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ENVIRONMENTAL GEOLOGY OF THE KEERS ENVIRONMENTAL, INC. ASBESTOS DISPOSAL SITE, TORRANCE COUNTY, NEW MEXICO

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Summary

Geologic, hydrologic, and soils conditions at the Keers Environmental, Inc. Asbestos Disposal Site in Torrance County have been reviewed as part of the Environmental Geology programs of the New Mexico Bureau of Mines and Mineral Resources, New Mexico Tech, Socorro.

The sanitary landfill operation for asbestos disposal is located in the north part of Sections 19 and 20, T. 2 N., R. 8 E. in southern Torrance County about 10 miles southeast of Mountainair (Figs. 1-3). The site is on the summit of the "West Mesa" area of northern Chupadera Mesa. This high plateau surface, with rolling to hilly topography and numerous closed depressions, is underlain by a thick (about 1,500 ft) sequence of interbedded sandstone, siltstone, shale, gypsum, and limestone of the Permian, Yeso, Glorieta, and San Andres Formations (Fig. 4). Resistant San Andres limestone, with interbedded gypsum and sandstone, caps the mesa. A north-south-trending zone of structural deformation, faulted or folded down to the east, is located just east of the site (Fig. 5). This feature, here called the Monte Prieto-Liberty Hill structural zone, includes a number of igneous dikes and sills.

The regional water table (top of the zone of ground-water saturation) occurs in the Glorieta Sandstone and the gypsiferous Yeso Formation about 500 feet below the mesa surface at the disposal site. Bodies of "perched" ground water have been reported by local residents above the regional zone of saturation, but these local ground-water occurrences are not documented in literature on the hydrogeology of the area. Cavernous voids and open fractures occur both above and below the water table in the Chupadera Mesa area. Solution-subsidence depressions are very common at the land surface and are present at the disposal site. The site appears to be located just south of the divide that separates regional ground-water flow systems with discharge areas in Estancia Valley (to the north) and Tularosa Basin (to the south). Surface-water discharge at the site is into several local closed depressions on the summit of West Mesa (including Brown Lake). Additional work is needed to better document ground-water and surface-water conditions in the disposal site area, particularly along the Monte Prieto-Liberty Hill structural trend.

Soils at the site are developed in a thin layer of unconsolidated geologic materials (mostly mixtures of fine sand, silt, and clay) that cover bedrock of San Andres Formation. Surficial deposits are probably no more than 10 to 15 ft thick. Pedogenic soil profiles developed in the upper 5 to 6 feet of these deposits are characterized by well-developed horizons of clay and carbonate (caliche) accumulation. Surface horizons enriched in organic matter are locally present. The published U.S. Soil Conservation Service (USDA) Soil Survey on the Torrance County Area clearly documents the fact that soils at the Asbestos Disposal Site have major limitations in terms of providing a suitable capping material for waste-disposal trenches. The soils are susceptible to wind (and water) erosion and difficult to revegetate. Clay-enriched horizons in most soils of the site also have high shrink-swell (and cracking) potential as soil-moisture contents decrease and increase.

The final section of the report reviews recent research at Los Alamos National Laboratory (LANL) on the design of trench covers for waste repositories in areas with surface conditions (climate, vegetation, and soils) that are very similar to those at the Chupadera (West) Mesa site. Furthermore, LANL research on trench covers shows that they can be quite vulnerable to serious disturbance of burrowing animals and plant roots. It is here suggested that the soil/gravel/cobble (soil/rock) intrusion barrier technology developed at Los Alamos be used in trench covers at the Keers Asbestos Disposal operation. Otherwise, long term burial (more than a few decades) of hazardous material in the landfill cannot be assured.

Environmental Geology of the Keers Environmental, Inc. Asbetos Disposal Site, Torrance County, New Mexico

Introduction

This report summarizes available geologic, hydrologic and soils information on the area of the Keers Environmental, Inc. Asbestos Disposal Site, a sanitary landfill operation located on Chupadera Mesa between Mountainair and Gran Quivira, in southern Torrance County. The report also includes a brief discussion of recent research on the technology of shallow land burial (SLB) with respect to landfill trench-cover design involving biointrusion and capillary barriers. Cited references on general geology, hydrology, soils, and landfill trench-cover technology are listed in the attached bibliography. Figures 1, 2, and 3, are index maps of landforms and surficial geologic features of the landfill site area, and Figure 4 is a generalized geologic cross section extending south to north through the site area from the vicinity of Gran Quivira on Chupadera Mesa to the Estancia Valley near Estancia. Figure 5 is a more detailed hydrogeologic cross section through the disposal site area (Fig. 2).

This study is based on current research in Torrance County (1977-1986) as part of the state environmental geology program of the New Mexico Bureau of Mines and Mineral Resources (Hawley and Love, 1981) and on previous work by the author (1962-1977) when he served as Areal Geologist for the Soil Survey Investigations division of the U. S. Soil Conservation Service and Leader of the Desert Soil-Geomorphology Project at New Mexico State University (Gile et. al. 1981).

