Appendix D Geotechnical

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March 8, 2005

Soils Southwest, Inc

Subject: Extension of Geologic Mapping to the Golf Course Area & Proposed Development

Gentlemen:

Based on proposed development plans recently supplied to us, we have extended our geologic mapping to those area as well as the mountain slopes above these areas. We have also changed color schemes and in some cases symbols to clarify geologic units covered by the original geologic map. As was the method for the original mapping, where there was no reason to change the map based on our observations, the mapped areas were unchanged for this map although the scale was changed from 1"= 2000' to 1"= 1000'. Most of the changes involved addition of areas which in our experience represent landslides either ancient or recent. No attempt at this time was made to refine the age or hazard potential of these features.

As can be seen from the Geologic Map, there are many landslides along the sidewalls of the canyon or perched along the sides of the ravines entering the canyon. Some of the proposed residential or structural development takes advantage of the more gentle slopes resulting from the landslides to provide level building areas. Other locations are not located on older slides but are located close to or at the base of ravines having slides perched upstream of them.

On additional conclusion must be made:

A) The proposed leveled structural pad areas will have to be carefully evaluated to determine whether these locations can be rendered safe and stable without potentially affecting offsite improvements. This will require much more detailed investigation and evaluation.

The geologic mapping represents surface observations and does not imply that additional investigation may not discover conditions no found based on these observations.

VERY TRULY YOURS

JAMES R. EVANS, CEG 974

SOILS SOUTHWEST, INC.

SOILS, MATERIALS AND ENVIRONMENTAL ENGINEERING CONSULTANTS

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Feasibility Study
Report of Preliminary Geotechnical Evaluations
Proposed Mixed-Use Development
Arrowhead Springs
City of San Bernardino
California

Project No. 05027-F1

February 14, 2005

Prepared for:

Transtech
624 Brea Canyon Road
Walnut, California 91789

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February 14, 2005

Project No. 05027-F1

Transtech
624 Brea Canyon Road
Walnut, California 91789

Attention: Mr. Ali Cayir

Subject: Feasibility Study/Report of Preliminary Geotechnical Evaluations
Proposed Mixed-Use Development
Arrowhead Springs
City of San Bernardino, California

Reference: Development Layout plan by American Development

Gentlemen:

Presented herewith is the Feasibility Study Report of the Geotechnical Evaluations conducted for the 500+/-acre site of the proposed mixed-use development to be located in Arrowhead Springs area of the City of San Bernardino, California.

Based on the results of geological and getechnical cursory visits and preliminary investigations completed at this time, it is our opinion that the proposed areas of planned developments should be considered suitable from geotechnical and geologic viewpoint. No landslide, subsidence, unstable slopes etc. are apparent. However, with the proximity of A-P Special studies zone nearby, supplemental geologic trenching etc. should be required and the tentative recommendations supplied should be verified following site-specific grading plan review.

Hillside in nature with numerous canyons and ridges, extensive site preparations and grading are expected. The soils encountered primarily consist of silty gravelly sand of decomposed granitic origin, or deeply weathered or decomposed or highly fractured bedrock. No unstable slopes with outdipping bedding Most of the grading should be accomplished using heavy duty construction equipment. No blasting and/or jack-hammering should be anticipated. Supplemental geotechnical and geological explorations, however, are recommended prior to actual grading and construction.

Based on analyses and evaluations completed at this time, it is our opinion that, from geolical and geotechnical viewpoint, the subject development should be feasible with no apparent major adverse soils and/or geologic constraint.

Thank you for the opportunity to be of service on this project. Should you have any questions regarding this report, please call the undersigned at your convenience.

Respectfully submitted,
Soils Southwest, Inc.

Moloy Gupta, RCE 31708

REGISTERED PROFESSIONAL ENGINEER
MOLOY K. GUPTA
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CIVIL
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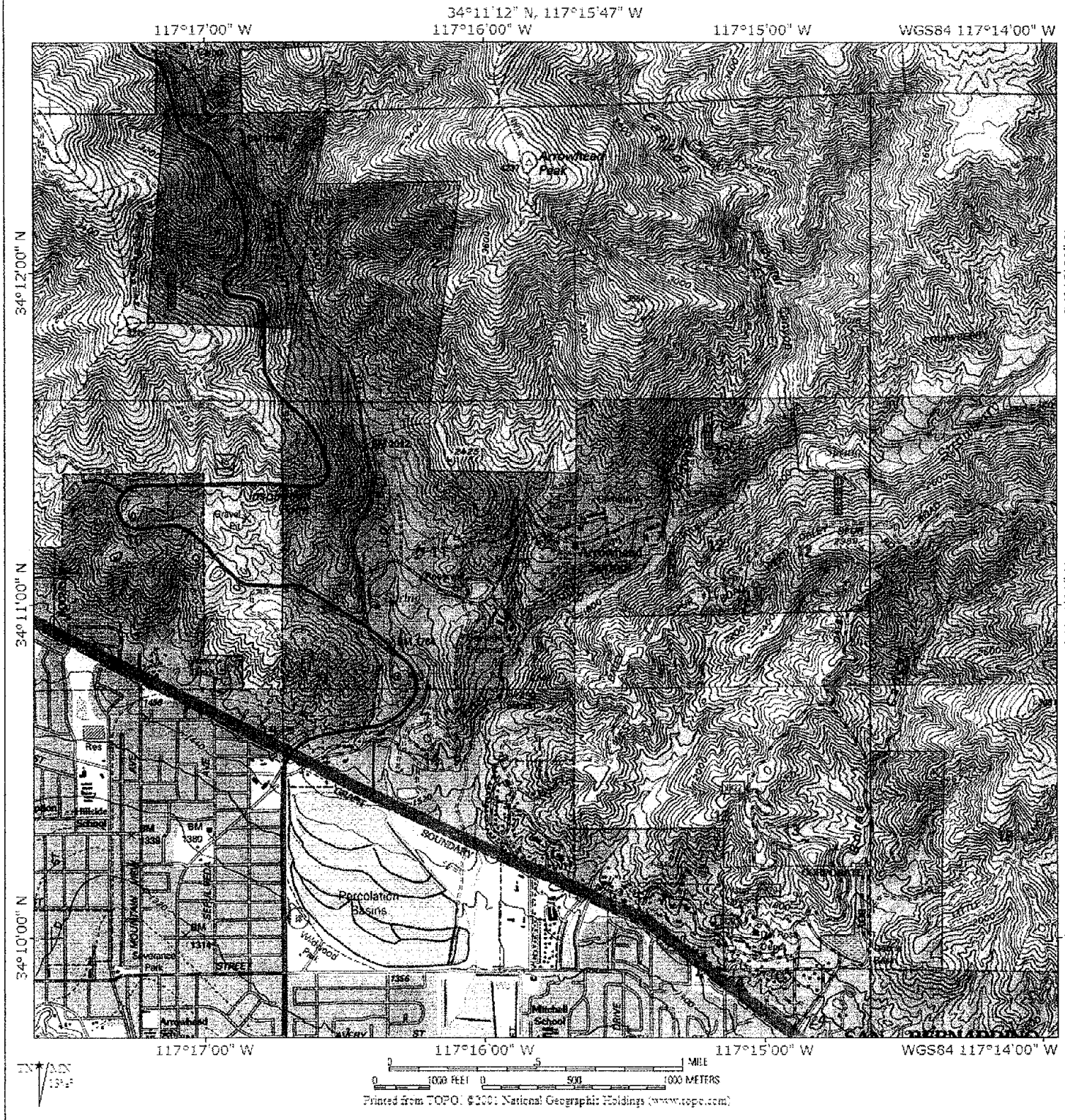
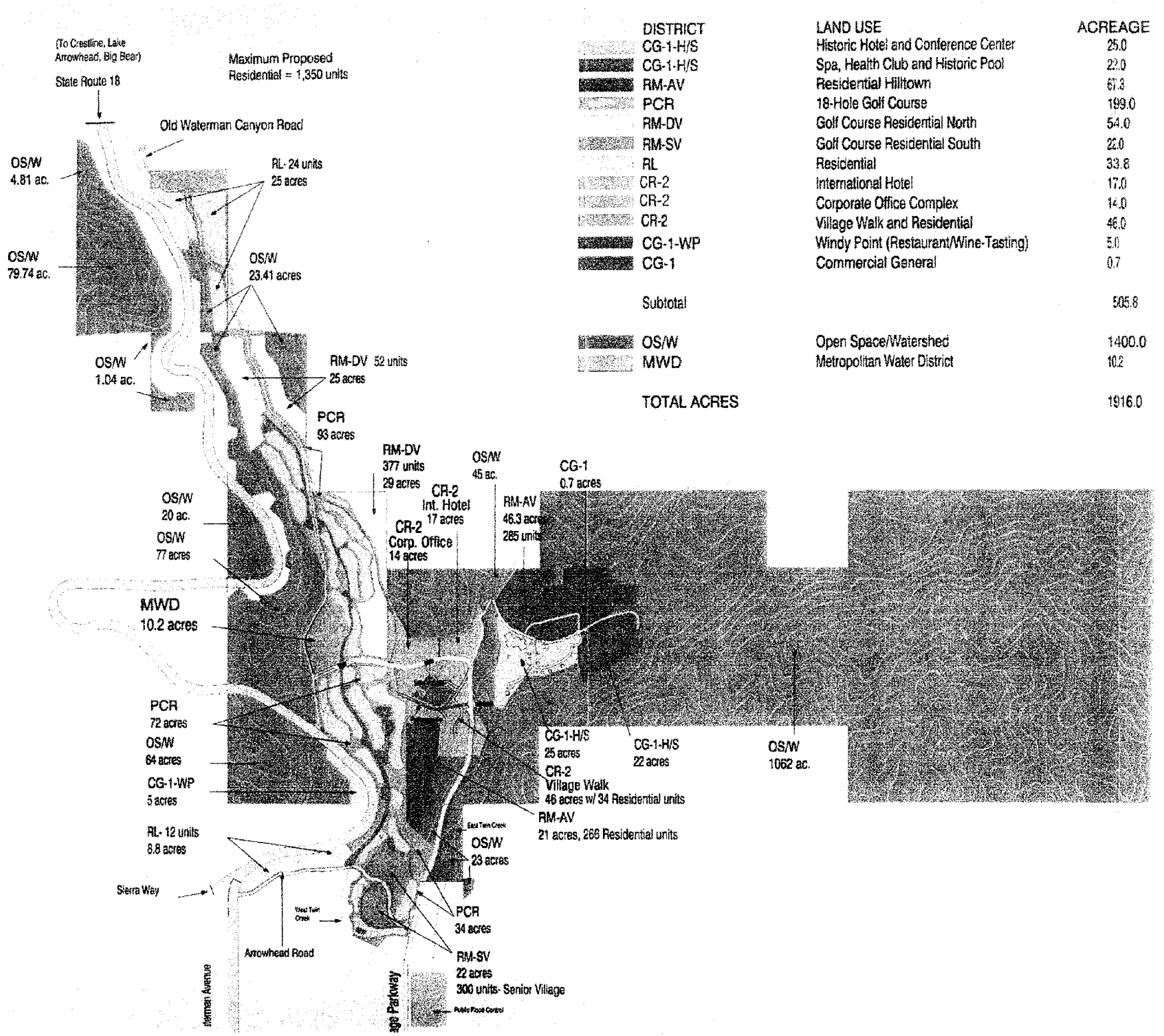
Roy White

dist/5-addressee



Soils Southwest, Inc.	Site Index Map **PROPOSED DEVELOPMENT** **ARROWHEAD SPRINGS** **SAN BERNARDINO, CA**	FIGURE: 1 PN: DATE: FEB 2005



DISTRICT	LAND USE	ACREAGE
CG-1-H/S	Historic Hotel and Conference Center	25.0
CG-1-H/S	Spa, Health Club and Historic Pool	22.0
RM-AV	Residential Hilltown	61.3
PCR	18-Hole Golf Course	199.0
RM-DV	Golf Course Residential North	54.0
RM-SV	Golf Course Residential South	22.0
RL	Residential	33.8
CR-2	International Hotel	17.0
CR-2	Corporate Office Complex	14.0
CR-2	Village Walk and Residential	46.0
CG-1-WP	Windy Point (Restaurant/Wine-Tasting)	5.0
CG-1	Commercial General	0.7
	Subtotal	505.8
OS/W	Open Space/Watershed	1400.0
MWD	Metropolitan Water District	10.2
	TOTAL ACRES	1916.0

1.0 Introduction

This report presents the results of Preliminary Soils and Foundation Evaluations conducted for the proposed Arrowhead Springs mixed-used development to be located within Arrowhead Springs area of San Bernardino, California. With the hillside in nature with numerous canyons and ridges, extensive site preparations and grading, should be expected.

The purpose of this evaluation is to tentatively determine the nature and engineering properties of the near grade and subsurface soils/bedrock, and to provide preliminary geotechnical and geological recommendations pertaining to construction of numerous structural pads, proposed cut and fill slopes, site grading, tentative foundation design, concrete slab-on-grade, paving and inspection during construction.

The geotechnical evaluations included geologic observations and limited soils sampling from the existing numerous exposed side-slopes, laboratory testing, engineering analyses and the preparation of this report. Following grading plan review, however, supplemental oils and geologic trenching, exploratory borings, soils sampling etc. should be warranted.

The recommendations contained reflect our best estimate of the soils/bedrock conditions as currently being exposed. It may not to be considered as a warranty for the soils and bedrock conditions that may be existing encompassing the entire project site area.

1.1 Site Descriptions

Hilly in nature with sharp terrain, valleys and inaccessible steep slopes, the subject property is located within San Bernardino mountains, off Highway 18, City of San Bernardino. In general, the site consists of numerous canyons primarily facing south, with anticipated thick deposits of alluviums within adjacent canyon bottoms. While most of the planned pads areas should be somewhat accessible using a dozer and a tractor-mounted backhoe, the general project area is considered accessible to drillrig. Supplemental geologic and geotechnical explorations and evaluations should be expected following grading plan review, when supplied.sign.

The existing slope gradients are estimated to vary anywhere from approximately 1:1 to 2:1 (horizontal to vertical) or flatter. Presence of minor surficial slopewash and/or minor surficial slides are also apparent.

1.2 Proposed Development

Based on the preliminary development plan supplied, it is understood that the subject property will be developed to accommodate the following:

- Expansion/addition to the existing historical hotel near the north-east
- Construction of hotel, office complex and residential housing near the north,
- Construction of golf course, primarily along existing canyon bottoms,
- Residential development on the ridge near the south of the historical pond,
- Construction of senior housing and single family dwellings near the south, and
- Construction of access highways and roadways.

The structural details for construction are not available at this time, however, it is expected that proposed dwellings will be of one or two-story structures of conventional wood frame and stucco

with concrete slab-on-garde. The office complex etc. is assumed of concrete block or concrete tilt-up or wood or steel framed conventional construction.
For this type of construction, relatively light loads will be imposed on the underlying foundation soils. Associated construction, among others, should include cut and fill slopes, interior streets, curb-gutter and installation of subsurface utilities. Use of on-site sewage disposal etc., may be required for private sewage disposal system.

For structural pad, extensive site grading is expected to include typical cut, fill or cut/fill transition conditions. Manufactured slopes with 2:1, 1.5:1 or 1:1, may be expected.

Grading requiring major cuts to about 50 feet into ridges and to about 20 feet of hillsides are expected. Similar massive grading requiring new fill soils placements should be anticipated for the southern residential development as proposed. Structural setbacks adjacent to the known A-P zones should be evaluated following supplemental geologic trenching and geologic investigations.

2.0 Scope of Work

Geologic evaluations included monitoring of the existing numerous slope-sidewalls and other excavations currently exposed in connection with the Inland Feeder project. The preliminary Geologic Evaluation Report for the site prepared by James Evans, CEG, is attached.

For preliminary geotechnical evaluations, scope of work included soil sampling from the exposed slopes or exposed cuts currently existing, necessary laboratory testing, engineering analyses and the preparation of this report. No exploratory test borings are presently included. Exploratory borings will b e programmed following grading plan review, when supplied.

For the preliminary report prepared herein, the scope of work included the following tasks:

- Review of the geologic report prepared by James Evans, CEG.
- Undisturbed and bulk soil sampling from expose cuts or exposed slopes or from the existing temporary roadways.
- Laboratory testing conducted on selected bulk, undisturbed and on mixed-oil samples were programmed according to the project requirements. The laboratory testing included determinations of:

  Maximum Dry Density and Optimum Moisture Content (ASTM D1557),
  Soil's Shear Strengths (ASTM D3080),
  Consolidation Characteristics (ASTM D2435), and
  Expansion Potential, EI (ASTM D4928 & UBC Table 29-2).

