Proposed Baseball Stadium
Stadium Road
University of California
Santa Barbara, California

GEOTECHNICAL ENGINEERING REPORT

File No. KC-1405-03
May 31, 1990

Mr. Dave Inouye
Facilities Management, Building 439
University of California
Santa Barbara, California 93106

Subject: Proposed Baseball Stadium
Stadium Road
University of California
Santa Barbara, California
GEOTECHNICAL ENGINEERING REPORT

Dear Mr. Inouye:

K-C Geotechnical Associates (K-C) is pleased to present this Geotechnical Engineering Report for the proposed baseball stadium at Stadium Road, University of California, Santa Barbara, California. This report completes our assignment in accordance with our proposal of November 6, 1989, and addendum proposal of January 19, 1990, as authorized by the University of California Authorization No. 51/89-90 and No. 51/89-90 (R1), dated November 1, 1989, and February 13, 1990, respectively.

Based on our evaluation of the data acquired and presented this report, it is our opinion that the proposed baseball stadium can be constructed essentially as planned, provided the recommendations given in this report are incorporated into the project design and implemented during construction. In addition, it is our opinion that active faults likely do not pass within at least 50 feet of the proposed stadium. Foundation support for the stadium and related facilities can be obtained from conventional spread footings founded in compacted on-site soils.

The accompanying report summarizes data gathered in this study and provides recommendations based on those data. The conclusions and recommendations contained therein are based upon the generally accepted standards of our profession at the location and time this report was prepared.

Please contact the undersigned if there are any questions concerning the report.

Very truly yours,
K-C Geotechnical Associates
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PROPOSED BASEBALL STADIUM

STADIUM ROAD

UNIVERSITY OF CALIFORNIA

SANTA BARBARA, CALIFORNIA

1. INTRODUCTION

K-C Geotechnical Associates (K-C) is pleased to present this Geotechnical Engineering Report for the proposed baseball stadium on Stadium Road, University of California, Santa Barbara (UCSB), California. This report completes our assignment in accordance with our proposal of November 6, 1989, and addendum proposal of January 19, 1990 as authorized by the University of California Authorization No. 51/89-90, and No. 51/89-90 (R1), dated November 1, 1989, and February 13, 1990, respectively.

1.1 Purpose and Scope

The purpose of the geotechnical engineering evaluation was to explore and evaluate the soil conditions at the site, and based on the geotechnical conditions revealed by the exploration and testing programs, to provide geotechnical recommendations for the design of the proposed baseball stadium. In addition to the geotechnical evaluation, the site geologic conditions were evaluated with respect to faults reportedly located in the vicinity of the project site. Our understanding of the proposed project and the general scope of geotechnical services was based on discussions with Mr. Dave Inouye and Mr. Tom Tomeoni of UCSB, discussions with Mr. John Fulton of Barry A. Berkus (Architect), and our review of conceptual plans (three sheets) prepared by Barry A. Berkus, Architects, undated.

The scope of our services was presented in our proposal of October 6, 1989 and on addendum to our proposal, dated January 19, 1990. The work completed by K-C is the following:

- o Review of selected geotechnical and geologic reports prepared by others in the vicinity of the project site;

- o An exploratory program involving excavating and sampling five exploratory borings, one exploratory trench approximately 145 feet in length, and approximately 2,875 lineal feet of seismic refraction survey lines;

- o Laboratory tests on soil samples selected from materials obtained from the field exploration;

- o Evaluation of field and laboratory tests, assessment and organization of the data, and project evaluation with other members of the design team; and

- o Evaluation of geologic data and field information relating to fault locations at the site as they relate to the project.

- o This written report, with graphics, based on data obtained from the exploration and testing programs. The report presents the results of laboratory tests, boring logs of the subsoil strata, a discussion as to the soil characteristics with respect to the planned project, discussion of the geologic setting and faulting in the region and at the site, and geotechnical opinions and recommendations with respect to:

  - o Site preparation and grading,

  - o Foundation support of structures, soil bearing pressures, foundation embedment depths, and foundation design; and

  - o Soil compaction recommendations for the site fill, and for support of the structures

1.2 Limitations

K-C prepared the conclusions and professional opinions presented herein in accordance with generally accepted geotechnical engineering principles and practices at the time and location this report was prepared. This statement is in lieu of all warranties, express or implied.

This report has been prepared for use by the University of California and their authorized agents only. It may not contain sufficient information for the purposes of other parties or other uses. If any changes are made in the project as described in this report, the conclusions and recommendations contained herein should not be considered valid unless K-C reviews the changes and modifies and approves in writing the conclusions and recommendations of this report. This report and the drawings contained herein are intended for design-input purposes; they are not intended to act as construction drawings or specifications.

Soil and rock deposits may vary in type, strength, and many other geotechnical properties between points of observations and exploration. Additionally, groundwater and soil moisture conditions can also vary seasonally or for other reasons. Therefore, we do not and cannot have a complete knowledge of the subsurface conditions underlying the site. The criteria presented herein are based upon the findings at the points of exploration and upon interpretive data, that is, on interpolation and extrapolation of information obtained at points of observation.

2. LOCATION AND DESCRIPTION OF SITE

The proposed baseball stadium will be located at the athletic fields east of Stadium Road, University of California, Santa Barbara, California. The location of the site relative to nearby streets and local landmarks is shown on the Vicinity Map, Figure 1. The project site is presently occupied by the existing baseball field, bleachers, soccer field, softball field, and a gravel parking area (see Site Plan, Figure 3). Based on review of the topographic plan, undated, provided by UCSB Facilities Management, the site slopes slightly to the north with existing grades ranging from approximately elevation 44 feet mean sea level (MSL) in the vicinity of the soccer and softball fields to approximately elevation 36.5 feet MSL in the north end of parking lot 30.

3. PROJECT DESCRIPTION

We understand that the project, as presently planned, will consist of constructing a baseball stadium in three phases that will ultimately provide seating for approximately 1,500 fans. Mr. Fulton of Barry A. Berkus has indicated to us that the bleachers will be constructed from prefabricated units that will be built independent of structures constructed below the bleachers. The bleachers will be constructed in three sections. The central portion will be constructed immediately behind home plate, and additional seating will be provided in two other sections constructed along the first baseline and third baseline. The plans show that a structure for public toilets and concessions will be provided below the central portion of the bleachers. Clubhouse facilities, locker rooms, and offices space will be provided in structures constructed below the other two bleacher sections. Appurtenant construction will consist of a ticket office, dugouts, parking areas, architectural facades in front of the bleachers, a press box, and utilities. Structural design information for the structure is not available at this time; we should review our recommendations once this information is available.

4. WORK PERFORMED

4.1 Report Review

Selected geotechnical and geologic reports prepared for the University in the vicinity of the project site were provided by Facilities Management. We reviewed these reports to evaluate the local geologic conditions as they relate to faults reported and/or mapped near the site. Reports that we have reviewed are listed on the Reference page. The information obtained from previous reports is discussed in the Fault Setting section.

4.2 Field Exploration and Laboratory Testing

The geotechnical engineering investigation for this project consisted of a program of field exploration, laboratory testing, and engineering evaluation. Field exploration consisted of excavation and sampling of five exploratory borings to depths ranging between approximately 31 and 37 feet below the ground surface, a seismic refraction survey and an exploratory trench to locate possible subsurface anomalies that could be related to fault zones. Three seismic refraction survey lines totaling approximately 2,875 lineal feet were conducted in a north-south alignment in the vicinity of the baseball field. The seismic refraction investigation identified several subsurface anomalies that could possibly be attributed to faulting. In order to evaluate the potential that the anomalies were fault-related, an exploratory trench was excavated in approximately a north-south alignment. The alignment was selected because reported faults in the area generally have east-west trending alignments. The length of the trench was approximately 145 feet and the depth ranged from 11 to 13 feet. The approximate locations of the borings, seismic lines and exploratory trench are shown on the Site Plan, Figure 3.

Laboratory testing was conducted on selected soil samples obtained from the borings to characterize general geotechnical engineering properties of the soils. The field and laboratory data generated for this study are presented in Appendices A and B, respectively. The Seismic Refraction Investigation by Ryland Associates is attached as Appendix C.

5. GENERAL SUMMARY OF SITE CONDITIONS

5.1 Regional Geology

The University is situated within the western portion of the Transverse Range Province. The province is locally dominated by the east-west trending Santa Ynez Mountain Range, which extends continuously from Point Arguello eastward for 75 miles into Ventura County. The Santa Ynez Mountains and adjacent lowlands are composed mostly of sedimentary rocks ranging in age from Cretaceous to Recent. Structural geology in the Santa Barbara and Goleta area consists of a south-dipping homocline and adjacent coastal plain, cut by a series of subparallel faults and folds that extend from the mountains into the Santa Barbara Channel.

5.2 Geologic Setting

The project site is located on the northern edge of an elevated mesa that is bounded by the Pacific Ocean to the south, the Goleta slough to the north and east, and the Devereaux slough to the west. The mesa is generally a flat lying marine terrace elevated 20 to 45 feet above the sea level. Tectonic uplift during the Pleistocene is believed to be the cause of the elevated feature (Dibblee, 1966). Stream erosion has dissected the marine terrace to produce the present isolated mesa.

The general geology of the main campus consists of a relatively thin cap of Pleistocene terrace deposits unconformably overlying Pliocene and Pleistocene sedimentary rocks. The geologic formations that reportedly underlie the campus vicinity consist of Miocene through Recent age deposits. These deposits are the Monterey Shale (Miocene), the Sisquoc Formation (Miocene-Pliocene), the Santa Barbara Formation (Plio-Pleistocene), Terrace deposits (Pleistocene), Older Alluvium (Late Pleistocene), and Alluvium (Recent).

As encountered in the exploratory trench and borings, the project site is underlain by earth materials that we classified as shallow fills and topsoil, terrace deposits, Santa Barbara Formation and Sisquoc Formation. A description of the materials encountered is presented in the Soil Conditions, Section 5.4.

5.3 Site Faulting

5.3.1 Fault Setting

The Santa Barbara and Goleta area is characterized by east-west trending near vertical faults (Dibblee, 1966). Displacement along the faults is believed to be mainly vertical, with the majority of faults having upthrown south blocks. In the vicinity of the campus active, or potentially active, faults are the Goleta Point Fault, the Cambell Fault, the Campus Fault, and faults within the More Ranch Fault zone. Activity levels of faults are a function of the age of materials documented to be displaced by faulting. An active fault, as defined by the Santa Barbara County Seismic Element, is a fault that shows displacement during the last 11,000 years (Holocene); whereas, a potentially active fault is defined as displacing deposits of late Pleistocene age (11,000 to 500,00 years), but not showing signs of Holocene displacement. In addition to these faults, a potential fault termed the Briggs Lineation is inferred to crosscut the main campus. Faults are located in the Goleta Valley north of the project site; among them are the Dos Pueblos Fault, the Glenn Annie Fault, the Carneros Fault, the Goleta Fault, and the San Jose Fault (Dibblee, 1987).

The approximate locations of faults in the vicinity of the project are shown on Figure 2, Fault Location Map. Faults located in the vicinity of the project site reportedly are the main branch of the More Ranch Fault and the North Ellwood Fault. The More Ranch Fault and the North Ellwood Faults have been mapped by previous investigations in the vicinity of the baseball field. These faults are believed to be part of the More Ranch Fault zone. The Campus Fault has been mapped (Hoover, 1987) approximately 2,500 feet southeast of the proposed building area. Hoover considers the Campus Fault as being potentially active.

The main branch of the More Ranch and North Ellwood Faults are interpreted to be high angle reverse faults that dip to the south along the margin of the campus mesa area (Dames & Moore, 1973). Oil well logs east of the campus report vertical displacements (at depths), of as much as 2,000 feet along the More Ranch Fault. Displacement along the fault zone decreases to the west, particularly in the vicinity of the Ellwood anticline, located approximately 2 miles northwest of Coal Oil Point (Dames & Moore, 1973). The south branch of the More Ranch Fault shows an approximately two-foot displacement of late Pleistocene terrace deposits in the sea-cliff, 0.8 miles northwest of Coal Oil Point and approximately 1.75 miles west of the project site.

5.3.2 Geophysical Survey

A seismic refraction survey was performed to locate subsurface anomalies that could be related to the More Ranch fault zone. Two survey lines were located in the approximate vicinity of a series of 24-inch diameter borings drilled by LeRoy Crandall and Associates in 1976. The third line was located approximately midway between the other lines.