Landforms and Topographic Features

The asbestos disposal site is located in the northern half of Section 19 and the northwest quarter of Section 20 Township 2 North, Range 8 East, Mesa Draw Quadrangle (7.5 minute series, topographic, U. S. Geological Survey, 1972). The site is on the rolling to hilly surface of a broad upland plain designated Chupadera Mesa. Several miles north of the disposal site, steep north-facing slopes cut by canyons and draws form the northern escarpment of the mesa and the southern border of the Estancia Valley (Fig. 1). In the immediate vicinity of the disposal site the summit area of Chupadera Mesa is designated West Mesa (Figs. 1 and 2). This upland area is separated from the northeastern prong of Chupadera Mesa (Mesa de los Jumanos) by Liberty Valley and Gooch Flats. The 200 to 250-ft, north-trending escarpment that separates West Mesa and Liberty Valley at Liberty Hill is near the northern end of a major structural (fault or fold) zone that offsets the surface of Chupadera Mesa and underlying rock units down to the east (Figs. 1, 2, and 5; Woodward et al., 1978). This structural feature includes the "Monte Prieto bluff" of Bates and others (1946, p. 10, 44), which extends southward past Gran Quivira into Socorro County. It is here called the Monte Prieto-Liberty Hill structural zone.

The summit area of West Mesa is characterized by numerous closed depressions underlain by deep loamy soils (discussed below) and low hills and ridges capped with limestone, gypsite, and sandstone bedrock (Figs. 2-5). Solution subsidence features associated with subsurface dissolution of gypsiferous and carbonate bedrock units are the dominant landforms of mesa summit area. Active sinkholes associated with cavernous voids are present within one mile of the disposal site. Elevations range from 6,625-6,630 feet in the bottoms of draws and closed depressions to nearly 6,800 feet on the highest ridge crests. A low drainage divide at about 6,655-6,660 feet elevation (estimated from topographic maps, Fig. 3) separates the closed basin area at the disposal site from the Chavez Draw system that drains north into Estancia Valley. Local residents report that runoff from very large rainstorms at the site flows into Brown Lake basin, which is located to the southwest across Highway 14.

Bedrock Geology and Hydrogeology

The summit of Chupadera Mesa (Figs. 4 and 5) is capped with the lower (limestone) member of the San Andres Formation (Bates et al., 1947; Wilpolt et al., 1946; Smith, 1957). This rock unit is as much as 250 ft thick and consists of finely crystalline limestone, massive white gypsum, and white to yellow sandstone. Much of the local relief on the summit of West Mesa is produced by dissolution of gypsum beds in the San Andres and underlying Yeso Formations.

The Glorieta Sandstone (basal sandstone member of the San Andres Formation on older maps) is a white to yellow sandstone, from 150 to 280 ft thick, that is usually well cemented. It may be highly fractured or jointed in the vicinity of fault zones, igneous intrusive bodies, or areas of solution subsidence in the underlying Yeso Formation. The Glorieta Sandstone crops out along the northern escarpment of Chupadera Mesa south of Willard and Mountainair, and it underlies Chupadera Mesa (Figs. 4 and 5). The regional water table (top of zone of ground-water saturation) occurs near the base of the Glorieta in the site area and about 500 feet below the West Mesa surface; however, local perched zones of saturation probably occur in overlying rocks, particularly in areas of ground-water recharge beneath draws and closed depressions that collect surface runoff.

The next lower rock unit in the stratigraphic succession (Figs. 4 and 5), and the main aquifer in the asbestos disposal site area, is the Yeso Formation. The Yeso Formation ranges (Bates et al., 1947; Hunter and Ingersoll, 1981) from 600 to 1,000 feet in thickness and includes beds of orange-red, buff and yellow sandstone, white to gray gypsum, pink and gray siltstone, and gray limestone. The upper 100 to 200 feet of the formation comprises (1) a siltstone and sandstone unit, the Joyita Member, which is transitional with the overlying Glorieta Sandstone, and (2) a thick basal gypsum layer, the Canas Gypsum Member, with thin beds of siltstone, sandstone, and limestone. Much of this member may be locally missing due to dissolution of gypsum.

The main body of the Yeso Formation, the Torres Member is an interbedded sequence of sandstone, siltstone, limestone, and gypsum 350 to 600 feet thick. This member is underlain by about 100 to 200 feet of sandstone and minor shale, the Meseta Blanca Sandstone Member, which rests conformably on dark-red shale and sandstone of Abo Foramtion.

