Location Restriction Criteria - Certification Report

Public Service Company of Colorado – Comanche Station

CCR Impoundment Pueblo, Colorado

October 2018

Prepared For:
Public Service Company of Colorado

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303.764.8800

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Contents

List of Figures

List of Attachments

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF Ash Disposal Facility
AMSL Above Mean Sea Level
CCR Coal Combustion Residuals
CDPHE Colorado Department of Public Health and Environment
CFR Code of Federal Regulations
CGS Colorado Geological Survey
EPA U.S. Environmental Protection Agency
NEHRP National Earthquake Hazards Reduction Program
PGA Peak Ground Acceleration
PSCo Public Service Company of Colorado
RCRA Resource Conservation and Recovery Act
USGS United States Geological Survey

Qualified Professional Engineer Certification

I hereby certify, as a Professional Engineer in the State of Colorado, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse by PSCo or others without specific verification or adaptation by the Engineer.

I hereby certify, as a Professional Engineer in the State of Colorado, that the information contained in this report has been prepared in accordance with the requirements of 40 CFR §257. I further certify that a satisfactory demonstration of the requirements of 40 CFR Sections §257.60, §257.61, §257.62, §257.63 and §257.64 have been made.

SIGNATURE:

COLORADO LICENSED PROFESSIONAL ENGINEER
MATTHEW MICHAEL ROHR
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16OCT2018

Matthew M Rohr, PE
Colorado Licensed Professional Engineer No. 0053467
My license renewal date is October 31, 2019

1 Introduction

This Location Restriction Certification report has been prepared for the existing CCR impoundment (Bottom Ash Pond) located at the Public Service Company of Colorado (PSCo) - Comanche Station (the Site). This report conforms to 40 (CFR) Part 257. This report was prepared to address the federal CCR regulations for disposal of ash under subtitle D of the Resource Conservation and Recovery Act (RCRA). The final rule was published in the Federal Register, Volume 80 Number 74 on April 17, 2015, and became effective on October 19, 2015.

1.1 General Information

Figure 1, shows the Comanche Station located west of Lime Road approximately three miles south of Colorado Highway 50 in Pueblo County, Colorado. The Station is located in the west half of Section 20, Township 21 South, Range 64 West of the 6th Principal Meridian, Pueblo, Colorado. The facility is located in an area zoned I-3 (Industrial) by the City of Pueblo Zoning Department. The CCR Impoundment is located approximately 1,400 feet southeast of the main power plant building. Figure 2, Comanche Station Layout shows the various facilities and infrastructure located at Comanche Station.

1.2 Type of Facility

The CCR impoundment is located in the southeastern area of the Site (Figure 2). The impoundment was constructed in 1972 and has a surface area of approximately 1.6 acres. Historic documents at the Site indicate that this impoundment was built with a 3-foot thick soil base liner; however, the soil base liner does not meet the requirements of 40 CFR §257.71. The impoundment is approximately 513 feet long by 138 feet wide and 26 feet deep. The primary influent to this impoundment is bottom ash sluiced from Units 1, 2 and 3.

The primary purpose of this impoundment is to settle out bottom ash from the influent water. The dewatered ash is then excavated from this impoundment and transported to an on-Site dry ash disposal facility approximately 1,700 feet west of the impoundment. Additional smaller volume influent sources include the continuous deionization softeners waste, brine and rinse, and activated carbon filter backwash and rinse. Effluent from the CCR impoundment discharges to the immediately adjacent Polishing Pond prior to being discharged to the St. Charles River under the Site's Clean Water Act discharge permit.

2 Location Restrictions

40 CFR §257.60-64 applies to new CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units.

2.1 Placement Above The Uppermost Aquifer 40 CFR §257.60

The 40 CFR §257.60 places restrictions on locating the base of a new CCR landfill or surface impoundment within 5 feet of the uppermost aquifer. It states the following:

"New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be constructed with a base that is located no less than 1.52 meters (5 feet) above the upper limit of the uppermost aquifer, or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations (including the seasonal high water table)."

Comanche Station is underlain by unconsolidated colluvium consisting of stiff clays and silts. Typical colluvium thickness is less than 20 feet but has been found to range between 5 and 75 feet across the site (Woodward-Clyde, 1987; URS, 2005). The colluvium is underlain by the Pierre Shale, the uppermost bedrock at the Comanche Station. A water table does not exist regionally in the Pierre Shale, which has a measured hydraulic conductivity of $3x10^{-10}$ to $3x10^{-7}$ centimeters per second (cm/s) (Tetra Tech, 2013). Underlying the approximate 1,450 feet of shale bedrock deposits is the Dakota Sandstone, the uppermost bedrock aquifer in this region (Tetra Tech, 2012).

The shallow unconsolidated colluvium deposits beneath Comanche Station are predominantly unsaturated, with some isolated areas of perched water (GeoTrans, Inc. 2009). Previous studies have reported that a continuous water table does not appear to exist in the colluvium above the thick Pierre Shale bedrock (Xcel Energy, 2005; Tetra Tech, 2012; GeoTrans, Inc., 2009). The bedrock contact surface does not appear to have a consistent gradient across the site for perched water to flow across site-wide (GeoTrans, 2009). According to GeoTrans (2009), shallow perched water detected in the colluvium deposits beneath the site is not laterally extensive or continuous across the site.

Data collected by HDR during well drilling and water level monitoring for compliance with the CCR Rule indicate that consistent with previous reports by others, a continuous water table does not exist under the regulated CCR units. Therefore, a potentiometric contour map of the water levels cannot be developed and wells cannot be identified as upgradient/downgradient. Each of the wells that were not dry and were able to be sampled appear to be independently recharged by localized infiltration from surface water

The definition of an aquifer from the CCR Rule (40 CFR 257.53), is a geologic formation, group of formations, or portion of a formation capable of transmitting water fast enough to yield usable quantities of groundwater to wells or springs. Usable quantity can be defined as a sufficient amount of water to supply a single family home. Many states would require a well between 0.5 and 5 gallons per minute depending on available storage. A well with yield less than 0.5 gpm is not recommended for use. Woodward Clyde (1987) installed 10 to 30 foot deep test holes at the site for permeability (hydraulic conductivity) testing. These holes were dry and soil samples were sent to a laboratory for geotechnical testing. Laboratory results showed calculated permeability of the colluvium of 10^{-6} to 10^{-7} cm/sec, which is very low permeability. This is consistent with HDR's groundwater sampling experience as only one well was able to be sampled immediately after the well was purged. Most wells purged dry rapidly and would not recharge with sufficient volume for sample collection until the following day. One well would purge dry and take weeks for a couple of liters to accumulate in the well sump for sampling and analysis. During sampling, wells recharged at a rate of approximately 0.007 gpm or less, which further reflects the low permeability. The yield of a well in the colluvium at Comanche would be less than 0.5 gpm and not capable of supplying a single-family home with water and thus the colluvium does not meet the definition of an aquifer.