  Brief descriptions of the test procedures used and the test results are provided in Appendix B.
- Based on the data of our soil sampling and laboratory testing, engineering analyses and evaluations were made, on which to base our recommendations for foundation design, slab-on-grade, site preparations and grading and inspection during construction.

3.0 Existing Soil Conditions

3.1 Subsurface Conditions

Within the areas of the upper plateau and ridges near the south as planned for residential development following 50'+/-cuts, the subgrade soils, in general, is expected of moderately dense, deeply weathered gravelly sand with some silts considered excavatible using conventional construction equipment. No outdipping bedding to adjacent slopes or underlying massive bedrock requiring blasting etc. should be expected within the maximum cuts currently planned.

Within the areas of the upper plateau and hillsides near the north proposed for hotel, commercial and office complex, the subgrades are expected to consist of grayish brown to gray highly fractures metamorphic rocks, weathered gravelly sand of decomposed granitic origin, and/or calcite as derived from old hot springs.

Within the areas of the planned addition to the hotel near the northeast, the site soils re expected of upper gravelly sand, overlying relatively fractured metamorphic bedrock considered excavatible by using conventional constriction equipment. No outdipping bedding should be associated with the hillside cuts proposed.

Within canyon bottoms, subgrade soils should consist of alluviums of silty fine sand and fine to medium coarse gravelly sand of variable consistency along with numerous cobbles and isolated rocks. Typical minor slide debris may be associated with the north-south direction canyons near the northwest. Subgrade soils underlying the upper described alluviums are expected to consist of well consolidated gravelly sand or weathered bedrock of siltstone/sandstone origin. Generally compressible in nature,

Slope surface includes minor slippage along with upper loose silty gravelly sand (top-soils), overlying moderately dense gravelly sand and/or weathered and fractured bedrock considered excavatable using conventional heavy-duty construction equipment. While most of the natural slopes appear stable with no apparent outdipping bedrock conditions as described in the geologic report, supplemental verifications on such should be made prior to actual grading and construction. For localized slope stabilization, if warranted, as determined by the project geologic, stabilization recommendations on such will be supplied in form of buttress using soil reinforcing. Again, determinations of which will be made based on supplemental geologic investigations as required.

Presence of minor landslides comprised of remnants of bedrock of broken sandstone with gravel deposits are described in the geologic report (attached). The landslides described are related to localized slumping of weathered bedrock materials.

Free groundwater and presence of numerous hot springs are evidenced generally within upper elevations of the property. Supplemental shallow depth groundwater is expected within the southern ares of the project proposed for senior housing and single family dwellings. Considering hilly nature of the project site, perched groundwater conditions may be expected.

Based on the field and laboratory testing and geologic and geotechnical evaluations, the following general site-soil characteristics are described;

In absence of precise grading plan review, the pads planned are expected either fills, or on grades to be constructed following cuts of the ridges and hillside, or on the pads constructed of cut/fill transition. Detailed recommendations for structures constructed on such pads will be supplied prior to actual grading and construction. In general, within valley areas, being susceptible to consolidation and unequal settlements to footings, the near surface soils existing at their present state are considered unsuitable for structural support or new structural fill soils placement. For adequate support, such low-lying valley areas should be graded as recommended herein. In overall, such undesirable site soils are expected to exist in between 3 to 5 feet within the upper ridges and upper plateau, and to about 12 to 18 feet or more within the canyon bottoms. Actual depth of such loose soil deposits should be determined during grading and construction.

The results of shear tests conducted on bulk soil samples procured from exposed slope surface areas and from ridge top remolded to 90% indicate moderate shear strengths under increased moisture conditions. Laboratory test results are shown on Appendix B of this report.

Consolidation tests are conducted on representative undisturbed soils sampled at depth and on remolded bulk soil samples exhibit relatively 'low' compressibility under anticipated structural loading.

Expansion tests conducted on representative near grade soils exhibit 'very low' expansion potential with Expansion Index, EI, less than 20. Supplemental evaluations on such should be made following grading plan review.

Local soils free of organic should be considered suitable for use as structural backfill.

Additional information regarding subsurface conditions may be obtained from the geologic report, attached.

3.2 Excavatability

Based on the cursory investigations, including exposed road cuts and slope surface, it is our opinion that grading and excavations required for the project may be accomplished using conventional heavy-duty construction equipment. In absence of shallow-depth bedrock, no blasting and/or jack-hammering should be anticipated.

3.3 Groundwater

Natural spring water is expected during grading and construction. Shallow depth groundwater, however, should be expected within the southern low-lying areas. As per USGS Bulletin 1898, groundwater within southern boundary and along the National Forest boundary areas are expected at about 10 feet below grade. Actual groundwater conditions should be verified during detailed subsurface investigation.

3.4 Subsurface Variations

During grading, buried irrigation, debris, organic and others may be encountered. In addition, variations in bedrock, their continuity and orientations may be exposed different from those as described in this and in the geologic report. Detailed geotechnical recommendations on such will be supplied when requested.

3.5 Liquefaction

Liquefaction is caused by build up of excess hydrostatic pressure in saturated cohesionless soils due to cyclic stress generated by ground shaking during an earthquake. The significant factors on which liquefaction potential of a soil deposit depends, among others include, soil type, relative soil density, intensity of earthquake, duration of ground shaking, and depth of ground water.

Based on the USGS Bulletin 1898, it is our opinion that the that the low-lying areas near the south current proposed for residential development, may be susceptible to liquefaction in event os a strong motion earthquake. Considering hillside nature of the remaining areas underlain by bedrock, no other liquefiable soils should be anticipated. Detailed evaluations for site soil liquefaction susceptibility should be performed during subsequent geotechnical evaluations.

3.6 Seismic Design Parameters as UBC/CBC

The site is situated at about 0.0 km from A-Fault (San Andreas-South), and at about 2 km from B-Fault (North Frontal Fault Zone-west). Accordingly, for structural design, the following seismic parameters are suggested based on UBC/CBC.

UBC Chapter 16 Table No.	Seismic Design Parameters	Recommended Value
16-I	Seismic Zone Factor, Z	0.4
16-J	Soil Profile Type	S_d
16-Q	Seismic Coefficient, C_a	$0.44N_a$
16-R	Seismic Coefficient, C_v	$0.64N_v$
16-S	Near Source Factor, N_a	1.5
16-T	Near Source Factor, N_v	2.0
16-U	Seismic Source Type	M>/=7.4

Supplemental seismic design parameters are provided in Appendix C.

4.0 Preliminary Evaluations and Tentative Recommendations

4.1 General Evaluations

Based on geologic and geotechnical site reconnaissance, limited soils sampling and laboratory testing completed at this time, it is our opinion that from geotechnical viewpoint, the site should be considered suitable for the planned development provided supplemental geotechnical and geologic evaluations are made to verify certain assumptions that are made in preparing this report. In absence of detailed geologic and geotechnical evaluations, the following tentative recommendations are supplied for project "overview' only.

With the presence of slope wash, dry alluvium and loose soils existing as observed during site reconnaissance and limited soils sampling etc., it is our opinion that no structural footings, concrete slabs or paving should be installed directly bearing on the surface soils presently existing.

For adequate support, subgrade preparations should include subexcavation of the upper dry and loose gravelly sandy soils, and their replacement as engineered fill compacted to uniform higher density as described in the following sections.

Site preparations and grading should be performed in accordance with Appendix Chapter 33 of the current UBC and as per the general applicable grading recommendations as provided Section 5 of this report.

4.2 Preparations for Structural Pads (general)

No detailed development and grading plan is available at this time for review. Consequently, the tentative recommendations presented in the following sections should be used for pre-planning purpose, and should not be used for design and construction.

being hillside in nature, it is expected that site grading requiring cut, fill and/or cut-fill transition conditions will be associated with the building pads planned. Considering the upper existing fractured bedrock or unconsolidated to- soils or loose canyon alluviums, it is recommended that no structural footings, paving or new fill soils placements shall be allowed bearing directly on the near surface soils existing. Additionally, in order to minimize potential differential settlements to footings, no transition conditions should be allowed underneath footings and slabs straddling over cut and fill subgrades. For adequate structural support, the following tentative general recommendations are supplied:

A> For the residential units proposed following 50'+/- cuts of the central ridge described earlier, subject to grading plan review, it is recommended that, following the required terraced cuts to proposed grades, the cut surface exposing moderately dense subgrades should be further subexcavated to depth as required either to, (i) expose the underlying damp to moist, dense and non-porous natural subgrades, or (ii) to minimum 5 feet below cut-pad grade, or (iii) to the minimum vertical depth equal to the planned footing embedment + 24-inch, whichever is greater. Following the cuts described, the site grading should also include 6-inch scarification, moisturizations to 3 to 5 percent over the soil's Optimum Moisture Content, and recompaction prior to the excavated local soil replacement as engineered fill compacted to 90%. Cut pads which may expose shear zones or faults at finish grades should be overexcavated to a minimum depth of 4 feet and such replaced with engineered fills of local soils compacted to minimum 90%.

B> Within the low-lying areas requiring fill soils for finish grades, following removal of the upper loose alluviums or fractured rock debris and upper soft soil deposits as required to expose the underlying moist and dense subgrades, the surface exposed should be further scarified, moisture conditioned as described earlier, and recompacted prior to the new engineered fill placement to the proposed pad grade compacted to minimum 90%.

In order to minimize excessive potential differential settlements to footings and concrete slabs-on-grade, it is recommended that the overall engineered fills placed with the planned building pads and 10 feet beyond should be at least 5 feet in thickness. Consequently, within the areas requiring lesser fills, it is recommended that such areas exposed following site clearance should be further overexcavated so as to maintain the overall recommended 5 feet thick compacted soil mat below pad finish grades. The fills placed should be in 6 to 8-inch in compacted layers, placed at near optimum moisture conditions.

Within canyon bottoms requiring engineered fills for planned grade, it is recommended that such should be placed following removal of all loose soils so as to expose the underlying firm terrace deposits or bedrock material. Based on field investigation, it is our opinion that such removal within canyon bottoms may vary vertically from 12 to 18 feet or more. Actual removal depths should be determined during grading and construction. All alluvium removals and removals for fill placement adjacent to natural slope areas and within active drainage courses will require field review and documentation by the project geologist.

Approved canyon bottoms will require subdrains recommendations on such will be supplied following grading plan review.

For the fills placed within a canyon bottom and against an adjacent upslope steeper than 5:1 (horizontal to vertical), horizontal keys and vertical benches should be excavated into the slope area. Keying and benching should be sufficient so as to provide at least 6 feet wide benches and a minimum 4 feet of vertical bench height within firm natural ground, firm bedrock, or engineered compacted fill. Typical keying and benching details are described in Appendix C.

D> For the areas of the planned office, hotel and commercial development as proposed on near plateau hillside near the north underlain by desiccated and highly fractured bedrock, following cuts to planned grades, the subgrades and bedrock exposed should be further subexcavated to minimum 5 feet, followed by their replacement as engineered fill compacted to minimum 95%. Fill soils placement against adjacent uphill leading to canyon should be incorporated with at least equipment with "key" established into underlying bedrock as approved by soils engineer and project geologist. Supplemental "benching" should be requred during new fill soils placement against the uphill. With the possible presence of traces of earthquake faults (A-P Zone) along the current fire access road, adequate structural and grading set-back should be established as recommended by the project geologist following supplemental geologic study.

E> Within cut/fill transition pads, if any, it is recommended that within areas requiring cuts, following cuts to planned grade, such portion of the pad should be further subexcavated to depth equal to 1/2 the maximum depth that will be required within the areas of fills, or to the depth so as to maintain an overall minimum 5-foot thick compacted fill blanket below footings, whichever is greater. Schematic descriptions for transition pad construction are provided in Appendix C.

F> Within liquefaction susceptible areas near the south proposed for residential construction, subgrade preparations, in general, should consist of minimum 5 feet subexcavations below proposed finish pad grades, followed by their replacement as engineered fills reinforced with geogrid, or other similar reinforcing materials. Structured planned within liquefiable soils areas should be constructed of post-tension load bearing slabs as opposed to convention construction. being with A-P zones, building setback within southern areas should be determined by the project geologist following detailed geologic investigation requiring trenching, etc.

4.3 Slope Construction

FILL SLOPES:

Fill slopes, if any, planned in association with structural pads should be constructed at a gradient no steeper than 2:1 (horizontal to vertical). Fill slopes placed within canyon bottom or against existing uphill steeper than 5 :1 (horizontal to vertical), will require keys and benching as described earlier.

For the fill slopes planned over existing uphill with 'favorable' bedding conditions, should consist of at least 15 feet wide 'key' sloping inward with minimum 2% inclination and established at least 3 feet into approved dense soil or firm bedrock as shown in Appendix C.

Fill slopes planned should also consist of 'parallel to slope' subdrains, typically consisting of 4-inch diameter perforated pvc pipes, encased within 2 cft. of crushed rock or gravel per foot length of the pipe, wrapped within commercially available filter fabric. Pipes such described should be placed at mid-height of the constructed slopes, or at a vertical not exceeding 30 feet in vertical intervals as required by the UBC/CBC. In addition, installation of 4-inch diameter pvc non-perforated outlet at 100 feet maximum horizontal intervals, should also be considered with 2% sloping and discharging to approved intermediate swale drains.

Structures built in close proximity to a slope should be setback as per the current UBC requirements. A minimum 10 feet setback is recommended measuring horizontally from the outer face of foundations to slope-daylight. Further, in order to minimize slope surface erosion, it is recommended that the slope surface should be grid-rolled or such be over-built and trimmed so as to expose the underlying compacted inner surface. Use of adequate ground-covering in form of planting deep-rooted draught resistant vegetation, is suggested. During construction, continuous inspections by project soils engineer and project engineering geologist, is recommended. Supplemental information for slope construction is provided in Appendix C.

CUT SLOPE WITH FAVORABLE BEDDING:

Based on the observed soil shear strength parameters for site soils as procured from the exposed slope surface as described earlier, for a Factor of Safety of 1.5, provided no out-dipping bedding conditions are exposed, for initial planning purposes, the following tentative maximum cut and fill slopes may be considered.

Slope Gradient	Tentative Maximum Slope Heights, ft.
2:1	40
1.5:1	20
1:1	12

The above slope heights described should be verified following supplemental geological and geotechnical investigations.

Cut and ill slopes constructed should be associated with intermediate benching and swale drains as required by the current UBC. Supplemental installation of slope surface covering as described earlier, should be considered in order to minimize slope surface erosion. During construction, continuous monitoring by project geologist should be arranged in order to identify out-dipping bedding conditions, if any. Although no expected, in the event out-dipping bedding is exposed during the cut for the slopes described, slope stabilization will be required. Recommendations for such stabilization will be supplied during grading.

CUT SLOPES WITH BUTTRESS STABILIZATION

Following supplemental geologic evaluations, where adverse out-dipping bedding conditions are exposed, it is our opinion that the portions of the natural slopes commencing at the 'critical plane' day-light should be stabilized by using 'buttress'. Detailed recommendations on supplied following supplemental geologic and geotechnicl evaluations.

4.3.1 Structural Fill Materials

Local soils free of organic, debris and rocks larger than 8-inch in diameter, should be considered suitable for use as structural backfill.

4.4 Tentative Foundation Recommendations

Since greater fills are generally associated with larger settlements, it is our opinion that post-tension construction should be considered for structural pads with engineered fills 10 feet and more. Within lesser non-expansive structural fill soils areas, conventional foundations may be considered. The following presents tentative foundation recommendations that may be considered for the various structures proposed, subject to subgrade soils verifications following subsequent detailed geotechnical investigations.

A> For residential construction as proposed within the central ridge areas or within areas where soils are considered non-susceptible to earthquake induced liquefaction, conventional spread footings may be designed based on an allowable soil vertical bearing capacity of 1800 psf. If normal code requirements are applied, the above capacity may further be increased by an additional 1/3 for short duration of loading which includes the effect of wind and seismic forces.

Considering the non-expansive local soils as encountered, from geotechnical view point, the conventional spread footings may be sized to 12"x12" for 1-story and 15"x18" for 2-story construction. Larger footing dimensions may be required if such are recommended by the project structural engineer. Structural design should conform to the 1997 UBC Seismic Design requirement criteria as described in Section 3.6 of this report.