The Yeso Formation is the oldest part of the sequence of Permian rocks that is exposed in the north escarpment of Chupadera Mesa (Fig. 4). To the north (Willard-Estancia area), the formation extends under the alluvial, lake, and windblown (eolian) deposits that cover the floor of Estancia Valley (Smith, 1957; Titus, 1973). Underlying formations, not discussed in this report, but illustrated in Figures 4 and 5, include the (1) Abo and Bursum Formations (mostly red shales and sandstones) of early Permian age, (2) limestone, shales, and sandstones of Pennsylvanian age (Madera Group and Sandia Formation), and (3) crystalline metamorphic rocks of Precambrian age (Foster and Stipp, 1961). These rocks have not been penetrated by water wells on Chupadera Mesa, but they have been explored by a few oil test holes. Recent oil tests indicate that the Paleozoic (San Andres to Sandia) formations above the Precambrian rocks are more than 4,000 ft thick (Figs. 4 and 5). Limestones of the Madera Group form the major aquifer on the west slope of Estancia Valley (east slope of the Manzano and Sandia Mountains) north of Estancia (Jenkins, 1982; Titus, 1980); however, these rocks probably contain ground-water of very poor quality in the Chupadera Mesa area.

A north-south structural trend, here called the Monte Prieto-Liberty Hill structural zone, is located about one mile east of the disposal site (Figs. 1, 2, and 5). The San Andres Foramtion is tilted to the east along this zone, and intrusive igneous rocks (dikes and sills) of middle Tertiary age are present along the escarpment between Liberty Hill and Monte Prieto (Bates, et al., 1947; Wilpolt, et al., 1946). These igneous bodies have been injected along deep-seated facture systems into the San Andres and underlying formations. Woodward and others (1978) map the Monte Prieto-Liberty Hill structural zone as the surface expression of a major down-to-the-east fault zone that offsets Precambrian and Paleozoic rocks across southern and central Chupadera Mesa. Bates and others (1947, p. 44) infer that this structural trend may extend into the southeastern Estancia Valley across an area of folded rocks at the north edge of Chupadera Mesa.

Hydrology

The asbestos disposal site is located near the surface-water divide on West Mesa and is probably just south of a subsurface divide in the regional ground-water flow system. Both these divides separate surface and subsurface flows that drain northward into the Estancia Valley and southward to closed basins of the Chupadera Mesa surface and ultimately to the Tularosa Basin ground-water system.

The main reference on ground-water resources of southern Torrance County is the 1957 report by R. E. Smith. Basic data on ground-water flow systems and water quality in the Chupadera Mesa area have been reviewed recently by the U. S. Geological Survey and the NMBM&MR staffs as part of a regional study of potential future sites for radioactive waste disposal (Bedinger et al., 1984; Brady et al., 1984; and Thompson et al., 1984). Water-well data used in the above cited studies were replotted on modern topographic maps for this report (Figs. 2, 3), and tentative corrections of water-table contours have been made for published maps (Smith, 1957; Brady et al., 1984). Ground-water flow in the Glorieta Sandstone and Yeso Formation aquifer below the asbestos disposal site, using the corrected water levels, is southeastward toward Liberty Valley and Gooch Flat and southward into the Gran Quivira-Claunch area of Chupadera Mesa (NE Socorro County). The regional southward flow pattern is similar to the more generalized interpretations of water-level data by Smith (1957) and Brady and others (1984). However, on the basis of water-level corrections made in the present study, a local ground-water trough has been noted in the Liberty Valley-Gran Quivira area (Figs. 1, 2, 5). This trough in the regional water table may reflect higher hydraulic conductivity associated with increased fracturing and dissolution along the north-trending, Monte Prieto-Liberty Hill structural zone. It is possible that some ground-water discharge from Estancia Valley moves along this zone.

Reports by residents of the site area (5/28/86) indicate perched zones of saturation are present above the regional water table and the Glorieta-Yeso Formation aquifer. These reports of perched ground water (probably in the Glorieta Sandstone and basal San Andres Formation) and the ridges or mounds in the regional water table near the site (Fig. 2; Smith, 1957) indicate that the northern end of Chupadera Mesa (West and Jumanos Mesas) includes local areas of ground-water recharge.

No detailed study of water-well or other subsurface records has been made in the area since the early 1950's, so general conclusions on ground-water conditions presented herein still remain to be documented on a site-specific basis. However, geologists and well drillers in the area concur on one significant point with respect to the geologic formations that cap Chupadera Mesa (San Andres-Yeso sequence, Figs. 4 and 5). They agree on the common occurrence of surface and subsurface features (e.g. closed depressions, lack of integrated surface drainage, active sink holes, and caverns or open fractures in subsurface) that are caused by the dissolution of very soluble gypsum and less soluble limestone beds in the San Andres and Yeso Formations, and subsidence of overlying beds into voids created by such dissolution.

Soils

Soils of the disposal site area, and elsewhere in Torrance County, have been mapped and characterized in detail as part of the published Soil Survey of the Torrance area (Bourlier, Neher et al., 1970). The unconsolidated deposits that form the parent materials for the deeper soils on West Mesa, and in most other parts of Chupadera Mesa, are primarily wind-deposited mixtures of fine sands, silts, and clays that have been reworked by running water and mass movement on steeper hill slopes. Thin localized, playa-lake deposits are present on the floors of closed depressions. Gravelly sediments are also locally present near the base of hillslopes or they occur as widely scattered remnants of ancient alluvial deposits (Tertiary age) laid down before formation of the present mesa uplands (Hawley, 1984).