The CCR Rule requires that the base of the impoundment will be greater than 5 feet above the uppermost aquifer beneath the impoundment. There is no aquifer in the very low permeability Pierre Shale bedrock at the Comanche Station. The uppermost aquifer is the regional Dakota Sandstone underlying the approximate 1,450 feet of shale bedrock deposits (Tetra Tech, 2012). Therefore, **the base of the impoundment is greater than 5 feet above the uppermost aquifer (Dakota Sandstone) beneath the impoundment.**

2.2 Wetlands 40 CFR §257.61

The 40 CFR §257.61 places restrictions on locating new CCR landfills and surface impoundments in areas designated as wetlands. It states the following:

"New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in wetlands, as defined in §232.2 of this chapter, unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that the CCR unit meets the requirements of paragraphs (a)(1) through (5) of this section."

Definition of Wetlands

The CFR Regulations (40 CFR *§232.2*) defines wetlands and other waters of the U.S. as:

- *All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide.*
- *All interstate waters including interstate wetlands.*
- *All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:*
    - *Which are, or could be, used by interstate or foreign travelers for recreational or other purposes; or*
    - *From which fish or shellfish are, or could be, taken and sold in interstate or foreign commerce; or*
    - *Which are used, or could be used, for industrial purposes by industries in interstate commerce.*

- *All impoundments of waters otherwise defined as waters of the U.S. under the definition.*
- *Tributaries of waters of the U.S. identified above.*
- *The territorial seas.*
- *Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in the paragraphs above. The term "adjacent" means bordering, contiguous, or neighboring. Wetlands separated from other waters of the U.S. by human-made dikes or barriers, natural river berms, beach dunes, and the like are "adjacent" wetlands.*

Wetlands can be waters of the U.S. and are defined by 40 CFR *§232.2 (3)(iv)* as areas that are *inundated or saturated by surface or ground water at a frequency and duration sufficient to support—and that under normal circumstances do support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas*.

No wetlands were identified within the project study area. The National Wetlands Inventory incorrectly identified the CCR impoundment as freshwater emergent wetlands. The CCR impoundment is open water with little to no riparian or wetland vegetation. It is isolated from the nearby St. Charles River, and is not considered waters of the United States. Topographic, National Hydrology Dataset, and National Wetlands Inventory maps within and near the project study area are provided in Figure 3.

Based on the site reconnaissance, the CCR impoundment is not located within any known wetlands.

2.3 Fault Areas 40 CFR §257.62

The 40 CFR §257.62 places restrictions on locating new CCR landfills and surface impoundments in close proximity to active fault areas. It states the following:

"New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that an alternative setback distance of less than 60 meters (200 feet) will prevent the damage to the structural integrity of the CCR unit."

The Holocene time period is defined in the CCR Rule (40 CFR § 257.53, 2015) as the most recent epoch of the Quaternary period, extending from the end of the Pleistocene Epoch, at 11,700 years before present, and continues to present.

The proximity of the Comanche Station to faults that have been active in Holocene time was investigated through research conducted for identifying such fault zones. The results of this research document the absence of Holocene time fault zones within 200 feet from the Comanche Station and the CCR impoundment.

This conclusion is supported by a review of project reports and published literature that included:

Regional Topographic and Geologic Maps and Hydrogeologic Study
Topographically, the Comanche Station is located on a gently sloping upland area west of Lime Road approximately 3 miles south of Colorado Highway 50 as shown by the *U.S. Geological Survey*, *2016* map (Figure 4). Elevations vary from a high of approximately 4,830 feet AMSL at the southwest and northwest corners of the Station property to a low of approximately 4,800 feet AMSL at the southeast corner. Geologically, the Station resides in unconsolidated materials consisting of Upper Holocene-age colluvium as shown in the *Scott, 1969* map (Figure 5). The colluvial deposits consist of stiff clays and silts that are intermixed with sand and gravel in some locations. Underlying the colluvium are low-permeability shale deposits. The first consolidated layer beneath the Station property is the Upper Cretaceous-age Pierre Shale bedrock consisting of silty shale containing sandstone and limestone concretions. The Pierre shale is underlain by the chalk and shale deposits of the calcareous Niobrara Formation. The Pierre Shale also crops out along a thin band that extends from the southeastern corner of the site northeastward. Significant geologic activity since before the formation of the Rocky Mountains has not been identified in this formation.

Maps and Reports by the Colorado Geological Survey (CGS), and the United States Geological Survey (USGS) relative to faulting in the area.
Using information from a variety of sources, the Colorado Geological Survey compiled information on nearly 100 potentially hazardous faults in Colorado that ruptured the earth's surface during the past 2 million years (*Widmann et al., 1998*). These faults are shown as wide lines on the map in Figure 6. Faults with evidence of movement during the past 130,000 years are often considered active faults. These faults are shown in red on Figure 6. Similar information, while further dividing the Quaternary faults into late, latest, middle and latest Quaternary, is depicted by the interactive Quaternary Fault and Fold Database released by the *U.S. Geological Survey and Colorado Geological Survey, 2006*. In addition to identifying well-constrained or inferred locations of faults, this interactive database also provides information, such as geologic setting, fault orientation, fault type, sense of movement, slip rate, recurrence interval, and the time of the most recent surface-faulting event, on faults and associated folds that are believed to be sources of earthquakes greater than magnitude 6 (M>6). These faults are shown as color-coded lines on the map in Figure 7, with the latest Quaternary (<15,000 years) being denoted by orange. The closest documented latest Quaternary active fault to the site is the Cheraw Mountains fault, which is located approximately 60 miles to the east. Nevertheless, review of available geologic and fault maps does not indicate the presence of active or potentially active faults in the proximity of the Comanche Station that have been active in Holocene or previous time (epoch).

2.4 Seismic Impact Zones 40 CFR §257.63

The 40 CFR §257.63 places restrictions on locating new CCR landfills and surface impoundments in seismic impacted zones. It states the following:

"New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in seismic impacted zones unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that all structural

components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for site."

The Federal Register Volume 80 No. 74 defines a seismic impact zone as the following:

"A Seismic impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of earth's gravitational pull (g), will exceed 0.10 g in 50 years."

To determine whether the existing CCR impoundment is located in a seismic impact zone, the USGS Earthquake Hazards Program tool was used to determine the earthquake hazard for the Site. The 2009 NEHRP seismic design maps indicated a mapped peak ground acceleration of 0.081 g for the Station area on rock (seismic site classification B). According to the historical May 14, 1979 Stearns-Roger Dwg. No. L-22000, the base of the CCR impoundment was excavated into medium hard to hard claystone, which suggests the entire impoundment is founded on bedrock. Considering the CCR impoundment is founded on bedrock, this corresponds to a seismic site classification C or better. Using the default seismic site classification adjustment factor (1.2) for seismic site classification C, the analysis results in a design peak ground acceleration of 0.097 g (Attachment A). This calculated design peak ground acceleration value is less than 0.10 g in 50 years.

