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Fault Information Report
Lots 23, 24, 25, 41, 42, & 43
Hickory Ridge Estates
Draper, Utah
IGES Job No. 00522-001

May 20, 2004

Prepared for:

Holman and Walker
c/o Mr. Jeff Walker

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May 20, 2004

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c/o Mr. Jeff Walker
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Subject: **Fault Information Report**
Lots 23, 24, 25, 41, 42, & 43
Hickory Ridge Estates
Draper, Utah

INTRODUCTION

PURPOSE AND SCOPE OF WORK

The purpose of this investigation and report is to present information on faults identified on the subject site approximately located at 12900 S Hickory Ridge (1950 E) at Hickory Ridge Estates Subdivision in Draper, Utah. This report is not a surface fault rupture hazard assessment. The scope of this report does not include recommendations on fault setbacks or any other structural or foundation elements. This data report will provide information on the faults observed during our investigation; it is our understanding that the client will present this information to a structural engineer who anticipates designing footings etc. for residential structures. Four trenches were excavated on Lots 23, 24, 25, 41, 42, and 43. Our services were performed in accordance with our proposal dated November 18, 2003, verbal requests, and your authorization. Specifically, our scope of services included the following:

- Review of available reports and maps of the area;
- Review and evaluation of aerial photographs covering the site area;
- Geologic reconnaissance of the site by an engineering geologist to observe and document fault characteristics;

- Subsurface investigation consisting of photo-logging four trenches approximately oriented perpendicular to the mapped orientation of the Cottonwood section of the Salt Lake City segment of the Wasatch fault zone, and
- Summarize fault characteristics and features in this fault information report.

PROJECT DESCRIPTION

The project, as planned consists of a residential development that includes 43 single-family home lots. However, the focus of our investigation is limited to the 6 lots previously listed in this report. The project site is shown on the Site Vicinity Map (Plate 1). A Site/Exploration Location Map is also included (Plate 2).

METHODS OF STUDY

OFFICE INVESTIGATION

As part of this investigation we reviewed pertinent available literature and maps listed in the references section of this report, which provided background information on the local geologic history of the area and the locations of suspected or known faults. A detailed knowledge of the stratigraphic units expected in the area provided a useful time-stratigraphic framework for interpreting the units exposed in the trenches excavated for the study.

Stereographic aerial photograph interpretation was performed for the site using photographs purchased from the United States Department of Agriculture (USDA). A set of six 9 x 9 inch photographs dated 10/7/71 and 9/12/97 were studied for this report. Copies of these photographs are included in this report and presented as Plates 3 and 4. A graben and other fault splays were observed in the site area on the aerial photos reviewed for this study on the eastern portions of Lots 23, 24, and 25.

Fault investigation maps and reports from two previous investigations of the subdivision were reviewed as a part of our scope. A report by AGEC dated April 9, 2001 (AGEC, 2001) and a draft report by Stantec dated June 24, 2002 (Stantec, 2002) both reported evidence of faulting on the subject property. IGES, Inc. has performed additional investigations on other lots in the development (IGES, 2004).

GEOLOGIC INVESTIGATION

An engineering geologist investigated the geologic conditions within the general site area. A field geologic reconnaissance was conducted to observe existing geologic conditions and to observe fault characteristics at the site. The findings of the geologic investigation are presented in the following sections of this report. Based on the geologic reconnaissance and our review of pertinent available literature and maps, four sites were located for subsurface investigation by means of trenching.

SUBSURFACE INVESTIGATION

Four exploration trenches were excavated across the site in order to investigate the subsurface geology and to examine the sediments for evidence of faulting. The locations of the trenches are shown on the Site/Exploration Location Map (Plate 2). The trenches were excavated approximately perpendicular to the mapped trend of the nearby splay of the Cottonwood section of the Salt Lake City segment of the Wasatch fault zone. The Cottonwood section is one of three main splays of the Salt Lake City segment. The geology of the trenches will be described and interpreted in subsequent sections of this report. Soils exposed in these trenches were classified by field observations only for the purpose of identifying sequence stratigraphy, and were not verified by laboratory testing.

GEOLOGIC CONDITIONS

GEOLOGIC SETTING

The site is located, at an elevation between approximately 4,674 to 4,728 feet, within the southeastern portion of the Salt Lake Valley. The Salt Lake Valley is a deep, sediment-filled structural basin of Cenozoic age flanked by two uplifted blocks, the Wasatch Range on the east and the Oquirrh Mountains to the west (Hintze, 1980). The northern portion of the Salt Lake Valley extends beyond the northern limits of the Oquirrh mountain range and is bordered on the west by the southeast shore of the Great Salt Lake. The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah.

The near-surface geology of the Salt Lake Valley is dominated by sediments, which were deposited within the last 30,000 years by Lake Bonneville (Scott and others, 1983;

Personius and Scott, 1992). The lacustrine sediments near the mountain front consist mostly of gravel and sand. As the lake receded, streams began to incise large deltas formed at the mouths of major canyons along the Wasatch Range, and the eroded material was deposited in shallow lakes and marshes in the basin and in a series of recessional deltas and alluvial fans. Sediments toward the center of the valley are predominately deep-water deposits of clay, silt and fine sand. However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover. Most surficial deposits along the northern Wasatch fault zone were deposited during the Bonneville Lake Cycle that was the last cycle of Lake Bonneville between approximately 32 to 10 ka (thousands of years ago) and in the Holocene (< 10 ka). Surface sediments at the project site are discussed in the stratigraphy section below.

STRATIGRAPHY

Surface sediments at the project site are mapped as upper Pleistocene lacustrine sands and gravels related to the regressive phase of Lake Bonneville and are moderately to well sorted (Personius and Scott, 1992). A Site Geologic Map of the site area is included with this report (Plate 5).

Quaternary

Fan Alluvium (af1)

Upper Holocene clast-supported pebble and cobble gravel, locally bouldery, in a matrix of sand, silt, and minor clay (Personius and Scott, 1992). This unit is poorly sorted with angular to subrounded clasts and is medium to thickly bedded to massive. This unit contains sparse amounts of well-rounded recycled Lake Bonneville Cycle gravel clasts. Exposed thicknesses are reported to be < 5 meters. This unit is mapped in the local vicinity but not at our project site.

Fan Alluvium (af2)

Middle Holocene to uppermost Pleistocene clast-supported pebble and cobble gravel, locally bouldery and matrix supported, in a matrix of sand, silt and minor clay (Personius and Scott, 1992). This unit is poorly sorted with angular to subrounded clasts and is medium to thickly bedded to massive. This unit contains sparse amounts of well-rounded recycled Lake Bonneville Cycle gravel clasts. Exposed thicknesses are reported to be < 10 meters. This unit is mapped in the local vicinity but not at our project site.

Lacustrine Sand and Gravel Related to Regressive Phase (lpg)

Uppermost Pleistocene clast-supported pebble and cobble gravel in a matrix of sand and silt, interbedded with sand beds (Personius and Scott, 1992). The bedding in this unit is thin to thick, parallel to cross-bedded, and horizontal to dipping as much as 15°. These sediments represent coarse-grained transgressive shoreline deposits. Personius and Scott, (1992) report that the thickness of this unit is expected to be up to 25 meters thick (approximately 75 feet). In general, our site appears to be contained within a mapped sequence of this material type as illustrated on Plate 5.

TECTONIC SETTING

The site is located just west of and adjacent to the mapped location of a splay of the Cottonwood section of the Salt Lake City segment of the Wasatch fault, northwest of Corner Canyon. The subject site is located on the eastern edge of the graben that comprises the Salt Lake Valley. The Cottonwood section is one of three major splays of the Salt Lake City segment of the Wasatch fault zone. Personius and Scott (1992) report scarp heights along the central portions of the Cottonwood section to be 30 to 40 meters high. Surface offsets resulting from post-Bonneville faulting events are reported to be no more than 15 meters high in the central portion of the Cottonwood section. The height of late Quaternary fault scarps decreases to the south along the Cottonwood section towards the Corner Canyon area. Recurrence intervals of 2,400 to 4,000 years between major earthquakes are reported for the Cottonwood section. The most recent earthquake events are reportedly 5,500 to 6,000, 8,000 to 9,000 and 1,100 to 1,800 years ago on the Cottonwood section (Personius and Scott, 1992).

SEISMICITY AND FAULTING

Review of the "Surface Rupture and Liquefaction Potential Special Study Areas" map dated March 31, 1989 and published by Salt Lake County Public Works - Planning Division, as well as other published maps indicates that a splay of the Cottonwood section that includes several antithetic faults of the Salt Lake City segment of the Wasatch fault zone trends through the central to eastern portion of the Hickory Ridge subdivision (Personius and Scott, 1992). The site is also located approximately 15 miles southeast of the West Valley fault zone (Keaton and Curry, 1993). The West Valley fault zone trends in a north - south orientation and is located in the central portion of the Salt Lake valley. While the West Valley fault zone is reported to be active and probably seismically independent of the Wasatch fault zone, sympathetic movement on the West Valley fault zone resulting from major earthquakes on the Wasatch fault zone is a possibility. Analyses of ground shaking hazards along the Wasatch Front suggest that the Wasatch fault zone is the single greatest contributor to the seismic hazard in the Salt Lake City region. However, due to its proximity to the site, the West Valley fault zone may be a large contributor to the seismic hazard at the site.

The expected maximum ground acceleration from a large earthquake at this site with a two (2) percent probability of exceedance in 50 years is 0.67g (United States Geological Survey's (USGS) Earthquake Hazards Program - National Seismic Hazard Mapping Project). These values are estimated ground surface accelerations for a "firm rock" site, which is identified as having a shear-wave velocity of 760 m/sec (2500 ft/sec) in the top 30 meters (100 Feet). Sites with different soil types may experience amplification or de-amplification of these values. The site is situated within the International Building Code (IBC) Region 2. Based on our field observations and experience in the area, it is our opinion the subsurface conditions at this site are representative of a "stiff soil" profile having an average shear wave velocity $600 \leq V_S \leq 1{,}200$ (ft/sec) in the top 100 feet and having site coefficients F_a= 1.0 and F_v=1.5, best represented by IBC Site Class D. The following table reports the ground motion from the values obtained from the USGS website for the subject site.

LOCATION	40.5191° Latitude	-111.8375° Longitude
Distance to nearest grid point	2.37 kilometers	
Nearest grid point	40.50° Latitude	-111.85° Longitude
Probabilistic ground motion values at the nearest grid point are:	**10% Probability of Exceedence in 50 Years (% gravity)**	**2% Probability of Exceedence in 50 Years (% gravity)**
PGA	23.19	67.47
0.2 sec SA	54.93	156.83
1.0 sec SA	18.73	67.46

GENERALIZED SITE CONDITIONS

SURFACE CONDITIONS

The site is approximately located at 12900 S Hickory Ridge (1950 E) Hickory Ridge Estates in Draper, Utah. At the time of our investigation the subject site consisted of 6 undeveloped lots consisting of approximately 2.5 acres. Vegetation on these lots consists of sagebrush and grass. The subject property slopes steeply down to the west with small portions of the property that are relatively flat on the easternmost and westernmost portions of the six lots. The land surrounding the subject site consists of undeveloped lots and homes currently under construction.