These surficial deposits form a thin, but fairly continuous veneer on bedrock of the San Andres Formation that caps the West Mesa section of Chupadera Mesa (Fig. 3). Limestone and some sandstone beds form the ridges and knobs of the mesa summit, and unconsolidated deposits are very thin or absent in such places. Relatively thick unconsolidated deposits (but rarely exceeding 10 to 15 ft in thickness) occur in valley and basin areas of West Mesa, such as the site being utilized for asbestos disposal.

Local erosion-sedimentation, accumulation of organic matter, and infiltration of water on or through these surficial deposits over long spans of time, and under semiarid climatic conditions, have produced a distinct set of pedogenic horizons in soils of the area. Profiles of well-developed soils on stable surfaces (places little affected by erosion or sedimentation) are characterized by soft upper horizons of organic matter accumulation, underlying horizons of clay enrichment, and basal horizons of secondary carboante accumulation (soft to hard caliche that locally may be irreversably cemented -- indurated). On surfaces subject to wind or water erosion the upper part of the profile is truncated and the carbonate-enriched (caliche) zone may be exposed at the ground surface. Areas of rapid sedimentation on floors of valleys or closed depressions usually contain young deposits ranging in texture from sand and gravel to silt and clay. These deposits do not exhibit much if any soil profile development except for surface horizons of organic matter accumulation.

Sheet 98 (northwest corner) of the Torrance Area Soil Survey (Bourlier, Neher et al., 1970) includes the asbestos disposal site. Soil mapping units at the Site (Fig. 3) include three phases of the Witt Soil Series, which cover most of the area, and one phase of the Penistaja Series. The Witt mapping unit also includes unnamed, fine-grained soils on the floors of several small closed depressions and draws, which are commonly subject to flooding after intense rainfall events or episodes of rapid snow melt.

Relatively uneroded phases of the Witt and Penistaja series (map units Wp-Witt loam and Pg-Penistaja fine sandy loam, both 1-6% slope range) have complete soil profiles with the downward sequence of organic-enriched, clay-enriched, and carbonate-enriched (caliche) horizons. Soils are generally deep (more than 60 inches thick), but the slightly coarser-textured Penistaja soils may overlie limestone or sandstone bedrock at depths of 40 to 60 inches. Eroded phases of the Witt Series (map units Wo-Witt clay loam 0-1% slopes, and Wr-Witt clay loam 1-6% slopes) are the dominant soils at the Disposal Site (Fig. 3). Wind and water erosion (some occurring during and since the dry-farming era) have truncated upper parts of these soils, and the land surface is now at the level of the horizons of clay or carbonate (caliche) accumulation. Slightly undulating topography is produced by wind erosion and local redeposition of wind-eroded material. As noted previously, several large depressions that are subject to flooding by rainstorm or snow-melt runoff are also present, particularly in map unit Wr.

The Torrance Area Soil Survey (Bourlier, Neher et al., 1970) includes much information (in text and tables) on use and management of soils, not only for agricultural, range, and wildlife management, but also for engineering uses. Table 11 (Engineering Interpretations, p. 98, 104) lists major land uses for which soils may be suitable or have serious limitations. The Witt and Penistaja soils of the Asbestos Disposal Site clearly have limitations in terms of being suitable for safe landfill disposal operations. All the mapping units at the site have potential for (and show clear evidence of having been affected by) wind erosion. In addition, the eroded phases of the Witt Series (Wo, Wr-Witt clay loam, 0-6% slopes) contain horizons of clay enrichment that have high shrink-swell potential (indicating presence of expansive clays of the smectite group and tendency for soils to severely crack when dry). Table 11 (p. 104) also indicates that these soils, which cover most of the Disposal Site, are "difficult to vegetate."

Biointrusion and Capillary Barriers in Trench Covers

Research during the past decade at Los Alamos National Laboratory and the Hanford Reservation in central Washington has demonstrated that biological processes (e.g. burrowing animals, plant root activity) can have a significant adverse effect on the integrity of waste-site trench covers in an arid/semiarid environment (Hakonson, 1986; Hakonson et al., 1982, 1983; Nyhan et al., 1986). The research at Los Alamos is particularly pertinent to ongoing asbestos disposal activity on Chupadera Mesa. While underlying bedrock units differ in the respective Pajarito Plateau and West Mesa areas (volcanic versus sedimentary rocks), surficial deposits, soils, grassland-pinon-juniper communities, local climatic conditions, and elevation of both areas are quite similar. Animal burrows (e.g. gophers, prairie dogs, and badgers) are common features in soils of the site area.