Based on the subsurface information and seismic hazard design response spectrum, the peak ground acceleration at the Site is less than the threshold value of 0.10 g in 50 years indicating the existing impoundment is not located in a seismic impact zone.

2.5 Unstable Areas 40 CFR §257.64

The 40 CFR §257.64 places restrictions on locating CCR landfills and surface impoundments in unstable areas. It states the following:

"An existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit must not be located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted. The owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable (1) on-site or local soil conditions that may result in significant differential settling; (2) On-site or local geological or geomorphologic features; and (3) On-site or local human-made features or events (both surface and subsurface)."

Based on the historical information, subsurface conditions, and considering that the base of the impoundment is founded on bedrock, the existing impoundment is not located in an unstable area.

The ground surface around the CCR impoundment is relatively flat on the north, south, and east sides. The perimeter access road on the west side of the impoundment is on a constructed embankment according to the historical May 14, 1979 Stearns-Roger Dwg. No. L-22000 and visual observations from HDR's September 2018 site visit. The natural land surface in the vicinity of the impoundment is relatively flat, and lacking in characteristics that could result in instability.

Slope stability analysis was performed for the earth embankment on the west side of the impoundment. Analysis was performed using Slope/W 2018 software utilizing Spencer's method which satisfies both force and moment equilibrium to compute the critical factor of safety. Conservative soil parameters were selected for the stability analysis based on experience with similar materials and the results of historical subsurface explorations on-site. Slope stability analysis resulted in factors of safety greater than the required minimum values for long term drained loading conditions in Table 2-4 in Section 2.7.3 of the EPA Technical Manual for Solid Waste Disposal Facility Criteria, 40 CFR Part 258, dated November 1993 (EPA530-R-93-017).

Considering the base of the impoundment is underlain by medium hard to hard claystone and the western perimeter road embankment is constructed with compacted clay and claystone fill, subsurface soils at the base of the impoundment exhibit low compressibility characteristics and high shear strengths. This further confirms that the impoundment is not located in an unstable area.

3 Summary

The Comanche Station CCR impoundment meets and/or exceeds location restriction requirements required for existing impoundments detailed in 40 CFR Part 257. The specific rules evaluated for the aforementioned impoundment from 40 CFR Part 257 are listed below:

40 CFR §257.60 – Upper Most Aquifer

40 CFR §257.61 – Wetlands

40 CFR §257.62 – Fault Areas

40 CFR §257.63 – Seismic Impact Zones

40 CFR §257.64 – Unstable Areas

4 References

1) Comanche Unit 3 Generating Station, Comanche Station, Pueblo, Colorado, URS 2005.
2) Comanche Station Ash Disposal Facility Engineering Design and Operations Plan, Pueblo, Colorado, HDR September 2017, Revised January 2018.
3) Crone, A.J., Machette, M.N., Bradley, L.A., and Mahan, S.A. 1997, Late Quaternary surface faulting on the Cheraw fault, southeastern Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations I-2591,7 p. pamphlet, 1 pl.
4) Feasibility Investigation, Two Ash Disposal Areas for Comanche Station, Pueblo, Colorado, Woodward- Clyde Consultants, 1987.
5) GeoTrans, Inc., 2009. Surface Water Impoundment Infiltration Characterization Analysis, Public Service Company of Colorado, Comanche Station, Pueblo, Colorado. December 1, 2009.
6) Scott, G.R., 1969, Geologic Map of the Southwest and Southeast Pueblo Quadrangles, Colorado: U.S. Geological Survey Geologic Quadrangle Map I-597, scale 1:24,000.
7) Tetra Tech, 2012. Inventory and Preliminary Classification Report, Waste Impoundments, Comanche Station, Pueblo, Colorado. November 1, 2012.
8) Tetra Tech, 2013. Evaluation of Monitoring Well MW-3 and ADF Stormwater Pond Water Quality Chemistry at the Public Service Company of Colorado Comanche Station in Pueblo, Colorado. March 29, 2013.
9) URS, 2005. Geotechnical Investigation, Unit 3, Comanche Generating Station, Pueblo, Colorado. March 2, 2005.
10) U.S. Geological Survey and Colorado Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed September 21, 2018, from USGS web site: http://earthquake.usgs.gov/hazards/qfaults/.
11) U.S. Geological Survey, 2016, Southeast Pueblo Quadrangle, Pueblo County, Colorado - 7.5 Minute Topographic Map Series, 1:24,000.
12) Widmann, B.L., Kirkham, R.M., and Rogers, W.P., 1998, Preliminary Quaternary fault and fold map and database of Colorado: Colorado Geological Survey Open-File Report 98-8, 331 p.
13) Xcel Energy, 2005. Comanche Station Coal Ash Disposal Facility Design and Operations Plan. August 24, 2005.
14) HDR, 2018. CCR Impoundment Slope Stability Analysis. October 16, 2018

