PRELIMINARY GEOLOGIC/GEOTECHNICAL INVESTIGATION REPORT

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HIGHLAND ESTATES

San Mateo County, California

Submitted to: **THE CHAMBERLAIN GROUP**
San Carlos, California

Prepared by: **SOIL FOUNDATION SYSTEMS, INC.**
Fremont, California

September, 1990

SFS

SOIL FOUNDATION SYSTEMS, INC.

Geotechnical Engineers • Engineering Geologists
Soil Mechanics Laboratories

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File No. S20-634-1
September 17, 1990

The Chamberlain Group
P. O. Box 970
San Carlos, California 94070

Attention: Mr. Jack Chamberlain

Subject: **HIGHLAND ESTATES**
San Mateo, California
PRELIMINARY GEOLOGIC/GEOTECHNICAL INVESTIGATION

Gentlemen:

At your request, we have completed preliminary geologic and geotechnical investigations of the subject site for your proposed residential development, and transmit herewith our report covering these investigations.

During the course of our investigations, several alternate grading schemes were developed by the project design team. In light of the findings of our investigations, each of these alternate grading schemes was reviewed and the related significant geologic and geotechnical constraints were identified by us. We, then, have determined the most practical grading scheme from geotechnical engineering considerations among the alternate schemes studied. The accompanying report discusses this grading scheme, identifies the significant geologic and geotechnical hazards associated with this grading scheme, and presents the hazard mitigation options.

Very truly yours,

SOIL FOUNDATION SYSTEMS, INC.

Richard A. Widebrook

K. C. Sohn
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Engineering Geologist, EG 71

RAW;JCW;KCS;ls

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for

HIGHLAND ESTATES

San Mateo, California

INTRODUCTION

Highland Estates is located in San Mateo County just north of State Highway 92 and east of U.S. Highway 280, and comprises the 98 acres of the natural terrain within the area bounded on the north by Bunker Hill Drive, on the east by Bunker Hill Drive and Polhemus Drive, on the south by Ticonderoga Drive, and on the west by Yorktown Road and Brunswick Drive. The site is a part of the easterly facing flank of the northwest trending Pulgas Ridge. The topography is quite rugged, with natural slopes as steep as 1-1/2:1.

A residential development is proposed on the site, which includes eighteen detached single-family lots at four separate locations along parts of the northerly and westerly boundaries of the site and townhomes over a 12-acre portion at the southeast end section, as shown on Figure No. 2. The proposed residential development takes up approximately 20 acres, and the remaining portion will be preserved as an open space.

The purpose of this study was to identify various geologic, seismic, soil, and site conditions that present potential hazards as related to the proposed residential development and to provide various mitigation options that could be implemented to reduce the level of risks associated with these potential hazards.

Our investigation began approximately two years ago, starting with mapping the significant site and geologic features. Our interim findings were verbally presented at meetings of the project design team for consideration in development of the tentative plans which went through a series of changes. Our assessment of the potential hazards treated in this report is based on the proposed land development scheme outlined in the plans "HIGHLAND ESTATES - TENTATIVE MAP", prepared by Brian Kangas Foulk Consulting Engineers. These plans show the last revision date of August 24, 1990.

SITE DESCRIPTION

The site is essentially surrounded by existing residential areas and other improvements on all sides. The Pulgas Ridge, on which the site is located, is a dominant northwest-trending landform. Several spur ridges of this main landform dominate the topography of the site. The highest peak occurs in the northwestern section and reaches Elevation 750. Maximum elevation relief is over 350 feet. Outcrops of massive hard bedrock exist at several locations on the steep slopes. Thick vegetation covers most of the area and generally the northward facing slopes are covered by mature coast-range type of oak forest.

Drainage of the site is generally northeastward into Polhemus Creek. The site contains three prominent natural drainages. One is located through the central portion and is completely contained in the proposed open space area. Another lies in the northwestern end section. The other is located through the area proposed for the townhome development. In addition to these main drainages numerous ancillary drainages exist. Erosion gullies formed by the flow of water released from the water storage tank located atop the high peak in the northwestern section of the site are present in the lower elevations below the tank. These gullies are locally as deep as 15 to 20 feet.

There are several existing landslides of various sizes on the site, as shown on Figure No. 2. However, these landslides are located in the proposed open space areas, mostly a considerable distance away from the limits of the proposed development.

SCOPE OF INVESTIGATION

Our investigation consisted of a review of pertinent geologic literature and reports, site reconnaissance, mapping of the significant site and geologic features, stereoscopic examination of aerial photos, exploratory borings, laboratory soil tests, and analysis of the resulting data.

Geologic literature and reports cited in our study are listed in "SELECTED REFERENCES", page 15.

Our site reconnaissances and mapping were carried out during the last two years over the entire portion of Highland Estates covering an area of close to 100 acres. Our reconnaissances also included the immediate adjoining areas. Much of our efforts were devoted to detailed mapping of the geologic features by examining the exposures on cut slopes and in the numerous deeply eroded steams. Our geologic mapping was also aided by examination of aerial photos using the stereo pairs of Pacific Aerial Surveys photos AV-432-9-7 and -8, taken June 20, 1961, and AV-2670-9-8 and -9, taken October 15, 1985.

