# RGDSS Memorandum

**To:** Mike Sullivan, P.E. Colorado Division of Water Resources
Andy Moore, P.E. Colorado Water Conservation Board
**From:** HRS Water Consultants, Inc.
Eric J. Harmon, P.E., G. Eric Saenger, CPG, Steven K. Barrett
**Subject:** Hydrogeologic Review of the Mesita Fault, Costilla County CO
**Date:** July 17, 2012

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## INTRODUCTION

This memorandum summarizes the results of a review of the extent and hydrogeologic characteristics of the Mesita Fault, a north-south structural geologic feature located in the central Costilla Plain region south of the San Luis Hills, Costilla County, Colorado (see Figure 1). This work was done as part of HRS' participation in the peer review process to identify and implement improvements to the RGDSS. The study area for this hydrogeologic review included the Costilla Plain region south and east of the San Luis Hills, north of the CO / NM state line, and west of San Pedro Mesa.

Modeling results as compared to water-level observations in the study area over the past few years has shown significant differences in water table elevation between wells located very close together in the Costilla Plain and the valley of Culebra Creek between San Acacio and the Rio Grande River. Discussions in the RGDSS Peer Review Team led to a hypothesis that the Mesita Fault, or a related feature, may be responsible for the water level differences, which could not be explained adequately by well depth differences or stratigraphic differences in the geologic layers as they were mapped. HRS was asked to review the available hydrogeologic data to determine whether there may be geologic or structural reasons for the observed water level differences.

We have relied on published and unpublished geologic and hydrologic data, including work done during previous phases of RGDSS, on previous project work by HRS personnel, and on our many visits to the region over the past 30+ years.

## APPROACH

This review has been based on review of available publications on the Mesita Fault, including geologic and geophysical maps of the area. Other data reviewed included water levels from the Rio Grande Water Conservation District monitoring wells RG 90, RG 92, RG 96, and monitoring well CB000307435ADA. No aquifer testing or test drilling were done as part of this review. Hydrogeologic studies by HRS personnel in this study area have been done at various times since 1979.

## Mesita Fault: Previous Mapping and Investigations

The Mesita Fault has been documented in published and unpublished maps and studies since at least 1977. The geologic map of the Trinidad Quadrangle[1] (Johnson, 1969) does not show the Mesita Fault. The Geologic Map of Colorado[2] (Tweto, 1979) does show the Mesita Fault, but the fault is shown mapped north of the Mesita Volcano (aka Mesita Hill) only as far north as the topographic escarpment that forms the southern edge of the Culebra Creek flood plain.

The Mesita Fault has been known and mapped since at least 1977[3] (Epis, 1977). Also its general configuration as a normal fault (downthrown on the west side, upthrown on the east side) in the immediate area of Mesita Hill has been known since at least 1977[4] (Epis, 1977). Epis, and H. W. Erker, the principal investigator of a ground water exploration project ("San Marco project") in the Mesita area in the 1970's, the project for which the Epis work was done, both recognized the hydrogeologic character of the Mesita Fault:

> "The Mesita fault not only offsets the prime aquifer (Servilleta), it also strongly affects the elevation and gradient of the static groundwater level probably by acting as a local subsurface barrier or dam to free westward movement of groundwater."[5]

[1] Johnson, R., 1969, Geologic Map of the Trinidad Quadrangle, South-Central Colorado. U.S. Geological Survey Miscellaneous Investigations Map no. I-558.
[2] Tweto, O., 1979, Geologic Map of Colorado. U.S. Geological Survey Special Map.
[3] Epis, R., April 1977, Surface and subsurface geology of the Mesita Volcano area, Costilla County, Colorado. Unpublished consultant's report, 16p along with notes and a map and cross-section.
[4] Ibid.
[5] Ibid., p. 12 and Figure 2.