Figures

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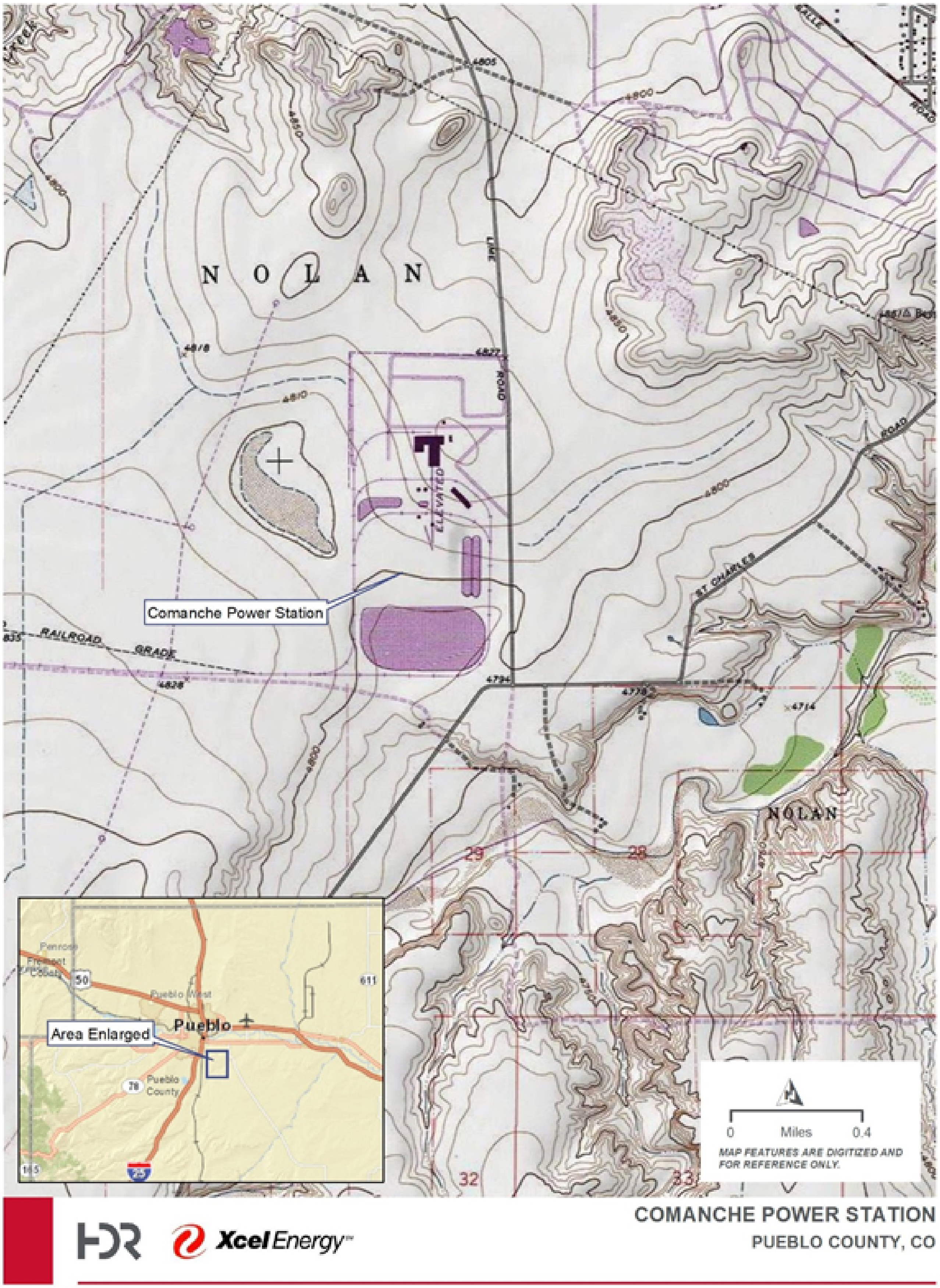
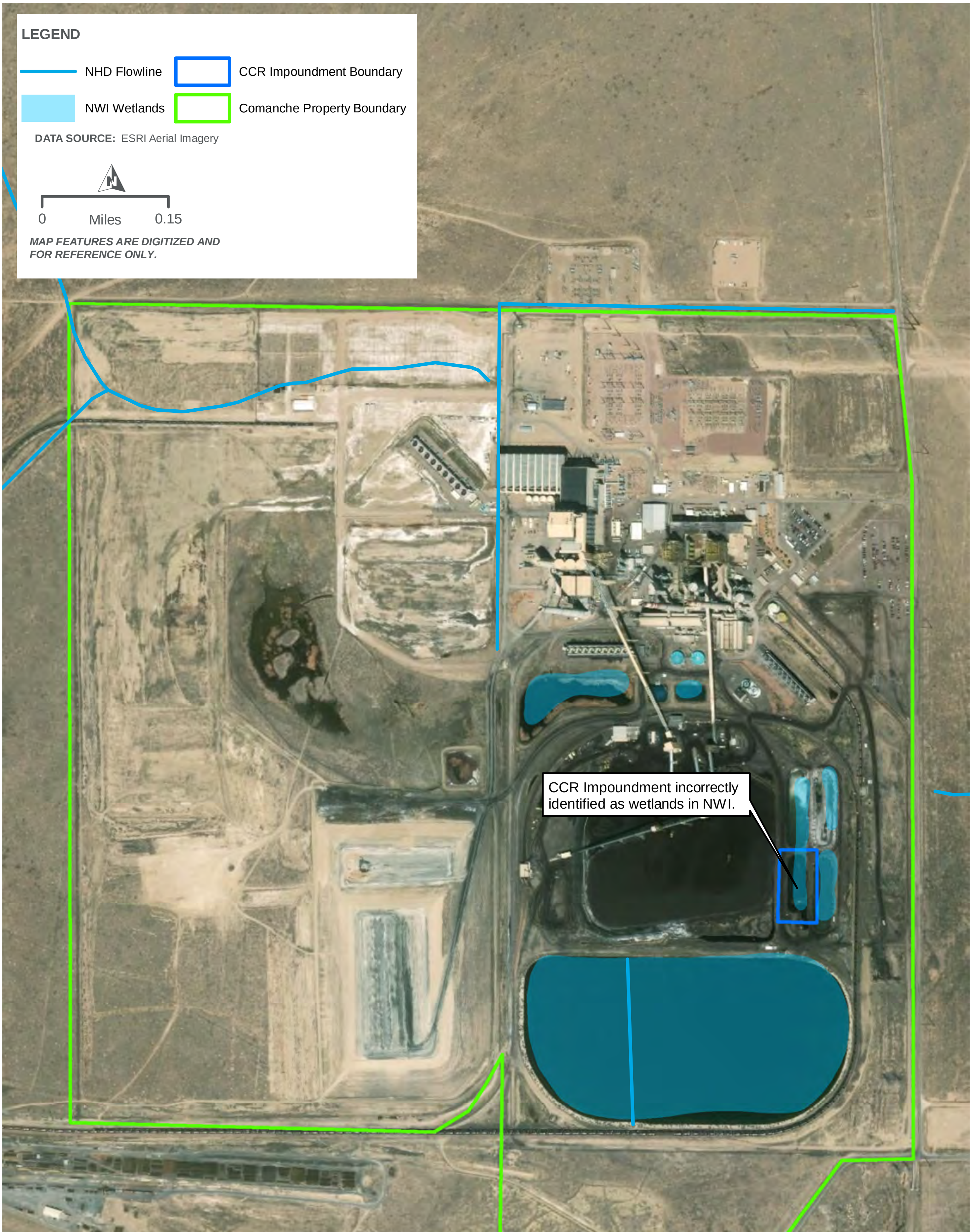


FIGURE 1: COMANCHE STATION LOCATION MAP

FIGURE 2: COMANCHE STATION LAYOUT AND MONITORING WELLS LOCATION MAP



COMANCHE POWER STATION

PUEBLO COUNTY, CO

PATH: J:\2015\15-115_XCEL_CORE_SAMPLING_TESTING_(WALTHER)\MAP_DOCS\DELINATIONREPORT_COMANCHE\COMANCHE_ASHDISPOSALSTUDYAREAWOUSREV.MXD - USER: AKAPLE - DATE: 10/17/2018