The Seismic Refraction Investigation indicated several anomalous subsurface features in the vicinity of the project. The location of the anomalous features corresponded with differing elevations of the Sisquoc/Santa Barbara Formation contact logged by Crandall, (1976). The origin of the anomalies could be related to differing elevations on refracting horizons due to factors such as: erosion, geologic contacts, facies changes, variations in permeability, groundwater, and juxtaposition of dissimilar materials along faults. Interpreted cross sections with the locations of these anomalies are given in the Seismic Refraction Investigation, Appendix C. The majority of the anomalies indicated approximately north side-up geometry, which is not the reported characteristic geometry of the majority of faulting in the area. The seismic survey indicated that the northern portion of the project site is generally underlain by relatively continuous horizontal sediment layers.

5.3.3 Exploration Trenching

The exploratory trench excavated at the site (at the location indicated on the Site Plan, Figure 3, and as shown on the Exploratory Trench Log, Figure A-13), exposed relatively continuous strata of sedimentary materials. The sediments are composed of a sequence of fill, topsoil, eolian sands and terrace deposits. A continuous soil profile was observed to be formed on the eolian and terrace deposits. Bedding was not observed within the trench excavation. Numerous root casts were present, as well as poorly defined fractures.

The description of the strata exposed in the trench, when compared to the general description of the geologic units reported in the vicinity of the campus, combined with the observation of a relatively well developed soil profile, indicates that the age of the materials are pre-Holocene and possibly several tens of thousands of years old.

5.3.4 Site Faulting

The information obtained from the geophysical survey, along with the boring information indicate that the area from the proposed structure areas to approximately 100 feet north appears to be underlain by relatively continuous, horizontal layers of sediments. In the area south of the proposed structures several anomalies within the bedrock were observed. The Sisquoc and Santa Barbara Formation contact is believed to be an erosional unconformity (Dibblee, 1966). Because of the general differing geometry of (approximately north side-up) the anomalies indicated by the geophysical survey, and the relatively continuous profile of terrace materials exposed in the trench, it is our opinion that the anomalies are most likely related to erosional features on the surface of the Sisquoc Formation. In addition, if the anomalies are fault related, it does not appear that Late Pleistocene or Holocene sediments have been displaced, and therefore would indicate that faulting, if present, would be classified as being potentially active at the youngest.

Based on the observations in the trench excavation borings and the geophysical survey made on the project site, it is our opinion that it is likely that active faulting is not present within at least 50 feet of the proposed stadium structures. The possibility of the occurrence of a potentially active fault being present in the deposits at depths greater than the trench does exist; however, the suggested age of the sediments exposed in the trench excavation would indicate that the deeper fault displacement would have to predate several tens of thousands of years. It is our opinion that there is a low probability of such an occurrence and of associated surface rupture.

Building setback parameters from faults are indicated by various government agencies. A generally accepted criteria, and also the one contained in the Santa Barbara County Seismic Element, recommends that critical structures, such as schools, should not be constructed within fifty feet of active or potentially active faults. Although, our evaluation did not locate faults within the project area, it is our opinion that the planned location of the stadium could meet at least a setback requirement of 50 feet.

5.4 Soil Conditions

The description of soil conditions is based on visual classification of samples obtained from our field exploration, laboratory tests performed on selected samples, and our review of selected geotechnical documents and geological investigations performed in the vicinity of the site by K-C and others. Relative densities, and consistency, of the soils encountered were estimated from penetration resistances obtained from borings, and observations from exploratory trenches. The soils encountered during our field exploration generally consisted of terrace deposits overlying bedrock consisting of the Santa Barbara and Sisquoc Formations.

The upper approximately 1 to 4 feet of the soils encountered generally consist of a mixture of dense shallow fill, topsoils and eolian sand. The topsoil and fill material generally consisted of silty sand and sandy with silt. The eolian soils consisted of poorly graded sand and, as revealed by the exploratory trench, had a variable depth extending to approximately 5 feet below the ground surface.

Below the surficial soil, terrace deposit was encountered. The terrace deposits generally consisted of medium dense to very dense sand, with varying amounts of silt, and relatively hard silty and sandy clay. Laboratory tests indicate that the terrace deposits have an average unit weight of approximately 102 pounds per cubic foot, and average moisture content of approximately 16 percent. The terrace deposits were encountered to approximately 15 feet below the ground surface in the exploratory borings.

Bedrock, consisting of Santa Barbara and Sisquoc Formations, was encountered below the terrace deposits in the exploratory borings. The bedrock encountered is predominantly comprised of relatively hard siltstone with varying amounts of sand and clay. Laboratory tests indicate that the bedrock has an average unit weight of approximately 100 pcf, and average moisture content of 22 percent. Bedrock was encountered to the maximum depth explored, approximately 37 feet below the ground surface in the exploratory borings.

5.5 Groundwater Conditions

At the time of exploration, groundwater seepage was encountered at a depth of approximately 10 feet below the ground surface in the exploratory trench and in Borings 1 and 3. Based on our observations during our exploratory boring program, a perched groundwater condition was observed within the terrace deposit and Santa Barbara Formation at depths ranging between approximately 9 and 20 feet below the ground surface. Free groundwater was also encountered at approximately 30 feet below the ground surface within the Sisquoc Formation. Previous explorations performed by others (PML, 1987) indicated a groundwater level at approximately 11 feet below the ground surface. Variations in the groundwater level can occur as a result of variations in irrigation schedules, rainfall, temperature, and other factors.

6. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the data obtained from the exploration and testing programs described in this report and on our understanding of the project as currently planned. A summary of our conclusions and geotechnical recommendations for the project are as follows:

- The site is considered geotechnically suitable for the project as presently planned, provided the recommendations presented in this report are incorporated into design and implemented during construction.

- The results of our field explorations indicated that it is likely that active faults are not present within 50 feet of the proposed structures, and that there is a low probability that potentially active faults are present. It is our opinion that the location of the proposed structures meets or exceeds a setback of 50 feet.

- The proposed baseball stadium and appurtenant structures can be supported on conventional spread footings bearing in compacted existing on-site soils.

- We recommend that the structure be designed to at least minimum code standards for Seismic Zone 4, as designated by the latest approved edition of the Uniform Building Code.

6.1 Site Development and Grading - General

Fill placement and grading operations should be performed under the observation (and testing) of K-C and in accordance with the grading recommendations of this report and applicable grading ordinances for the County of Santa Barbara. The recommendations contained in the grading ordinances set forth the standards needed to satisfy other recommendations of this report. We recommend that, unless otherwise noted, the fill and backfill materials be compacted to at least 95 percent relative compaction determined by ASTM Test Method D1557.

6.1.1 Clearing and Grubbing

Prior to commencing grading operations, existing non-complying fills and soil containing debris, organics, pavement, and other unsuitable materials, should be excavated and removed. Demolition areas should be cleared of old foundations, slabs, abandoned utilities, and soils disturbed during the demolition process. Depressions or disturbed areas left from the removal of such material should be replaced with compacted fill.

6.1.2 Fill Materials

On-site soils (terrace deposit, shallow surficial fills, and eolian sands) free of organic and other deleterious materials can be used as compacted fill below footings and slabs. During grading operations, K-C should check the soil for organic content and expansion potential. Imported material, if used, should be reviewed by K-C before being brought to the site. The materials used should be free from vegetation, oversized rock (greater than 6 inches in diameter), and other deleterious material. Imported soils, if used, should have an expansion index less than 3.

6.1.3 Fill Placement

The selected fill or backfill material should be placed in layers that can be compacted with the equipment being used. Each layer should be spread evenly and should be thoroughly blade-mixed during the spreading to provide relative uniformity of material within each layer.

Rocks larger than 3 inches in diameter should not be permitted in the upper 18 inches of fill within the building areas. The maximum size of rock permitted in the remainder of the fill will depend on the ability of the compacting equipment to achieve a compacted, uniform fill. Rocks should not be nested, and voids should be filled with compacted materials.

When the moisture content of the fill material is below that sufficient to achieve the recommended compaction, water should be added to the fill until the moisture content is at or near the optimum. While water is being added, the soil should be bladed and mixed to provide a relatively uniform moisture content throughout the material. When the moisture content of the fill material is excessive, the fill material should be aerated by blading or other methods until the moisture content is at or near the optimum. After each layer has been placed and mixed, it should be spread in loose lifts no thicker than approximately 8 inches, and compacted.

6.1.4 Observation and Testing

K-C should perform field density tests during the placement of the compacted fill. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests should be performed in compacted material below the disturbed surface. When these tests indicate that the density of any layer of fill or a portion thereof is below the recommended compaction, that particular layer or portion should be reworked until the recommended density has been obtained. The fill operations should be continued in relatively thin compacted layers, as recommended above, until the fill has been brought up to the finished slopes and grades as shown on the plans. Exposed surfaces should be graded to prevent water from running into excavated areas. Ponded water should be promptly removed, and the soils at the site should be kept at near-optimum moisture content.

K-C should be present at preconstruction meetings with the contractor's representatives to review scheduling and the contractor's anticipated scope of work. K-C should be notified of preconstruction meetings and grading operations at least 48 hours in advance, so that we can coordinate field personnel and dispatch them to the site when needed.

6.2 Grading for Pavement Areas

We understand that asphalt pavements are planned for driveway and parking areas as part of the proposed construction. In these areas, soil should be removed to a depth of at least 12 inches. The exposed surface should be scarified to a depth of at least 6 inches and recompacted. In pavement areas, prior to receiving base course material, the upper 12 inches of the subgrade soil should be compacted to at least 95 percent relative compaction.

6.3 Grading for Building Areas

To provide a relatively uniform support for slabs-on-grade and foundations , we recommend that, within the building footprint (the building perimeter plus 5 feet outside the exterior perimeter), the existing soils should be excavated at least 24 inches below existing grade or 24 inches below the bottom of footing, whichever is deeper. In areas of existing fills or loose soils, deeper excavations may be required. The surfaces exposed at the base of the excavations should be scarified at least 6 inches and compacted in-place to a dry density of at least 95 percent relative compaction. Fill can then be placed and compacted in thin (approximately 6 inches in compacted thickness) lifts to at least 95 percent relative compaction. We recommend that the subgrade soils be tested for swell potential at the time of grading.

6.4 Structure Foundations

We recommend using conventional, shallow continuous strip footings and/or isolated pad footings, bearing on compacted soil, for the proposed baseball stadium and structures below the bleachers. An embedment depth of at least 18 inches into compacted soils should be used. Where footings are founded in recompacted soil, a maximum allowable bearing pressure of 2,500 pounds per square foot is recommended. As a foundation alternative, the ticket office can be supported on a concrete slab-on-grade, placed on soils prepared in accordance with our recommendations for grading for pavement areas, Section 6.2. The slab-on-grade should be designed for a maximum allowable bearing pressure of 1,000 psf. Design information for the bleachers is not available at this time. If drilled pier foundations are considered as an alternative for support of the bleachers, we should be notified so that we can review our foundation recommendations, and provide geotechnical recommendations for the design of the foundations, once structural loading information is available. Maximum allowable bearing pressures can be increased by one-third when considering short-term wind or seismic loads.

We estimate that settlement of footings, if placed as recommended, should not exceed 1 inch total. Differential settlement between adjacent members is estimated at 1/2 inch.

The Structural Engineer responsible for foundation design should specify reinforcing of foundations based on loading conditions. Based on the expected soil conditions, we recommend that at least two Number 4 reinforcing bars be placed in continuous footings, one near the top and one near the bottom. Soils should be tested for expansion at the time of grading. If the soils used as backfill or fill materials are more expansive than anticipated prior to construction, K-C can recommend additional reinforcement, if necessary.

6.5 Frictional and Lateral Coefficients

Resistance to lateral loading can be provided by sliding friction acting on the base of foundations founded on compacted soil. We recommend a coefficient of friction of 0.30 for dead-load forces. For resistance to lateral load, we recommend using passive resistance acting on the sides of foundation stems (350 psf, equivalent fluid weight) where concrete is placed against compacted materials. No passive resistance should be included for the upper one foot of soils that are not constrained by slab-on-grade or pavement. A one-third increase in the recommended passive value can be used for wind or seismic loads.

6.6 Slab-on-Grade Construction

We recommend that concrete slabs without vehicular traffic should be at least 4 inches thick. Based on the expected soil conditions, we recommend that slabs be reinforced with at least Number 3 reinforcing bars placed at 24 inches on center both ways, at mid-depth of concrete slabs. Additional reinforcing should be provided as recommended by the Structural Engineer. Concrete slab-on-grade in vehicle traffic areas should be designed based on the anticipated traffic loads.

