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# PRELIMINARY
# GEOLOGIC/HYDROGEOLOGIC ASSESSMENT
# PROPOSED CHOLLA SANITARY LANDFILL
# MARICOPA COUNTY, ARIZONA

Prepared for

BROWNING-FERRIS INDUSTRIES OF ARIZONA, INC.

February 1989

By

EMCON Associates
4636 East Elwood, #8
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Project No. 372-15.01

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February 9, 1989
Project No. 372-15.01

Browning-Ferris Industries
of Arizona, Inc.
1580 East Elwood Street
Phoenix, Arizona 21596

Dear Sirs:

EMCON submits the Preliminary Geologic/Hydrogeologic Assessment Report for the Proposed Cholla Sanitary Landfill in Maricopa County, Arizona.

If you have any questions, please feel free to call us at (602) 894-2794.

Very truly yours,

EMCON Associates

Michael H. Green

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Project Manager
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MHG:jh

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# 1.0 INTRODUCTION

Browning-Ferris Industries of Arizona, Inc. (BFI) is currently pursuing development of a solid waste sanitary landfill (to be named the Cholla Sanitary Landfill) located within the limits of the City of El Mirage in the northwestern part of Maricopa County. BFI retained EMCON Associates to conduct site characterization studies, and to provide engineering and waste management services. EMCON conducted a preliminary geologic/hydrogeologic assessment to gather information necessary to satisfy preliminary design and permitting requirements for the proposed landfill site. The first part of this report presents the findings of that assessment.

The site, located in south El Mirage along the Agua Fria River, is currently mined by Union Rock and Materials. Currently, about 3,000 tons of sand and gravel are removed per day from the 320-acre site. The preliminary plan for development of the landfill will result in converting gravel pit excavations on the property to waste cells for solid waste disposal.

The technical investigation included a geologic and hydrogeologic assessment as described in this report with literature review, field reconnaissance, geophysical surveys, drilling and soil sampling, a well survey, and laboratory testing of site soils. The information generated during this investigation will be utilized in the design and construction of the landfill, as well as in the planning of measures to provide protection of the ground water.

The second part of the report addresses plans for further hydrogeologic and geotechnical work necessary for final design of the landfill, and presents a preliminary plan for monitoring ground-water quality at the site.

# 2.0 SITE CHARACTERISTICS

## 2.1 LOCATION

The property (site) to be developed consists of 320-acres located about 15 miles northwest of downtown Phoenix, Arizona (Figure 1), within the corporate limits of the City of El Mirage. The site occupies the west half of Section 36 (Township 3 North, Range 1 West, Gila and Salt River Meridian). The site is bounded on the north by Olive Avenue, on the south by Northern Avenue, and on the west by El Mirage Avenue (Figure 2). The Agua Fria River Channel comprises approximately one quarter of the 320-acre site, trending almost parallel to the east boundary of the site (Figure 3).

## 2.2 TOPOGRAPHIC SETTING

The site lies within the Western Salt River Valley (WSRV), a sub-basin of the greater Salt River Valley Basin (SRV). The WSRV is rimmed by mountain ranges, the closest to the site being the White Tank Mountains, located about 10 miles to the west (Figure 1). The White Tank Mountains attain a maximum elevation of about 4,100 feet above mean sea level (MSL). The floor of the WSRV basin slopes gently eastward from these mountains down to the Agua Fria River. Figure 2 shows the relatively flat local topography in the area of the site. Quarrying activities on the proposed site have disturbed the original topography. Elevations on the site currently range from approximately 1,012 (bottom of gravel pit) to 1,098 feet above mean sea level (MSL).

## 2.3 LAND USE

The site is currently being quarried for sand and gravel on the northern half of the property (Figure 3). Union Rock and Materials acquired the property in 1976. The previous owner farmed as well as extracted gravel on the site. Union Rock currently extracts approximately 3,000 tons of gravel per day, primarily for their asphalt and concrete operations.

With the appropriate regulatory permits for development of a landfill, the sand and gravel mining would be continued. Engineering plans are being developed to enable the conversion of abandoned gravel pits into landfill waste cells. No landfill operations would be conducted in the area of the site covered by the 100-year floodplain of the Agua Fria River.

Adjacent lands have historically been used primarily for agriculture. Farming continues to be the dominant land use in the area between El Mirage/Sun City and the White Tank Mountains but farming acreage will decrease with the increasing urbanization of the WSRV. Luke Air Force Base, located approximately 3 miles west-southwest of the site, is utilized as an advanced training facility for pilots of F-15 and F-16 aircraft.

The property was annexed by the City of El Mirage in 1987 and is zoned as Heavy Industrial Zone (I-3). The project site is principally permitted for asphalt and cement mixing, mining, mineral extraction and sand and gravel operation by the City of El Mirage.

## 2.4 CLIMATOLOGY

The climatological data given in this section were collected in Youngtown which is located approximately 2 miles north of the proposed site. These records indicate that the proposed landfill site is characterized by a desert-type climate.

The average yearly rainfall is 7.65 inches. December and August have the highest average monthly rainfall of 1.03 inches, and 1.05 inches, respectively. August of 1939 had the highest rainfall in one day, 3.00 inches.

Monthly temperatures in the Youngtown area range from an average daily high of 106$^{o}$ in June to an average daily low of 35$^{o}$ in January. The average yearly maximum temperature is 86.3$^{o}$. The average yearly minimum temperature is 52.4$^{o}$.

Pan-A evaporation data, recorded at the Mesa Experiment Farm in Mesa, Arizona between 1916 and 1963, indicate an average evaporation rate of 82.97 inches per year, with the maximum average monthly evaporation rate of 11.5 inches in June. Mesa is approximately 40 to 45 miles southeast of the proposed site. However, evaporation rates are anticipated to be similar to the site area.

The free-water surface evaporation rate for the site area has been estimated to be approximately 50 to 58 inches per year, based on readings from Mesa Experiment Farm. These numbers are determined from lake evaporation studies and are typically 30 to 40 percent smaller than pan evaporation rates.

Table A-1 (Appendix A) is a summary of mean monthly and annual temperatures and precipitation from the Youngtown, Arizona, station.

# 3.0 METHODS OF INVESTIGATION

The geologic and hydrogeologic features of the proposed landfill site were characterized by research of pertinent records and literature and by a field exploration program. The exploration program included drilling, soil sampling, and geophysical survey work. Soil samples collected from site borings were subjected to laboratory testing to evaluate the index properties of subsurface materials.

Ground-water conditions and water well data were obtained by reviewing available Arizona Department of Water Resources (ADWR) and private records.

## 3.1 FIELD EXPLORATORY PROGRAM

### 3.1.1 Geophysical Exploration

A geophysical survey program was undertaken to identify the existence of earth fissures on the site. A known cluster of earth fissures exists in the area between Luke Air Force Base and the project site. No earth fissures were discovered on the site during the geophysical exploration. The subject of earth fissures is discussed in detail later in Section 4.3.2 of this report.

Geophysical work included conventional refraction and reflection surveys. Six seismic lines ("spreads") were "shot," three of which were on the site property (Figure 3). The seismic techniques were tested by shooting the first two spreads over known earth fissures west of the site. Plate 1 in Appendix B shows the locations of each seismic line. The geophysical work was performed by Terrametrics Associates of Tucson, Arizona. A separate report detailing their methods and conclusions is presented in Appendix B.

### 3.1.2 Exploratory Drilling and Soil Sampling

The subsurface conditions at the proposed landfill site were explored by drilling four borings at the locations shown on Figure 3. Borings B-1 through B-4 were drilled to total depths of 121, 61.5, 120, and 119.5 feet, respectively.

The borings were drilled with a reverse circulation, dual-walled, percussion hammer drill rig (commonly known as a "Becker" rig). The drilling activities were continuously supervised by an EMCON geologist who classified the soils encountered and maintained a detailed log of each boring. Copies of the boring logs are presented in Appendix C.

Soil sampling was an integral part of the field exploration program. Bulk (disturbed) and tube samples were collected from all borings. Tube samples were obtained with either California-modified (2-1/2-inch O.D.) or standard (2-inch O.D.) type split-spoon samplers, which were advanced into the soil material by a 140-pound hammer falling freely a distance of 30 inches for each blow. These sampler types could not be used in intervals containing mostly gravels and cobbles. Soil samples were classified in accordance with the Unified Soil Classification System (see Appendix C).

Soil samples were also collected from materials stockpiled by Union Rock and Materials. These soil materials originated from (1) near-surface soils not useable in their asphalt and concrete business, and (2) residual materials from sand and gravel processing.

### 3.1.3 Laboratory Testing of Soils

Selected soil samples collected at the site were submitted for laboratory testing for classification purposes and to evaluate their engineering properties. Tests included grain-size distributions and Atterberg Limit determinations. An additional purpose of the testing was to characterize the sand and gravel reserves available for future use. Testing of fine-grained soils (Atterberg Limits) is geared towards identifying soils that are suitable landfill cover or liner material.

Test results relative to characterizing the geology of the site are discussed in Section 4.4. Evaluation of the engineering properties of the site soils is critical to design and actual disposal operations at the proposed landfill. Complete laboratory results are included as Appendix D.

# 4.0 GEOLOGY

## 4.1. REGIONAL GEOLOGY

The proposed landfill site is located within the Basin and Range Physiographic Province. The Basin and Range Province is structurally characterized by north-northwest trending, narrow block-faulted mountain ranges separated by broad sediment-filled basins. Faulting that formed these structures began approximately 18 million years ago during the Late Tertiary Period and ceased about 1.5 million years ago during the Early Quaternary Period (Nations and Stump, 1981).

The WSRV basin is filled primarily with alluvial debris eroded from bordering mountain ranges to the west and north. The nearby White Tank Mountains are composed chiefly of Precambrian granite rocks, gneiss and schist, and Tertiary-Cretaceous granite rocks. To the north of the basin, the Hieroglyphic Mountains are composed chiefly of volcanic rocks, including Precambrian rhyolite and Cretaceous andesitic and rhyolitic flows and tuffs. Isolated and contiguous outcrops of Precambrian granitics and schist are also exposed at the southern end of the Hieroglyphic Mountains. Figure 4 shows the general geology of the WSRV and the remainder of Central Arizona.

The valley fill deposits, described in detail by Stulik and Twenter (1964), are composed of unconsolidated to semi-consolidated clay, silt, sand, and gravel. Locally they contain caliche and thin evaporites, predominantly discontinuous beds of gypsum, in the upper 1,500 feet of the section. These deposits are generally highly lenticular and laterally discontinuous.

The thickness of the entire sequence of alluvial sediments (i.e., depth of basin) in the central area of the WSRV is estimated, based on gravity surveys, to be at least 10,000 feet (Oppenheimer and Sumner, 1981).

The sedimentary deposits of the WSRV basins (and other SRV sub-basins) are informally broken down into four units. These are, from oldest to youngest: the Red Unit, the Lower Conglomerate Unit, the Middle Fine-Grained Unit, and the Upper Alluvial Unit. This breakdown of the stratigraphy is convenient from a hydrogeological viewpoint, but stratigraphically the divisions are not well defined in much of the SRV. The units range in age from Tertiary to Quaternary.

The Red Unit comprises reddish-colored, well-cemented breccia, conglomerate, sandstone, and siltstone containing granitic and rhyolitic detritus.

The Lower Conglomerate Unit is composed mostly of fanglomerate materials deposited during the very early phases of formation of the basins. The top of the unit occurs at an elevation of approximately -200 to -300 feet MSL (U.S. Bureau of Reclamation, 1976), about 1,275 to 1,375 feet below the surface in the deepest parts of the WSRV.

The Middle Fine-Grained Unit includes playa, alluvial-fan, and fluvial deposits of silt, siltstone, and silty sand and gravel. The distribution of water-bearing sands and gravels is very irregular, partially due to changes in sediment sources during the period of deposition. The unit yields large amounts of water in some parts of the SRV, but is not the chief water-bearing unit in the site area.

The Middle Fine-Grained Unit occurs at an uppermost elevation of approximately 300 feet (MSL) in the area of the site, or roughly 775 feet below the site. The unit encloses much of the upper part of the Luke Salt Body, which is discussed in Section 4.2. The known thickness of the Middle Fine-Grained Unit ranges to nearly 1,500 feet (U.S. Bureau of Reclamation, 1976).

The Middle Fine-Grained Unit and Lower Conglomerate Unit thin toward the edges of the basins. The finest-grained material of each unit generally occurs near the centers of the basins.

The Upper Alluvial Unit underlies most of the SRV Valley floor and includes recent channel, flood plain, terrace, and alluvial fan deposits that consist mostly of gravel, sand, and silt. This unit is the principal water producer in the WSRV, and ranges in thickness from approximately 600 to 900 feet in the area of the site.

## 4.2 LUKE SALT BODY

The generalized SRV stratigraphy described above is complicated in the WSRV by the existence of a large salt body enclosed within the upper part of the Middle Fine-Grained Unit. The salt mass is believed to be continental in origin, with the salt accumulating in a long-standing saline lake perhaps during the Middle Tertiary, or possibly earlier. Morton Salt Company currently extracts salt at their facility located approximately 3/4 mile southwest of the Cholla site. California Liquid Gas has drilled several natural gas storage wells adjacent to the salt extraction facility.

Figure 5 shows the approximate areal extent of the Luke Salt Body based on drilling information. Eaton, Peterson, and Schumann (1972) described its gross shape as "an irregular, locally domed, ridge-like mass that has an arcuate crest and a broad triangular base." Configurational models of the salt body developed by Eaton, et al. are presented in Figure 6.

The highest part of the salt dome is interpreted to be near the center of Section 2 (T.2N., R.1W.), approximately 1/2 mile southwest of the proposed landfill site. The top of the salt dome dips steeply northward from Section 2. Exploration wells by the U.S. Bureau of Reclamation in Section 32, T.3N., R.1W. (4 miles west of the site) and Section 32, T.3N., R.1E. (1-1/2 miles east of the site), which did not reach the salt or the caprock, establish that the top of the salt dome drops at least 1,100 feet in distances of approximately 2-1/2 miles northwest and 3-3/4 miles northeast of the high point on the salt dome. A seismic line conducted immediately north of the site during this site assessment project indicated a depth of greater than 1,700 to the top of the salt body.

The Luke Salt Body strongly controls the structure of local basin deposits and has had a significant impact on the depositional environment and hydrogeology of the deposits.

Eaton, Peterson, and Schumann (1972) offer two explanations as to the effects of the Luke Salt Body on the overlying sediments: 1) the area overlying the salt body "stood relatively high throughout the period of deposition" of the sediments, and 2) the sediments are older and were lifted by doming. Gross grain-size variations in the upper 200 to 500 feet of basin sediments, studied by Stulik and Twenter (1964), suggest facies variations of the same age resulting in a high proportion (60 percent) or greater of fine-grained sediments overlying the crest of the salt body.

## 4.3 GEOLOGIC HAZARDS

The geologic hazard or earth process most often examined in landfill siting and design is faulting and associated seismicity. More common problems in this part of Arizona that often are critical issues in identifying geologic hazards are land subsidence and earth fissures.

### 4.3.1 Faulting and Seismicity

Seismicity of sufficient intensity to cause major damage is rare in Arizona. The frequency of a "felt" earthquake anywhere in Arizona is approximately one per year during the last 100 years (Nations and Stump, 1981). In the vicinity of the proposed site, there is no surface indication of active (Holocene) faulting. The proposed site is within a zone having a 50 percent probability of minor damaging earthquakes within the next 50 years (Krieski, 1984).

### 4.3.2 Land Subsidence and Earth Fissures

Land subsidence due to ground water withdrawal has been a common occurrence in southern Arizona basins, affecting more than 3,000 square miles including parts of the metropolitan areas of Phoenix and Tucson (Strange, 1983). As a result of the water level declines and land subsidence, alluvial deposits in the basins have been subjected to stress, and earth fissures have developed in some areas.

Most of the basin areas of arid southern Arizona have experienced water table declines due to ground-water pumpage. Significant withdrawal of ground water in Arizona began about 1910 (Schumann and Poland, 1970). From 1915 to 1975, more than 109 million acre-feet of ground water was withdrawn from alluvial deposits of the SRV (Babcock, 1977). Overdraft (i.e., ground water withdrawal greater than recharge) has occurred, with subsequent water level declines, since about 1923. In the WSRV Basin water level declines exceeding 300 feet were noted between 1923 and 1977 in the vicinity of the site (Laney, Raymond, and Winikka, 1978).

This ground-water depletion has led to subsidence of the land surface. Lofgren (1968) and Poland (1969) discussed the mechanisms by which subsidence occurs. Once water is removed from the pore spaces of the valley-fill sediments, a volume decrease of the sediments due to the weight of the overlying materials occurs by two irreversible mechanisms. The most important mechanism is the consolidation of clay and silt layers resulting from the expulsion of water from clay minerals into the pore spaces of adjoining sands and gravels. A secondary mechanism is the grain readjustment of the coarse-grained sediments.

Subsidence and its associated problems have long been known to occur in the WSRV. Levelings conducted in 1948, 1967, and 1981 indicate subsidence along the entire western edge of the basin. Between 1948 and 1981 a maximum of 4.1 feet was recorded just east of the White Tank Mountains (Strange, 1983).

In some areas of ground-water level decline and land subsidence, earth fissures have subsequently developed in alluvial deposits. The fissures, which can be thousands of feet in length, are initially cracks less than an inch wide. However, erosion can widen these cracks and cause gullying along their trends. Eroded fissures up to 50 feet wide and 16 feet deep are known to exist in Arizona (Schumann and Poland, 1970). Areas in Arizona where earth fissures have been discovered include the Picacho-Eloy Basin; the Lower Santa Cruz Basin; Harquahala Plains; McMullen, Salt River (including the Western Salt River Valley), and Avra Valleys, and Wilcox and San Simon Basins (Schumann and Genualdi, 1986). All of these areas have experienced significant amounts of ground-water depletion.

The greatest concentration of earth fissures generally occurs near the margins of overdrafted basins adjacent to the mountains. A prime setting for fissure formation is where the thickness of an alluvial sequence increases rapidly, as along mountain fronts where the rock slopes basin-ward steeply. Deposits over and around buried geologic structures are also susceptible to earth fissures due to differential settlement of the overlying sediments. These structures may include bedrock knobs, pediment surfaces, or, as may be the case in the Luke area, an underlying salt dome.

Earth fissures have been known in the WSRV since the late 1950s. The phenomenon of earth fissuring in the WSRV has not been extensively investigated as it has been in several areas in Arizona, such as the Picacho-Eloy Basin. Eaton, Peterson, and Schumann (1972) mapped fissures in the vicinity of the Luke Salt Body. Other mapping was performed during geotechnical investigations for engineering projects in the WSRV. Sergent, Hauskins, and Beckwith (1982), in a study concerning the McMicken Dam (approximately 10 miles northwest of the site), mapped fissures in the WSRV using photogeologic methods. Thomas-Hartig and Associates (1986) and the U.S. Army Corps of Engineers (1983) investigated fissures along the proposed Cotton Lane - Northwest Loop Highway Corridor for the Arizona Department of

Transportation. Laney, Raymond, and Winikka (1978) compiled a map showing the major fissures discovered in the WSRV prior to 1976. In the vicinity of the site, earth fissures just east of Luke Air Force Base were first observed in 1959 and are well documented (Robinson and Peterson, 1962; Kam, Schumann, Kister, and Arteaga, 1966; Eaton, Peterson, and Schumann, 1972; Laney, Raymond, and Winikka, 1978; Schumann, 1974; and Sergent, Hauskins, and Beckwith, 1982).

The origin of earth fissures in the central WSRV appears to be more complex than most other fissures identified in Arizona. Typically, fissures will open up on the periphery of basins. The WSRV fissures are anomalously situated near the center of the basin. While the basin has experienced the ground-water depletion and subsequent ground subsidence that is characteristic of fissure areas, it is very possible that the anomalous WSRV fissures may be associated with the underlying Luke Salt Body.

With better management of ground water in the future, the related problems of land subsidence and earth fissures should ultimately decrease in the WSRV. However, even though the rate of ground-water decline has decreased in the last ten years, and in many cases ceased, the rate of subsidence in the WSRV has generally increased. This is believed to be a reflection of the time lag between induced stress (from ground-water withdrawal) and actual response of sediments. As fine-grained sediments within the alluvial sequence of sediments dewater very slowly, the ultimate volume reduction of the alluvial sediments can be delayed for many years (Lofgren, 1968). Thus, the potential exists in the WSRV for continued subsidence and fissuring.

Another contributory factor which may influence potential subsidence and fissuring in the WSRV to a lesser degree is the future behavior of the Luke Salt Body. Adjustments may occur in the salt dome due to density changes and/or the removal of water and storage of natural gas. Water is reinjected to maintain pressures within the part of the salt dome being developed for natural gas storage and salt extraction.

This significantly reduces the risk of collapse of solution cavities and resulting effects on the ground surface (such as subsidence).

### 4.3.3 Exploration for Site Fissures

The occurrence of subsidence and earth fissures may pose problems to overlying man-made structures. The study of earth fissures in the vicinity of the site was considered important to this project due to the potential hazard they pose for damage to engineered landfill structures and the potential for degradation of ground water quality.

An exploration program was conducted to determine whether concealed earth fissures exist on the proposed landfill site. The program included the following components:

- Examination of aerial photographs of the site property and surrounding 1-mile area.
- Field reconnaissance of the site property and perimeter.
- Field verification of nearby previously mapped fissures in adjacent areas.
- Geophysical survey.

To begin the program, aerial photography from 1959, 1971, 1981, and 1987 was reviewed for evidence of fissures. No evidence indicating a fissure in the immediate vicinity of the site was found. Fissures can often be identified by linear gullying, topographic offsets, or conspicuous alignment of vegetation. An EMCON geologist then visually surveyed the site property and perimeter and did not find evidence for fissures on or around the site.

EMCON also evaluated previous studies of earth fissures in the WSRV, and attempted to verify fissures mapped in the vicinity (within a 1-mile radius) of the site. No previous investigation identified the presence of fissures on the site. Sergent, Hauskins, and Beckwith (1982) mapped fissures in the WSRV based on suspicious lineations on aerial photographs. When field checked by SH&B and Thomas-Hartig (1986), many of the lineations reported by SH&B were discovered to be simply natural gullies or plants growing in shallow furrows in farm fields.

EMCON geologists observed earth fissures west and southwest of the site, in Sections 2 and 35 during survey reconnaissance. Some of the fissures are more conspicuous than others. The north-south trending fissure zone in Section 35, one-half mile west of the site, displays piping and gullying, and is marked by vegetation alignments. The most prominent surface opening in this zone (eroded fissure) is approximately 4 feet wide, 5 feet deep and 2,500 feet long. In some places side gullying has increased the opening to more than 10 feet wide. The zone is traceable across Northern Avenue and extends southward into the Morton Salt facility in the southwestern corner of Section 2 (T.2N., R.1W.) (see Figure 7).

EMCON did not find evidence for a northeast-trending fissure shown by Laney et al. (1978) as occurring immediately west of the site. Personal communications with R.L. Laney, R.H. Raymond, and C.C. Winikka (January - February, 1989) indicate that the fissure was shown on their map due apparently to an error in compilation. Work performed by Sergent, Hauskins, and Beckwith in 1982 confirms that no fissure occurs in that area.

EMCON did not observe current surficial expression of the small fissure mapped approximately 1/4 mile to the west of the northwest corner of the site (Laney et al., 1978). According to the Maricopa County Highway Department (personal communication, 1988), road work was completed at that location on Olive Avenue to repair a crack/dip in the roadway. The cause of the road damage was not documented, however it was attributed to the presence of an underlying fissure.

State-of-the-art geophysical methods (seismic refraction and seismic reflection) were utilized to survey the subsurface of the proposed landfill site for the presence of fissures. To check the effectiveness of the seismic method in identifying a fissure in the subsurface, an initial test seismic line (Line 1, see Appendix B) was run perpendicularly across the known fissure zone in Section 35. The seismic record generated from that test clearly indicates the presence of the fissure by recording the attenuation of energy across the fissure (less energy crosses the fissure, and the surface wave amplitude decreases).

With evidence that fissures (though they may be concealed at the surface) could be identified with seismic techniques, the seismic team used those techniques on the proposed landfill site. Three seismic lines on the site, and one immediately north of the site, did not reveal any evidence of fissuring. Details of the geophysical program are discussed in a separate report included as Appendix B.

Based on the information developed in this program, it is concluded that there are no fissures on or in the immediate vicinity of the site. Furthermore, there are no known fissures trending toward the site.

## 4.4 SITE GEOLOGY

Based on information from the exploratory borings and gravel pit exposures, the site is underlain by a highly variable sequence of alluvial deposits composed of clay, silt, sand, gravel and cobbles. The lenticular and discontinuous nature of the strata beneath the site is typical of a braided stream type depositional environment where the change in lithology reflects shifts in the river's (i.e., Agua Fria) course.

Figure 8 shows a north-south subsurface profile at the site depicting the stratigraphy observed in borings and gravel pits ("active" and "inactive" pits labelled in Figure 3). It is apparent from the profile that coarse-grained materials (sands, gravels, and cobbles) dominate the stratigraphy to the depth explored.

Limited soil classification testing was performed on representative site samples. Soil analysis reflected the heterogeneity of site deposits. The soils ranged from CL (clay, low plasticity) to GP-GC (poorly graded to clayey gravel) on the USCS. Test results are summarized in Appendix D.

The driller's log for Water Well W-1 on site shows that mostly fine-grained materials were penetrated during drilling to the total depth of 900 feet. Of the total thickness of sediments penetrated, roughly 58 percent were fine-grained. However, fine-grained materials account for only about 22 percent of the upper 250 feet of the alluvium logged for the well (see Appendix E).

# 5.0 HYDROGEOLOGY

## 5.1 REGIONAL HYDROGEOLOGY

A survey was conducted to identify water wells within 1 mile of the proposed landfill site. One active well is located on site and is used as a source of water for the Union Rock and Materials operation. According to well records compiled by the Arizona Department of Water Resources (ADWR), 56 water wells exist within a 1-mile square area surrounding the site. Figure 9 shows well locations within an area of approximately 23-1/2 square miles surrounding the site.

The principal aquifer tapped by these wells is the Upper Alluvial Unit, which comprises the upper 600 to 900 feet of the alluvial sediments in the central WSRV. The depth to water in the Luke area currently ranges from about 250 to 400 feet. Water in the Upper Alluvial Unit is usually under unconfined conditions, but semi-confined or perched conditions occur where extensive clay layers are present. Perched water conditions have been identified in wells 1 to 4 miles west-northwest of the site.

A significant portion of the recharge to the upper Alluvial Unit occurs along the Agua Fria river channel. Recharge also occurs from intermittent streams along the edge of the basin and from irrigation canals within the basin. The aquifer also receives excess irrigation water that filters down through the soil column.

Few wells in the basin produce water from the older, deeper Middle Fine-Grained Unit. Most of the unit is considered an aquiclude. The Luke Salt Body acts as a partial barrier to the flow of ground water within the Middle Fine-Grained Unit. The unit does yield some water from coarser deposits mostly east of the Agua Fria River and from thin sandy horizons (U.S. Bureau of Reclamation, 1976).

The Lower Conglomerate Unit is a lesser-used, but important, deep aquifer. Ground water in the unit is primarily under confined conditions.

The hydraulic characteristics of the Upper Alluvial aquifer within the WSRV area are partially influenced by the Luke Salt Body as previously discussed. Figure 10 shows a local area of low transmissivity existing southeast of Luke Air Force Base and extending northward along the course of the Agua Fria River.

## 5.2 SITE HYDROGEOLOGY

Two water wells, one active and one inactive, exist within the site boundary. No records could be obtained for the inactive well (Well W-2), which needs to be properly abandoned. Well W-1 was drilled in 1960 to a depth of 900 feet for an irrigation water supply source. The well currently supplies water to the Union Rock and Materials operation. Records of a well test conducted after pump installation in 1960 indicate a discharge rate of 2,000 gallons per minute. Static water level at that time was 220 feet below ground surface. Measurements in December 1988 indicated a depth to water of approximately 295 feet below ground surface and a discharge rate of 1,075 gallons per minute.

Ground water beneath the site flows to the west towards a large cone of depression situated west of Luke Air Force Base. This trough is centered approximately 6 to 7 miles southwest of the site. Figure 9 shows water-level contours for the site area, based on 1984 measurements by ADWR.

Based on 1984 levels, the water level change across (east to west) the proposed landfill portion of the property is approximately 40 feet (hydraulic gradient of approximately .02). The maximum excavation at the proposed landfill site is planned to be approximately 82 feet below the present ground surface. With a current depth to ground water ranging from 255 to 295 feet beneath the site, the calculated separation between the base of planned waste cells and the present water table ranges from approximately 173 to 213 feet. No evidence exists for the occurrence of water (i.e., perched water) between the design landfill base and the water table. EMCON did not encounter perched water in any of the four exploratory borings drilled (to a maximum depth of 120 feet) during this site assessment. Likewise, no perched water conditions are indicated on the drillers log prepared for Well W-1 (Appendix E).