From geotechnical view point, footing reinforcements consisting of 2-#4 rebar placed near the top and 2-#4 rebar near bottom of continuous footings are recommended. Additional reinforcements if specified by project structural engineer should be incorporated during construction.

The settlements of properly designed and constructed conventional or other alternative

foundation systems as recommended earlier, supported exclusively into engineered fills of local soils or its equivalent or better, and carrying the maximum anticipated structural loadings, are expected to be within tolerable limits. Estimated total and differential settlements are about 1 and 1/2-inch, respectively.

B> For the planned commercial/office/hotel complex planned near the north, spread footings may be designed based on the following equations:

Load bering footings should be established exclusively into compacted fills comprised of local silty sandy soils or its equivalent or better. Conventional footings established into compacted fills of local soils free of organic may be designed based on the following equations:

Supplemental recommendations, including footing setback, etc. will be supplied following grading plan review.

Continuous Footings: $q = 650 + 700d + 280b$, and
Square Footings: $q = 850 + 700d + 220b$; where

q = allowable soil vertical bearing capacity, in psf,
d = footing depth in ft., recommended min. 2 ft. below grade,
b = smallest footing width in ft., recommended min. 1.5 ft.

C> Residential Structures with Post-Tensioned Foundations

For the residential development proposed within areas of possible liquefiable soils existing near the southern low-lying areas described earlier, post-tension load bearing concrete slab-on-grade is suggested. Presented below are the preliminary design parameters that may be implemented by the project structural engineer when post-tension slab/foundation systems are utilized based on Section 1816 and 1817 of the 1997 UBC.It will be the responsibility of the post-tension slab designer to select the appropriate design methodology and properly designed foundation system for the soil conditions indicated herein. The slab designer should provide deflection potential to the architect and/or to structural engineer for incorporation into structural design. Assuming EI<20, post-tension systems may be designed with the following tentative parameters subject to verifications following detailed geotechnical evaluations.

Tentative Post-Tension Design Parameters

Thornwaite Index	-20
Depth of Constant suction	7 ft.
Clay Type	Montmorillonite
Clay portion maximum	30%
Soil Suction, pF	3.5
Approx. Moisture Velocity *	0.7 in./month
Avg. Edge Moisture Variation Distance, e_m (ft)	Center Lift = 5.3 Edge Lift = 2.9
Anticipated Swell, y_m (inch)	Center Lift = 1.72 Edge Lift = 0.194
Minimum Slab Thickness (inch)	6
Minimum Footing Depth (inch)	24

Structural design should conform to the 1997 UBC Seismic Design requirements as described in Section 3.6 of this report.

It should be noted that variations in subgrade moisture may significantly affect soil volume change which may directly influence slab-on-grade performance. As stated in the UBC, the Post-Tensioning Institute procedure is applicable ".. only in those cases where site conditions have been corrected so that soil moisture conditions area controlled by the climate alone". Accordingly, it is suggested that post-construction subsurface moisture conditions within the vicinity of the structure should be controlled by restricting irrigation water and/or any other efficient surface drainage, etc.

Should the project structural engineer determine that more stringent design criteria are required, those criteria should supersede the design parameters supplied. Following are the supplemental recommendations as provided in conjunction with the post-tension construction recommended:

a. Unless otherwise specified, load bearing perimeter edge bemas for both one and two-story construction should be founded at a minimum depth of 24-inch below the lowest adjacent final grade.

b. Recommended minimum slab-on-grade thickness is 6-inch, actual thickness, however, should be determined by the project structural engineer.

c. Prior to concrete pour, subgrade soils to receive concrete slab-on-grade should be moistened to achieve at least the soil Optimum moisture conditions. Premoistening, if used, will promote uniform curing and minimize potential for shrinkage cracks.

c. Use of vapor barrier, such as commercially available 6-mil thick plastic sheeting or its equivalent or better, is suggested underneath concrete slab-on-grade planned to receive vinyl, tile or marble flooring. It should be noted that use of vapor barrier shall not prevent 'dampness' near the top and bottom of concrete slab-on-grade. Accordingly, supplemental use of 'vapor retarder' should be considered within areas expected to use tiles and/or vinyl flooring.

d. Large openings, such as garage entrance etc., should be provided with 12-inch wide grade beams founded at the same depth of the adjacent load bearing foundations.

e. Post-grading supplemental soil expansion testing is recommended in order to provide revised recommendations, if warranted.

f. Establishing and maintaining positive drainage away from structural pads.

4.5 Conventional Concrete Slab-on-Grade

The prepared subgrades to receive footings as described, should be adequate for concrete slab-on-grade placement. For normal load bearing conditions, 4-inch thick (net) concrete slabs reinforced with #3 rebar at 24-inch o/c, is recommended. For driveways, concrete slabs should be 5.5-inch thick (nominal) placed over local soils compacted to at least 95%. Driveway slab reinforcing, along with construction and expansion joints should be incorporated as required by the project structural engineer.

Within moisture sensitive areas, concrete slabs should be underlain by 2-inch of compacted clean gravelly sand of SE greater than 30, followed by 6-mil thick Visqueen.

Subgrades to receive concrete slabs should be moistened as would be expected in any such concrete placement. Low-slump (4"-5") concrete is recommended with water/cement ratio not exceeding 0.5. In addition, it is strongly recommended that utility trenches underlying concrete slabs and driveways should be adequately backfilled with gravelly soils and such should be mechanically compacted prior to concrete pour. Water jetting should not be considered as an alternative to mechanical compaction. Slab subgrades should be verified by soils engineer immediately prior to concrete pour.

4.6 Resistance to Lateral Loads

Resistance to lateral loads can be restrained by friction acting at the base of foundation and by passive earth pressure. A coefficient of friction of 0.29 may be assumed with normal dead load forces for footing established on compacted fill.

An allowable passive lateral earth resistance of 230 pounds per square foot per foot of depth may be assumed for the sides of foundations poured against compacted fill. The maximum lateral passive earth pressure is recommended not to exceed 2300 pounds per square foot.

For design, lateral pressures from local soils when used as level backfill may be estimated from the following equivalent fluid density:

Active:	33 pcf
At Rest:	60 pcf

4.7 Shrinkage and Subsidence

It is our opinion that during grading, the upper soils may be subjected to a volume change. Assuming a 90% relative compaction for structural fills and assuming an overexcavation and re-compaction depth of 60 inches, such volume change due to shrinkage may be on the order of 18 to 20 percent within canyon bottom. Lesser shrinkage may be expected within areas of ridges and plateau. Further volume change may be expected due to supplemental shrinkage during preparation of subgrade soils. For estimation purpose, such may be approximated to about 2-inch when conventional construction equipments are being used.

4.8 Construction Consideration

4.8.1 Unsupported Excavation

Site soils may be highly susceptible to caving. Temporary excavations up to 5 feet in vertical height may be made without rigorous lateral supports. Excavated surface should, however, be 'wetted' during construction in order to minimize potential surface soil ravelling. Further, no surcharge shall be allowed within an imaginary 1:1 line drawn upward from toe of temporary excavations. Flatter slopes should be considered.

4.8.2 Supported Excavations

If vertical excavations exceeding 5 feet in depths become warranted, such should be achieved using shoring to support side walls.

4.9 Site Preparations

Site preparations should include subexcavation of the upper loose and disturbed soils, stock-piling, moisturization by overnight sprinkler or aeration to 3% to 5% over optimum moisture content. Site preparation should also include re-placement of the excavated soils and other approved imported fills compacted to 90 percent or better. Such earth work should be in accordance with the applicable grading recommendations provided in the current UBC and as recommended in Section 5.0 of this report.

4.10 Soil Caving

Considering dry in nature, the site soils are considered susceptible to caving. Temporary excavations in excess of 5 feet should be made at a slope 2 to 1 (h:v), or flatter, and as per the construction guidelines as provided by the CalOsha.

4.11 Structural Pavement Thickness

Flexible Asphalt Paving: Based on estimated Traffic Index (TI) and on assumed soil R-value of 50, the following paving sections are supplied for estimation purposes. Following mass grading, actual paving sections should be determined based on R-value of the soils sampled from street grade.

Service Area	Traffic Index, TI	Paving Type	Paving Thickness, in.
Interior Street	6.0	a.c over base	3.5 over 4"

For a.c over base, upper 12-inch of the subgrade soils should be compacted to 90% along with the base material being compacted to minimum 95%.

4.12 Retaining Wall

Earth retaining walls, if any, should be designed based on the following Equivalent Fluid Density:

Slope of Retained Material (H:V)	Equivalent Fluid Density, pcf	
	Clean Sand	Local Soil
level	30	34
2:1	42	55

Walls adjacent to traffic areas should be designed to resist a uniform lateral pressure of 100 pounds per square foot, which is a result of an assumed 300 pounds per square foot surcharge behind the walls due to normal traffic. If the traffic is kept back ten feet from the wall, the traffic surcharge may be neglected.

The design parameters do not include any hydrostatic pressure build-up. Consequently, installation of 'french-drain' behind retaining walls are recommended to minimize water pressure build-up behind retaining walls. Use of impervious material is preferred within upper the 18 inches of the backfill placed.

Backfill behind retaining wall should be compacted to a minimum 90 percent. Flooding and/or jetting behind wall should not be permitted. Local sandy soils may be used as backfill.

4.13 Utility Trench Backfill

Utility trench backfill within the structural pad and beyond, should be placed in accordance with the following recommendations:

- Trench backfill should be placed in 6 to 8-inch thick lifts and mechanically compacted to minimum 90 percent. Jetting is not recommended as a substitute for mechanical compaction. Within paving areas, the upper 12-inch of the backfills should be compacted to minimum 95%.

- Exterior trenches along foundations or a toe of a slope extending below a 1:1 imaginary line projected from outside bottom edge of the footing or toe of the slope, should be compacted to 90 percent of the Maximum Dry Density for the soils used as backfill. All trench excavations should conform to the requirements of Cal-Osha

4.14 Seasonal Limitations

No fill shall be placed, spread or rolled during unfavorable weather conditions. Where the work is interrupted by heavy rains, fill operations shall not be resumed until moisture conditions are considered favorable by the soils engineer.

4.15 Planters

To minimize potential differential settlement to foundations, planters requiring heavy irrigation should be restricted from using adjacent to footings. In event such becomes unavoidable, planter boxes with sealed bottoms, should be considered.

4.16 Landscape Maintenance

Only the amount of irrigation necessary to sustain plant life should be provided. Pad drainage should be directed towards streets and to other approved areas away from foundations. Slope areas should be planted with draught resistant vegetation. Over watering landscape areas could adversely affect the proposed site development during its life-time use.

4.17 Observations and Testing During Construction

The tentative recommendations provided are based on the assumption that supplemental detailed geologic and geotechnical evaluations should be made and structural footings and slab-on-grade be established exclusively into compacted fills. Excavated footings should be inspected, verified and certified by soils engineer prior to steel and concrete placement to ensure their sufficient embedment and proper bearing as recommended. Structural backfills discussed should be placed under direct observations and testing by this facility. Excess soils generated from footing excavations should be removed from pad areas and such should not be allowed on subgrades underlying concrete slab.

4.19 Plan Review

No grading and/or development plans are reviewed and none such are available at this time. Consequently, the recommendations supplied are exclusively for preliminary project review only, and should not be used in design and construction without written approval by soils engineer and the project geologist. In addition, it is recommended that 'precise' grading, development and structural plans should be reviewed to ensure applicability of the assumptions made in preparing this report. If during supplemental investigation conditions are observed different from those as assumed and described herein, revised and/or supplemental recommendations will be required.

5.0 Earth Work/General Grading Recommendations

It is assumed that site preparations and grading should involve overexcavation and replacement of local soils as structural fill compacted to the minimum relative compactions as described earlier. The following tentative recommendations may be considered for initial project review only.

Structural Backfill:

Local soils free of debris, large rocks and organic should be considered suitable for reuse as backfill. Loose soils, formwork and debris should be removed prior to backfilling retaining walls. On-site sand backfill should be placed and compacted in accordance with the recommended specifications provided below. Where space limitations do not allow conventional backfilling operations, special backfill materials and procedures may be required. Pea gravel or other select backfill can be used in limited space areas. Recommendations for placement and densification of pea gravel or other special backfill can be provided during construction.

Site Drainage:

Adequate positive drainage should be provided away from the structure to prevent water from ponding and to reduce percolation of water into backfill. A desirable slope for surface drainage is 2 percent in landscape areas and 1 percent in paved areas. Planters and landscaped areas adjacent to building perimeter should be designed to minimize water filtration into subsoils. Considerations should be given to the use of closed planter bottoms, concrete slabs and perimeter subdrains where applicable.

Utility Trenches:

Buried utility conduits should be bedded and backfilled around the conduit in accordance with the project specifications. Where conduit underlies concrete slab-on-grade and pavement, the remaining trench backfill above the pipes should be placed and compacted in accordance with the following grading specifications.

General Grading Recommendations:

Recommended general specifications for surface preparation to receive fill and compaction for structural and utility trench backfill and others, are presented below.

1. Areas to be graded, backfilled or paved, shall be grubbed, stripped and cleaned of all buried and undetected debris, structures, concrete, vegetation and other deleterious materials prior to grading.

2. Where compacted fill is to provide vertical support for foundations, all loose, soft and other incompetent soils should be removed to full depth as approved by soils engineer, or at least up to the depth as previously described in this report. The areas of such removal should extend at least 5 feet beyond the perimeter of exterior foundation limit or to the extent as approved by soils engineer during grading.

3. The fills to support foundations and slab-on-grade should be compacted to minimum 90% of the soil's Maximum Dry Density at 3 to 5% over Optimum.

To minimize potential differential settlements to foundations and slabs straddling over cut and fill transition, cut portions following cut, should be further overexcavated and such be replaced as engineered fill compacted to at least 90% of the soil's Maximum Dry Density as described in this report.

4. Utility trenches should be backfilled with granular material and such should be mechanically compacted to at least 90% of the maximum density for the material used.

5. Compaction for structural fills shall be determined relative to the maximum dry density as determined by ASTM D1557-91 compaction methods. All in-situ field density of compacted fill shall be determined by the ASTM D1556-82 standard methods or by other approved procedures.

6. All new imported soils, if required, shall be clean, granular, non-expansive material or as approved by the soils engineer.

7. During grading, fill soils shall be placed as thin layers, thickness of which following compaction shall not exceed six to eight inches.

8. No rocks over six to eight inches in diameter shall be permitted to use as a grading material without prior approval of the soils engineer.

9. No jetting and/or water tampering be considered for backfill compaction for utility trenches without prior approval of the soils engineer. For such backfill, hand tampering with fill layers of 8 to 12 inches in thickness, or as approved by the soils engineer is recommended.

10. Utility trenches at depth and cesspool and abandoned septic tank existing within building pad areas and beyond, should be excavated and removed, or such should be backfilled with gravel, slurry or by other material as approved by soils engineer.

11. Imported fill soils if required, should be equivalent to site soils or better. Such should be approved by the soils engineer prior to their use.

12. Grading required for pavement, side-walk or other facilities to be used by general public, should be constructed under direct observation of soils engineer or as required by the local public agencies.

13. A site meeting should be held between grading contractor and soils engineer prior to actual construction. Two days of prior notice will be required for such meeting.

6.0 Closure

The conclusions and recommendations presented are based on site reconnaissance and on soil sampling from exposed slope surface and from level grades. No detailed geotechnical explorations and made. Consequently, the recommendations supplied should be considered as "tentative" subject to verification following actual geotechnical and geologic investigations.

Final grading and foundation plans should be reviewed by this office when they become available. Site grading must be performed under inspection by geotechnical representative of this office. Excavated footings should be inspected and approved by soils engineer prior to steel and concrete placement to ensure that foundations are founded into satisfactory soils and excavations are free of loose and disturbed materials.

A pregrading meeting between grading contractor and soils engineer is recommended prior to construction preferably at the site, to discuss the grading procedures to be implemented and other requirements described in this report to be fulfilled.

This report has been prepared exclusively for the use of the addressee for the project referenced in the context. It shall not be transferred or be used by other parties without a written consent by Soils Southwest, Inc. We cannot be responsible for use of this report by others without inspection and testing of grading operations by our personnel.

Should the project be delayed beyond one year after the date of this report, the recommendations presented shall be reviewed to consider any possible change in site conditions.

The recommendations presented are based on the assumption that the necessary geotechnical observations and testing during construction will be performed by a representative of this office. The field observations are considered a continuation of the geotechnical investigation performed.