SUBSURFACE CONDITIONS

The subsurface soil conditions were explored for the purpose of observing fault characteristics at the subject property by excavating four exploration trenches. The trenches were approximately excavated east to west from Hickory Ridge Lane on the east to Hickory Ridge Lane on the west as seen on the Site/Exploration Location Map (Plate 2). The trench locations as surveyed by Civil Science Inc. (CSI) are shown on Plate 2. The trenches were approximately excavated 50 to 200 feet in length and 5 to 15 feet in depth; some portions of the trenches were deepened to 20 feet or more. Subsurface soil conditions and soil stratigraphy were photo-logged at the time of trenching and are included on the Trench Photo Log plates included with this report (Plates 6 to 9). It should be noted that trench excavation was extremely difficult due to the granular nature of the subsurface soils. Logging soils in the trench was extremely challenging as the walls of the trench only remained standing for short periods of time (in some cases only seconds). Photos were taken, during the field investigations that have been collated for a nearly continuous photo log of each of the four trenches. These logs are included at the end of this report on the Trench Photo Logs (Plates 6 to 9). Continuous photo logs were obtained for Trenches 1, 3, and 4, two short 10 to 15 foot sections in Trench 2 were not photo logged, but were visually observed. Faults were observed in each of the four trenches; offsets observed on these faults ranged from less than one inch to more than 15 feet. The faults discussed in the following sections are those that had evidence of 4 inches or more of displacement and were not observed in the setback zone defined by Stantec (2002).

Trench 1

Trench 1 was excavated approximately 150 feet long. The trench was oriented approximately perpendicular to the mapped trend of the nearby splay of the Cottonwood section and extended across the subject property from approximately 48 feet southwest of the northeast property corner of lot 25, to near the middle of the northern property boundary of lot 41. The trench was excavated to a depth approximately between 7 to 12 feet. A photo log of the trench that shows soil stratigraphy and geologic features is included on Plate 6 at the end of this report.

The uppermost soil in the eastern portion of Trench 1 appears to be fill soils 3 to 6 feet thick that may extend through the native topsoil into underlying sands. The fill soils and topsoil are comprised of dark brown, moist sandy silt and silty sand. The topsoil in the western portion of the trench is up to 4 to 5 feet thick.

Sediments exposed in Trench 1 below the fill soils and topsoil generally consist of poorly graded sand with occasionally interbedded, silty sand and sandy silt. The subsurface soil profile exposed in Trench 1 was observed to be stratified and in general was observed to be laterally continuous throughout the length of the trench except where offsets were observed at fault locations (Plates 2 & 6). Based on our observations and mapping completed by Personius and Scott (1992), it is our opinion that the sand observed in Trench 1 consist of uppermost Pleistocene lacustrine sediments related to the Provo regressive phase (Plate 5).

Based on our observations of the subsurface profile exposed in Trench 1, faults were observed at approximately 20, 45, 85, 112, and 148 feet in the trench from east to west. These faults are respectively labeled faults 1a, 1b, 1c, 1d, and 1e on the Site Exploration/Location Map (Plate 2). A table that summarizes the approximate location, trend, dip, direction of dip, and displacement of the faults observed in Trench 1 is presented below:

Fault	Approximate Fault Location (From east to west)	Trend	Approximate Dip (Degrees, direction of dip)	Estimated Incremental Displacement	Approximate Cumulative Displacement
1a	20 feet	N 25 to 30°E	60 to 65, East	Not Observed	6½ feet
1b	45 feet	N 25 to 30°E	60 to 65, East	12 to 14 inches	12 to 14 inches
1c	85 feet	S 20°E	45 to 50, West	3 to 8 feet	Not observed
1d	112 feet	N 25 to 30°E	60 to 65, West	14 to 16 inches	14 to 16 inches
1e	148 feet	N 25°W	60 to 65, East	12 inches	12 inches

The approximate cumulative displacement of Fault 1c could not be determined because no soil layers could be matched on the foot wall and hanging wall; the nature of site soils made it extremely difficult to excavate the trench deep enough to find matching soil layers. In general, incremental offsets were not readily observable, therefore the incremental offsets or single event offsets are estimated to be approximately equal to the cumulative offset; this applies to Faults 1b, 1d, and 1e. As with Faults 1b, 1d, and 1e, a single event offset was not readily observable on Fault 1a, but a cumulative displacement of approximately 6½ feet was observed. Based on our observations on other faults in this and other trenches in the area, it is our opinion that a seismic event is capable of producing a 3 to 8-foot offset on or within the immediate vicinity of Fault 1a. An approximate 3-foot offset was observed in the topsoil on Fault 1c; it is our opinion that a single seismic event is capable of producing a 3 to 8-foot offset on or within the vicinity of this fault. It is our opinion that Faults 1a and 1c may be splays of the Cottonwood section of the Wasatch Fault zone. Black and others, 1995 consider 8 feet to be the maximum offset on the main splay of the Cottonwood segment.

Trench 2

Trench 2 was excavated approximately 225 feet long. The trench was oriented approximately perpendicular to the mapped trend of the nearby splay of the Cottonwood section and extended across the subject property from 95 feet northwest of the southeast corner of lot 24, to the west section of lot 42. The trench was excavated to a depth approximately between 10 to 14 feet. A photo log of the trench that shows the soil stratigraphy of the subsurface is included as Plate 7 at the end of this report.

The uppermost soil in the eastern portion of Trench 2 appears to be fill soils 3 to 5 feet thick that may extend through the native topsoil into underlying sands. The fill soils and topsoil are comprised of brown to black, moist sandy silt and silty sand. The topsoil thickness in the western portion of the trench is up to 4 to 5 feet thick or greater.

Sediments exposed in Trench 2 below the fill soils and topsoil generally consist of poorly graded sand with occasionally interbedded, silty sand and sandy silt. The subsurface soil profile exposed in Trench 2 was observed to be stratified and in general was observed to be laterally continuous throughout the length of the trench except where offsets were observed at fault locations (Plates 2 & 7). Based on our observations and mapping completed by Personius and Scott (1992), it is our opinion that the sand observed in Trench 2 consist of uppermost Pleistocene lacustrine sediments related to the Provo regressive phase (*lpg*, Plate 5).

Based on our observations of the subsurface profile exposed in Trench 2, several faults were observed at approximately 2, 5, 12, and 35 feet in the trench from east to west in the set back zone that was previously defined by Stantec (2002). Additional faults were observed at approximately 99, 125, and 163 feet in the trench from east to west. These faults are respectively labeled fault 2a, 2b, and 2c on the Site Exploration/Location Map (Plate 2). A table that summarizes the location, trend, dip, and displacement of the faults observed in Trench 2 is presented below:

Fault	Approximate Fault Location (From east to west)	Trend	Approximate Dip (Degrees, direction of dip)	Estimated Incremental Displacement	Approximate Cumulative Displacement
2a	37 feet	N 25 to 30°E	65 to 70, East	2 to 3 feet	2 to 3 feet
2b	99feet	N 25 to 30°E	60 to 65, West	Not Observed	Not Observed
2c	125 feet	S 20°E	45 to 50, West	3 to 8 feet	Not observed

2d	163 feet	N 25 to 30°E	60 to 65, East	13 to 14 inches	13-14 inches

The approximate cumulative displacement of Fault 2b could not be determined because no soil layers could be matched on the foot wall and hanging wall, however a minimum offset of 4 inches was observed but is likely greater than 4 inches and possibly as great or greater than the depth of the trench at this location. As with Fault 2b the approximate cumulative displacement of Fault 2c could not be determined; the nature of site soils made it extremely difficult to excavate the trench deep enough to find matching soil layers. In general incremental offsets were not readily observable, therefore the incremental offsets or single event offsets are estimated to be approximately equal to the cumulative offset; this applies to Faults 2a, 2b, and 2d. An approximate 3-foot offset was observed in the topsoil on Fault 2c; it is our opinion that a single seismic event is capable of producing a 3 to 8-foot offset on or within the immediate vicinity of this fault. It is our opinion that Fault 2c may be a splay of the Cottonwood section of the Wasatch Fault zone. Black and others, 1995 consider 8 feet to be the maximum offset on the main splay of the Cottonwood segment.

Five faults with a cumulative offset of 4 inches or more on each were observed in the eastern most portion of Trench 2 that were not characterized in this section because they were observed in the previously defined set back zone (Stantec, 2002). These faults were observed between 0 and 38 feet west of the east end of the trench. The easternmost fault at approximately 0 feet west of the east end of the trench dips west, and the third fault dips east at approximately 11 feet west of the east end of the trench. These two faults form a graben that is approximately 4 feet deep and approximately 11 feet wide. The fourth and fifth faults in this setback zone dip to the east at approximately 32 and 38 feet west of the east end of the trench respectively. At this site faults that dip west are dipping in a direction similar to that of the Wasatch Fault and are referred to as synthetic faults; faults that dip east are dipping in a direction that is opposite that of the Wasatch Fault and are referred to as antithetic faults. Blocks of earth that are bound on the east by west dipping faults and on the west by east dipping faults are called grabens. Faulting on faults that bound a graben cause the graben to subside relative to the surrounding topography.

Trench 3

Trench 3 was excavated approximately 180 feet long. The trench was oriented approximately perpendicular to the mapped trend of the nearby splay of the Cottonwood section and extended west from a point approximately located 71 feet southwest of the northeast corner of lot 23, to near the western property boundary of lot 43. The trench was excavated to a depth approximately between 10 to 20 feet. A photo log of the trench that shows the soil stratigraphy of the subsurface soils is included as Plate 8 at the end of this report.

The uppermost soil in Trench 3 appears to be topsoil 3 to 5 feet thick. There appears to be well-developed A Horizon and B Horizon layers. The A Horizon is dark brown and generally 1 to 3 feet thick. The B Horizon is orange-brown and generally 2 to 3 feet thick and thickens significantly approximately between 90 and 145 feet in the trench from east to west at the location of an observed normal fault.

Sediments exposed in Trench 3 below the topsoil layers generally consist of poorly graded sand with occasionally interbedded, silty sand and sandy silt. The subsurface soil profile exposed in Trench 3 was observed to be stratified and in general was observed to be laterally continuous throughout the length of the trench except where offsets were observed at fault locations (Plates 2 & 8). Based on our observations and mapping completed by Personius and Scott (1992), it is our opinion that the sand observed in Trench 3 consist of uppermost Pleistocene lacustrine sediments related to the Provo regressive phase (*lpg*, Plate 5).

Based on our observations of the subsurface profile exposed in Trench 3, several faults were observed at approximately 0, 5, 7, and 15 feet in the trench from east to west in the set back zone that was previously defined by Stantec (2002). Additional faults were observed at approximately 85 and 89 feet in the trench from east to west. These faults are respectively labeled fault 3a and 3b on the Site Exploration/Location Map (Plate 2). A table that summarizes the location, trend, dip, and displacement of the faults observed in Trench 3 is presented below:

Fault	Approximate Fault Location (From east to west)	Trend	Approximate Dip (Degrees, direction of dip)	Estimated Incremental Displacement	Approximate Cumulative Displacement
3a	24 feet	S 20 to 30°E	70 to 75, East	4 to 5 inches	4 to 5 inches
3b	85 feet	S 20 to 30°E	50 to 55, West	30 to 32 inches	30 to 32 inches
3c	189 feet	S 20 to 30°E	45 to 50, West	3 to 8 feet	≥ 15 feet

Based on the excavation in the area of Fault 3c, an approximate minimum cumulative displacement of 15 feet was observed. In general, incremental offsets were not readily observable, therefore the incremental offsets or single event offsets are estimated to be approximately equal to the cumulative offset; this applies to Faults 3a and 3b. An approximate 3-foot offset was observed in the topsoil on Fault 3c; it is our opinion that a single seismic event is capable of producing a 3 to 8-foot offset on or within the vicinity of this fault. It is our opinion that Fault 3c may be a splay of the Cottonwood section of the Wasatch Fault zone. Black and others, 1995 consider 8 feet to be the maximum offset on the main splay of the Cottonwood segment.

