-Feature) or a Potential Surface Fault Feature (G-Feature).

An anomalous feature was considered to be a Potential Paleoliquefaction Feature (L-Feature) if it was viewed remotely as being circular or linear or a line of circular features (sand blows, sand boils, dikes, etc.) much like the interpretations in Al-Shukri, 2000.

An anomalous feature was considered to be a Potential Surface Fault Feature (G-Feature) if it appears on the remote image or map as a non-man-made photo-linear, such as a natural change in color or type of vegetation, an alignment of abrupt changes in stream pathways, a sag pond or alignment of ponds that could be viewed as sag ponds, an alignment of springs as evidenced by vegetative color changes, linear topographic features inconsistent with the dominant pattern of topographic features in the area of the Site.

#### 1.3.1.1 Results of Phase 1

As mentioned above, Figure No. 27 depicts a large scale aerial image showing both the Potential Paleoliquefaction Features and the Potential Surface Fault Features.

The results of Phase 1 are summarized on two tables --Table No. 1, which is an assessment of the Potential Paleoliquefaction Features (L-Features), and Table No. 2, which is an assessment of the Surface Fault Features (G-Features). Each table includes a label for the feature, its longitude and latitude and a summary of the field observations at each feature.

During the field work for Phase 1, digital photographs were taken of the L-Features and the G-Features for purposes of documentation and future reference. Selected photos of the suspected fault-features are provided on Figure No. 1 through Figure No. 7.

#### 1.3.1.2 Potential Paleoliquefaction Features from Phase 1

As indicated on Table No. 1, most of the L-Features located in Phase 1 were determined to be associated with agricultural activities. For example, the circular features are most often circular hay bales. Linear features are usually a line of hay bales and several drainage features are man-made ditches. All of the L-Features are interpreted as being derived from man's activities (hay harvesting/farming, roads, accesses, clearings, gardens, constructions, graveyard), and surface water processes (runoff water erosion features, and pond water features). No indication of paleoliquefaction was observed during Phase 1.

While it is recognized that much of the area around the Site has been impacted by agricultural activities or is wooded, which might mask such features on remote images, no such features were found in non-developed areas along water bodies, either. Those are the areas where paleoliquefaction features would tend to be more prevalent if they exist at all in the area.

These Phase 1 findings are in accordance with the reported liquefaction for the Site Region, where the closest reported indication of paleoliquefaction is referred to in Crone, 2000 and Tuttle, 2005 as being in the St. Louis–Cape Girardeau area, 90 miles (145 km) southeast from the Site. These liquefaction features were found along the Cache, Cuivre, Femme Osage Creek, Meramec, and Missouri Rivers. The inferred seismic source for these features was reported to be 37 miles (60 km) east of St. Louis, 122 miles (200 km) east of the Site.

#### 1.3.1.3 Potential Surface Fault Features

The descriptions of Potential Surface Fault Features investigated in Phase 1 are provided on Table No. 2. As seen on the table, 60 suspected fault features were investigated in the field, which included finding and confirming the location (longitude and latitude co-ordinates), observing the feature, interpreting the stratigraphy, lithology and mineralogy of the rocks at the feature, preparing written logs and, finally, photographing the feature. None of the features yielded evidence of faulting. Three of the features described on Table No. 2 are slump features associated with old landslides or consolidation. None showed evidence of faulting. These slump and/or consolidation type features are tabulated below and more fully on Table No. 2. Photos of the three locations with deformation are attached as Figure No. 1 through Figure No. 3. Other photos of representative features without deformation are shown on Figure No. 4 through Figure No. 7.

**Summary of Deformation Features**

| Feature | Latitude | Longitude | Brief Description of Feature |
|---|---|---|---|
| G23 | 38°43'17.28"N | 91°46'54.23"W | Slump feature on one side of road cut. Deformation as much as 43 inches. |
| G24 | 38°43'21.68"N | 91°46'55.00"W | |
| G39 | 38°42'30.44"N | 91°47'14.56"W | Slump feature that resulted in facies change. |
| G43a | 38°43'21.32"N | 91°48'9.97"W | Convolute structure attributed to slumping or lateral compression |

None of the above listed features is tectonically derived and none indicates evidence of faulting.

#### 1.3.1.4 Conclusions From Phase 1

The conclusions emanating from Phase 1 of this Site Area Paleoliquefaction and Surface Faulting Investigation Program are summarized as follows:

- There is no evidence of paleoliquefaction in the area of the Site.
- No surface faulting features were found in the area of the Site that represents a geologic hazard which could impact the safety-related facilities of the proposed plant.
- The ground truthing work led to observations of small deformations (less than five (5) feet) – each one associated with slumping or consolidation and contained within Ordovician rocks. No long linear features indicative of faulting were found.

### 1.3.2 PHASE 2 WORK PLAN IMPLEMENTATION

Recognizing the geology and the nature of the watercourses within the area of the Site defined as being within 5 miles (8 km) of the Site, the Phase 2 Work Plan was implemented initially with the aid of the working map prepared in the office, secondly with field work from a boat or utility vehicle, and finally with office work.

The initial working map was prepared and culminated with the production of Figure No. 28 which is a map from the electronic version of USGS topographic maps by the National Geographic Society. This map shows the area around the Site, overlaid with all of the targeted features located in the office, later modified to include additional features encountered in the field.

The reconnaissance field work activities defined in the Phase 2 Work Plan were performed in the fall of 2008 by a team of geologists led by Dr. John Sims, a recognized expert in paleoliquefaction identification and assessment. Dr. Sims was supported by a geologist from RIZZO, a geologist assistant who regularly works with Dr. Sims, and a boat operator from AmerenUE. The work was accomplished in the field using a combination of a 17- ft shallow draft Jon Boat, a four-wheel drive vehicle and hiking. USGS Quadrangle Maps and portable GPS Units were used for determining locations. Log books and digital cameras were used for logging and documenting the features.

#### 1.3.2.1 Results of Phase 2

As mentioned above, Figure No. 28 is the working map used to initially define the Phase 2 waypoints in the office to be investigated in the field. The working map was modified after the Phase 2 field work to include those additional waypoints located and investigated in the field.

The results from Phase 2 for the Site Area are summarized on Table No. 3, which is a summary of the 95 waypoints investigated, including the label, latitude and longitude as well as appropriate comments on the observations in the field.

During the field work for Phase 2, digital photographs were taken at all of the waypoints for purposes of documentation and future reference. Since there were no features positively identified as paleoliquefaction sites, no samples were submitted for age dating.

#### 1.3.2.2 Potential Paleoliquefaction Features from Phase 2

During the Phase 2 reconnaissance search for paleoliquefaction sites, 95 waypoints were investigated either from a boat or by foot working out of four wheel drive vehicle. The investigation within the 5-mile (8 km) Site Area inspected 23 locations and found no evidence of earthquake-derived paleoliquefaction features. Figure No. 8 and Figure No. 9 display photos of typical sites containing evidence of slumping or flood-deposition processes. The investigation for the larger area, extending to the 25-mile (40 km) Site Vicinity inspected an additional 72 sites, and found a single location (Waypoint 47, at a distance of 7.1 miles (11.4 km) from the Site) containing a feature of interest (Figure No. 10 and Figure No. 11). All other features were interpreted as being derived from flood deposition processes or slumping.

#### 1.3.2.3 Conclusions From Phase 2

The preliminary conclusions emanating from Phase 2 of this Site Area Paleoliquefaction Investigation Program are summarized as follows:

None of these waypoints within the 5-mile (8 km) Site Area yielded any evidence of paleoliquefaction. All anomalous features were preliminarily interpreted as being derived from flood deposition processes or slumping. Only one of the waypoints in the Site Vicinity (to 25 mi (40 km)) contained a feature of interest. All other anomalous features in the Site Vicinity were preliminarily interpreted as being derived from flood deposition processes or slumping. None of the features observed provided any conclusive evidence that strong ground motion from paleoseismic activity has occurred within the Site Area or Site Vicinity.



### 1.3.3 PHASE 3 WORK PLAN IMPLEMENTATION

At the time of the original studies for the Callaway Plant Unit 1 FSAR, published maps showed no faults within a 5 mile (8 km) radius of the Site. More recent references (MODNR, 2007) confirm that there are no identified faults within a 5 mile (8 km) radius of the Site. Current references confirm the existence of only three faults in or close to the limits of the Site Vicinity: the Kingdom City Fault, Mineola Fault, and Cuba Fault. These three faults, plus two others (the Fox Hollow and Wardsville Faults) were visited and inspected in October 2008 (Figure No. 12).

The Kingdom City Fault and the Mineola Fault lie within the 25 mile (40 km) radius of the Callaway Plant Site, and the Cuba, Fox Hollow, and Wardsville Faults lie just outside the Site Vicinity 25 mile (40 km) radius. Each of these features is fully described in Section 2.5.1.1.4.2.2, and summary descriptions of each fault are provided below. No other faults or related tectonic features have been identified in the Site Vicinity.

#### 1.3.3.1 Results of Phase 3

The locations for these five faults are shown in Figure No. 12. The absence of activity as evidenced by identifiable surface features was confirmed during the field reconnaissance as described above in Section 2.5.1.1.4.2.2, and in further detail below.

**Mineola Fault** is the closest reported geologic structure (either fault or fold) to the Site, approximately 12 miles (19 km) east-northeast of the Site (Table No. 4 and Figure No. 13). Interpretation of well log data from the Missouri Geological Survey and Water Resources files (1974) indicates 200 feet (61 m) of downward displacement to the southwest. MODNR (2007) describes the Mineola fault as the Mineola Structure-Mineola Dome, first mapped as a pronounced anticline in the vicinity of Mineola, with a North 75° East trend, and 10° to 20° dips on both flanks. More recent investigations (MODNR, 2007) show the structure to be closed with a short north-south axis.

The Mineola Fault is more appropriately named the Mineola Feature, because of the recent work by MODNR (in 2007). Sections 2.5.1.1.4.2.1 and 2.5.1.1.4.2.2 describe the details of the regional folds and faults.

Discussions with the Missouri Geologic Survey yielded a number of additional references for this feature including Dake (1918), Clark and Wharton (1926), Barrett (1940), Barnes (1943), Strassberg (1935), and Sinclair (1956), all in AmerenUE (2004). This feature was first mapped by Dale 1918, in AmerenUE, 2004. His work, published as part of Dake's report (1918), showed a pronounced anticline in a vicinity of Mineola, with a N 75° E trend, and 10° to 20° dips on both flanks; the dips are generally steeper on the south limb. Later work showed the structure to be closed with a short north-south axis. It is asymmetrical with a steep south-southwest dip and more gentle north-northeast dip. An additional closure was mapped in Sections 13 and 14, T. 48 No., R. 7 W Barnes (1943 in AmerenUE, 2004) pointed to a number of closed anticlines or domes striking N 70° W in an en echelon pattern from the Mineola area to the Browns Station anticline in Boone County. The Mineola dome brings Cotter (lower Ordovician) rocks to the surface in Loutre Creek, where they are surrounded by rocks ranging in age from Middle Ordovician (St. Peter) to Pennsylvanian (Cherokee Group).

The above references cite two different strikes for the feature, specifically N 75° E and N 70° W The strike shown on the figures in the Callaway Plant Unit 1 FSAR plot the latter trend.

This feature is a small anticline with a relatively short axis such that it could be viewed as domal in shape, giving rise to the terminology "Mineola Dome." Observations in the field during October 2008 clearly indicate a northeast trending anticlinal structure with the uppermost member being the St. Peter Sandstone. The feature, as shown in the photo (Figure No. 14), is known locally as the Graham Cave in the Graham Cave State Park. The cave developed by dissolution of the Jefferson City Limestone formation under the St. Peter Sandstone by way of water flowing down through minor fractures in the Sandstone and then through the Jefferson City.