IF ANOTHER FIRM IS RETAINED FOR GEOTECHNICAL OBSERVATIONS AND TESTING, OUR PROFESSIONAL LIABILITY AND RESPONSIBILITY SHALL BE LIMITED TO THE EXTENT THAT SOILS SOUTHWEST, INC. WOULD NOT BE THE GEOTECHNICAL ENGINEER OF RECORD. FURTHER, USE OF THE GEOTECHNICAL RECOMMENDATIONS BY OTHERS WILL RELIEVE SOILS SOUTHWEST, INC. OF ANY LIABILITY THAT MAY ARISE DURING LIFETIME USE OF THE STRUCTURES CONSTRUCTED.

IT SHOULD BE NOTED THAT A LETTER OF TRANSFER OF RESPONSIBILITY SHOULD BE PREPARED BY OTHER GEOTECHNICAL CONSULTANT AND SUCH BE SUBMITTED TO THE CITY FOR THEIR APPROVAL AND TO SOILS SOUTHWEST, INC. PRIOR TO SITE PREPARATIONS AND GRADING.

7.0 APPENDIX A

Field Explorations

No actual field explorations are included within the scope of work described. However, where feasible, relatively undisturbed soils were sampled using a drive sampler lined with soil sampling rings. The split barrel steel sampler was driven into the bottom of test excavations at various depths. Soil samples were retained in brass rings of 2.5 inches in diameter and 1.00 inch in height. The central portion of each sample was enclosed in a close-fitting waterproof container for shipment to our laboratory. In addition to undisturbed sample, bulk soil samples were procured as described in the logs. Considering trench excavations, in-situ density testing was programmed either by Sand-Cone or by Nuclear Density Gauge.

8.0 APPENDIX B

Laboratory Test Programs

Laboratory tests were conducted on representative soils for the purpose of classification and for the determination of the physical properties and engineering characteristics. The number and selection of the types of testing for a given study are based on the geotechnical conditions of the site. A summary of the various laboratory tests performed for the project is presented below.

Moisture Content and Dry Density (D2937):

Data obtained from these test, performed on undisturbed samples are used to aid in the classification and correlation of the soils and to provide qualitative information regarding soil strength and compressibility.

Direct Shear (D3080):

Data obtained from this test performed at increased and field moisture conditions on relatively remolded soil sample is used to evaluate soil shear strengths. Samples contained in brass sampler rings, placed directly on test apparatus are sheared at a constant strain rate of 0.002 inch per minute under saturated conditions and under varying loads appropriate to represent anticipated structural loadings. Shearing deformations are recorded to failure. Peak and/or residual shear strengths are obtained from the measured shearing load versus deflection curve. Test results, plotted on graphical form, are presented on Plate B-1 of this section.

Consolidation (D2835):

Drive-tube samples are tested at their field moisture contents and at increased moisture conditions since the soils may become saturated during life-time use of the planned structure.

Data obtained from this test performed on relatively undisturbed and/or remolded samples, were used to evaluate the consolidation characteristics of foundation soils under anticipated foundation loadings. Preparation for this test involved trimming the sample, placing it in one inch high brass ring, and loading it into the test apparatus which contained porous stones to accommodate drainage during testing. Normal axial loads are applied at a load increment ratio, successive loads being generally twice the preceding.

Soil samples are usually under light normal load conditions to accommodate seating of the apparatus. Samples were tested at the field moisture conditions at a predetermined normal load. Potentially moisture sensitive soil typically demonstrated significant volume change with the introduction of free water. The results of the consolidation tests are presented in graphical forms on Plate B-2.

Potential Expansion

Considering sandy gravelly in nature, the site soils are considered non-expansive. Supplemental soil expansion testing is suggested to verify the soil's expansion potential following site grading completion.

Laboratory Test Results

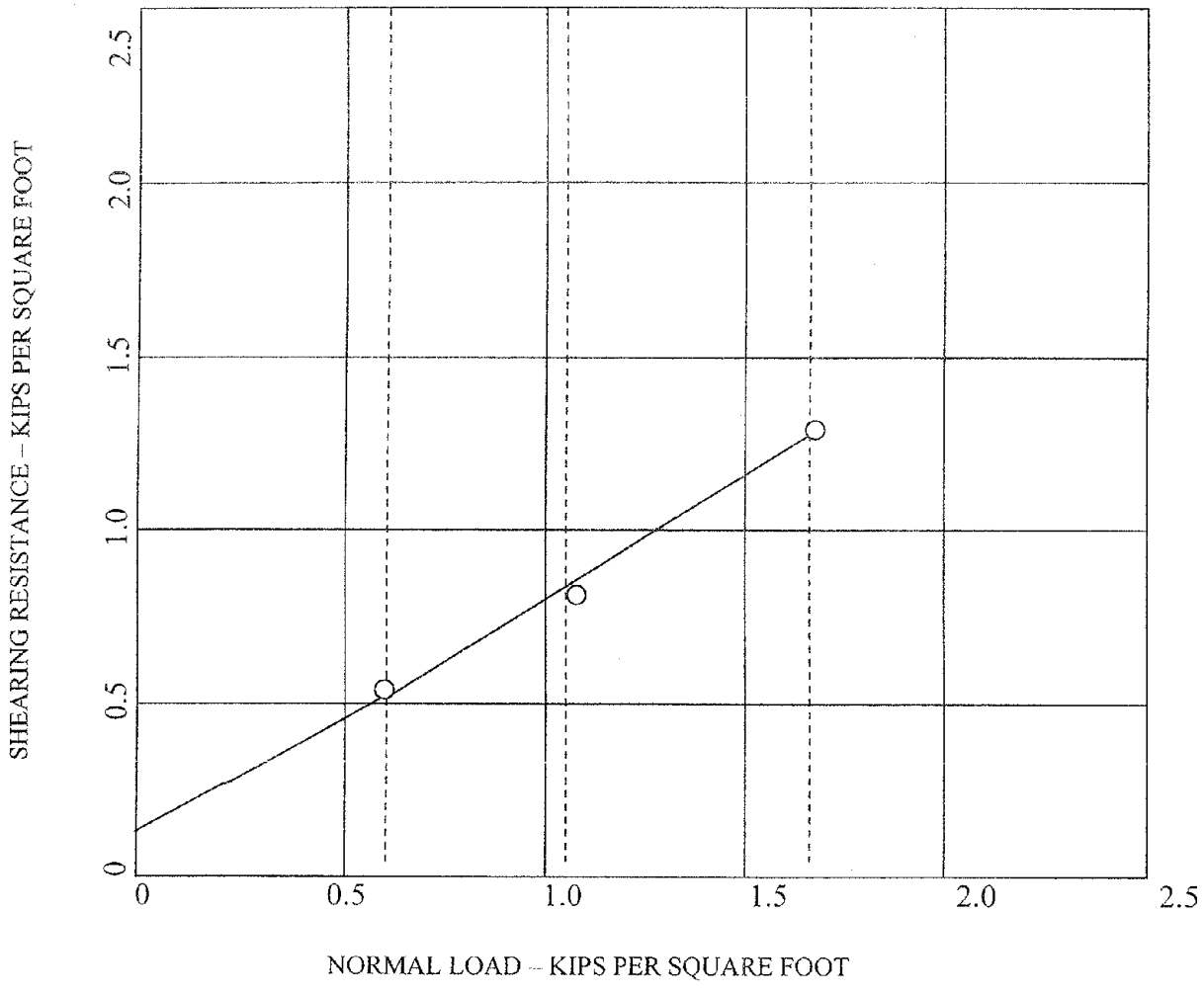
Table I: Expansion Index, EI (UBC 29-2)

Soil Description	Expansion Index, EI
Sand-dark reddish brn., slightly silty, fine to medium coarse, gravelly, traces of clay (central ridge area)	17 (very low expansive)

Table III: Max. Density/Optimum Moisture Content (ASTM D1557-91)

Sample Location, @ Depth, ft.	Max. Dry Density, pcf	Opt. Moisture (%)
Central Ridge Area	130	9
Northern Commercial Area	118	13

DIRECT SHEAR TESTS

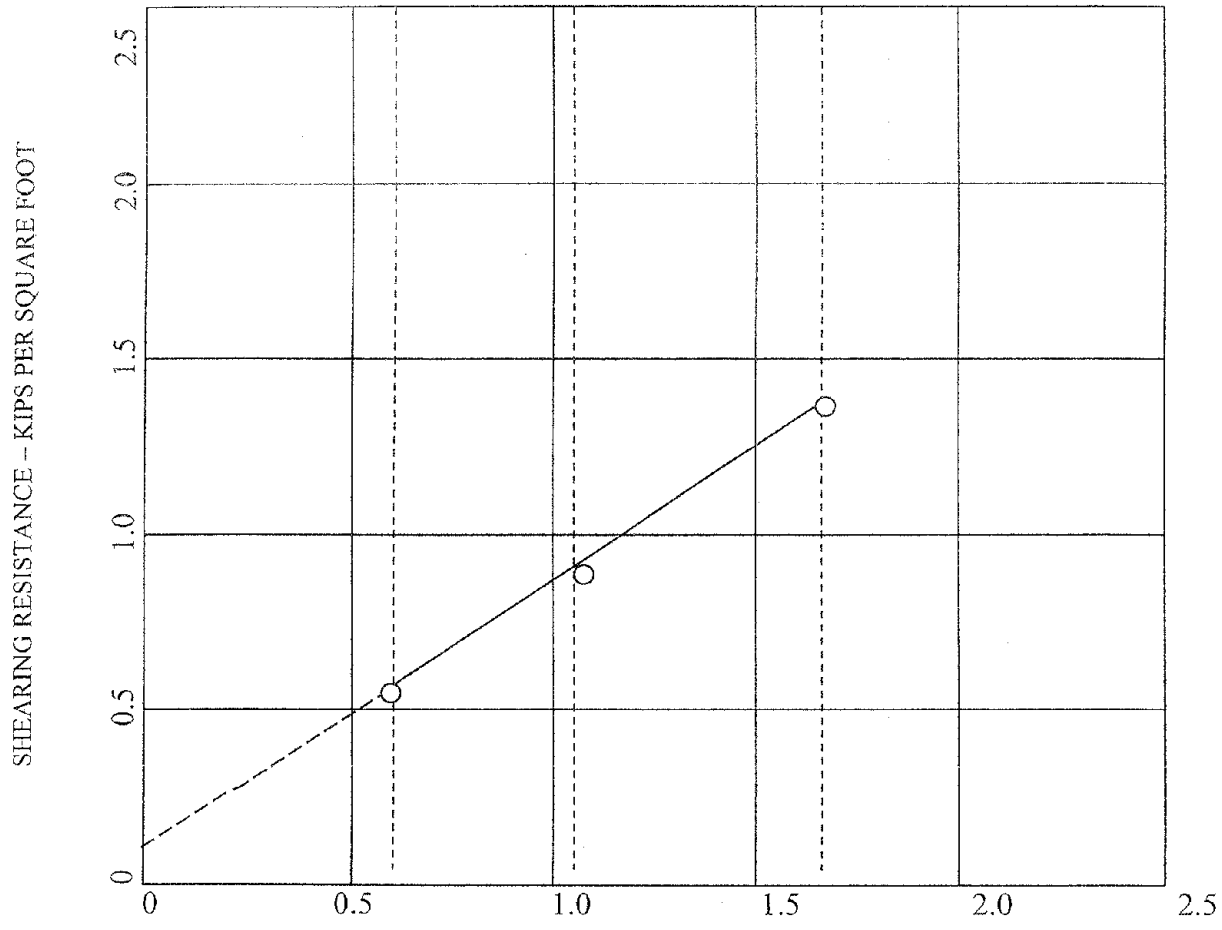


SYMBOL	LOCATION	DEPTH (ft)	TEST CONDITION	COHESION (psf)	FRICTION (degree)
O	New Hotel	0-2	Bulk-remolded to 90%	175	31

Arrowhead Springs Mixed-Use Development City of San Bernardino San Bernardino, California	PROJECT NO.	05027-F1
	PLATE	A-1

SOILS SOUTHWEST INC.
Consulting Foundation Engineers

DIRECT SHEAR TESTS

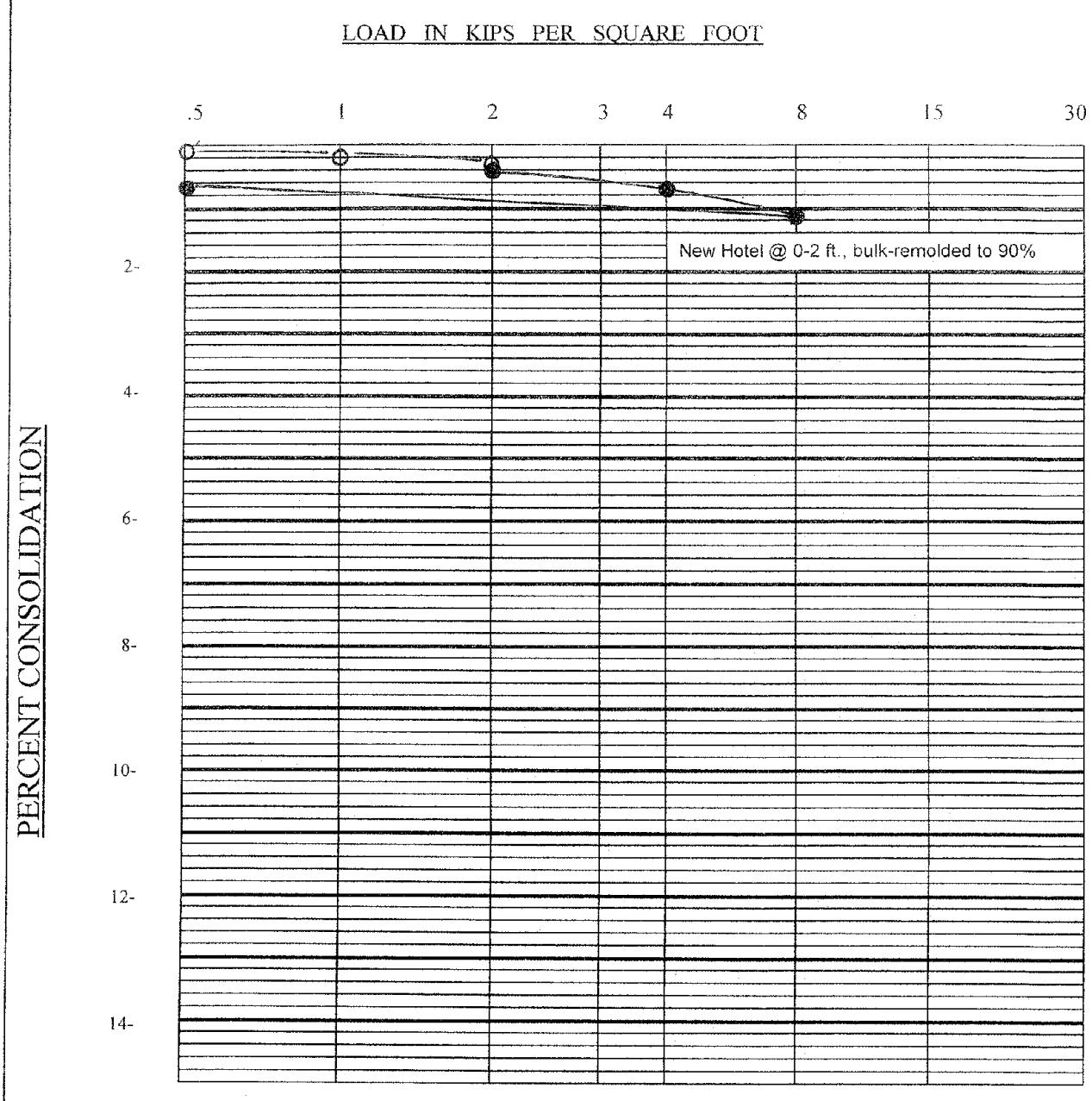


SYMBOL	LOCATION	DEPTH (ft)	TEST CONDITION	COHESION (psf)	FRICTION (degree)
○	Residential Hilltown	0-2	Bulk-remolded to 90%	160	34

Arrowhead Springs Mixed-Use Development City of San Bernardino San Bernardino, California	PROJECT NO.	05027-F1
	PLATE	A-2

SOILS SOUTHWEST INC.
Consulting Foundation Engineers

CONSOLIDATION TESTS



● WATER PERMITTED TO CONTACT SAMPLE

Arrowhead Springs Mixed-Use Development City of San Bernardino San Bernardino, California	PROJECT NO.	05027-F1
	PLATE	A-3