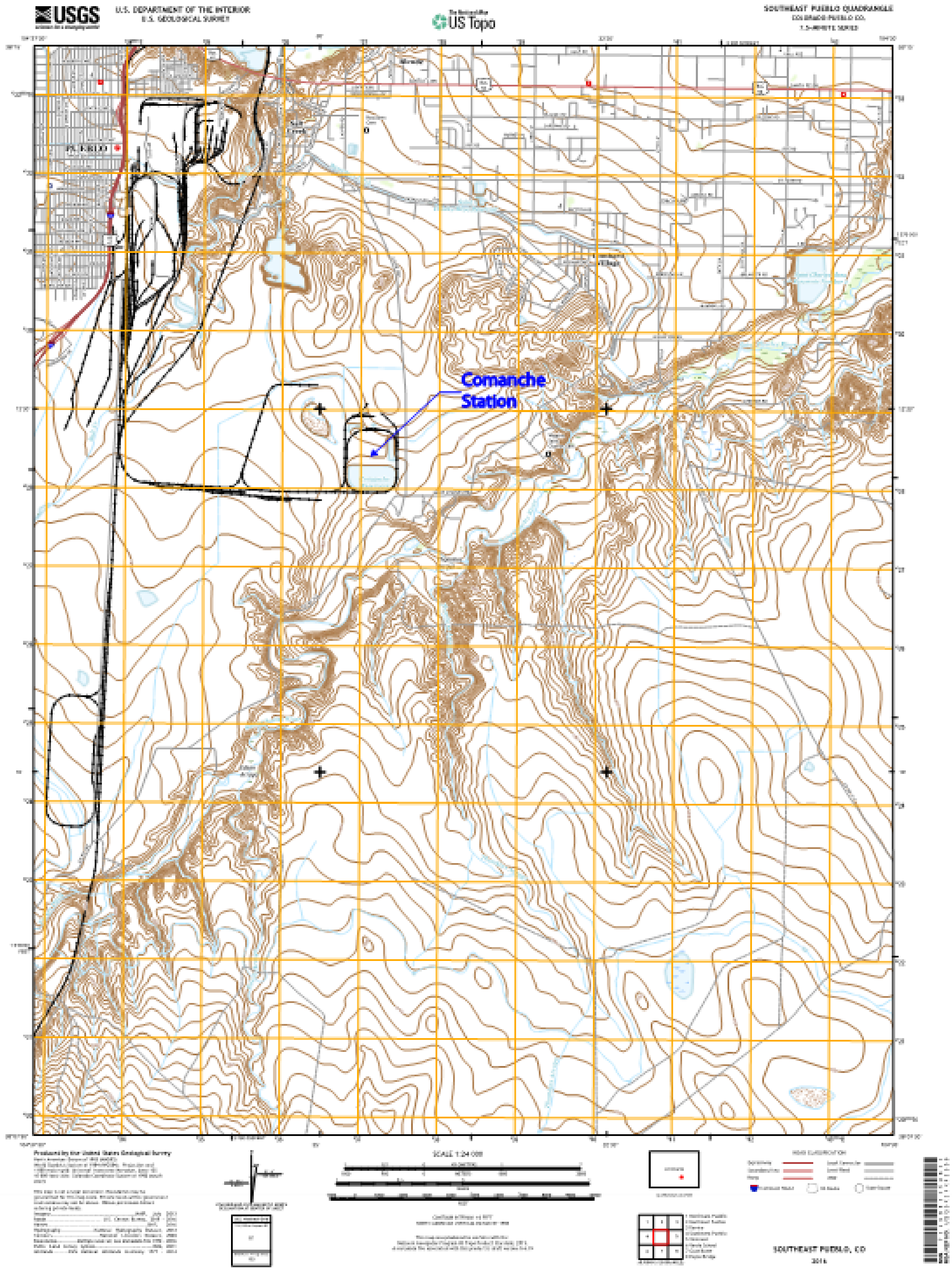
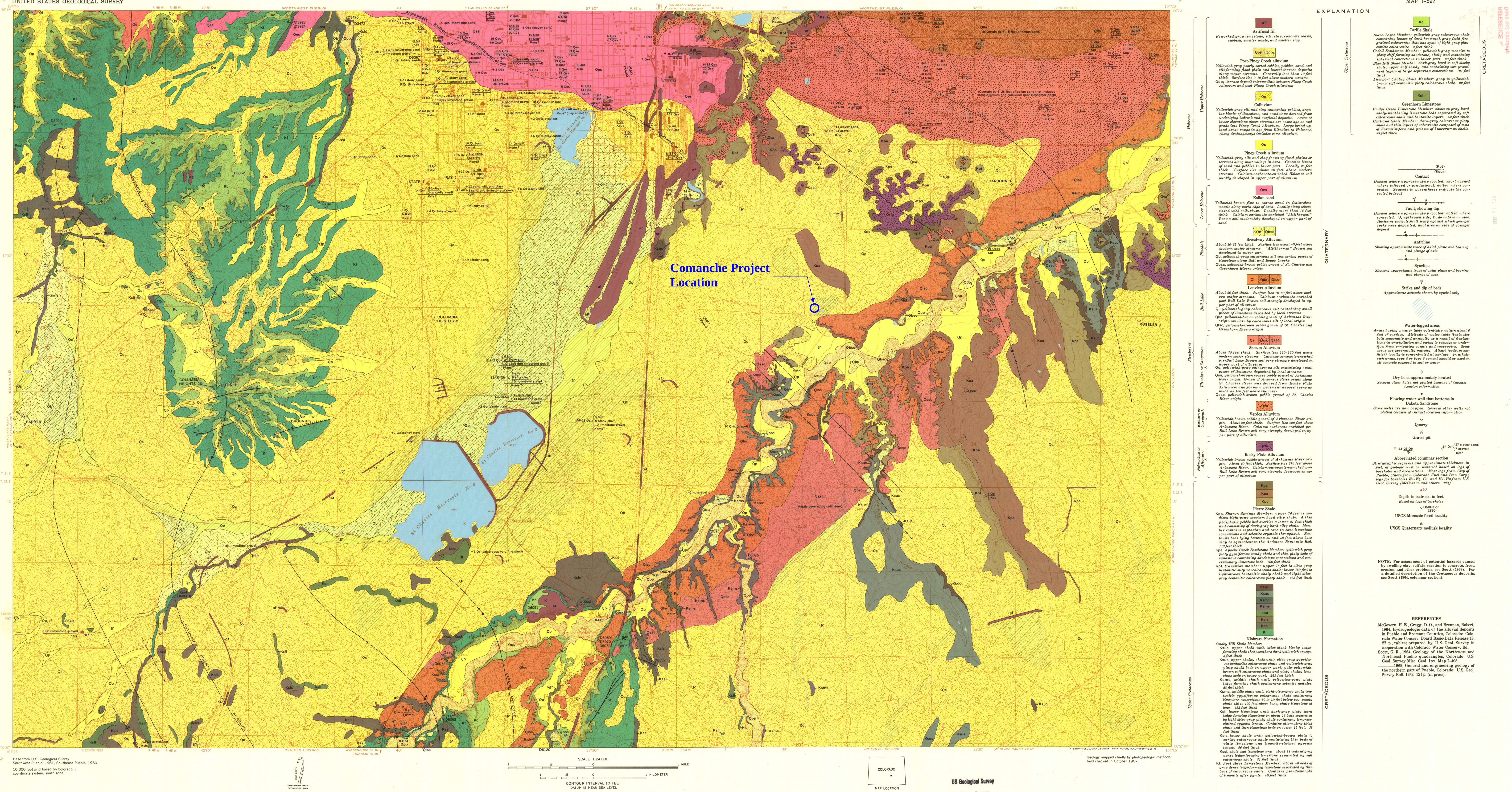