**Kingdom City Fault,** as reported in section 2.5.1.1.4.2.2, trends east-northeast in Callaway County, Missouri on the Kingdom City Quadrangle Map, 14 miles (23 km) to the northwest of the Site (Table No. 5 and Figure No. 15. The evidence for this fault is on well log 26595 at the Missouri Geological Survey and Water Resources. It is interpreted to be a reverse fault that cuts the St. Peter Formation twice, displacing the formation 200 to 300 ft (61 to 91 m) with the downthrown side being to the southeast. A reproduced version of well log 26595 is provided in Table No. 6 showing the interpretation that indicates an offset.

This level of offset would seem to be of such magnitude as to be observable on the ground surface or in nearby creek valley walls. However, as shown on the photos (Figure No. 16 and Figure No. 17, the area is relatively flat, re-worked agricultural land with no surface manifestation visible during the Site visit. This lack of surface manifestation is to be likened to the lack of surface manifestation for the reported Mineola Feature discussed above.

**Cuba Fault** passes 3 miles (4.8 km) west of Cuba, MO, across Crawford, Gasconade, and Osage Counties, MO. It is located 35 miles (56 km) to the south-southeast of the Site on the Cooper Hill Quadrangle Map in the vicinity of Owensville, MO. (McQueen, 1943 in AmerenUE, 2004).

According to McCracken (1971), the Fault is downthrown on the east side with a vertical displacement of approximately 125 to 150 feet (38 to 46 m). The age of last movement is Pennsylvanian, or possibly younger.

The Cuba Fault was revisited during this investigation to determine if any new evidence has been developed. For example, the investigation was directed at new road cuts and new facilities, if any, in the area of the Fault that would provide more knowledge of the feature.

The alignment of the feature is basically north-south, and road cuts on east-west roads in Osage and Gasconade Counties were the focus of the effort (Figure No. 18 and Table No. 7). The published alignment was traversed at twelve waypoints where visual observations were made. These, plus other road cuts in the local area, were investigated for evidence of offsets and shears. No new roads have been cut and no significant new development has occurred in recent years.

The results of the new investigation indicate that in many instances the area of the alignment is heavily vegetated, or reworked for agricultural purposes. At most road cuts across the alignment, such as at Waypoint 1 (Figure No. 18), no deformation is apparent. In contrast, the road cut at Waypoint 6 (Figure No. 19) showed small offsets but the upthrown side is to the east, which is contrary to the overall throw reported for the Fault in the literature.

At Waypoint 8 (Figure No. 20), a road cut along Highway A near Peaceful Valley Lake, the deformation on the north side of the road cut is intense, but very old. At another road cut on Highway A, Waypoint 9 (Figure No. 18), the road cut indicates massive, undisturbed limestone with no evidence of deformation. No deformation was observed in road cuts at Waypoints 10 and 11, both of which intersect the reported fault trace (Figure No. 18).

While the literature reports the location of the Fault and the observations in this investigation report deformation at some locations, there is no evidence of recent deformation and very few new road cuts to allow for intense mapping or measurement.

**Fox Hollow Fault** lies northwest and west of Ashland, MO, located on the Ashland Quadrangle in Boone County. As reported in Section 2.5.1.1.4.2.2, it is a small fault, striking northeast that fades into a monocline at its two ends. It is reportedly a normal fault with a throw of approximately 120 feet (37 m) down to the southwest and shows Mississippian Chouteau beds faulted against Ordovician Jefferson Dolomite (McCracken, 1971). It is located approximately 25 miles (40 km) west of the Callaway Plant Site.

Additional mapping as described by Middendorf et al (1987 in AmerenUE, 2004) has indicated a somewhat more complex structure with a significantly different interpretation, specifically, that the feature is

> "a monocline because no definite fault plane was discovered and because the stratigraphic displacement can be accounted by dip alone. However, it is probable that faulting and fracturing accompany the folding. The monocline is uplifted to the east relative to the west. Areas of Chouteau which have been uplifted relative to the overlying Burlington are exposed in the valley of Bass Creek in Section 28 and in small creek branches in Section 31 and 32."

South of the main feature, basically south of Fox Hollow, and on the same trend toward Grider Branch in T 46, the strike of the fault or fold axis bends to a more southerly azimuth with a reported 80 ft (24 m) of throw on the west. Gore (1949 in AmerenUE, 2004) reported that a quarry in the SW 1/4 of the Section has an "excellent section of Chouteau Limestone with Burlington Limestone resting on it." He also notes that approximately 0.25 miles (0.40 km) to the southeast of a cliff at the same elevation as the quarry section that is entirely comprised of Jefferson City Dolomite and that 0.125 miles (0.20 km) to the north-northeast of the quarry is another exposure of the Jefferson City at the same elevation and he reported no noticeable dip in either section.

The Fox Hollow Fault was revisited during this investigation to determine if any new evidence has evolved since the feature was reported in the Callaway Plant Unit 1 FSAR (Figure No. 21 and Table No. 8). For example, the investigation was directed at new road cuts and new facilities, if any, in the area of the Fault that would provide more knowledge of the feature.

The alignment of the feature was re-visited and traversed at six waypoints where visual observations were made. These, plus other road cuts in the local area, were investigated for evidence of offsets and shears. No new roads have been cut and no significant new development has occurred in recent years.

At Waypoint 1, which is in Fox Hollow where the valley runs normal to the Fox Hollow Fault, the valley is heavily vegetated and reworked for agriculture. An outcrop of Jefferson Dolomite, about 300 ft (91 m) long, was observed on the north side of the valley. The Jefferson is dipping about 5 degrees to the west on the west flank or down-dipping of a monocline - consistent with the interpretation reported in Middendorf (1987 in AmerenUE, 2004).

At the other waypoints along the Fault alignment (Figure No. 22 and Figure No. 23), the vegetation is heavy and the ground surface has been reworked for agriculture. No evidence of the feature was observed in any road cuts in the area and no surface manifestation of the feature was observed at any of the waypoints.

The field investigation was expanded to the east of the Fault along State Highway 63 which runs sub-parallel to the main feature and reportedly on the upthrown side. Depending on the location, State Highway 63 runs about 3 to 3.5 miles (4.8 to 5.6 km) to the east of the feature. All road cuts along State Highway 63, as well as east west roads running from the Fault to State Highway 63, were examined for offsets, abrupt changes in dip, and evidence of shearing. In each case, questionable features were linked to non-tectonic causes, primarily erosion or slumping associated with the road itself.

**Wardsville Fault** as reported in Section 2.5.1.1.4.2.2, McCracken (1971) stated that the Wardsville Fault runs from west of Wardsville, MO, northeast to Cole County, MO as defined on the Jefferson City Quadrangle Map. This feature is about 30 miles (48 km) southwest of the Callaway Plant Site.

The fault is reportedly downthrown about 100 feet (30 m) to the northeast as substantiated by water well borings at the town of Wardsville. The Callaway Plant Unit 1 FSAR also reported that work by Martin of the Missouri Geological Survey Staff on the ground surface in the area showed a collapse structure with the Mississippian-aged Burlington Limestone preserved. The Callaway Plant Unit 1 FSAR states that these findings point to an extension of the Wardsville Fault beyond St. Martins, MO and, consistent with the findings of Martin, indicate the age of the fault to be post Early Mississippian.

Other writers who describe the feature include Duewel (1957), and Ward (1973), all in AmerenUE (2004). Ward described the Wardsville Fault as having approximately 50 feet (15 m) of downthrown to the northeast along its northeast extension as compared to the 100 feet (30 m) of throw cited above. In the western half of Section 6, T 43 N, R 11 W, the fault changes to a more southerly direction. The fault trace at this location is expressed by a linear ridge of re-cemented Roubidoux sandstone. The fault is interpreted to be downthrown to the west-southwest at this location, although the evidence is not conclusive and contrary to the observations of others including Ward (1973 in AmerenUE, 2004). The apparent explanation for the re-cemented sand is that the Roubidoux sandstone was caught in the fault zone, fractured and later re-cemented with silica.

McCracken (1971) reports that the absence of 100 ft (30.5 m) of Eminence Dolomite in a well at the St. Martins Church, and surface evidence, indicates the fault to be downthrown to the northeast in the Wardsville area and northward.

The Wardsville Fault was revisited during this investigation to determine if any new evidence has evolved since the feature was reported in the Callaway Plant Unit 1 FSAR. For example, the investigation was directed at new road cuts and new facilities in the area of the fault that would provide more knowledge of the feature.

The area of the feature was re-visited and studied at several waypoints where visual observations were made (Figure No. 24 and Table No. 9). Several new road cuts are now available for inspection. These road cuts as shown on photos in Figure No. 25 and Figure No. 26 show clear offsets that indicate an alignment and suggest a total offset in the range of 100 feet (30 m), as reported in the Callaway Plant Unit 1 FSAR. At Waypoint 3 along the west side of Lorenzo Green Road (Figure No. 25) and east of Tanner Bridge Road, approximately 100 ft (30 m) offset could be accounted over several steps associated with the road cut and adjacent residential development. New road cuts on Route B near the intersection with Christy Drive (Figure No. 26) allow for verification of the strike in this area (generally to the east). At a waypoint at the intersection of Route B and Tanner Bridge Road, the down thrown blocks were observed on both sides of the Route B, allowing for a determination of strike-generally northeast in this area.

### 1.3.3.2 Conclusions from Phase 3

The five faults described above are considered to be inactive, non capable tectonic sources, and are incapable of generating earthquakes and/or ground deformation and shaking. Therefore, these faults pose no identifiable risk to the operation of Callaway Plant Unit 2.

As regards a fault on the west flank of the Mineola Feature, no fault or fault-like feature was observed. Other than being a anticline with 10 to 20 degree dipping beds on the flanks, the feature is not significant from a geologic hazard perspective. It is not seismogenic and has no influence on the seismic behavior, the seismic response, or the seismic hazard of the Callaway Plant Site.

The evidence that the Kingdom City Fault actually exists is minimal (a single boring log of unknown quality) and possibly questionable. Regardless of its suspect origins, this feature is not seismogenic and has no influence on the seismic behavior, the seismic response or the seismic hazard of the Callaway Plant Site.

Based on the information in the literature, the observations of the Cuba Fault along its reported alignment, and observations off of the alignment, it is concluded that the Cuba Fault is not seismogenic and has no influence on the seismic behavior, the seismic response or the seismic hazard of the Callaway Plant Site.

Based on the information in the literature, our observations of the Fox Hollow Fault along its reported alignment and observations off alignment, it is concluded that the Fox Hollow Fault is not seismogenic and has no influence on the seismic behavior, the seismic response or the seismic hazard of the Callaway Plant Site.

It is concluded from these observations that the Wardsville Fault is very old, probably Mississippian in age, and that it is either highly segmented, probably somewhat winding and/or consists of a pattern of en echelon type faults. In any event, based on the information in the literature, our observations of the feature along its observed alignment, it is concluded that the Wardsville Fault(s) is not seismogenic and has no influence on the seismic behavior, the seismic response or the seismic hazard of the Callaway Plant Site.

## 1.4 OVERALL CONCLUSIONS OF THE PROGRAM

The overall conclusions for this two Phase Field Reconnaissance Program as conducted for the Site Area within 5 miles (8 km) of the Site as defined in the USNRC Regulatory Guidelines and Standard Review Plans indicates that

- There are no immediately identifiable paleoliquefaction features in the Site Area that would indicate paleoseismic activity that could impact the safety-related facilities of Callaway Plant Unit 2.
- No surface faulting features were found in the area of the Site that represents a geologic hazard which could impact the safety-related facilities of Callaway Plant Unit 2.