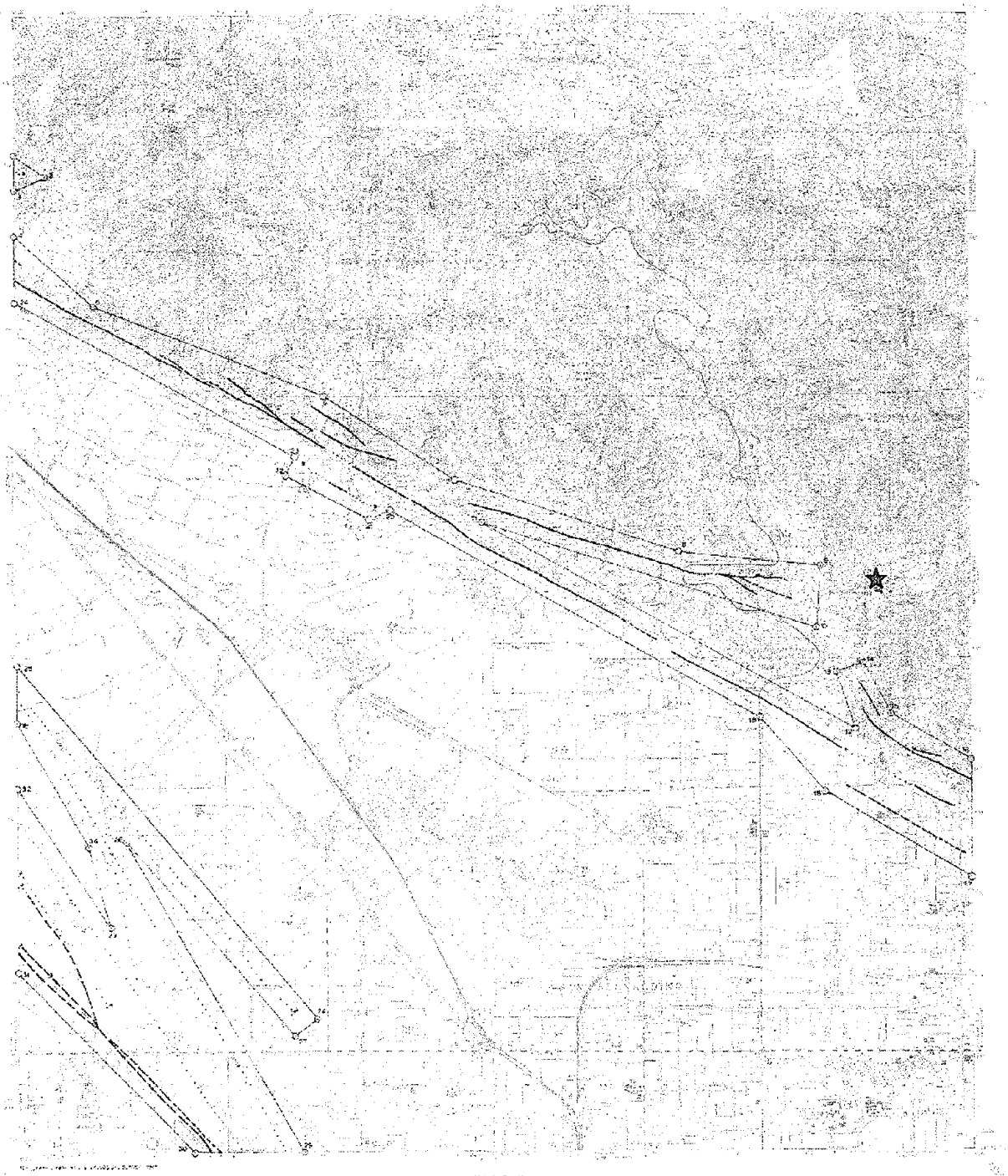
SOILS SOUTHWEST INC.
Consulting Foundation Engineers

Appendix C
Supplemental Seismic Design Parameters

CALIFORNIA DIVISION OF MINES AND GEOLOGY
JAMES E. GLOSSON, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

SAN BERNARDINO NORTH QUADRANGLE
CALIFORNIA—SAN BERNARDINO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



SCALE 1:24,000

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
CONTOUR INTERVAL 10 FEET

MAP EXPLANATION

Potentially Active Faults

Faults considered to have been active during Quaternary time; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed, query (?) indicates additional uncertainty. Evidence of historic offset indicated by year of earthquake-associated event or 2 for displacement caused by creep or possible creep.

Aerial photo lineaments not field checked; based on youthful geomorphic and other features believed to be the results of Quaternary faulting.

Special Studies Zone Boundaries

These are delineated as straight line segments that connect consecutively numbered turning points so as to define one or more special studies zone segments.

Seaward projection of zone boundary.

STATE OF CALIFORNIA
SPECIAL STUDIES ZONES

Delineated in compliance with
Chapter 7.5, Division 2 of the California Public Resources Code

SAN BERNARDINO NORTH QUADRANGLE

OFFICIAL MAP

Effective: July 1, 1974

State Geologist

IMPORTANT - PLEASE NOTE

1) This map may not show all potentially active faults, either within the special studies zones or outside their boundaries.

2) Faults shown are the basis for establishing the boundaries of the special studies zones.

3) The identification of these potentially active faults and the location of such faults traces are based on the best available data. Traces have been drawn as accurately as possible at this map scale, however the quality of data used is highly varied. The faults shown have not been field checked during this map compilation.

4) Fault information on this map is not sufficient to serve as a substitute for information developed by the special studies that may be required under Chapter 7.5, Division 2, Section 2623 of the California Public Resources Code.

REFERENCES USED TO DIGITIZE FAULT DATA

San Bernardino North Quadrangle

[illegible]

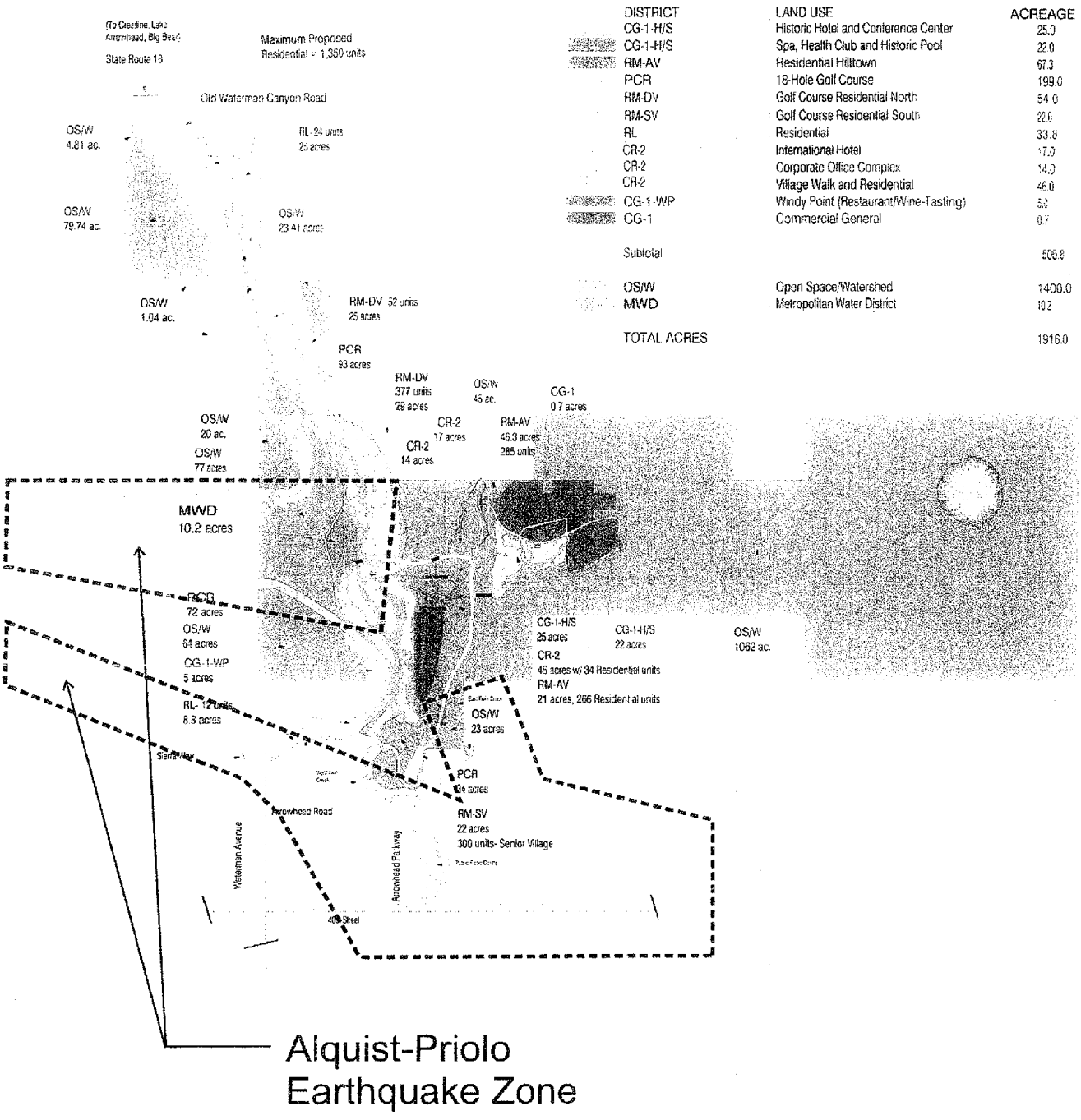
[illegible]

[illegible]

[illegible]

[illegible]

ALQUIST-PRIOLO EARTHQUAKE ZONES



DISTRICT	LAND USE	ACREAGE
CG-1-H/S	Historic Hotel and Conference Center	25.0
CG-1-H/S	Spa, Health Club and Historic Pool	22.0
RM-AV	Residential Hilltown	67.3
PCR	18-Hole Golf Course	199.0
RM-DV	Golf Course Residential North	54.0
RM-SV	Golf Course Residential South	22.0
RL	Residential	33.8
CR-2	International Hotel	17.0
CR-2	Corporate Office Complex	14.0
CR-2	Village Walk and Residential	46.0
CG-1-WP	Windy Point (Restaurant/Wine-Tasting)	5.0
CG-1	Commercial General	0.7
	Subtotal	505.8
OS/W	Open Space/Watershed	1400.0
MWD	Metropolitan Water District	10.2
	TOTAL ACRES	1916.0

Not to Scale

Source: American Development Group

Figure 5.6

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*                    *
*    U B C S E I S   *
*                    *
*    Version 1.03    *
*                    *
**********************
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COMPUTATION OF 1997
UNIFORM BUILDING CODE
SEISMIC DESIGN PARAMETERS