### 5.3 GROUND-WATER LEVEL CHANGES

As discussed earlier, the WSRV Basin has experienced severe ground-water depletion. As illustrated on Figure 7, water level declines of 200 to 300 feet were recorded between 1923 and 1977 in the WSRV (approximate mean annual decline of 5 feet per year) (Laney, Raymond, and Winikka, 1978). A ground-water contour map prepared by U.S. Bureau of Reclamation (1976), showing 1923 water levels, indicates that the water table may have been as high as 1,050 feet MSL in the northwest portion of the site (depth to water of approximately 25 feet). Water level records for the active well on the site (Well W-1 on Figure 3) indicate that the static water level declined 64 feet between 1960 (the year of its construction) and 1984 (change in elevation from approximately 877 feet MSL in 1960 to 813 feet in 1984).

Slight water level rises have been observed over much of the SRV over the past several years. Biannual measurements by Arizona Department of Water Resources (ADWR) personnel in a well approximately 1-1/4 mile west of the site indicate a rise of approximately 14 feet between 1984 and 1988. However, the water level in Well W-1 rose 11 feet during the same time interval.

## 5.4 GROUND-WATER QUALITY

Ground water in the WSRV is generally suitable for most agricultural and industrial uses. Locally, high concentrations of total dissolved solids (TDS) (greater than 500 ug/l) and fluoride can make the water from some areas unsuitable for domestic use, however, if untreated.

In the area surrounding the site, water is generally of the sodium-bicarbonate or magnesium-bicarbonate type with TDS concentrations averaging about 300 to 400 mg/L. To EMCON's knowledge, water quality tests have never been conducted on water samples from the water well W-1.

The Luke Salt Body has had a pronounced effect on the salinity of ground water in the immediate vicinity of the salt mass, but is not expected to influence the quality of water underlying the immediate site. Figure 11 shows contours of TDS concentrations in the WSRV. Note the anomalous area of high TDS values, ranging from 500 to more than 9,000 mg/L, reflecting the impact of the Luke Salt Body on ground-water quality south and east of Luke Air Force Base. Stulik and Twenter (1964) studied the salinity problem and reported on salt-influenced ground water from several wells in the area.

Wells showing the highest salinity values are those that pump water from the Middle Fine-Grained Unit, which encloses the upper part of the salt body. High ion concentrations have not dispersed appreciably to the east and north of the Salt Body because of the low transmissivity of the sediments surrounding the Salt Body and because ground water generally moves to the west-southwest.

## 6.0 SUMMARY OF PRELIMINARY GEOLOGIC/HYDROGEOLOGIC FINDINGS

Based on data and other information gathered from the investigative activities completed thus far, the following conclusions have been reached regarding geologic and hydrogeologic conditions at the proposed Cholla Landfill site.

- The site lies on alluvial basin-fill sediments of the Western Salt River Valley (WSRV), which are believed to reach a maximum depth of at least 10,000 feet.

- The Luke Salt Body, a large salt mass discovered in 1968, lies beneath the site at depths of possibly up to 1,700 feet (top of salt mass). The salt mass has influenced the depositional environment and structural geology of local basin deposits, and it has increased the salinity of nearby ground water.

- Reductions in volume of the valley-filling sediments due to ground-water overdraft has caused land subsidence in much of the WSRV. Leveling records indicate a maximum subsidence of 4.1 feet between 1948 and 1981, along the western edge of the basin. Land subsidence evidence has not been observed on the site. Comprehensive, accurate leveling records for the central WSRV are not known (by EMCON) to exist.

- Earth fissures exist within one-half mile to the west and southwest of the site. Earth fissures generally occur as a result of stress build-up within sediments that have undergone consolidation caused by ground-water withdrawal. These stresses are greater over buried structures. The location of the Luke area fissures indicates that they are clustered along the west side of the crest of the underlying Luke Salt Body. The area west of the

Luke Salt Body has been subjected to severe ground-water depletion.

- Based on information developed from aerial photograph study, reconnaissance surveys, and geophysical (seismic) testing, it is concluded that no earth fissures exist on or in the immediate vicinity of the proposed landfill site.

- The site is underlain by a highly variable sequence of alluvial deposits comprised of clay, silt, sand, gravel, and cobbles. Coarse-grained materials (sands, gravels, and cobbles) apparently dominate the stratigraphy to a depth of at least 120 feet (elevation of approximately 953 feet MSL). The drillers' log for the active water well on the site indicates that deeper deposits (to a maximum depth of 900 feet) are predominantly fine-grained.

- The site is located in an area that has experienced severe ground-water depletion. Water levels have declined 200 to 300 feet since the 1920s. With an increased effort to better manage WSRV ground-water resources and expected decreases in ground-water pumpage, water levels declines in the area have appeared to stop.

- Depth to water beneath the site currently ranges from approximately 233 to 295 feet below ground surface (at an elevation of 802 to 842 feet MSL). Ground-water flow is to the west.

- The quality of ground water in the site vicinity is generally good. It is of sodium-bicarbonate or magnesium-bicarbonate type, with TDS concentrations averaging approximately 300 to 400 mg/L.

## 7.0 ADDITIONAL SITE CHARACTERIZATION

Additional site exploration will be needed to provide the geotechnical geologic and hydrogeologic information necessary to design and permit the proposed solid waste landfill at the El Mirage site. This section of the report discusses critical components of landfill design and presents EMCON's preliminary work plan to obtain the necessary information.

### 7.1 COMPONENTS OF LANDFILL DESIGN

The purpose of the exploration program described in this section is to define subsurface stratigraphy as it relates to the landfill design and obtain soil samples for laboratory testing. Components of the landfill design may include 1) a composite lining system composed of compacted low permeability soil overlain by a geomembrane, 2) evaluation of liner and excavation slope stability, 3) a slurry wall located between the Agua Fria River channel and the landfill, and 4) a drainage system located between the slurry wall and the landfill liner. Each of these components is described individually below. Section 7.2 presents plans for field and laboratory work to obtain data to be utilized in the components of landfill design.

#### 7.1.1 Liner Design

Based on the site reconnaissance and preliminary exploration work at the site, it is not anticipated that significant quantities of low permeability material will be obtained during site quarry operations. Therefore, it is anticipated that bentonite or other commercially available materials will be mixed with on-site sands and silty sands to obtain suitable low permeability material for the soil component of the landfill's composite liner. Bulk samples of the sands and silty sands will be obtained for laboratory testing. These materials will be mixed with bentonite to determine the percentage of bentonite needed to achieve the design hydraulic conductivity. It is anticipated that the laboratory program will include gradation, Atterberg limits, specific gravity, compaction and laboratory hydraulic conductivity tests on fabricated samples.

### 7.1.2 Liner and Excavation Slope Stability

As part of the landfill design, slope stability computations will be performed on the proposed excavation slopes and lining system. In order to obtain strength parameters for these analyses, laboratory strength tests will be performed. Triaxial shear strength tests will be performed on fabricated samples of the proposed soil component of the landfill's composite liner system. In addition, shear tests will be performed on the proposed soil component - geomembrane lining system. These tests will be used to evaluate the soil - geomembrane friction angle.

The proposed landfill excavation slopes will also be analyzed during the design. It is not anticipated that excavation slope stability will present a significant design issue. However, the preliminary field exploration encountered lenses of clays and silts. These materials, if they are extensive and have low shear strength could impact excavation slopes. If these materials are encountered during the exploration program, attempts will be made to obtain undisturbed samples of them using a Pitcher Barrel or other similar sampling device. Laboratory density and triaxial shear tests would be performed on representative samples. Data from the laboratory strength testing will be correlated with laboratory classification tests of disturbed samples as well as field data including boring logs and blow counts for use in stability analyses.

### 7.1.3 Slurry Wall Design

A slurry wall may be required between the proposed landfill and the Agua Fria River channel to prevent affecting of the landfill due to lateral flow during the rare periods that the channel conveys water. Data obtained during the exploration will be used to assess if a slurry wall or other hydraulic barrier is needed, the vertical and lateral limits of that barrier and to provide soil data for slurry wall design. It is anticipated that unsaturated/saturated flow hydrogeologic modeling will be needed to estimate the need for and limits of the hydraulic barrier. Data obtained from the exploration will include stratigraphy, in-situ hydraulic conductivity, and samples for laboratory testing. The laboratory testing could include classification tests, dry density, and specific gravity. This information will be used along with data obtained for slope stability evaluations to develop a slurry wall design.

#### 7.1.4 <u>Drainage System Design</u>

Modelling and design evaluations may indicate that a drainage system alone or in combination with a slurry wall may be the most effective means of controlling transient subsurface flows from the Agua Fria River channel. The exploration program will obtain adequate information to design this system. Data obtained will include stratigraphy and in-situ hydraulic conductivity.

### 7.2 SCOPE OF PROPOSED WORK

#### 7.2.1 <u>Liner Material Evaluation</u>

Eight additional exploratory borings will be drilled to a depth of 80 feet, the design base for landfill burial. Figure 3 shows the proposed locations for these borings. The purpose of these borings is to further determine the availability and properties of site soils potentially useable as liner material or daily, intermediate, or final refuse cover materials.

Drilling and sampling equipment and techniques will be identical to those described earlier in this report. The borings will be logged in detail by an EMCON geologist for lithologic identification. The completed borings will be backfilled with a neat cement grout. Representative soil samples will undergo laboratory testing including Atterberg Indices; sieve analysis; and moisture content and dry density.

7.2.2 Subsurface Hydraulic Characterization

The preliminary design base elevation of waste cells is between approximately 990 and 1,015 feet (MSL), or a depth of approximately 80 feet below the present ground surface. Therefore, the base elevation of waste cells will be approximately 60 to 70 feet below the current river channel bottom. Under this condition, it is theoretically possible that shallow perched water under the channel, accumulated due to flood water flow, could migrate laterally towards buried waste.

The potential for this scenario depends on the hydraulic properties of the sediments, and the extent and quantity of flood water flow in the river channel. The aim of this task of the work plan is to characterize the hydraulic properties of site alluvial deposits that could potentially allow hydraulic connection between the river channel and waste cells.

The preliminary work plan calls for 15 to 20 borings to be drilled along the eastern edge of the site, adjacent to the river (Figure 3). Eleven of these borings will be drilled on 500-foot centers along the western bank of the river channel. The remaining borings will be drilled along lines perpendicular to the river channel. This boring network will define the stratigraphy both parallel and perpendicular to the Agua Fria River. The borings will be drilled to 40 feet below the design base for waste burial, i.e., approximately 120 feet deep. Geophysical logs will also be performed on all the soil borings.

A variety of soil samples will be retrieved from these borings for physical testing. As described in Section 7.1.3, tests may include classification tests, dry density, and specific gravity.

In-situ permeability testing will be performed on selected sediment types encountered in the borings. The actual number of tests will depend on the lithologic continuity of alluvial soil types on the site. Identified fine-grained units (silts and clays) that could allow perched water conditions, or highly permeable units (sands and gravels), which could allow hydraulic connection between waste cells and the river, will be targeted for the majority of testing.

The permeability tests are essentially falling-head tests, conducted in temporary dry wells, sometimes called permeameters. Hydraulic conductivity derivations from the test data, along with data from soils geotechnical testing will be used in design criteria for a system to protect landfill waste cells from flood water infiltration. Several options for the protective system are being considered, including slurry wall construction and a well extraction network.

## 7.3 PRELIMINARY GROUND-WATER MONITORING PLAN

Solid waste disposal facilities (landfills) are considered to be discharging facilities (ARS 49-241 B.2.) and will be required to obtain an Aquifer Protection Permit (formerly Ground-Water Quality Protection Permit), which becomes the basis for regulating ground-water quality protection practices at such facilities. Final Aquifer Protection Permit rules are expected to become effective in early 1989. Current draft rules stipulate that the Arizona Department of Environmental Quality (ADEQ) will have authority to specify the geologic/hydrogeologic data required before issuance of a permit (A.A.C., Title 9, Ch. 8, Art. 9, Sec. R18-9-107), and for requiring any monitoring necessary to assure compliance with applicable water quality standards (R18-9-111).

EMCON will develop a ground-water monitoring plan designed to comply with requirements established by ADEQ. A detailed monitoring plan would be premature at this time.

However, the plan to be developed will enable the definition of hydrologic parameters necessary for comprehensive ground-water monitoring, such as site specific ground-water flow direction, gradient, and velocity. Upgradient wells will be sited to supply data on the background quality of ground water entering the landfill area. Downgradient wells will be located at compliance points approved by the ADEQ, and will provide detection monitoring for potential impacts on ground-water quality associated with landfill activities.

Water quality protection standards (chemical parameters) to be set for the landfill will be approved by the ADEQ, in compliance with the Aquifer Protection Program. EMCON recommends that quarterly sampling begin before landfill operations commence to identify seasonal fluctuations in ground-water characteristics.

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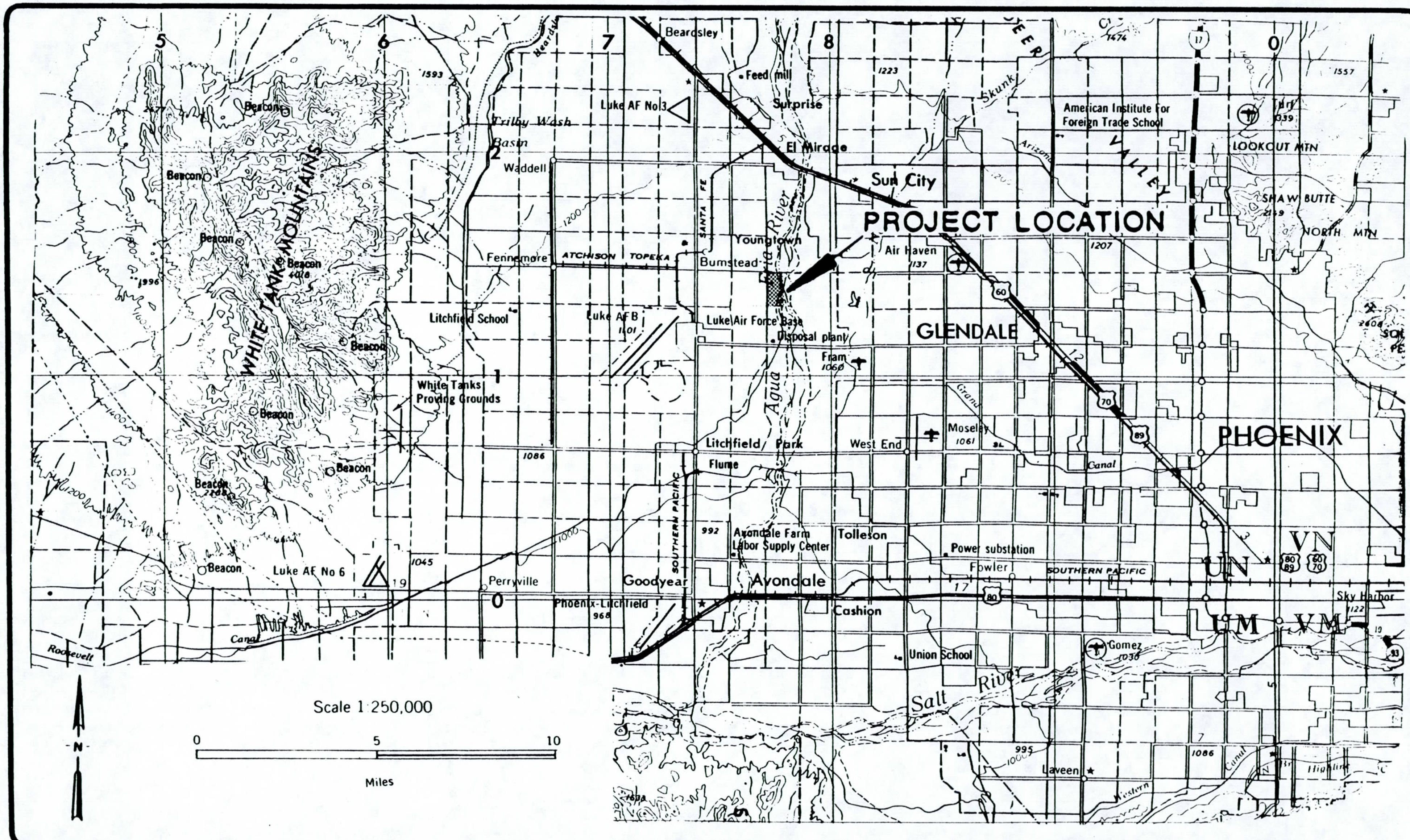
FIGURES

117149

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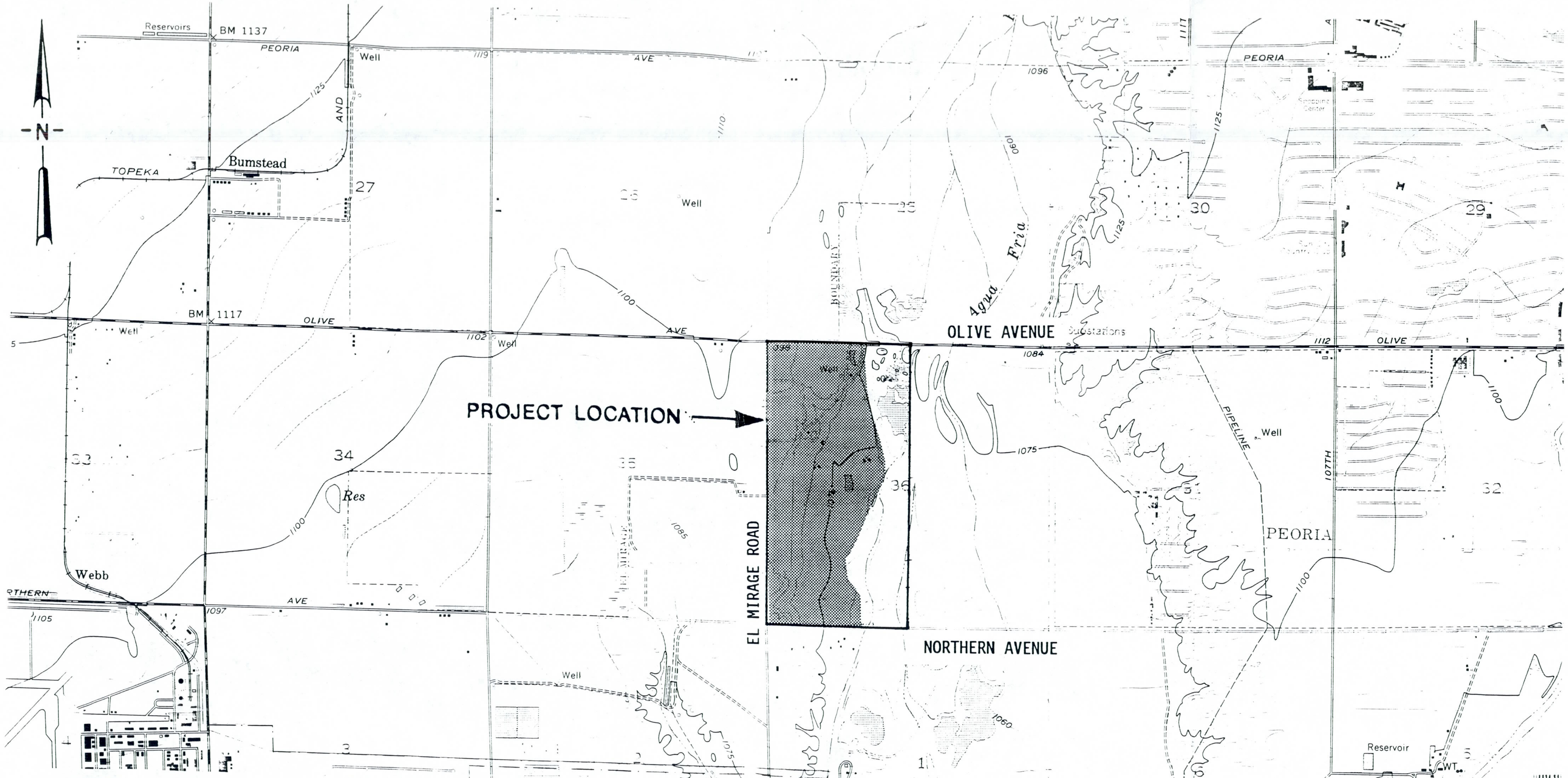
BROWNING-FERRIS INDUSTRIES
PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

LOCATION MAP

FIGURE 1

PROJECT NO. 372-15.01

117149




UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EL MIRAGE QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

— PROPERTY BOUNDARY

PROPOSED AREA OF LANDFILL

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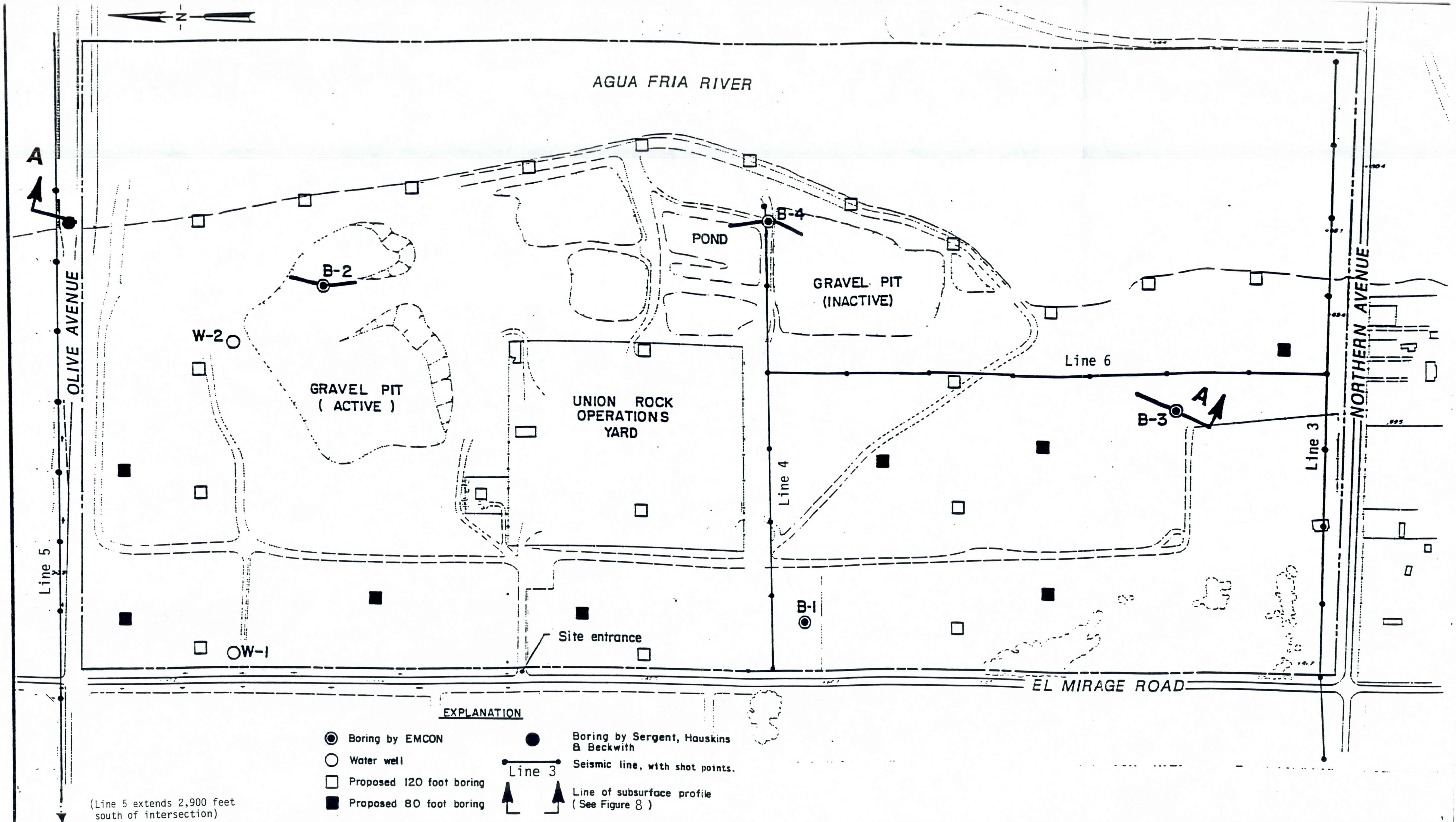
PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

MAP OF LOCAL TOPOGRAPHY

FIGURE
2
PROJECT NO.
372-15.01

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Scale: 0 400 800 1200 1600 Feet

BROWNING-FERRIS INDUSTRIES
PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

SITE EXPLORATION MAP

FIGURE 3

PROJECT NO. 372-15.01

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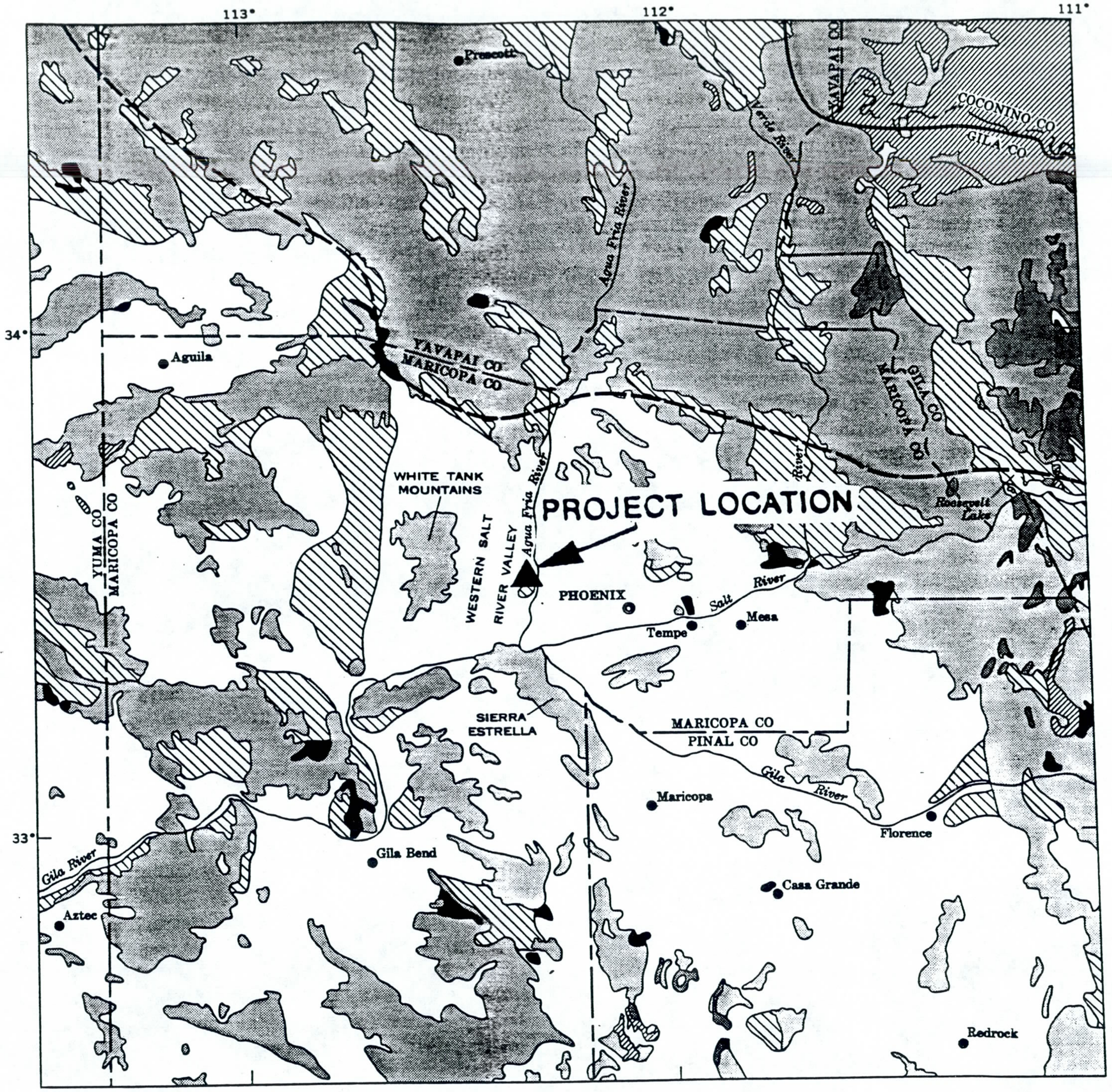


Index map of central Arizona, showing general geology of region around western Salt River Valley (generalized from Wilson and others, 1969, with modifications from Cooley, 1967, and M. E. Cooley, written commun., 1971). Note the general scarcity of lower Cenozoic and older sedimentary rocks throughout the region. The heavy solid line in the northeast corner of the map marks the Mogollon Rim, at the southern edge of the Colorado Plateaus. South of the heavy dashed line is the Basin and Range province. The region between these lines is transitional.