K-C should take samples of the subgrade soils in slab-on-grade areas to evaluate the expansion potential of the soils at the time of grading. This will allow us to review the soil conditions at this time and recommend additional slab reinforcement, if needed .

A vapor barrier should be placed below concrete slabs-on-grade in the interior of the buildings. The vapor barrier should consist of 2 inches of clean, well-graded sand, overlain by a visqueen membrane and an additional 2 inches of sand.

If concrete slab-on-grade is proposed in vehicle traffic areas, the concrete thickness should be designed based on expected loadings and repetitions of load. Concrete slab on-grade should be underlain by at least 4 inches of Class 2 Aggregate Base (Caltrans) in areas where wheeled equipment will operate. The subgrade in areas to receive pavement slab-on-grade should be prepared in accordance with Section 6.2.

6.7 Utility Trenches

Utility trenches can probably be excavated with a backhoe. Trenches over 5 feet deep should be properly braced or sloped in accordance with OSHA standards. Utility trench backfill should be governed by the provisions stated in other sections relating to compaction recommendations where they are applicable. In general, backfill for service lines extending inside the property should be compacted to at least 90 percent of the maximum dry density. Backfill materials should be mechanically compacted, and placed in accordance with the recommendations provided in Sections 6.1.2, 6.1.3, and 6.1.4. Where the surface of the backfill is to receive pavement, the upper 12 inches of the material should be compacted to 95 percent of the maximum dry density.

6.8 General Construction Comments

Pad grading should be such that positive drainage away from the structure is provided, so that water will not pond near the structure.

We recommend that roof gutters be installed and that solid pipes or splash blocks be provided at the down spouts to carry roof waters well away from the foundations. Surface drainage swales should be positioned to allow for rapid removal of rain and irrigation water away from the foundations.

6.9 Seismic Considerations

We recommend that the structure be designed to at least the code standards for Seismic Zone 4, as designated by the latest edition of the Uniform Building Code.

6.10 Additional Services

6.10.1 Plan Review

We recommend that K-C be retained to provide a general review of the grading, improvement, and foundation plans. The purpose of this review is to assess general compliance with the earthwork and foundation recommendations of this report, and to confirm that the recommendations given in this report are incorporated in the project design plans and specifications.

6.10.2 Observation and Testing

We further recommend that K-C be retained to provide services during the grading, excavation, and foundation phases of the work. Localized loose pockets of soil can be encountered in the foundation areas. Foundation excavations should be checked at the time of construction. The purpose of these services is to observe compliance with the initial development concept, the specifications, and the geotechnical recommendations. The observation and testing services will allow for changes in the recommendations in the event that subsurface conditions differ from those anticipated prior to construction.

END OF TEXT

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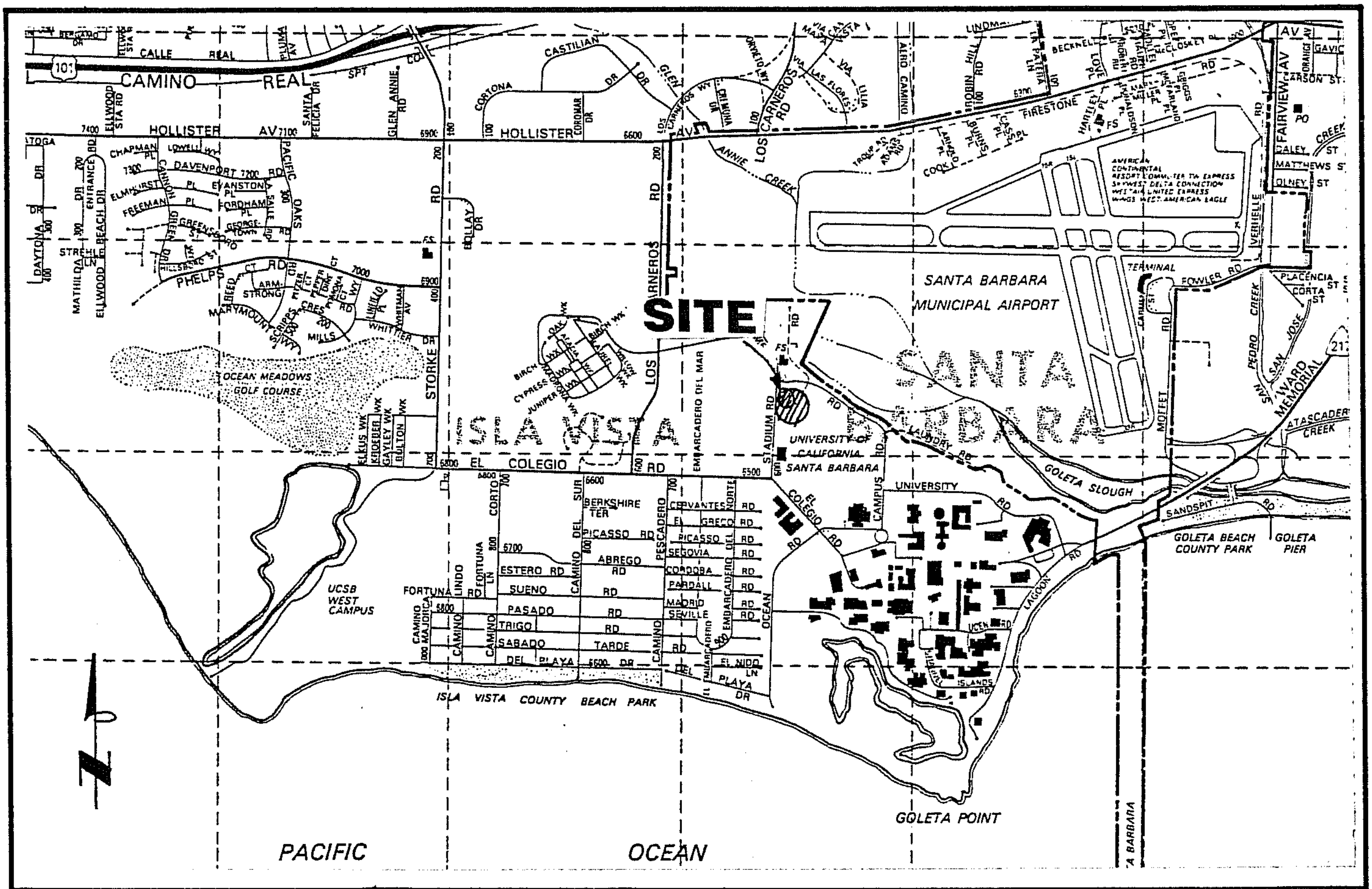


VICINITY MAP

Baseball Stadium

University of California

Santa Barbara, California

K-C GEOTECHNICAL ASSOCIATES

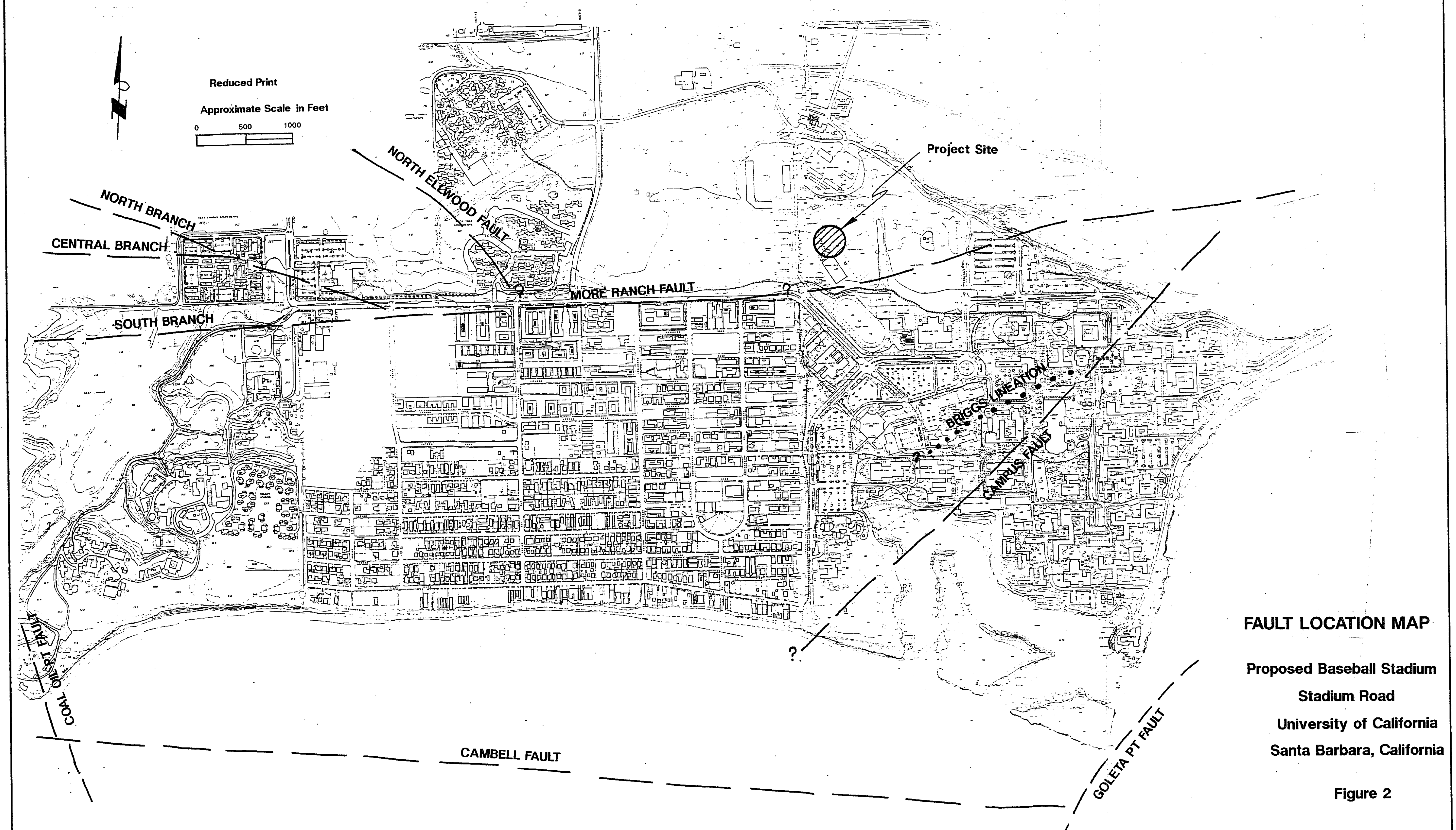
Geotechnical Engineering
Engineering Geology

"Reproduced with permission granted by Thomas Brothers Maps"

Figure 1

File KC-1405-03

By RM Date 4/90



FAULT LOCATION MAP

Proposed Baseball Stadium
Stadium Road
University of California
Santa Barbara, California