JOB NUMBER: 05027-F1 DATE: 02-11-2005

JOB NAME: Transtech Arrowhead Springs San Bernardino

FAULT-DATA-FILE NAME: CDMGUBCR.DAT

SITE COORDINATES:
SITE LATITUDE: 34.1865
SITE LONGITUDE: 117.2628

UBC SEISMIC ZONE: 0.4

UBC SOIL PROFILE TYPE: SD

NEAREST TYPE A FAULT:
NAME: SAN ANDREAS - Southern
DISTANCE: 0.0 km

NEAREST TYPE B FAULT:
NAME: NORTH FRONTAL FAULT ZONE (West)
DISTANCE: 9.6 km

NEAREST TYPE C FAULT:
NAME:
DISTANCE: 99999.0 km

SELECTED UBC SEISMIC COEFFICIENTS:
Na: 1.5
Nv: 2.0
Ca: 0.66
Cv: 1.28
Ts: 0.776
To: 0.155

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**********************************************************************
* CAUTION:  The digitized data points used to model faults are       *
*           limited in number and have been digitized from small-    *
*           scale maps (e.g., 1:750,000 scale).  Consequently,       *
*           the estimated fault-site-distances may be in error by    *
*           several kilometers.  Therefore, it is important that     *
*           the distances be carefully checked for accuracy and      *
*           adjusted as needed, before they are used in design.      *
**********************************************************************
```

SUMMARY OF FAULT PARAMETERS

ABBREVIATED FAULT NAME	APPROX. DISTANCE (km)	SOURCE TYPE (A,B,C)	MAX. MAG. (Mw)	SLIP RATE (mm/yr)	FAULT TYPE (SS,DS,BT)
SAN ANDREAS - Southern	0.0	A	7.4	24.00	SS
NORTH FRONTAL FAULT ZONE (West)	9.6	B	7.0	1.00	DS
CLEGHORN	9.8	B	6.5	3.00	SS
SAN JACINTO-SAN BERNARDINO	12.0	B	6.7	12.00	SS
CUCAMONGA	15.8	A	7.0	5.00	DS
SAN JACINTO-SAN JACINTO VALLEY	19.0	B	6.9	12.00	SS
SAN ANDREAS - 1857 Rupture	28.2	A	7.8	34.00	SS
SAN JOSE	40.1	B	6.5	0.50	DS
SIERRA MADRE (Central)	40.6	B	7.0	3.00	DS
HELENDALE - S. LOCKHARDT	40.7	B	7.1	0.60	SS
NORTH FRONTAL FAULT ZONE (East)	42.4	B	6.7	0.50	DS
CHINO-CENTRAL AVE. (Elsinore)	46.0	B	6.7	1.00	DS
ELSINORE-GLEN IVY	50.5	B	6.8	5.00	SS
ELSINORE-WHITTIER	50.5	B	6.8	2.50	SS
PINTO MOUNTAIN	51.7	B	7.0	2.50	SS
CLAMSHELL-SAWPIT	54.0	B	6.5	0.50	DS
SAN JACINTO-ANZA	59.0	A	7.2	12.00	SS
LENWOOD-LOCKHART-OLD WOMAN SPRGS	59.7	B	7.3	0.60	SS
ELSINORE-TEMECULA	60.9	B	6.8	5.00	SS
JOHNSON VALLEY (Northern)	65.7	B	6.7	0.60	SS
RAYMOND	68.3	B	6.5	0.50	DS
LANDERS	74.8	B	7.3	0.60	SS
VERDUGO	76.4	B	6.7	0.50	DS
EMERSON So. - COPPER MTN.	77.0	B	6.9	0.60	SS
BURNT MTN.	79.2	B	6.5	0.60	SS
EUREKA PEAK	80.2	B	6.5	0.60	SS
GRAVEL HILLS - HARPER LAKE	82.6	B	6.9	0.60	SS
CALICO - HIDALGO	86.4	B	7.1	0.60	SS
NEWPORT-INGLEWOOD (L.A.Basin)	88.5	B	6.9	1.00	SS
HOLLYWOOD	89.3	B	6.5	1.00	DS
NEWPORT-INGLEWOOD (Offshore)	89.3	B	6.9	1.50	SS
ELSINORE-JULIAN	92.9	A	7.1	5.00	SS
SAN GABRIEL	94.7	B	7.0	1.00	SS
PISGAH-BULLION MTN.-MESQUITE LK	95.1	B	7.1	0.60	SS
SIERRA MADRE (San Fernando)	95.4	B	6.7	2.00	DS
BLACKWATER	95.8	B	6.9	0.60	SS
PALOS VERDES	103.5	B	7.1	3.00	SS
SANTA MONICA	106.0	B	6.6	1.00	DS
SAN JACINTO-COYOTE CREEK	106.8	B	6.8	4.00	SS
SANTA SUSANA	114.4	B	6.6	5.00	DS
MALIBU COAST	117.4	B	6.7	0.30	DS
ROSE CANYON	118.4	B	6.9	1.50	SS
CORONADO BANK	119.0	B	7.4	3.00	SS
HOLSER	121.0	B	6.5	0.40	DS
EARTHQUAKE VALLEY	128.1	B	6.5	2.00	SS
ANACAPA-DUME	133.6	B	7.3	3.00	DS

SUMMARY OF FAULT PARAMETERS

Page 2

ABBREVIATED FAULT NAME	APPROX. DISTANCE (km)	SOURCE TYPE (A,B,C)	MAX. MAG. (Mw)	SLIP RATE (mm/yr)	FAULT TYPE (SS,DS,BT)
OAK RIDGE (Onshore)	136.0	B	6.9	4.00	DS
GARLOCK (West)	136.8	A	7.1	6.00	SS
GARLOCK (East)	140.7	A	7.3	7.00	SS
SAN CAYETANO	140.7	B	6.8	6.00	DS
SIMI-SANTA ROSA	141.7	B	6.7	1.00	DS
SAN JACINTO - BORREGO	147.3	B	6.6	4.00	SS
SANTA YNEZ (East)	156.5	B	7.0	2.00	SS
ELSINORE-COYOTE MOUNTAIN	159.1	B	6.8	4.00	SS
OWL LAKE	161.8	B	6.5	2.00	SS
TANK CANYON	161.8	B	6.5	1.00	DS
PANAMINT VALLEY	161.9	B	7.2	2.50	SS
So. SIERRA NEVADA	162.0	B	7.1	0.10	DS
LITTLE LAKE	162.3	B	6.7	0.70	SS
PLEITO THRUST	164.3	B	6.8	2.00	DS
WHITE WOLF	167.4	B	7.2	2.00	DS
BRAWLEY SEISMIC ZONE	170.9	B	6.5	25.00	SS
VENTURA - PITAS POINT	173.7	B	6.8	1.00	DS
BIG PINE	175.2	B	6.7	0.80	SS
DEATH VALLEY (South)	176.4	B	6.9	4.00	SS
M.RIDGE-ARROYO PARIDA-SANTA ANA	177.9	B	6.7	0.40	DS
SUPERSTITION MTN. (San Jacinto)	181.2	B	6.6	5.00	SS
ELMORE RANCH	181.7	B	6.6	1.00	SS
SUPERSTITION HILLS (San Jacinto)	184.9	B	6.6	4.00	SS
RED MOUNTAIN	187.1	B	6.8	2.00	DS
ELSINORE-LAGUNA SALADA	206.3	B	7.0	3.50	SS
SANTA CRUZ ISLAND	208.4	B	6.8	1.00	DS
IMPERIAL	210.2	A	7.0	20.00	SS
DEATH VALLEY (Graben)	212.0	B	6.9	4.00	DS
SANTA YNEZ (West)	220.4	B	6.9	2.00	SS
OWENS VALLEY	232.5	B	7.6	1.50	SS
SANTA ROSA ISLAND	243.8	B	6.9	1.00	DS
HUNTER MTN. - SALINE VALLEY	255.2	B	7.0	2.50	SS
LOS ALAMOS-W. BASELINE	262.4	B	6.8	0.70	DS
DEATH VALLEY (Northern)	264.8	A	7.2	5.00	SS
INDEPENDENCE	268.5	B	6.9	0.20	DS
SAN JUAN	270.2	B	7.0	1.00	SS
LIONS HEAD	279.2	B	6.6	0.02	DS
SAN LUIS RANGE (S. Margin)	281.1	B	7.0	0.20	DS
CASMALIA (Orcutt Frontal Fault)	294.4	B	6.5	0.25	DS
LOS OSOS	310.3	B	6.8	0.50	DS
RINCONADA	323.6	B	7.3	1.00	SS
HOSGRI	324.4	B	7.3	2.50	SS
BIRCH CREEK	325.3	B	6.5	0.70	DS
WHITE MOUNTAINS	328.8	B	7.1	1.00	SS
DEEP SPRINGS	346.3	B	6.6	0.80	DS
DEATH VALLEY (N. of Cucamongo)	349.6	A	7.0	5.00	SS

Page 3

SUMMARY OF FAULT PARAMETERS

Page 3

ABBREVIATED FAULT NAME	APPROX. DISTANCE (km)	SOURCE TYPE (A,B,C)	MAX. MAG. (Mw)	SLIP RATE (mm/yr)	FAULT TYPE (SS,DS,BT)
ROUND VALLEY (E. of S.N.Mtns.)	361.9	B	6.8	1.00	DS
SAN ANDREAS (Creeping)	364.4	B	5.0	34.00	SS
FISH SLOUGH	368.0	B	6.6	0.20	DS
HILTON CREEK	388.3	B	6.7	2.50	DS
HARTLEY SPRINGS	413.6	B	6.6	0.50	DS
ORTIGALITA	440.6	B	6.9	1.00	SS
MONO LAKE	449.9	B	6.6	2.50	DS
CALAVERAS (So.of Calaveras Res)	450.9	B	6.2	15.00	SS
MONTEREY BAY - TULARCITOS	461.1	B	7.1	0.50	DS
QUIEN SABE	462.5	B	6.5	1.00	SS
PALO COLORADO - SUR	467.4	B	7.0	3.00	SS
ROBINSON CREEK	481.4	B	6.5	0.50	DS
ZAYANTE-VERGELES	483.0	B	6.8	0.10	SS
SARGENT	487.1	B	6.8	3.00	SS
SAN ANDREAS (1906)	488.2	A	7.9	24.00	SS
ANTELOPE VALLEY	522.0	B	6.7	0.80	DS
GREENVILLE	530.7	B	6.9	2.00	SS
HAYWARD (SE Extension)	534.6	B	6.5	3.00	SS
SAN GREGORIO	535.0	A	7.3	5.00	SS
MONTE VISTA - SHANNON	536.9	B	6.5	0.40	DS
GENOA	548.6	B	6.9	1.00	DS
HAYWARD (Total Length)	553.2	A	7.1	9.00	SS
CALAVERAS (No.of Calaveras Res)	553.2	B	6.8	6.00	SS
CONCORD - GREEN VALLEY	597.7	B	6.9	6.00	SS
WEST NAPA	636.9	B	6.5	1.00	SS
RODGERS CREEK	637.4	A	7.0	9.00	SS
HUNTING CREEK - BERRYESSA	656.6	B	6.9	6.00	SS
POINT REYES	661.1	B	6.8	0.30	DS
MAACAMA (South)	698.4	B	6.9	9.00	SS
COLLAYOMI	713.6	B	6.5	0.60	SS
BARTLETT SPRINGS	714.9	A	7.1	6.00	SS
MAACAMA (Central)	739.7	A	7.1	9.00	SS
MAACAMA (North)	797.5	A	7.1	9.00	SS
ROUND VALLEY (N. S.F.Bay)	800.9	B	6.8	6.00	SS
BATTLE CREEK	813.8	B	6.5	0.50	DS
LAKE MOUNTAIN	858.9	B	6.7	6.00	SS
GARBERVILLE-BRICELAND	877.4	B	6.9	9.00	SS
MENDOCINO FAULT ZONE	935.2	A	7.4	35.00	DS
LITTLE SALMON (Onshore)	938.6	A	7.0	5.00	DS
MAD RIVER	939.5	B	7.1	0.70	DS
CASCADIA SUBDUCTION ZONE	950.2	A	8.3	35.00	DS
McKINLEYVILLE	950.4	B	7.0	0.60	DS
TRINIDAD	951.5	B	7.3	2.50	DS
FICKLE HILL	952.4	B	6.9	0.60	DS
TABLE BLUFF	959.5	B	7.0	0.60	DS
LITTLE SALMON (Offshore)	972.5	B	7.1	1.00	DS

Page 4

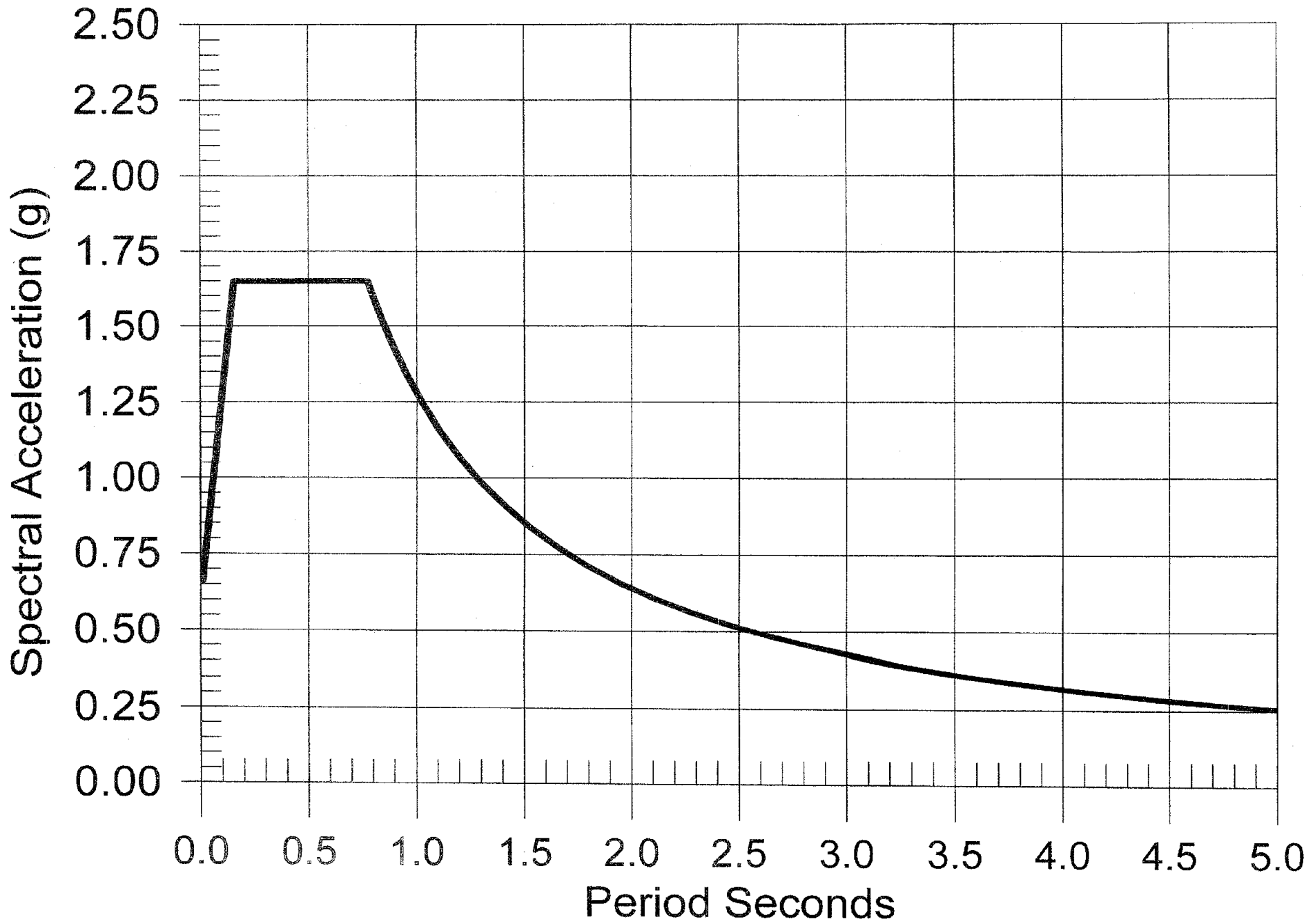
SUMMARY OF FAULT PARAMETERS

Page 4