Four faults with offsets of 4 inches or more on each were observed in the eastern most portion of Trench 3 that were not characterized in this section because they were observed in the previously defined set back zone (Stantec, 2002). These faults were observed between 0 and 17 feet west of the east end of the trench. The easternmost fault at approximately 0 feet in the trench dips west. The second fault was observed at approximately 5 feet, west of the east end of the trench and dips west. The third fault was observed at approximately 7 feet west of the east end and dips east. The fourth fault was observed at approximately 17 feet and dips east. These four faults combine to form a series of small grabens that are approximately 3 to 11 feet wide.

Trench 4

Trench 4 was excavated approximately 50 feet long. The trench was oriented approximately parallel to Trenches 2 and 3 and perpendicular to the mapped trend of the nearby splay of the Cottonwood section as located on the Site Exploration/Location Map (Plate 2). The trench was excavated to a depth approximately between 5 and 6 feet. A photo log of the trench that shows the soil stratigraphy of the subsurface is included as Plate 9 at the end of this report.

The uppermost soil in Trench 4 is similar to that observed in Trench 3. There appears to be well developed A and B Horizon layers. The A Horizon is dark brown and generally 1 to 3 feet thick. The B Horizon is orange-brown, generally 2 to 3 feet thick, and thickens significantly approximately between 33 feet in the trench from east to west and the end of the trench corresponding to the location of an observed normal fault.

Sediments exposed in Trench 4 below the topsoil layers generally consist of poorly graded sand with occasionally interbedded, silty sand and sandy silt. The subsurface soil profile exposed in Trench 4 was observed to be stratified and in general was observed to be laterally continuous throughout the length of the trench except where offsets were observed at fault locations (Plates 2 & 9). Based on our observations and mapping completed by Personius and Scott (1992), it is our opinion that the sand observed in Trench 4 consist of uppermost Pleistocene lacustrine sediments related to the Provo regressive phase (*lpg*, Plate 5).

Based on our observations of the subsurface profile exposed in Trench 3, the fault that has shown at least 15 feet of displacement appears to correlate to this fault approximately observed at 32 feet from east to west in Trench 4, and is labeled Fault 4a on the Site Exploration/Location Map (Plate 2). A table that summarizes the location, trend, dip, and displacement of the fault observed in Trench 4 is presented below:

Fault	Approximate Fault Location (From east to west)	Trend	Approximate Dip (Degrees, direction of dip)	Estimated Incremental Displacement	Approximate Cumulative Displacement
4a	32 feet	S 20°E	45 to 50, West	3 to 8 feet	Not observed

The approximate cumulative displacement of Fault 4a was not observed because this trench was excavated to an approximate depth of 6 feet. It is our opinion that Fault 4a is part of a larger fault labeled Fault 1c-2c-4a-3c. Trench 4 was excavated to assist in assessing the trend of Fault 1c-2c-4a-3c as seen on the Site Exploration/Location Map (Plate 2). In general incremental offsets were not readily observable, therefore the incremental offsets or single event offsets are estimated to be approximately equal to the cumulative offset. An approximate 3-foot offset was observed in the topsoil on Fault 4a; it is our opinion that a single seismic event is capable of producing a 3 to 8-foot offset on or within the vicinity of this fault. It is our opinion that Fault 4a may be a splay of the Cottonwood section of the Wasatch Fault zone. Black and others, 1995 consider 8 feet to be the maximum offset on the main splay of the Cottonwood segment.

Groundwater

No groundwater was encountered in the exploration trenches during this investigation. Based on the alluvial deposits mapped in the area, we anticipate that the groundwater is significantly deeper than the extent of our explorations.

LABORATORY TESTING

CARBON DATING

Fill soils cover a significant portion of the study area, as well as topsoil that is relatively young. Topsoil samples have previously been collected from other lots (Lots 22 and 32) in this subdivision and tested to determine their approximate age by radiometric carbon dating. These test results report that the topsoil in the area is approximately 3,000 to 4,000 years old (Carbon Dating Results Letter, IGES, Inc., 2004), this letter is also attached to this report. All of the faults were observed to offset the uppermost Pleistocene sands and gravels, and frequently the overlying topsoil layers.

CLOSURE

LIMITATIONS

The fault information contained in this report is based on the information available to us at the time of our exploration, the results of our field observations, our limited subsurface exploration and our understanding of the proposed site development. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible and likely that variations in the geology, soil, and groundwater conditions could exist beyond the trench explorations, i.e. between trench locations, and beneath and adjacent to roadways and existing residential structures. The nature and extent of variations may not be evident until construction occurs. As the information presented in this report is limited to describing fault characteristics and does not include any recommendations, IGES, Inc. will not be liable for residential structures constructed on any of these six lots described in this report. Information contained in other reports prepared by IGES, Inc. for other lots in this subdivision should not be extrapolated to the lots described in this report.

This report does not contain recommendations for surface fault rupture hazard mitigation and is only intended to report the location and nature of faults observed during the field investigation conducted at the subject site. No warranty, expressed or implied, is made. Development of property in the immediate vicinity of active faults involves a certain level of inherent risk. It is impossible to predict where ground rupture will occur during a seismic event. New faults may develop, existing faults may propagate beyond their current lengths, and displacement and ground shaking may be greater or less than that currently anticipated.

This report was written for the exclusive use of Holman and Walker and only for the proposed project described herein. It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. We are not responsible for the technical interpretations by others of the information described or documented in this report. Specifically IGES, Inc. is not responsible for structural elements of residential structures designed by other entities.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience (801) 270-9400.

Sincerely,
IGES, Inc.

David Petersen, EIT
Staff Engineer

Reviewed by

5/20/04

Tim Thompson, P.G.
Project Geologist

Hiram Alba, P.E., P.G.
Principal

Attachments:

Plate	1	Site Vicinity Map
Plate	2	Site/Exploration Location Map
Plates 3 & 4		Site Aerial Photos
Plate	5	Site Geologic Map
Plates 6 to 9		Trench Photo Logs

Carbon Dating Letter, IGES, Inc., February 4, 2004

Aerial Photographs Reviewed for this Project:

Date	Photo ID	Reference
Oct. 7, 1971	AAL-1MM-31	USDA
Oct. 7, 1971	AAL-1MM-32	USDA
Oct. 7, 1971	AAL-1MM-33	USDA
Sept. 12, 1997	NAPP 10096-242	USDA
Sept. 12, 1997	NAPP 10096-243	USDA
Sept. 12, 1997	NAPP 10096-244	USDA

REFERENCES CITED

AGEC, 2001, Geologic Hazard Study, Proposed Hickory Ridge Subdivision, 13000 South Highland Drive, Draper, Utah, April 9, 2001.

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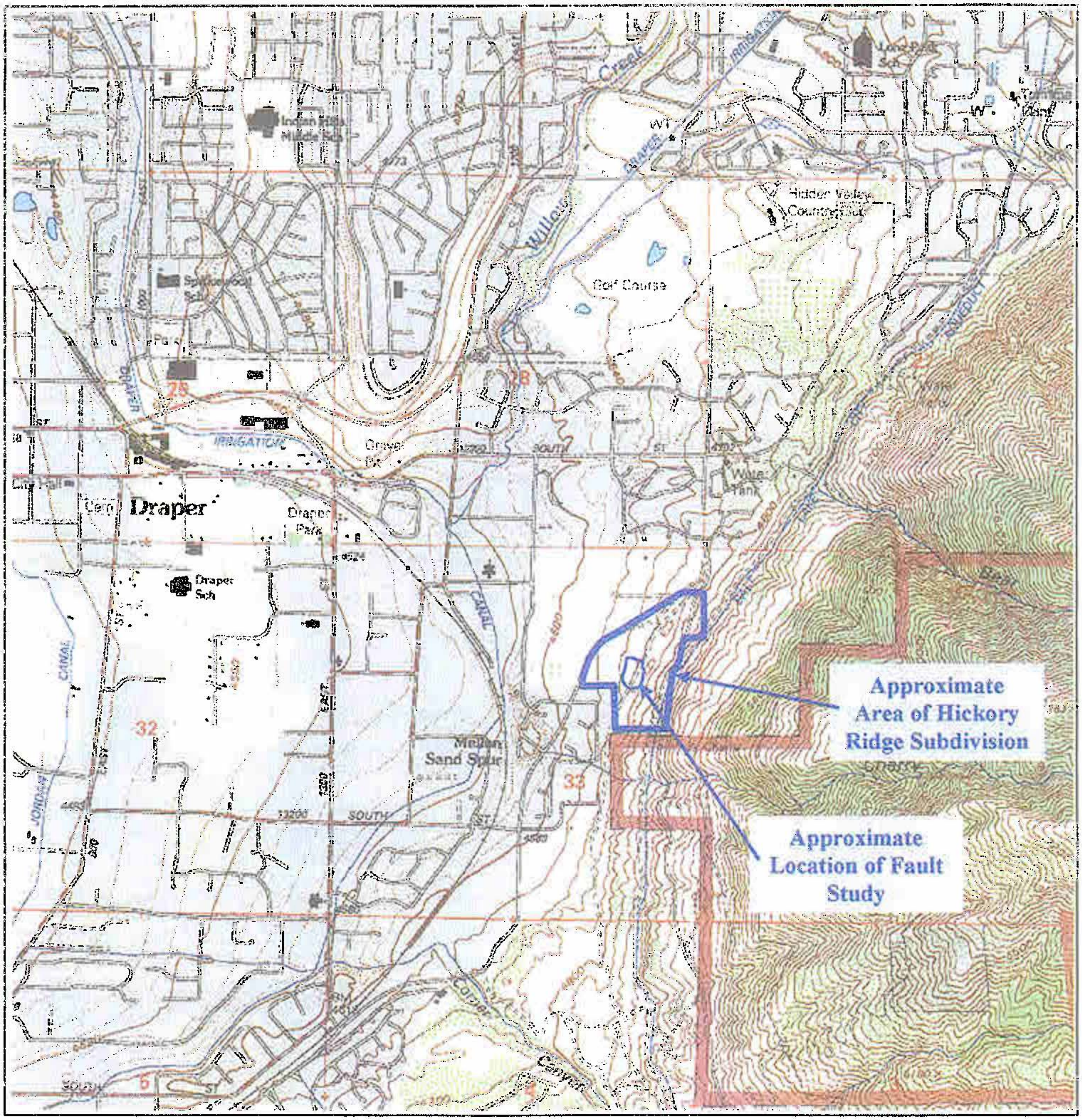


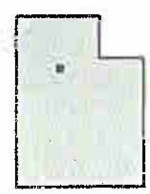
BASE MAP:

Draper, UTAH
U.S.G.S. 7.5 MINUTE QUADRANGLE

0' 1000' 2000'