Figure 2

— — — Approximate Surface Trace of Active or Potentially Active Fault

• • • • • • • Approximate Surface Trace of Potential Fault

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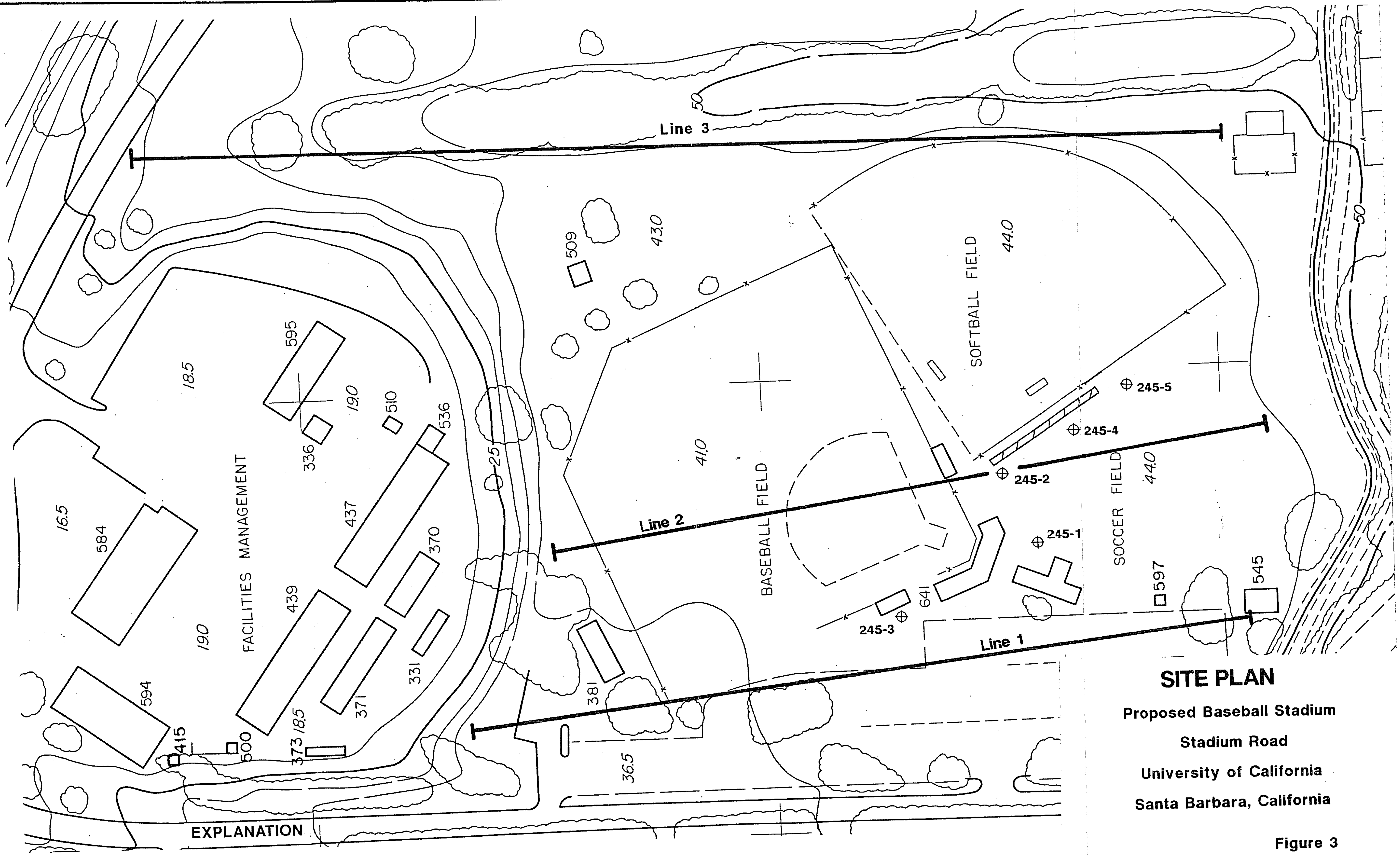
Geotechnical Engineering

Fault locations based on previous investigations listed on reference page



SITE PLAN

Proposed Baseball Stadium

Stadium Road

University of California

Santa Barbara, California

Figure 3

EXPLANATION

- ⊕ – Approximate Location of Exploratory Boring
- ▨ – Approximate Location of Exploratory Trench
- ├─┤ – Approximate Location of Seismic Refraction Line (see Appendix C)

Approximate Scale: 1 in. = 100 ft.

K-C GEOTECHNICAL ASSOCIATES
Geotechnical Engineering

APPENDIX A

FIELD EXPLORATION

A.1 General

The field exploration for this Geotechnical Engineering Report consisted of excavating five exploratory borings on November 27 and 29, 1989, conducting a seismic refraction survey on November 7, 1989, and excavating one exploratory trench on March 26, 1990. This exploration was conducted in accordance with the scope of services given in the K-C proposal dated November 6, 1989 and addendum proposal of January 19, 1990.

A.2 Borings

The drilling subcontractor on the project, Valley Well Drilling of Ventura, California, used a truck-mounted Georex T-500 drill rig with a hollow stem auger to advance the borings. The drilling was performed under the observation of a staff geologist of K-C, who prepared logs of the soil conditions and obtained soil samples for laboratory observation and testing. The soils were classified in the field in accordance with the Unified Soil Classification System (see Figure A-2). Five 8-inch-diameter borings were drilled to depths ranging from approximately 31 to 37 feet below the existing ground surface. The approximate locations of the exploratory borings are shown on Figure 3. Boring locations were assessed approximately in the field by taping and sighting from existing topographic features.

Drive samples were obtained from the exploratory borings using a modified California sampler and/or a Standard Penetration Sampler. The modified California sampler has a 3-inch outside diameter and a 2.37-inch inside diameter; it contains 1-inch-high fiber liners. The sampler was generally driven 12 inches into the material at the bottom of the hole by dropping a 140-pound hammer 30 inches. The number of blows needed to drive the sampler into the soils a measured depth was recorded, as shown on the Log of Borings. Recovered samples were sealed in transport containers and returned to the laboratory for further classification and testing. The borings were backfilled with excavated cuttings and were not compacted.

Standard Penetration Tests (split spoon) were performed to obtain an indication of the density of the soil and to allow visual observation of at least a portion of the soil column. Soil samples obtained with the split spoon sampler were retained for further observation and testing. The split spoon samples were driven approximately 18 inches by dropping a

140-pound hammer 30 inches. The number of blows required to drive the split spoon to three 6-inch increments was recorded on the field boring log. The number of blows per foot (Standard Penetration N Value) is equal to the sum of the last two 6-inch increments.

Bulk samples were collected from cuttings obtained from the borings. The bulk samples were selected for classification and testing purposes and may represent a mixture of soils within the noted depths. Recovered samples were placed in transport containers and returned to the laboratory for further classification and testing.

Logs of the borings, showing the depths and descriptions of soils encountered, geologic structure where applicable, vertical locations of drive samples, penetration resistances, and results of density and moisture content tests, are presented in the Appendix. A legend of symbols typically used on the Log of Boring is given in Figure A-1. The logs represent the interpretation of field logs and tests, the interpolation of soil conditions between samples, and the results of laboratory observations and tests. The noted stratification lines represent approximate boundaries between soil types; the transitions can be gradual.

A.3 Exploratory Trench

The excavation subcontractor on the project, Steve Beausoleil Backhoe Service of Goleta, California, used a rubber-tired backhoe to excavate the exploratory trench. The trenching was performed under the observation of a staff geologist and senior geologist, who prepared a log of the soil conditions and geologic features (Figure A-13). The soils were classified in the field in accordance with the Unified Soil Classification System. One, 30-inch wide trench was dug to depths ranging from 11 to 13 feet below the existing ground surface. The length of the trench was approximately 145 feet, and the approximate location is shown on the Site Plan, Figure 3. The trench was backfilled with the excavated soils and compacted with a vibratory compactor.

A.4 Seismic Refraction Survey

The seismic survey subcontractor on the project was Ryland Associates of Pasadena, California. Three seismic refraction lines comprising length of approximately 2,875 feet were conducted in order to evaluate subsurface anomalies that could be interpreted as postulated faults. The Seismic Refraction Investigation Report prepared by Ryland Associates is attached as Appendix C.

LEGEND FOR SYMBOLS
COMMONLY USED ON BORING LOGS

- 3-Inch O.D. Modified California Split-Barrel Sampler

- Standard Penetration Test (SPT)

- Loose Bulk Sample

- Water Level First Encountered

- Water Level After Drilling

NR - No Recovery

ROTARY AND CORE BORING LOGS

DATA ON THESE LOGS IS APPROXIMATE BECAUSE OF POSSIBLE DEVIATION FROM THE INTENDED DIRECTION OF DRILLING, INCOMPLETE RECOVERY OF DRILL CORE, AND THE LIMITED AND POSSIBLY DISTURBED SAMPLE PROVIDED BY A SMALL DIAMETER HOLE.

THESE LOGS INDICATE CONDITIONS ONLY ON THE DATE INDICATED AND MAY NOT REPRESENT CONDITIONS AT OTHER LOCATIONS AND ON OTHER DATES.

BORINGS WERE LOGGED IN SUCH A WAY AS TO PRIMARILY PROVIDE DATA FOR DESIGN PURPOSES AND NOT NECESSARILY FOR PURPOSES OF SPECIFIC CONSTRUCTORS.

SOIL CLASSIFICATIONS SHOWN ON THE LOGS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM.

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES; THE TRANSITIONS MAY BE GRADUAL.

FILE NO.: KC-1405-03	**LEGEND FOR SYMBOLS**	FIGURE A-1

Major Divisions			Graphic Symbol	Letter Symbol	Typical Descriptions
Coarse-Grained Soils More than 50% of material retained on No. 200 sieve	Gravel and Gravelly Soils More than 50% of coarse fraction retained on No. 4 seive	Clean Gravels (Little or no fines)		GW	Well-graded gravels, gravel-sand mixtures, little or no fines
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines (Appreciable amount of fines)		GM	Silty gravels, gravel-sand-silt mixtures
				GC	Clayey gravels, gravel-sand-clay mixtures
	Sand and Sandy Soils 50% or more of coarse fraction passing No. 4 seive	Clean Sands (Little or no fines)		SW	Well-graded sands, gravelly sands, little or no fines
				SP	Poorly-graded sands, gravelly sands, little or no fines
		Sands with Fines (Appreciable amount of fines)		SM	Silty sands, sand-silt mixtures
				SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils 50% or more of material passing No. 200 sieve	Silts and Clays	Liquid limit less than 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 and Clays	Liquid limit 50 or more		MH	Inorganic siltys, micaceous or diatomaceous fine sand or silty soils
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic clays of medium to high plasticity, organic silts
Highly Organic Soils				PT	Peat, humus, swamp soils with high organic contents

NOTE: Dual symbols are used to indicate borderline soil classifications.

FILE NO.: KC-1405-03	**UNIFIED SOIL CLASSIFICATION SYSTEM**	FIGURE A-2

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger
LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling
DRILLING DATE: November 27, 1989
SURFACE EL.: 43 feet
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
0										
	1A	31	SP/SM	Poorly graded SAND with silt, dense, light gray brown, moist to 6 inches, then dry, very fine grained						4.5+
	1-1	51			--	12.0				
5	1-2	36	SM	Silty SAND, dense, light gray to tan, moist	109.3	14.9				2.0
	1B									
	1-3			-Terrace-	--	23.8				
10	NR	31		Perched water at 10 feet ∇	--	--				
	1-4		CL/ML	Clayey SILT with sand (CL-ML), hard, medium gray-green, wet	92.0	29.8				
	1C	36								
15	1-5	40		-Terrace-	87.6	28.7				2.5
			ML	"SILT", hard, mottled tan to orange brown, moist						
20	1-6	37		-Santa Barbara Formation- ∇	93.5	24.6				4.0
25			ML	"SILT", hard, dark gray with brown mottling in fractures, moist, with carb. filled fracture -Sisquoc Formation-						

(Boring log continued on Figure A-4.)

GROUNDWATER DATA:
Groundwater initially encountered at 10 ft.

LOG OF BORING
BORING NO. 245-1

FILE NO.: KC-1405-03
FIGURE A-3

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slaymen
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 43 feet
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
25					ML	"SILT," very hard, dark gray with brown mottling in fractures, wet, with carb. filled fractures						
30		1-7	50/ 10"			-Sisquoc Formation-	104.6	20.0				
						Boring terminated at 31 feet.						

GROUNDWATER DATA:
Groundwater initially encountered at 10 ft.

LOG OF BORING
BORING NO. 245-1 (cont.)

FILE NO.: KC-1405-03
FIGURE A-4

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 44.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
0										
	2-1	50	SM	Silty SAND, dense to very dense, light gray brown, dry	106.3	8.1				
	2-2	50/ 6"			103.3	10.6				
5										
	2-3 2D	33			--	10.1				
	2-4	31			--	23.8				
10				-Terrace-						
	2-5	35	ML	SILT with sand, hard, medium brown, moist	99.6	24.6				3.5
15	2-6	30			100.7	23.5				
				-Terrace-						
20	2-7	32	ML	"SILT", hard, mottled orange brown to blue-gray, wet	--	22.1			10	
				-Santa Barbara Formation-					22	
25										

(Boring log continued on Figure 11-6)

GROUNDWATER DATA:
Groundwater initially encountered at 22 ft.

LOG OF BORING
BORING NO. 245-2

FILE NO.: KC-1405-03
FIGURE A-5

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger
LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling
DRILLING DATE: November 27, 1989
SURFACE EL.: 44.0
DATUM: MLS-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
25					ML							
					CL	"Lean CLAY", hard, dark gray, wet						
30		2-8	43			- Sisquoc Formation -	98.2	26.9				4.5+
						Boring terminated at 31 feet.						

GROUNDWATER DATA:
Groundwater initially encountered at 22 ft.

LOG OF BORING
BORING NO. 245-2 (cont.)