ABBREVIATED FAULT NAME	APPROX. DISTANCE (km)	SOURCE TYPE (A,B,C)	MAX. MAG. (Mw)	SLIP RATE (mm/yr)	FAULT TYPE (SS,DS,BT)
BIG LAGOON - BALD MTN.FLT.ZONE	987.5	B	7.3	0.50	DS

DESIGN RESPONSE SPECTRUM

Seismic Zone: 0.4 Soil Profile: SD



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*    E Q F A U L T   *
*                    *
*    Version 3.00    *
*                    *
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DETERMINISTIC ESTIMATION OF
PEAK ACCELERATION FROM DIGITIZED FAULTS

JOB NUMBER: 05027-F1

DATE: 02-11-2005

JOB NAME: Transtech Arrowhead Springs San Bernardino

CALCULATION NAME: 05027-F1

FAULT-DATA-FILE NAME: CDMGFLTE.DAT

SITE COORDINATES:
SITE LATITUDE: 34.1865
SITE LONGITUDE: 117.2628

SEARCH RADIUS: 10 mi

ATTENUATION RELATION: 26) Idriss (1994) Horiz. - Soft Soil
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
DISTANCE MEASURE: rdist
SCOND: 0
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

FAULT-DATA FILE USED: CDMGFLTE.DAT

MINIMUM DEPTH VALUE (km): 0.0

EQFAULT SUMMARY

DETERMINISTIC SITE PARAMETERS

Page 1

ABBREVIATED FAULT NAME	APPROXIMATE DISTANCE mi (km)	ESTIMATED MAX. EARTHQUAKE EVENT: MAXIMUM EARTHQUAKE MAG.(Mw)	PEAK SITE ACCEL. g	EST. SITE INTENSITY MOD.MERC.
SAN ANDREAS - Southern	0.0(0.0)	7.4	0.578	X
SAN ANDREAS - San Bernardino	0.0(0.0)	7.3	0.570	X
CLEGHORN	6.1(9.8)	6.5	0.349	IX
NORTH FRONTAL FAULT ZONE (West)	7.3(11.7)	7.0	0.469	X
SAN JACINTO-SAN BERNARDINO	7.5(12.0)	6.7	0.349	IX
CUCAMONGA	9.8(15.8)	7.0	0.428	X

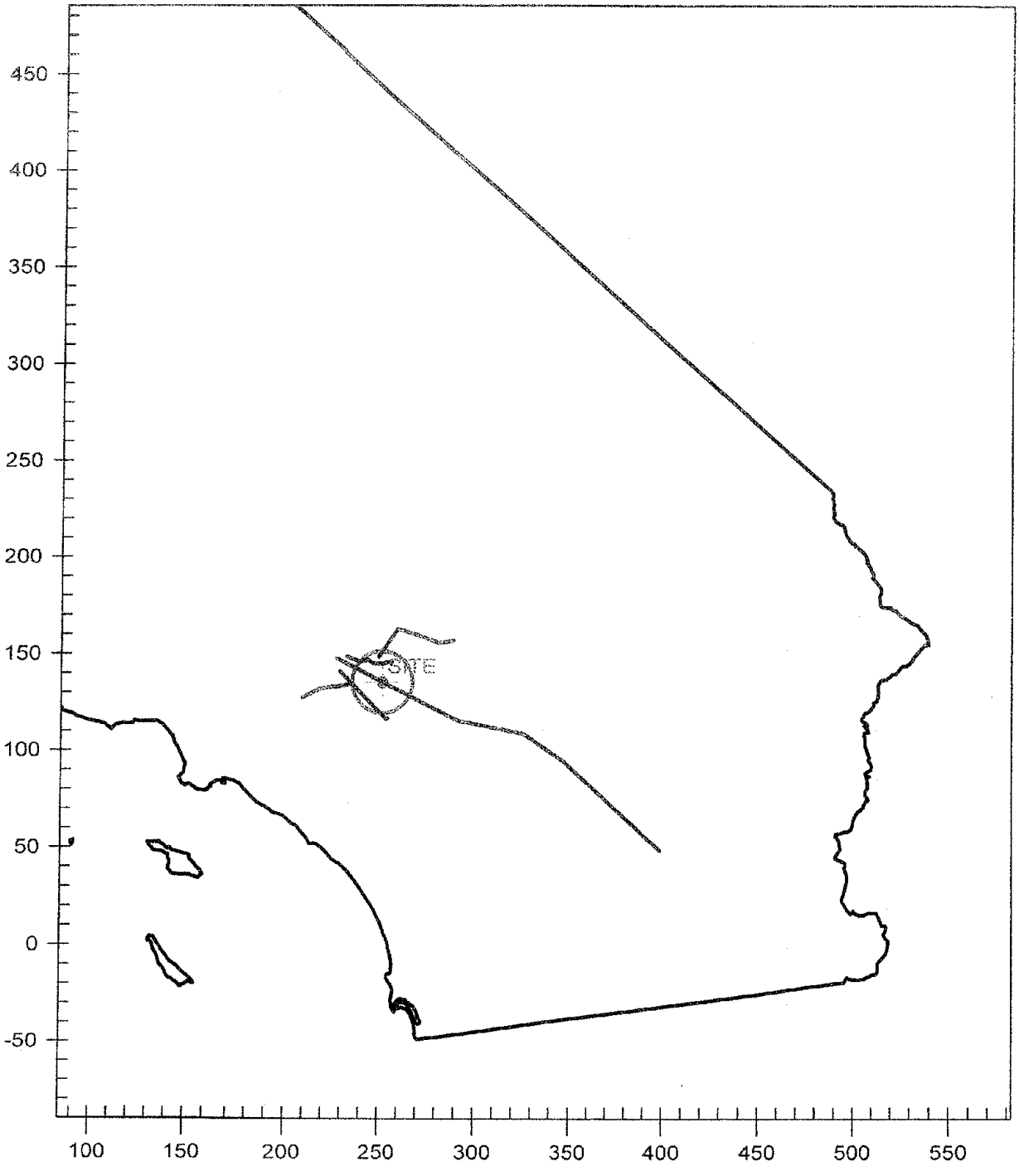
-END OF SEARCH- 6 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

THE SAN ANDREAS - San Bernardino FAULT IS CLOSEST TO THE SITE.
IT IS ABOUT 0.0 MILES (0.0 km) AWAY.

LARGEST MAXIMUM-EARTHQUAKE SITE ACCELERATION: 0.5783 g

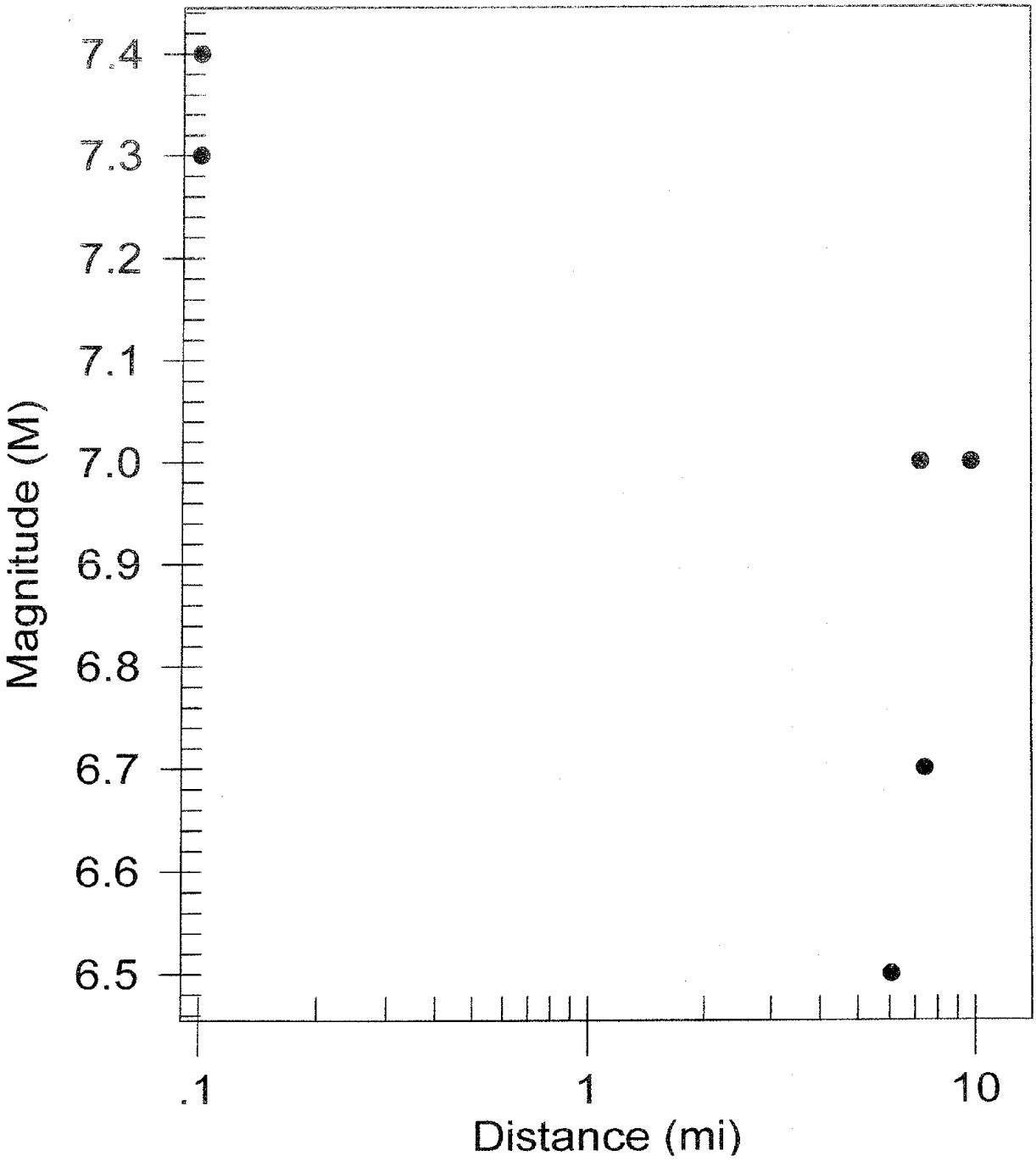
CALIFORNIA FAULT MAP

Transtech Arrowhead Springs San Bernardino



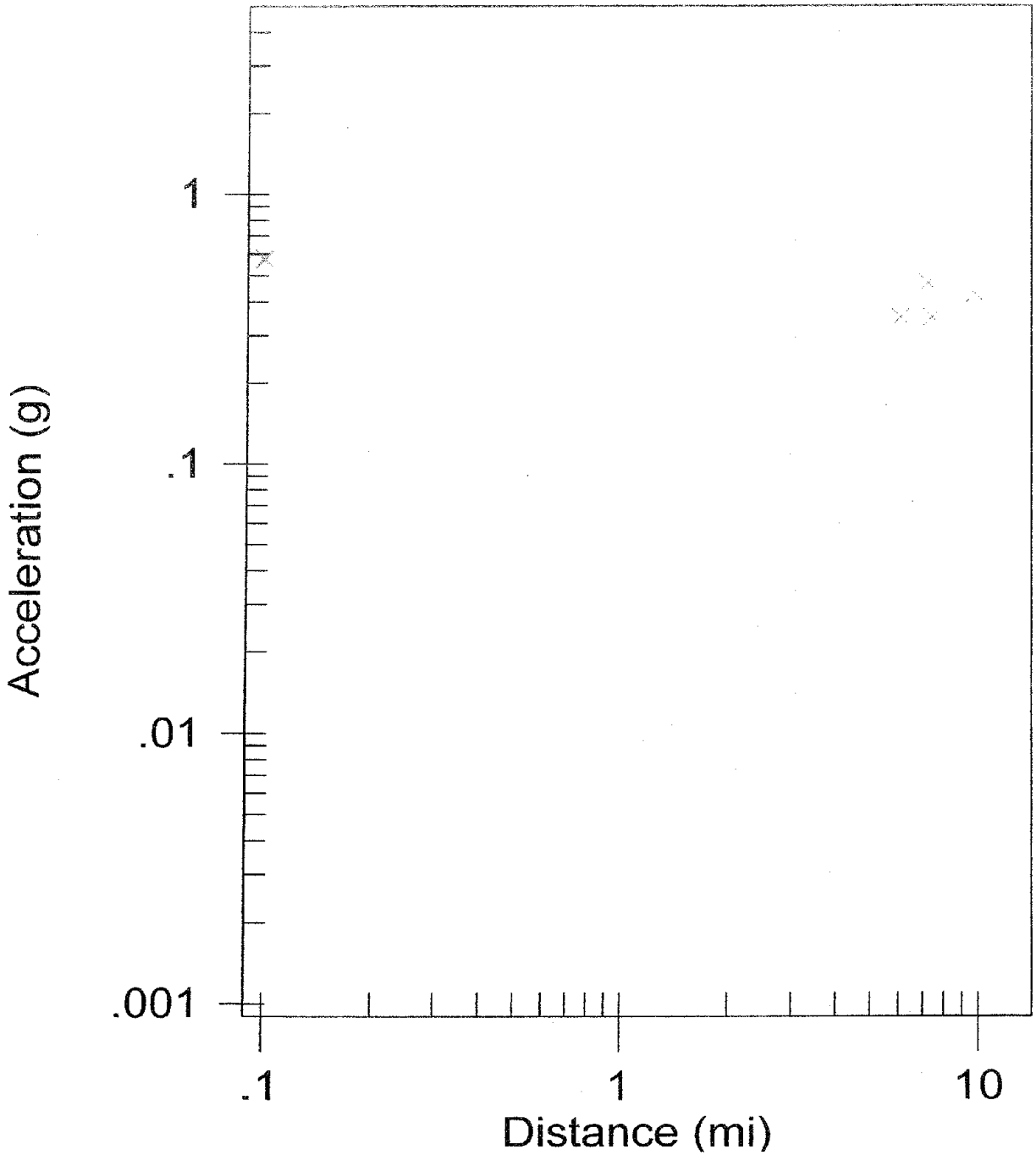
EARTHQUAKE MAGNITUDES & DISTANCES

Transtech Arrowhead Springs San Bernardino



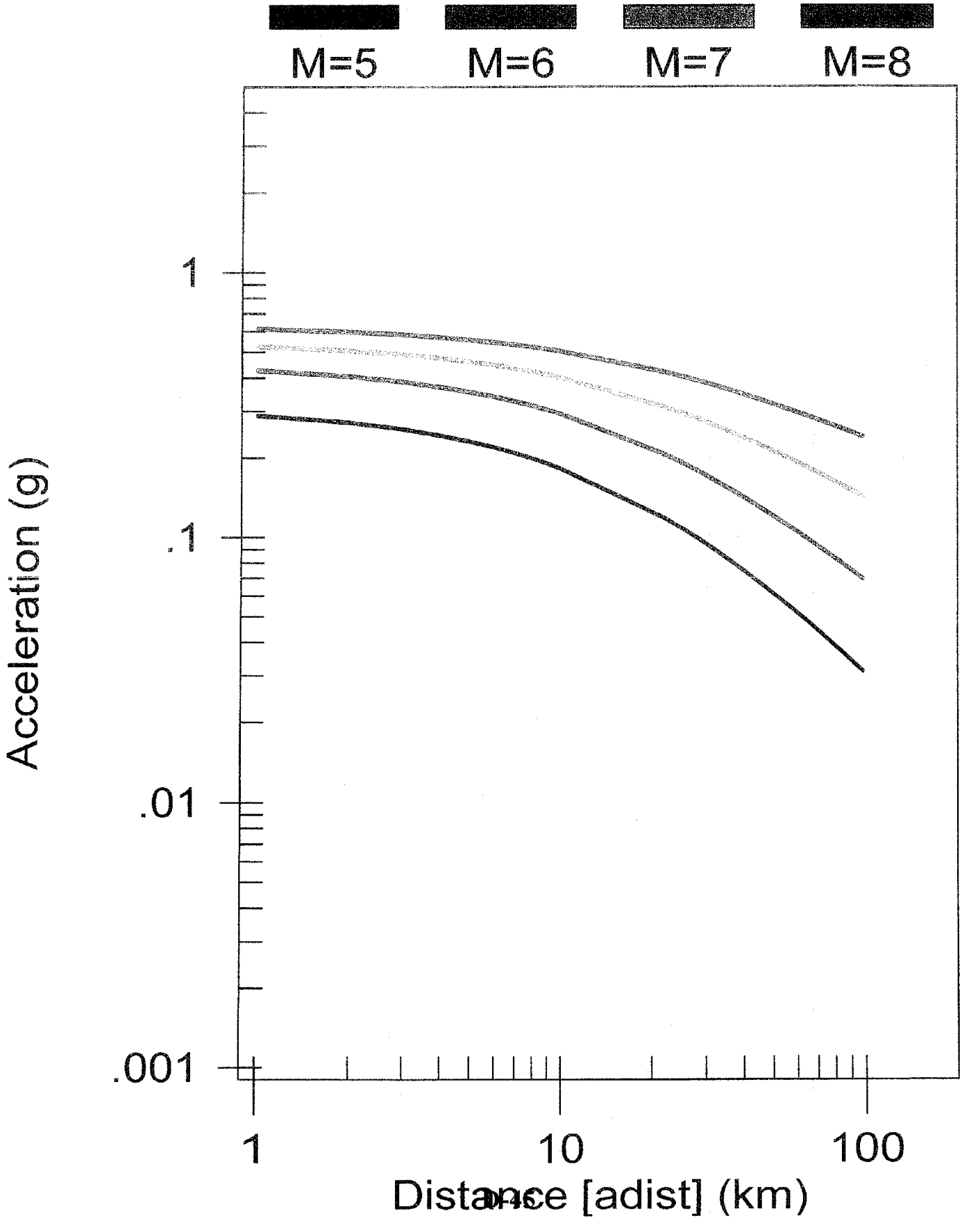
MAXIMUM EARTHQUAKES

Transtech Arrowhead Springs San Bernardino



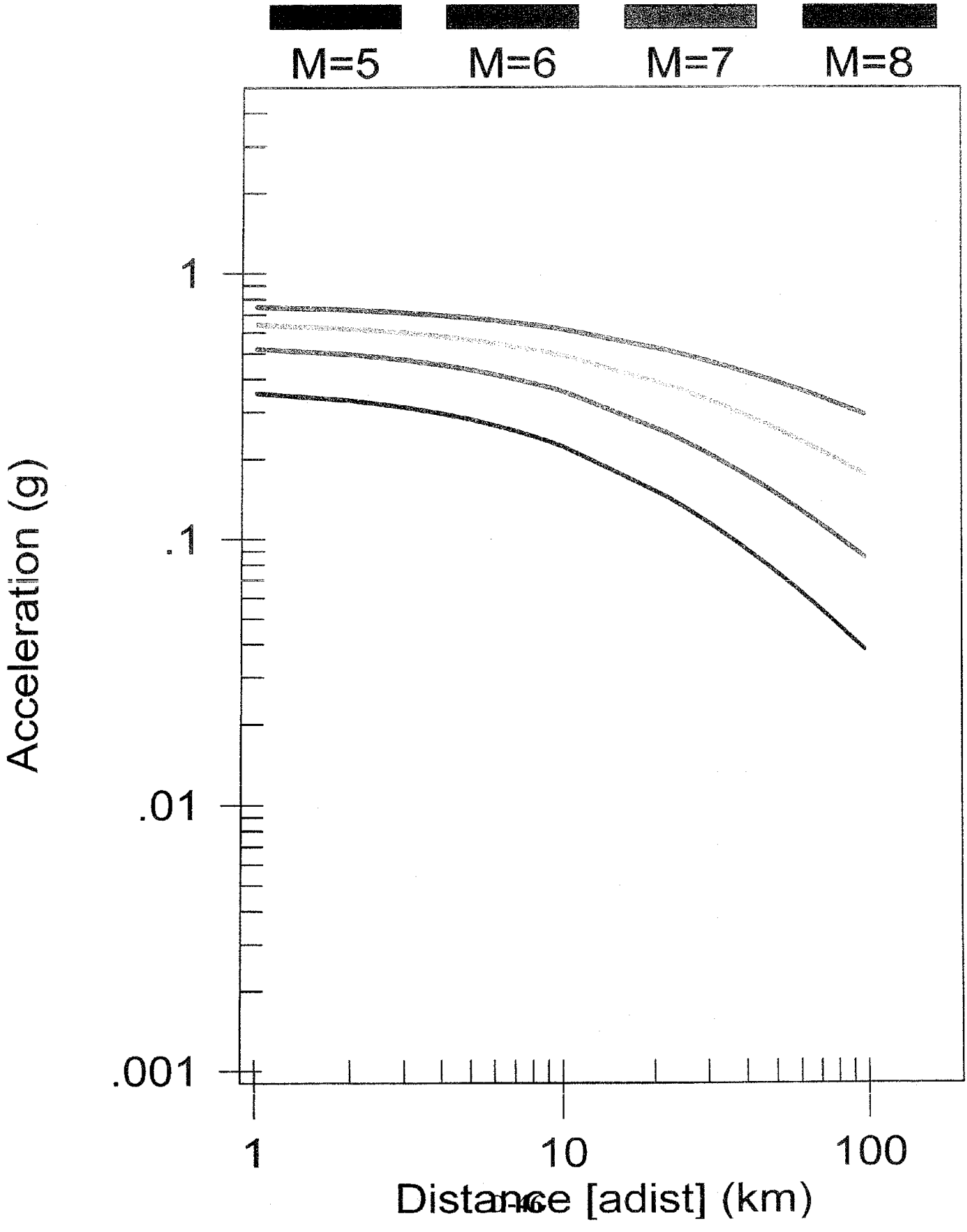
STRIKE-SLIP FAULTS

26) Idriss (1994) Horiz. - Soft Soil



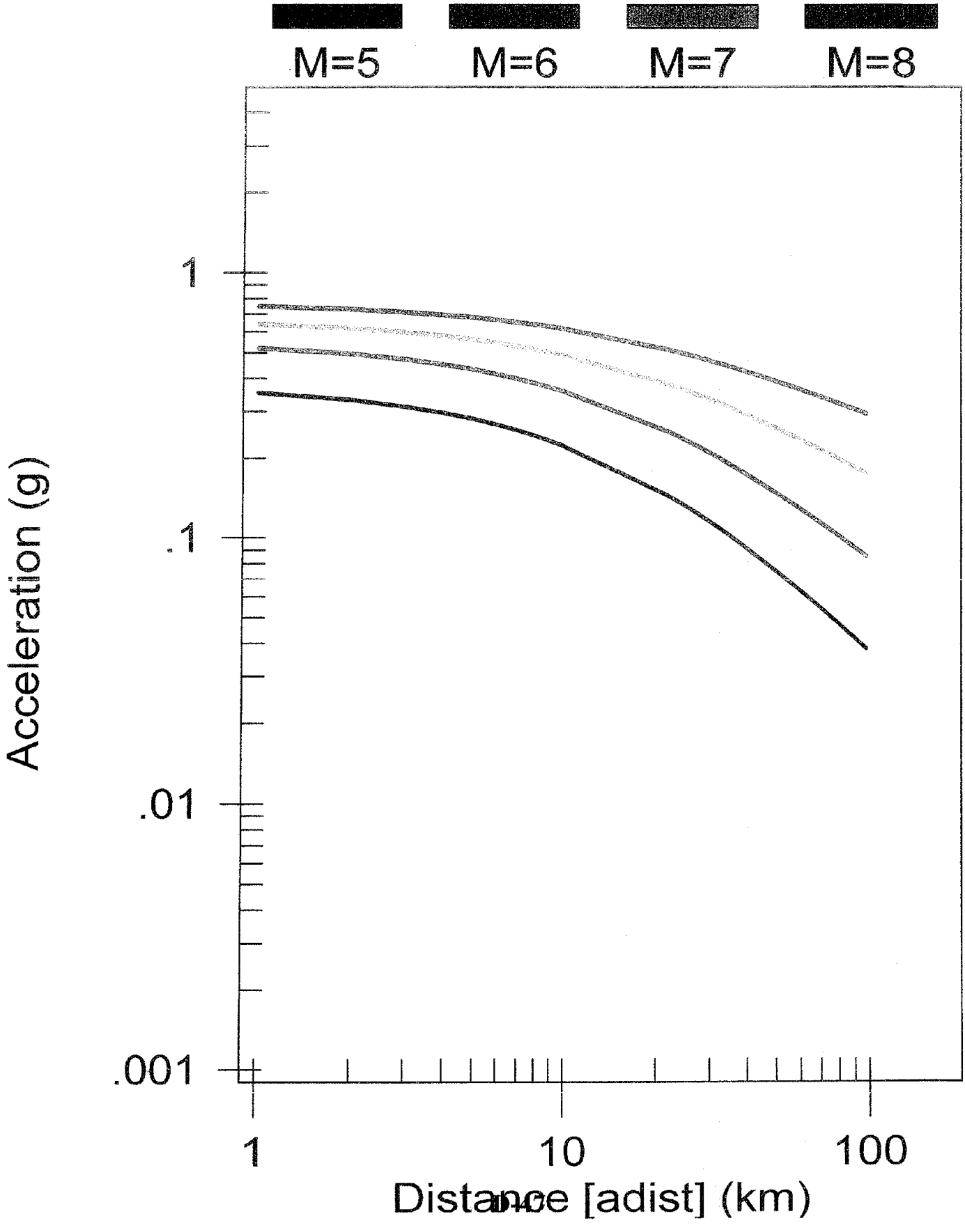
DIP-SLIP FAULTS

26) Idriss (1994) Horiz. - Soft Soil



BLIND-THRUST FAULTS

26) Idriss (1994) Horiz. - Soft Soil



PROFESSIONAL LIMITATIONS

Our preliminary investigation was performed using the degree of care and skill ordinarily exercised, under similar circumstances by other reputable geotechnical consultants practicing in this general or similar localities. No other warranty, expressed or implied, is made as to the conclusions and professional advise included in this report.

The investigations are based on soil samples procured from exposed slope surface and from level areas where accessible, consequently the recommendations provided shall be considered 'preliminary'. The samples taken and used for testing and the observations made are believed representative of site conditions; however, soil and geologic conditions can vary significantly between test excavations. If this occurs, the changed conditions must be evaluated by the Project Soils Engineer and designs adjusted as required or alternate design recommended.

The report is issued with the understanding that it is the responsibility of the owner, or of his representative, to ensure that the information and recommendations contained herein are brought to the attention of the project architect and engineers. Appropriate recommendations should be incorporated into structural plans. The necessary steps should be taken to see that out such recommendations in field.

The findings of this report are valid as of this present date. However, changes in the conditions of a property can occur with the passage of time, whether they due to natural process or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur from legislation or broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by change outside of our control. Therefore, this report is subject to review and should be updated after a period of one year.

RECOMMENDED SERVICES

The review of grading plans and specifications, field observations and testing by the geotechnical representative is an integral part of the conclusions and recommendations made in this report. If Soils Southwest, Inc. (SSW) is not retained for these services, the Client agrees to assume SSW's responsibility for any potential claims that may arise during and after construction, or during the life-time use of the structure and its appurtenant. The required tests, observations and consultation by the geotechnical consultant during construction includes, but not be limited to:

The tentative recommendations supplied should be considered valid and applicable subject to supplemental detailed geologic and geotechnical investigation, as well as when the following conditions are fulfilled:

i. Pre-grade meeting with contractor, public agency and soils engineer,
ii. Excavated bottom excavation inspections and verifications by soils engineer prior to engineered fill soil placement,
iii. Continuous observations and testing during site preparations and grading,
iv. Observations a nd inspections of footing trench excavations prior to steel and concrete placement,
v. Plumbing trench backfill placement inspections and compaction testing prior to steel and concrete placement,
vi. Off-site and on-site utility trench backfill compaction testing and their verifications on on-call basis,
vii. consultations as required during construction, or upon request.

Geologic Report

JAMES R. EVANS, CEG 974
2926 HARRIS DRIVE
VISTA, CALIFORNIA, 92084
760-758-3176

February 12, 2005

Soils Southwest, Inc.
897 Via Lata, Suite N
Colton, California, 92324

Subject: Engineering Geologic Evaluation of the Arrowhead Springs Project

Gentlemen:

In accordance with your request, we have performed preliminary geologic mapping and evaluation of the proposed project. The evaluation included research of the Alquist-Priolo zones with respect to the project in addition to examination of the numerous road cuts and canyon slope exposures. The attached geologic map is a modification of an enlarged portion of the Open File Geologic Map of the San Bernardino North Quadrangle. The modifications include changes in geologic unit identification when our opinion differed from that shown on the map and identification of landslides. In addition, the property boundaries and Alquist-Priolo zones are shown on the map.

PROPOSED DEVELOPMENT

The project is to include expansion of the existing hotel, adding conference facoilities, condominiums, and single family housing. Water sources exist on site including hot springs for heat sources. Grading details are not determined but will include leveling terraces at various elevations for the different components of the project. Streets including arterial width roads are to be constructed to serve the project including bridge construction. Cuts of as much as fifty feet are proposed.