EXPLANATION

Mainly Quaternary deposits

Mainly upper Tertiary (Pliocene) deposits

Middle Tertiary sedimentary rocks

Mesozoic and Paleozoic sedimentary rocks

Precambrian sedimentary rocks; slightly metamorphosed

Phanerozoic and Precambrian intrusive, extrusive, and metamorphic rocks

Contact

Physiographic province boundaries


0 10 20 30 40 50 MILES

0 10 20 30 40 50 KILOMETERS

(From Eaton, et al., 1972)

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PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

MAP OF REGIONAL GEOLOGY

FIGURE 4

PROJECT NO. 372-15.01

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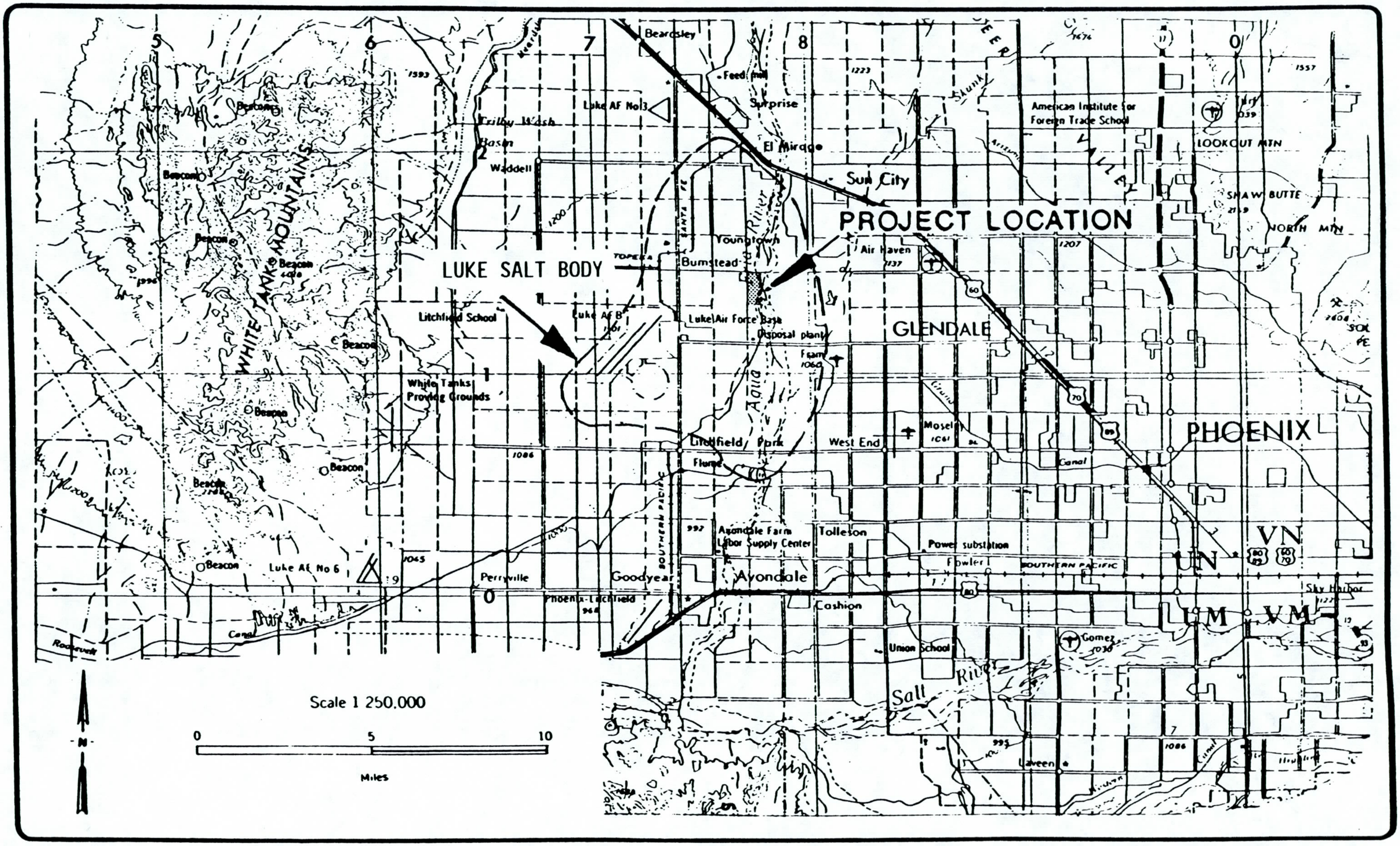


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MARICOPA COUNTY, ARIZONA

APPROXIMATE AREAL EXTENT OF LUKE SALT BODY

FIGURE 5

PROJECT NO. 372-15.01

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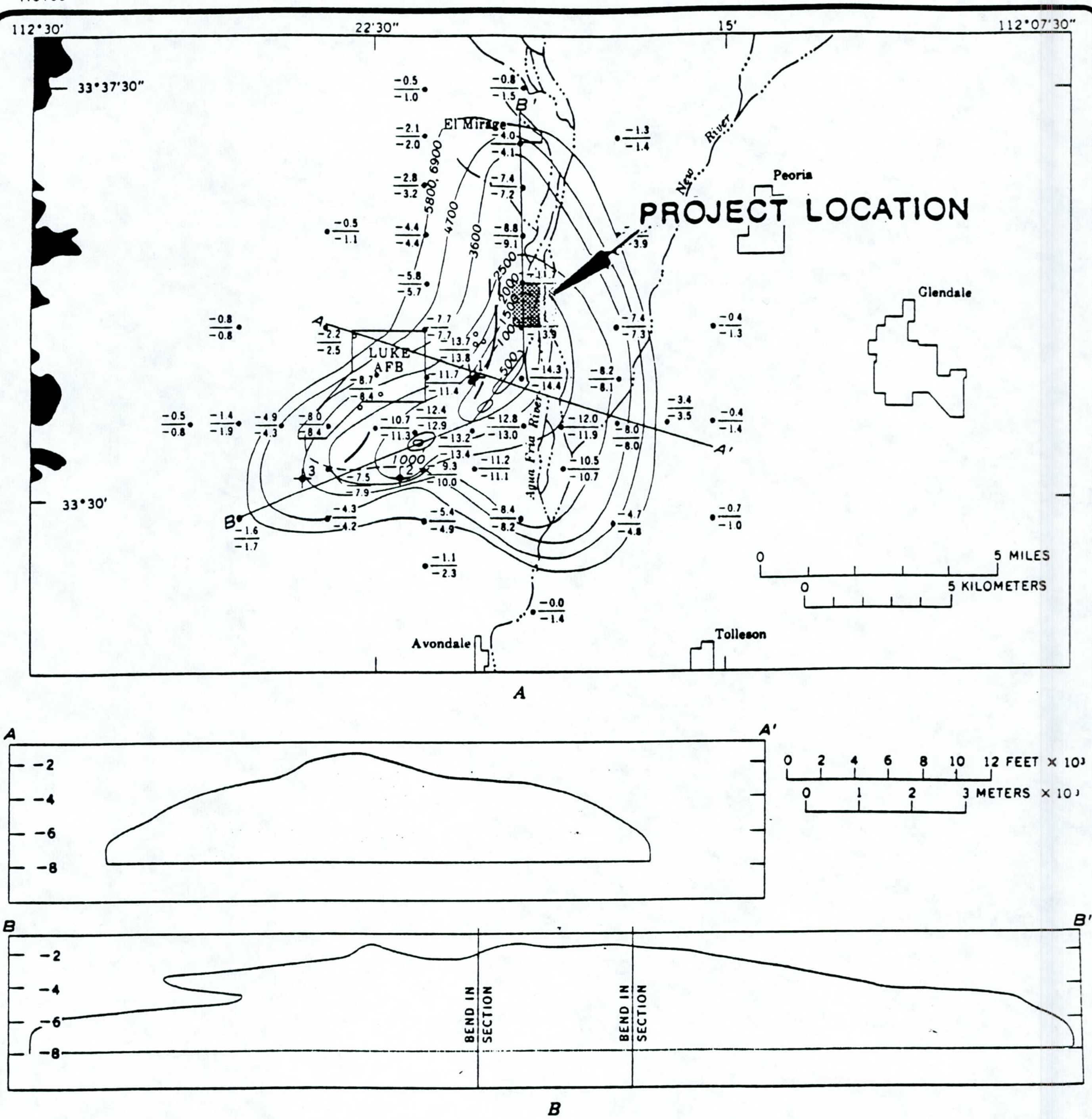


Limiting configuration model of the Luke Salt Body, developed by Eaton et al. (1972) based on residual gravity field data and alluvium density data. This model has a minimum depth to the base of the salt; all other models tested had deeper bases and, therefore, greater vertical dimensions.

**A.** Map of the salt body. Depth contour lines are referred to a surface datum. Contour interval is 500 to 1100 feet. The basal 1100 feet of the body (5800 or 6900) has vertical flanks. Small dots are points at which discreet values of the gravity field of this model were calculated. Fraction next to each dot provides a means of comparing values of observed residual gravity (numerator) with those of the modeled gravity field (denominator). Large solid dots with ticks are wells that penetrated halite. Small open circles are wells with collapsed casings. Heavy curved lines represent open earth fractures. Solid pattern represents areas of exposed bedrock.

**B.** Cross sections A-A' and B-B' through the salt body. No vertical exaggeration. Numbers on vertical scale are altitudes relative to sea level, in thousands of feet.

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MARICOPA COUNTY, ARIZONA

LUKE SALT BODY CONFIGURATION

FIGURE 6

PROJECT NO. 372-15.01

(From Eaton et al., 1972)

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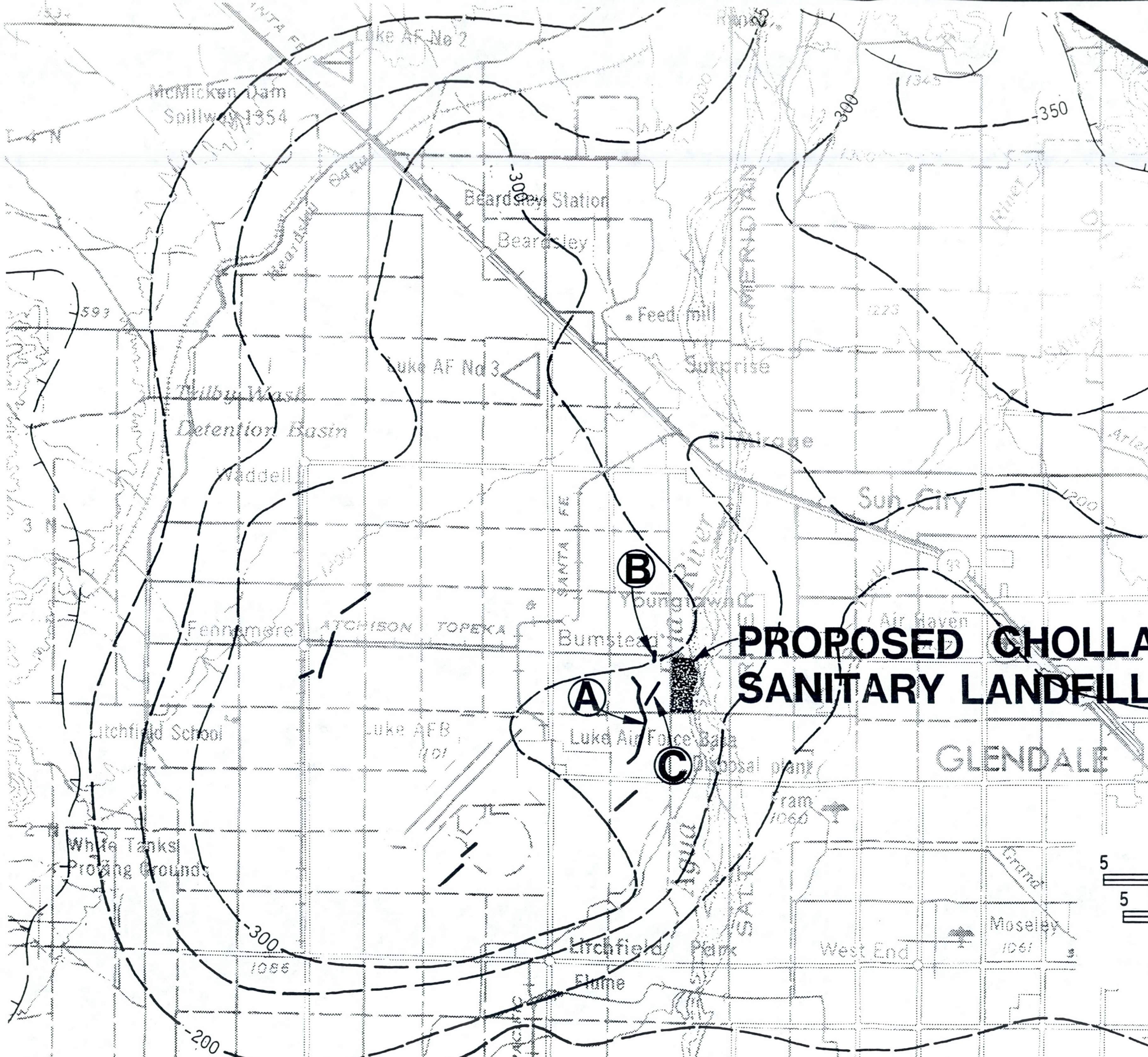


EXPLANATION

--------- -250 ------- APPROXIMATE LINE OF EQUAL WATER-LEVEL CHANGE, 1923-77, Interval 50 feet

/ EARTH FISSURE
As shown on Laney et al. (1978, Sheet 2)

LEGEND

A - Identified by Kam et al. (1966), Eaton et al. (1972), Laney et al. (1978), Sergent, Hauskins and Beckwith (SHB) (1982), and EMCON (1988)

B - Shown on Laney et al. (1978) map, Eaton et al. (1972), U.S. Bureau of Reclamation (1976), but not identified by Kam et al. (1966), SHB (1982) or EMCON (1988)

C - Shown on Laney et al. (1978) map but not identified by Kam et al. (1966), Eaton et al. (1972), U.S. Bureau of Reclamation (1976), SHB (1982), EMCON (1988), or Laney, Raymond, Schumann, and Winikka (personal communication, 1989)

SCALE

5 0 5 MILES

5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

(Modified from Laney, Raymond, and Winikka, 1978)

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MARICOPA COUNTY, ARIZONA

MAP OF EARTH FISSURES AND GROUNDWATER DECLINE AS SHOWN BY LANEY ET AL.

FIGURE 7

PROJECT NO. 372-15.01

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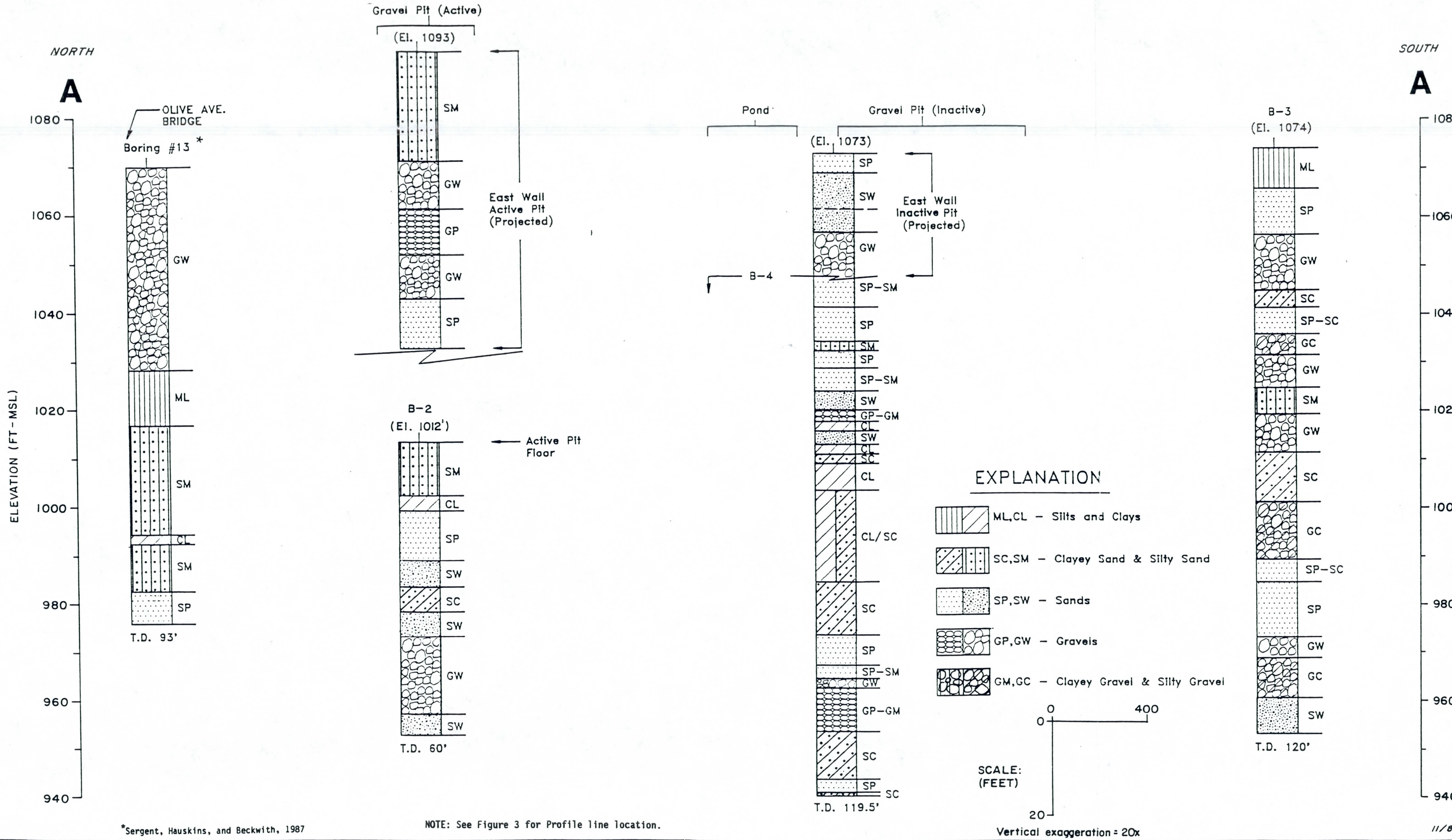


*Sergent, Hauskins, and Beckwith, 1987

NOTE: See Figure 3 for Profile line location.

11/88

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MARICOPA COUNTY, ARIZONA

SUBSURFACE PROFILE A - A

FIGURE 8

PROJECT NO. 372-15.01

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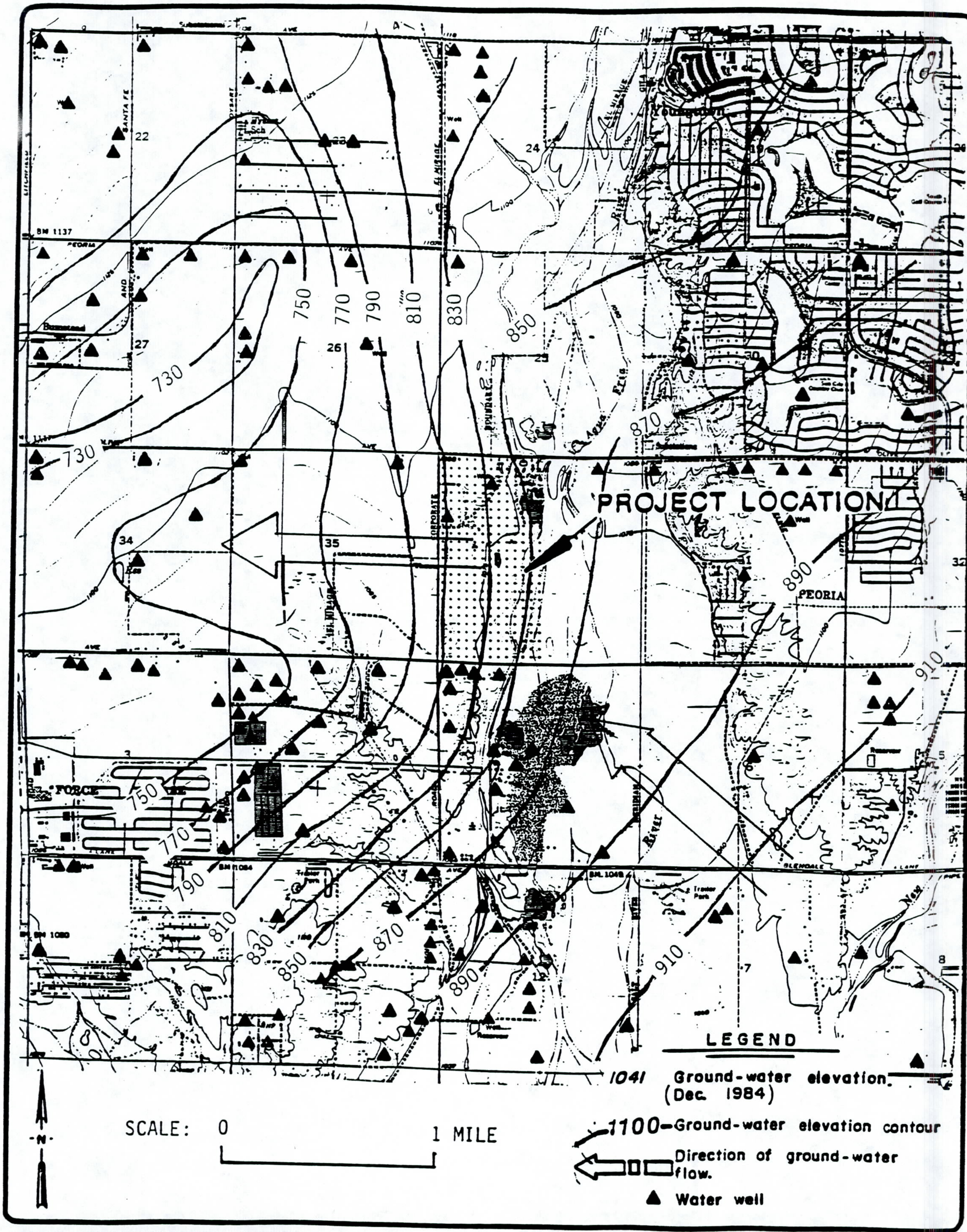
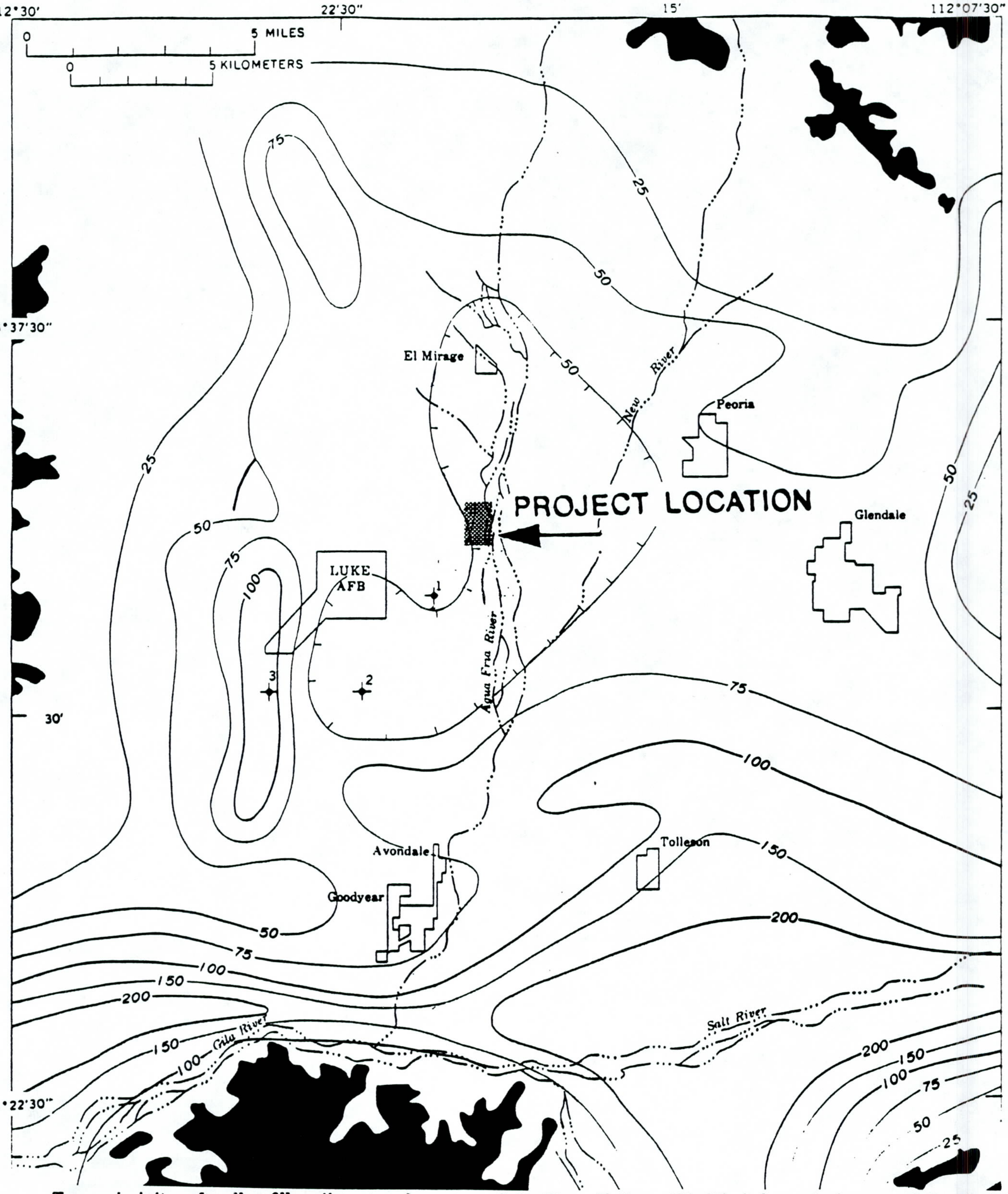



| | | |
|---|---|---|
| EMCON Associates | BROWNING-FERRIS INDUSTRIES<br>PROPOSED CHOLLA SANITARY LANDFILL<br>MARICOPA COUNTY, ARIZONA | FIGURE<br>9 |
| | GROUND-WATER FLOW DIRECTION<br>WITH WELL LOCATIONS | PROJECT NO.<br>372-15.01 |

110169




Transmissivity of valley-fill sediments of western Salt River Valley. (Modified from Anderson, 1968, pl. 2.) Contours indicate transmissivity, in thousands of gallons per day per foot, of the upper 1,000 to 1,200 feet of the section. Solid pattern represents areas of exposed bedrock. Note area of reduced transmissivity (<50) south and east of Luke Air Force Base

[1]Contour interval is 25,000 or 50,000 gallons per day per foot.

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PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

TRANSMISSIVITIES OF WSRV BASIN SEDIMENTS

FIGURE 10

PROJECT NO. 372-15.01

*(From Eaton et al., 1972)

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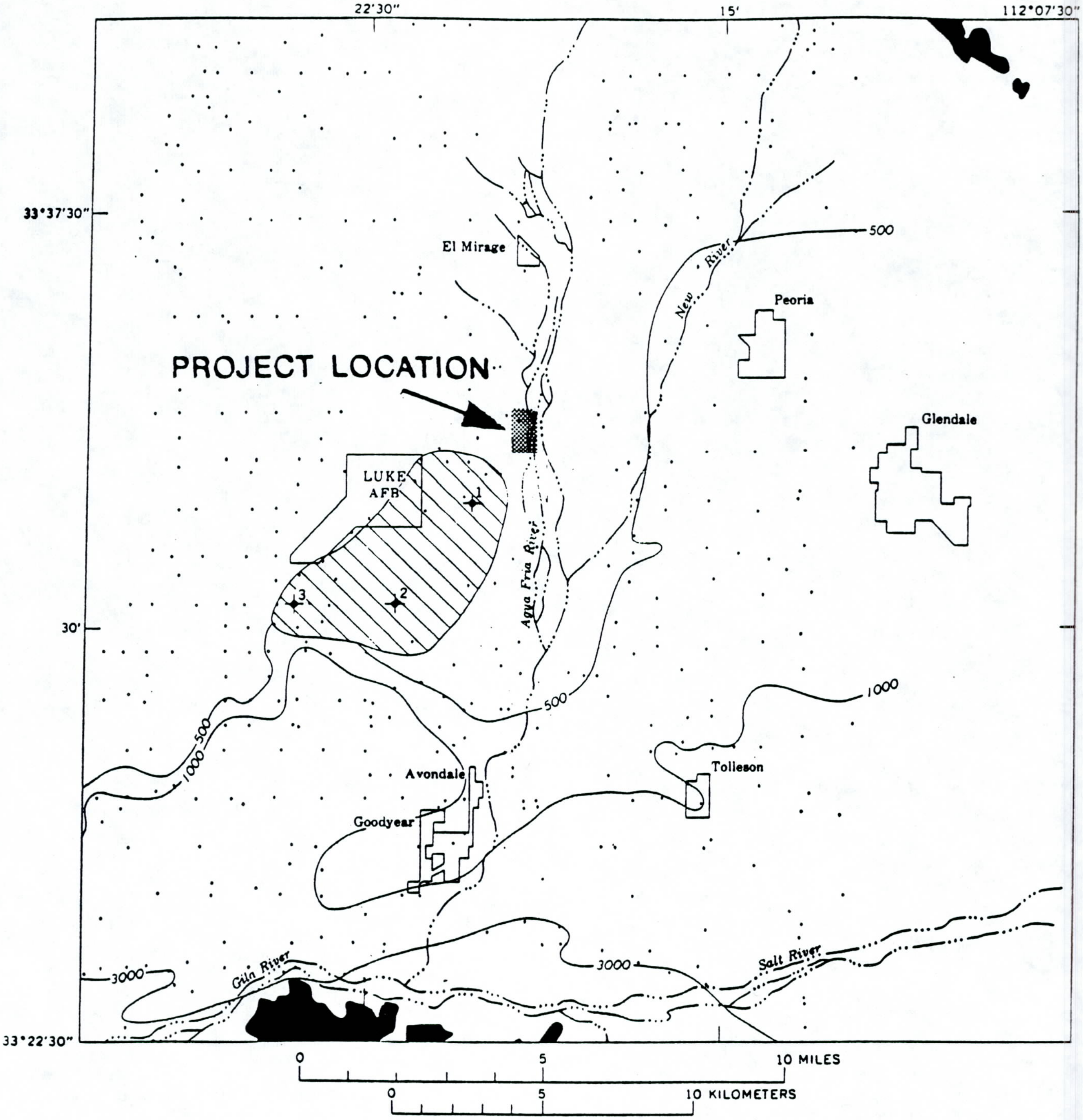


Ground-water salinity in western Salt River Valley. Contours show total dissolved solids, in milligrams per liter. Small dots are wells whose salinity values were used in preparation of the map. Crosshatching indicates area of brackish to saline water ranging erratically in salinity from 500 to more than 9,000 mg/l. Large dots with ticks show location of the three wells that penetrated halite. Solid pattern represents areas of exposed bedrock.