> "Certain of the faults, and especially those along which there has been a significant amount of movement, appear to be zones of lower permeability than the adjacent fractured and jointed basaltic flow units. This is apparently due to the creation of lower permeability gouge material in the plane of the fault itself by the grinding action of the fault movement."[6]

Geophysical surveys conducted as part of the San Marco study showed that the Mesita Fault extended northward from Mesita Hill, although there is little surface evidence of the faulting. A geologic map of the area, prepared as part of the San Marco study, showed the Mesita Fault extending northward approximately to Culebra Creek.[7] A water-table elevation map of the Servilleta aquifer, also produced as part of the San Marco study, shows significant flexure in the water level contours in the vicinity of the Mesita Fault, although the data at that time apparently was not sufficient to cause the authors of that study to map a discontinuity in the water levels at the mapped location of the fault.

## Recent Geological and Geophysical Mapping

The geologic mapping of the Mesita Hill area by Thompson, et al (2007; see Figure 1)[8] clearly shows the Mesita Fault mapped as continuing to the north across the Culebra Creek floodplain, connecting with a mapped fault in the San Luis Hills.

Recent geophysical survey work by the U.S. Geological Survey shows clear evidence of the continuity of the Mesita Fault in the subsurface both north and south of Mesita Hill. Figure 2 is a composite of aeromagnetic survey shaded-relief images (magnetic intensity, reduced to the pole) from recent U. S. Geological Survey work[9] (V.J.S. Grauch, personal communication, 2011).

[6] Zorich-Erker Engineering, Inc., 1980, Ground water availability, San Marco Property, Mesita, Colorado. Unpublished consultant's report, volume 1 of 3, p. 94.
[7] Ibid., Volume II, Plate 1: Generalized Geologic Map, Mesita Area.
[8] Thompson, R., Machette, M., R. Shroba, C. Ruleman, 2007, Geology of Mesita Volcano, Colorado — Eruptive History and Implications for Basin Sedimentation During the Quaternary. U.S. Geological Survey OF 07-1193, Chapter H.
[9] Bankey, V., V.J.S. Grauch, A. Webbers, and PRJ, Inc., 2011, Digital data and derivative products from a high-resolution aeromagnetic survey of the central San Luis basin, covering parts of Alamosa, Costilla, and Rio Grande Counties, Colorado, and Taos County, New Mexico. U.S. Geological Survey Open File 2005-1200.

Overlaid on the aeromagnetic data are Mesita Volcano (red), Mesita Fault (dark red), the San Acacio Fault (dashed dark red) and other features. As can be seen, the mapped location of the Mesita Fault shows up clearly on the aeromagnetic shaded-relief image as a north-south trending shadow feature. This magnetic anomaly is due to vertical offset in the buried basaltic rocks of the Servilleta Formation due to the Mesita Fault. The recent geologic mapping (Thompson et al) and the geophysics (Bankey et al) are in good agreement as to the location of the Mesita Fault, although the aeromagnetic shaded-relief image does show other anomalies with a dominant north-south trend in the Costilla Plain.

## Water Levels across the Mesita Fault

Available data in the Costilla Plain has shown that in areas close to the Mesita Fault, the saturated thickness of the Alamosa aquifer (unconfined; Layers 1 and 2) rapidly decreases to the west across the fault. This was seen in the RGDSS Piezometer no. 4 aquifer test[10] (See Figure 3) (HRS, 2001) and also in the San Marco Pipeline study, which mapped the Alamosa aquifer declining to near-zero saturated thickness across the fault. Also, water levels were seen in the San Marco study to drop abruptly in the Servilleta Formation (Layer 3) across the Mesita Fault as discussed previously.

