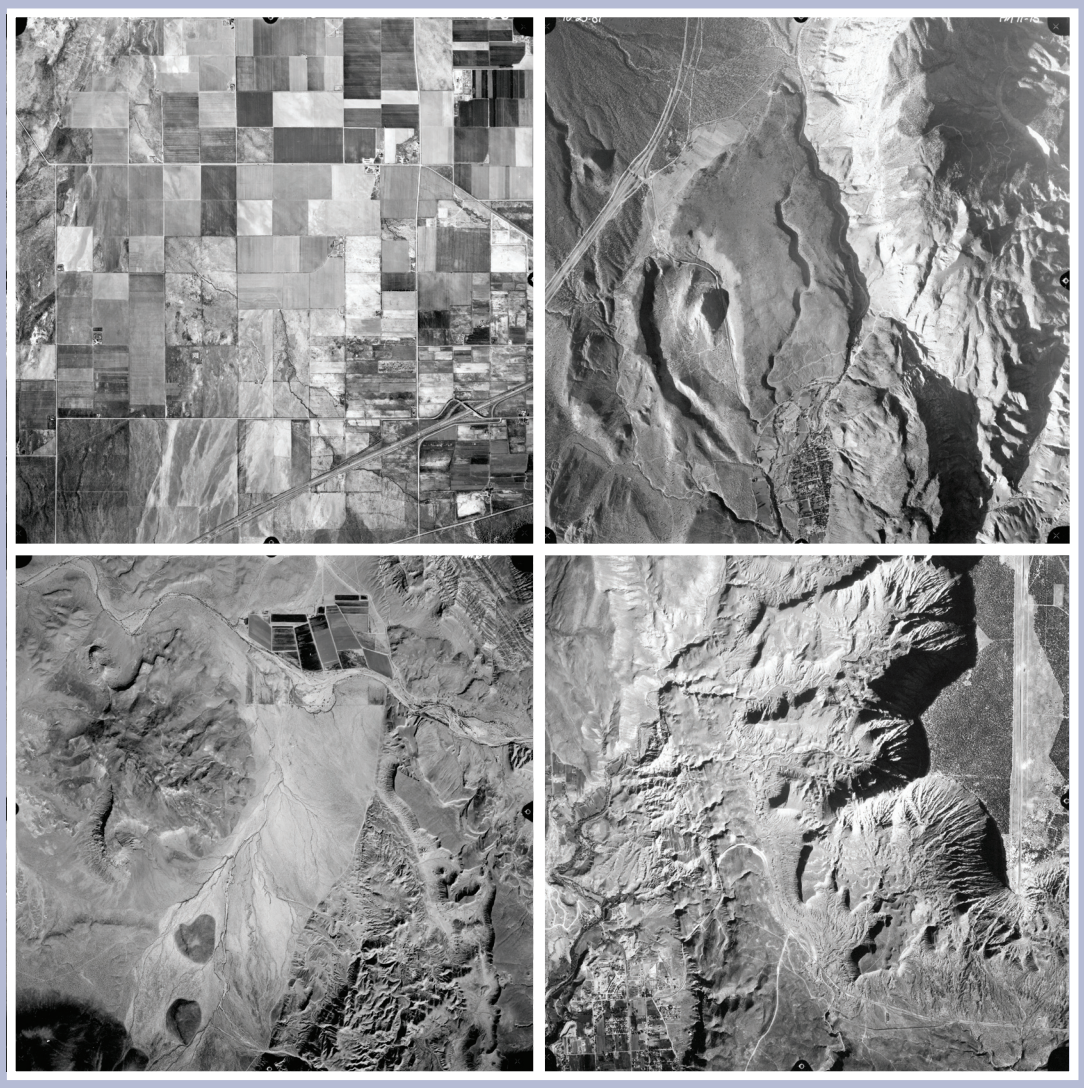
Paleoseismology of Utah, Volume 21

Compilation of 1982–83 Seismic Safety Investigation Reports of Eight SCS Dams in Southwestern Utah (Hurricane and Washington Fault Zones) and Low-Sun-Angle Aerial Photography, Washington and Iron Counties, Utah, and Mohave County, Arizona

Compiled by Steve D. Bowman, Brennan W. Young, and Corey D. Unger



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PALEOSEISMOLOGY OF UTAH SERIES PUBLICATIONS

UGS publications produced as part of the Paleoseismology of Utah series may be found online at http://geology.utah.gov/ghp/consultants/paleoseismic_series.htm.