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## Table No. 1—Assessment of Potential Paleoliquefaction Features in Site Area

(Page 1 of 2)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| L1 | No | Blocked. Area looks to be used for cattle grazing. Hay field. | 38°46'26.18"N | 91°46'23.22"W |
| L2 | No | Wheat field. No evidence of circular feature or change in soil color. | 38°46'3.68"N | 91°46'20.27"W |
| L3 | No | Feature present is a depression (E to W) in a Silty/Clay (dark yellowish brown) soil. | 38°45'58.98"N | 91°47'24.60"W |
| L4 | No | Oval cut/fill small corn field. | 38°50'12.48"N | 91°46'50.15"W |
| L5 | No | Grooves in hay field. Leveled high ground in the middle of a bean field. No evidence of circular features along this path. | 38°49'58.96"N | 91°46'48.18"W |
| L6 | No | Hay bales/Hay field. | 38°49'12.81"N | 91°45'57.56"W |
| L7 | No | Hay bales/Hay field. | 38°49'5.35"N | 91°45'57.27"W |
| L8 | No | Drains running down hill to mid field drainage. | 38°48'18.96"N | 91°45'3.93"W |
| L9 | No | Drainage area of wheat field, draining to small pond. | 38°47'44.82"N | 91°45'45.46"W |
| L10 | No | Drainage toward wooded area. | 38°47'58.38"N | 91°45'57.11"W |
| L11 | No | Clearing for power pole line. | 38°47'43.00"N | 91°44'58.07"W |
| L12 | No | House/warehouse. | 38°47'38.73"N | 91°45'7.71"W |
| L13 | No | Hay field. Blocked access to top of hill. | 38°47'4.65"N | 91°44'38.16"W |
| L14 | No | Hay field. Blocked access to top of hill. | 38°46'53.79"N | 91°44'37.45"W |
| L15 | No | Hay bales in hay field. | 38°46'36.32"N | 91°42'59.75"W |
| L16 | No | Hay bales in hay field. | 38°46'45.67"N | 91°43'8.82"W |
| L17 | No | Hay bales in hay field. | 38°46'56.74"N | 91°42'46.20"W |
| L18 | No | Hay bales/lines in hay field. | 38°47'4.02"N | 91°43'6.94"W |
| L19 | No | Hay bales/lines in hay field. | 38°47'17.38"N | 91°43'13.30"W |
| L20 | No | Depression in field, once harvested for hay. The lines are along lower areas. | 38°45'52.74"N | 91°42'38.79"W |
| L21 | No | Farmed field with no evidence of circular features. | 38°45'26.63"N | 91°43'10.10"W |
| L22 | No | Clear areas between trees in wooded forest area. | 38°44'20.57"N | 91°42'24.93"W |
| L23 | No | Potato crop, circular features relate to harvest. | 38°42'21.68"N | 91°45'14.19"W |
| L24 | No | Wheat field, linear features are in direction of cropping. | 38°42'8.16"N | 91°47'11.88"W |
| L25 | No | Concrete pads in potato fields. | 38°42'23.32"N | 91°47'7.14"W |
| L26 | No | Graveyard. | 38°42'49.31"N | 91°49'15.96"W |
| L27 | No | Hay field/hay bales. | 38°42'28.60"N | 91°50'17.00"W |
| L28 | No | Access road from gate to tree. | 38°43'54.73"N | 91°48'47.81"W |
| L29 | No | Hay bales/ hay field. | 38°44'3.68"N | 91°48'48.73"W |
| L30 | No | Farmed field, linear features associated with ditch and circular features not evident, checked for soil color changes and none found. | 38°43'21.11"N | 91°46'7.97"W |
| L31 | No | Farmed field. Dark yellowish brown Silty/Clay soil. No evidence of soil type change of circular features. | 38°43'39.05"N | 91°45'46.63"W |
| L32 | No | Upper edge of "pond like" depression. | 38°42'47.61"N | 91°43'12.33"W |
| L33 | No | Crop related circular feature. Not visible now. | 38°42'56.58"N | 91°43'9.33"W |
| L34 | No | Linear features are drainage in bottom of hill towards the SW and then to the Missouri River. | 38°42'50.86"N | 91°42'38.51"W |
| L35 | No | Hay field not in use. No evidence of circular features. | 38°43'42.38"N | 91°42'24.86"W |
| L36 | No | Pine tree forest and junk yard. | 38°43'48.14"N | 91°44'35.22"W |
| L37 | No | Farmed field. Dark yellowish brown Silty/Clay soil. No evidence of soil type change of circular features. Similar to L31. | 38°43'42.69"N | 91°45'31.81"W |
| L38 | No | Drainage pattern running to ditch and then to creek. | 38°44'14.35"N | 91°50'1.53"W |
| L39 | No | Drainage lines to center of field. | 38°44'32.50"N | 91°50'43.46"W |
| L40 | No | Linear feature is an access road in the middle of bean field. Appears to be drainage patterns. | 38°44'52.48"N | 91°50'27.18"W |

**Table No. 1—Assessment of Potential Paleoliquefaction Features in Site Area**
(Page 2 of 2)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| L41 | No | Drainage in low areas of bean field. Appears to be drainage patterns. | 38°44'51.39"N | 91°50'44.63"W |
| L42 | No | Appears to be drainage patterns. Corn field. | 38°45'11.29"N | 91°50'31.51"W |
| L43 | No | Hay bales/hay field. | 38°45'19.55"N | 91°49'7.36"W |
| L44 | No | No evidence of linear fracture type feature. Lineament matches the alignment of two signal poles. | 38°44'58.53"N | 91°46'37.48"W |
| L45 | No | Features are grooves from farming (bean crop). | 38°44'55.97"N | 91°46'20.68"W |
| L46 | No | Hay bales/hay field. | 38°45'16.90"N | 91°44'32.31"W |
| L47 | No | Linear and circular features are hay bales (spots and aligned). By the house there is a pond. | 38°45'57.84"N | 91°50'40.06"W |
| L48 | No | Soil is Silty/Clay. Wheat farmed field. No indication of feature. | 38°46'24.79"N | 91°48'3.60"W |
| L49 | No | Soil is Silty/Clay. Wheat farmed field. No indication of feature. | 38°46'10.59"N | 91°47'58.03"W |
| L50 | No | Linear features are groups and drainage patterns in farm field. | 38°46'41.14"N | 91°47'2.57"W |
| L51 | No | Linear features are groups and drainage patterns in farm field. | 38°46'50.96"N | 91°46'20.03"W |
| L52 | No | No evidence of circular features. Wheat farmed field, moderate to dark yellowish brown Silty/Clay soil. Similar to L54. | 38°47'10.40"N | 91°46'16.38"W |
| L53 | No | Corn field. Dark yellowish brown silty/clay soil. | 38°47'8.77"N | 91°45'56.56"W |
| L54 | No | No evidence of circular features. Wheat farmed field, moderate to dark yellowish brown Silty/Clay soil. | 38°47'11.24"N | 91°46'49.56"W |
| L55 | No | No indication of circular features. | 38°46'20.03"N | 91°52'30.18"W |
| L56 | No | Cut is on the side of a meandering creek. | 38°47'7.88"N | 91°51'50.84"W |
| L57 | No | Linear features are groups and drainage patterns in farm field. | 38°47'53.08"N | 91°50'17.71"W |
| L58 | No | Hay field/hay bales. | 38°49'6.03"N | 91°48'29.08"W |
| L59 | No | Hay field, no active harvesting. | 38°49'42.34"N | 91°48'24.79"W |
| L60 | No | Hay field, no active harvesting. | 38°49'51.63"N | 91°48'9.63"W |
| L61 | No | Different Clay soil color. Linear features are grayish black to light gray Clay, and surrounding Clay is moderate yellowish to moderate brown. | 38°46'58.50"N | 91°49'1.04"W |
| L62 | No | No evidence of feature (circular) on the ground. Soil is Clay, dark to moderate yellowish brown (Evidence of being a corn field/crop). | 38°47'6.96"N | 91°47'59.17"W |
| L63 | No | Cardboard, trees, and junk cars. Material associated with construction of lake. | 38°47'22.12"N | 91°47'38.03"W |
| L64 | No | Hay fields/rows. | 38°47'28.67"N | 91°45'49.47"W |

Note:
Feature label refers to Figure No. 27

## Table No. 2—Assessment of Potential Surface Fault Features in Site Area

(Page 1 of 4)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| G1 | No | Sequence on both sides of road shows no sign of faulting or visible offset. | 38°50'46.97"N | 91°52'28.70"W |
| G2 | No | Approximately 10 ft of calcareous shale, medium to medium dark gray; on top there is a dark yellowish orange limestone with white chert; rapid reaction to HCl. | 38°50'27.11"N | 91°48'34.43"W |
| G3 | No | Similar limestone as observed at G2 with sub horizontal /horizontal layering; grayish to gray shale is not calcareous; the grayish red shale pockets are calcareous. Clay pockets observed in “auger” lens type shape, 8 inches x 1.5 ft; very thin chert layer; discontinuous. | 38°48'58.83"N | 91°48'19.98"W |
| G4 | No | Thin bedded, very hard, yellowish gray shale with alluvial material, dark reddish brown, silty clay. No indication of any faulting in either the shale or alluvium; joints do not penetrate into upper layer. Pale bluish green thin coating and very thin dark brown veins; positive reaction to HCl. | 38°47'7.51"N | 91°53'17.18"W |
| G5 | No | Thin bedded, very hard, yellowish gray shale with alluvial material, dark reddish brown, silty clay. No indication of any faulting in either the shale or alluvium; joints do not penetrate into upper layer. Pale bluish green thin coating and very thin dark brown veins; positive reaction to HCl. No indication of faulting from G4 to G5. | 38°47'0.62"N | 91°53'27.65"W |
| G6 | No | Thin bedded calcareous sandstone; slow reaction to HCl. Light olive gray to pale olive, very hard, layers range from 1 inch to 4 inches with ripple marks. | 38°44'1.99"N | 91°49'9.24"W |
| G7 | No | Yellowish gray, very hard limestone. Slow reaction to HCl, **convolute structure**, layering horizontal on top is a grayish limestone with closely spaced thin chert layers, not continuous. | 38°43'16.05"N | 91°48'7.95"W |
| G8 | No | Very hard dolomite, nonreactive to HCl, yellowish gray. Thin layer of shale, nonreactive to HCl, includes a **lens of breccia** (6 ft x 2 ft) that does not penetrate into the shale layer. Dolomite just above the shale layers shows **gentle folding**, intra-layered. | 38°42'32.22"N | 91°47'37.21"W |
| G9 | No | Quarry wall with **minor shear zones**, interpreted as non-tectonic; they are confined by overlaying light brownish gray dolomite (~6 ft thick). Below this top dolomite there is a light greenish gray dolomite with greenish gray shale. None of the three reacts to HCl. | 38°42'37.68"N | 91°44'34.64"W |
| G10 | No | 4 inch to 6 inch thick layers of limestone, dark yellowish orange to grayish orange, positive reaction to HCl. On top there is an approximately 10 inch layer of grayish green shale, nonreactive to HCl. Above continues same limestone as below but layering is 1 inch to 2 inches thick. | 38°47'44.88"N | 91°52'41.36"W |
| G11 | No | G11 is at western end of outcrop. Fossiliferous limestone, dark yellowish brown to dark yellowish orange. Bottom and top of sequence is an overlain by a 4 ft thick massive layer. | 38°47'42.54"N | 91°52'46.48"W |
| G12 | No | Crest of anticline with open fractures (10º). Axis of anticline is approximately N15ºE with flanks (10º) towards the NW and SE. Limestone is pale yellowish brown to moderate yellowish brown, reactive to HCl. There are thin layers of shaley material nonreactive to HCl. | 38°47'39.00"N | 91°51'53.71"W |
| G13 | No | Thinly layered fossiliferous limestone, siltstone, and shale. Siltstone is nonreactive to HCl. Limestone is yellowish gray as well as siltstone. Shale is pale yellowish green. **Convolute structures on top of siltstone.** No evidence of faulting. | 38°47'25.85"N | 91°51'42.25"W |