*(From Eaton et al., 1972)

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BROWNING-FERRIS INDUSTRIES
PROPOSED CHOLLA SANITARY LANDFILL
MARICOPA COUNTY, ARIZONA

GROUND-WATER SALINITY IN THE WSRV

FIGURE 11

PROJECT NO. 372-15.01

APPENDIX A

CLIMATOLOGICAL DATA

TABLE A-1

MEAN MONTHLY AND ANNUAL
TEMPERATURES AND PRECIPITATION
YOUNGTOWN STATION, YOUNGTOWN, ARIZONA

CLIMATOLOGICAL SUMMARY

YOUNGTOWN

9634

MEANS FOR PERIOD 1941 - 1970 EXTREMES FOR PERIOD 1931 - 1972

LATITUDE: 33° 36'
LONGITUDE: 112° 18'
ELEV. (FT.): 1135

| Month | Temperature (°F) Means: Daily maximum | Means: Daily minimum | Means: Monthly | Extremes: Record highest | Year | Record lowest | Year | Mean degree days** | Precipitation Totals (Inches): Mean | Greatest daily | Year | Snow, Sleet, Hail: Mean | Maximum monthly | Year | Estimated mean relative humidity (percent): 0600 MST | 1800 MST | Mean number of days: precip. .10 inch or more | Temperatures Max.: 90° and above | Max.: 32° and below | Min.: 32° and below | Min.: 0° and below | Month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A) | 22 | 21 | 21 | 33 | | 33 | | 16 | 25 | 35 | | 25 | 35 | | | | 25 | 17 | 17 | 17 | 17 | (A) |
| JAN | 66.5 | 35.0 | 50.8 | 87 | 1971 | 17 | 1937* | 415 | 0.76 | 1.60 | 1951 | T | T | 1949 | 59 | 32 | 2 | 0 | 0 | 11 | 0 | JAN |
| FEB | 70.9 | 38.6 | 54.8 | 91 | 1957 | 20 | 1960* | 278 | 0.72 | 1.45 | 1958 | T | T | 1966* | 58 | 27 | 2 | * | 0 | 5 | 0 | FEB |
| MAR | 76.4 | 42.0 | 59.2 | 99 | 1971 | 24 | 1971* | 186 | 0.83 | 1.36 | 1941 | T | T | 1966 | 50 | 19 | 2 | 1 | 0 | 2 | 0 | MAR |
| APR | 84.5 | 48.3 | 66.4 | 105 | 1931 | 33 | 1960* | 52 | 0.38 | 1.42 | 1952 | T | T | 1942 | 39 | 14 | 1 | 8 | 0 | 0 | 0 | APR |
| MAY | 93.4 | 55.7 | 74.6 | 115 | 1934 | 38 | 1965* | 7 | 0.07 | 0.40 | 1941 | 0.0 | 0.0 | | 31 | 10 | * | 23 | 0 | 0 | 0 | MAY |
| JUN | 102.4 | 65.2 | 83.8 | 118 | 1970* | 49 | 1932 | 0 | 0.11 | 0.55 | 1958 | 0.0 | 0.0 | | 27 | 10 | * | 29 | 0 | 0 | 0 | JUN |
| JUL | 106.3 | 74.7 | 90.5 | 119 | 1961* | 56 | 1935 | 0 | 0.82 | 1.65 | 1964 | 0.0 | 0.0 | | 43 | 28 | 2 | 31 | 0 | 0 | 0 | JUL |
| AUG | 103.5 | 73.1 | 88.3 | 117 | 1937* | 54 | 1968* | 0 | 1.05 | 3.00 | 1939 | 0.0 | 0.0 | | 52 | 24 | 2 | 31 | 0 | 0 | 0 | AUG |
| SEP | 99.2 | 65.2 | 82.2 | 116 | 1945 | 46 | 1941 | 0 | 0.63 | 2.40 | 1970 | 0.0 | 0.0 | | 47 | 22 | 1 | 28 | 0 | 0 | 0 | SEP |
| OCT | 88.1 | 52.8 | 70.5 | 107 | 1934 | 25 | 1935 | 18 | 0.73 | 1.71 | 1964 | 0.0 | 0.0 | | 49 | 27 | 1 | 16 | 0 | 0 | 0 | OCT |
| NOV | 77.1 | 42.0 | 59.6 | 96 | 1934 | 21 | 1935 | 172 | 0.52 | 1.73 | 1941 | 0.0 | 0.0 | | 50 | 31 | 1 | 1 | 0 | 2 | 0 | NOV |
| DEC | 67.8 | 35.6 | 51.7 | 89 | 1950 | 21 | 1968* | 399 | 1.03 | 1.80 | 1967 | T | T | 1965 | 61 | 36 | 3 | 0 | 0 | 10 | 0 | DEC |
| YEAR | 86.3 | 52.4 | 69.4 | 119 | JUL 1961* | 17 | JAN 1937* | 1527 | 7.65 | 3.00 | AUG 1939 | T | T | MAR 1966* | 47 | 23 | 17 | 168 | 0 | 30 | 0 | YEAR |

SOURCE: Sellers and Hill, ed., 1974.

APPENDIX B

GEOPHYSICAL REPORT

# RESULTS OF A SEISMIC REFRACTION AND REFLECTION SURVEY OVER PORTIONS OF THE CENTRAL PART OF EL MIRAGE QUADRANGLE MARICOPA COUNTY ARIZONA

Prepared For:

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November 10, 1988

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FIGURES



TABLES

# INTRODUCTION

This report describes the results of seismic work performed in the central portion of the U.S.G.S. El Mirage 7 1/2 minute Maricopa County, Arizona quadrangle. The work was conducted between the dates of 12 September and 17 September, 1988, and was performed at the request of EMCON Associates. The study area includes portions of Sections 25, 26, 35, and 36, T3N, R1W (Plate 1) and was part of a subsurface investigation intended to evaluate the suitability of a proposed waste disposal site.

Primary objective of the seismic geophysical work was to locate earth fissures, especially in the west half of Section 36. Secondary objectives were to provide information on depth and thickness of gravel deposits.

The approach was three-fold:

1. To first test seismic methods over a known earth fissure using conventional seismic techniques.
2. Then, if successful, use the same techniques over other assigned areas of interest to see if any similar fissure evidence could be detected.
3. If conventional techniques proved unfeasible, to test the applicability of shear wave energy generation as an alternative procedure.

The test over the known fissure was successful and it was not necessary to use shear wave generation devices.

A glossary of geophysical terms used in this report is included in Appendix A.

# CONCLUSIONS

1. The initial conventional test seismic line (Line 1) which was run across a known fissure zone in Section 35, clearly indicated the presence of fissuring by producing heavy energy attenuation of the traces beyond the fissure from the corresponding shot point on the other side of the fissure. The seismic method was successful in the test area, using conventional methods.

2. Other seismic coverage conducted on the west half of Section 36 and along the south line of Sections 25 and 26 revealed no similar evidence of fissures or fissuring causing energy transmission attenuation.

3. Seismic refraction data showed undulating, discontinuous and lenticular strata of varying velocities under Section 36. The velocities when correlated with drill hole data, will help to identify gravel layers.

# METHODOLOGY

The field procedures were designed to use the general principal of seismic wave attenuation in fissure detection as described by Wrege, et al. (1985, p. 121). The work by Wrege, et al. found that seismic surface waves generated by shear wave energy generation devices and detected in the horizontal component are noticeably attenuated when they cross an earth fissure. By orienting seismic lines so that they cross fissure zones, the fissure locations are shown by sudden decreases of surface wave amplitude. Conversations with Mr. Gus Harrell of the Bureau of Reclamation revealed that longitudinal or "P" wave motion is also attenuated across the fissures. In other words, all seismic waves are effected.

The work of Wrege, et al. (1985, p. 121) was an experimental project by the U. S. Geological Survey near Hawk Rock and Picacho Mountains, Arizona, using shear wave energy and horizontal component geophones. Mr. Harrel indicated that the Bureau of Reclamation has successfully used conventional refraction - reflection seismic methods to locate fissures along irrigation canals in the Phoenix, Arizona area. This conventional approach fit our own thinking and experience and, therefore, was what we proposed to try first although we were also prepared to resort to shear wave analysis if necessary.

Field work for the study covered by this report was conducted between September 13 and September 17, 1988. The first day was devoted to laying out seismic survey lines and locating drill hole locations for shot points. Subsequent time was spent conducting the seismic surveys. Seismic spread parameters are listed in Table 1 and spread locations are shown on Plate 1.

Seismic signals for most of the spreads were generated using two patented Betsy blank shot gun shells loaded with 500 grains of black powder. The shells were placed in holes drilled from three to eight feet deep, tamped with water and mud and detonated with a standard electrical detonator. Distance between shot points was approximately 330 feet, depending on specific offsets from geophones number 1, 6, 7, and 12 respectively. The seismic signals were detected using twelve standard vertical component geophones with 8 hertz (Hz) characteristic design frequency placed along a line at 60 foot intervals. All shot points of each spread were laid out in line and were offset from 0 to 30 feet from the nearest geophone depending on whether the geophone was number 1, 6, 7, or 12 of the spread involved. Seismic signals generated by the blast were recorded with minimum or no gain control and no filtering on a Geometrics Model ES1225 digital recorder and amplifier. This included all energy waves, both refracted and reflected as generated by the Betsy shots and recorded by the system. No particular distinction of various wave forms and types was made except that the characteristics of the seismic generation and recording system would inherently cause the recorded waves to be mostly compressional waves and the P component of surface waves. Each record was then transmitted in the field to a laptop computer and stored on 3.5 inch floppy discs for later processing.

Table 1: Seismic spread parameters. Location coordinates run from west to east or south to north according to line azimuth.

| Line No. | Spread No. | Shot No. | Spread Azimuth (Geoph. #1 to #12) | Location Coordinates (ft) Geoph. 1 | Shot Pt | Shot Depth | Location of Line Coordinate Base |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | W | 330 | 0 | 8 | 1150' N & 2100' W |
| | 1 | 2 | W | 330* | 330 | 7 | of SE cnr, Sect. 35 |
| | 1 | 3 | W | 330 | 660 | 8 | |
| | 1 | 4 | E | -330* | -330 | 8 | |
| 2 | 2 | 45 | W | -330 | -330 | 4 | 1500' N & 2100' W |
| | 2 | 46 | W | -330 | -660 | 5 | of SE cnr, Sect. 35 |
| | 2 | 47 | E | -990* | -990 | 3 | |
| 3 | 3 | 8 | E | 330* | 330 | 7 | 270' W of SW cnr, |
| | 3 | 9 | E | 330 | 0 | 6 | Sect. 36 |
| | 3 | 10 | E | 330 | 660 | 6 | |
| | 3 | 12 | W | 990 | 1320 | 5 | |
| | 4 | 13 | E | 990 | 1320 | 5 | |
| | 4 | 14 | E | 990* | 990 | 4 | |
| | 4 | 15 | E | 990 | 660 | 5 | |
| | 5 | 16 | W | 1980 | 1650 | 8 | |
| | 6 | 17 | W | 2310 | 1980 | 4 | |
| | 7 | 18 | W | 2640 | 2310 | 3 | |
| | 8 | 19 | W | 2970 | 2640 | 4 | |
| | 8 | 20 | W | 2970* | 2970 | 4 | |
| 4 | 9 | 21 | E | 0 | 0 | 5 | 2400' N of SW cnr, |
| | 9 | 22 | E | 0 | 330 | 5 | Sect. 36 |
| | 10 | 23 | E | 330 | 660 | 5 | |
| | 11 | 24 | E | 660 | 990 | 5 | |
| | 12 | 25 | E | 990 | 1320 | 7 | |
| | 13 | 26 | E | 1320 | 1650 | 5 | |
| | 13 | 27 | W | 1980* | 1980 | 4 | |

Table 1: (Continued).

| Line No. | Spread No. | Shot No. | Spread Azimuth (Geoph. #1 to #12) | Location Coordinates (ft) Geoph. #1 | Location Coordinates (ft) Shot Pt | Shot Depth | Location of Line Coordinate Base |
|---|---|---|---|---|---|---|---|
| 5 | 14 | 28 | E | -330* | -330 | 8 | |
| | 14 | 29 | E | -330 | 0 | 7 | 2740' W of NW cnr; |
| | 15 | 30 | E | 0 | 330 | 7 | Sect. 36 |
| | 16 | 31 | E | 330 | 660 | 8 | |
| | 17 | 32 | E | 660 | 990 | 8 | |
| | 18 | 33 | E | 990 | 1320 | 8 | |
| | 19 | 34 | E | 1320 | 1650 | 8 | |
| | 20 | 35 | E | 1650 | 1980 | 8 | |
| | 21 | 36 | E | 1980 | 2310 | 9 | |
| | 22 | 37 | E | 2310 | 2640 | 6 | |
| | 23 | 38 | E | 2640 | 2970 | 7 | |
| | 24 | 39 | E | 2970 | 3300 | 6 | |
| | 25 | 40 | E | 3300 | 3830 | 4 | |
| | 26 | 41 | E | 3830 | 3960 | 5 | |
| | 27 | 42 | E | 3960 | 4290 | 3 | |
| | 28 | 43 | E | 4290 | 4620 | 0 | |
| | 28 | 44 | W | 4950 | 5280 | 0 | |
| 6 | 29 | 48 | S | 2310* | 2310 | 4 | |
| | 29 | 49 | S | 2310 | 1980 | 5 | |
| | 30 | 50 | S | 1980 | 1650 | 5 | |
| | 31 | 51 | S | 1650 | 1320 | 6 | |
| | 32 | 52 | S | 1320 | 990 | 5 | |
| | 33 | 53 | S | 990 | 660 | 7 | |
| | 34 | 54 | N | 0 | 330 | 7 | |
| | 34 | 55 | N | 0* | 0 | 4 | |

* Shot point geophone offset five feet to side of shot point.

Note: "Shot numbers refer to individual shot points recorded by a unique set of geophone locations. A "spread" is a unique layout of geophones. One spread may be used to record one or more shots. A "line" consists of one or more contiguous spreads.

For the easternmost spread on Line 5 (Plate 1) a "common offset" method of shooting and recording was used. Here, a sledge hammer was used to generate signals. A signal was generated 60 feet east of and on line from each geophone on the spread and recorded at each successive geophone from 1 through 12. Signals at successive geophones were recorded one at a time by "freezing" all signals except the one geophone recording the shot. This procedure was also the one used by the Bureau of Reclamation. Because of the weaker hammer energy it did not prove as satisfactory for total penetration depth and was slower than the more conventional procedure earlier described. The common offset procedure was not used on any other locations.

Lines 1 and 2 (Plate 1) were laid out across a known fissure zone in order to test the use of conventional seismic shooting to detect fissures. Appendix B shows records of the raw, unprocessed data from each seismic line. The records are shown exactly as recorded with no filtering or any other alteration. Each line contains several records, one for each shot point. Each record has twelve traces, one for each geophone. Surface features noted in the field showed fissures at locations 0.0' and -240'. The locations of shot points and known fissures are shown on each record along Spread 1 (Lines 1 and 2). The arrows above each record indicate the direction of travel of the seismic signal on each record. The signal propagates outward from each shot point across the individual records. As noted on Line 1, Shots 1, 2, and 4, where a fissure is crossed the signal level or amplitude is sharply reduced or disappears altogether. Fissure detection involved only visual examination of the raw records. Neither refraction nor reflection analysis was required for this phase.

After verifying efficacy of this method of fissure detection, additional lines designated by EMCON were surveyed using seismic methods on and around the property of interest. Locations of the lines and the shot points are shown on Plate 1.

Upon completion of the field work, the data were processed. In addition to fissure analysis, refraction analyses were performed along each line using the generalized reciprocal method (Palmer, 1980). These analyses were performed at the request of EMCON in order to estimate thicknesses of gravel deposits. Resultant geophysical cross sections were constructed and are shown in Appendix C. These cross sections were also used to make conventional corrections for the relatively low velocity, near surface "weathered" layer when processing records for reflection analysis.

The seismic records were also analysed for reflections. Purpose of the analyses was to determine if anomalous reflections could be discerned associated with fissures. Reflection processing (Dobrin, 1976) included conventional post-recording filtering, normal moveout corrections and so called statics (weathering and topography) corrections and common depth point stacking. In order to improve the visual appearance and continuity of the reflections recorded so as to enhance interpretation, shot and geophone locations were modified by up to 30 feet on some spreads prior to stacking. This simply involved a conventional fitting process. The processed reflection records are shown in Appendix D. All of the processing parameters with the exception of normal moveout velocities are shown on each record. The normal moveout velocities are shown in Table 2. Layer velocities shown in Table 2 were derived from density data in Eaton, et al. (1972, Figure 10).

Table 2: Velocity functions used for normal movement corrections. Velocities were derived from data in Eaton, et al. (1972, Figure 10).

| Formation | Velocity (ft/sec) | Depth (Ft) | Time to Formation (ms) | Reflection Coefficient |
|---|---|---|---|---|
| 1 | 2600 | 0 | 0.000 | 0.0000 |
| 2 | 6000 | 50 | 0.038 | 0.3953 |
| 3 | 6600 | 250 | 0.105 | 0.0476 |
| 4 | 7700 | 600 | 0.211 | 0.0769 |
| 5 | 9600 | 650 | 0.224 | 0.1098 |
| 6 | 9600 | 900 | 0.276 | 0.0000 |
| 7 | 9600 | 1200 | 0.339 | 0.0000 |
| 8 | 7600 | 1500 | 0.401 | -0.1163 |
| 9 | 15000 | 1700 | 0.454 | 0.3274 |

# DISCUSSION

The primary purpose of Lines 1 and 2 was to test the fissure detection method used in this study. Line 1 was placed over a zone of known fissures marked on Plate 1. Line 2 was offset slightly north of Line 1 in order to avoid crossing a pond. Line 2 was run to see if the fissure zone extended westward beyond those noted on the surface. These two lines, plotted together in Appendix B, definitely show the fissure locations on Line 1 and no fissures on Line 2. Fissure locations are marked on the individual records in Appendix B. Appendix B contains copies of the unprocessed records along each line. Arrows at the top of each record indicate the direction of travel of seismic waves from each shot. Shots at spread center (between geophones 6 and 7) are noted by a pair of arrows pointing away from spread center. Spread one is the only spread which records abnormal rates of attenuation of wave amplitude.

Lines 1 and 2 were also processed for reflections (Appendix D). Unusually good energy transmission was obtained as the energy from the blank shotgun shells was sufficient to reach depths of 1700 feet and detect the probable top of the Luke Salt Body (Eaton, et al., 1972). A sharp reflection, probably representative of this body, is present just before the end of the record (roughly 500 milliseconds in time after shot instant). This reflection and some other, less obvious, shallower reflections may be noted where they occur on all the lines in Appendix D. The reflection believed from the Luke Salt Body is labeled and highlighted where it occurs. Along some lines, notably 3 and 5, the reflection arrived too late to be recorded.

Based on the character of unprocessed seismic records over the known fissure zone in Section 35, there is no suggestion of fissuring present on any lines except Line 1.

Figure 1 is a synthetic seismogram of the velocities and depths listed in Table 2. Synthetic seismograms are computer derived, theoretical models of expected seismic parameters and responses. They are prepared as an aid to interpretation and as confirmation of acquired field data. They are prepared from any source believed to have some reasonable relevance to subsurface conditions in any particular project.

The synthetic seismogram in Figure 1 indicates that, in addition to a sharp reflection from the Luke Salt Body, there should be a less prominent reflection from a layer at about 200 milliseconds. The reflection at about 200 milliseconds in Figure 1 had no consistent counterpart along the lines surveyed. The data in Figure 1 came from a well (Eaton, et al. 1972, Well No. 1) about three miles southwest of the survey site. The intermediate layer probably does not correlate with any of the numerous reflecting layers marked in Appendix D. In fact, except for the Luke Salt Body, none of the reflections seem to have any significant lateral extent and are not considered important to this study. The reflections match the lenticular nature of the basin fill deposits. This is very common in most Arizona basins and therefore was expected.

The records were also processed for refraction analysis. The

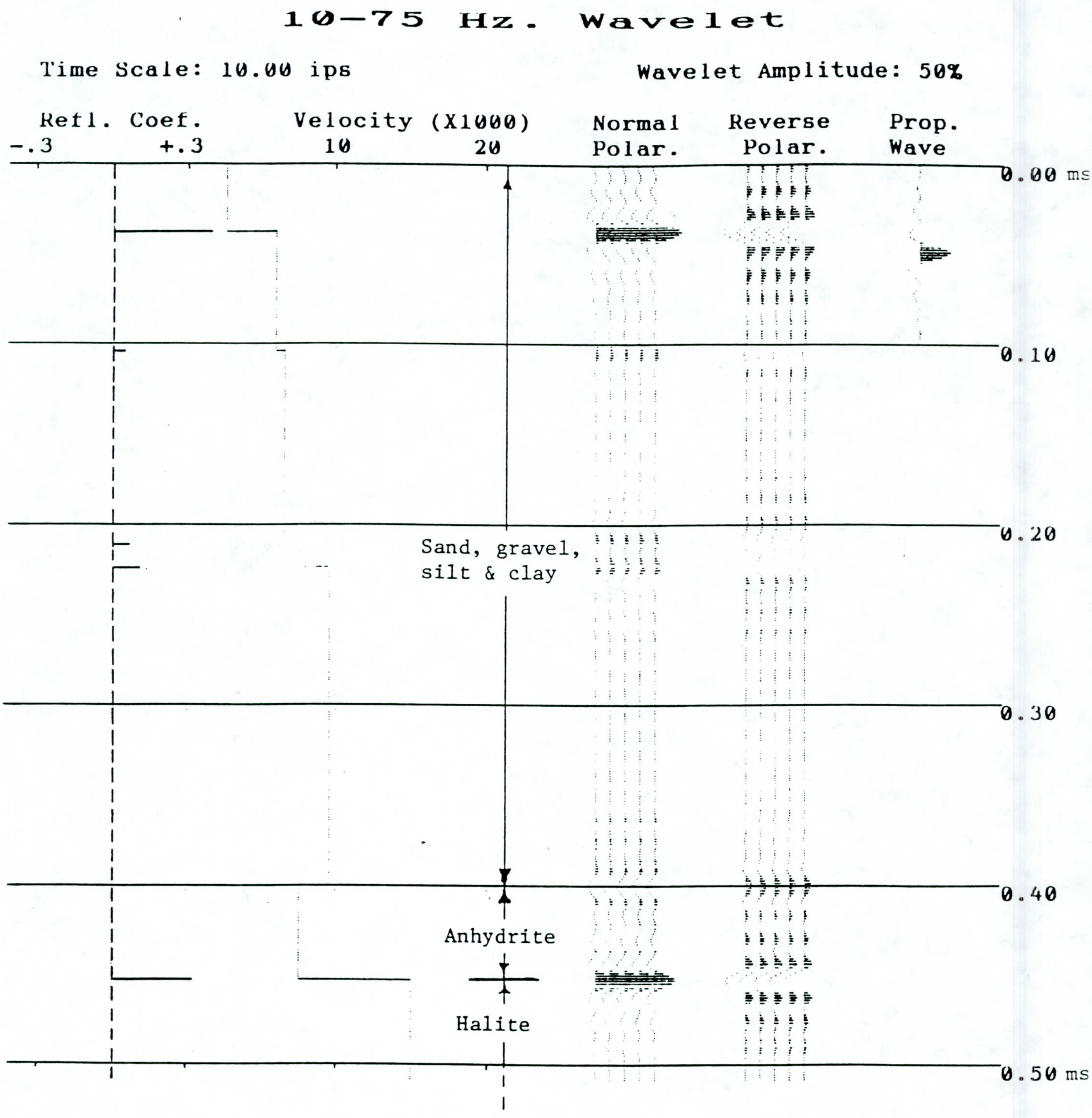
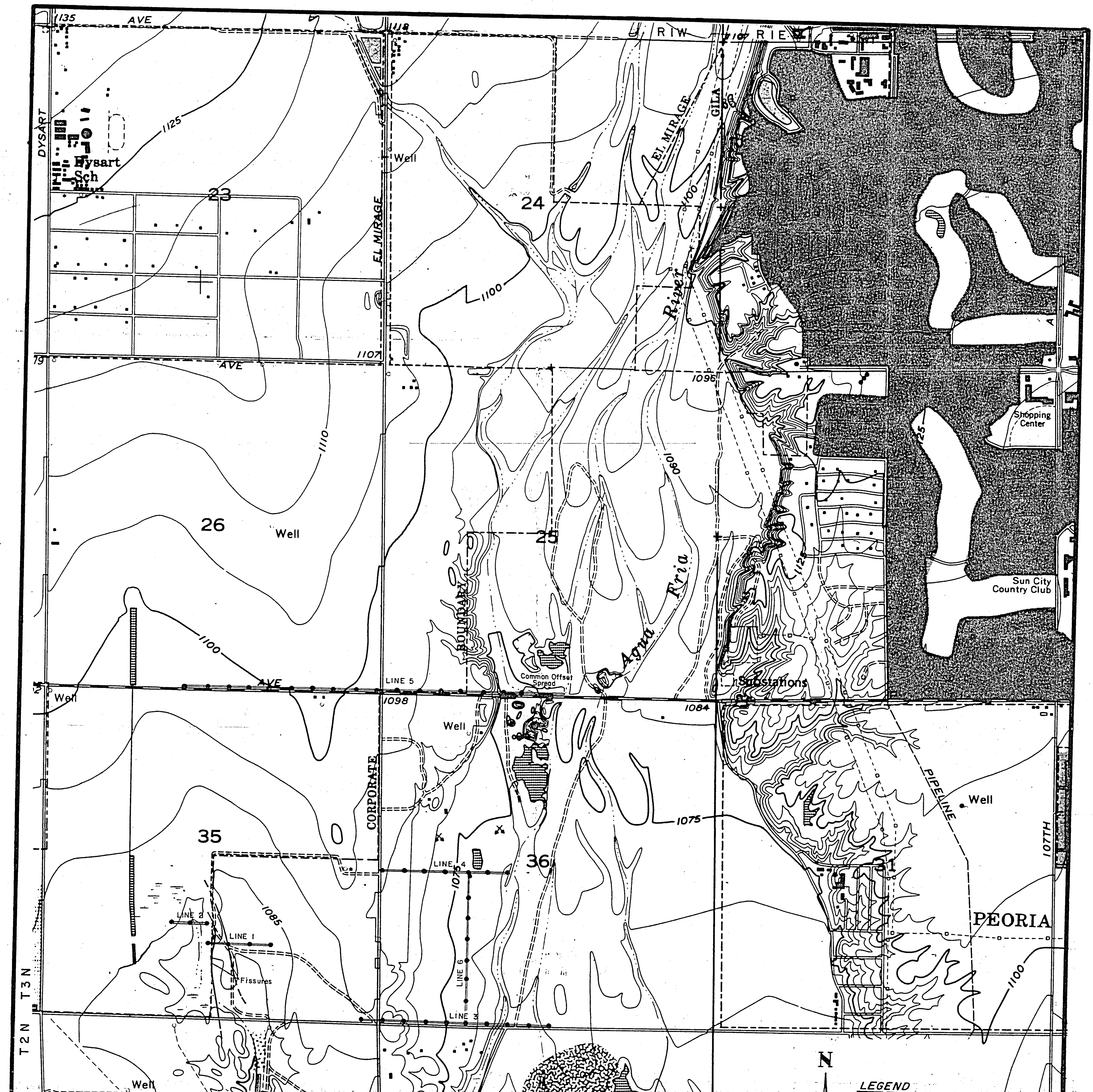



Figure 1: Synthetic seismogram using velocity function calculated from density data in Eaton, et al. (1972, Figure 10).

results of the analysis are shown in a series of geophysical cross sections in Appendix C. The velocities in each layer are noted on the cross sections. In order to effectively use the records for evaluation of gravel reserves, the geophysical cross sections should be compared with drill hole records to identify the velocity characteristics of various types of lithologies.