The topsoil/gravel/cobble trench caps designed and developed for use at full-scale radioactive waste disposal operations (Hakonson et al., 1986; and Nyhan et al., 1986) are also ideally suited for capping landfills such as the asbestos disposal operation in question. Not only do such trench caps limit biological intrusion into shallowly-buried hazardous material, but research by Nyhan and others (1986) also shows that coarse-grained materials (with no interstitial fines--silt, clay, and fine sand) placed as a cover on or envelope around the upper part of a waste-disposal (SLB) trench can act as a capillary barrier to soil water that might otherwise move into and possibly through the buried wastes.

The recent cited research at Los Alamos and long-term studies by the author (and SCS, USSA associates) on desert soil-geomorphic relationships (Gile et al., 1981) indicate that neither the trench-capping procedures recommended by the State Environmental Improvement Division nor those planned by Keers Environmental, Inc. for the asbestos disposal operation in question will be adequate to prevent exposure of trench contents to the atmosphere. A combination of natural processes, including soil cracking, biological intrusion, and wind and water erosion, can readily expose the hazardous contents of the disposal trenches in short spans of time (one to three decades). Gravel caps using the design technology developed at Los Alamos National Laboratory would provide not only barriers against biological and moisture intrusion, but such coarse-grained caps would be completely resistant to wind erosion and reasonably resistant to water erosion.

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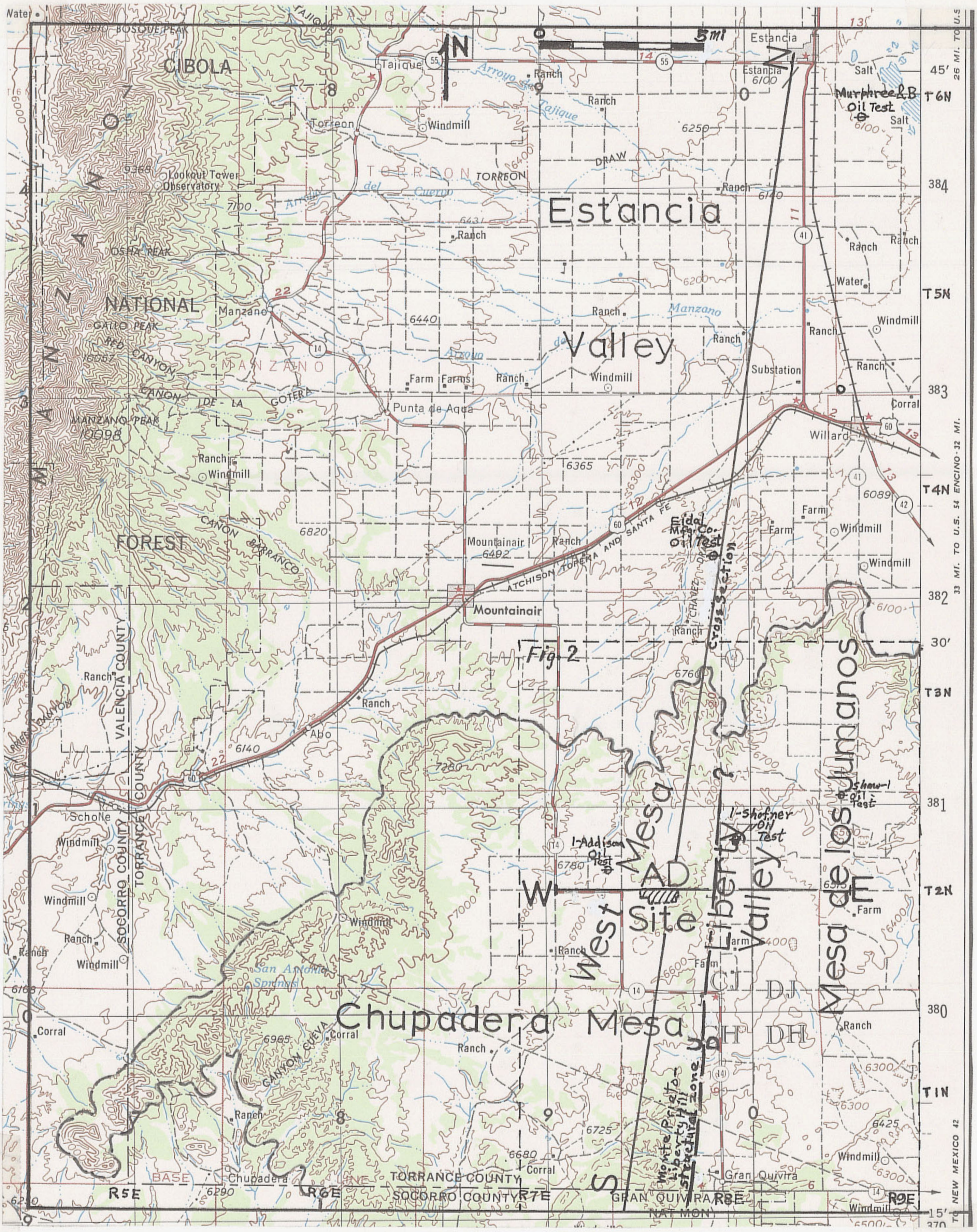