## Table No. 2—Assessment of Potential Surface Fault Features in Site Area

(Page 2 of 4)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| G14 | No | Thin Layered Limestone with thin shale layers. Slow reaction to HCl in all layers. Bottom of sequence is finer grained (silty), top is sandier and with ripple marks and undulated top surfaces. Top is 1 inch to 1.5 inch thick layer and bottom is an average of 2.5 inches thick with a 12 inch thick layer. Grayish green shale and limestone is light to very light gray in bottom layers and pale yellowish orange to grayish orange in top layers (sandier). | 38°46'42.47"N | 91°50'47.55"W |
| G15 | No | G15 is an outcrop approximately 100 ft from access road. Massive Sandstone, approximately 10 ft thick and 250 ft long, dissected by intermittent ditch that runs forward to the west, to access road. Non reactive to HCl. Pale yellowish brown to yellowish gray. Very friable. | 38°42'35.00"N | 91°50'8.20"W |
| G16 | No | Light olive gray Limestone, slow reaction to HCl, very hard. Outcrops between G16 and G17 in access road do not show evidence of faulting. Multiple isolated outcrops. | 38°44'29.77"N | 91°50'7.35"W |
| G17 | No | Sub horizontal to horizontal layering across the access road. | 38°44'36.89"N | 91°50'6.33"W |
| G18 | No | All part of a sequence of limestone, reactive to HCl; Bottom of sequence is 1.5 ft of thinly bedded very hard, fine grained limestone, followed by 2 ft of massive coarser grained limestone. Top of sequence is 3 ft of the coarser grained limestone, grayish orange, very hard. Bottom three layers are light olive gray. | 38°42'57.17"N | 91°50'12.72"W |
| G19 | No | Description same as that for G-18. (Latitude estimated from G18) | 38°42'57.17"N | 91°50'11.59"W |
| G20 | No | Top 2 sequences in layer No.1 are similar to G18-G19. A **slump structure** on top of unit 1 with listric type deformation on both ends, completely healed. Interpreted as derived from slope movement and not tectonics. A 20' long outcrop between G19 and G20. | 38°42'51.31"N | 91°50'13.00"W |
| G21 | No | Same sequence as outcrop at G20 but layer No.1 is more massive and thicker (5 ft). Bottom layer is also thicker (5 ft). | 38°42'48.68"N | 91°50'16.28"W |
| G22 | No | End of outcrop between G18 and G22. | 38°42'46.48"N | 91°50'17.12"W |
| G23 | No | Evidence of an old non-tectonic deformation with 43 inches of vertical offset. "Hanging wall" is to the south but does not continue completely to the other side of road, where its effect is not evident. Rock is a limestone, very hard, yellowish gray, alternates with layers between 1 inch to 2 inches thick and layers 2.5 inch to 3 inch thick. Alteration exists in six zones from a more massive bottom layers to top of sequence, thin layered, reactive to HCl with grain size in the very fine sand to silt range, fracture surface N40°/80°W. | 38°43'17.28"N | 91°46'54.23"W |
| G24 | No | Description same as that for G23. | 38°43'21.68"N | 91°46'55.00"W |
| G25/G26 | No | G25/G26 is near Thunderbird Lakes. Outcrop is limestone with rapid reaction to HCl; hard, dark yellowish orange 1 ft to 3 ft thick layers. Outcrops are intermittent. | 38°48'0.33"N | 91°48'24.18"W |
| G27 | No | G27 is in a rock quarry. No evidence of faulting on any of the outcrops around the quarry. Several pictures taken. Also, inspected cut toward the east to point G28. | 38°49'22.88"N | 91°48'54.57"W |
| G28 | No | Location of Feature is on access road from gate to tree at quarry in G27. | 38°49'28.08"N | 91°48'34.25"W |
| G29 | No | Light brown, very hard limestone with rapid reaction to HCl. | 38°50'38.72"N | 91°48'18.48"W |
| G30 | No | Outcrop (quarry face) on side of Route 94. | 38°43'15.16"N | 91°41'28.49"W |

## Table No. 2—Assessment of Potential Surface Fault Features in Site Area

(Page 3 of 4)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| G31 | No | Outcrop along Katy Trail. Layer No.1 pale red, very hard dolomite. One ft to 1.5 ft thick individual layers. Layer No.2 is very light gray. Silty sized grains with slow reaction to HCl. Bottom consists of 8 inch thick layer with 1 inch thick layering followed on top by layers 4 inches thick, 2 ft thick and 3 inches thick. Layer No.3 very light gray limestone with rapid reaction to HCl, thickening upward layer from <1 inch to 6 inches. Layer No.4 repeated No.3 with sequence same thickness and character. No evidence of faulting in stretch from G31 to G32. | 38°42'38.05"N | 91°45'20.79"W |
| G32 | No | No evidence of faulting between layer No.4 and top. Limestone is less resistant to weathering and stuck out only in upper layers. No evidence of faulting in stretch from G32 to G33. | 38°42'35.49"N | 91°45'2.54"W |
| G33 | No | East of G33 layer dips slightly to the east. No evidence of offset between layering. No evidence of faulting in stretch from G33 to G34. | 38°42'34.86"N | 91°44'58.06"W |
| G34 | No | Same as G33. | 38°42'33.93"N | 91°44'51.42"W |
| G35 | No | G35 is toward the west along trail on the levee. | 38°42'36.03"N | 91°45'51.81"W |
| G36 | No | Several spots of vegetation. No evidence of faulting in stretch from G35 to G36. | 38°42'35.62"N | 91°46'1.46"W |
| G37 | No | Top of sequence above layer No.4 detailed at G31. Grayish orange pink limestone. Slow reaction to HCl. Thin layered 1 inch to 6 inches seems **like western flank of an open anticline**. Layer No.5 includes an exotic block of pale yellowish brown to grayish orange dolomite with a very slow reaction to HCl; very hard. **Block shows shear and slickensided surface. Shows "brecciated" characteristics, folded and fractured.** Layer No. 6 is more massive 2 ft to 3 ft thick individual layers and more resistant. To the west there is a stretch of discontinuous outcrop with opened rock surface not showing signs of faulting. | 38°42'36.12"N | 91°46'14.80"W |
| G38 | No | Same description as G37. This location is to the west of G37. No signs of faulting. | 38°42'31.86"N | 91°47'9.92"W |
| G39 | No | Facies change in outcrop interpreted to be associated with **slumping or ancient settlement**. The facies change appears is N45º/vertical, healed with numerous brecciated fragments. These fragments are opaline, quartz, and similar to rocks in both side of the feature. Covered with vegetation. Layer No.1 is pale yellowish brown to grayish orange, very hard, calcareous, very fine sandstone, slow reaction to HCl. Layer No. 2 is very pale orange, hard calcareous, very fine sandstone, slow reaction to HCl. Sequence on the west end of the structure is similar to described in G31and G37 combined layers of No.1 to No.6. | 38°42'30.44"N | 91°47'14.56"W |
| G40 | No | Outcrop is near G-39. No evidence of faulting in this outcrop. | 38°42'32.23"N | 91°47'21.58"W |
| G41 | No | Outcrop is near G-39. No evidence of faulting in this outcrop. | 38°42'32.33"N | 91°47'37.13"W |
| G42 | No | Pale olive shale and siltstone in bottom, nonreactive to HCl, very hard, visible 2.5 ft thick layer, thin bedded. Top layers pale yellowish orange to grayish orange Limestone, hard, slow reaction to HCl. On south end of outcrop there is a **small (6 ft) anticline**, E to W trending, with flanks dipping 25º toward N and S. | 38°42'31.50"N | 91°47'37.86"W |
| G43a & G43b | No | Bottom is yellowish gray, very hard Limestone. Moderate reaction to HCl. Feature includes **convolute structure** that does not penetrate into the overlying layer. Top layer is grayish orange calcareous sandstone, positive reaction to HCl with no evidence of convolute structure. Feature interpreted as being derived from ancient settlement or slumping. Non-tectonic. | 38°43'21.32"N | 91°48'9.97"W |

## Table No. 2—Assessment of Potential Surface Fault Features in Site Area

(Page 4 of 4)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared from field notes and photos) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| G44 | No | Complete sequence of layering (Layer No.1 thru layer No.6). | 38°42'24.07"N | 91°48'21.43"W |
| G45 | No | Upper layer No.6 seems to have two more, coarsening upward layers (~8 ft each) of the same as below, but not possible to sample. | 38°42'28.35"N | 91°48'2.91"W |
| G46 | No | Same description as that for G45. | 38°42'28.62"N | 91°47'59.96"W |
| G47 | No | “Standing Rock”, very fine sandstone, friable, outcrop partially covered with vegetation. | 38°42'29.10"N | 91°47'55.72"W |
| G48 | No | Cave above Katy Trail, extends ~50’ to the north, roof is very fine sandstone, friable. It looks like it developed in **brecciated material**; very fine sandstone matrix and gravel sized sub angular fragments of chert material. | 38°42'31.03"N | 91°47'40.93"W |
| G49 | No | 150 ft of outcrop with no visible evidence of faulting. | 38°43'15.50"N | 91°50'32.55"W |
| G50 | No | Top of outcrop is 40 ft above. Bottom unit is thin layered (1 inch to 3 inch), yellowish gray limestone, top is 3 inch to 6 inch layered, very hard, grayish red, non reactive to HCl. | 38°43'11.23"N | 91°50'30.48"W |
| G51 | No | Same description as that for G50. | 38°43'3.66"N | 91°50'29.90"W |
| G52 | No | Base of sequence is 25 ft from location point, towards the north and consists of approximately of 35 ft of very hard calcareous sandstone, with bottom third part a very hard; very light gray, slow reaction to HCl, calcareous, massive to thickly bedded (1 ft to 2 ft). | 38°42'13.01"N | 91°49'17.66"W |
| G53 | No | Same description as that for G52. | 38°42'14.51"N | 91°49'19.59"W |
| G54 | No | Interbedded calcareous sandstone and limestone. Slow reaction to HCl for the sandstone but rapid reaction for massive limestone. | 38°42'11.50"N | 91°49'17.13"W |
| G55 | No | No evidence of faulting. Located adjacent to G54. | 38°42'11.65"N | 91°49'13.93"W |
| G56 | No | Sequence is similar to that described in G54. No evidence of faulting. | 38°42'11.63"N | 91°49'9.21"W |
| G57 | No | Sequence is similar to that described in G54. No evidence of faulting. | 38°42'13.00"N | 91°49'3.77"W |
| G58 | No | Limestone outcrop. No evidence of faulting. | 38°48'12.54"N | 91°46'30.04"W |
| G59 | No | Rocks along the creek are intact; show no sign of faulting. Rocks comprising floor of creek are very hard, light olive gray, limestone with an abundant calcite overgrowth. The other type is a weathered limestone, moderately hard, dark yellowish orange. Both have a rapid reaction to HCl. | 38°48'17.69"N | 91°46'24.90"W |
| G60 | No | Layer No.1, light brown, very hard Limestone, rapid reaction to HCl. 1 inch to 3 inch thick undulating layers. Layer No.2 is similar to No.1 but massive (grain size). Layer No.3 is light olive gray, fine grained limestone with rapid reaction to HCl; 3 inch to 1inch (average 5 inch) thick layers. | 38°46'56.61"N | 91°50'51.80"W |

Notes:

Feature Labels refers to Figure No. 27.
**Bold Type** indicates deformations found, but of a non-tectonic nature