1. Fault behavior and earthquake recurrence on the Provo segment of the Wasatch fault zone at Mapleton, Utah County, Utah—Paleoseismology of Utah, Volume 1, 1991, by Lund, W.R., Schwartz, D.P., Mulvey, W.E., Budding, K.E., and Black, B.D.: Utah Geological Survey Special Study 75, 41 p.
2. Paleoseismic analysis of the Wasatch fault zone at the Brigham City trench site, Brigham City, Utah and the Pole Patch trench site, Pleasant View, Utah—Paleoseismology of Utah, Volume 2, 1991, by Personius, S.F.: Utah Geological Survey Special Study 76, 39 p.
3. The number and timing of paleoseismic events on the Nephi and Levan segments, Wasatch fault zone, Utah—Paleoseismology of Utah, Volume 3, 1991, by Jackson, M.: Utah Geological Survey Special Study 78, 23 p., 3 plates.
4. Seismotectonics of north-central Utah and southwestern Wyoming—Paleoseismology of Utah, Volume 4, 1994, by West, M.W.: Utah Geological Survey Special Study 82, 93 p., 5 plates, scale 1:100,000.
5. Neotectonic deformation along the East Cache fault zone, Cache County, Utah—Paleoseismology of Utah, Volume 5, 1994, by McCalpin, J.P.: Utah Geological Survey Special Study 83, 37 p.
6. The Oquirrh fault zone, Tooele County, Utah—surficial geology and paleoseismicity—Paleoseismology of Utah, Volume 6, 1996, by Lund, W.R., editor: Utah Geological Survey Special Study 88, 64 p., 2 plates, scale 1:24,000.
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12. Neotectonics of Bear Lake Valley, Utah and Idaho; a preliminary assessment—Paleoseismology of Utah, Volume 12, 2003, by McCalpin, J.P.: Utah Geological Survey Miscellaneous Publication 03-4, 43 p.
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UTAH GEOLOGICAL SURVEY
contact
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
telephone: 801-537-3300
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CONTENTS

FOREWORD vii
ABSTRACT 1
INTRODUCTION 1
REPORTS 1
AERIAL PHOTOGRAPH SCANNING AND INDEXING 1
DIGITAL FILES 2
LIMITATIONS 3
ACKNOWLEDGMENTS 3
REFERENCES 4

FIGURES

Figure 1. File naming convention for TIFF and JPEG images in compilation 4

TABLES

Table 1. Acquisition dates of aerial photograph frames 3
Table 2. Catalog of aerial photograph frames on compilation DVDs 3

PLATES

Plate 1A. Index Map of Aerial Photography ..... on DVD
Plate 1B. Index Map of Aerial Photography ..... on DVD

FOREWORD

This Utah Geological Survey Open-File Report, *Paleoseismology of Utah, Volume 21—Compilation of 1982–83 Seismic Safety Investigation Reports of Eight SCS Dams in Southwestern Utah (Hurricane and Washington Fault Zones) and Low-Sun-Angle Aerial Photography, Washington and Iron Counties, Utah, and Mohave County, Arizona,* is the twenty-first report in the Paleoseismology of Utah series. This series makes the results of paleoseismic investigations in Utah available to geoscientists, engineers, planners, public officials, and the general public. These studies provide critical information regarding paleoearthquake parameters such as earthquake timing, recurrence, displacement, slip rate, fault geometry, and segmentation, which can be used to characterize potential seismic sources and evaluate the long-term seismic hazard of Utah's Quaternary faults.