SITE CONDITIONS

The existing hotel and grounds have been in existence since the 1940s. These features appear to be in good condition as are the bungalows. The southerly portion of the project includes some fire damaged and abandoned homes. Aqueducts cross the project which will have to be protected in place. Existing water tanks are to be removed as will portions of the existing road system. Existing grading includes cut and fill grading for these roads as well as the other existing developments including pipelines of various sorts.

Much of the site however, while not in pristine condition is in a more or less natural state. Waterman canyon on the west side has cut down to bedrock during the past year as

has East Twin Creek and an unnamed tributary bordering the hotel ground on the west side. All of these drainages exhibit remnant boulders of enormous size.along the sides and bottom.

REGIONAL GEOLOGY

The site is located at the base and extending up the flank of the San Bernardino Mountains. These mountains are composed of metamorphic and igneous rocks ranging in age from Paleozoic to Cretaceous age. Stream and fan deposits emanating from thes mountains reflect this diversity.

The southerly flank of these mountains is bounded by the San Andreas Fault zone which is a designated Alquist-Priolo zone. Portions of these zones exist on the property (see Geologic Map, Plate G1).

SITE GEOLOGY

The site consist of ridges underlain by either Potato Formation or by granitic-metamorphic complex. These units are deeply weathered and are offset by faulting of uncertain age. Hot springs travertines and quartz deposits mark the ridge exposures of these faults as do active hot springs. Deep cut for roads and tanks all exhibit the deep weathering as do steep walled ravines cut into these crystaline basement units. The U. S. G. S. map shows older rock where we have shown Potato Formation. Exposures show bedding planes and rounded nodules in the weathered rock similar to previously identified Potato Formation Exposures which resulted in our reassignment of the units.

We also reclassified one of the Fan units to a mudflow deposit due to a road cut exposure and found two landslides not identified on the open file map. Other units covering the basement units were correctly mapped an remain unchanged.

Portions of Alquist-Priolo zones exist on the west side and southerly end of the project. These active faults have not yet been trenched to locate fault traces in a precise manner.

SEISMIC SETTING

The entire site lies in the near source zone of the San Andreas Fault. It is 7 Km from the near source zone of the Class B Frontal Fault system, 13 Km from this zone of the Class A Cucumonga Fault system and 9 Km from the near source zone of the San Jacinto Fault

Earthquakes on these faults could generate vibrations on site with maximum horizontal accelerations ranging from 0.4G to 0.7G and with durations of strong shaking exceeding 20 seconds

GROUNDWATER

Numerous hot springs as well as conventional springs on the property testify to water conducted in fractures in the rock. Near surface water also has been reported to occur near the traces of the San Andreas Fault in the southerly edge of the property in the fan and other alluvial deposits which are offset by the fault(s).

SLOPE STABILITY

The cuts made in weathered bedrock materials are expected to be stable in general. Geologic inspection during grading however is imperative to ensure that no adversely dipping shear or bedding planes are exposed which would result in slope instability.

The existing landslide below the hotel grounds should be dealt with to prevent blockage of the creek.

SECONDARY HAZARDS

Liquefaction is possible near the southerly end of the project due to the high groundwater and will have to be further evaluated for mitigation purposes.

When grading plans are nearing final stages, areas near steep natural slopes should be evaluated for potential rockfall or mudflow and appropriate mitigation.

GEOLOGIC CONCLUSIONS

1) The development can be constructed in a geologically safe and stable manner if the finding and recommendations of this report are incorporated into project design.
2) The Alquist-Priolo zones near the southerly edge of the project will require trenching and detailed logging. Appropriate setbacks for structures for human occupancy will be established at that time.
3) Faults shown on the attached geologic map should be evaluated with respect to development plans and appropriately investigated.
4) It is our opinion based on existing exposures that cuts up to fifty feet probably will not require blasting.
5) Due to the nature of the bedrock all cuts should be inspected by a qualified geologist during grading

6) The site will experience at least one major earthquake during any reasonable project lifetime with high accelerations and long duration.
7) Liquefaction potential requires further subsurface investigation and evaluation at the southerly end of the project.
8) Siting of buildings should be reviewed with respect to rockfall or mudflow potential at a later date for mitigation requirements- if any are required.

GEOLOGIC RECOMMENDATIONS

1) Grading plans should be reviewed by this geologist
2) The project should be graded under the inspection and approval of a qualified soils engineer.
3) All design professionals should review this report and incorporate appropriate features into project design.

This Investigation and this report have been prepared using current standards for the profession of engineering geology. No other warranty is expressed or implied. The report may be subject to review by local agencies. If this is the case, we are available for further consultation. The user of this report should be aware that without all attachments and a wet ink signature, the report is not a legal document. We appreciate this opportunity to have been of service to you.

VERY TRULY YOURS

JAMES R. EVANS, CEG 974- Exp.04

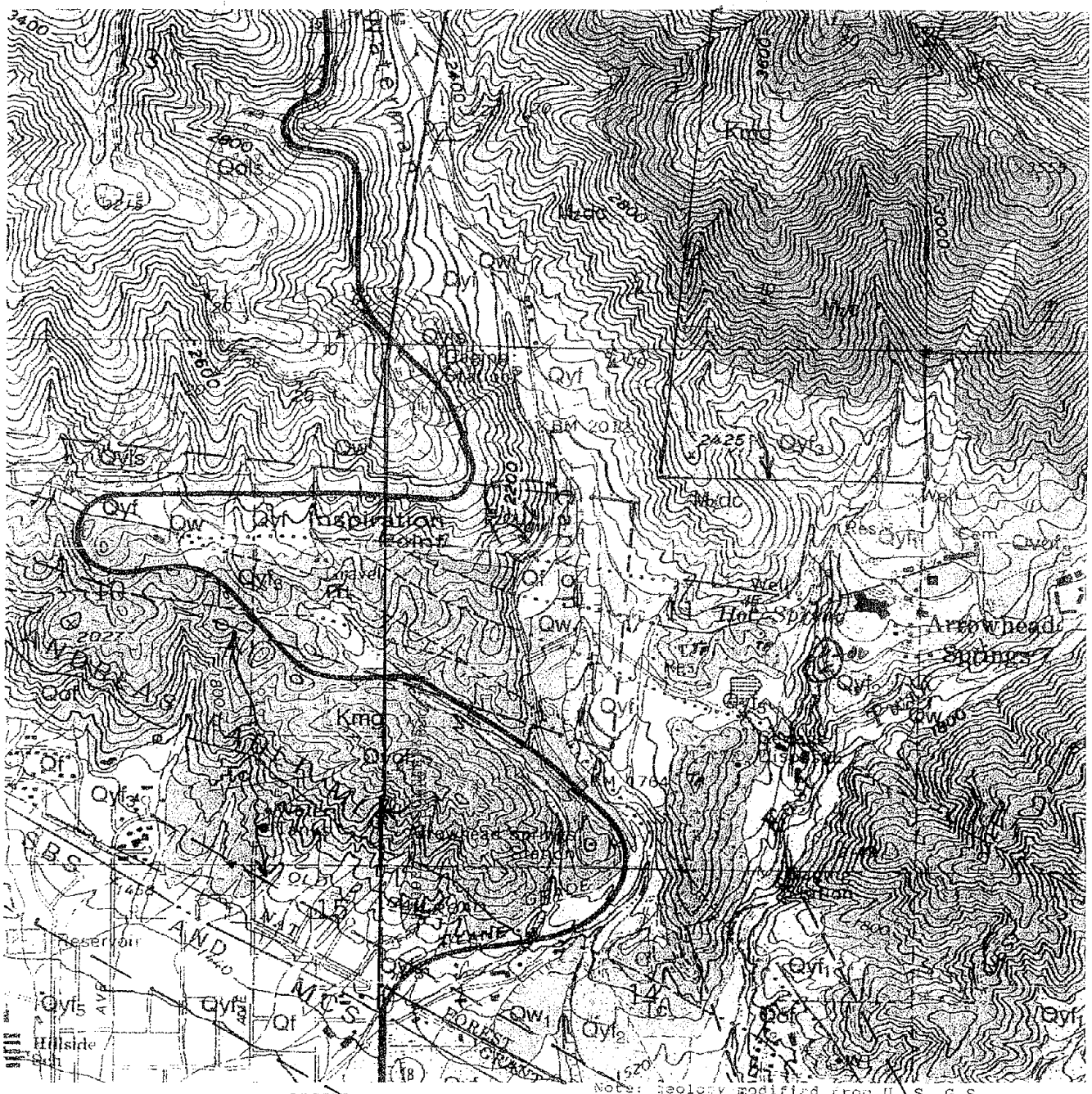
ATTACHMENTS

1) Geologic Map, Plate G1

REFERENCES

1) Geologic Map of the San Bernardino North 7.5' Quadrangle, 2001, Miller, Matti & Carson, U. S. G. S. Open File 01-131
2) Maps of Known Active Fault Near Source Zones in California and Adjacent Portions of Nevada, 1998, Prepared By C. D. M. G. Published By I. C. B. O.
3) Alquist-Priolo San Bernardino North Quadrangle, 1988, C. D. M. G.
4) Landis Fairchild San Bernardino Area Photo-Map series, 1969 K43
5) Ground Motions And Soil Liquefaction During Earthquakes, 1982, Seed, H. B. & Idriss, I, M., Monograph E. E. R. I

AERIAL PHOTOGRAPHS USED



LEGEND

Qls	Landslide Debris
Qw	Very Young Stream Deposits
Qyf1	Very young FAn Deposits
Qyf2	Older Fan Deposits
Qyf3	Older Mudflow Deposits
Tp	Potatoe Formation
Kmg	Granitic Rock
Mzdc	Pelona Schist

scale 1" = 1000'

ARROWHEAD SPRINGS PROJECT
ENGINEERING GEOLOGIC INVESTIGATION
GEOLOGIC MAP PLATE G1