Figure 1. Index map to asbestos disposal site (A D Site) area. DRAFT 7/86
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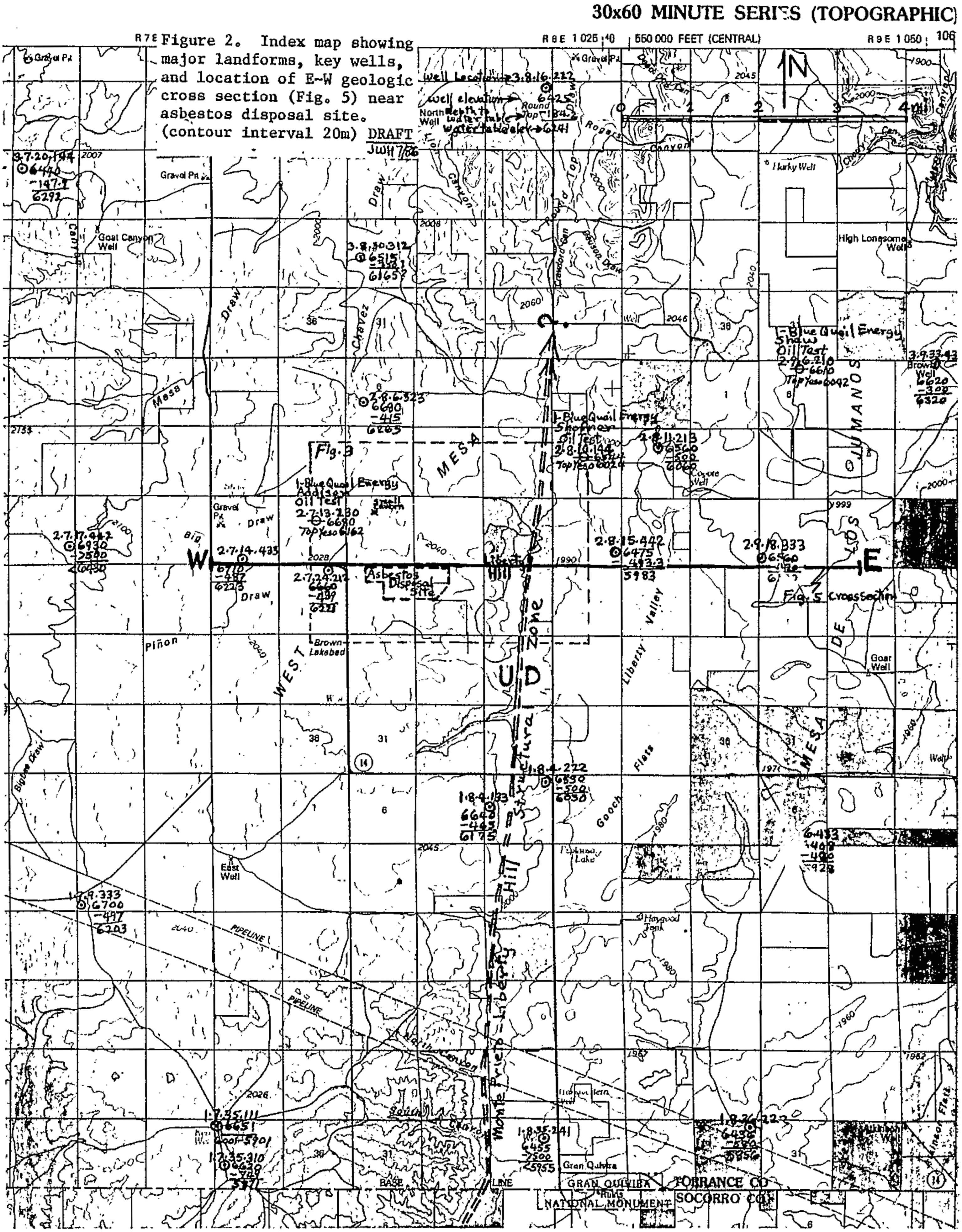

Figure 2. Index map showing major landforms, key wells, and location of E-W geologic cross section (Fig. 5) near asbestos disposal site. (contour interval 20m) DRAFT JWH 1/86