As part of the Paleoseismology of Utah series, the Utah Geological Survey has begun to acquire, scan, and release in digital format heretofore hard to access "legacy" paleoseismic fault investigations conducted in Utah. This compilation of two reports and 798 low-sun-angle aerial photographs pertaining to seismic safety evaluations of eight Soil Conservation Service (now Natural Resources Conservation Service) dams in southwestern Utah performed by Earth Science Associates in 1982–83 is the second such legacy document in the Paleoseismology of Utah series. The principal Quaternary faults addressed by these reports are the Hurricane and Washington faults, as well as a number of smaller, likely closely related faults in the study area. The compilation includes:

- Earth Sciences Associates, Inc., 1982, *Phase I report, Seismic safety investigation of eight SCS dams in southwestern Utah*, and
- Earth Sciences Associates, Inc., 1983, *Phase II report, Seismic safety investigation of eight SCS dams in southwestern Utah.*

The Phase I report includes descriptions of geologic, tectonic, and seismic conditions in southwestern Utah, as well as geologic maps, trench logs, test pit and borehole logs, and laboratory soil test results from seismic safety investigations conducted at the dam sites. The Phase II report describes various engineering analyses conducted to determine the susceptibility of selected dams to strong earthquake ground shaking and liquefaction.

Accompanying the two reports are 798 low-sun-angle, black-and-white, 1:20,000-scale, morning and afternoon aerial photographs used as part of the seismic safety investigation project. The photographs cover an area of about 960 square miles that extends from approximately the north end of Parowan Valley (Interstate 15 and State Route 20 interchange) south along the Hurricane Cliffs to just south of the Utah-Arizona border on the east and from near Central, Utah, south to St. George, Utah, on the west.

This compilation presents the first paleoseismic trenching information generated for the Hurricane and Washington faults, and although now largely superseded by subsequent investigations, still represents important information for understanding the behavior of these two large and potentially active structures. The accompanying low-sun-angle aerial photographs, in addition to being a valuable historical archive, will be useful for consultants and governmental agencies involved with current paleoseismic investigations; other geological, geotechnical, and environmental investigations; and land-use planning efforts.

Determining the paleoseismic parameters for Utah's Quaternary faults is important because those data help refine fault activity and hazard models and improve earthquake-hazard evaluations for the region, all of which help reduce Utah's earthquake-related risk.

William R. Lund, Editor
Paleoseismology of Utah Series

Compilation of 1982–83 Seismic Safety Investigation Reports Of Eight SCS Dams In Southwestern Utah (Hurricane and Washington Fault Zones) and Low-Sun-Angle Aerial Photography, Washington And Iron Counties, Utah, And Mohave County, Arizona

ABSTRACT

This compilation of the *Seismic Safety Investigation of Eight SCS Dams in Southwestern Utah* Project by Earth Sciences Associates includes two separate reports and 798 scanned low-sun-angle aerial photographs (frames) that were produced to determine the seismic safety of the eight flood control dams relative to surface faulting, ground shaking, and liquefaction. The aerial photographs will be useful for professionals involved with paleoseismology investigations; geologic, geotechnical, and environmental assessment and investigation projects; land-use planning; governmental agencies; and for the general public and others as a historical archive.

INTRODUCTION

The *Seismic Safety Investigation of Eight SCS Dams in Southwestern Utah* Project includes two separate reports and 798 scanned low-sun-angle aerial photographs (frames) that were part of the project. Earth Sciences Associates, Inc. of Palo Alto, California, performed the seismic safety investigation between 1982 and 1983 under contract to the Soil Conservation Service (SCS) (now Natural Resources Conservation Service), West Technical Service Center (now part of the West National Technology Support Center) in Portland, Oregon, to determine the seismic safety of eight flood control dams relative to surface faulting, ground shaking, and liquefaction.

This compilation covers an area from approximately the north end of Parowan Valley, Utah, (Interstate 15 and State Route 20 interchange) south along the Hurricane Cliffs to just south of the Utah-Arizona border and from near Central, Utah, south to St. George, Utah. The section in Utah includes parts of Washington and Iron Counties, and the section in Arizona includes part of Mohave County. The accompanying scanned low-sun-angle aerial photographs will be useful for professionals involved with paleoseismology investigations; geologic, geotechnical, and environmental assessment and investigation projects; land-use planning; governmental agencies; and for the general public and others as a historical archive. The low-sun-angle aerial photography was used to highlight certain topographic features, such as fault scarps and traces, for mapping purposes.