The Mesita Fault zone is characterized as having lower hydraulic conductivity than the Alamosa Fm. and the Servilleta Fm. adjacent to, but outside of, the fault zone (RGDSS Piezometer no. 4 study and San Marco Study). The RGDSS Piezometer no. 4 aquifer test, done on Lorenz Well (Permit no. 22152-F) in the Alamosa Fm. (Layer 2) showed a time-drawdown curve characteristic of a low-permeability boundary or an aquifer of abruptly thinning saturation, within the radius of influence of the aquifer test. The San Marco study showed that a production well in the Servilleta Fm drilled directly into the Mesita Fault zone had a significantly lower transmissivity than a production well in the Servilleta Fm. approximately 1,800 feet west of the fault zone.

[10] HRS Water Consultants, Inc., 2001, RGDSS Ground Water, Task 28 – Confined Aquifer Testing Piezometer no. 4, Lorenz well 22152-F.

North of the San Marco / Mesita area and the RGDSS Piezometer no. 4 area, water levels are seen to vary in monitoring wells RG 90, RG 92, RG 96, and monitoring well CB000307435ADA. These monitoring wells are located north of Mesita Hill, near Culebra Creek (see Figure 3). East to west, the water levels vary by several tens of feet between RG 90 and CB000307435ADA (lower to the west) and also between RG 92 and RG 96 (lower to the west). Although the mapped location of the Mesita Fault on Figure 2 appears slightly east of monitoring well RG 96, the magnetic anomaly map shows that the magnetic anomaly signature is somewhat complex: the differences in water levels in the fault zone area indicates that the fault is more likely located between RG 92 and RG 96 at that location. The Mesita Fault is mapped between wells CB000307435ADA and RG 90).

## Conclusions and Recommendations

1. This review has shown that the Mesita Fault extends northward from its original mapped location at Mesita Hill. From the USGS aeromagnetic shaded relief data, the fault is seen to extend northward at least through the Culebra Creek floodplain to the San Luis Hills.
2. Earlier work (the San Marco study, 1980, and the RGDSS P-4 aquifer testing, 2001) have shown that water levels are discontinuous across the Mesita Fault, and the fault appears to act as a lower-permeability boundary. In Layers 1 and 2 (Alamosa Fm), there is saturation east of the fault, and little or no saturation west of the fault. In Layer 3 (Servilleta Formation) the water level is seen to be several tens of feet lower on the west side of the fault as compared to the east side.
3. The available evidence shows that the fault itself tends to be of lower hydraulic conductivity than the adjacent non-faulted areas, probably due to the presence of clay-rich fault gouge material within the fault zone.
4. From this review, we recommend that it is appropriate to revise the RGDSS model as follows:
    a. Extend the Mesita Fault north to the San Luis Hills.
    b. Characterize the Mesita Fault as having a lower hydraulic conductivity than the surrounding aquifer cells, so that the model may better reflect the water level differences across the Mesita Fault.

## Comments and Concerns

None.