FILE NO.: KC-1405-03
FIGURE A-6

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 43.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
0					SP	SAND with silt, medium dense to dense, dark brown, moist						
		3-1	40		SP	Poorly graded SAND, dense, light gray-brown, moist	115.0	12.1				
5		3-2	43				104.2	15.2				
10		NR	28			Perched water at 10 feet ▽	--	--				
						-Terrace-						
15												
20		3-3	46		ML	"SILT with sand",hard, mottled dark gray to orange brown, wet	98.0	21.0				
						-Santa Barbara Formation-						
25					CL/ML	"Clayey SILT", very hard, dark gray-brown, wet						

(Boring log continued on Figure A-8)

GROUNDWATER DATA:
Groundwater initially encountered at10 ft

LOG OF BORING
BORING NO. 245-3

FILE NO.: KC-1405-03
FIGURE A-7

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 43.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
25					CL/ML	"Clayey SILT," very hard, dark gray-brown, wet - Sisquoc Formation -						
30		3-4	50/10"			▽	107.6	19.7				
						Boring terminated at 31.5 feet.						

GROUNDWATER DATA:
Groundwater initially encountered at10 ft

LOG OF BORING
BORING NO. 245-3 (cont.)

FILE NO.: KC-1405-03
FIGURE A-8

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 44.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
0–7					SP	Poorly graded SAND, dense, light gray-brown, dry -Terrace-						
7–14					SM	Silty SAND, dense, medium gray-brown -Terrace-						
15	▯	4-1	31			"SILT" with sand, dense, mottled, orange and gray-brown, moist						
20	▯	4-2	35		ML	Becoming very moist						
23						∇						
						-Santa Barbara Formation-						

(Boring log continued on Figure A-10)

GROUNDWATER DATA:
Groundwater initially encountered at 23 ft

LOG OF BORING
BORING NO. 245-4

FILE NO.: KC-1405-03
FIGURE A-9

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 27, 1989
SURFACE EL.: 44.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
25		4-3	10/ 1"		ML							
30		4-4	48		SP	Poorly graded SAND, very dense, orange-brown, wet, traces of shell fragments - Santa Barbara Formation -						
35		4-5	50/ 6"		CL	Silty CLAY,hard, dark gray-brown, wet - Sisquoc Formation -						
						Boring terminated at 36 feet.						

GROUNDWATER DATA:
Groundwater initially encountered at 23 ft

LOG OF BORING
BORING NO. 245-4 (cont.)

FILE NO.: KC-1405-03
FIGURE A-10

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger

LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling

DRILLING DATE: November 29, 1989
SURFACE EL.: 44.0
DATUM: MSL-USGS

DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
0–14					SP	Poorly graded SAND, medium gray-brown, moist - Terrace -						
14–20					ML	"SILT", firm, mottled dark gray-brown to orange-brown, moist - Santa Barbara Formation -						
20–27					ML	"SILT", firm, mottled dark gray-brown to orange-brown, wet -Santa Barbara Formation-						
20.5	▧	5-1	17									
23.5	▧	5-2	22									
25.5	▧	5-3	29									

(Boring log continued on Figure A-12)

GROUNDWATER DATA:
Groundwater initially encountered at 30 ft.

LOG OF BORING
BORING NO. 245-5

FILE NO.: KC-1405-03
FIGURE A-11

K-C GEOTECHNICAL ASSOCIATES

PROJECT: Baseball Stadium
LOCATION: UCSB Main Campus
DRILLING METHOD: Hollow Stem Auger
LOGGED BY: R. Slayman
DRILLED BY: Valley Well Drilling
DRILLING DATE: November 29, 1989
SURFACE EL.: 44.0
DATUM: MSL-USGS

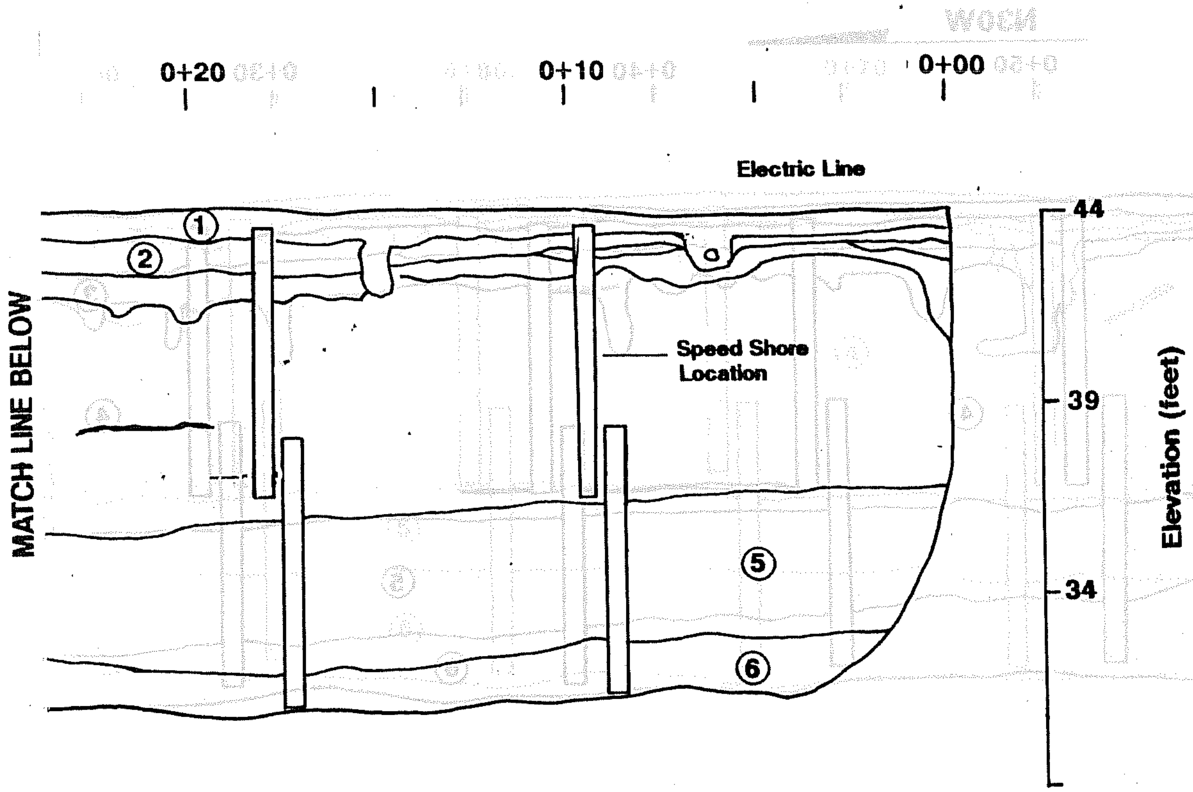
DEPTH (FEET)	SAMPLE INTERVAL	SAMPLE NUMBER	BLOW COUNT (BLOWS/FOOT)	SYMBOLS: GRAPHIC LOG	SYMBOLS: USC	DESCRIPTION AND CLASSIFICATION	DRY DENSITY	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTIC INDEX (%)	TORVANE	POCKET PENETROMETER (TSF)
25	⧄	5-3	29		ML	SILT, firm, mottled, dark gray-brown to orange-brown, moist - Santa Barbara Formation -						
	⧄	5-4	37		CL/ML	Silty CLAY, firm, mottled brown to orange-brown - Santa Barbara Formation - ▽						
30	⧄	5-5	34		SP	Poorly graded SAND, medium dense, mottled, light gray to orange-brown, wet						
	⧄	5-6	10			- Santa Barbara Formation -						
35					CL	"Silty CLAY," hard, dark brown, wet - Sisquoc Formation -						
						Boring terminated at 37 feet.						
40												

GROUNDWATER DATA:
Groundwater initially encountered at 30 ft.

LOG OF BORING
BORING NO. 245-5 (cont.)

FILE NO.: KC-1405-03
FIGURE A-12

K-C GEOTECHNICAL ASSOCIATES



on

) (SM), light brown, dry to moist,
ıd (FILL)

) (SM), gray brown, moist, fine
ESIDUAL SOIL)

ded SAND (SP), tan, moist
)EPOSIT)

) (SM), mottled yellow and gray
ist, with pockets of sandy CLAY
SAND, minor clay filled fractures
ructures (TERRACE DEPOSIT)

) (SM), light gray brown, moist,
ıon organics, carbon staining
tructures at base (TERRACE

I silty CLAY (CL, CL-ML),
llow and gray brown, wet
ıl seepage zones between (5) &
ıon organics (TERRACE

ded SAND (SP), tan to gray
ı (TERRACE DEPOSIT)

EXPLORATORY TRENCH LOG

Proposed Baseball Stadium

Stadium Road

University of California

Santa Barbara, California

Figure A-13

K-C GEOTECHNICAL ASSOCIATES
Geotechnical Engineering

APPENDIX B

LABORATORY TESTING

B.1 General

This appendix discusses the results of the laboratory test program performed for this Geotechnical Engineering Report. Laboratory tests were performed on selected samples obtained from the field to help classify the soils and estimate some of their engineering properties. The program was carried out employing, wherever practical, currently accepted test procedures of the American Society for Testing and Materials (ASTM).

Driven-ring and bulk samples used in the laboratory testing program were obtained from various locations during the course of the field exploration, as discussed in Appendix A. Each sample is identified by sample number and depth. The various laboratory tests performed are described below.

B.2 Index Properties Testing

The method of identifying and classifying soils according to their engineering properties used in this study is ASTM Test Method D2487-83, based on the Unified Soil Classification System. The index properties tests discussed in this report are for water content and dry density, and grain-size distribution (mechanical and hydrometer).

Tests for water content and dry density of the soils were performed, often in conjunction with other tests, on selected drive samples. The samples were trimmed to obtain a smooth, flat face, measured to obtain volume and wet weight, extruded, and visually classified. The samples were dried for approximately twelve hours in an oven maintained at 110 degrees Celsius. After drying, each sample was weighed, and the moisture content and dry density were calculated. The water content and dry density results are summarized on Table B-1 and are included on the boring log data in Appendix A.

The gradation characteristics of selected samples were estimated by hydrometer and sieve analysis procedures. Samples were soaked in water until individual soil particles were separated, then washed on the No. 200 mesh sieve, oven dried, weighed to assess the percent passing the No. 200 sieve, and mechanically sieved. Additionally, hydrometer analyses were performed to assess the distribution of the minus No. 200 mesh material of selected samples. The hydrometer test was run using sodium hexametaphosphate as a dispersing agent. The grain size distribution tests are presented on Figures B-1 and B-2.

B.3 Engineering Properties Testing

The engineering properties testing consisted of tests for consolidation, estimation of maximum density, and direct shear analysis.

One-dimensional consolidation tests were performed on selected driven-ring samples. The samples were typically loaded to .57 or 1.1 kips per square foot (ksf), flooded with water, and incrementally loaded to 2.3, 4.6, and 9.2 ksf. The samples were allowed to consolidate under each load increment. Rebound was measured under reverse alternate loading. Compression was measured by dial gauges accurate to 0.0001 inch. Results of the consolidation tests, in the form of percent consolidation versus log of pressure curves, are presented on Figure B-3.

The direct shear tests were performed on selected driven-ring and remolded samples. The samples were pre-loaded with a confining pressure and flooded with water for at least twenty-four hours. The samples were sheared horizontally at a controlled strain rate, allowing partial drainage. The shear stress on the samples was recorded at regular strain intervals. The results of the direct shear tests are tabulated on Table B-1.

Maximum density tests were performed to estimate the moisture-density relationship of typical soil materials. The tests were performed in accordance with ASTM Test Method D1557. The results of the maximum density tests are presented on Table B-2.

TABLE B-1

Summary of Moisture, Density & Direct Shear Testing

Sample Number	Depth Feet	In-Place Conditions: Dry Density pcf	In-Place Conditions: Moisture Content % Dry Wt.	Direct Shear Testing: Angle of Internal Friction	Direct Shear Testing: Unit Cohesion psf
1-1	3	--	12.0		
1-2	5	109.3	14.9		
1-3	7	--	23.8		
1-4*	11	92.0	29.8		
1-5	15	87.6	28.7		
1-6	20	93.5	24.6		
1-7	30	104.6	20.0		
1A**	1-4	122.8	13.0	25°	500
2-1	1	106.3	8.1		
2-2*	3	103.3	10.6		
2-3	5	--	10.1		
2-4	7	--	23.8		
2-5	12	99.6	24.6		
2-6	15	100.7	23.5		
2-7	20	--	22.1		
2-8	30	98.2	26.9		
3-1	2	115.0	12.1	55°	400
3-2	5	104.2	15.2		
3-3	20	98.0	21.0		
3-4	30	107.6	19.7		

* Consolidation test, see Figure B-2
** Remolded to approximately 90-percent maximum density.