REPORTS

This publication includes the two reports prepared for the SCS on the seismic safety investigation of eight flood control dams:

- Earth Sciences Associates, Inc., 1982, Phase I report, Seismic safety investigation of eight SCS dams in southwestern Utah: Palo Alto, California, unpublished consultant's report for the Soil Conservation Service, variously paginated.
- Earth Sciences Associates, Inc., 1983, Phase II report, Seismic safety investigation of eight SCS dams in southwestern Utah: Palo Alto, California, unpublished consultant's report for the Soil Conservation Service, variously paginated.

The Phase I report includes descriptions of geologic, tectonic, and seismic conditions in southwestern Utah. The Phase II report describes various engineering analyses conducted to determine the seismic safety of eight SCS flood control dams. The eight dams include Green's Lake Dams No. 2, 3, and 5; Frog Hollow Dam; Gypsum Wash Dam; Warner Draw Dam; Stucki Dam; and Ivins Diversion Dam No. 5.

We scanned the two reports, previously available only in paper format, on a Canon C5280 scanner, using either an 8-bit color or grayscale color space at a resolution of 300 dots per inch (dpi), and saved the resultant scans directly in Adobe PDF format. After scanning, we converted each report PDF file to a searchable text PDF format using Adobe Acrobat 9 and optical character recognition (OCR) features. Oversize plates were scanned on a Contex Chroma HS 42 scanner, using an 8-bit grayscale color space at a resolution of 300 dpi. We performed some image enhancement on each oversize plate; however, due to the sometimes poor quality of the available original plates, some areas of the plates may not be legible.

AERIAL PHOTOGRAPH SCANNING AND INDEXING

We have included within this compilation 798 low-sun-angle aerial photographs acquired in 1981 (Aerial Proj-

ect Code 810941) and used as part of the seismic safety investigation project. Frames were taken along similar flight lines in the morning and afternoon for two different illumination angles. Of the complete set, we scanned 790 frames from paper photograph prints and eight frames from the original film.

We scanned the paper photograph frames on an Epson 1640XL scanner, using an 8-bit grayscale color space at a resolution of 600 dpi (42 microns) with unsharp mask enhancement, and saved the resultant image scans in TIFF format. Cooper Aerial Surveys, Inc. of Phoenix, Arizona, scanned the film frames from the original project film rolls using a Leica DSW 700 scanner. Cooper scanned the frames using an 8-bit grayscale color space at a resolution of 1200 dpi (21 microns), and also saved the resultant image scans in TIFF format.

Because an index map is not available for the aerial photographs, we determined the center point of each image scan using a grid in Adobe Photoshop CS. We then compared the center point locations to modern Google Earth imagery to determine approximate coordinates in the simple cylindrical (Plate Carree or latitude/longitude) projection, WGS84 datum. We projected the center point coordinates to the NAD83 datum and used them to create index maps for each report as a Google Earth compressed keyhole markup language (KMZ) file and as an Environmental Systems Research Institute (ESRI) feature class within a geodatabase for use in GIS software.

DIGITAL FILES

We developed the KMZ files in Google Earth version 6 with photograph center points indicated as placemarks. Each placemark contains an embedded thumbnail (reduced resolution) image of the corresponding image frame for reference and ease in locating aerial photograph frames. The latest version of Google Earth may be downloaded from http://earth.google.com.

To more easily view the photograph center point placemarks, we recommend turning off unneeded layers in Google Earth by unchecking selection boxes next to the Gallery, Traffic, Weather, Global Awareness, and Places layers in the Layers pane. Other layers may also be turned off; however, at a minimum, the Roads and Borders and Labels layers should be checked (turned on) to create an adequate base map for viewing the photos. The Layers pane is along the left side of the Google Earth window, below the Search and Places panes. Thumbnail images of the frames may be viewed by clicking once on either the red bulls-eye placemark symbol on the map or on the frame number in the Places frame. Double clicking on the frame number in the Places pane will zoom to the selected frame center point location.