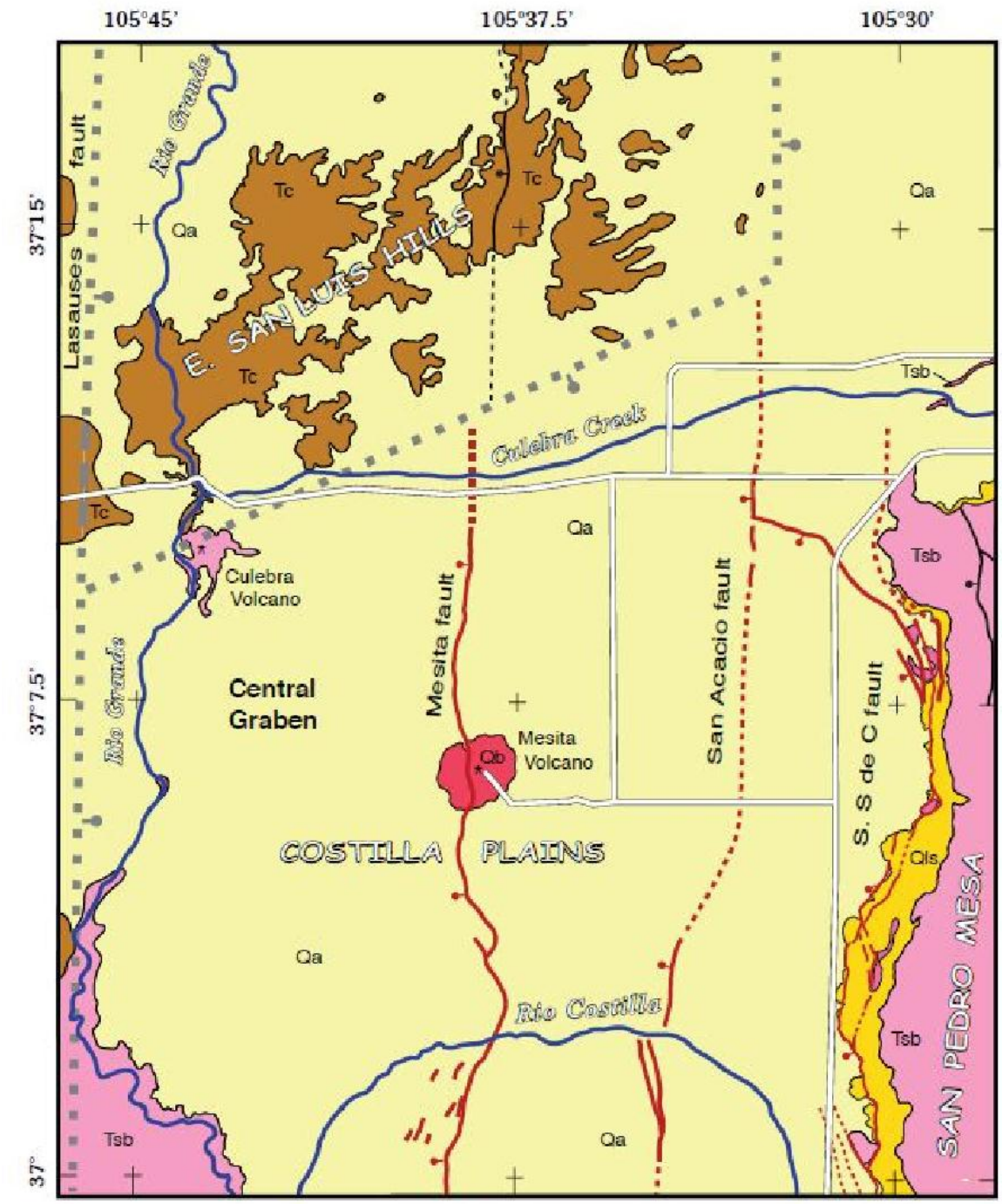


**Figure 1: Mapped Location of the Mesita Fault. This depiction is Figure H-5 from Thompson, R., Machette, M., R. Shroba, C. Ruleman, Geology of Mesita Volcano, Colorado — Eruptive History and Implications for Basin Sedimentation During the Quaternary. U.S. Geological Survey OF 07-1193, Chapter H.**