SCALE 1:24,000

Contour Interval 40 feet
And 10 feet



Approximate Map Location

IGES

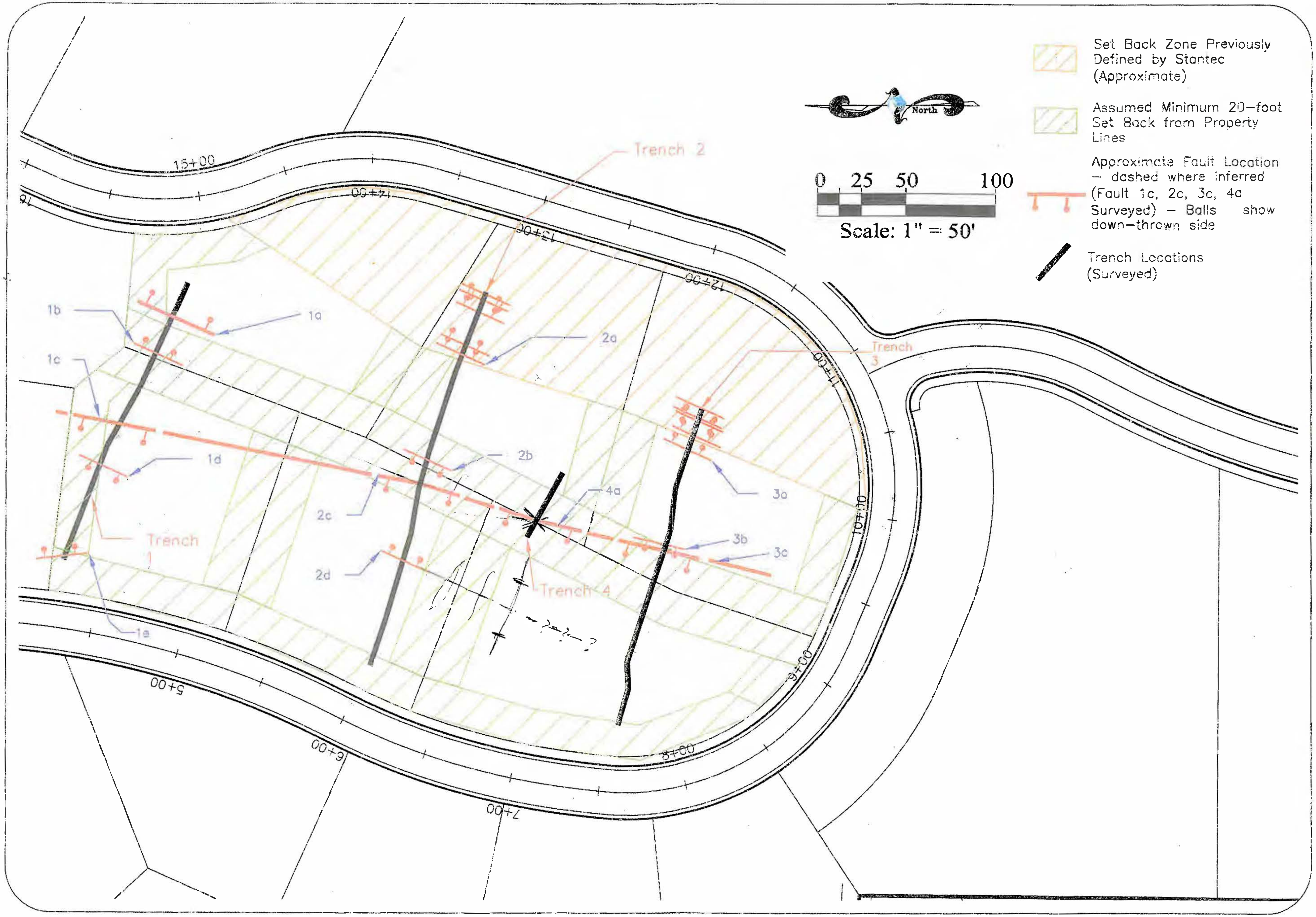
Project Number – 00522-002

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

SITE VICINITY MAP

Plate

1



SITE EXPLORATION/LOCATION MAP

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

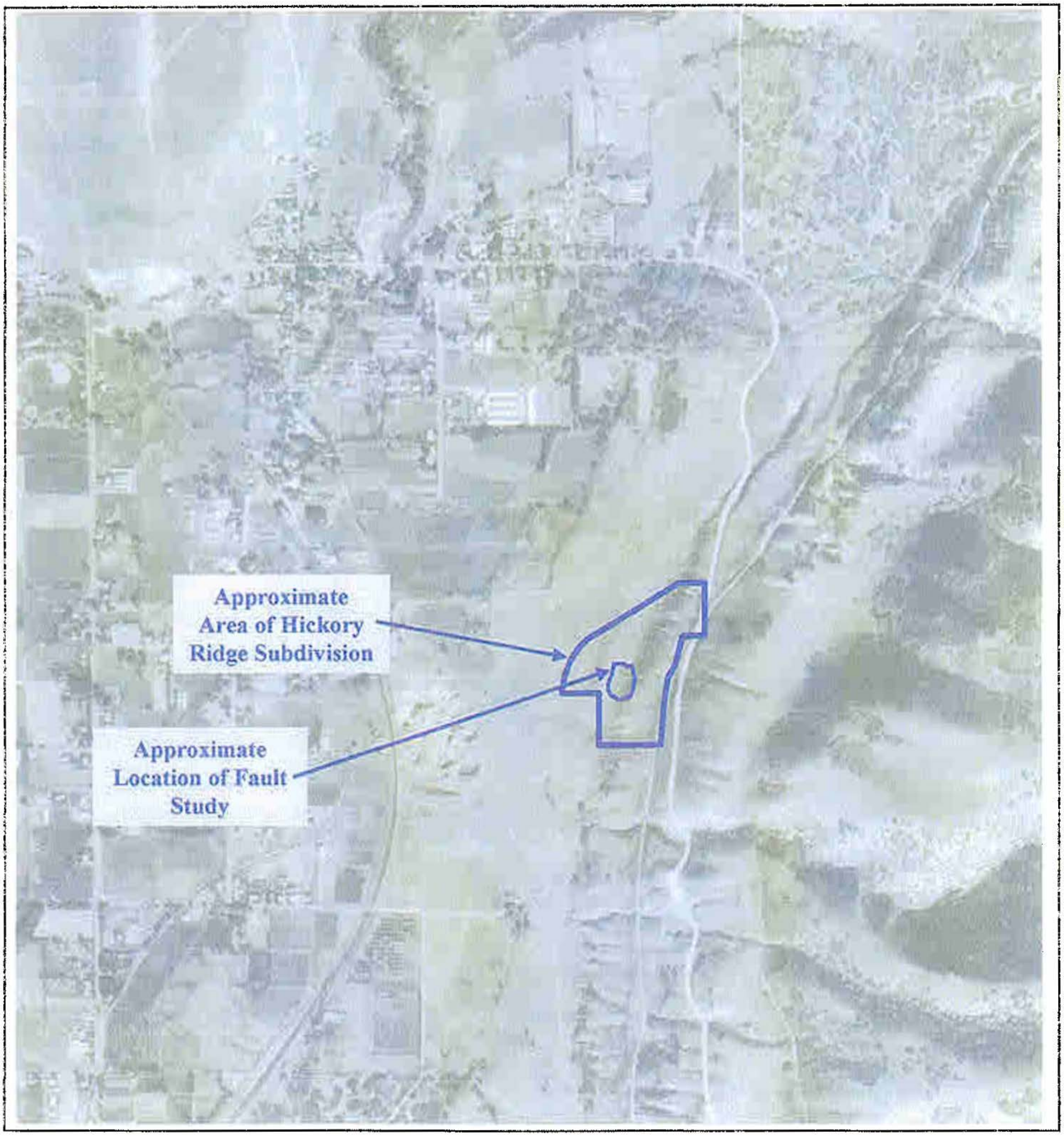
Project Number 00522-002

Drawing Notes

No.	Revision/Issue	Date

Plate 2

jah/dap 1/9/04 I:\Projects\00522-002



IGES

Date of Aerial Photo:
October 7, 1971

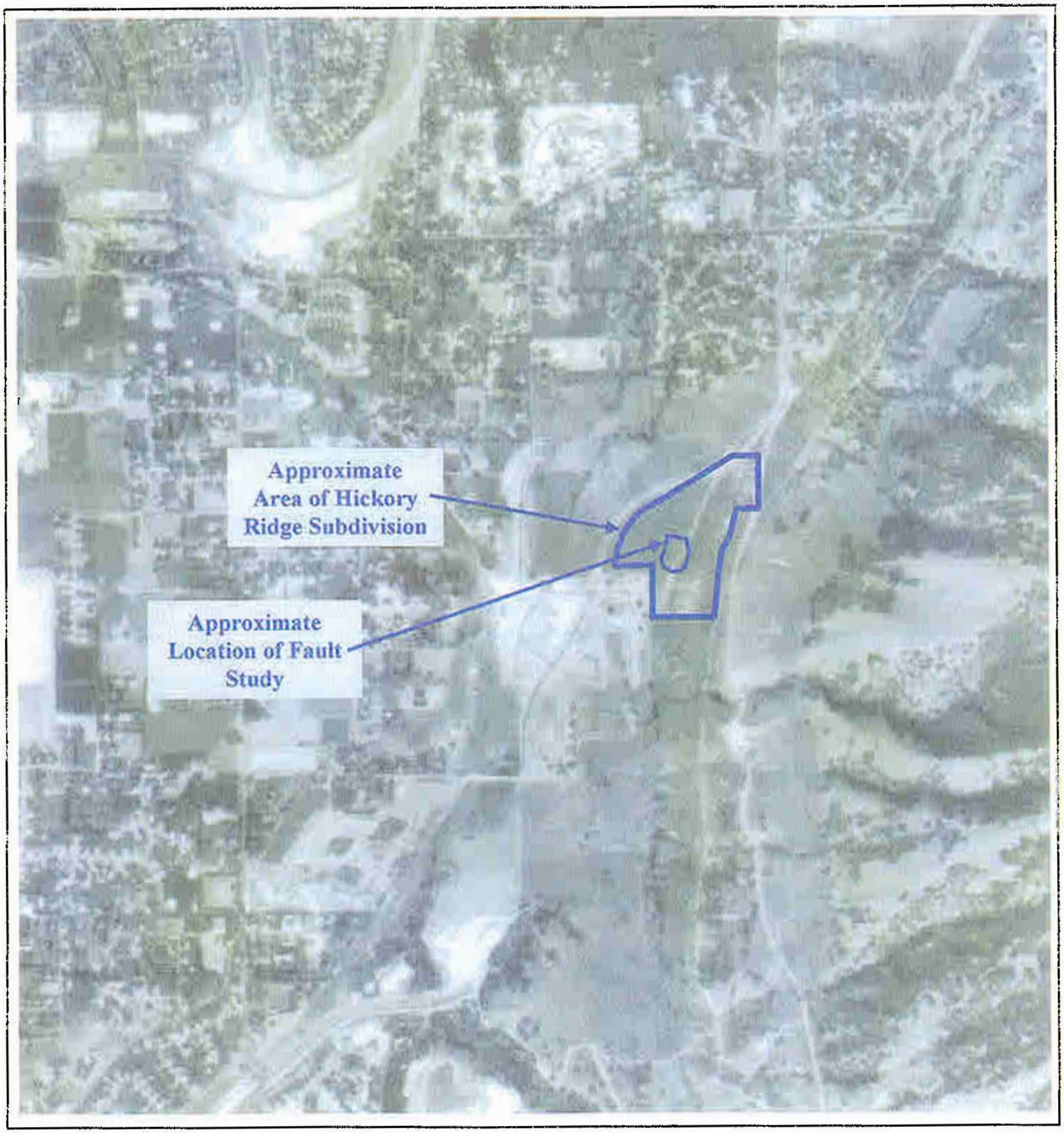
Project Number – 00522-002

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

AERIAL PHOTOS

Plate

3



IGES

Date of Aerial Photo:
September 12, 1997

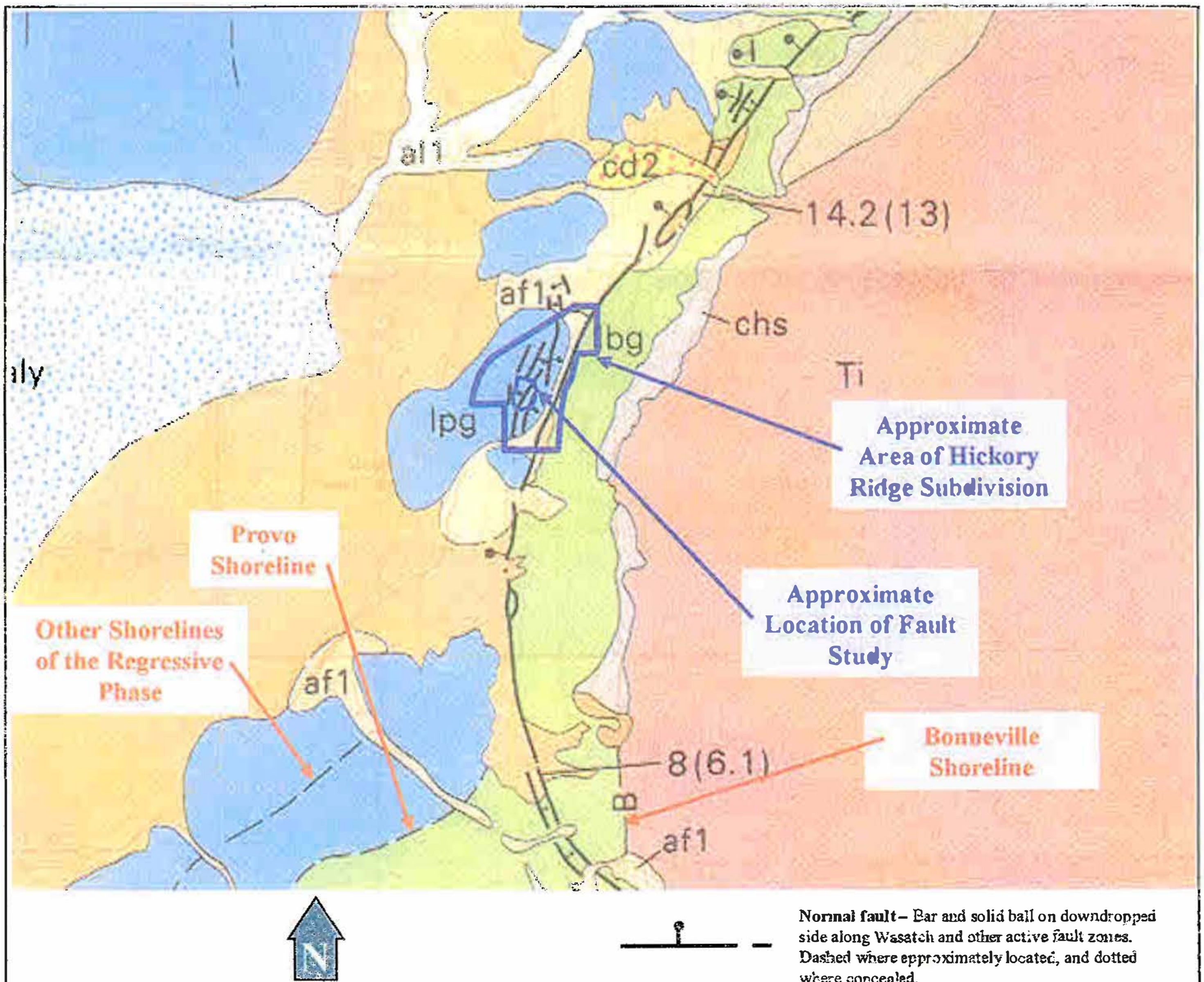
Project Number – 00522-002

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

AERIAL PHOTOS

Plate

4



Normal fault – Bar and solid ball on downdropped side along Wasatch and other active fault zones. Dashed where approximately located, and dotted where concealed.

laly — **Lacustrine, marsh, and alluvial deposits (Holocene to uppermost Pleistocene)** – Undivided clay, silt, sand, peat, and very minor pebble gravel. Deposited after the regressive phase of the Bonneville lake cycle in shallow lakes and marshes.

lpg — **Lacustrine sand and gravel related to regressive phase (uppermost Pleistocene)** – Clast-supported pebble and cobble gravel, in a matrix of sand and pebbly sand; locally interbedded with beds and lenses of silt and sandy silt.

lbg — **Lacustrine sand and gravel related to transgressive (upper Pleistocene)** – Clast-supported pebble, cobble, and rarely boulder gravel, in a matrix of sand and pebbly sand; locally includes interbedded silt and clay.

al1 — **Stream alluvium 1 (upper Holocene)** – Sand, silt, and minor clay and gravel along Jordan River and lower reaches of its tributaries.