## Table No. 3—Assessment of Potential Paleoliquefaction Features along Rivers in the Site Vicinity

(Page 1 of 2)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared by Dr. John Sims) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| Callaway | N/A | Plant Site Location | 38.76033 | -91.78137 |
| 1 | No | Site Vicinity, Bushy Creek | 38.76234 | -92.20642 |
| 2 | No | Site Vicinity, Cedar Creek | 38.72099 | -92.13618 |
| 3 | No | Site Vicinity, Cedar Creek | 38.72445 | -92.19391 |
| 4 | No | Site Vicinity, Cedar Creek | 38.72537 | -92.19025 |
| 5 | No | Site Vicinity, Cedar Creek | 38.73635 | -92.18512 |
| 6 | No | Site Vicinity, Cedar Creek | 38.79083 | -92.01242 |
| 7 | No | Site Vicinity, Stinson Creek | 38.84441 | -91.94655 |
| LO1 | No | Site Area, Missouri River Flood Plain | 38.70882 | -91.74240 |
| 8 | No | Site Area, Auxvasse Creek | 38.77933 | -91.85022 |
| MC1 | No | Site Area, Auxvasse Creek | 38.70882 | -91.79294 |
| MC2 | No | Site Area, Auxvasse Creek | 38.72717 | -91.80413 |
| 9 | No | Site Area, Auxvasse Creek | 38.75947 | -91.83988 |
| AV-1 | No | Site Area, Auxvasse Creek | 38.69753 | -91.82787 |
| AV2 | No | Site Area, Auxvasse Creek | 38.70818 | -91.84240 |
| AV3 | No | Site Area, Auxvasse Creek | 38.71419 | -91.84226 |
| AV4 | No | Site Area, Auxvasse Creek | 38.75980 | -91.84035 |
| AV5 | No | Site Area, Auxvasse Creek | 38.77991 | -91.84991 |
| CFC1 | No | Site Vicinity, Fork Creek | 38.79447 | -91.86503 |
| CFC2 | No | Site Vicinity, Fork Creek | 38.79611 | -91.87643 |
| 10 | No | Site Area, Mud Creek | 38.71272 | -91.79489 |
| 11 | No | Site Area, Mud Creek | 38.71589 | -91.79962 |
| CRC4 | No | Site Vicinity, Cedar Creek | 38.70904 | -92.21492 |
| CRC6 | No | Site Vicinity, Cedar Creek | 38.73646 | -92.18484 |
| CRC7 | No | Site Vicinity, Cedar Creek | 38.75811 | -92.17438 |
| 12 | No | Site Area, Missouri River Flood Plain | 38.70965 | -91.75558 |
| 13 | No | Site Vicinity, Osage River | 38.49204 | -92.00977 |
| GR9 | No | Site Vicinity, Gasconade River | 38.46547 | -91.62850 |
| 14 | No | Site Vicinity, Osage River | 38.43965 | -92.16561 |
| 15 | No | Site Vicinity, Osage River | 38.44130 | -92.16042 |
| 16 | No | Site Vicinity, Osage River | 38.45853 | -92.17057 |
| 17 | No | Site Vicinity, Osage River | 38.46391 | -92.16847 |
| 18 | No | Site Vicinity, Gasconade River | 38.60782 | -91.64029 |
| 19 | No | Site Vicinity, Gasconade River | 38.66770 | -91.55528 |
| 20 | No | Site Area, Missouri River | 38.70870 | -91.71806 |
| 21 | No | Site Area, Missouri River | 38.70820 | -91.72206 |
| 22 | No | Site Area, Missouri River | 38.70784 | -91.72596 |
| 23 | No | Site Area, Missouri River | 38.70327 | -91.73820 |
| 24 | No | Site Area, Missouri River | 38.70098 | -91.74144 |
| 25 | No | Site Vicinity, Missouri River | 38.68635 | -91.75238 |
| 26 | No | Site Vicinity, Missouri River | 38.68182 | -91.75943 |
| 27 | No | Site Vicinity, Missouri River | 38.68233 | -91.76473 |
| 28 | No | Site Vicinity, Missouri River | 38.68120 | -91.77305 |
| 29 | No | Site Vicinity, Missouri River | 38.68086 | -91.77685 |
| 30 | No | Site Vicinity, Missouri River | 38.68050 | -91.78062 |
| 31 | No | Site Vicinity, Missouri River | 38.68460 | -91.78700 |
| 32 | No | Site Vicinity, Missouri River | 38.68456 | -91.79030 |
| 33 | No | Site Vicinity, Missouri River | 38.68198 | -91.82151 |

## Table No. 3—Assessment of Potential Paleoliquefaction Features along Rivers in the Site Vicinity

(Page 2 of 2)

| Feature Label | Evidence Found? | FIELD DESCRIPTION OF FINDINGS (prepared by Dr. John Sims) | LOCATION | |
|---|---|---|---|---|
| | | | LATITUDE | LONGITUDE |
| 34 | No | Site Vicinity, Auxvasse Creek | 38.69249 | -91.82136 |
| 35 | No | Site Area, Auxvasse Creek | 38.70269 | -91.83692 |
| 36 | No | Site Area, Auxvasse Creek | 38.71093 | -91.84218 |
| 37 | No | Site Area, Auxvasse Creek | 38.71271 | -91.84193 |
| 38 | No | Site Area, Auxvasse Creek | 38.71457 | -91.84161 |
| 39 | No | Site Vicinity, Missouri River | 38.68083 | -91.82577 |
| 40 | No | Site Vicinity, Missouri River | 38.67874 | -91.83359 |
| 41 | No | Site Vicinity, Missouri River | 38.67720 | -91.83724 |
| 42 | No | Site Vicinity, Middle River | 38.62923 | -91.94139 |
| 43 | No | Site Vicinity, Middle River | 38.64303 | -91.92452 |
| 44 | No | Site Vicinity, Cedar Creek | 38.64497 | -92.20425 |
| 45 | No | Site Vicinity, Cedar Creek | 38.65375 | -92.19007 |
| 46 | No | Site Vicinity, Cedar Creek | 38.68236 | -92.19114 |
| CRC3 | No | Site Vicinity, Cedar Creek | 38.67879 | -92.18972 |
| 47 | Possibly | Site Vicinity, Missouri River, 7.1 miles from plant | 38.67237 | -91.84883 |
| 48 | No | Site Vicinity, Osage River | 38.48485 | -92.01302 |
| 49 | No | Site Vicinity, Osage River | 38.46834 | -92.05655 |
| 50 | No | Site Vicinity, Osage River | 38.46832 | -92.05996 |
| 51 | No | Site Vicinity, Osage River | 38.46425 | -92.16620 |
| 52 | No | Site Vicinity, Osage River | 38.46207 | -92.13092 |
| 53 | No | Site Vicinity, Osage River | 38.51987 | -92.02034 |
| 54 | No | Site Vicinity, Loutre River | 38.88724 | -91.57154 |
| 55 | No | Site Vicinity, Loutre River | 38.88809 | -91.57502 |
| 56 | No | Site Vicinity, Loutre River | 38.82336 | -91.52802 |
| 57 | No | Site Vicinity, Loutre River | 38.82212 | -91.53078 |
| LR23 | No | Site Vicinity, Loutre River | 38.93150 | -91.60633 |
| LR2 | No | Site Vicinity, Loutre River | 37.72919 | -91.44757 |
| LR8 | No | Site Vicinity, Loutre River | 38.80334 | -91.48616 |
| LR9 | No | Site Vicinity, Loutre River | 38.82001 | -91.53524 |
| 58 | No | Site Vicinity, Tavern Creek | 38.71771 | -91.68711 |
| 59 | No | Site Vicinity, Tavern Creek | 38.71982 | -91.69020 |
| 60 | No | Site Area, Eagle Creek | 38.71072 | -91.71928 |
| MR1 | No | Site Vicinity, Moreau River | 38.55520 | -92.09448 |
| MR2 | No | Site Vicinity, Moreau River | 38.54078 | -92.10699 |
| MR6 | No | Site Vicinity, Moreau River | 38.52382 | -92.13692 |
| MR12 | No | Site Vicinity, Moreau River | 38.53746 | -92.16914 |
| 61 | No | Site Vicinity, Moreau River | 38.52542 | -92.18145 |
| 62 | No | Site Vicinity, Moreau River | 38.52339 | -92.13767 |
| 63 | No | Site Vicinity, Rising Creek | 38.51918 | -92.08993 |
| MA4 | No | Site Vicinity, Maries River | 38.43184 | -91.98912 |
| 64 | No | Site Vicinity, Dry Fork | 38.77489 | -91.56490 |
| DF2 | No | Site Vicinity, Dry Fork | 38.80697 | -91.50927 |
| 65 | No | Site Vicinity, Loutre River | 38.82835 | -91.50850 |
| 66 | No | Site Vicinity, Auxvasse Creek | 38.92682 | -91.83614 |
| 67 | No | Site Vicinity, Auxvasse Creek | 38.91047 | -91.81439 |
| 68 | No | Site Vicinity, Auxvasse Creek | 38.91306 | -91.81178 |
| 69 | No | Site Vicinity, Auxvasse Creek | 38.86349 | -91.79994 |

**Table No. 4—Waypoint Descriptions for the Mineola Feature Field Investigation**

| Waypoint No. | Longitude | Latitude | Photo | Remarks |
|---|---|---|---|---|
| 1 | N38°54'27.9" | W91°34'36.8" | None | Waypoint is at entrance to Graham Cave State Park along axis of anticline; area has been reworked by the Park personnel |
| 2 | N38°54'13.2" | W91°34'32.2" | 831<br>832 | Waypoint is at entrance to Graham Cave at the Axis of the anticline, often interpreted as a dome. No evidence of fault on either flank at the area of the Cave in either direction off the crest. |

**Table No. 5—Waypoint Descriptions for the Kingdom City Fault Field Investigation**

| Waypoint No. | Longitude | Latitude | Photo | Remarks |
|---|---|---|---|---|
| 1 | N38°56'27.5" | W91°54'37.4" | 842 | Waypoint is on Rt 127 within 1/4 mile of Mapped location of Well No. 26595. Access road crosses a small draw with no sign of tectonically derived deformation. Area is heavily vegetated or re-worked for agriculture. |
| 2 | N38°56'09.0" | W91°54'21.2" | 843 | Waypoint on Rt. 127 within about 1/4 mile of mapped location of Well No. 26595. At this location, Rt. 127 crosses small stream valley. No evidence of tectonically derived deformation. |
| 3 | N38°55'56.4" | W91°54'07.9" | 847 | Waypoint is adjacent mapped location of Well No. 26595 which is reported to indicate 200 ft of vertical offset. |

**Table No. 6—Annotated Well Log 26595**

| Depth Interval (ft) | | Formation | Remark | Description | Age |
|---|---|---|---|---|---|
| Top | Bottom | | | | |
| 0 | 55 | Drift | | Sand & Clay | |
| 55 | 80 | Residuum & Topsoil | | Chert & Sand | |
| 80 | 135 | Burlington Limestone | | Chert, Dolomite & Limestone | Mississippian |
| 135 | 225 | Chouteau Group | | Limestone, Chert, & Sand | Mississippian |
| 225 | 255 | Cedar Valley LImestone | | Limestone & Sand | Devonian |
| 255 | 325 | Joachim Dolomite | | Dolomite & Sand | Ordovician |
| 325 | 425 | St. Peter Sandstone | | Sandstone | Ordovician |
| 425 | 475 | Everton Formation | Fault Zone - 205 ft of offset | Dolomite & Sand | Ordovician |
| 475 | 630 | Powell-Cotter Dolomites | | Dolomites, Shale & Chert | Ordovician |
| 630 | 685 | St. Peter Sandstone | | Sandstone | Ordovician |