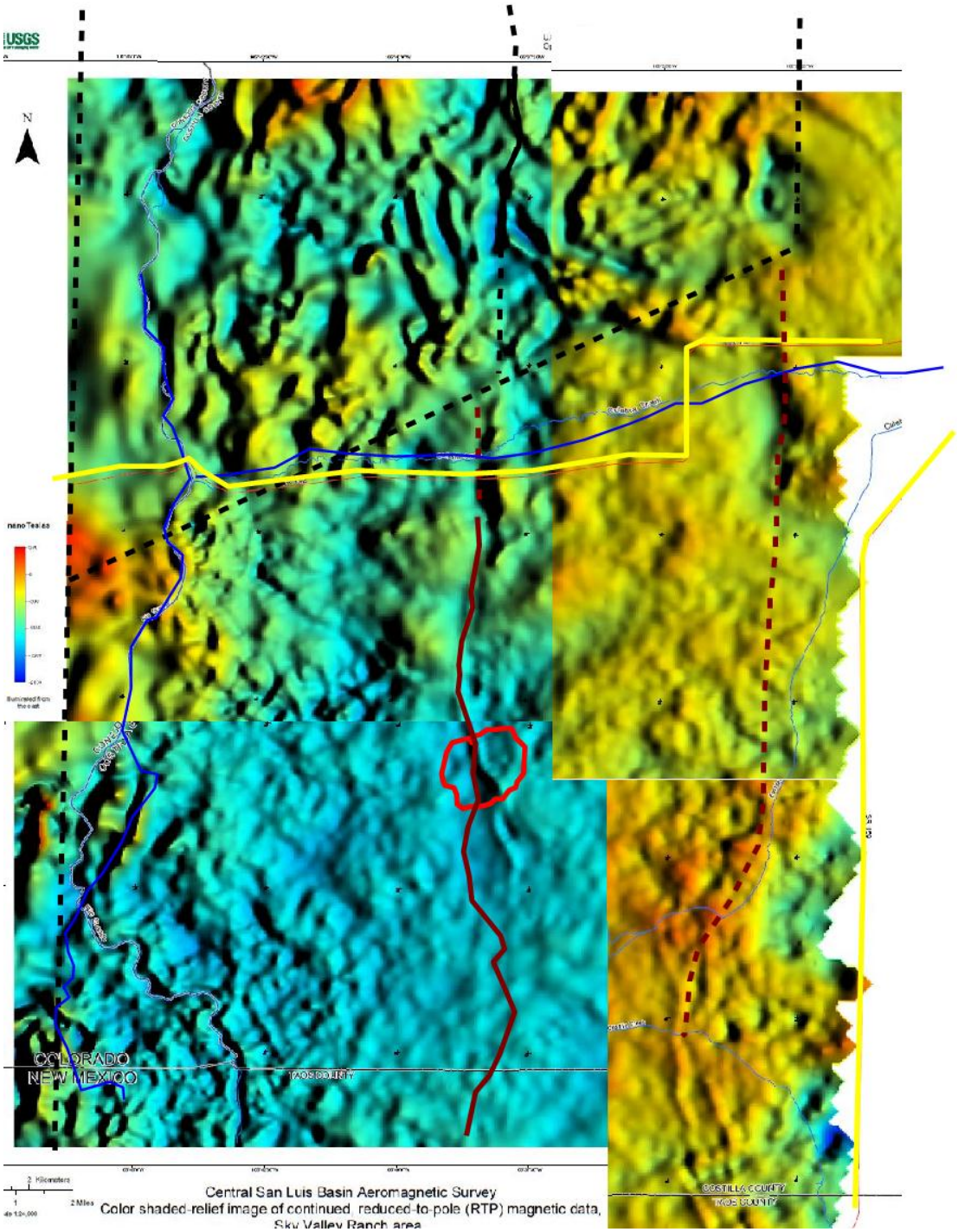


**Figure 2: Composite of aeromagnetic survey shaded-relief image (magnetic intensity, reduced to the pole). Overlaid on the aeromagnetic data are Mesita Volcano (red), Mesita Fault (dark red) the San Acacio Fault (dashed dark red) and bounding faults on the east and south sides of the San Luis Hills. (Thompson et al, U.S. Geological Survey OF 07-1193, Chapter H; see Figure 1 of this report). Magnetic images source: Bankey, V., V.J.S. Grauch, A. Webbers, and PRJ, Inc., 2011, Digital data and derivative products from a high-resolution aeromagnetic survey of the central San Luis basin, covering parts of Alamosa, Costilla, and Rio Grande Counties, Colorado, and Taos County, New Mexico. U.S. Geological Survey Open File 2005-1200.**