af1 — **Fan alluvium 1 (upper Holocene)** – Clast-supported pebble and cobble gravel, locally bouldery, in a matrix of sand and silty sand; poorly sorted; clasts subangular to round.

af2 — **Fan alluvium 2 (middle Holocene to uppermost Pleistocene)** -- Clast-supported pebble and cobble gravel, locally bouldery, in a matrix of sand and silty sand; poorly sorted; clasts subangular to round.

cd2 — **Debris-flow deposits 2 (middle Holocene to uppermost Pleistocene)** – Clast-supported pebble, cobble, and boulder gravel in a matrix of sand, silt, and clay; boulders are as much as several meters in diameter and are angular to subround.

chs — **Hillslope colluvium (Holocene to upper Pleistocene)** – Pebble, cobble, and boulder gravel, usually clast supported, in a matrix of sand and silt; clasts usually anguiar to subangular.

Ti — **Tertiary intrusive igneous rocks (Oligocene)** -- Consists primarily of quartz monzonite of the Little Cottonwood stock of Oligocene age.

BASE MAP: SURFICIAL GEOLOGIC MAP OF THE SALT LAKE CITY SEGMENT AND PARTS OF ADJACENT SEGMENTS OF THE WASATCH FAULT ZONE, DAVIS, SALT LAKE AND UTAH COUNTIES, UTAH By Stephen F. Personius and William E. Scott Published by the U.S. Geological Survey, 1992

IGES

Project Number – 00522-002

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

SITE GEOLOGIC MAP

Plate 5

Approximately 10 -30 Feet, North Side of Trench 1

W

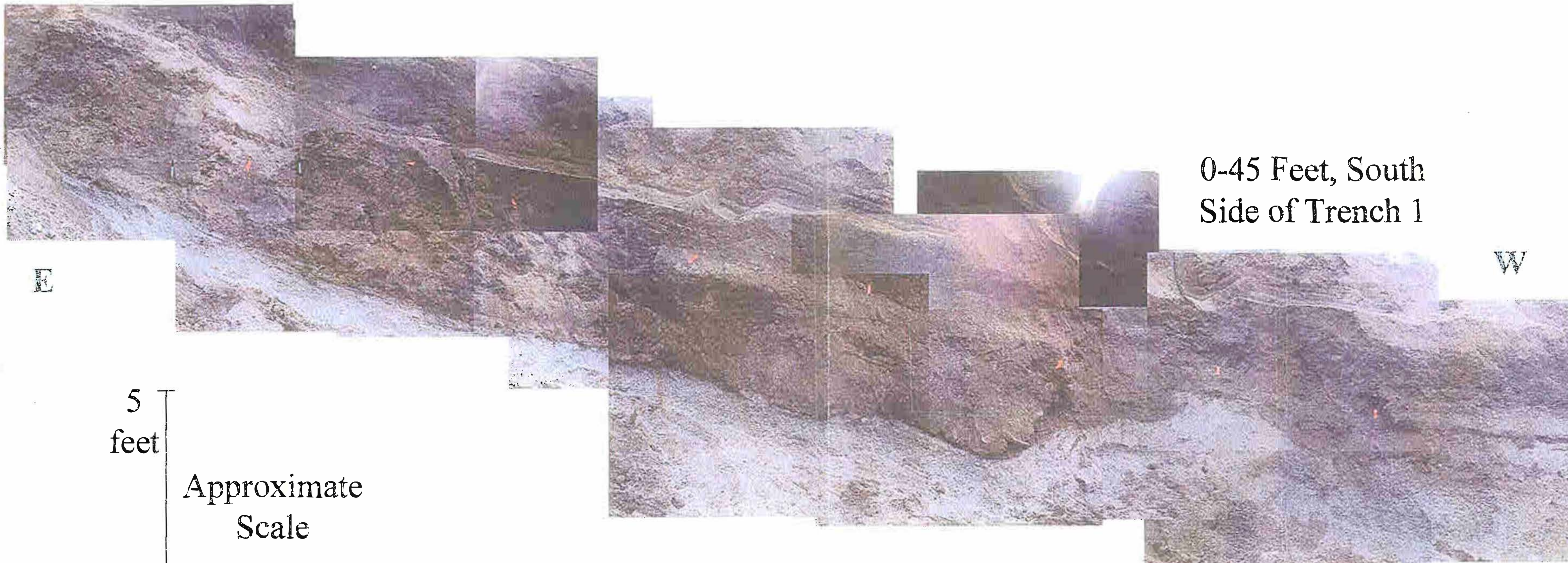
E

5 feet

0

5 feet

Approximate Scale



0-45 Feet, South Side of Trench 1

Approximate Scale: 0 – 5 feet (horizontal), 5 feet (vertical)

45 – 80 Feet, South Side of Trench 1

IGES

Project Number – 00522-002

TRENCH 1

TRENCH PHOTO LOG

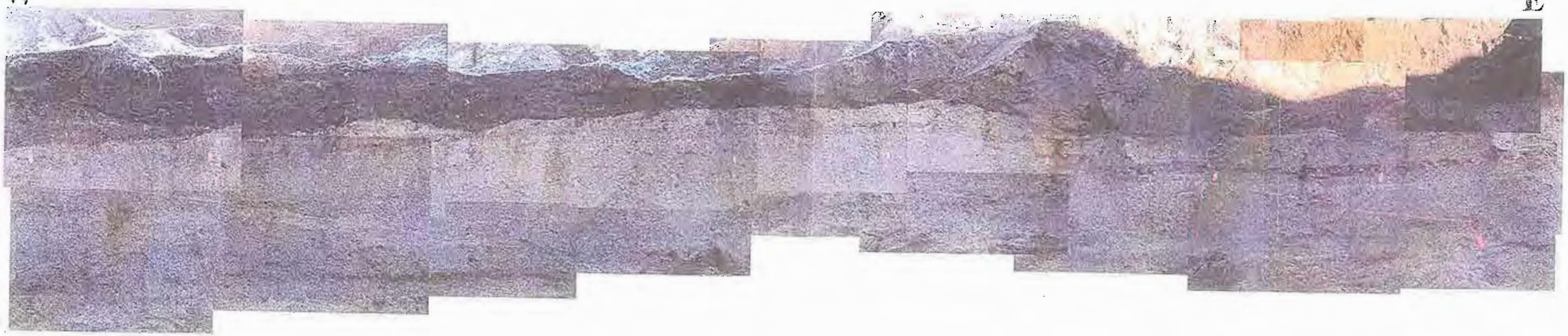
Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate 6b