We developed a file geodatabase in ESRI ArcGIS 10 software, which contains a feature class that includes an attribute table with frame information where known. The table contains the approximate frame center point coordinates (utilizing the point geometry type and the Universal Transverse Mercator (UTM), Zone 12 North, NAD83 coordinate system), frame number, and exposure (acquisition) date and time. In addition, we included an ESRI shapefile (SHP) with the same information. Table 1 lists the acquisition dates for the various frames in the project. Additional information about the frames, such as camera and film specifications, is not available. The geodatabase, shapefile, and metadata files are on the \AutoPlay\Docs\GIS directory of the first DVD.

Users who do not have ArcGIS or other GIS software may view the geodatabase or shapefile using ESRI's ArcExplorer software which can be downloaded from http://www.esri.com/software/arcgis/explorer/download.html.

The first DVD includes a complete index map for the frames as plates 1A and 1B in Adobe PDF format. The base map utilizes U.S. Department of Agriculture 2006 National Agriculture Imagery Program (NAIP) orthophotography (Utah Automated Geographic Reference Center, 2010) for easy reference to current cultural features. Quaternary faults shown on the index maps are based on the U.S. Geological Survey Quaternary Fault and Fold Database of the United States (USGS and others, 2006).

PDF files may be viewed using the free Adobe Reader software. The latest version of the software may be downloaded from http://www.adobe.com/products/acrobat/readstep2.html. For enabling geospatial features, we recommend using Adobe Reader version 9 or later to view the index map.

Once individual frames are identified from the indexes, the corresponding high-resolution TIFF files may be located on the \AutoPlay\Docs\Images folder of each DVD. Due to the number of scanned frames and file size requirements,

Table 1. *Acquisition dates of aerial photograph frames.*

Acquisition Time	Starting Frame[1]	Ending Frame[1]	Acquisition Date
AM (Morning)	1 – 1	8 – 11	10/23/1981
	9 – 1	10 – 22	12/3/1981
	11 – 1	11 – 25	10/31/1981
	12 – 1	15 – 13	10/22/1981
	16 – 1	22 – 15	10/21/1981
	23 – 1	23 – 13	10/31/1981
	24 – 1	25 – 7	10/22/1981
PM (Afternoon)	1 – 1	8 – 11	10/23/1981
	9 – 1	11 – 31	10/25/1981
	12 – 1	15 – 14	10/22/1981
	16 – 1	22 – 14	10/21/1981
	23 – 1	23 – 13	12/23/1981
	24 – 1	25 – 9	10/22/1981

[1] First number is the flight line and the second number is the frame number.

the TIFF files span six DVDs. Small JPEG preview images are also available in the \AutoPlay\Docs\Images\Preview folder of each DVD for rapid viewing. The TIFF and JPEG images may be viewed in standard graphics software, including Adobe Photoshop, Windows Picture and Fax Viewer (part of Microsoft Windows), or a free viewer, such as Google Picasa, available at http://picasa.google.com/intl/en/. Table 2 presents a catalog of acquisition time, and flight line and frame numbers for each DVD. Figure 1 shows the individual graphic file naming convention using acquisition time, flight line number, and frame number designations.

LIMITATIONS

A few of the aerial photograph prints contain various markings from previous use. These markings may include alignment marks and lines, named geographic features, fault traces, and other features. None of these markings has been verified for accuracy in location and/or classification. As a result, these markings should not be relied upon for any purpose.

Since the aerial photograph frame-center points are estimated, some undetermined positional error exists between the frame center points and actual ground locations. Due to the use of low-sun-angle photography, some of the frames contain significant areas of shadowing in mountainous regions.

ACKNOWLEDGMENTS

This work was supported by the U.S. Geological Survey National Geological and Geophysical Data Preservation Pro-

Table 2. *Catalog of aerial photograph frames on compilation DVDs within \AutoPlay\Docs\Images folder. Small JPEG preview images are available in the \AutoPlay\Docs\Images\Preview folder of each DVD. Low-sun-angle aerial photography taken in the morning and afternoon was used to highlight topographic features for mapping purposes.*