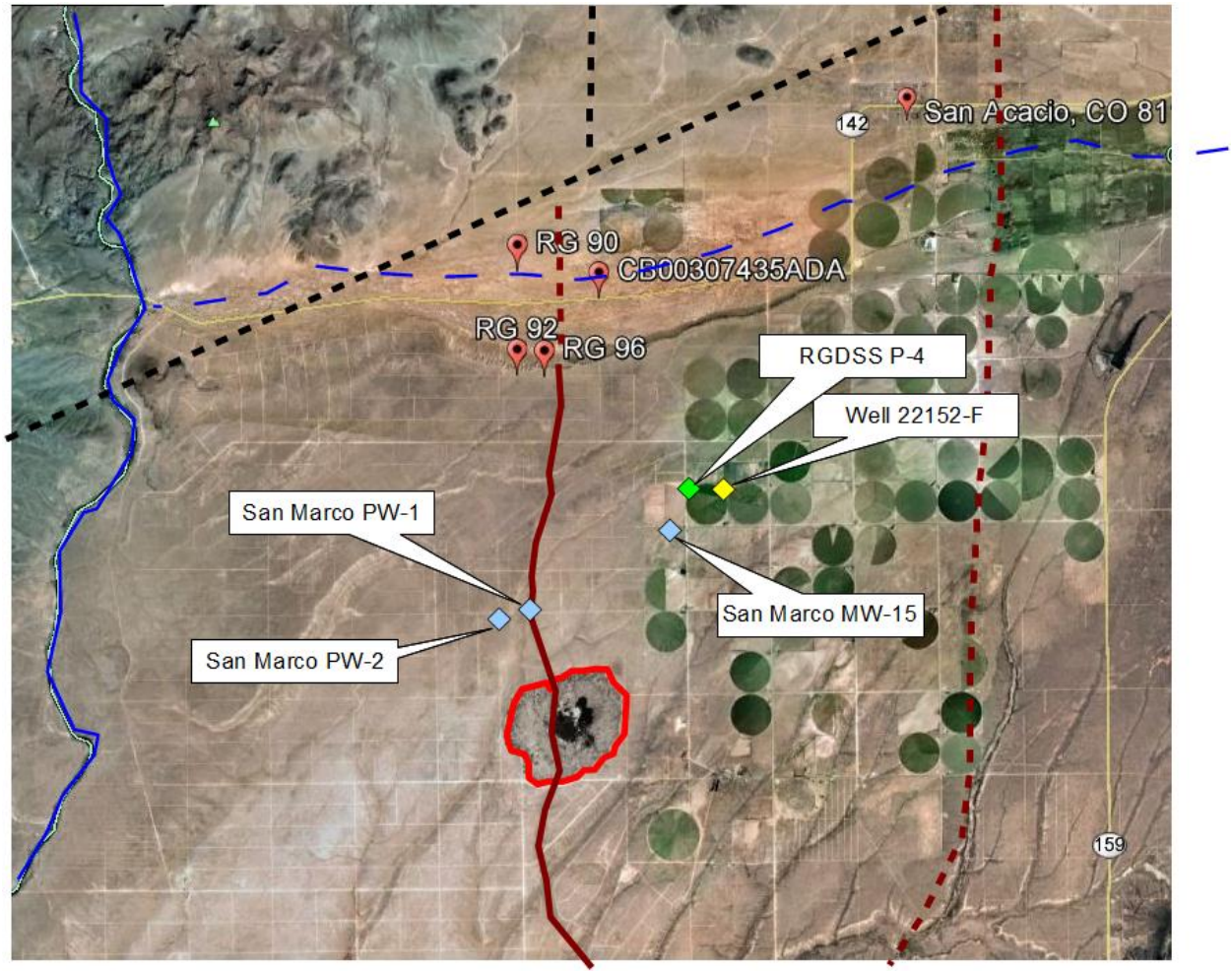


**Figure 3: Locations of monitoring wells and former (San Marco study) test-production wells in the vicinity of the mapped location of the Mesita Fault.**