FIGURE 4: TOPOGRAPHIC MAP

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-597



GEOLOGIC MAP OF THE SOUTHWEST AND SOUTHEAST PUEBLO QUADRANGLES, COLORADO

By
Glenn R. Scott
1969

FIGURE 5. GEOLOGY MAP

COLORADO'S EARTHQUAKE and FAULT MAP

Showing Locations of Historical Earthquakes and Known or Suspected Geologically Young Faults

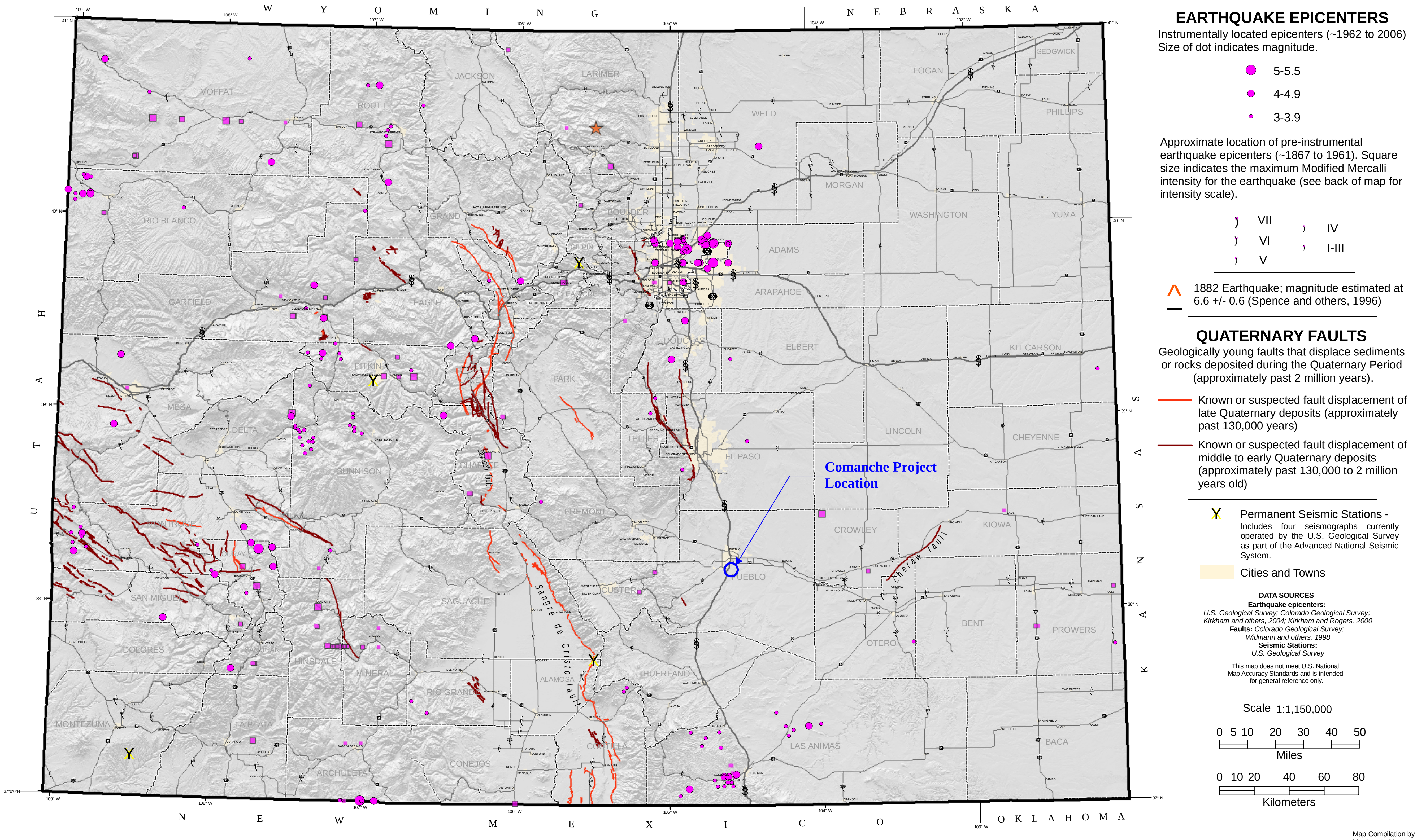
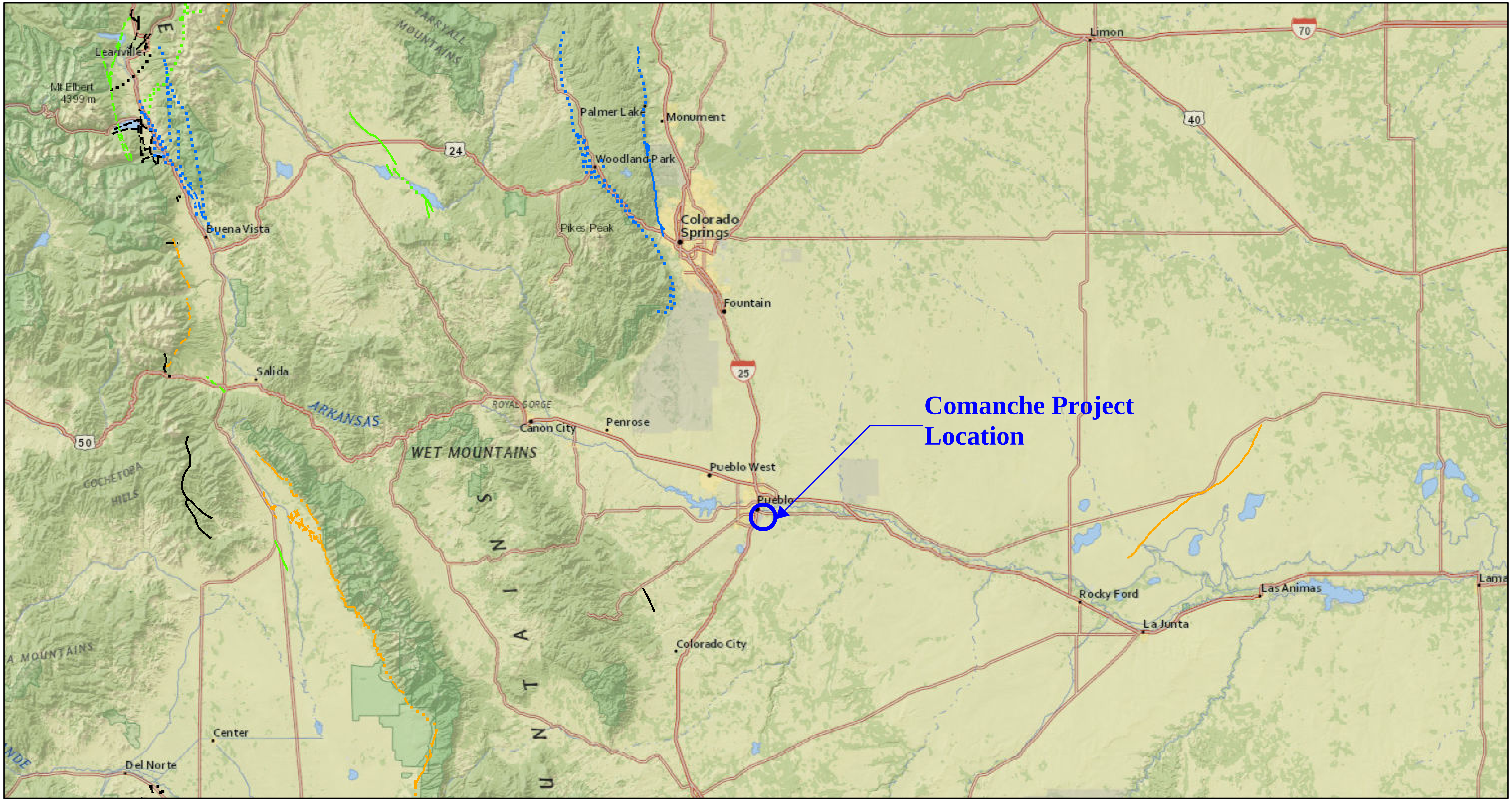