DVD Disk Number	Acquisition Time	Flight Line	Frame
1	AM (Morning)	1	1 – 8
		2	1 – 17
		3	1 – 17
		4	1 – 17
		5	1A – 15A
			1B – 10B
		6	1 – 12
		7	1 – 10
		8	1 – 11
		9	1 – 13
2		10	1 – 22
		11	1 – 25
		12	1 – 30
		13	1 – 13
		14	1 – 13
		15	1 – 13
		16	1 – 18
3		17	1 – 21
		18	1 – 20
		19	1 – 17
		20	1 – 14
		21	1 – 16
		22	1 – 15
		23	1 – 13
		24	1 – 10
		25	1 – 7

DVD Disk Number	Acquisition Time	Flight Line	Frame
4	PM (Afternoon)	1	1 – 8
		2	1 – 16
		3	1 – 15
		4	1 – 17
		5A	1 – 14
		5B	1 – 9
		6	1 – 9, 10A, 10B, 11, 12
		7	1 – 10
		8	1 – 11
		9	1 – 14
5		10	1 – 21
		11	1 – 31
		12	1 – 31
		13	1 – 14
		14	1 – 13
		15	1 – 14
		16	1 – 19
6		17	1 – 19
		18	1 – 22
		19	1 – 16
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		23	1 – 13
		24	1 – 9