LUKE PROJECT, ARIZONA
LOCATION OF SEISMIC SPREADS
PLATE I
LEGEND
Shot Point
Line of Geophone Spreads
SCALE
0
1000
2000
N
REVISIONS
Date
By
3-20-87
RWD
Prepared for:
EMCON ASSOCIATES
Phoenix, Arizona
Prepared by:
TERRAMETRICS ASSOCIATES
Tucson, AZ.
Laramie, WY.
Date: 9/24/86
Drawn by:
App: KWD
Scale:
LINE 1
LINE 2
LINE 3
LINE 4
LINE 5
LINE 6
Common Offset Spread
Fissures
Well
Dysart Sch
DYSART
EL MIRAGE
GILA
BOUNDARY
CORPORATE
ROAD
MERIDIAN
PIPELINE
107TH
AVE
Agua Fria River
PEORIA
Shopping Center
Sun City Country Club
Substations
R1W
R1E
T3N
T2N
23
24
25
26
35
36
31
1125
1110
1107
1100
1098
1095
1090
1085
1084
1075
1060

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Wrege, Beth M., Wilfred P. Hasbrouck, and Herbert H. Schumann, 1985, Seismic surface-wave attenuation across earth fissures in the alluvium, south-central Arizona: NWWA Conference on Surface and Borehole Geophysical Methods in Ground Water Investigations, February 12-14, 1985, Fort Worth, TX.

APPENDICES

# APPENDIX A

# GLOSSARY OF TERMS

Common depth point stack - A sum of traces which correspond to the same subsurface reflection point, but which are from different profiles and have different offset distances. The traces are corrected for statics and normal moveout before summing (or stacking).

Filtering - The process of attenuating unwanted seismic wave frequencies.

Geophone - The instrument used to transform seismic energy into an electrical voltage; a seismometer, a jug, or pickup.

Line - A linear arrangement of one or more seismic spreads to form a record section.

Normal Moveout - The variation of reflection arrival time because of variation in the shotpoint-to-geophone distance (offset). Normal moveout depends on velocity and (to a lesser extent) dip as well as offset and decreases with reflection time.

P-Wave - An elastic body wave in which particle motion is in the direction of propagation. The type of seismic wave assumed in conventional seismic exploration. Also called compressional wave, longitudinal wave, primary wave, pressure wave, dilatational wave, and irrotational wave.

Record - A recording of the energy from one shot (or other type of energy release) picked up by a spread of geophones. May be on photographic or other paper or on magnetic tape.

Record Section - Display of seismic traces side-by-side to show the continuity of events. Record sections were originally made by splicing together individual seismic records (and hence the name) but the entity of individual records now has been largely lost.

Reflection - The energy or wave from a shot or other seismic source which has been reflected (returned) from an acoustic-impedance contrast (reflector) or series of contrasts within the earth. The objective of most reflection-seismic work is to determine the location and attitude of reflectors from measurements of the arrival time of primary reflections and to infer from the reflectors the geologic structure and stratigraphy.

Reflection Survey - A program to map geologic structure employing the seismic-reflection method. Measurements are made of the arrival time of events attributed to seismic waves which have been reflected from interfaces where the acoustic impedance changes. The objective usually is to map variations in the depth and attitude of the interfaces, which usually are parallel to the bedding. A second objective is to define stratigraphic variations from normal-moveout measurements or from the amplitude and character of reflection events.

Refraction - The change in direction of a seismic ray upon passing into a medium with a different velocity.

Refraction Survey - A program to map geologic structure by using head waves. Head waves involve energy which enters a high-velocity medium (refractor) near the critical angle and which travels in the high-velocity medium nearly parallel to the refractor surface. Head wave arrivals are identified in terms of time after the shot and of distance from the shot. The objective is to determine the arrival times of the head waves in order to map the depth to the refractors in which they traveled.

Shear Wave - A body wave in which the particle motion is perpendicular to the direction of propagation. Also called S-wave or transverse wave.

Shot Point - The location where an explosive charge is detonated in one hole or in a pattern of holes to generate seismic energy.

Spread - The layout of geophone groups from which data from a single shot are recorded simultaneously. One spread may be used to record data from one or several successive shots.

Stack - A composite record made by mixing traces from different records.

Statics - Corrections applied to seismic data to eliminate the effects of variations in elevation, weathering thickness, or weathering velocity. The objective is to determine the reflection arrival times which would have been observed if all measurements had been made on a (usually) flat plane with no weathering or low-velocity material present. The information on which these corrections are based derives from uphole-time data, refraction first breaks, and/or data-smoothing considerations.

Station - A ground position at which a geophysical instrument (gravity meter, geophone, etc.) is set up for an observation. Usually designated as a number which represents a multiple of geophone spacing.

Surface Wave - Energy which travels along or near the surface; ground roll. Includes Rayleigh, Love, hydrodynamic waves, etc. Also called interface wave.

Trace - A record of one seismic channel, electromagnetic channel, etc.

Transducer - A device which converts one form of energy into another.

Topographic Correction - A correction to seismic data to remove the effect of variable overburden thickness on seismic velocity in areas of large surface relief.

Weathering Correction - A correction of seismic reflection or refraction times to remove seismic travel time delays caused by the weathered or low velocity layer.

# APPENDIX B

## UNPROCESSED SEISMIC RECORDS

The records are annotated to show which record traces were recorded with each shot. The direction of travel of the seismic wave from each shot point is indicated by arrows. Where the shot point was at spread center (between geophones 6 and 7) two arrows, one on either side of the shot point, are used.

Fissure locations on the records for Lines 1 and 2 coincide with both the actual field location and with a sudden decrease in wave amplitudes. No other records showed discernible evidence of fissures.

1851-1

TERRAMETRICS ASSOCIATES

Tucson, AZ & Laramie, WY

Lines 1 & 2

Complete Processing Sequence:

History Created : 10/ 5/88 12:37pm

Last Run I/O Parameters:

Data Input From : ORIGINAL Data Files.

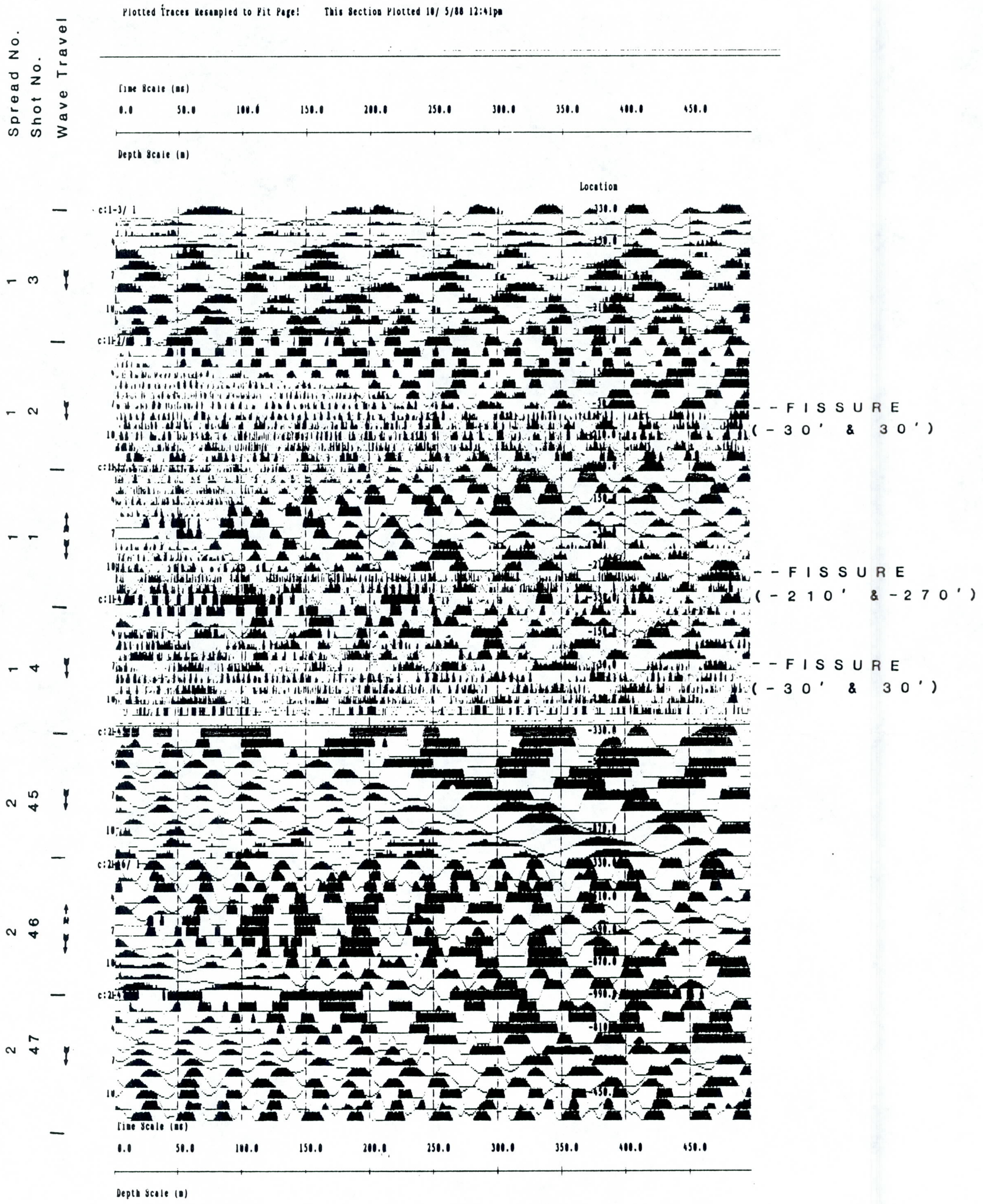
Processed Data Output To : Temporary TEST Data Files.

Display Parameters:

Selected Records Plotted Normal Polarity Normalize Traces is ON All Gains Adjusted by 1.00

Programmed Gain is OFF Automatic Gain Control is ON: Window Trailer = 30.00 ms,Leader = 30.00 ms,Scaled = 20 %

Plotted Traces Resampled to Fit Page! This Section Plotted 10/ 5/88 12:41pm



1851-3

TERRAMETRICS ASSOCIATES                                        Line 3

Tucson, AZ & Laramie, WY

Complete Processing Sequence:

History Created : 10/ 5/88 12:57pm

Last Run I/O Parameters:

Data Input From : ORIGINAL Data Files.

Processed Data Output To : Temporary TEST Data Files.

**Display Parameters:**

Selected Records Plotted    Normal Polarity    Normalise Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 10/ 5/00 01:02pm

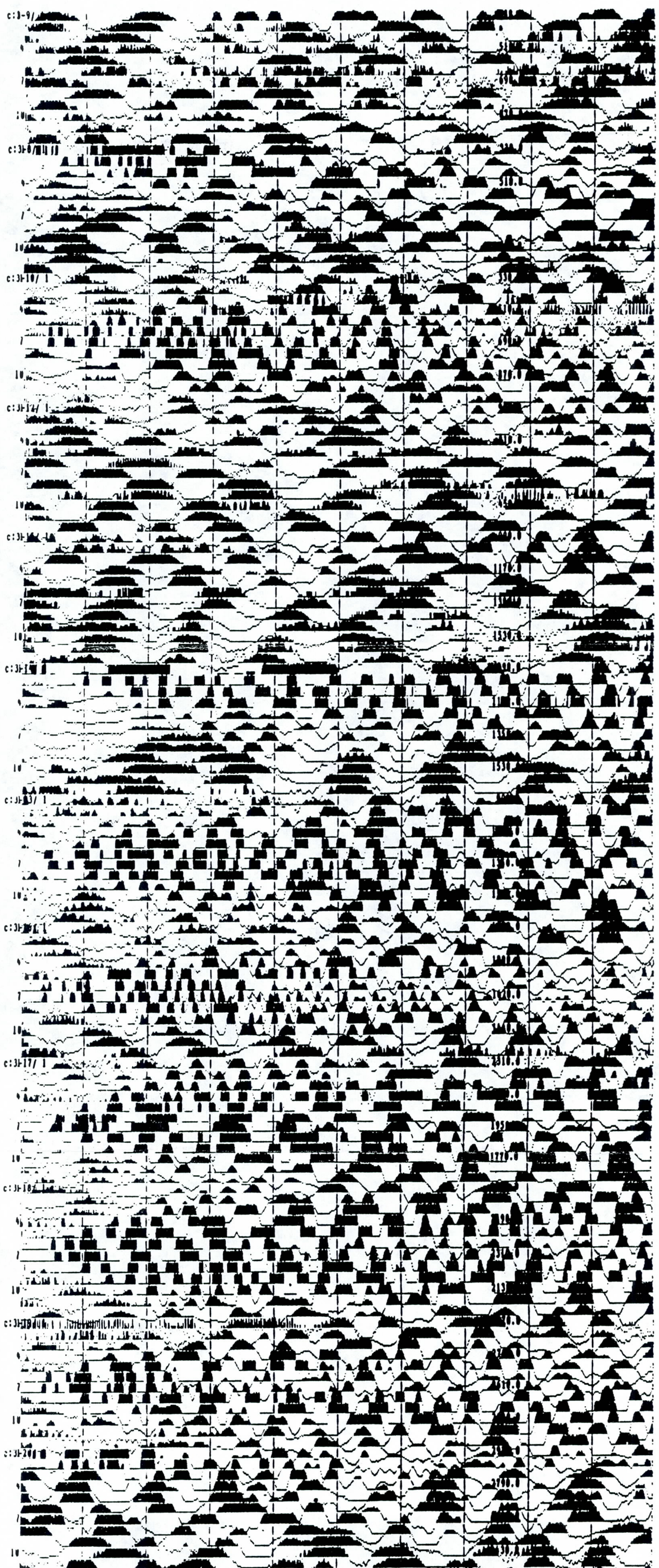
Time Scale (ms)

0.0  50.0  100.0  150.0  200.0  250.0  300.0  350.0  400.0  450.0

Depth Scale (m)

Location

| Spread No. | Shot No. | Wave Travel |
|---|---|---|
| 3 | 9 | |
| 3 | 8 | |
| 3 | 10 | |
| 3 | 12 | |
| 4 | 15 | |
| 4 | 14 | |
| 4 | 13 | |
| 5 | 16 | |
| 6 | 17 | |
| 7 | 18 | |
| 8 | 19 | |
| 8 | 20 | |



Time Scale (ms)

0.0  50.0  100.0  150.0  200.0  250.0  300.0  350.0  400.0  450.0

Depth Scale (m)

1851-4

TERRAMETRICS ASSOCIATES

Tucson, AZ & Laramie, WY

Line 4

Complete Processing Sequence:

History Created : 10/ 5/88 01:33pm

Last Run I/O Parameters:

Data Input From : ORIGINAL Data Files.

Processed Data Output To : Temporary TEST Data Files.

Display Parameters:

Selected Records Plotted    Normal Polarity    Normalize Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 10/ 5/88 01:35pm

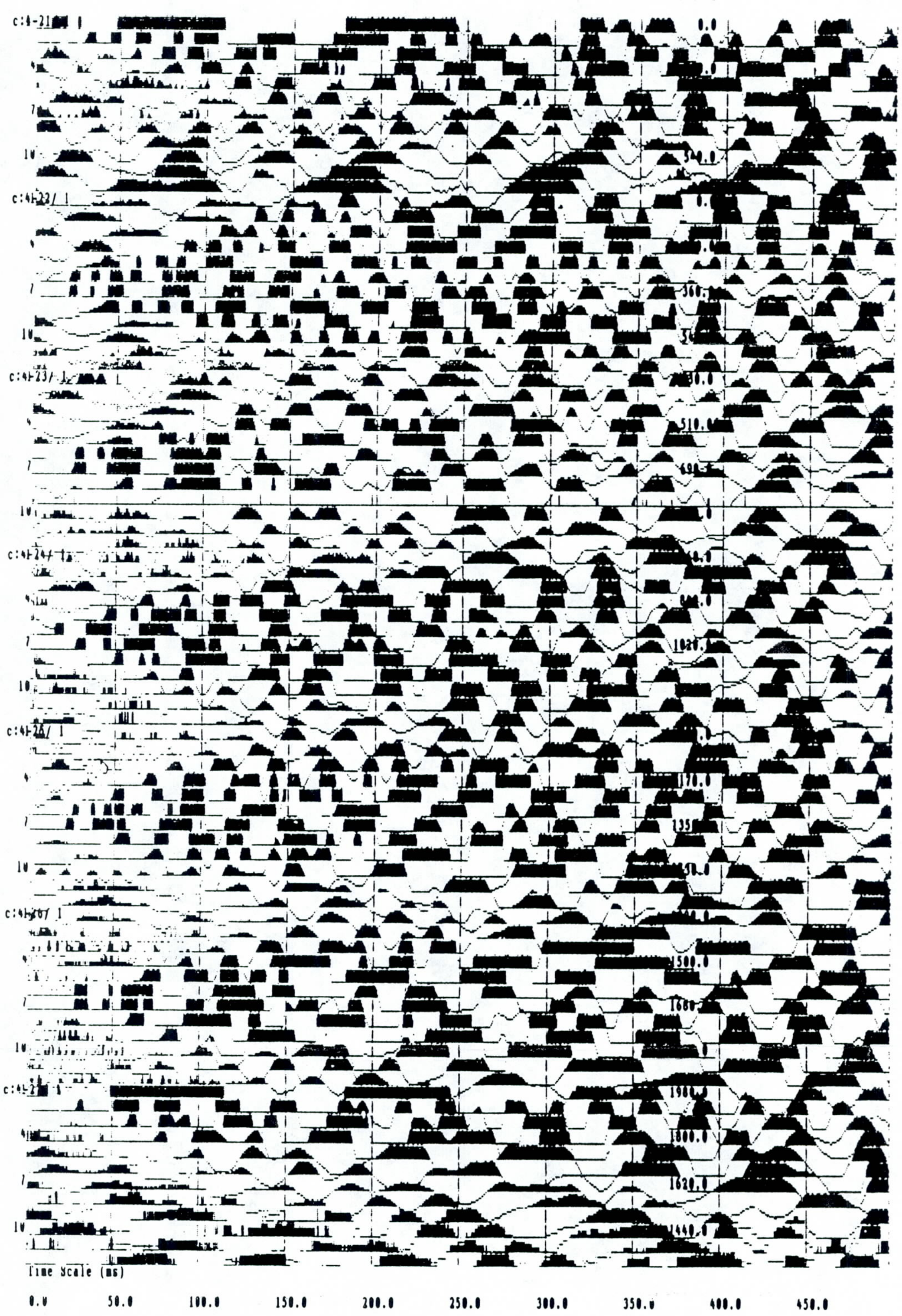
Spread No. | Shot No. | Wave Travel

Time Scale (ms)

0.0 50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0

Depth Scale (m)

Location



| Spread No. | Shot No. |
|---|---|
| 9 | 21 |
| 9 | 22 |
| 10 | 23 |
| 11 | 24 |
| 12 | 25 |
| 13 | 26 |
| 13 | 27 |

Time Scale (ms)

0.0 50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0

Depth Scale (m)

1851-5

TERRAMETRICS ASSOCIATES

Tucson, AZ & Laramie, WY

Line 5

**Complete Processing Sequence:**

**History Created : 10/ 5/88 02:18pm**

**Last Run I/O Parameters:**

**Data Input From :** ORIGINAL Data Files.

**Processed Data Output To :** Temporary TEST Data Files.

**Display Parameters:**

Selected Records Plotted    Normal Polarity    Normalize Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms,Leader = 30.00 ms,Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 10/ 5/88 02:21pm

Spread No.

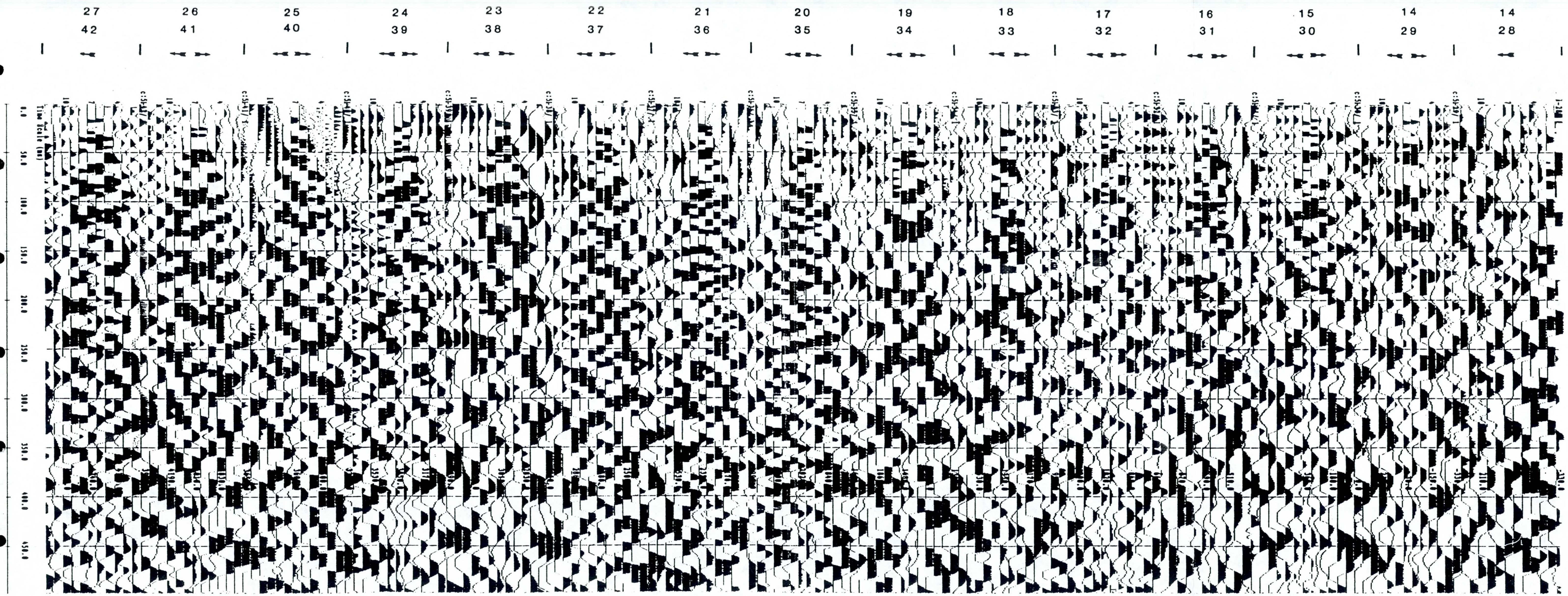
Shot No.

Wave Travel

Time Scale (ms)

0.0 50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0

Depth Scale (m)



27 42
26 41
25 40
24 39
23 38
22 37
21 36
20 35
19 34
18 33
17 32
16 31
15 30
14 29
14 28
Time Scale (ms)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
Location

1851-5A

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

East End of Line 5
Common Offset Spread

Complete Processing Sequence:

History Created : 10/ 5/88 02:50pm

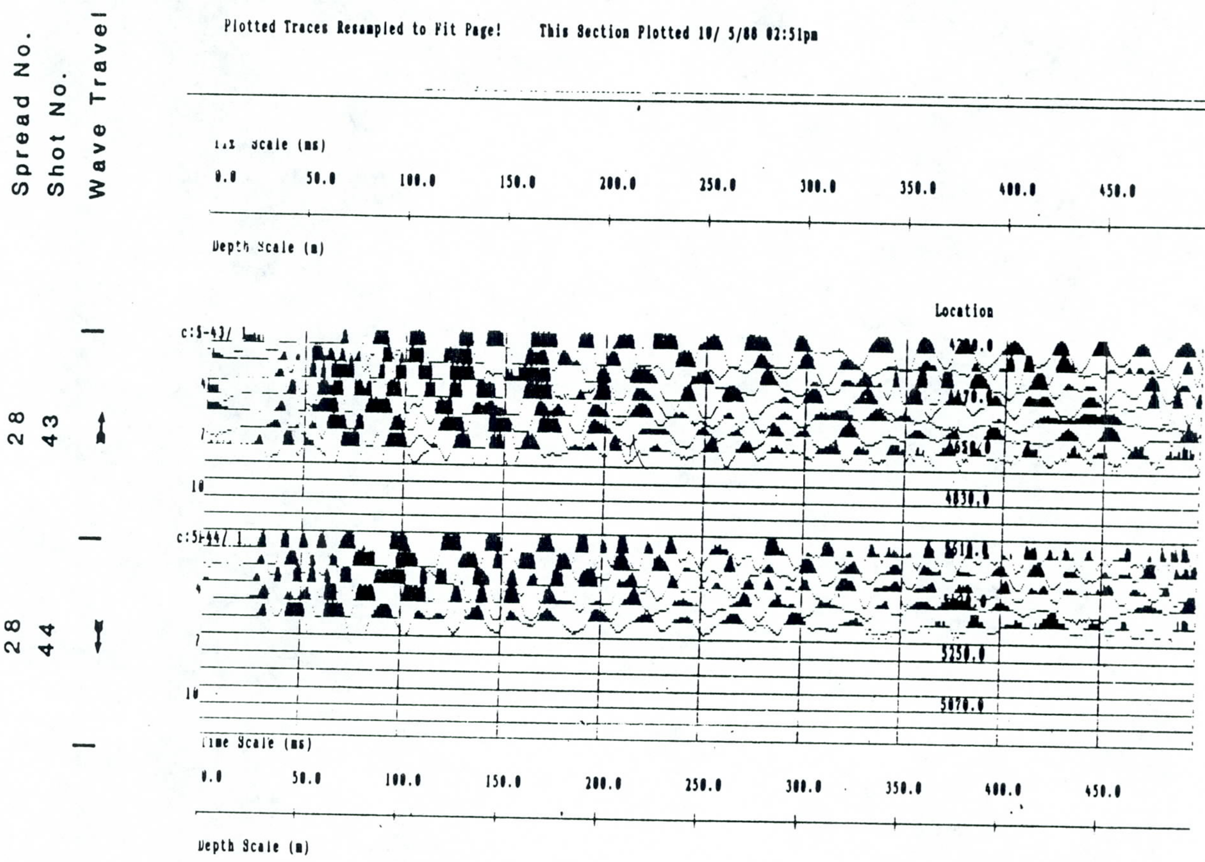
Last Run I/O Parameters:
Data Input From : ORIGINAL Data Files.
Processed Data Output To : Temporary TEST Data Files.

Display Parameters:

Selected Records Plotted    Normal Polarity    Normalize Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 10/ 5/88 02:51pm



1851-6

TERRAMETRICS ASSOCIATES

Tucson, AZ & Laramie, WY

Line 6

**Complete Processing Sequence:**

**History Created : 10/ 5/88 01:51pm**

**Last Run I/O Parameters:**

**Data Input From : ORIGINAL Data Files.**

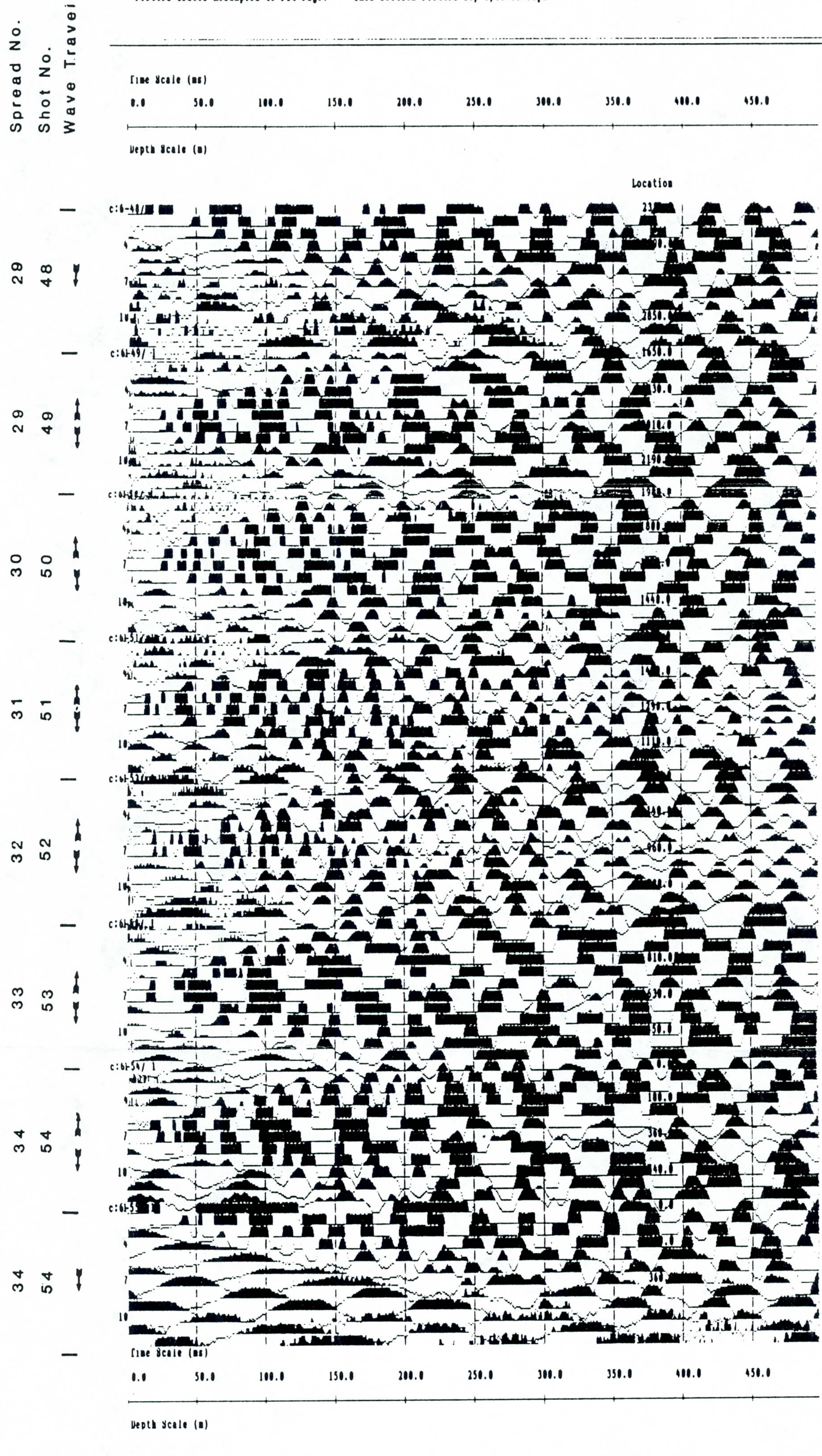
**Processed Data Output To : Temporary TEST Data Files.**

**Display Parameters:**

Selected Records Plotted    Normal Polarity    Normalize Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 10/ 5/88 01:53pm



## APPENDIX C

## REFRACTION CROSS SECTIONS

Station locations marked on sections are all 60 feet apart. Refraction station locations, when multiplied by 60, match trace locations in Appendices B & D.