TABLE B-2

Summary of Maximum Density - Optimum Moisture Testing

Sample No.	:	1A
Location, Boring	:	1
Depth, Feet	:	1-4
Maximum Density, pcf	:	115.8
Optimum Moisture, %	:	13.0

Description: Poorly graded SAND with silt (SP-SM), gray-brown

File No. KC-1405-03

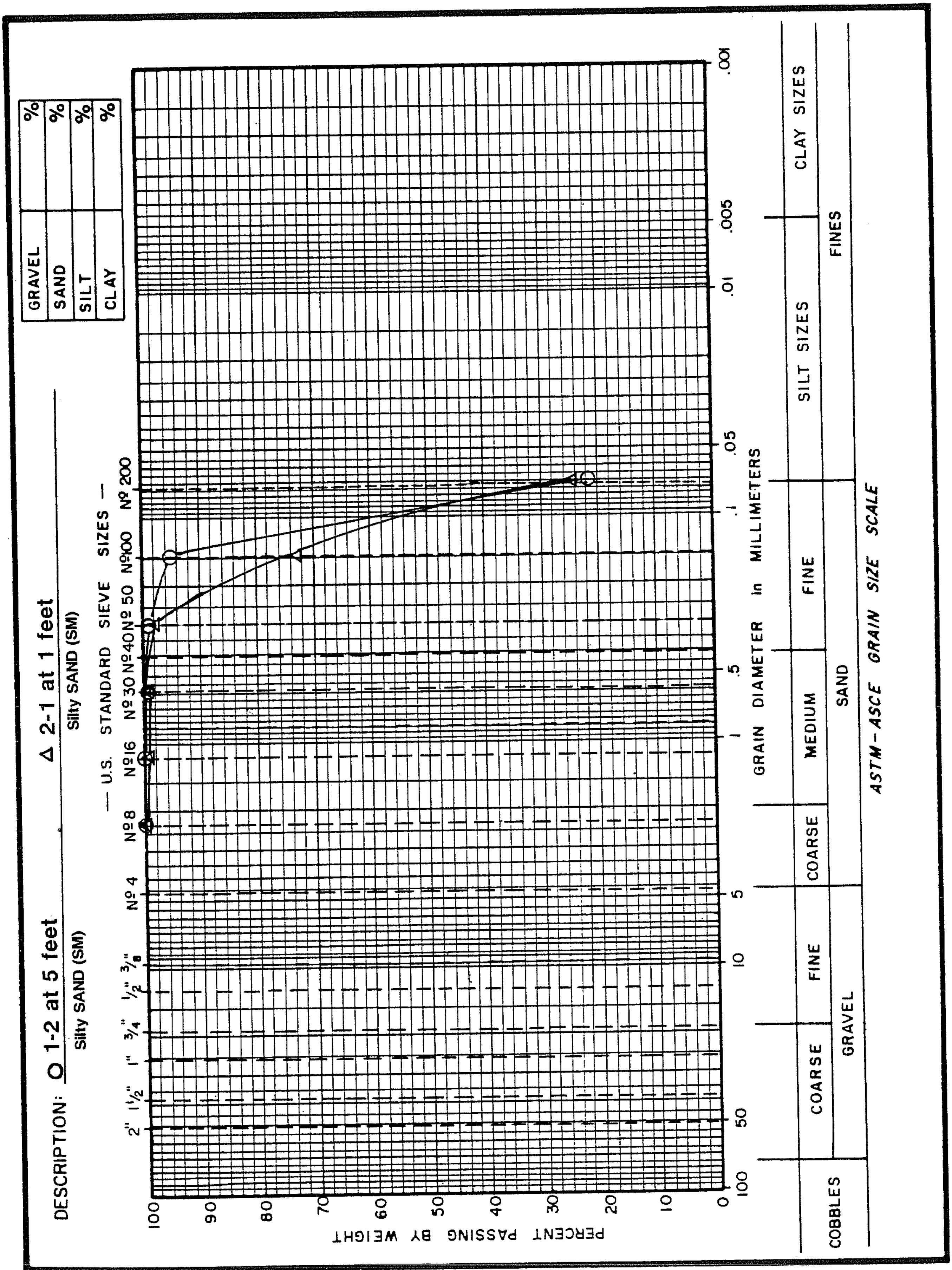


Figure B-1

File No. KC-1405-03

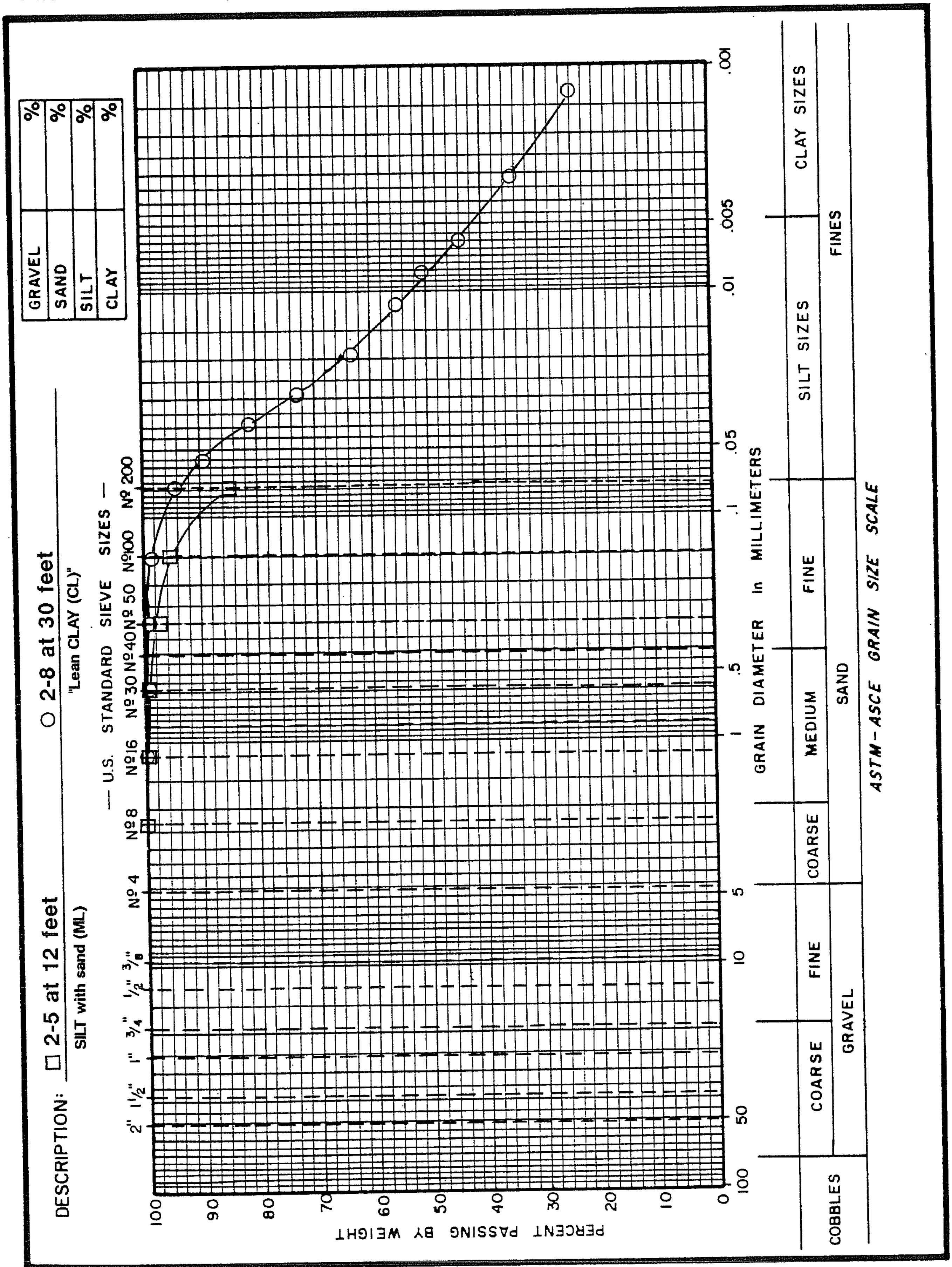
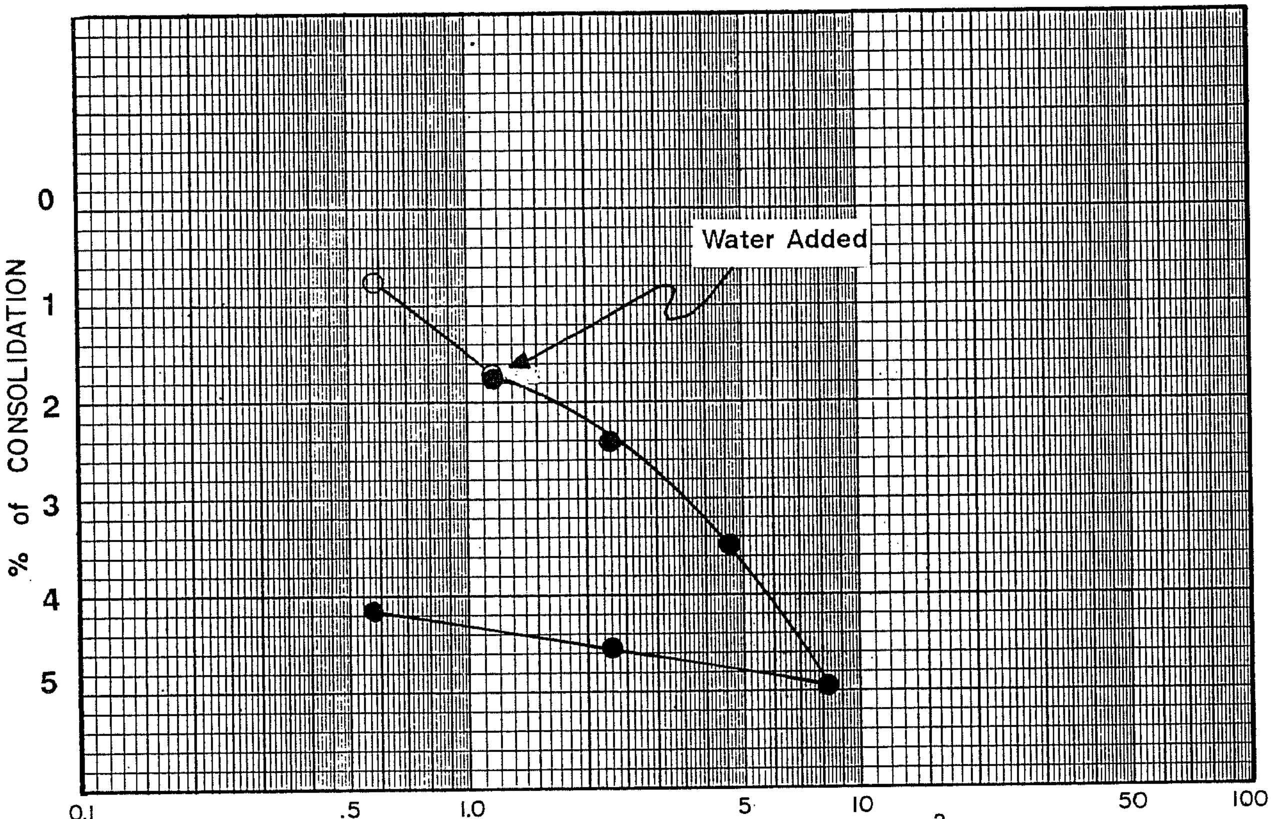