		25	1 – 9

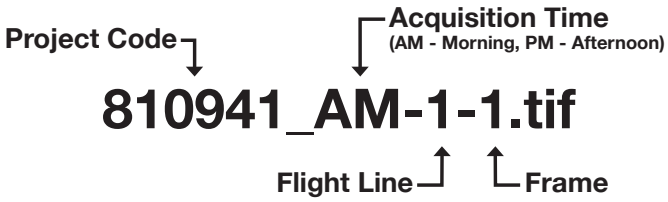

Figure 1. *File naming convention for TIFF and JPEG images in compilation.*

gram (award no. G10AP00102) and by the Utah Geological Survey (UGS). We thank Peter Robinson and the Natural Resources Conservation Service for granting permission to publish the reports and low-sun-angle aerial photography as a digital compilation. William Lund, Tyler Knudsen, and Michael Hylland (UGS) provided helpful review comments.

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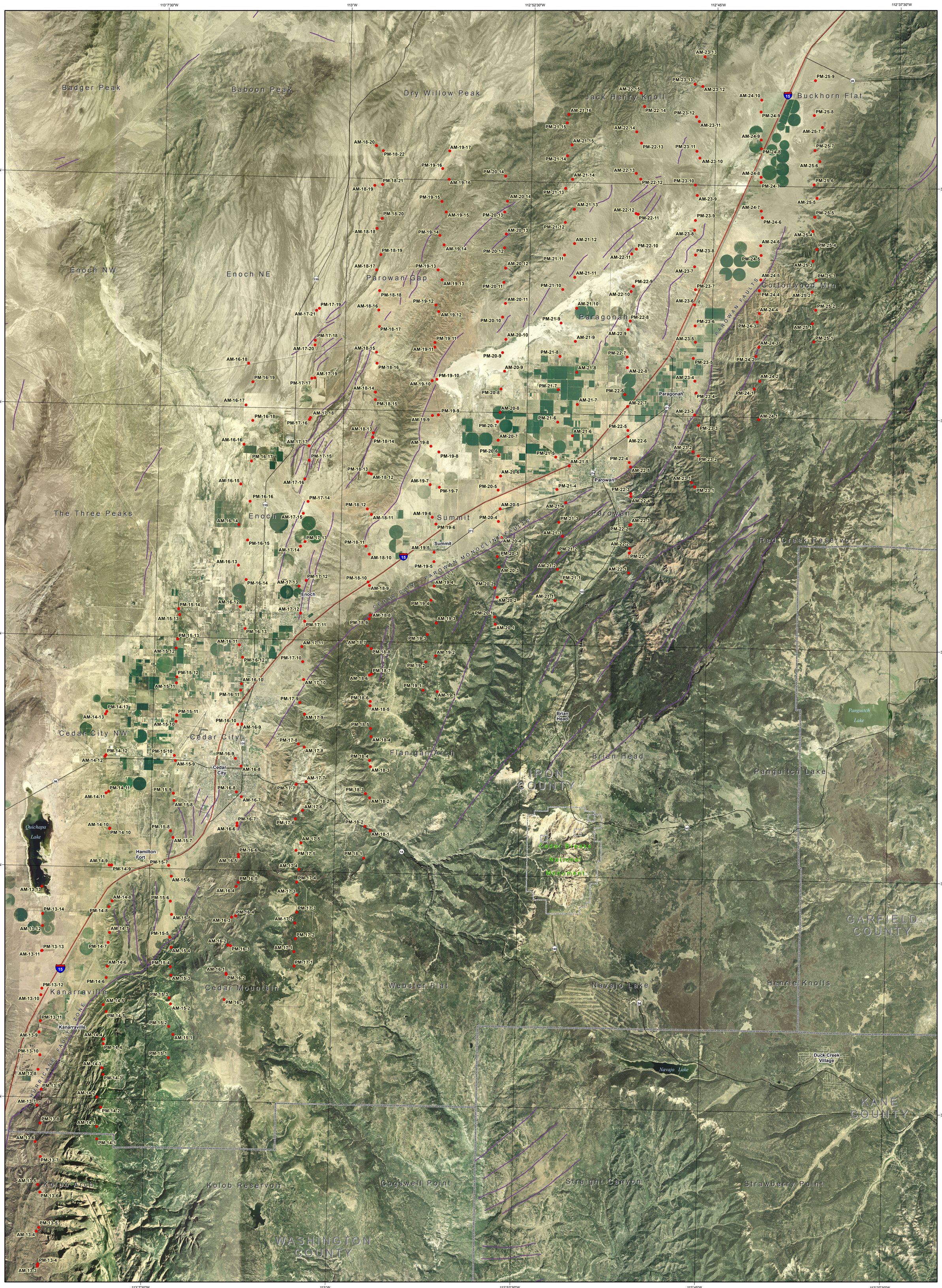
Plate 1A
Utah Geological Survey Open-File Report 583
Index Map of Aerial Photography, Compilation of 1982-83 SCS Seismic Safety Investigation Reports and Low-Sun-Angle Aerial Photography (Sheet 1 of 2)