FIGURE 6. EARTHQUAKE AND FAULT MAP

USGS Quaternary Faults and Folds Database



9/21/2018, 4:54:46 PM

1:1,155,581

0 10 20 40 mi

0 15 30 60 km

Quaternary faults

- unspecified age, well constrained location
- unspecified age, moderately constrained location
- unspecified age, inferred location
- undifferentiated Quaternary (< 130,000 years), well constrained location
- undifferentiated Quaternary (< 130,000 years), moderately constrained location
- undifferentiated Quaternary (< 130,000 years), inferred location
- middle and late Quaternary (< 1.6 million years), well constrained location
- middle and late Quaternary (< 1.6 million years), moderately constrained location
- middle and late Quaternary (< 1.6 million years), inferred location
- latest Quaternary (<15,000 years), well constrained location
- latest Quaternary (<15,000 years), moderately constrained location
- latest Quaternary (<15,000 years), inferred location
- late Quaternary (< 130,000 years), well constrained location

Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., USGS

FIGURE 7. USGS QUATERNARY FAULTS MAP

Web AppBuilder for ArcGIS

Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. | USGS |

Attachment A
PGA
Calculation

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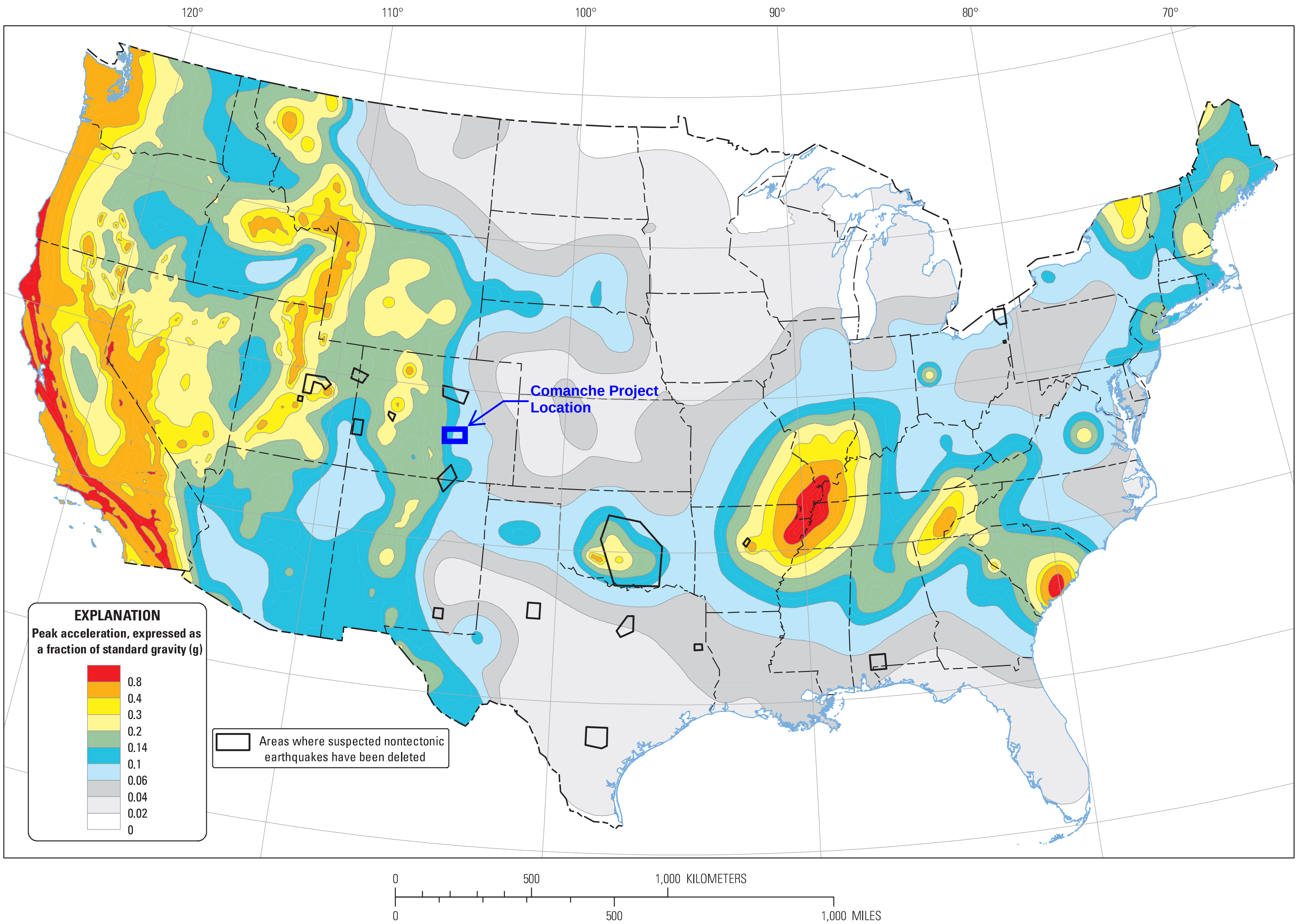
2014 U.S. Geological Survey National Seismic Hazard Map PGA 2% in 50 years