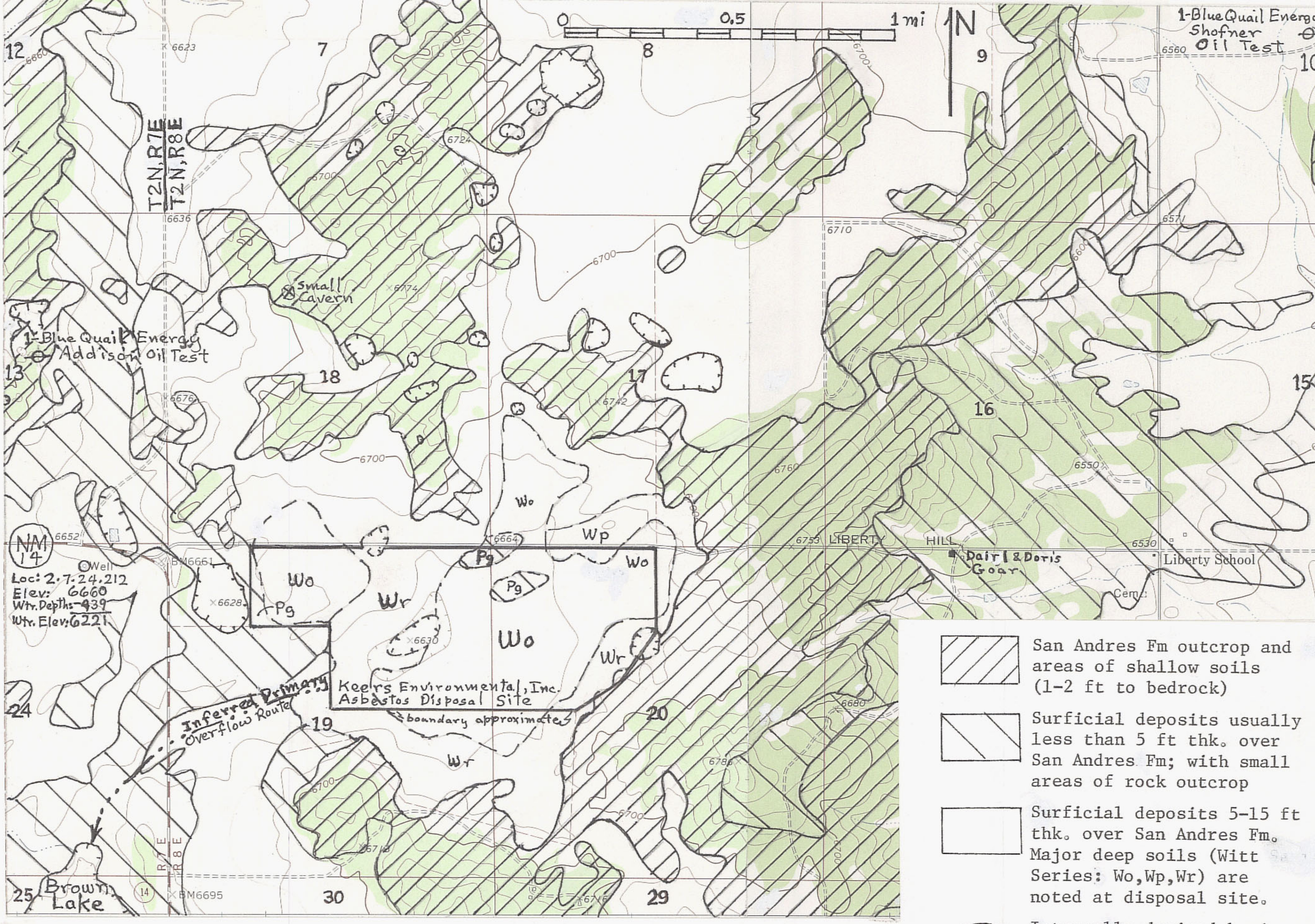

Figure 3. Map showing general distribution pattern of San Andres Fm outcrops, unconsolidated surficial deposits, and soils near asbestos disposal site (information adapted from Bourlier and others, 1970)

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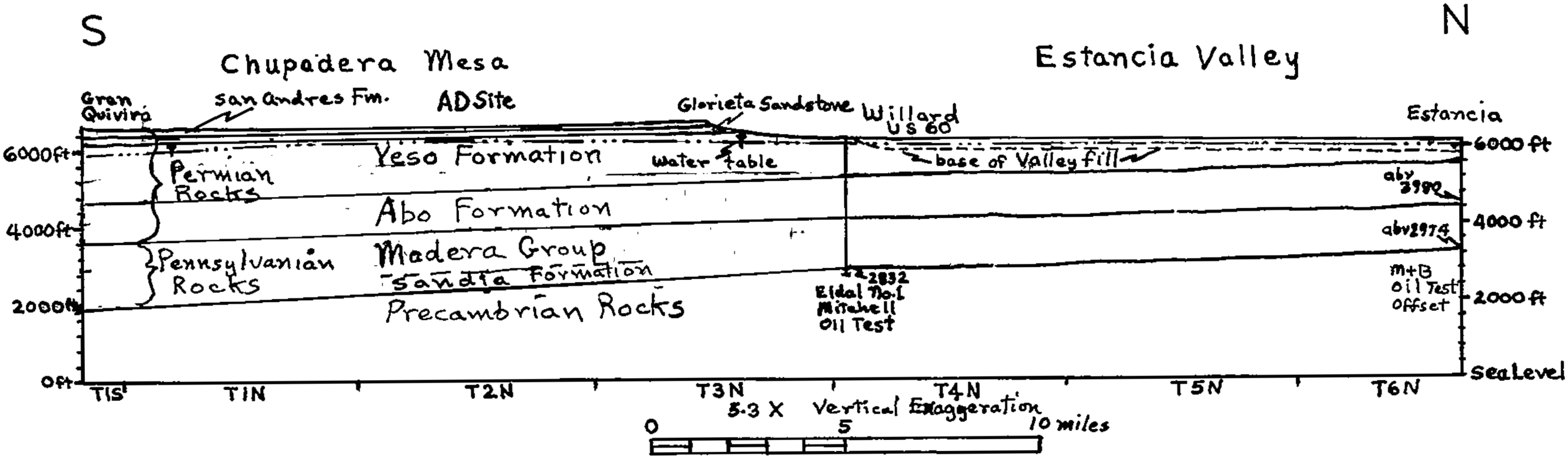