See Plate 1B for Continuation

Base from 2006 U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) Data.
Quaternary fault traces from 2006 U.S. Geological Survey Fault and Fold Database of the United States.
Photo center points and base map in NAD 1983.

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Utah Geological Survey
1594 West North Temple, Suite 3110
P.O. Box 146100, Salt Lake City, UT 84114-6100
Phone: 801-537-3300 Fax: 801-537-3400
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SCALE 1:100,000

5 2.5 0 5 Kilometers

5 2.5 0 5 Miles

Index Map of Aerial Photography
Compilation of 1982-83 Seismic Safety Investigation Reports of Eight SCS Dams in Southern Utah (Hurricane and Washington Fault Zones) and Low-Sun-Angle Aerial Photography Washington and Iron Counties, Utah, and Mohave County, Arizona

Steve D. Bowman, Brennan W. Young, and Corey D. Unger
2011

Explanation

- Approximate Frame Center Point
- Quaternary Fault
- U.S. Geological Survey 1:24,000 Scale Quadrangle
- County Boundary
- Interstate Highway
- Divided Highway
- State Highway
- Other Road

11°59'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2011

MAP LOCATION

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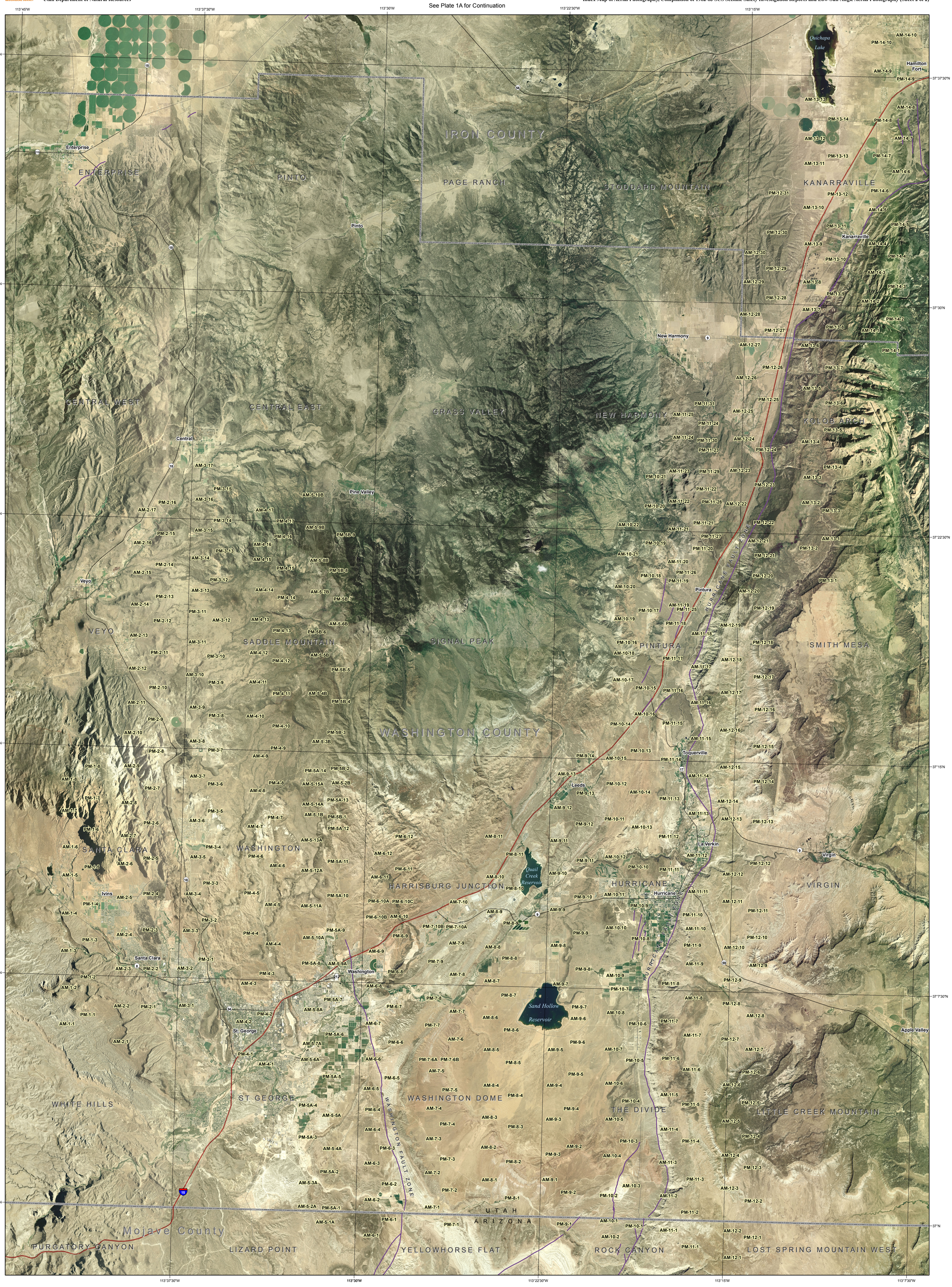
Plate 1B
Utah Geological Survey Open-File Report 583
Index Map of Aerial Photography, Compilation of 1982-83 SCS Seismic Safety Investigation Reports and Low-Sun-Angle Aerial Photography (Sheet 2 of 2)

See Plate 1A for Continuation



Base from 2006 U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) Data.
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1594 West North Temple, Suite 3110
P.O. Box 146100, Salt Lake City, UT 84114-6100
Phone: 801-537-3300 Fax: 801-537-3400
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SCALE 1:100,000

5 2.5 0 5 Kilometers

5 2.5 0 5 Miles

Index Map of Aerial Photography
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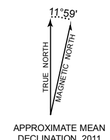
Steve D. Bowman, Brennan W. Young, and Corey D. Unger

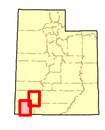
2011

Explanation

- Approximate Frame Center Point
- Quaternary Fault
- U.S. Geological Survey 1:24,000 Scale Quadrangle
- County Boundary
- State Boundary
- Interstate Highway
- Divided Highway
- State Highway
- Other Road



APPROXIMATE MEAN DECLINATION, 2011



MAP LOCATION