35 – 80 Feet, North Side of Trench 1

W

E



5 feet

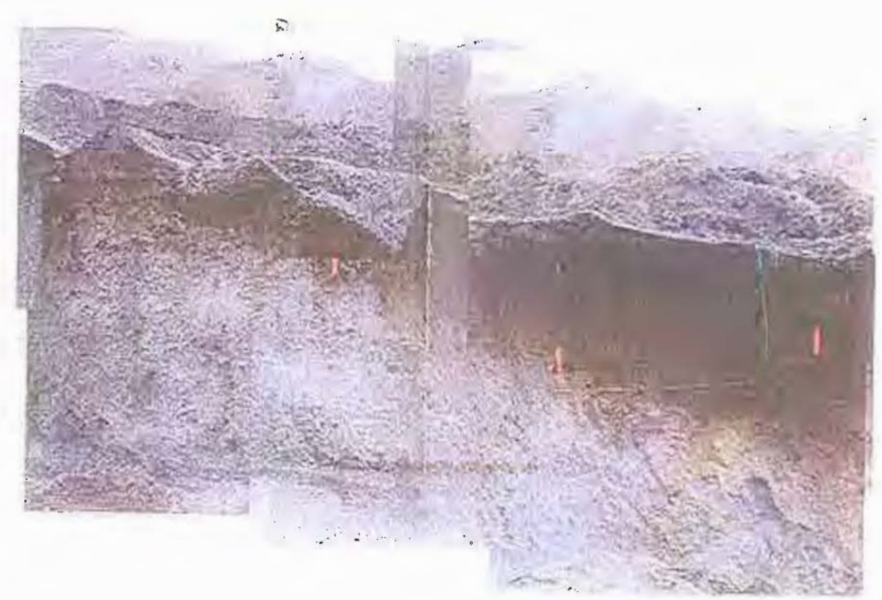
Approximate Scale

0

5 feet

75 – 90 Feet, South Side of Trench 1

E



W

IGES

Project Number – 00522-002

TRENCH 1

TRENCH PHOTO LOG

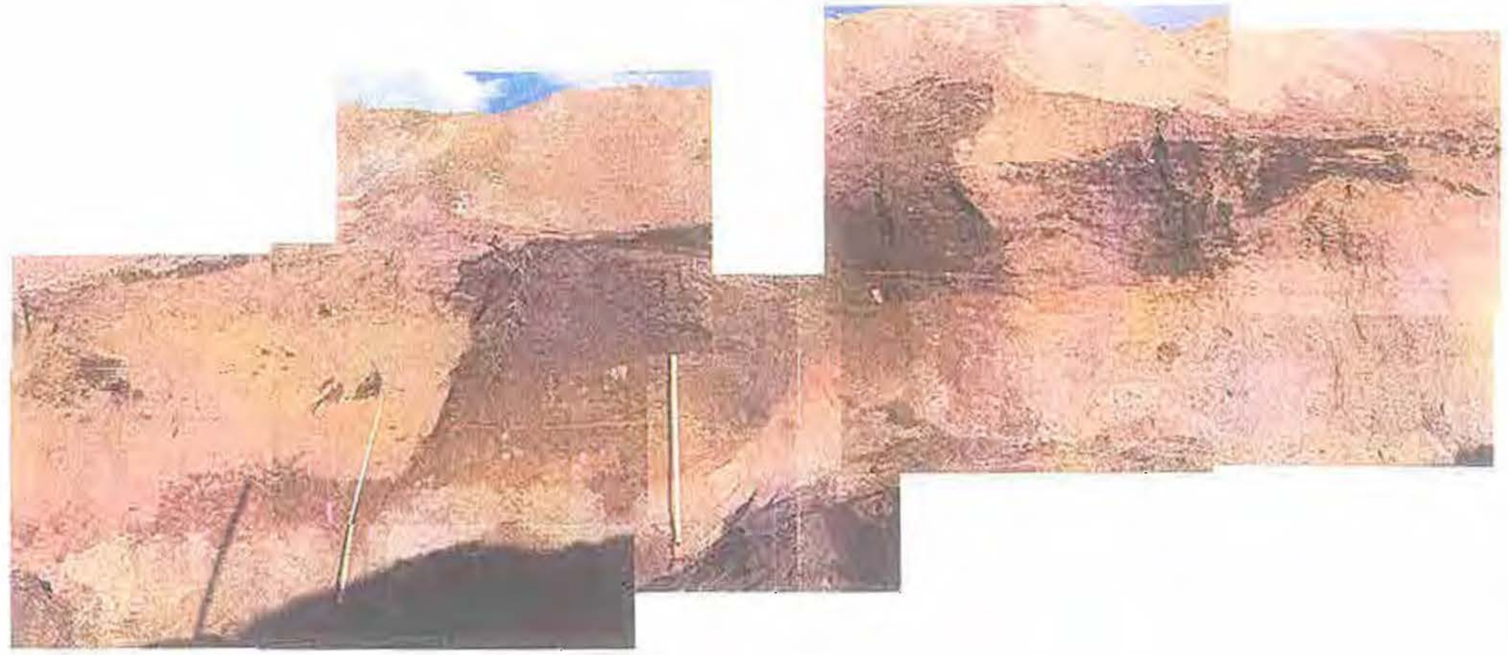
Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate

6c

80-105 Feet, North Side of Trench 1

W



E

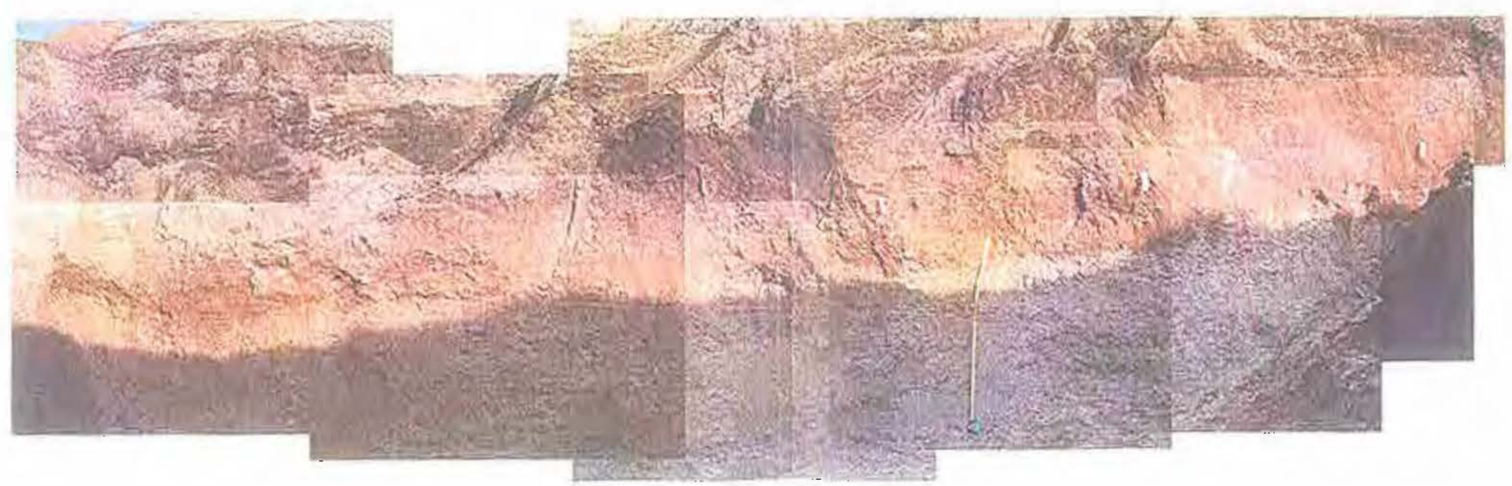
5
feet

Approximate
Scale

0
5
feet

105-130 Feet, North Side of Trench 1

W



E

IGES

Project Number - 00522-002

TRENCH 1

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate
6d

135-165 Feet, South Side of Trench 1

E

W

5 feet

Approximate Scale

0

5 feet

IGES

Project Number - 00522-002

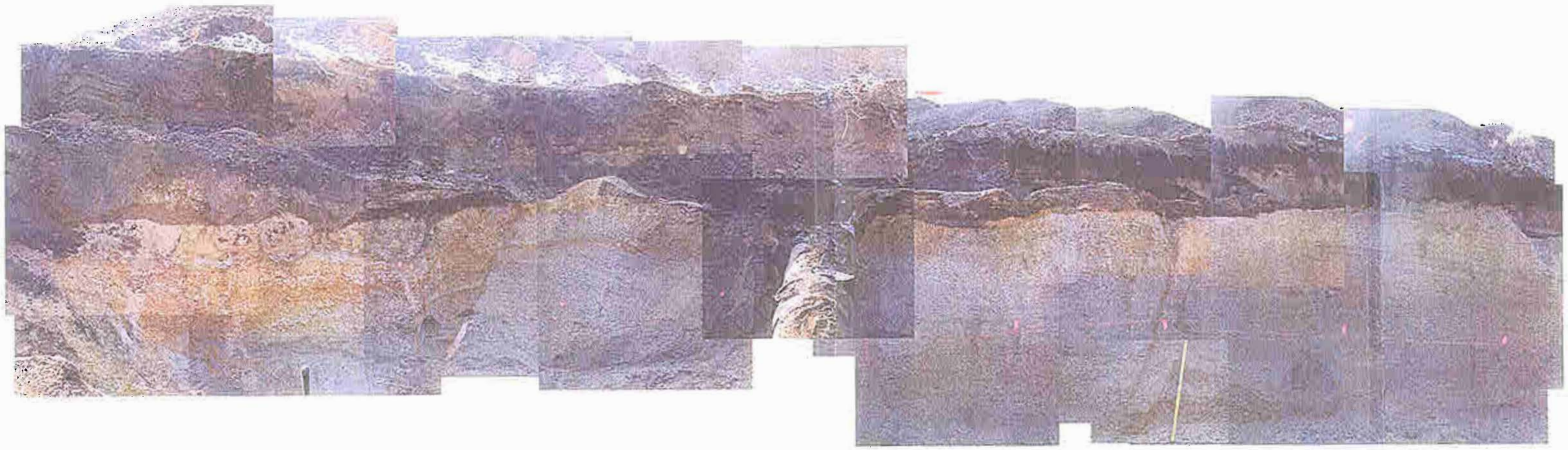
TRENCH 1

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate 6e

E 0-45 Feet, South Side of Trench 2 W



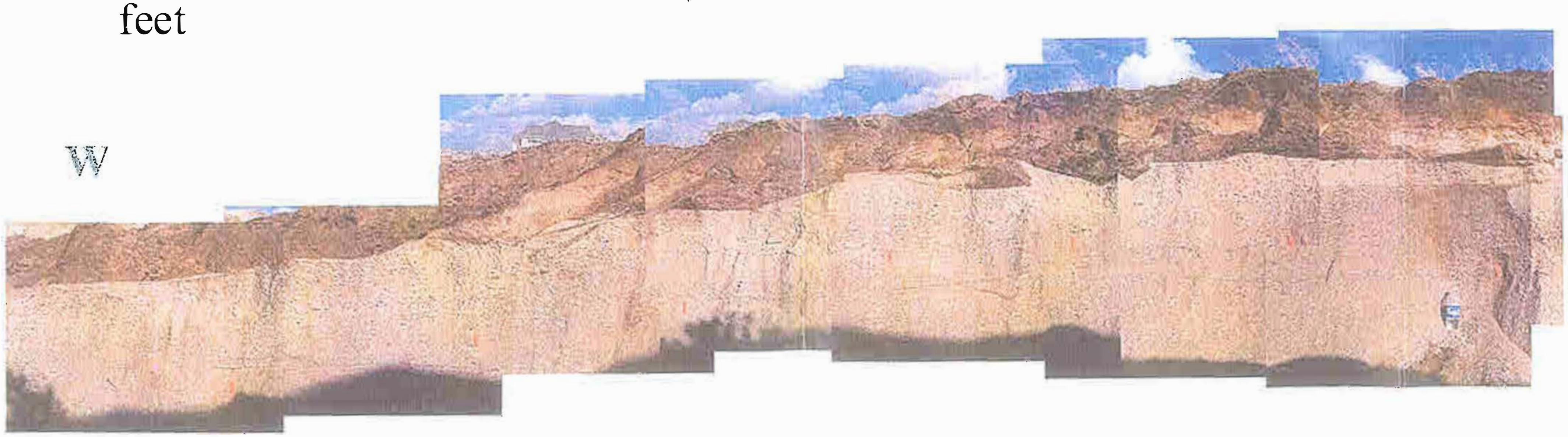
5 feet

Approximate Scale

0 5 feet

35-70 Feet, North Side of Trench 2 E

W



IGES

Project Number -- 00522-002

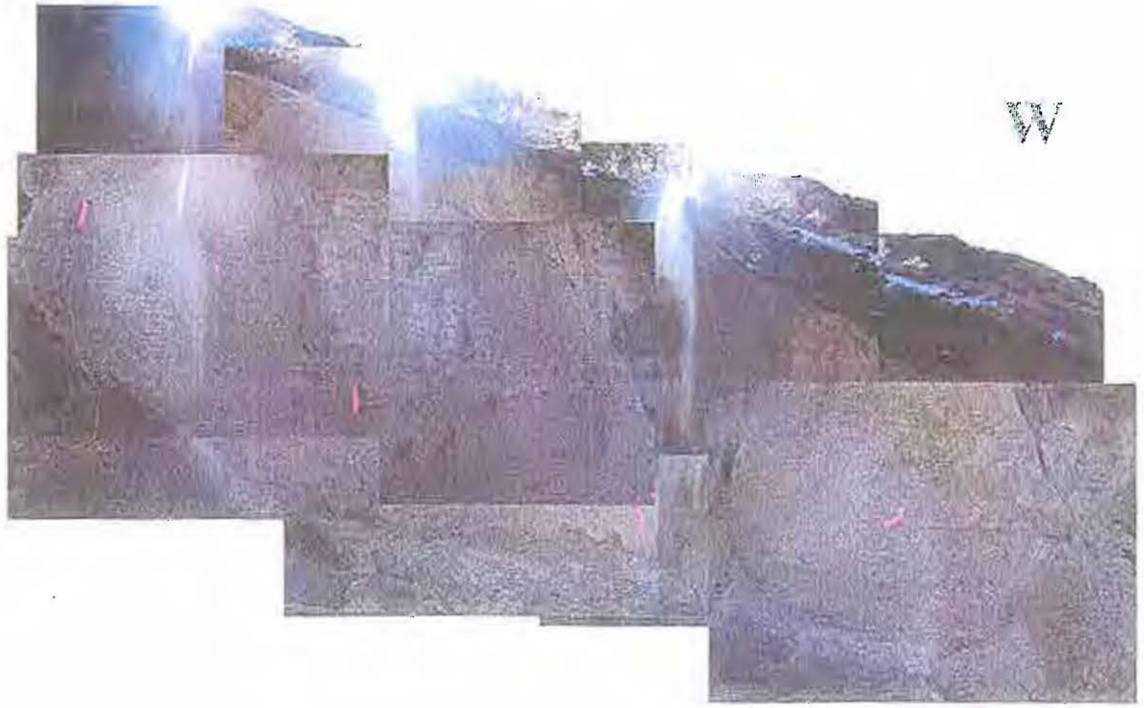
TRENCH 2

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate 7a

E 75 –95 Feet, South Side of Trench 2



W

115 – 140 Feet, North Side of Trench 2

W

E

5 feet

Approximate Scale

0

5 feet

155 – 175 Feet, South Side of Trench 2

E

W

IGES

Project Number - 00522-007

TRENCH 2

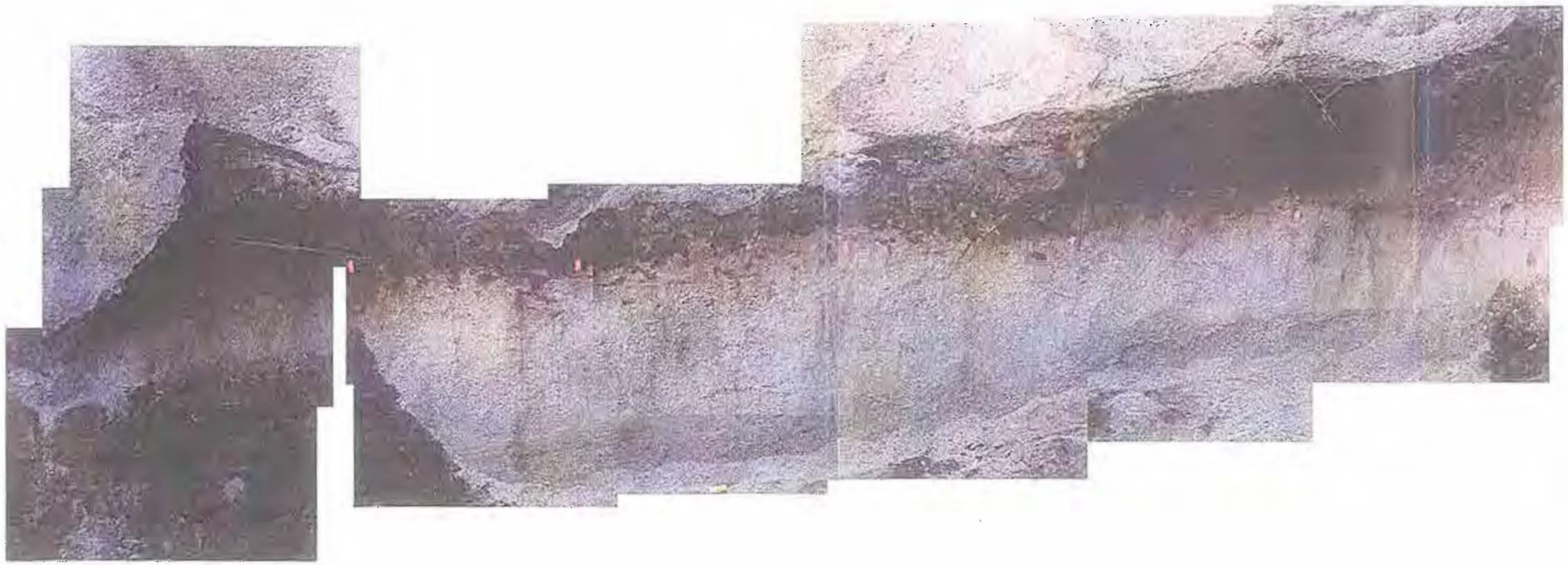
TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate
7b