Refraction interfaces normally are within 25% of the true interface depth. This means that where two refraction lines cross or join, there will not be an exact match of the seismic layering.

WEST EAST

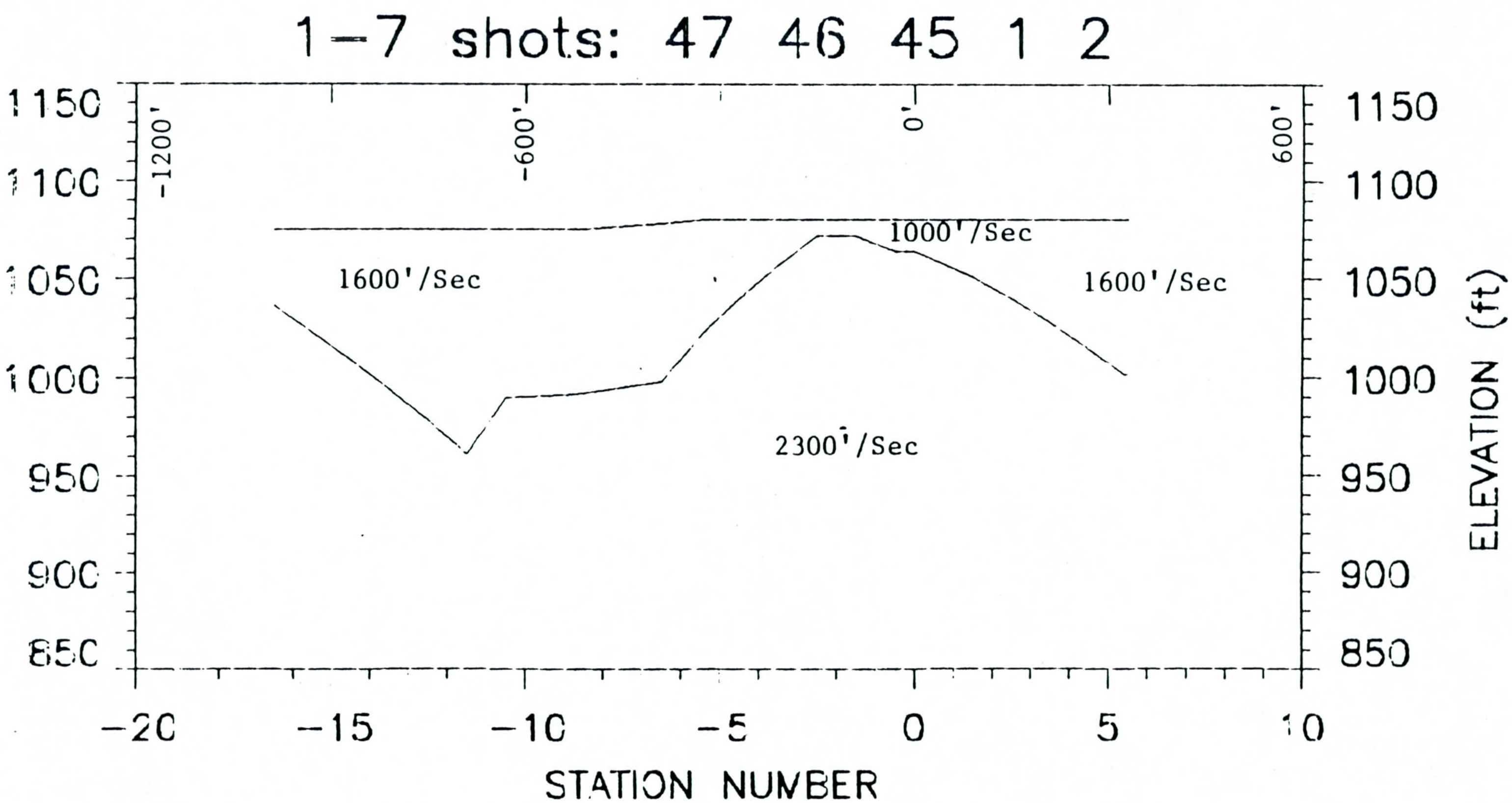



Figure 1-C: Geophysical cross section along Lines 1 and 2. Stations are 60 feet apart.

WEST

EAST

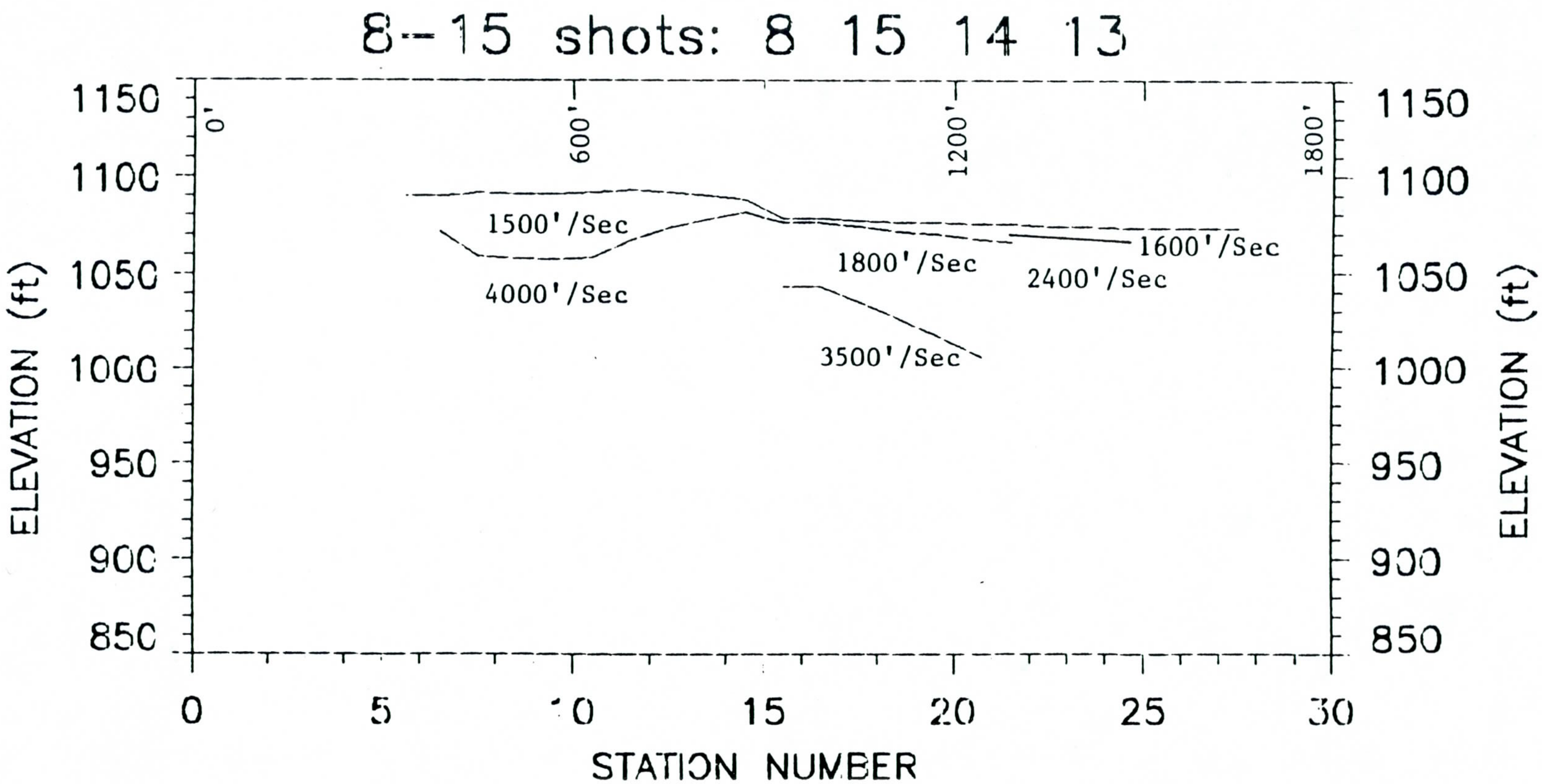



Figure 2-C: Geophysical cross section along west part of line 3. Stations are 60 feet apart.

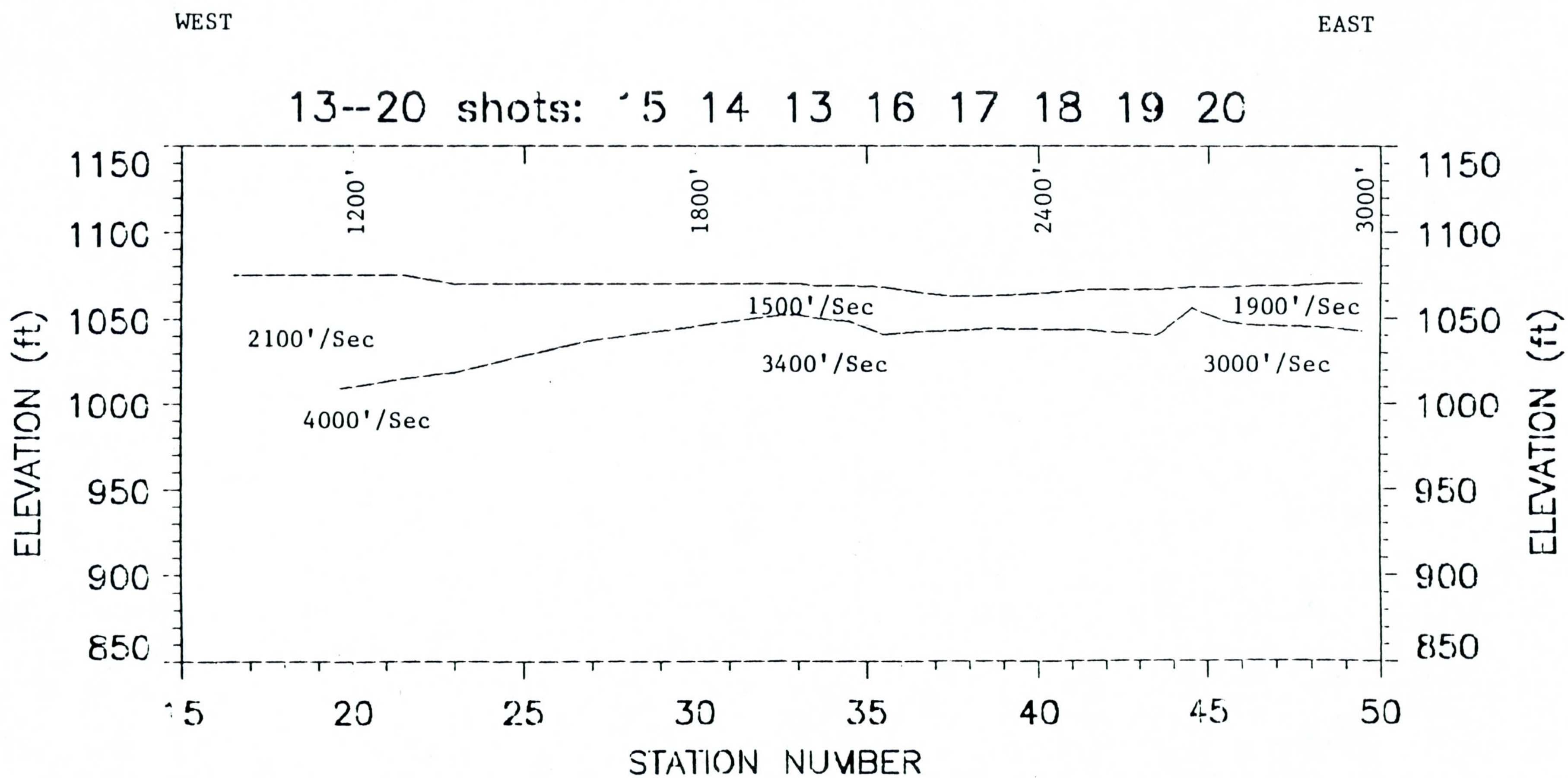



Figure 3-C: Geophysical cross section along east part of Line 3. Stations are 60 feet apart.

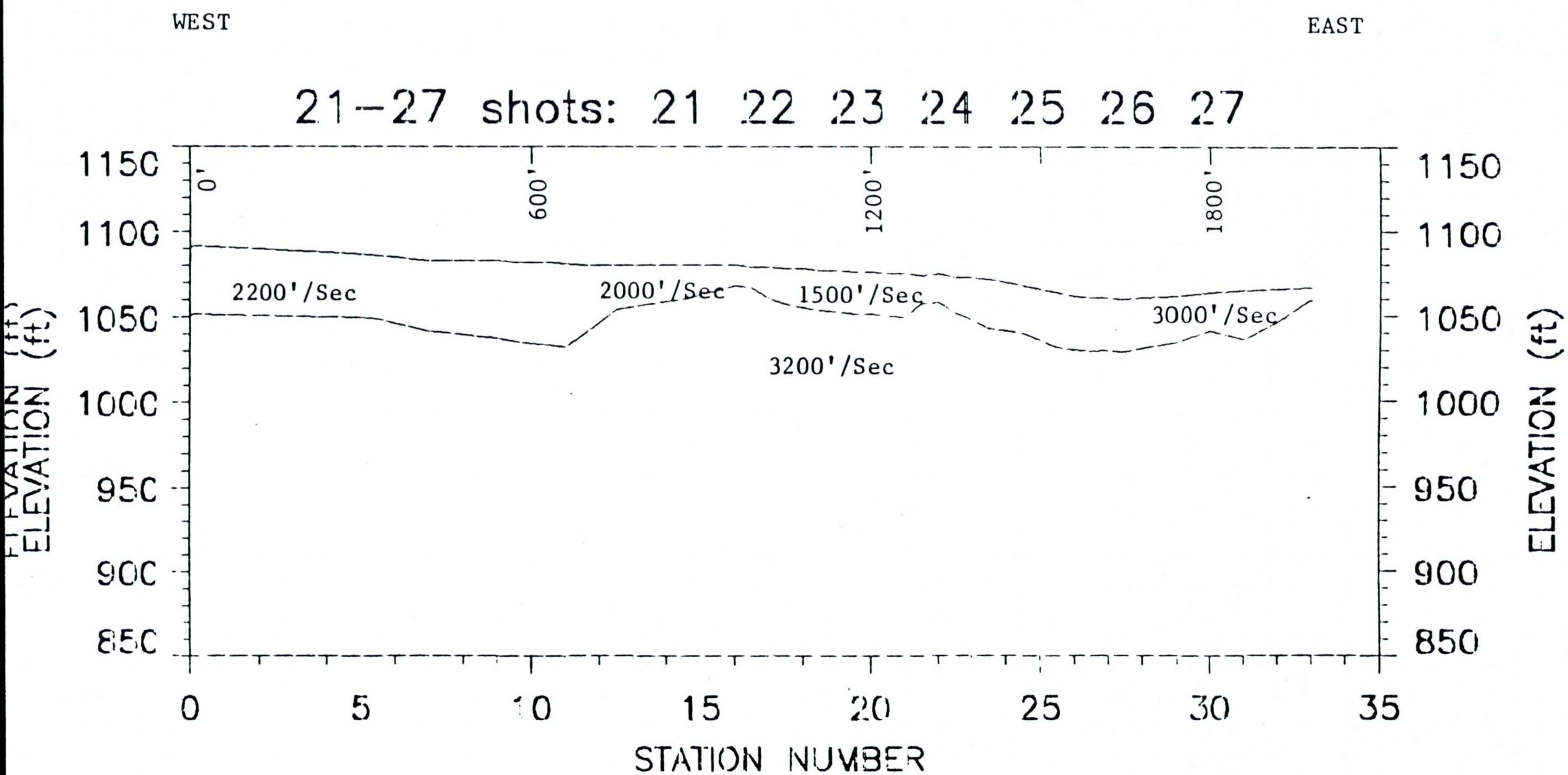



Figure 4-C: Geophysical cross section along Line 4. Stations are 60 feet apart.

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

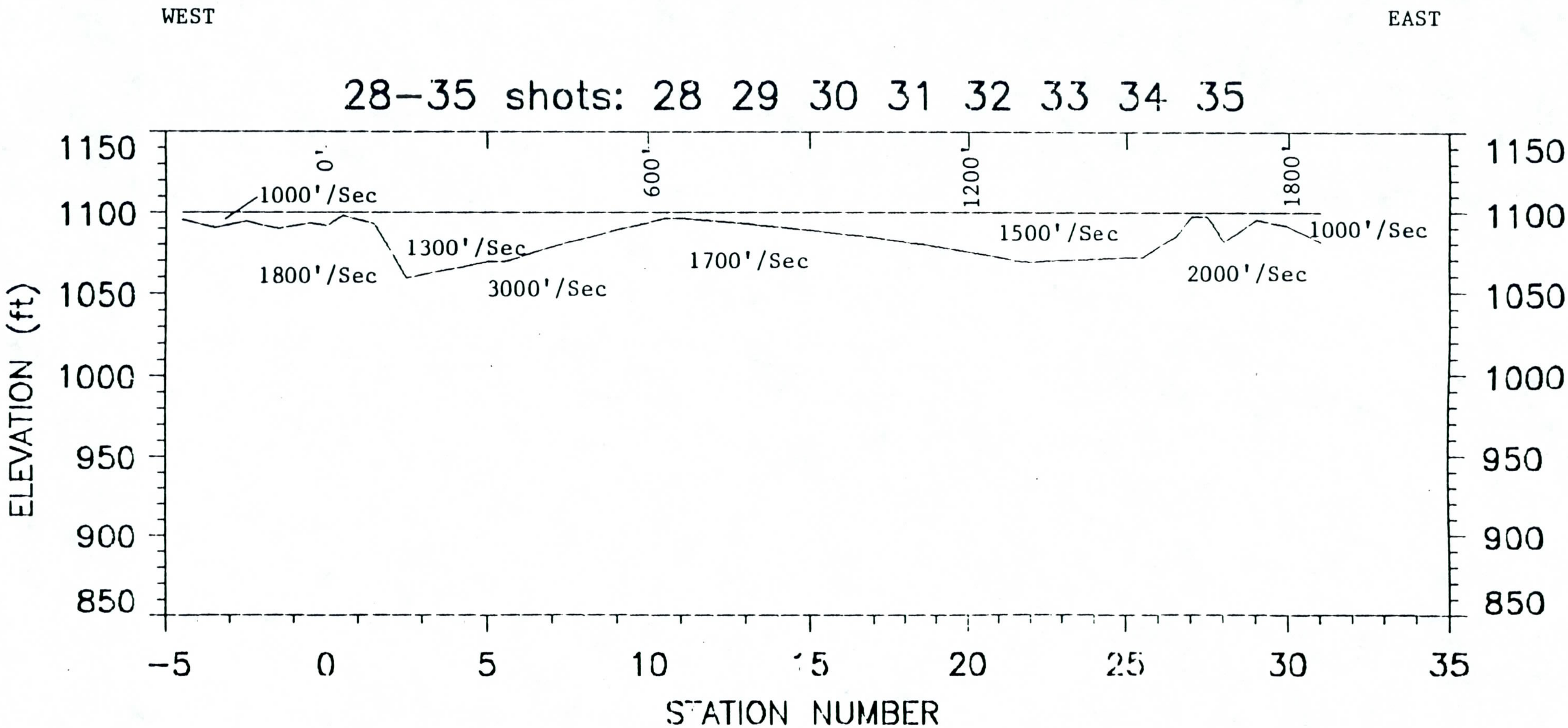



Figure 5-C: Geophysical cross section along west part of Line 5. Stations are 60 feet apart.

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

WEST

EAST

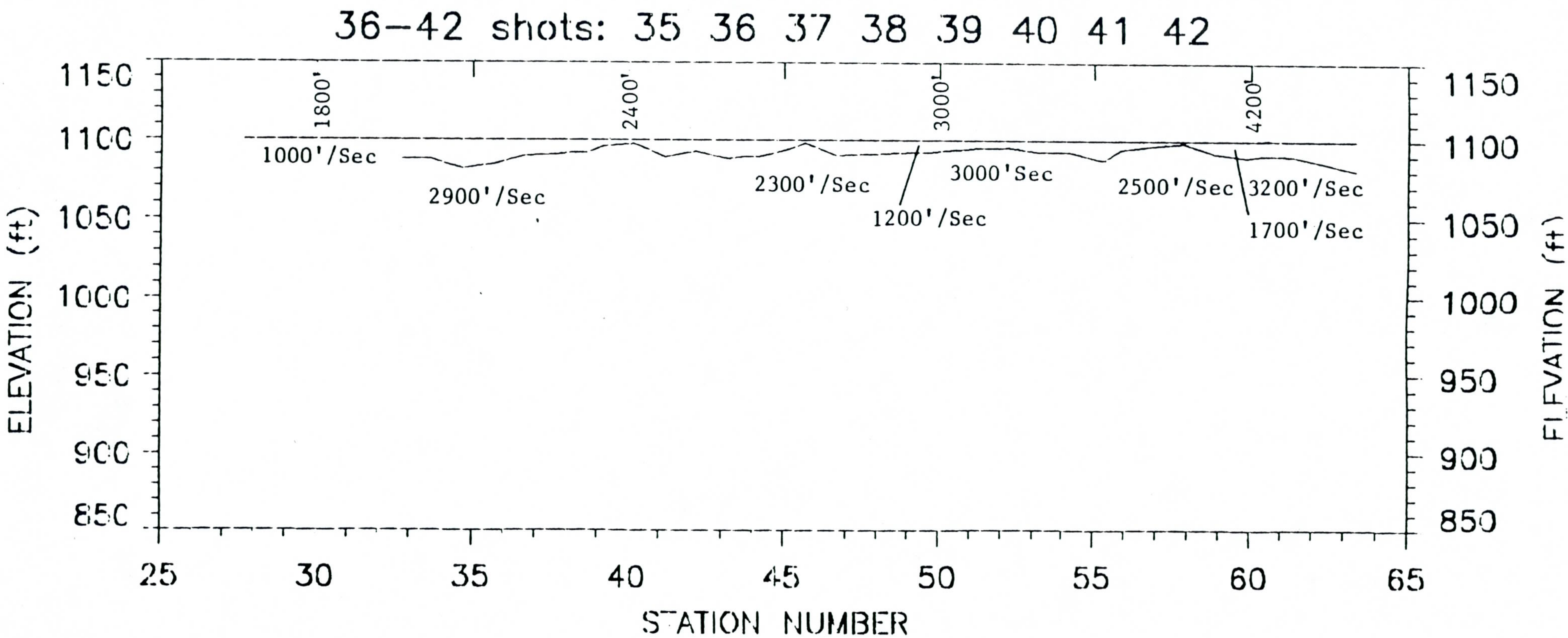



Figure 6-C: Geophysical cross section along east part of Line 5. Stations are 60 feet apart.

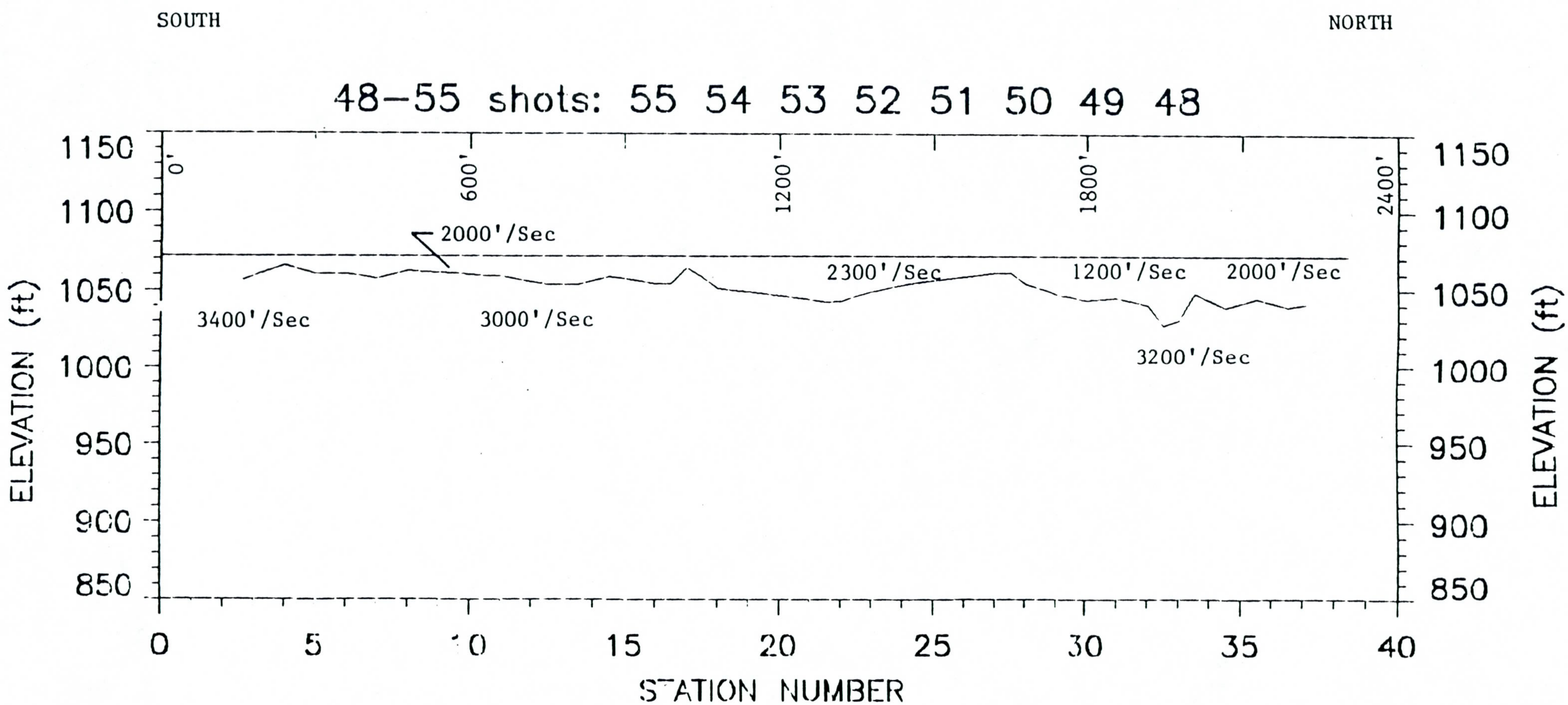



Figure 7-C: Geophysical cross section along Line 6. Stations are 60 feet apart.

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

# APPENDIX D

## PROCESSED SEISMIC REFLECTION RECORDS

The extent of each spread is noted by a horizontal bar and the spread number on the following records. The records are also annotated to indicate a probable reflection from the Luke Salt Body.

1851-1

TERRAMETRICS ASSOCIATES

Tucson, AZ & Laramie, WY

Lines 1 & 2

**Complete Processing Sequence:**

History Created : 9/22/88 06:37am

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 0.00 Off
Step 3: Shot and Receiver Statics Applied
Step 4: CDP Gather with Stack

Last Run I/O Parameters:

Data Input From : GATHERED Data Files.