**Table No. 7—Waypoint Descriptions for the Cuba Fault Field Investigation**

| Waypoint No. | Longitude | Latitude | Photo | Remarks |
|---|---|---|---|---|
| 0 | N38°27'34.2" | W91°40'04.9" | 810 | Waypoint is along Rt. 50 northeast of Useful, about 1/4 mile away. Area is heavily vegetated. If fault is present and downthrown to Northeast, feature should be visible at or near this location. No evidence of deformation at this Waypoint. |
| 1 | N38°27'59.3" | W91°37'34.4" | 812 | This Waypoint is near a road cut for bridge across the Gasconade River. No evidence of deformation was observed in this cut. |
| 2 | N38°25'55.5" | W91°39'07.0" | 813 | This Waypoint is at the intersection of Rt. D and the fault trace. No evidence of deformation was observed at this location. |
| 3 | N38°25'52.0" | W91°39'11.2" | 814 | This Waypoint is at intersection of Rt. D and the Fault trace. Area is heavily vegetated. Evidence of secondary deformational feature on north side of Rt. D, but no evidence of major offsets or deformation. |
| 4 | N38°25'32.5" | W91°38'01.5" | 816 | This Waypoint is at intersection of Rt. A and the fault trace. Area is heavily vegetated and/or developed. No evidence of deformation or abrupt topographical features. |
| 5 | N38°25'02.4" | W91°38'03.2" | None | Same as for Waypoint No.4 |
| 6 | N38°22'49.0" | W91°35'18.6" | 817<br>819 | This Waypoint is at intersection of Rt. A and fault trace. Area is developed and/or heavily developed. Small offset (3 to 4 ft) noted in road cut. Feature is very old, and is interpreted as a splay or secondary feature. It is upthrown to east which is contrary to the published direction of throw for the feature. |
| 8 | N38°20'47.4" | W91°37'21.9" | 821 | This Waypoint is along Highway A where a road cut was observed near Peaceful Valley Lake. Old, intense deformation was noted and photographed. No evidence of recent movement on the feature or in the area. |
| 9 | N38°20'38.3" | W91°37'21.4" | 823<br>824<br>825 | This Waypoint is along Highway A where a road cut through massive limestone was observed and photographed with three photos in panoramic style. No deformation was observed in any part of the road cut. |
| 10 | N38°18'54.6 | W91°32'44.7" | None | This Waypoint is near Jett Road, Rt. 28 and the fault trace. No evidence of deformation or abrupt changes in topography was noted. |
| 11 | N38°18'34.5" | W91°32'12.7" | 827<br>828 | This Waypoint is near intersection of Jett Road and Farry Road near the fault trace. No evidence or deformation or abrupt topographical changes were observed. |

**Table No. 8—Waypoint Descriptions for the Fox Hollow Fault Field Investigation**

| Waypoint No. | Longitude | Latitude | Photo | Remarks |
|---|---|---|---|---|
| 1 | N38°46′47.0″ | W92°19′33.7″ | 792 | Flat Bottom valley, heavily vegetated, reworked for agriculture; no evidence of offset or abrupt topographical features; outcrop visit indicating slight dip to west as on a monocline. |
| 2 | N38°46′52.3″ | W92°19′49.6″ | 791 | Outcrop present near stream crossing in the Fox Hollow Valley no evidence of offset or abrupt topographical features. |
| 3 | N38°46′48.8″ | W92°19′40.0″ | 795 | Area at Waypoint is heavily vegetated, reworked for agriculture; no evidence of offset or abrupt topographical features. |
| 4 | N38°45′14.3″ | W92°20′28.2″ | 796 | Discussed outcrops in the area with landowner; heavily vegetated, reworked for agriculture; no evidence of offset or abrupt topographical features. |
| 5 | N38°49′07.1″ | W92°18′05.1″ | 797 | Waypoint near Oakland Cemetery and transmission line ROW; no evidence of deformation, offset or abrupt topographical features. |
| 6 | N38°41′25.2″ | W92°15′17.6″ | 798<br>799<br>801 | Waypoint is at a road cut along Rt. 63 on the east side; Near Mt. Pleasant Road on the west side. Very old unconformity; low horizon deformed but upper horizon is not. We interpret the conditions such that the lower deposit was eroded, then upper limestone was deposited later. Deformation feature is depositional with intermediate erosion and later deposition of sediments. |

Part 11G

**Table No. 9—Waypoint Descriptions for the Wardsville Fault Field Investigation**

| Waypoint No. | Longitude | Latitude | Photo | Remarks |
|---|---|---|---|---|
| 1 | N38°32′49.9″ | W92°11′27.6″ | 802 | Waypoint is at Tanner Bridge Road. No evidence of young deformation. |
| 2 | N38°32′32.7″ | W92°11′35.5″ | 804 | New Road Cut at Stone Hill Road; Fault Trace evident in cut. |
| 3 | N38°32′44.5″ | W92°11′39.1″ | 806 | New Road Cut along Lorenzo Green Road at Intersection with Fault. |
| 4 | N38°32′06.0″ | W92°11′22.5″ | 808 | New Road Cuts near Christy Drive Intersection. Actual trace of the fault could be observed in new road cuts; took photos along strike. No evidence of young deformation. |
| 5 | N38°32′10.5″ | W92°11′40.8″ | 809 | On Route B north of juncture with Tanner Bridge Road; Down thrown block is obvious on both sides of road, strike is northeast. No evidence of young deformation. |