Approximately 170 –200 Feet,
North Side of Trench 2

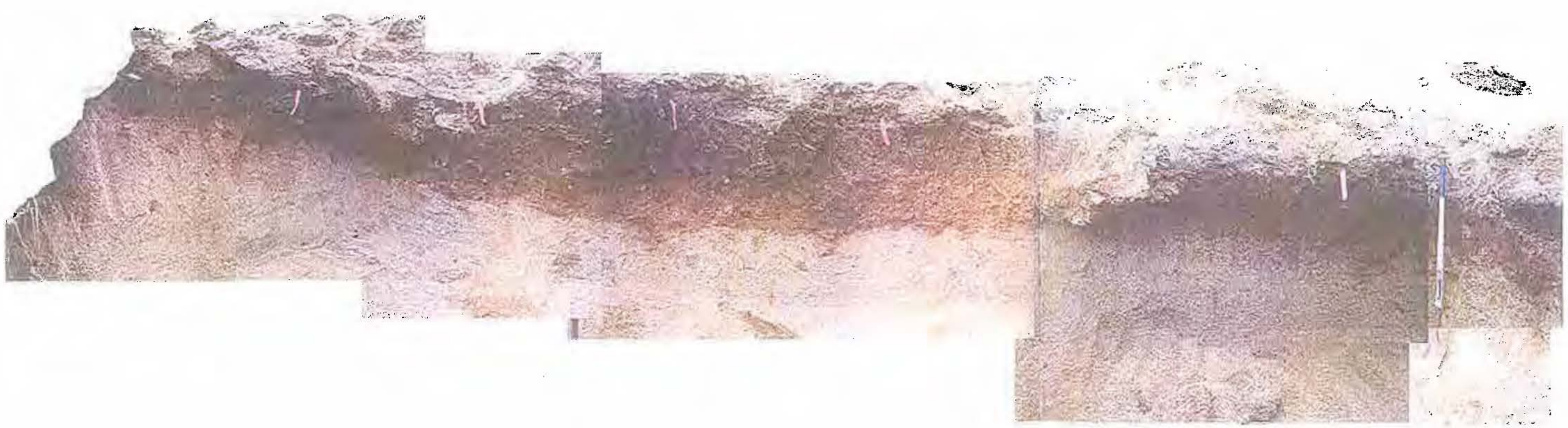
W



E

Approximately 195 –223 Feet,
South Side of Trench 2

E



W

5 feet

Approximate Scale

0

5 feet

Project Number – 00522-002

TRENCH 2

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate
7c

E

0-40 Feet, South Side of Trench 3

W

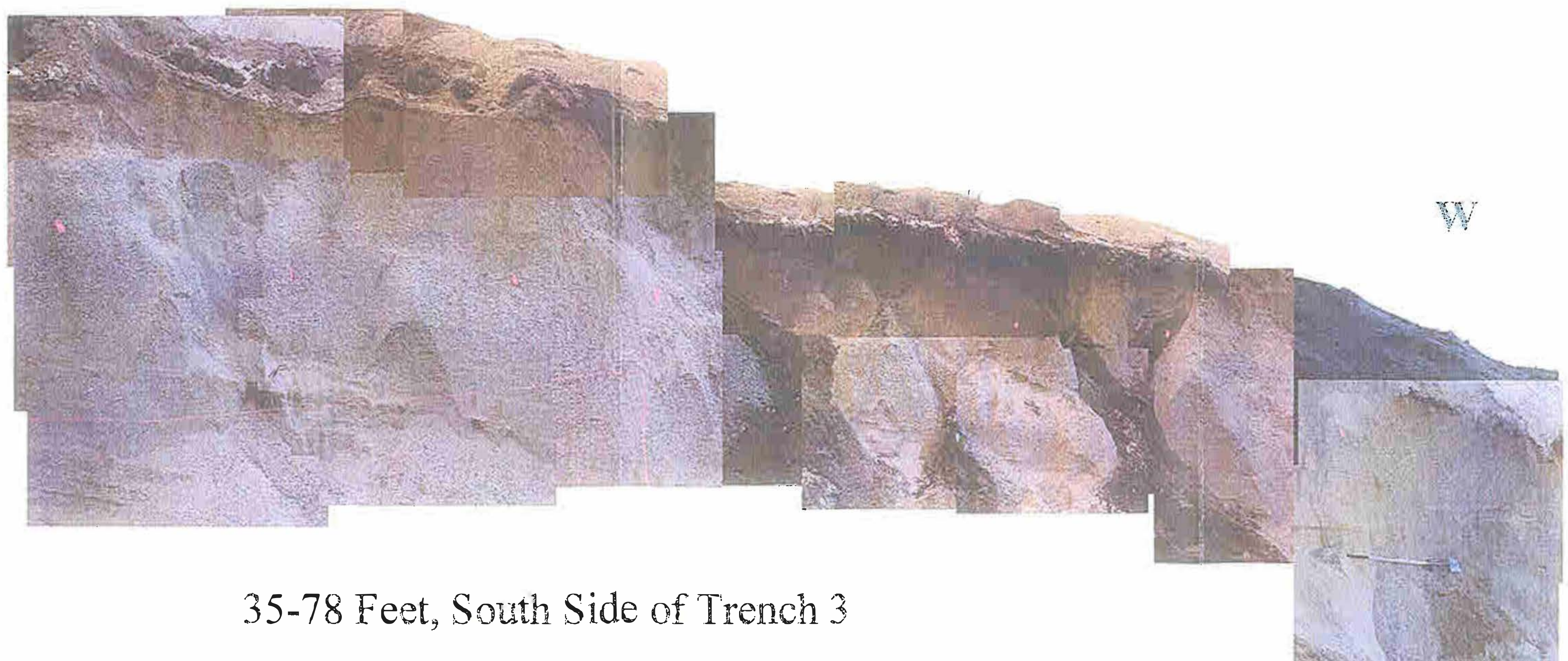
5
feet

Approximate
Scale

0

5
feet

E



W

35-78 Feet, South Side of Trench 3

IGES

Project Number – 00522-002

TRENCH 3

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate
8a

70-128 Feet, South Side of Trench 3

E

W

5 feet

Approximate Scale

0

5 feet

IGES

Project Number - 00522-002

TRENCH 3

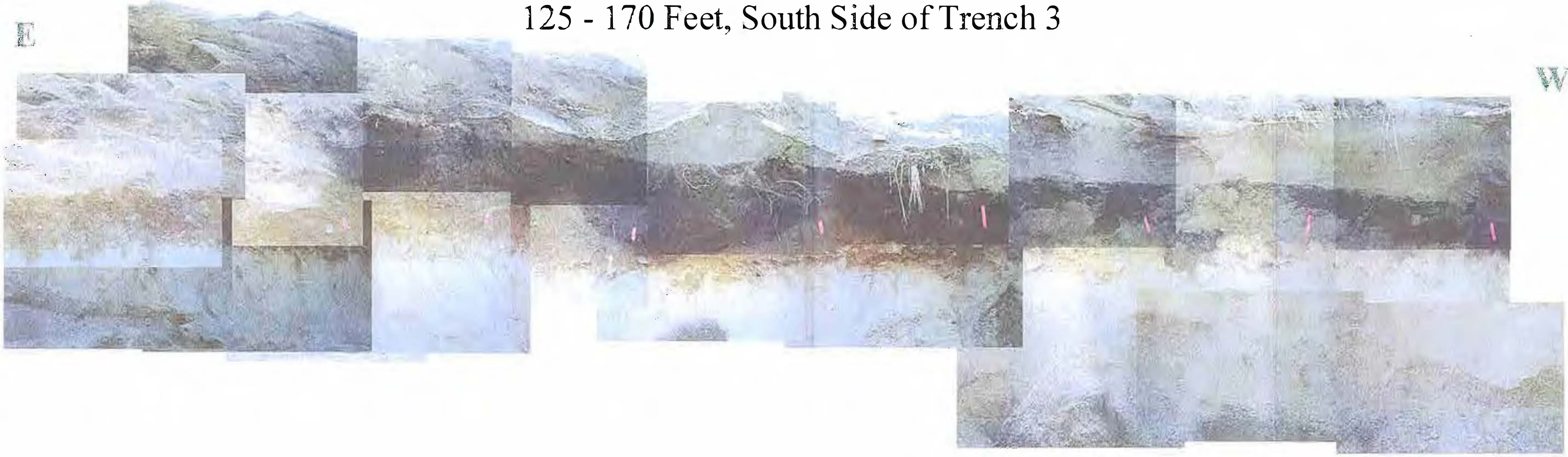
TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate 8b

125 - 170 Feet, South Side of Trench 3

E



W

165 - 175 Feet, South Side of Trench 3

5 feet — Approximate Scale — 0 — 5 feet

E

W

IGES

Project Number – 00522-002

TRENCH 3

TRENCH PHOTO LOG

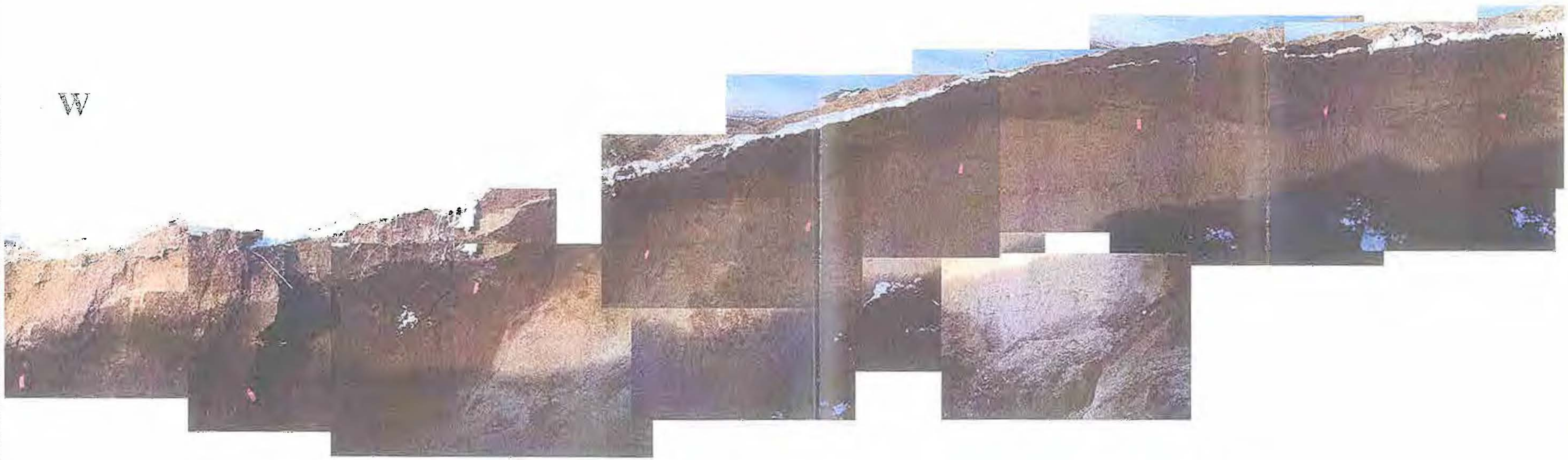
Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate
8c

3-45 Feet, North Side of Trench 4

W

E



5 feet

Approximate Scale

0

5 feet

IGES

Project Number - 00522-002

TRENCH 4

TRENCH PHOTO LOG

Fault Study - Hickory Ridge
Lots 23, 24, 25, 41, 42, & 43
Draper, UT

Plate 9

IGES
Intermountain GeoEnvironmental Services, Inc.
4153 South Commerce Drive - Salt Lake City, Utah 84107 - T: (801) 270-9400 - F: (801) 270-9401

February 4, 2004

Holman and Walker
c/o Mr. Jeff Walker
9537 South 700 East
Sandy, UT 84070

Subject: **Carbon Dating Results**
Hickory Ridge
Lots 32 and 19
Draper, Utah

Dear Mr. Walker,

This letter presents and discusses the results of the carbon dating laboratory analysis performed on bulk soil samples collected from Lots 22 and Lot 32. Bulk samples were collected from organic rich soil layers that were exposed in basement and garage excavations at each of these lots. The bulk samples were processed in our laboratory prior to being shipped to *Beta Analytic Inc.* in Miami, Florida; we removed oversized material to facilitate the carbon dating laboratory analysis.

Active faults are defined in the Salt Lake County Natural Hazards Ordinance as faults "displaying evidence of greater than 4 inches of displacement along one or more of its traces during Holocene time" (in the last 10,000 years) (Salt Lake County Planning, 1989). If active faults are observed near proposed habitable structures, offset guidelines as prescribed by the Utah Geological Survey (UGS) should be followed prior to development.

The purpose of the carbon dating analysis is to estimate the approximate time in years since the last seismic event offset the sand layers beneath the organic rich soil layers. The two samples were collected in soil layers that are stratigraphically above sand layers that were observed to have been offset by faults. These sand layers are mapped as lacustrine sand and gravel associated with the regressive phase of the Provo shoreline of the Bonneville Lake Cycle. These sands date to approximately 16,000 to 13,000 ka (thousands of years ago). If the organic rich soil layers were dated to ages older than but close to 10,000 years, then these layers could be used to assess the general age of the observed fault.

The 2 SIGMA CALIBRATION age of Sample Lot 22 was reported by Beta Analytic Inc. to be circa Cal BP 4,780-4,290. The 2 SIGMA CALIBRATION age of Sample Lot 32 was reported by Beta Analytic Inc. to be circa Cal BP 3,640-3,240. A copy of the laboratory results form is attached to this letter. Based on the results of the carbon dating, these soils are too young to be used to show that faults at the project site are inactive by Salt Lake County standards. In places where these soils are offset by a fault it would show the fault to be an active fault.

Please feel free to contact us if you have any questions 801.270.9400. We appreciate the opportunity to work with you on this project.

Respectfully submitted,
IGES, INC.

LICENSED PROFESSIONAL GEOLOGIST
HIRAM
ALBA
175774-2250
07/04/04
STATE OF UTAH

Hiram Alba, P.E, P.G.
Principal

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-5167 FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Timothy J. Thompson — Report Date: 11/25/2003

IGES LLC — Material Received: 11/20/2003

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 185686	3970 +/- 60 BP	-23.3 o/oo	4000 +/- 60 BP

SAMPLE : LOT 22
ANALYSIS : Radiometric-Priority delivery (bulk low carbon analysis on sediment)
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 2830 to 2830 (Cal BP 4780 to 4780) AND Cal BC 2650 to 2340 (Cal BP 4600 to 4290)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 185687	3170 +/- 90 BP	-22.8 o/oo	3210 +/- 90 BP

SAMPLE : LOT 32
ANALYSIS : Radiometric-Priority delivery (bulk low carbon analysis on sediment)
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 1690 to 1290 (Cal BP 3640 to 3240)

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.