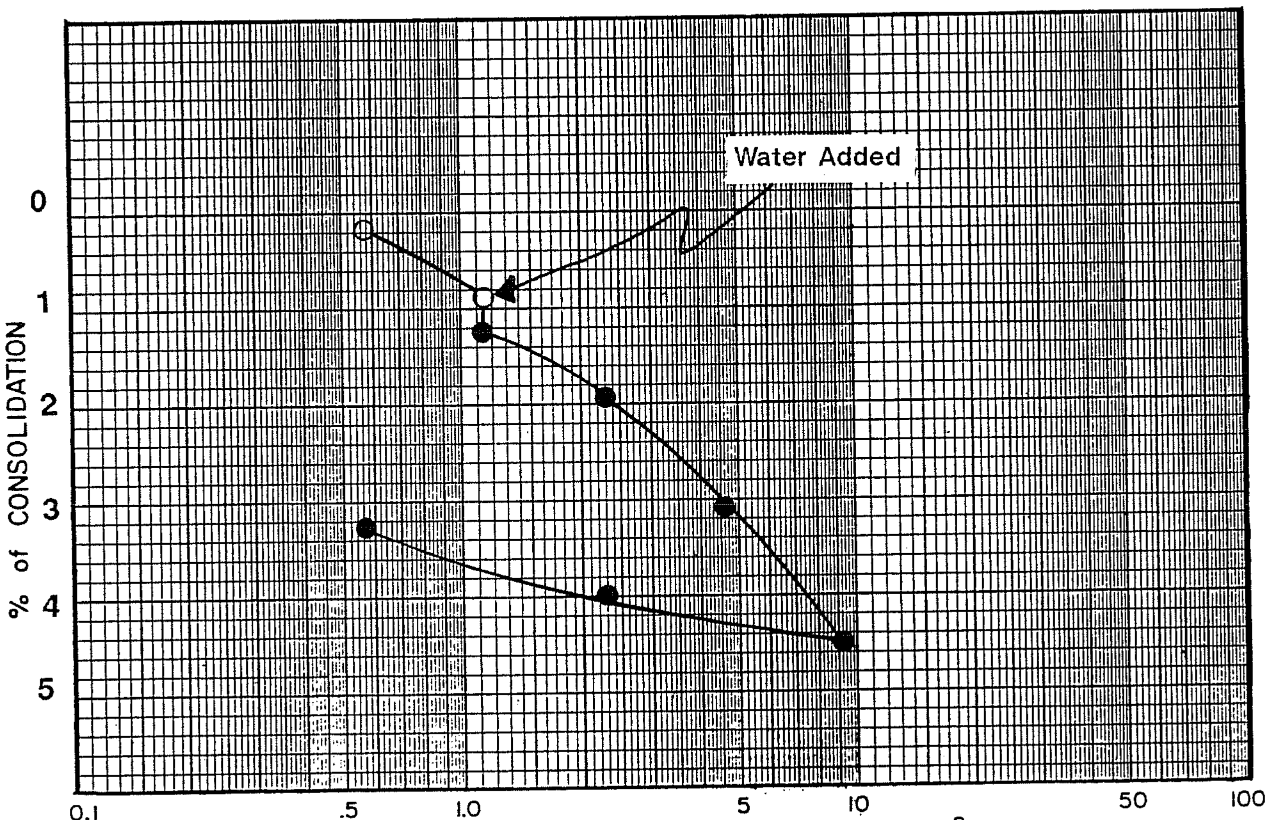
Figure B-2

File No. KC-1405-03



SAMPLE N°: 1-4 at 11 feet APPLIED PRESSURE (KIPS / ft^2)

CONSOLIDATION CURVE



SAMPLE N°: 2-2 at 3 feet APPLIED PRESSURE (KIPS / ft^2)

Figure B-3

SEISMIC REFRACTION INVESTIGATION
Proposed Baseball Installation
University of California-Santa Barbara
Goleta, California

RYLAND ASSOCIATES, INC.

Project Number 89-99-18

November 15, 1989

Prepared for
K-C Geotechnical Associates
Santa Barbara, California

INTRODUCTION

Three seismic refraction survey lines were conducted in the vicinity of the main baseball field on the campus of the University of California-Santa Barbara in Goleta, California. The purpose of this investigation was to locate the position of possible fault zones and the geologic stratigraphy of the site.

A total of 2875 feet of refraction line was surveyed. Field work was conducted in November, 1989. The locations of the seismic lines are plotted on the attached site study map.

METHODOLOGY

The seismic refraction method makes use of the time required for a seismic (acoustic) wave to travel various distances to calculate the subsurface configuration of the surveyed area.

In this series of surveys ground-motion sensitive transducers (geophones) were placed at 25 foot intervals along the survey lines. The lengths of the lines were:

Line 1	875 feet
2	800
3	1200

Seismic energy was initiated into the lines by means of repeated sledge hammer impacts. The small ground motion generated is converted into an electric current by the geophones and then amplified and displayed by the seismograph. For this investigation a Geometrics ES-1210F seismograph was used. This device has the ability to "build-up" or stack the small signals generated by several of these impacts into a larger-amplitude, readable signal. The arrival times of the seismic wave at each geophone and the time of impact are recorded by the seismograph and presented visually and on paper records. Impacts were made at each end of the profiles comprising the lines.

By plotting the delay time of arrivals versus distance and by various algebraic manipulations the depth and configurations may be measured. The end point approximation method was used in preliminary interpretation. The data reduction was computer-assisted.

The site was also investigated by the common offset method. In this type of survey impacts are made at a specific horizontal distance from each phone (in this survey 75 feet for Line 1 and 100 feet for Lines 2 and 3). This type of survey allows for study not only of the first seismic arrival but for variations in several later waveforms including reflections and surface waves. It is particularly sensitive to lateral variations.

OBSERVATIONS

The seismic refraction method produces a series of data from which an interpretation is made. The interpretation is generally not unique and may differ from actuality in some instances. A number of shallow boring logs were available along Lines 1 and 3 for correlation.

In this interpretation emphasis was placed on the location of anomalies which could represent geologic contacts or faulting in the subsurface. Anomalies in the travel time data indicate lateral variation in subsurface materials.

The site is characterized by several subsurface layers with considerable lateral variations. There is a low velocity surficial material with a seismic velocity of less than 1700 ft/sec. This represents some terrace deposits and some facies of the Santa Barbara fm.

This is underlain by the Sisquoc fm, consisting primarily of shale. The velocities of this material ranges from 4100-5150 ft/sec. The contact of the Santa Barbara fm and the Sisquoc is well known from the borings along Line 1. This range of values may also include some saturated conditions and near the beginning of Line 1 the water table is only a few feet different from the Sisquoc horizon; in other areas with similar velocities no water table was observed.

In other areas where Sisquoc is not observed (beginning and end of Line 3 and perhaps the end of Line 2) the second layer is apparently just a harder, perhaps older terrace material or a different facies of the Santa Barbara fm. It has velocities of 2900-3600 ft/sec and would be unsaturated.

The third layer may have several origins. In most cases it probably represents a facies change in deeper material. That is, it may be hard versus soft shale; it is possible that is could represent the Monterey fm although this is expected to be much deeper than the 100 feet maximum observed here. In other places it could be the change from water saturated to non-saturated; this could be a function of the lithology as well. Velocities of the third layer range from a low of 5400 ft/sec at the end of Line 3 and near the center of Line 2; this probably represents a saturated layer. At other locations velocities as high as 9000 ft/sec are observed, which probably represent hard, porcelaneous shales, or some very unusual subsurface topography.

Sources of Error

Unusual phenomena such as relatively thin intermediate velocity layers (blind zone) or lower velocity layers (hidden zone) beneath higher velocity layers may cause interpretive error.

Seismic waves do not travel only vertically. The depths given could also, in some instances, be lateral distances to a higher velocity material. That is, cross-section depths may not always be vertical.

Some rocks may have anisotropic behavior; that is higher velocity in some directions than in others.

Extreme topographic relief of the surface or a refractor can introduce errors in depth and velocity calculations.

Line Descriptions

Interpretive seismic sections with layers measured in terms of seismic velocity are attached. Anomalies are graded weak, moderate, and strong to convey their presence in the data. When senses of motion are given, this is apparent only and may represent juxtaposition of contrasting seismic velocities rather that true physical offset.

Line 1 was surveyed just west of the baseball field. A number of shallow borings had been conducted on this line and the first seismic refractor is almost perfectly correlated with the top of the Sisquoc fm. Surficial velocities are all less than 1700 ft/sec and the underlying Sisquoc ranges from 4280-5150 ft/sec. Near the beginning of the line the water table is just below the Sisquoc contact but is apparently somewhat deeper to the north. A third layer is present with a range in velocities and with perhaps an absence, or low velocity near station 650. The nature of this layer is not known; speculations are presented above.

There are several anomalies observed along this line. Some are due to small lateral changes and topography on top of the Sisquoc and others have a deeper origin. The first is a moderate feature near stations 135-160. The boring log shows this as a shallowing of the contact to the north but the data show this area to be a high with shallowing on both sides or a lateral velocity change; no ground water is observed north of this feature. A strong anomaly is observed near station 235-285 where an apparent north side up feature is noted. There is a few feet of change in the bedrock contact near here but most of the anomalous data is probably related to a lateral velocity change. A third feature is located near stations 510-540 (moderate). There is some indication of a north-down feature. The fourth anomaly is near stations 700-750. Many things happen here: the third layer is not well defined or has a much lower velocity, station 735 appears to be a bedrock high point or lateral velocity high (although this is not well shown in the section), and there is a lateral increase in second layer velocity (which could be related to ground water).

Line 2 was conducted through the center of the baseball diamond. No borings are located along this line but it appears rather similar to Line 1. The upper refractor may be Sisquoc although north of station 200 the velocity of the layer appears to decrease and the second layer north of there could be terrace material or Santa Barbara fm, unsaturated. The strongest anomaly is observed near station 300. Here there is a definite lateral velocity change and a shallowing of a third layer; this again could be ground water. It is remotely possible that this is a ground water mound from heavy watering on the playing field. There is also a slight shallowing of the first refractor. Near station 475 the first and second refractors appear to deepen. Near station 700 there appears to be a shallowing of both refractors to the north.

Line 3 is more complex. No Sisquoc fm is observed in borings south of station 600 to depths of over 35 feet (Santa Barbara fm appears to be intermittent). Thus the first refractor at both ends of the line probably represents a older terrace horizon. Sisquoc is observed north of the center of the line in a boring and saturated conditions are observed north of station 300. The first anomaly observed is near station 210-240. Here there must be a lateral change in the velocity; the first refractor appears to shallow, the lower refractor deepens. At the boring near station 260, terrace is observed to depths of 35 feet with ground water present near station 360 at a depth of 24 feet. These data indicate that the anomaly may be more "spread out" than indicated. A minor anomaly is observed near station 435 where the first refractor starts to deepen. Near stations 600-650 there is shallowing of both refractors.

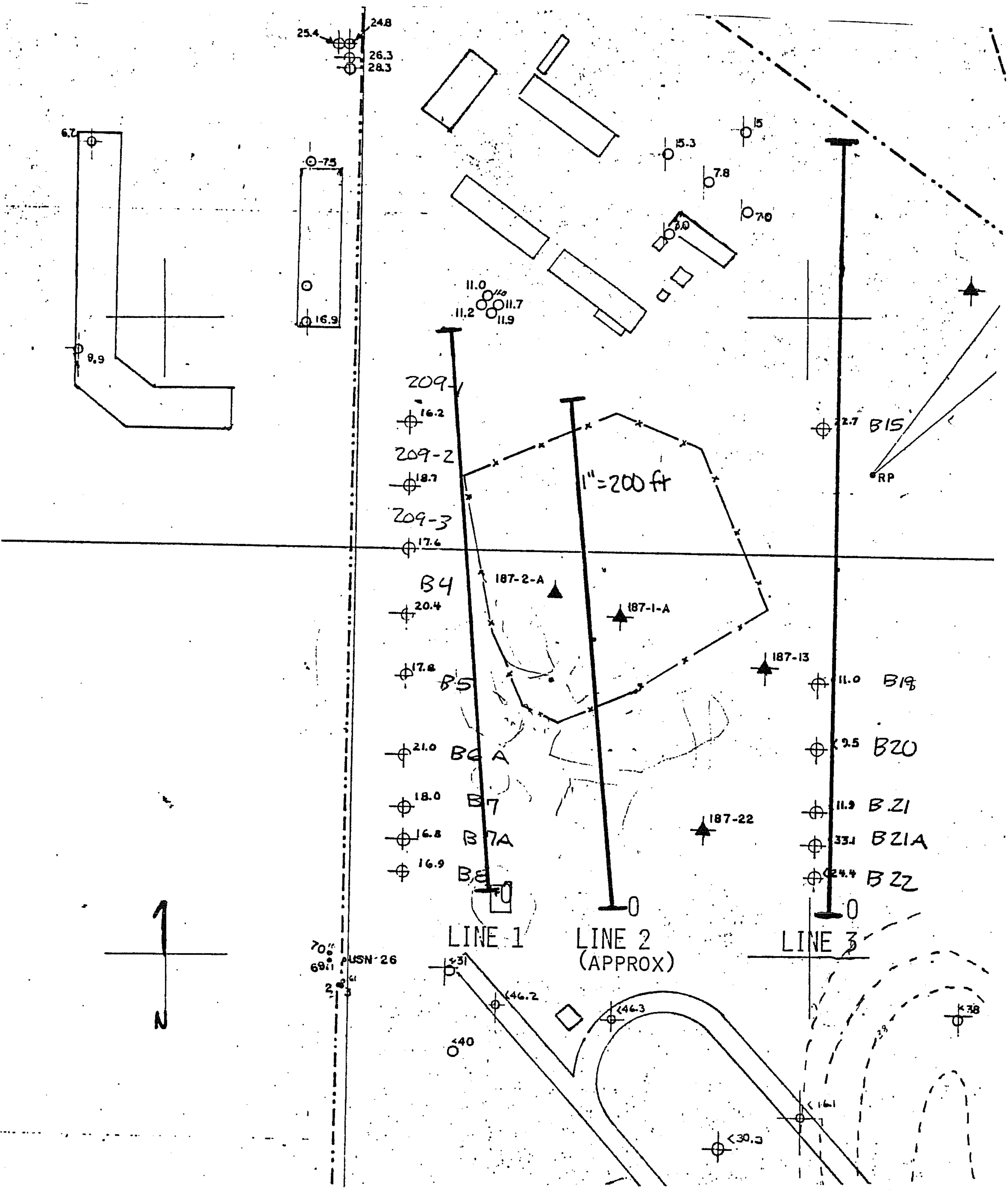
CONCLUSIONS

The seismic data collected during this investigation show several anomalous features along the three lines. There are several possibilities as to the origin of these anomalies including topography on refracting horizons due to erosion, geologic contacts, facies changes, variations in permeability, presence of ground water, and juxtaposition of dissimilar materials along faults. If a fault does not juxtapose such dissimilar materials it could remain undetected by these surveys. Cross sections are shown for each seismic line.