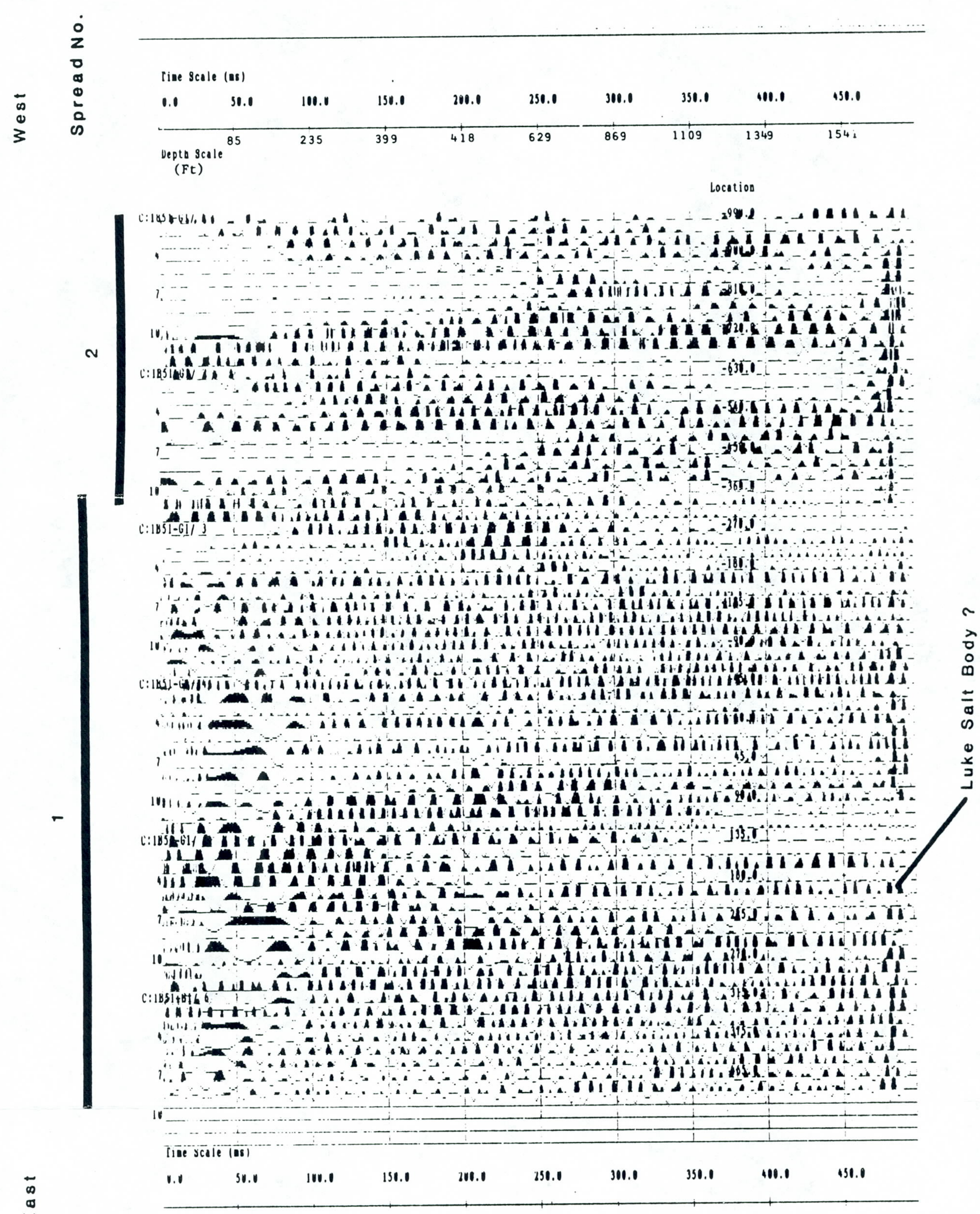
Processed Data Output To : Temporary TEST Data Files.

**Display Parameters:**

Selected Records Plotted — Normal Polarity — Normalize Traces is ON — All Gains Adjusted by 1.00

Programmed Gain is OFF — Automatic Gain Control is ON: Window Trailer = 30.00 ms,Leader = 30.00 ms,Scaled = 20 %

Plotted Traces Resampled to Fit Page! — This Section Plotted 9/23/88 07:04am



1851-3

TERRAMETRICS ASSOCIATES Line 3

Tucson, AZ & Laramie, WY

**Complete Processing Sequence:**

**History Created** : 9/21/88 12:37pm

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 0.00 Off
Step 3: Shot and Receiver Statics Applied
Step 4: CDP Gather with Stack

**Last Run I/O Parameters:**

**Data Input From** : GATHERED Data Files.

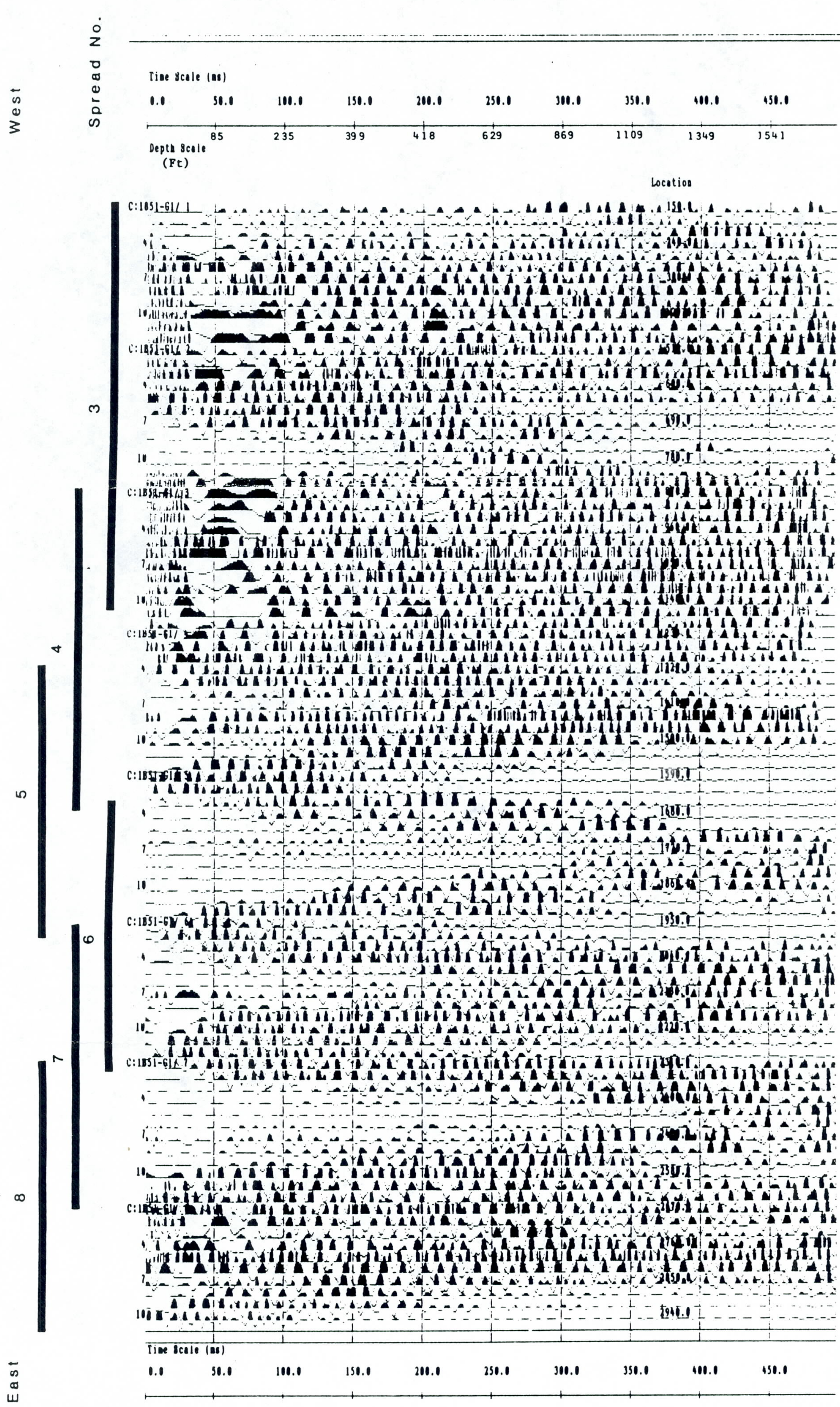
**Processed Data Output To** : Temporary TEST Data Files.

**Display Parameters:**

Selected Records Plotted Normal Polarity Normalize Traces is ON All Gains Adjusted by 1.00

Programmed Gain is OFF Automatic Gain Control is ON: Window Trailer = 30.00 ms,Leader = 30.00 ms,Scaled = 20 %

Plotted Traces Resampled to Fit Page! This Section Plotted 9/23/88 07:53am



1851—4

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

Line 4

**Complete Processing Sequence:**

History Created : 9/21/88 01:53pm

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 0.00 Off
Step 3: Shot and Receiver Statics Applied
Step 4: CDP Gather with Stack

**Last Run I/O Parameters:**

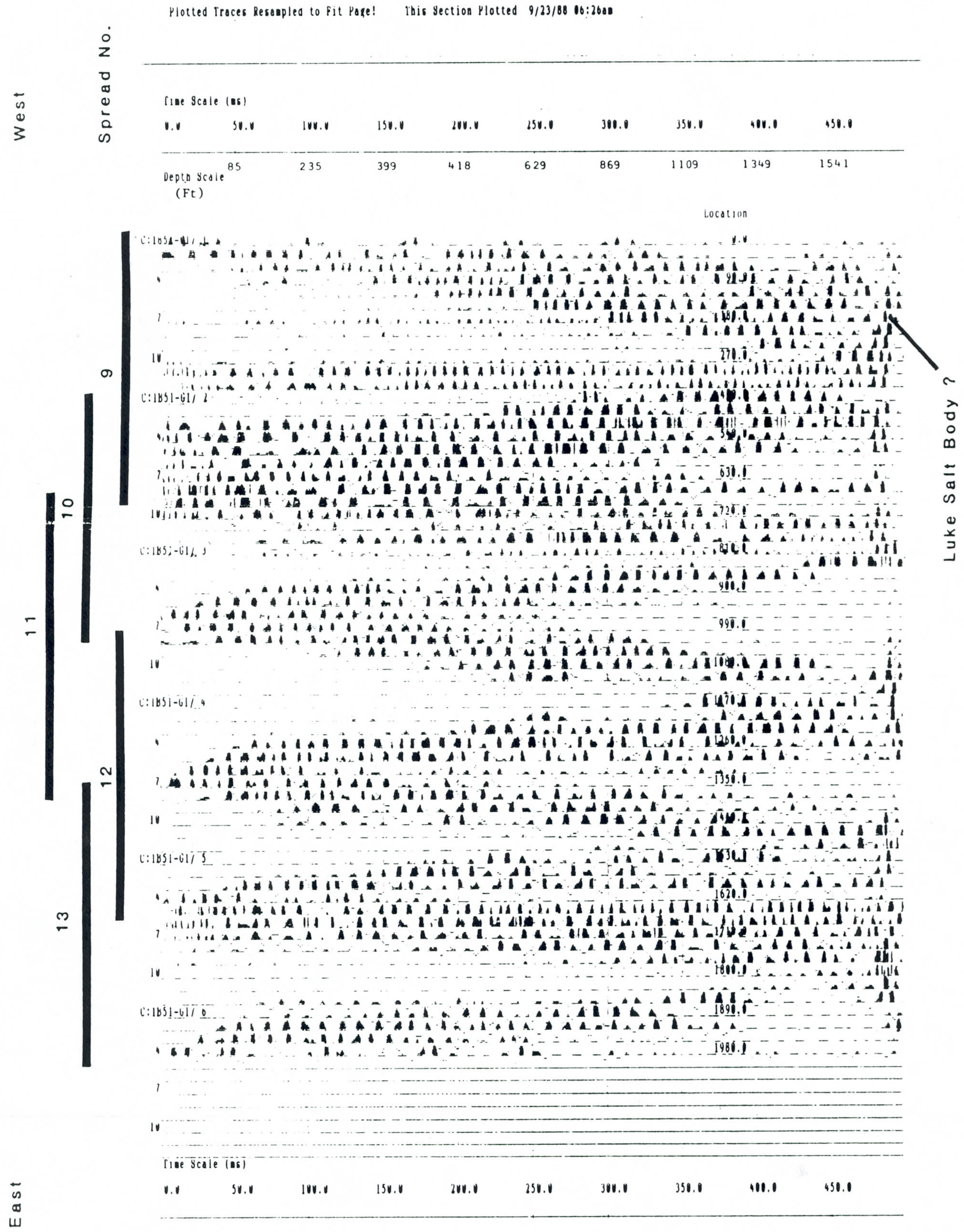
Data Input From : GATHERED Data Files.
Processed Data Output To : Temporary TEST Data Files.

**Display Parameters:**

Selected Records Plotted    Normal Polarity    Normalize Traces is ON    All Gains Adjusted by 1.00

Programmed Gain is OFF    Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page!    This Section Plotted 9/23/88 06:26am



1851-5

TERRAMETRICS ASSOCIATES

Line 5

Tucson, AZ & Laramie, WY

Complete Processing Sequence:

History Created : 9/20/88 06:17pm

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 0.00 Off
Step 3: Shot and Receiver Statics Applied
Step 4: CDP Gather with Stack

Last Run I/O Parameters:

Data Input From : GATHERED Data Files.

Processed Data Output To : Temporary TEST Data Files.

Display Parameters:

Selected Records Plotted     Normal Polarity     Normalize Traces is ON     All Gains Adjusted by 1.00

Programmed Gain is OFF     Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

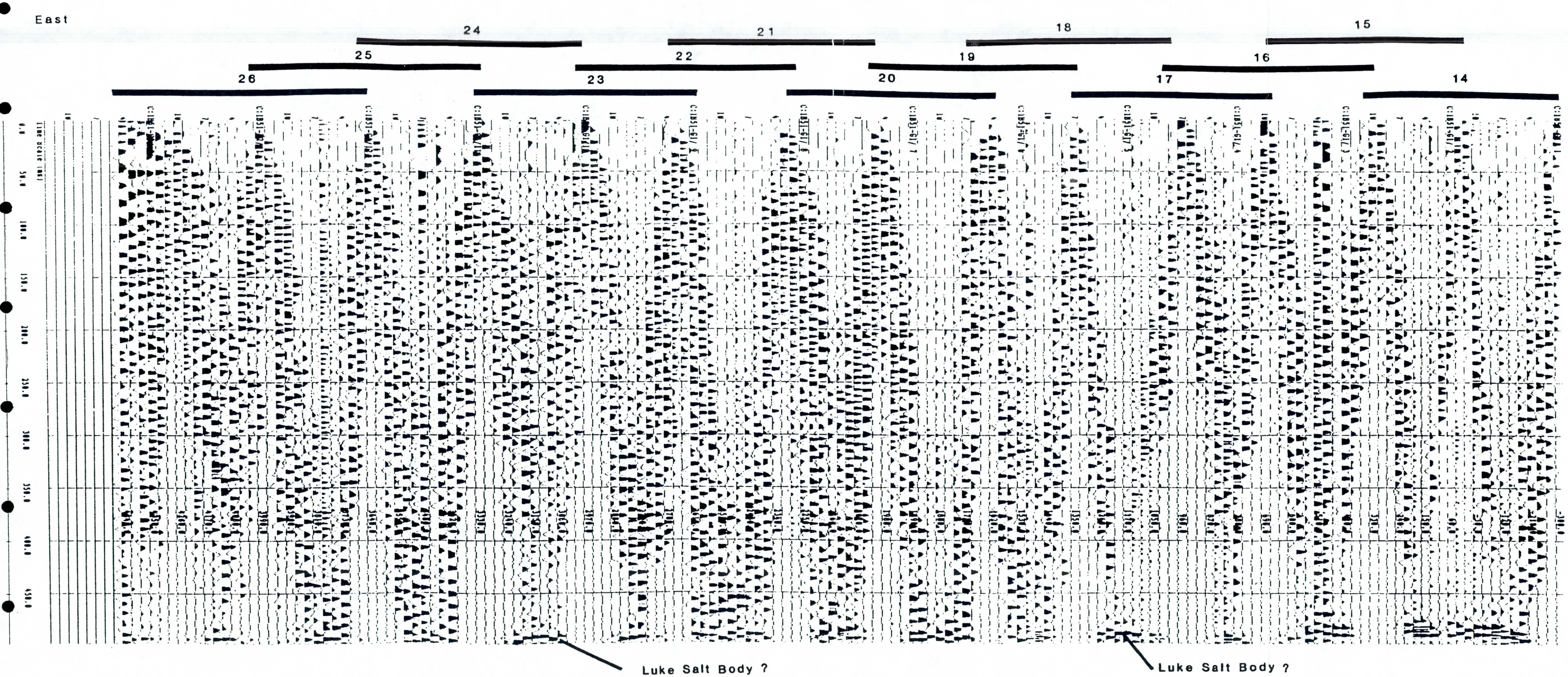
Plotted Traces Resampled to Fit Page!     This Section Plotted 9/23/88 09:18am

West

Spread No.

Time Scale (ms)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time Scale (ms) | 0.0 | 50.0 | 100.0 | 150.0 | 200.0 | 250.0 | 300.0 | 350.0 | 400.0 | 450.0 |
| Depth Scale (Ft) | | 85 | 235 | 399 | 418 | 629 | 869 | 1109 | 1349 | 1541 |


East
24
21
18
15
25
22
19
16
26
23
20
17
14
Time Scale (ms)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
Luke Salt Body ?
Luke Salt Body ?

1851-5A

TERRAMETRICS ASSOCIATES
Tucson, AZ & Laramie, WY

East End of Line 5
Common Offset Spread

Complete Processing Sequence:

History Created : 9/23/88 01:33pm

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 60.00 Off

Last Run I/O Parameters:

Data Input From : ORIGINAL Data Files.

Processed Data Output To : Temporary TEST Data Files.

Display Parameters:

Selected Records Plotted Normal Polarity Normalize Traces is ON All Gains Adjusted by 1.00

Programmed Gain is OFF Automatic Gain Control is ON: Window Trailer = 30.00 ms, Leader = 30.00 ms, Scaled = 20 %

Plotted Traces Resampled to Fit Page! This Section Plotted 9/23/88 01:56pm

Time Scale (ms)

0.0 50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0

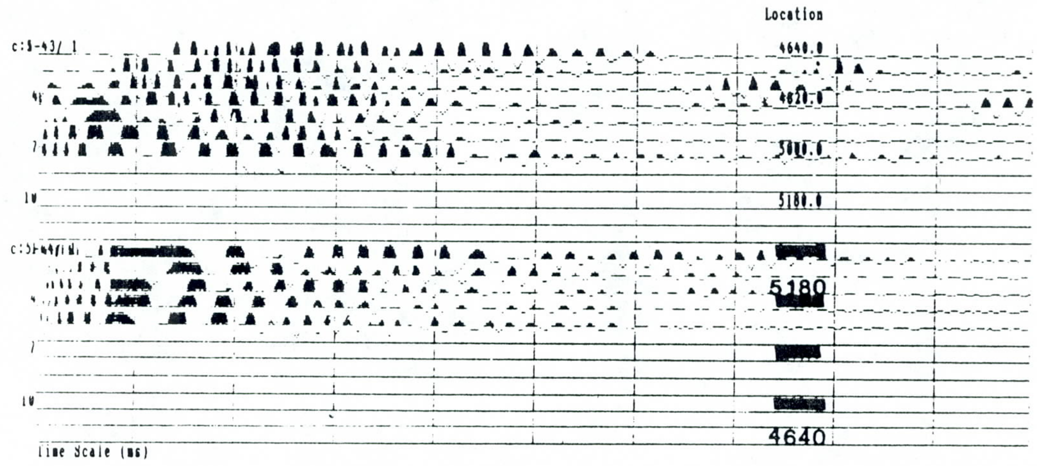
85 235 399 418 629 869 1109 1349 1541

Depth Scale
(Ft)

Location

East → | ← East

Spread No. 27




Time Scale (ms)

0.0 50.0 100.0 150.0 200.0 250.0 300.0 350.0 400.0 450.0

1851-6

TERRAMETRICS ASSOCIATES

Tucson AZ & Laramie, WY

Line 6

**Complete Processing Sequence:**

**History Created : 9/21/88 02:04pm**

Step 1: 75-200 hz Band Pass
Step 2: NMO'd with 1 Velocity Fn to 0.00 Off
Step 3: Shot and Receiver Statics Applied
Step 4: CDP Gather with Stack

**Last Run I/O Parameters:**

**Data Input From : GATHERED Data Files.**

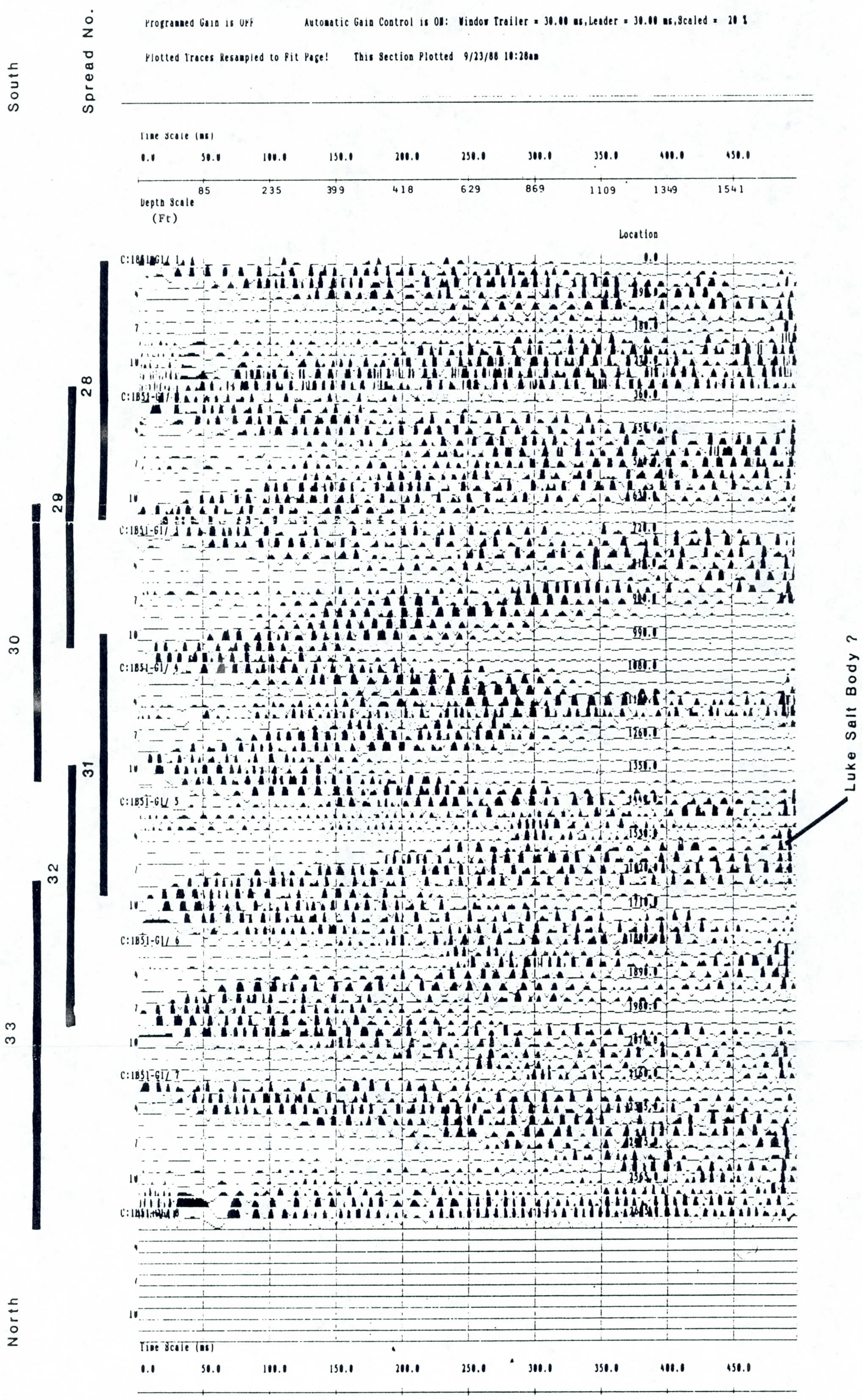
**Processed Data Output To : Temporary TEST Data Files.**

**Display Parameters:**

Selected Records Plotted   Normal Polarity   Normalize Traces is ON   All Gains Adjusted by 1.00

Programmed Gain is OFF   Automatic Gain Control is ON: Window Trailer = 30.00 ms,Leader = 30.00 ms,Scaled = 20 %

Plotted Traces Resampled to Fit Page!   This Section Plotted 9/23/88 10:28am



# APPENDIX C

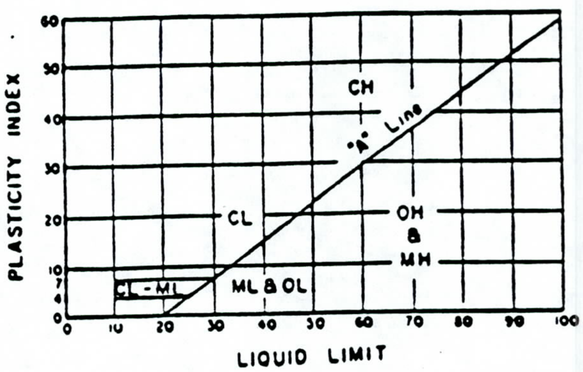
# LOGS OF EXPLORATORY BORINGS

| MAJOR DIVISIONS | | SYMBOLS | TYPICAL SOIL DESCRIPTIONS |
|---|---|---|---|
| COARSE GRAINED SOILS (More than 1/2 of soil > no. 200 sieve size) | GRAVELS (More than 1/2 of coarse fraction > no. 4 sieve size) | GW | Well graded gravels or gravel-sand mixtures, little or no fines |
| | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines |
| | | GM | Silty gravels, gravel-sand-silt mixtures |
| | | GC | Clayey gravels, gravel-sand-clay mixtures |
| | SANDS (More than 1/2 of coarse fraction < no. 4 sieve size) | SW | Well graded sands or gravelly sands, little or no fines |
| | | SP | Poorly graded sands or gravelly sands, little or no fines |
| | | SM | Silty sands, sand-silt mixtures |
| | | SC | Clayey sands, sand-clay mixtures |
| FINE GRAINED SOILS (More than 1/2 of soil < no. 200 sieve size) | SILTS & CLAYS LL < 50 | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | | OL | Organic silts and organic silty clays of low plasticity |
| | SILTS & CLAYS LL > 50 | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| | | CH | Inorganic clays of high plasticity, fat clays |
| | | OH | Organic clays of medium to high plasticity, organic silty clays, organic silts |
| HIGHLY ORGANIC SOILS | | Pt | Peat and other highly organic soils |

## CLASSIFICATION CHART
(Unified Soil Classification System)

| CLASSIFICATION | RANGE OF GRAIN SIZES | |
|---|---|---|
| | U.S. Standard Sieve Size | Grain Size in Millimeters |
| BOULDERS | Above 12" | Above 305 |
| COBBLES | 12" to 3" | 305 to 76.2 |
| GRAVEL | 3" to No. 4 | 76.2 to 4.76 |
| coarse | 3" to 3/4" | 76.2 to 19.1 |
| fine | 3/4" to No. 4 | 19.1 to 4.76 |
| SAND | No. 4 to No. 200 | 4.76 to 0.074 |
| coarse | No 4 to No 10 | 4.76 to 2.00 |
| medium | No. 10 to No. 40 | 2.00 to 0.420 |
| fine | No. 40 to No. 200 | 0.420 to 0.074 |
| SILT & CLAY | Below No. 200 | Below 0.074 |

## GRAIN SIZE CHART




## PLASTICITY CHART

# METHOD OF SOIL CLASSIFICATION

EMCON ASSOCIATES

F4 2(8-71)

## EXPLANATION OF SYMBOLS ON LOGS OF EXPLORATORY BORINGS

Modified CA sampler (driven)
(2.5-inch outside diameter split spoon)

Standard split-spoon sampler
(2-inch outside diameter)

**Bulk sample**
(Drill cuttings collected in bucket)

Grab sample
(Drill cuttings collected in small bag)

**2.5 YR 6/2** **Denotes color as field checked to Munsell Soil Color Charts (1975 Edition) or GSA Rock Color Chart**

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B1

PROJECT NAME **Proposed Cholla Sanitary Landfill** 

BY **C.Estes** DATE 9/16/88 SURFACE ELEV. 1087

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | **SILTY SAND**, very pale brown (10YR 7/3); 20% fines, low plasticity; 70% very fine to coarse grained sand; 10% gravel, up to 2.5"; medium dense; dry. |
| | | 29 | | 5 | | | |
| | | | | | | SP | **POORLY-GRADED SAND WITH GRAVEL**, very pale brown (10YR 7/3); 3% fines, low plasticity; 59% well-graded, medium grained sand; 38% fine to coarse gravel; medium dense; dry. |
| | | 22 | | 10 | | | |
| | | | | | | GM | **SILTY GRAVEL WITH SAND**, very pale brown (10YR 7/3); 15% fines, low plasticity; 30% fine-coarse grained sand; 55% fine to coarse gravel; dry. |
| | | | | | | SC | **CLAYEY SAND**, yellowish brown (10YR 5/6); 47% fines, low plasticity; 40% very fine grained sand; 13% fine gravel; very stiff; dry. |
| | | 48 | | 15 | | | |
| | | 53 | | 20 | | | |

REMARKS

Borings were drilled with a reverse circulation, dual-walled, percussion hammer drill rig. Following completion, the boring was backfilled with Type I/II Portland cement.