Figure 4. Diagrammatic geologic cross section of asbestos disposal site (AD Site) area from Gran Quivira on Chupadera Mesa to Estancia in Estancia Valley (DRAFT 7/86 JWH)

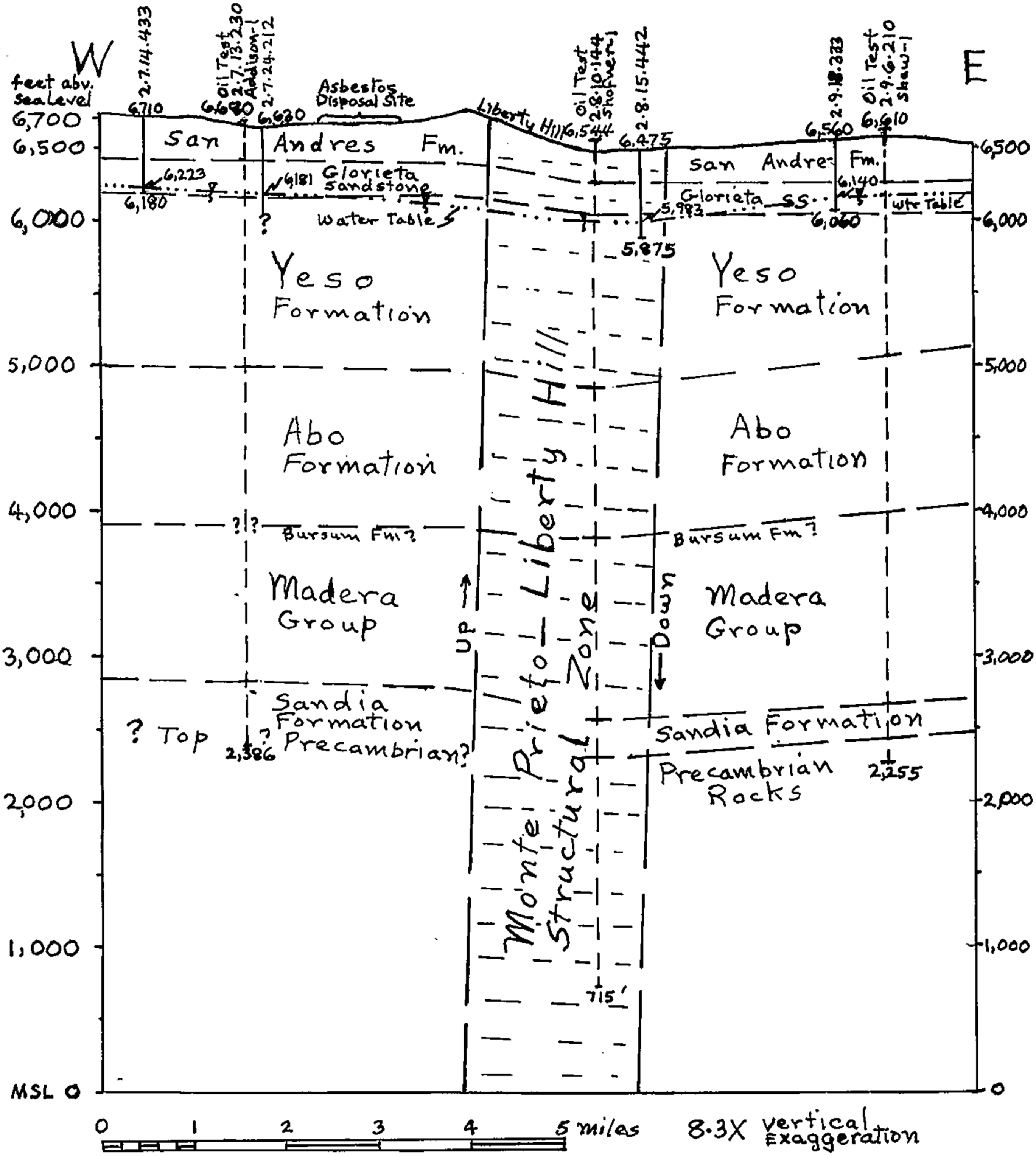

Figure 5. Diagrammatic geologic cross section of asbestos site area from West Mesa to Liberty Valley. Preliminary interpretations oil test holes based only on scout card data. (DRAFT 7/86 JWH)