The anomalies may be summarized as:

Line 1		Line 2		Line 3	
135-160	Moderate	300	Strong	210-240	Strong
260	Strong	475	Weak	435	Moderate
510-540	Moderate	700	Weak	610-650	Weak
700-750	Moderate				

Additional investigation such as trenching or borings could provide more information as to the nature of these and other subsurface features. However, the anomalies indicated are for the most part somewhat deep; trenches could be of limited probable success at this site. If there are surface expressions of the deeper anomalies these may be located at some distance from the anomaly locations given at depth. Additional data of this kind may also be used to provide additional constraints and refine the geophysical interpretation.



LOCATION OF SEISMIC LINES

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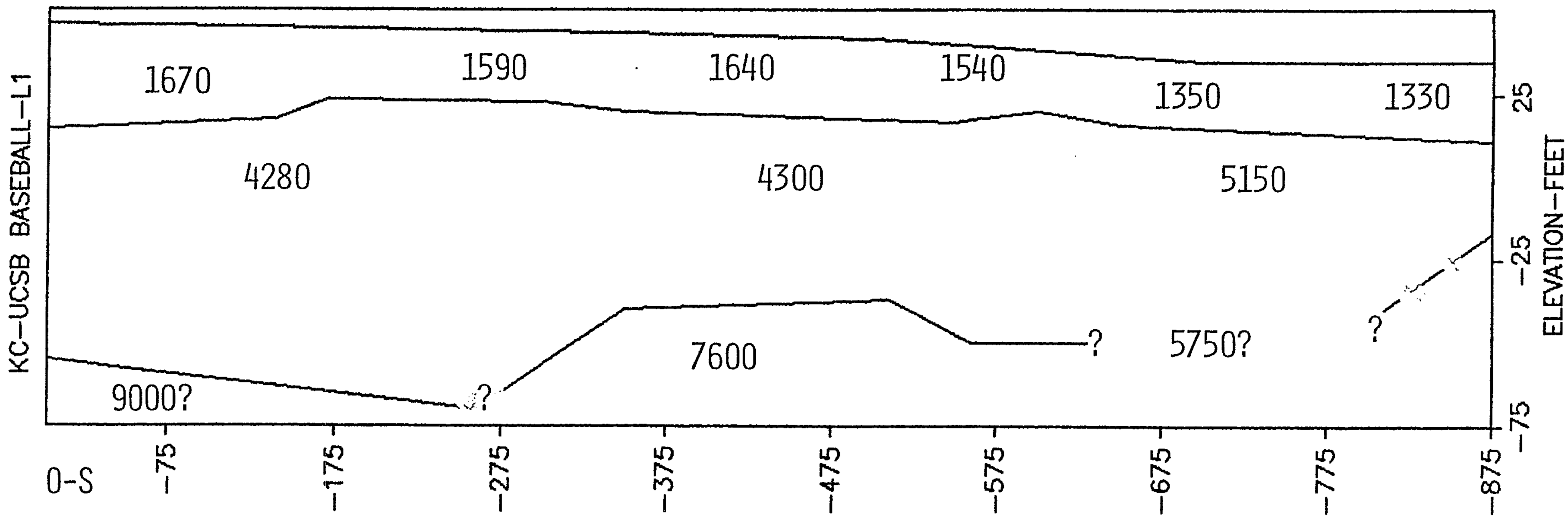
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ELEVATION-FEET
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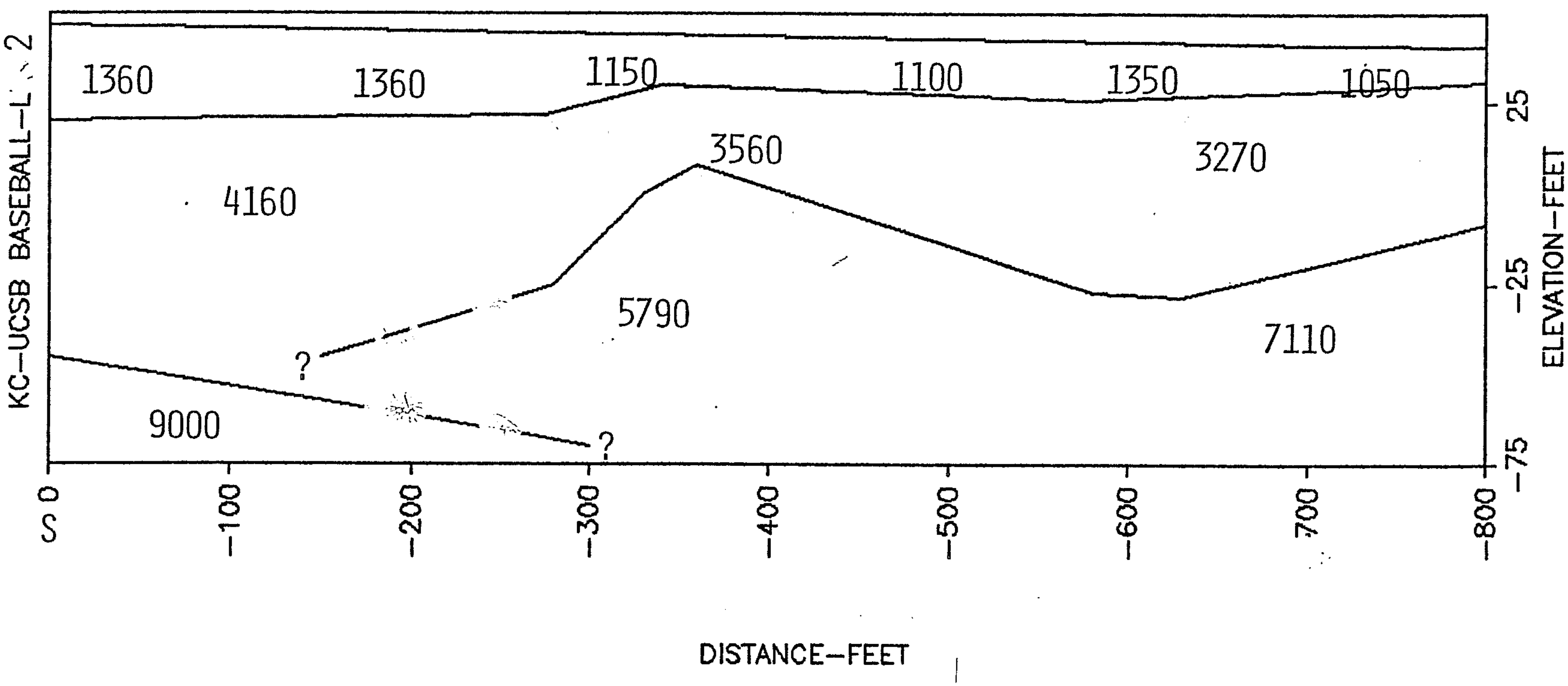
-25
-75
1670
1590
1640
1540
1350
1330
4280
4300
5150
7600
5750?
9000?
0-S
-75
-175
-275
-375
-475
-575
-675
-775
-875


KC-UCSB BASEBALL-L 2
ELEVATION-FEET
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-25
-75
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1100
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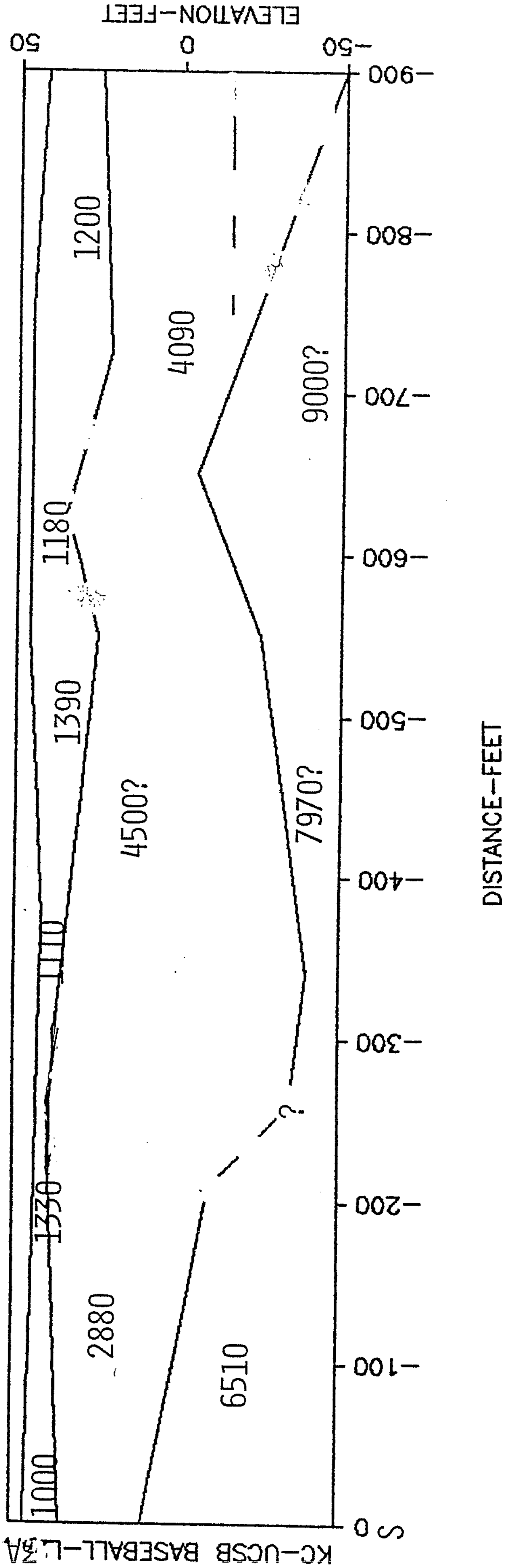
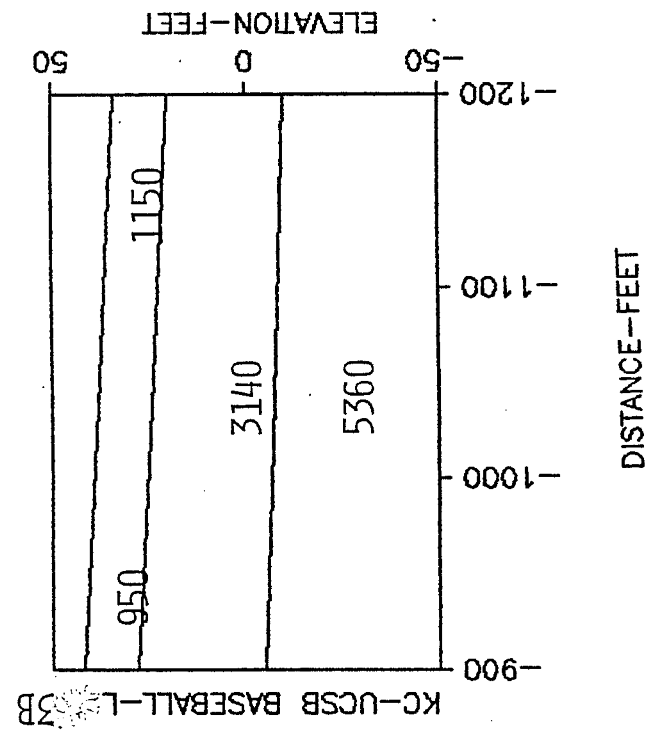
-200
-300
-400
-500
-600
700
-800
DISTANCE-FEET





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