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B1

PROJECT NAME Proposed Cholla Sanitary Landfill 

BY C.Estes DATE 9/16/88 SURFACE ELEV. 1087

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/ Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SC | **CLAYEY SAND WITH GRAVEL,** dark yellowish brown (10YR 4/6); 20% fines, low to medium plasticity; 60% fine to coarse sand; 20% coarse rounded gravel; very dense; dry. |
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND,** light grey (10YR 7/2); <5% fines; 30% fine to coarse grained sand; 70% fine to coarse grained, rounded gravel; very dense; dry. |
| | | 50 | | 25 | | | |
| | | | | | | | trace cobbles. |
| | | 100 | | 30 | | | increase cobbles to 10%. |
| | | | | | | ML | **SANDY SILT,** yellowish brown (10YR 5/4); 53% fines, medium plasticity; 47% very fine sand; trace cobbles; hard; slightly damp. |
| | | 50/6" | | 35 | | CL | **CLAY,** yellowish brown (10YR 5/4); medium plasticity; hard; damp. |
| | | | | | | CL ML | **CLAY WITH SILT,** yellowish brown (10YR 5/4); low to medium plasticity; hard; damp. |
| | | 98 | | 40 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01

PROJECT NAME **Proposed Cholla Sanitary Landfill**

BY C.Estes

DATE 9/16/88

BORING NO. **B1**



SURFACE ELEV. **1087**

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | CL ML | **CLAY WITH SILT** (CONTINUED) |
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND,** <5% fines; 30% fine to coarse sand; 70% fine to coarse, rounded gravel; dry; very dense. |
| | | 75 | | 45 | | | |
| | | 50/3" | | 50 | | | |
| | | 31 | | 55 | | SC | **CLAYEY SAND,** yellowish brown (10YR 5/6); 46% fines, low to medium plasticity; 52% fine to medium grained sand; 2% coarse gravel; dense dry. |
| | | | | | | CL | **SANDY CLAY,** dark yellowish brown (10YR 4/4); 70% fines, medium plasticity; 30% fine to medium grained sand; damp. |
| | | | | | | GC | **CLAYEY GRAVEL WITH SAND** (description on next page) |
| | | 30 | | 60 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B1

PROJECT NAME Proposed Cholla Sanitary Landfill 

BY C.Estes DATE 9/16/88 SURFACE ELEV. 1087

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/ Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GC | **CLAYEY GRAVEL WITH SAND**, yellowish brown (10YR 5/6); 43% fines, medium plasticity; 26% fine to coarse grained sand; 31% coarse gravel; dense; dry. |
| | | | | 65 | | | |
| | | 60 | | 70 | | | 35% fines, low to medium plasticity; 55% fine to coarse grained sand; 10% fine to coarse gravel; very dense. |
| | | | | 75 | | | increase fines, medium plasticity. |
| | | | | | | SM | **SILTY SAND**, yellowish brown (10YR 5/4); 44% fines, low to medium plasticity; 56% fine to medium grained sand; trace gravel; hard; dry. |
| | | 43 | | 80 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B1

PROJECT NAME **Proposed Cholla Sanitary Landfill**



BY C.Estes DATE 9/16/88 SURFACE ELEV. 1087

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | **SILTY SAND** (CONTINUED) |
| | | | | 85 | | | |
| | | 51 | | 90 | | GW | **WELL-GRADED GRAVEL WITH SAND**, very pale brown (10YR 7/4); <5% fines; 40% fine to coarse grained sand; 60% fine to coarse gravel; trace cobbles; very dense; dry. |
| | | | | 95 | | | |
| | | 63 | | 100 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B1

PROJECT NAME **Proposed Cholla Sanitary Landfill** 

BY C.Estes DATE 9/16/88 SURFACE ELEV. 1087

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND** (CONTINUED) increase cobbles to 10%, maximum size, 5-6" in diameter; very dense. |
| | | | | 105 | | | |
| | | 100 | | 110 | | | |
| | | | | 115 | | | |
| | | 50/0" | | 120 | | | BOTTOM OF BORING AT 120 FEET. BORING TERMINATED. |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER **372-15.01** BORING NO. **B2**

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE **1 OF 3**

BY **C.Estes** DATE **9/16/88** SURFACE ELEV. **1013**

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | **SILTY SAND**, yellowish brown (10YR 5/6); 40% fines, low plasticity; 60% fine to medium grained sand; trace fine to coarse gravel; dry. |
| | | | | 5 | | | |
| | | 25 | | 10 | | | |
| | | | | | | ML | **SANDY SILT**, brownish yellow (10YR 6/6); 82% fines, low to medium plasticity; 18% fine to medium grained sand; trace gravel; very stiff; dry. |
| | | | | 15 | | SP SC | **POORLY-GRADED SAND WITH CLAY AND GRAVEL**, light yellowish brown (10YR 6/4); 12% fines, medium plasticity; 67% fine to medium grained sand; 21% fine gravel; dense; dry. |
| | | 31 | | 20 | | | |

REMARKS

Exploratory boring drilled with a reverse circulation, dual-walled, percussion hammer drill rig. Following completion, the boring was backfilled with Type I/II Portland cement.

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 | BORING NO. B2

PROJECT NAME **Proposed Cholla Sanitary Landfill** | PAGE 2 OF 3

BY **C.Estes** | DATE **9/16/88** | SURFACE ELEV. 1013

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SP SC | **POORLY-GRADED SAND WITH CLAY AND GRAVEL** (CONTINUED). |
| | | | | | | | increase gravel and cobbles. |
| | | | | 25 | | SW | **WELL-GRADED SAND WITH GRAVEL,** light yellowish brown (10YR 6/4); <5% fines; 70% fine to coarse grained sand; 30% fine to coarse gravel; trace cobbles; slightly damp. |
| | | 37 | | 30 | | | |
| | | | | | | SC | **CLAYEY SAND WITH GRAVEL,** dark yellowish brown (10YR 4/6); 30% fines, medium plasticity; 45% fine to coarse grained sand; 25% fine to coarse gravel; dense; dry. |
| | | | | 35 | | | |
| | | | | | | SW | **WELL-GRADED SAND WITH GRAVEL,** very pale brown (10YR 7/3); 5% fines; 50% fine to coarse sand; 45% fine to coarse gravel; very dense;dry. |
| | | 64 | | 40 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 — BORING NO. B2

PROJECT NAME Proposed Cholla Sanitary Landfill — 

BY C.Estes — DATE 9/16/88 — SURFACE ELEV. 1013

| TIP I (units) | Ambient Air (units) | PENETRA-TION (Blows/ Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHO-GRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND**, very pale brown (10YR 7/3); 5% fines; 35% fine to coarse grained sand; 60% fine to coarse gravel; trace cobbles; very dense; dry. |
| | | | | 45 | | | |
| | | | | | | | increase coarse sand. |
| | | 109 | | 50 | | | very dense |
| | | | | 55 | | | |
| | | | | | | SW | **WELL-GRADED SAND WITH GRAVEL**, very pale brown (10YR 7/3); 5% fines, low to medium plasticity; 65% fine to coarse grained sand; 30% fine to coarse gravel; trace cobbles; very dense; dry. BOTTOM OF BORING AT 60 FEET. BORING TERMINATED. |
| | | 82 | | 60 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B3

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE 1 OF 6

BY **C.Estes** DATE 9/18/88 SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | 0 | | SM | **SILTY SAND**, yellowish brown (10YR 5/6); 29% fines, low plasticity; 46% fine to medium grained sand; 13% fine gravel; dry. |
| | | | | 5 | | | |
| | | | | | | SP SC | **POORLY-GRADED SAND WITH CLAY AND GRAVEL**, yellowish brown (10YR 5/6); 9% fines, low plasticity; 71% medium grained sand; 20% fine gravel; medium dense; dry. |
| | | 21 | | 10 | | | |
| | | | | | | | increase fine gravel |
| | | | | 15 | | | |
| | | | | | | SP | **POORLY-GRADED SAND WITH GRAVEL**, light grey (10YR 7/2); 4% fines; 50% fine to coarse sand; 46% fine to coarse gravel, up to 3" in diameter, rounded; dry. |
| | | | | 20 | | | |

REMARKS

Exploratory boring drilled with a reverse circulation, dual-walled, percusion hammer drill rig. Following completion, the boring was backfilled with Type I/II Portland cement.

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 | BORING NO. B3

PROJECT NAME Proposed Cholla Sanitary Landfill | PAGE 2 OF 6

BY C.Estes | DATE 9/18/88 | SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SP | **POORLY-GRADED SAND WITH GRAVEL** (CONTINUED). |
| | | | | | | | increase gravel size, some cobbles up to 4" to 5" in diameter. |
| | | | | 25 | | | |
| | | | | | | SC | **CLAYEY SAND**, yellowish brown (10YR 5/6); 40% fines, low to medium plasticity; 50% fine to coarse grained sand; 10% fine to coarse gravel; dry. |
| | | | | 30 | | | |
| | | | | | | SP SC | **POORLY-GRADED SAND WITH CLAY**, light yellowish brown (10YR 6/4); 10% fines, medium plasticity; 80% medium grained sand; 10% fine to coarse gravel, rounded; dry. |
| | | | | 35 | | | |
| | | | | 40 | | GC | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B3

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE 3 OF 6

BY C.Estes DATE 9/18/88 SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GC | **CLAYEY GRAVEL**, yellowish brown (10YR 5/4); 30% fines, medium plasticity; 20% fine to coarse grained moderately cemented sand; 50% fine to coarse clay coated gravel; slightly damp. |
| | | | | | | GW | **WELL GRADED GRAVEL WITH SAND**, very pale brown (10YR 7/3); 5% fines; 30% lightly to moderately cemented fine to coarse grained sand; 70% fine to coarse gravel. |
| | | | | | | SM | **SILTY SAND**, light yellowish brown (10YR 6/4); 40% fines, low plasticity; 50% fine grained sand; 10% fine gravel; dry. |
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND**, very pale brown (10YR 7/4); 5% fines, low plasticity; 40% fine to coarse grained sand; 55% fine to coarse rounded gravel, up to 3" in diameter, mostly 2" in diameter; some cemented sand. |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 — BORING NO. B3

PROJECT NAME Proposed Cholla Sanitary Landfill — 

BY C.Estes — DATE 9/18/88 — SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND** (CONTINUED) |
| | | | | | | SC | **CLAYEY SAND**, yellowish brown (10YR 5/6); 31% fines, low to medium plasticity; 64% fine to coarse sand; 5% fine to coarse gravel; dry. |
| | | | | 65 | | | |
| | | 52 | | 70 | | | 17% fines, medium plasticity; 49% fine to coarse sand; 34% fine to coarse gravel. |
| | | | | | | GC | **CLAYEY GRAVEL**, light yellowish brown (10YR 6/4); 30% fines, medium plasticity; 20% fine to coarse grained sand; 50% fine to coarse clay coated gravel; some cobbles, up to 5" in diameter. |
| | | | | 75 | | | |
| | | | | | | | increase sand to 40%. |
| | | | | 80 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B3

PROJECT NAME Proposed Cholla Sanitary Landfill PAGE 5 OF 6

BY C.Estes DATE 9/18/88 SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GC | **CLAYEY GRAVEL** (CONTINUED) |
| | | | | | | SP SC | **POORLY-GRADED SAND WITH CLAY AND GRAVEL**, very pale brown (10YR 7/4); 10% fines, medium plasticity; 70% medium grained sand; 20% fine to coarse gravel; dry. |
| | | | | 85 | | | |
| | | | | 90 | | SP | **POORLY-GRADED SAND WITH GRAVEL**, same as above, except <5% fines. |
| | | | | 95 | | | |
| | | | | 100 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 | BORING NO. B3

PROJECT NAME **Proposed Cholla Sanitary Landfill** | PAGE 6 OF 6

BY C.Estes | DATE 9/18/88 | SURFACE ELEV. 1074

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GW | **WELL-GRADED GRAVEL WITH SAND**, very pale brown (10YR 7/4); <5% fines; 30% fine to medium grained sand; 60% fine to coarse gravel, mostly 1"to 2" diameter; trace cobbles; dry. |
| | | | | 105 | | GC | **CLAYEY GRAVEL**, light yellowish brown (10YR 6/4); 15% fines, mostly covering the gravel; 40% fine to coarse grained sand; 45% coarse gravel, mostly 2" diameter, some fine gravel; some cobbles. |
| | | | | 110 | | | |
| | | | | | | SW | **WELL-GRADED SAND WITH GRAVEL**; 5% fines; 60% fine to coarse grained sand; 35% fine to coarse gravel, 1-2" diameter, clay coated. |
| | | | | 115 | | | |
| | | | | | | | BOTTOM OF BORING AT 120 FEET<br>BORING TERMINATED. |
| | | | | 120 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B4

PROJECT NAME Proposed Cholla Sanitary Landfill 

BY B.Benko DATE 9/19/88 SURFACE ELEV. 1061

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | | **GRADED ROAD SURFACE**, SILTY SAND WITH GRAVEL. |
| | | | | 5 | | | |
| | | | | 10 | | | |
| | | | | 15 | | SP SM | **POORLY-GRADED SAND WITH SILT**, light yellowish brown (10YR 6/4); 10% fines; 60% fine-grained sand, 20% medium grained sand, trace coarse grained sand; 10% fine, hard, rounded, gravel; damp. |
| 0.75/1~ | | 41 | | 20 | | | |

REMARKS

Exploratory boring drilled with a reverse circulation, dual-walled, percussion hammer drill rig. Following completion, the boring was backfilled with Type I/II Portland cement.

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER **372-15.01** BORING NO. **B4**

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE **2 OF 7**

BY **B.Benko** DATE **9/19/88** SURFACE ELEV. **1061**

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SP | **POORLY-GRADED SAND**, light yellowish brown (10YR 6/4); fine grained; 80% quartzose; damp. |
| | | | | | | SC | **CLAYEY SAND**, light yellowish brown (10YR 6/4); 21% fines; 48% fine to coarse sand; 31% fine to coarse gravel. |
| | | | | 25 | | | 40% medium grained; subangular-subrounded; 70% quartzose;trace coarse sand and fine gravel; damp. |
| | | | | | | SM | **SILTY SAND WITH GRAVEL**, light yellowish brown (10YR 6/4); 20% fines. |
| | | | | 30 | | SC | **CLAYEY SAND**, light yellowish brown (10 YR 6/4); 16% fines; 81% fine to coarse grained sand; 3% medium to coarse gravel. |
| | | | | | | SP SM | **POORLY GRADED SAND WITH SILT AND GRAVEL**, light yellowish brown (10YR 6/4); 10% fines; 65% fine to coarse grained sand; 25% fine to coarse, hard, rounded-subrounded, broken, gravel; hard, metamorphic, volcanic, and felsic intrusive mineralogy; occasional cobbles to 6" in diameter. |
| | | | | 35 | | | |
| | | 68 | | 40 | | GP GC | **POORLY-GRADED GRAVEL WITH CLAY AND SAND**, various colors; predominantly medium grained sand, 41% coarse sand; 27% fine, hard gravel; no HCl reaction; trace clay; damp. |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 — BORING NO. B4

PROJECT NAME Proposed Cholla Sanitary Landfill — PAGE 3 OF 7

BY B.Benko — DATE 9/19/88 — SURFACE ELEV. 1061

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/ Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GP GC | **POORLY-GRADED GRAVEL WITH CLAY AND SAND** (CONTINUED). |
| | | | | | | GP GM | **POORLY-GRADED GRAVEL WITH SILT AND SAND**, light yellowish brown (10YR 6/4); 15% fines; 40% fine to coarse grained sand; 35% fine to coarse grained gravel; 10% cobbles. |
| | | | | | | CL | **SANDY CLAY**, yellowish brown (10YR 5/4); 60% fines, medium plasticity; 35% fine grained, micaceous, sand; 5% fine gravel; moist. |
| | | | | 45 | | SW | **WELL GRADED SAND WITH GRAVEL** |
| | | | | | | CL | **SANDY CLAY**, pinkish white (7.5YR 8/2); calcareous; 60% fines, low to medium plasticity; 40% fine sand; damp. |
| 1.5/1.5 | | 45 | | 50 | | SC | **CLAYEY SAND**, yellowish brown (10YR 5/4); 35% fines, low to medium plasticity; 55% fine grained sand, 10% medium grained sand; micaceous; moist. |
| 1.5/1.5 | | | | 55 | | SC | **CLAYEY SAND WITH GRAVEL**, dark yellowish brown (10YR 4/4); 38% fines, low to medium plasticity; 35% fine to medium grained sand; 27% fine to coarse gravel; trace cobbles; thinly bedded interspersed caliche (1"); very hard; moist. |
| 1.5/1.5 | | 50 | | 60 | | CL SC | **SANDY CLAY TO CLAYEY SAND** (description on next page) |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER **372-15.01** BORING NO. **B4**

PROJECT NAME **Proposed Cholla Sanitary Landfill** 

BY **B.Benko** DATE **9/19/88** SURFACE ELEV. **1061**

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | CL SC | **SANDY CLAY TO CLAYEY SAND**, yellowish brown (10YR 4/4); 20-70% fines; fine grained sand, varying up to 30% medium grained sand; trace fine gravel; less caliche; micaceous, homogenous, moist. |
| | | | | 65 | | | |
| | | 49 | | 70 | | | 33% fines, medium plasticity; 36% fine to medium grained sand; 31% fine gravel. |
| | | | | 75 | | | |
| | | | | | | SC | **CLAYEY SAND**, brown (7.5YR 5/4); 38% fines, low plasticity; 37% fine grained sand, 25% medium to coarse grained sand; trace fine gravel; common caliche but not as hard as above; moist. |
| 1.5/1.5 | | 127 | | 80 | | | |

REMARKS

EMCON
ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 BORING NO. B4

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE 5 OF 7

BY **B.Benko** DATE 9/19/88 SURFACE ELEV. 1061

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | SC | **CLAYEY SAND** (CONTINUED) |
| | | | | 85 | | | occasionally varies to SANDY CLAY. |
| | | | | | | | cobble-size chunks of caliche. |
| | | | | | | SP | **POORLY-GRADED SAND**, brown (7.5YR 5/4); fine grained sand, 10% medium to coarse grained sand; 5% fine gravel to 1", calcareous coated, subrounded-subangular grains, trace coarse gravel; moist. |
| 1.5/1.5 | | 135 | | 90 | | | |
| | | | | 95 | | SP SM | **POORLY GRADED SAND WITH SILT AND GRAVEL**, brown (7.5YR 5/4); to yellowish brown (10YR 5/4); 10% fines, low plasticity; 25% fine gravel, 1/8" to 1" in size, subangular to subrounded; no HCl reaction; dry. |
| | | | | | | GW | **WELL-GRADED GRAVEL**, variable color; 50% fine gravel; 50% coarse gravel, volcanic and metamorphic mineralogy; subrounded; dry. |
| | | | | | | GP GM | **POORLY-GRADED GRAVEL WITH SILT AND SAND** (description on next page) |
| | | | | 100 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER 372-15.01 | BORING NO. B4

PROJECT NAME **Proposed Cholla Sanitary Landfill** | PAGE 6 OF 7

BY **B.Benko** | DATE 9/19/88 | SURFACE ELEV. 1061

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | GP GM | **POORLY-GRADED GRAVEL WITH SILT AND SAND**, pale brown (10YR 6/3) with various pebble colors; 5-10% fines; 40% fine to coarse grained sand; 40% 1/8" to 1/2" gravel, 10% 1/2" to 3/4" gravel; no HCl reaction; subangular; dry. |
| | | | | 105 | | | |
| | | | | | | SC | **CLAYEY SAND**, strong brown (7.5YR 4/6); 40% fines, low plasticity; 55-60% fine micaceous sand; homogenous; slight HCl reaction; very moist; softest material since surface. |
| | | 55 | | | | | |
| | | | | 110 | | | |
| | | | | 115 | | | |
| | | | | | | SP | **POORLY-GRADED SAND**, pale brown (10YR 6/3); very fine to fine grained sand; trace coarse sand; friable; moist. |
| 1.5/1.5 | | 47 | | | | | |
| | | | | | | SC | **CLAYEY SAND** (description on next page) |
| | | | | 120 | | | |

REMARKS

EMCON ASSOCIATES

# LOG OF EXPLORATORY BORING

PROJECT NUMBER **372-15.01** BORING NO. **B4**

PROJECT NAME **Proposed Cholla Sanitary Landfill** PAGE **7 OF 7**

BY **B.Benko** DATE **9/19/88** SURFACE ELEV. **1061**

| TIP I (units) | Ambient Air (units) | PENETRATION (Blows/Ft.) | GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOGRAPHIC COLUMN | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | | | | | | **CLAYEY SAND**, light brown (7.5YR 6/4); 40% fines; very fine grained; micaceous; homogenous; moist. BOTTOM OF BORING AT 120 FEET. BORING TERMINATED. |
| | | | | 125 | | | |
| | | | | 130 | | | |
| | | | | 135 | | | |
| | | | | 140 | | | |

REMARKS

EMCON ASSOCIATES

# APPENDIX D

## SOILS TESTING RESULTS

# PHYSICAL PROPERTIES

Job No. 2128J165

| Boring No. | Depth, ft. | Soil Class. | Particle Size Distribution, % Passing by wt. | | | | | Atterberg Limits | | Moisture - Density Rel. | | | Specific Gravity | Permeability | | 'R' Value | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 3" | #4 | #10 | #40 | #200 | LL | PI | Dry Density pcf | Optimum Moisture % | Meth. | | Dry Density pcf | K Cm/Sec | Corrected 'R' | |
| B-1 | 5-10 | SP | 100 | 62 | 53 | 17 | 3.2 | | | | | | | | | | 1 |
| B-1 | 15-20 | SC | 100 | 87 | 83 | 72 | 46.8 | 31 | 9 | | | | | | | | 2 |
| B-1 | 35-40 | ML | | | 100 | 98 | 52.6 | 27 | 3 | | | | | | | | 2 |
| B-1 | 35 | CL | | | | | | 36 | 15 | | | | | | | | 2 |
| B-1 | 40 | ML-CL | | | | | | 27 | 6 | | | | | | | | 2 |
| B-1 | 55 | SC | 100 | 98 | 97 | 82 | 45.8 | | | | | | | | | | 1 |
| B-1 | 70 | GC | 100 | 69 | 63 | 56 | 43.2 | | | | | | | | | | 1 |
| B-1 | 80 | SM | | | 100 | 94 | 43.6 | 27 | 3 | | | | | | | | 2 |
| | | | | | | | | | | | | | | | | | |
| B-2 | 10 | ML | | 100 | 99 | 96 | 82.4 | 42 | 16 | | | | | | | | 2 |
| B-2 | 20 | SP-SC | 100 | 79 | 61 | 24 | 11.9 | | | | | | | | | | 1 |
| B-2 | 30 | SC | 100 | 75 | 65 | 51 | 29.8 | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | | | | |
| B-3 | 2-4 | SM | 100 | 87 | 81 | 52 | 28.6 | 19 | 1 | | | | | | | | 2 |
| B-3 | 10 | SP-SC | 100 | 80 | 74 | 32 | 8.7 | | | | | | | | | | 1 |
| B-3 | 20-30 | SP | 100 | 54 | 46 | 18 | 4.2 | | | | | | | | | | 1 |
| B-3 | 60-70 | SC | 100 | 95 | 93 | 63 | 31.2 | | | | | | | | | | 1 |

| Boring No. | Depth, ft. | Comments |
|---|---|---|
| | | |
| | | |
| | | |

REMARKS

Classification/Particle Size
1 Visual
2 Laboratory Tested
3 Minus #200 Only

Moisture Density Relationship
4 Tested ASTM D-689/AASHTO T-99
5 Tested ASTM D-1557/AASHTO T-180

Specific Gravity
7 Minus #4
8 Plus #4

Permeability
9 Constant Head
10 Falling Head

'R' Value
11 Expansion Pressure ________ psf
12 Exudation Pressure ________ psi

Note: NP = nonplastic

Plate D-1

## PHYSICAL PROPERTIES

Job No. 2128J165

| Boring No. | Depth, ft. | Soil Class. | Particle Size Distribution, % Passing by wt. 3" | #4 | #10 | #40 | #200 | Atterberg Limits LL | PI | Moisture - Density Rel. Dry Density pcf | Optimum Moisture % | Meth. | Specific Gravity | Permeability Dry Density pcf | K Cm/Sec | 'R' Value Corrected 'R' | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-3 | 70 | SC | 100 | 66 | 59 | 33 | 16.8 | | | | | | | | | | 1 |
| B-3 | 80-85 | SC | 100 | 89 | 85 | 60 | 22.5 | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | | | | |
| B-4 | 22-24 | SC | 100 | 69 | 58 | 36 | 21.1 | | | | | | | | | | 1 |
| B-4 | 30-32 | SC | 100 | 97 | 94 | 50 | 15.9 | | | | | | | | | | 1 |
| B-4 | 40 | GP-GC | 100 | 49 | 36 | 15 | 8.1 | | | | | | | | | | 1 |
| B-4 | 51-54 | SC | 100 | 73 | 67 | 57 | 38.4 | | | | | | | | | | 1 |
| B-4 | 57 | ML | 100 | 84 | 82 | 77 | 54.3 | 37 | 8 | | | | | | | | 2 |
| B-4 | 70 | SC | 100 | 69 | 65 | 56 | 33.0 | 34 | 11 | | | | | | | | 2 |
| B-4 | 80 | SC | 100 | 75 | 69 | 54 | 38.0 | | | | | | | | | | 1 |

| Boring No. | Depth, ft. | Comments |
|---|---|---|
| | | |

REMARKS

Classification/Particle Size
1 Visual
2 Laboratory Tested
3 Minus #200 Only

Moisture Density Relationship
4 Tested ASTM D-689/AASHTO T-99
5 Tested ASTM D-1557/AASHTO T-180

Specific Gravity
7 Minus #4
8 Plus #4

Permeability
9 Constant Head
10 Falling Head

'R' Value
11 Expansion Pressure ________ psf
12 Exudation Pressure ________ psi

Note: NP = nonplastic

## SERGENT, HAUSKINS & BECKWITH

## TABULATION OF TEST RESULTS

Job No. LT8-3905
W/O 1

| HOLE NO | DEPTH | UNIFIED CLASS | L.L. | P.I. | SIEVE ANALYSIS-ACCUM % PASSING #200 .75" | #100 1" | #50 1.5" | #40 2" | #30 2.5" | #16 3" | #10 3.5" | #8 4" | #4 6" | .25" 8" | .375" 10" | .5" 12" | LAB NO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EL MIRAGE S-1 [1] | - | CL | 30 | 9 | | | | | | | | | | | | | 8-3905-1 |
| EL MIRAGE SP-1 [2] | - | ML | 24 | 1 | | | | | | | | | | | | | 8-3905-2 |

1. Sample Source - near surface soil materials stockpiled by Union Rock and Materials

2. Sample Source - stockpiled soil materials remaining from sand and gravel processing by Union Rock and Materials

APPENDIX E

DRILLERS' LOG OF WELL W-1

(ADWR FILE NO. B-3-1 36 BBC)

# LOG OF WELL

Indicate depth at which water was first encountered, and the depth and thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

| FROM (FEET) | TO (FEET) | DESCRIPTION OF FORMATION MATERIAL |
|---|---|---|
| 0 | 57 | gravel, boulders |
| 57 | 66 | clay |
| 66 | 77 | boulders |
| 77 | 80 | clay |
| 80 | 86 | boulders |
| 86 | 89 | clay |
| 89 | 122 | boulders |
| 122 | 158 | hard sand |
| 158 | 181 | boulders |
| 181 | 194 | clay |
| 194 | 196 | boulders |
| 196 | 209 | hard sandy with pebbles |
| 209 | 236 | sandy and sandy clay |
| 236 | 243 | very sandy, water |
| 243 | 259 | clay |
| 259 | 264 | sandy |
| 264 | 279 | clay |
| 279 | 292 | sandy |
| 292 | 295 | clay |
| 295 | 301 | sandy clay |
| 301 | 317 | caliche |
| 317 | 337 | clay |
| 337 | 346 | hard caliche, sand |
| 346 | 354 | clay |
| 354 | 371 | hard, sandy |
| 371 | 373 | sticky clay |
| 373 | 376 | sandy |
| 376 | 380 | clay |
| 380 | 384 | sandy clay |
| 384 | 391 | gravel |
| 391 | 394 | clays and sandy clay |
| 394 | 399 | gravel |
| 399 | 404 | sticky clay |
| 404 | 409 | sandy clay |
| 409 | 415 | sticky |
| 415 | 421 | gravel |
| 421 | 427 | clay, some sandy |
| 427 | 432 | caliche in clay |
| 432 | 469 | clay |
| 469 | 474 | sandy clay |
| 474 | 479 | clay |
| 479 | 486 | sandy |
| 486 | 502 | caliche and clay |
| 502 | 507 | hard slow sticky clay |
| 507 | 510 | hard caliche |
| 510 | 514 | tough gummy clay |
| 514 | 530 | hard sndy clay |
| 530 | 559 | clay |
| 559 | 563 | sandy clay, caving |
| 563 | 596 | clay |
| 596 | 602 | streaks of sandy clay |
| 602 | 606 | sandy hard, water |
| 606 | 609 | sticky clay |
| 609 | 611 | sand, hard, water |
| 611 | 613 | sticky clay |
| 613 | 621 | hard sand streaks |
| 621 | 624 | soft running sand no water |
| 624 | 627 | hard sand |
| 627 | 644 | sticky clay-yellow |
| 644 | 661 | white & gray clay |
| 661 | 679 | brown clay sticky |
| 679 | 684 | hard streaks of sand little water |
| 684 | 718 | sticky clay |
| 718 | 721 | sandy no water |
| 721 | 729 | clay |
| 729 | 732 | hard malapai in clay |
| 732 | 757 | little softer |
| 757 | 768 | much clay & malapa |
| 768 | 770 | hard |
| 770 | 800 | much clay malapai |
| 800 | 808 | clay, yellow & green streaks of pebbles |
| 808 | 822 | all clay, brown & white |
| 822 | 826 | green clay |
| 826 | 856 | sticky brown salt |
| 856 | 858 | black clay |
| 858 | 879 | brown adobe clay |
| 879 | 882 | hard sandy clay salt |
| 882 | 900 | hard, breaking clay blade, cemented conglomerate |

17203



I hereby certify that this well was drilled by me (or under my supervision), and that each and all of the statements herein contained are true to the best of my knowledge and belief.

Driller: Weber Well Drilling Co.
Name

P. O. Box 5354, 19 So. 40th Pl.
Address

Date: 12/12/60