**Figure No. 1—Deformation observed at Feature G24**

**Figure No. 2—Deformation observed at Feature G39**

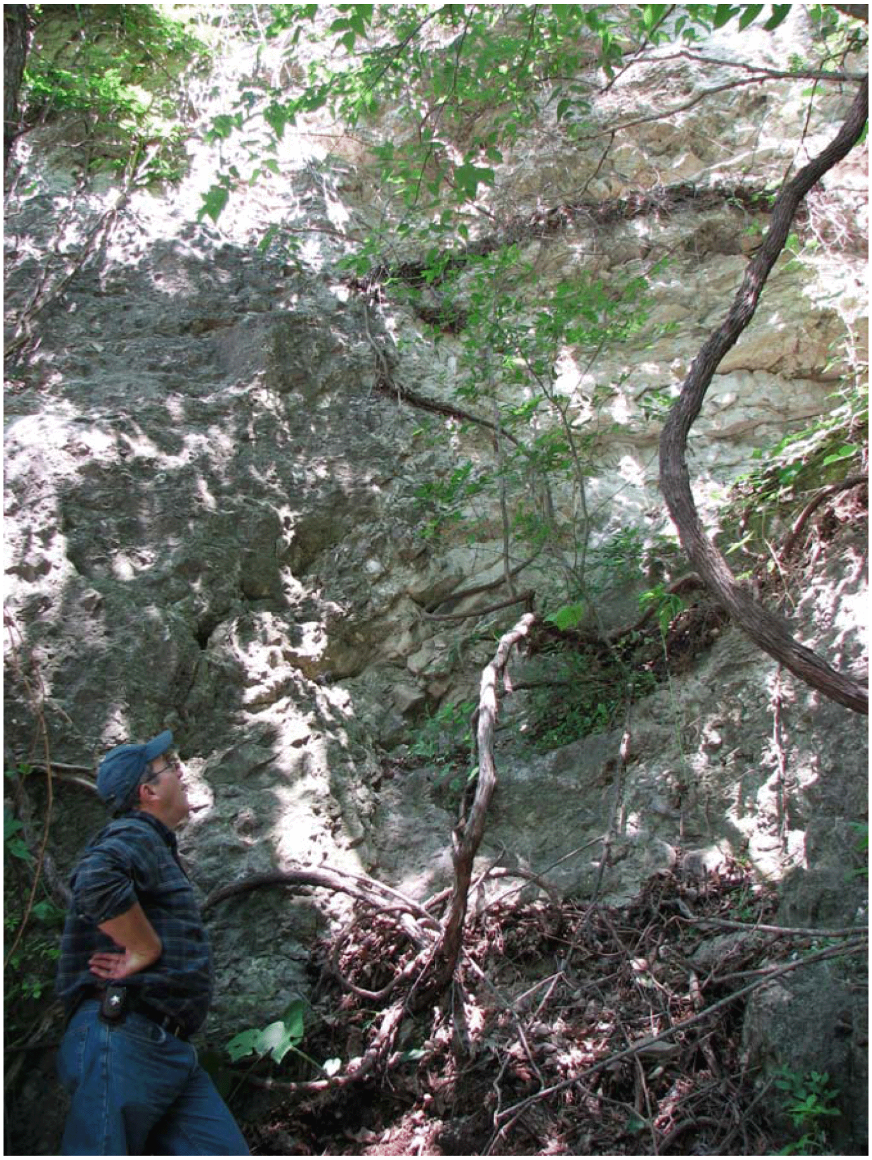


**Figure No. 3—Deformation observed at Feature G43**

**Figure No. 4— Rocks without deformation observed at Feature G9**

**Figure No. 5— Rocks without deformation observed at Feature G11**

**Figure No. 6— Rocks without deformation observed at Feature G30**

**Figure No. 7— Rocks without deformation observed at Feature G41**

**Figure No. 8—Non-Tectonic Deformation at Waypoint AV1**

**Figure No. 9—Non-Tectonic Deformation at Waypoint 008**

**Figure No. 10—Riverbank with Stratified Sediment and Feature at Waypoint 47**

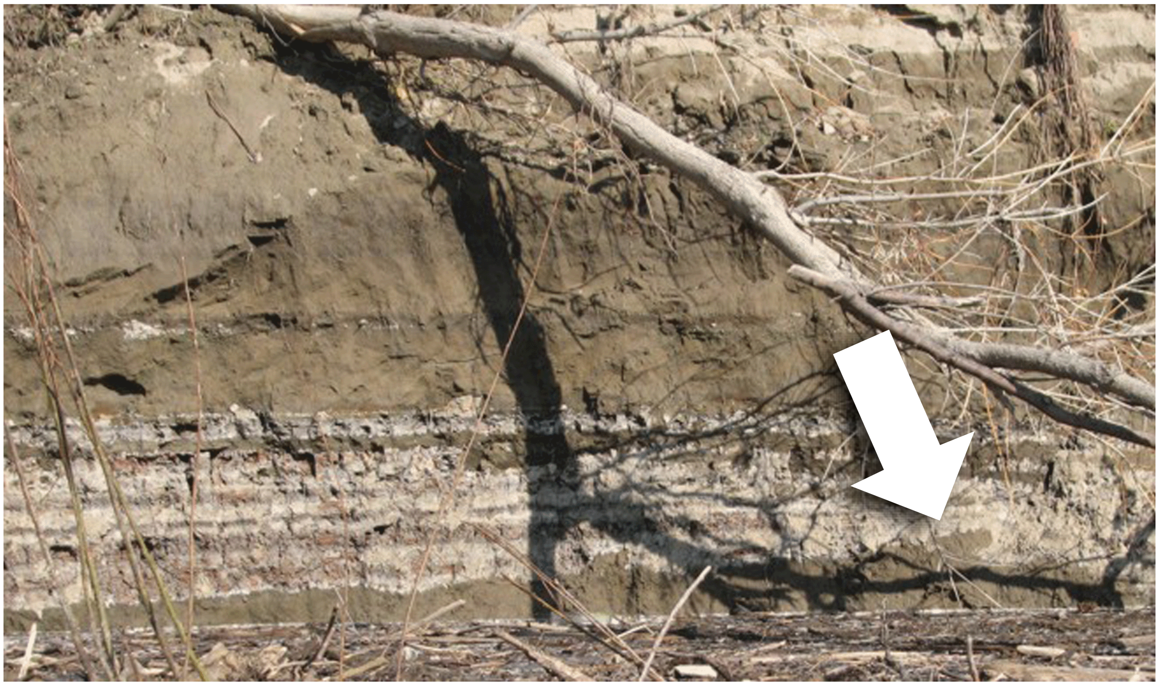
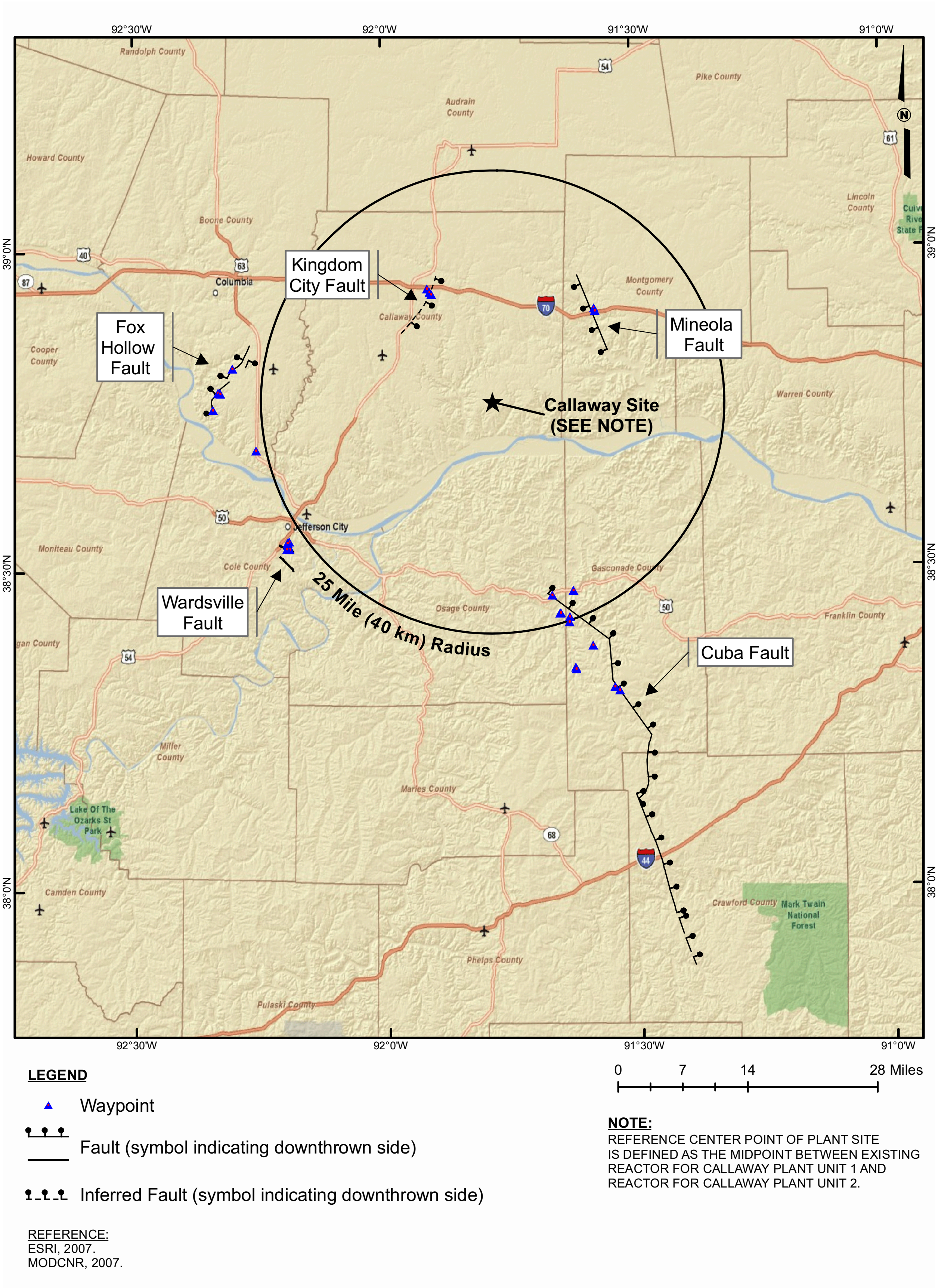
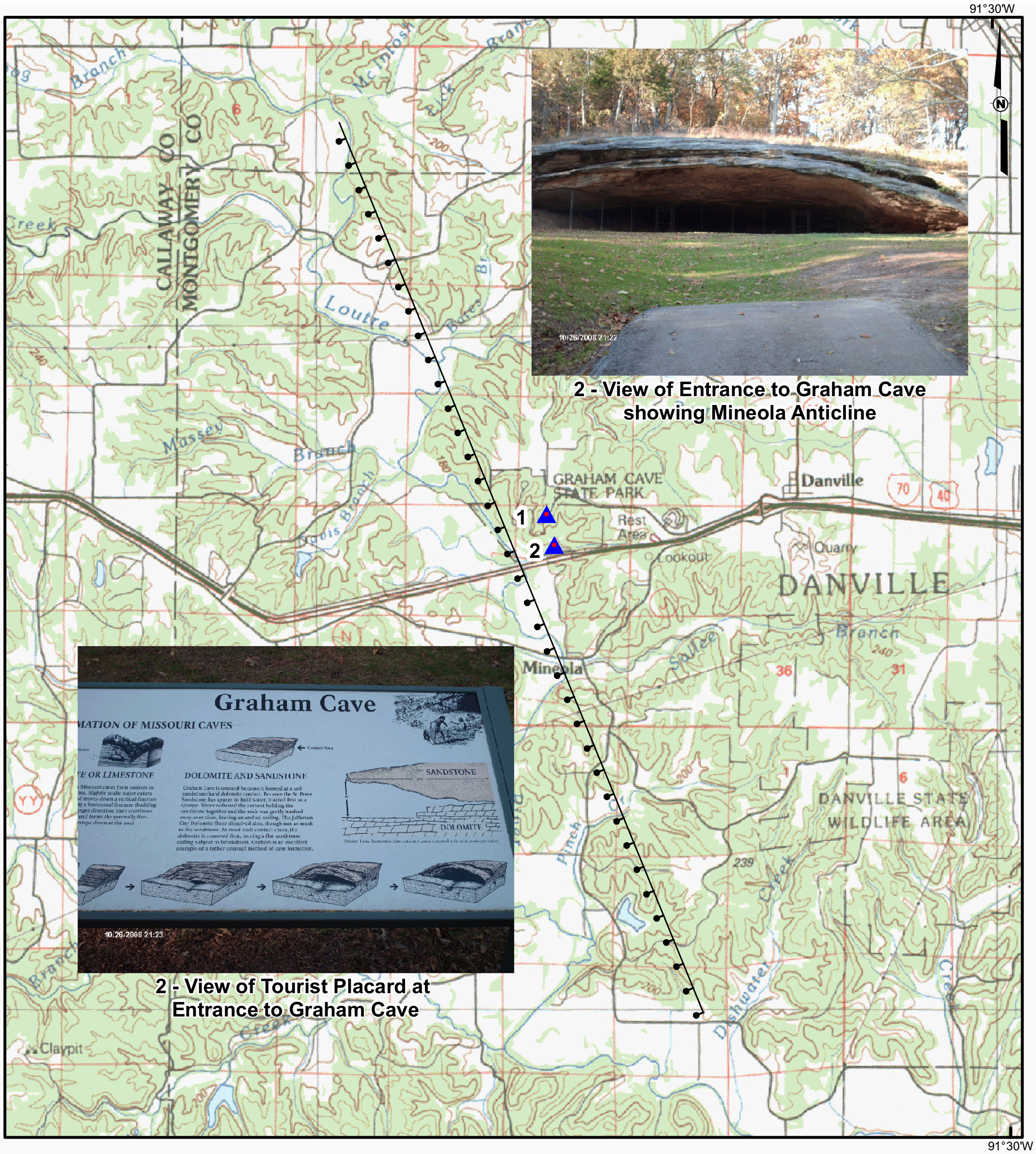


**Figure No. 11—Close-up of Interesting Feature at Waypoint 47**

## Figure No. 12—Map of Faults Visited During Mapping Exercise



## Figure No. 13—Waypoints along the Mineola Fault




**LEGEND**

▲1 Waypoint

Mineola Fault (symbol indicating downthrown side)

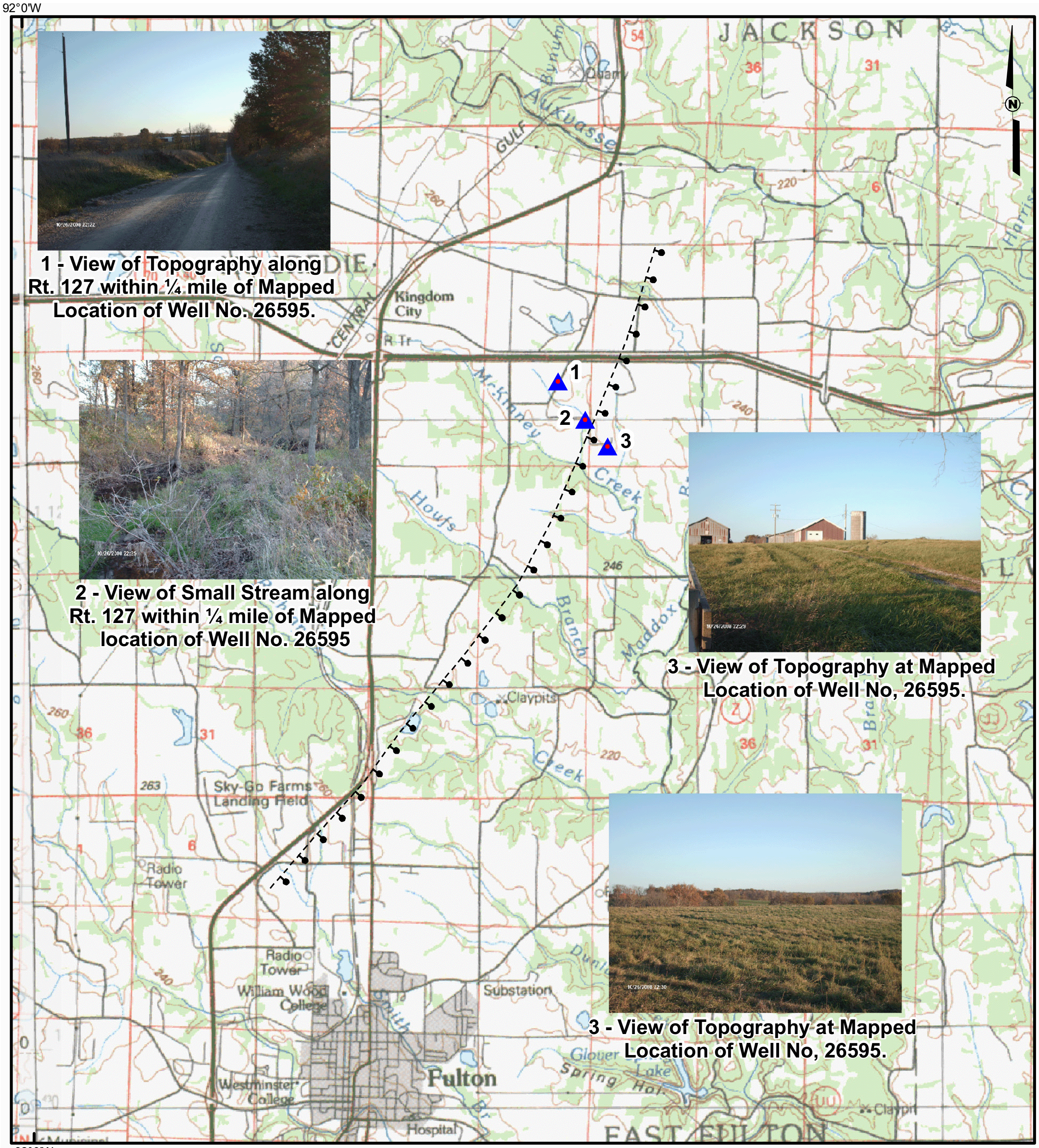
0 3,500 7,000 14,000 Feet

REFERENCE:
USGS, 1985.
MODCNR, 2007.