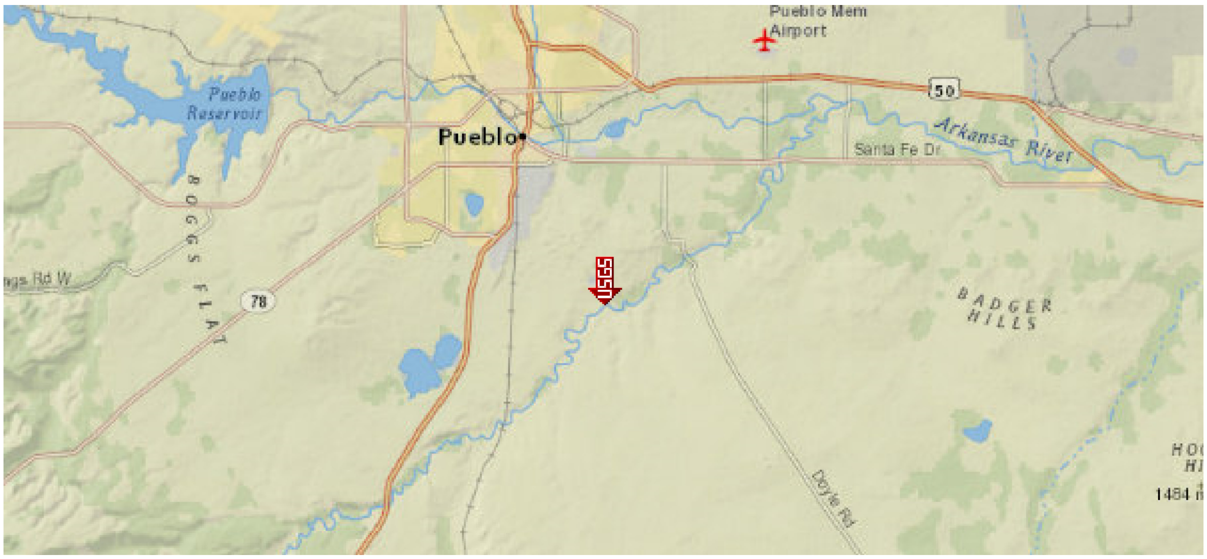


Two-percent probability of exceedance in 50 years map of peak ground acceleration

Design Maps Summary Report

User–Specified Input

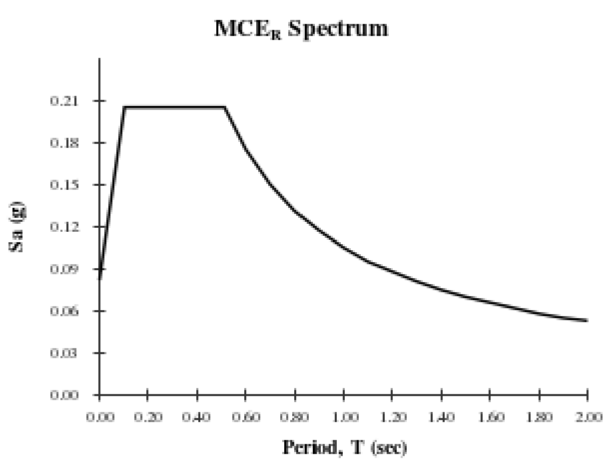
Report Title	2005 Lime Rd, Pueblo, CO 81006 Mon September 24, 2018 21:06:31 UTC
Building Code Reference Document	2009 NEHRP Recommended Seismic Provisions (which utilizes USGS hazard data available in 2008)
Site Coordinates	38.20194°N, 104.57096°W
Site Soil Classification	Site Class C – "Very Dense Soil and Soft Rock"
Risk Category	I/II/III

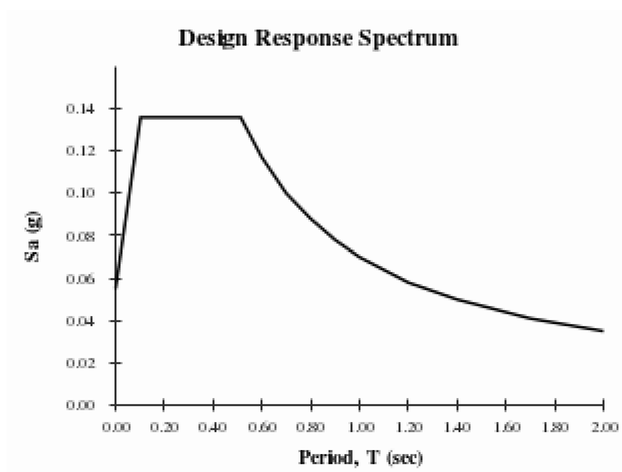


USGS–Provided Output

S_S =	0.170 g	S_{MS} =	0.205 g	S_{DS} =	0.136 g
S_1 =	0.062 g	S_{M1} =	0.105 g	S_{D1} =	0.070 g

For information on how the S_S and S_1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please view the detailed report.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index $PI > 20$, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients, Risk Coefficients, and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Equation (11.4–1): $C_{RS}S_{SUH} = 0.900 \times 0.190 = 0.170$ g

Equation (11.4–2): $S_{SD} = 1.500$ g

$S_S \equiv$ "Lesser of values from Equations (11.4–1) and (11.4–2)" = 0.170 g

Equation (11.4–3): $C_{R1}S_{1UH} = 0.893 \times 0.069 = 0.062$ g

Equation (11.4–4): $S_{1D} = 0.600$ g

$S_1 \equiv$ "Lesser of values from Equations (11.4–3) and (11.4–4)" = 0.062 g

Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	$\boxed{1.2}$	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = C and PGA = 0.081 g, F_{PGA} = 1.200

Mapped PGA	PGA = 0.081 g
Equation (11.8–1):	$\boxed{PGA_M = F_{PGA}PGA = 1.200 \times 0.081 = 0.097\ g}$