Part 11G

**Figure No. 14—Entrance to Graham Cave (Mineola Feature) (Waypoint 2)**

**Figure No. 15—Waypoints Along the Kingdom City Fault**




**LEGEND**

▲1 Waypoint

Kingdom City Fault (symbol indicating downthrown side)

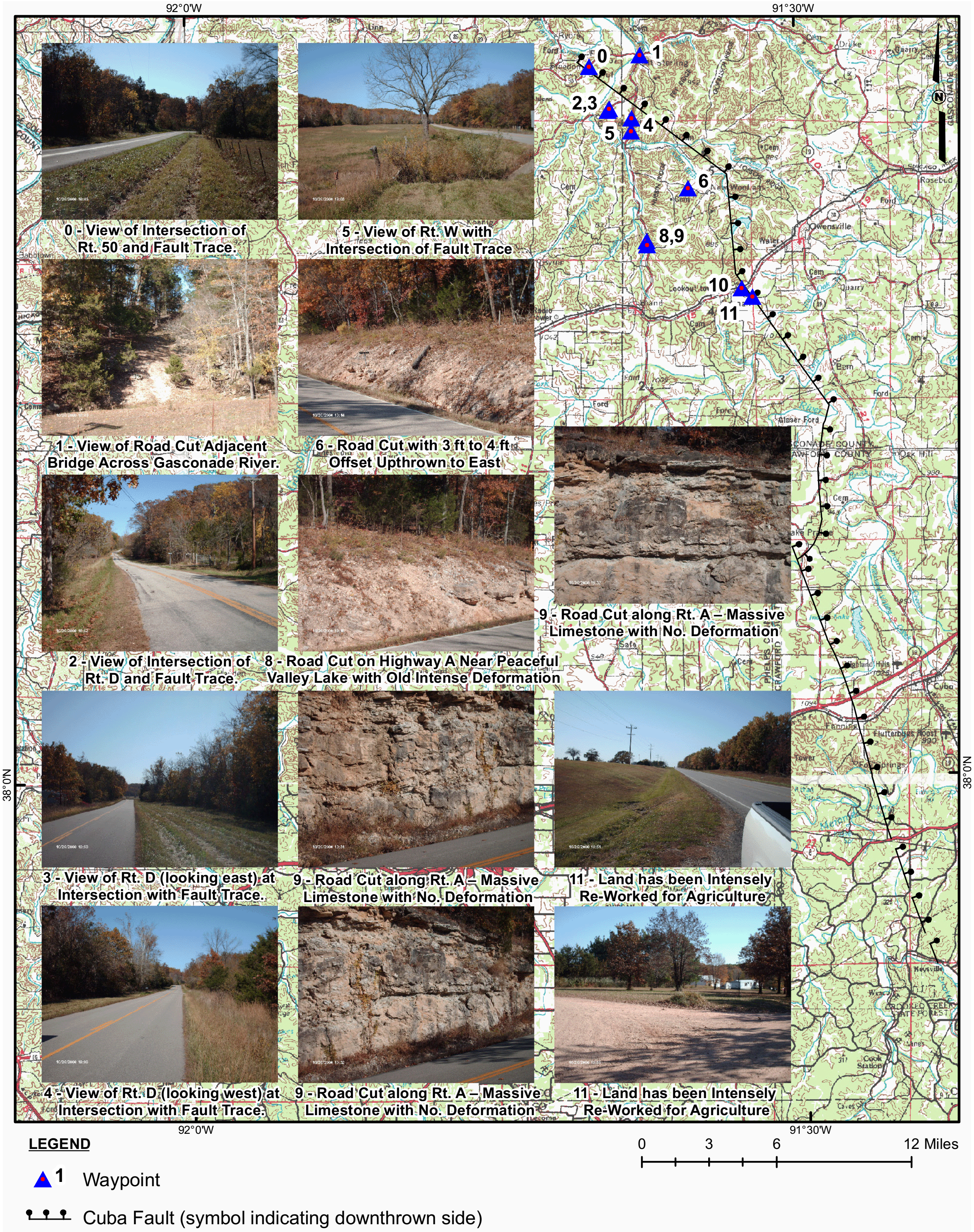
0 3,500 7,000 14,000 Feet

REFERENCE:
USGS, 1982.
USGS, 1985.
MODCNR, 2007.

**Figure No. 16—Topography Along Route 127, 0.25 miles (.4 km) from the Kingdom City Fault (Waypoint 1)**

**Figure No. 17—Topography at Mapped Location for the Kingdom City Fault (Waypoint 3)**

**Figure No. 18—Waypoints Along the Cuba Fault**

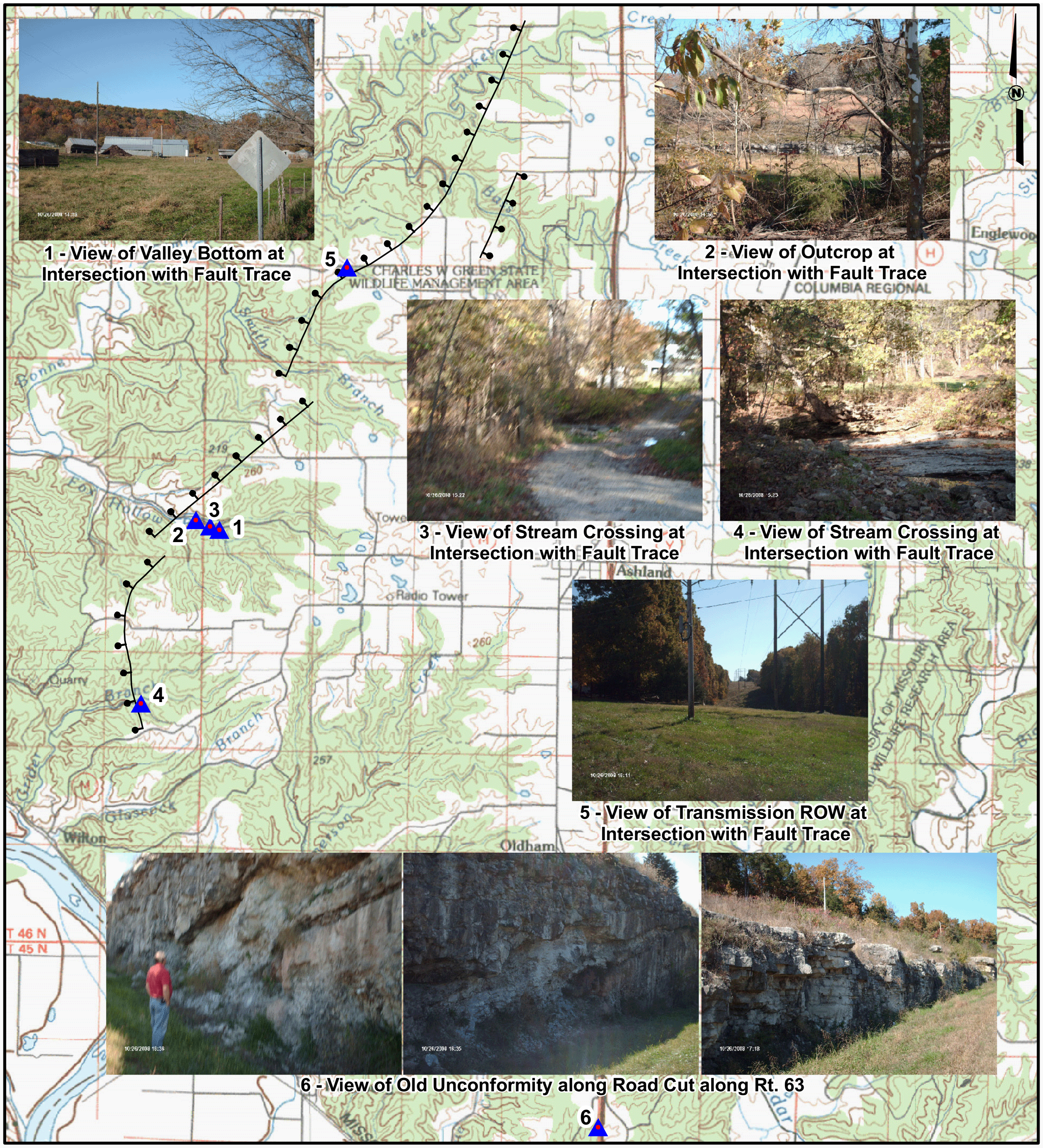



REFERENCE:
USGS, 1985.
USGS, 1983.
MODCNR, 2007.

**Figure No. 19—Road Cut with 3 - 4 ft of Offset for the Cuba Fault (Waypoint 6)**

**Figure No. 20—Road Cut on Highway "A" near Peaceful Valley Lake (Cuba Fault) (Waypoint 8)**

## Figure No. 21—Waypoints along the Fox Hollow Fault




**LEGEND**

1 Waypoint

Fox Hollow Fault (symbol indicating downthrown side)

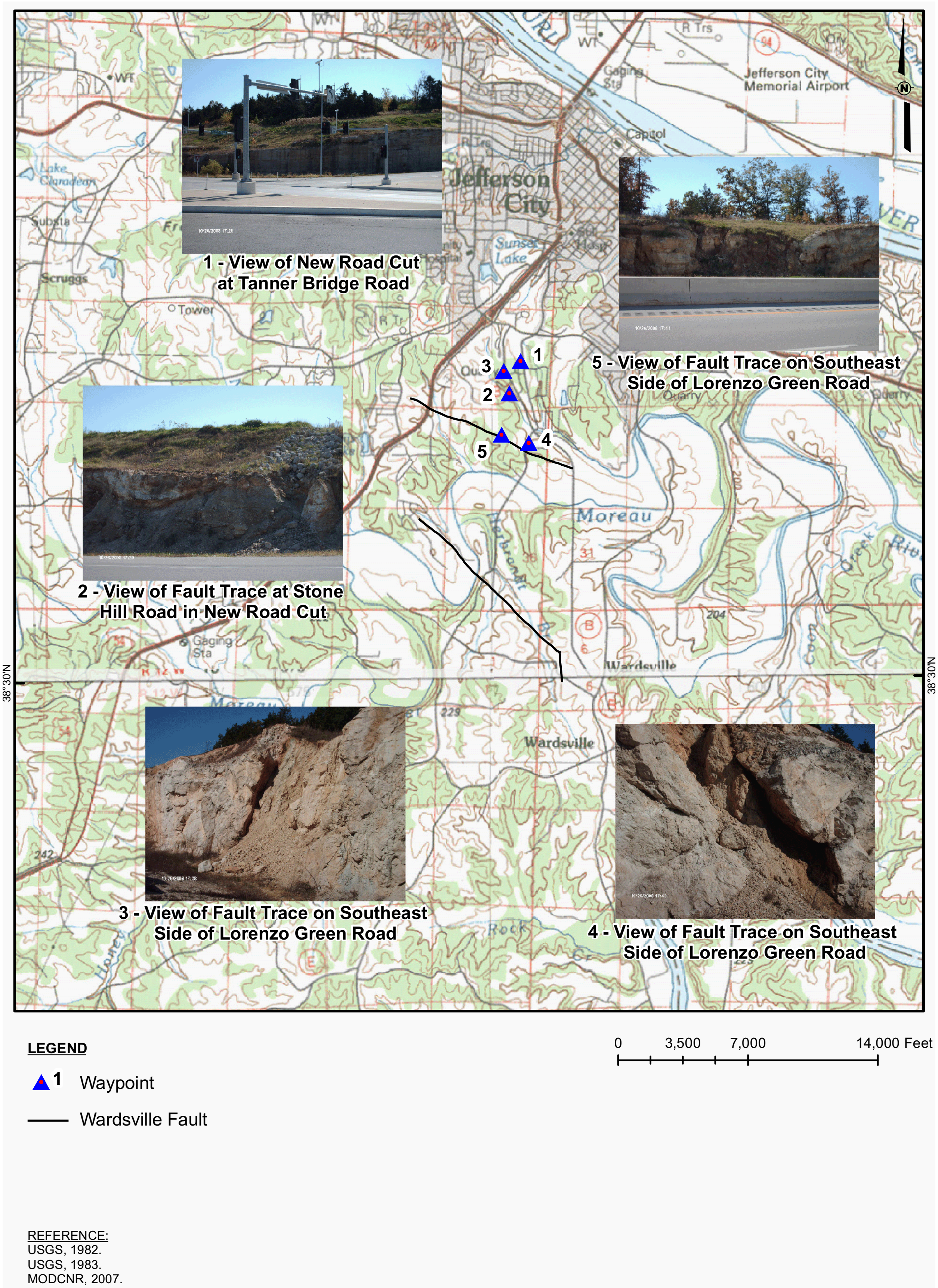
0 3,500 7,000 14,000 Feet

REFERENCE:
USGS, 1982.
MODCNR, 2007.

**Figure No. 22—Depositional Unconformity on Route 63, No Offset for Fox Hollow Fault (Waypoint 6)**

**Figure No. 23—No Offset for Fox Hollow Fault in Road Cut on Route 63 (Waypoint 6)**

**Figure No. 24—Waypoints along the Wardsville Fault**




Part 11G

**Figure No. 25—View of Wardsville Fault Trace on Lorenzo Green Road (Waypoint 3)**

**Figure No. 26—Additional View of Wardsville Fault Trace on Lorenzo Green Road (Waypoint 4)**