During the geologic reconnaissance, core samples of the subsurface material were obtained from deep stream banks by driving shelby tubes. Also bulk soil samples were obtained from various locations for laboratory analysis.

Much of the proposed development areas are inaccessible by heavy equipment for subsurface explorations due to the rugged nature of the terrain and heavy vegetation. Therefore, subsurface explorations utilizing drilling equipment were very much limited to areas near the perimeter at this time. Altogether six test borings were drilled to a maximum depth of 30 feet below the ground surface at the locations shown on Figure No. 2. Three test borings, B-1, B-2 and B-3, were drilled with a portable drill rig, while the remaining three borings were drilled with a truck-mounted rig. During the drilling operations, core samples of the subsurface materials were obtained at various depths. Logs of the test borings, which show the description of the material encountered in the borings, sample locations and resistance of the sampler to driving, are presented on Figures No. 3 through 6.

Our laboratory soil tests included determination of dry density of the core samples, determination of Plasticity Index, unconfined compression tests, direct shear tests and compaction tests. Direct shear tests samples were placed in water under surcharge for one day before testing in order to increase the degree of saturation, and the tests were performed at a constant strain rate of 1/100 inch per minute. Results of these tests are presented on Figures No. 3 through 7. Results of our laboratory tests on soil samples obtained from banks and bottom of deep erosion gullies and other locations outside of the proposed development area are summarized in Table I, included in Appendix A of this report.

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DISCUSSIONS AND CONCLUSIONS

A) Regional Geologic Setting and Seismicity

The ridges and slopes in and around the vicinity of the subject site are comprised primarily of the Jurassic-Cretaceous Franciscan assemblage, mainly graywacke sandstones, shales, altered volcanic rocks, chert and limestone. This assemblage of rocks was deposited in deep marine troughs, and may be thousands of feet in thickness.

The entire Franciscan assemblage in this region has been subjected to repeated episodes of deformation and is intensely and complexly folded, faulted and sheared. The region is geomorphically characterized by a series of discontinuous northwest trending parallel ridges with intervening valleys. Fold axes and the active San Andreas fault located less than a mile west of the site also subscribe to this regional trend. No mapped faults pass through the site.

The seismicity of the region is dominated by the San Andreas fault. The maximum credible earthquake magnitude for the San Andreas fault is generally estimated at 8.3 (Wesnousky, 1986). Peak horizontal ground accelerations in the range of 0.7g are anticipated at the site in the event of earthquakes of greater than 7.0 in magnitude along the segment of the San Andreas fault near the site.

B) Site Geology and Soil Conditions

The overall geology of the area comprising the 100-acre Highland Estates is first discussed, and then the specific features pertinent to each location of the proposed development areas are treated more in detail.

The bedrock type present at the subject site is predominantly graywacke-type sandstone and shale, interbedded with small amounts of chert and conglomerate. There are also minor amounts of metamorphic rocks present in this assemblage. The sandstone and shale is sometimes firm where fresh, but generally highly fractured. Zones of intensely sheared rocks are common. These zones consist of a soft, clayey, highly sheared matrix containing minor spheroidal rock masses. The hard rock masses are of all sizes generally less than 20 feet in diameter. Landsliding is common on slopes of this material, and the erratic distribution of more coherent rock masses within the shear zones gives rise to considerable local variation in physical characteristics.

Serpentinite, with associated greenstone is present peripherally to the subject site to the south and west, and the contact between the two units can be found crossing the northern corner of the school grounds at Yorktown and Bunker Hill Roads. For the purpose of this study, the contact between the serpentinite and graywacke can be considered to lie mostly outside of the site, with only very small area is crossed by it at the extreme south and northwest corners, as shown on Figure No. 2. It is notable that this bedrock distribution on the site generally conforms to compilations showing the regional bedrock distribution by Brabb and Pompeyan (1972).

No clearly defined continuous bedrock structure exists at the subject site, which is characteristic of the Franciscan Formation. Approximate bedding attitudes obtained throughout the site indicate a variable but generally NW-SE strike, along the axis of the ridge, with variable dips.

Slopes directly below the water storage tanks contain deep erosional gullies with vertical banks up to twenty feet deep. The material which comprises the gully walls is, in most cases, a talus deposit of variable depth deposited on highly fractured sandstone. Deep in the section the material is essentially a framework of angular sandstone fragments, fairly uniform in size with little or no matrix material. Notably, even at a depth of 20 feet much of this material is easily broken up by hand. Most of the talus has probably been shed from surrounding topographic high areas. This talus area is confined in the proposed open space area.

As discussed above, the site geology is rather complex and variable across the entire site of Highland Estates. In addition to the overall geology of the site, our investigation focused on evaluation of specific geologic features pertinent to each location of the proposed development, and these are discussed below:

Area of Lots 1 through 4

This area is underlain by relatively hard graywacke sandstone, and the descending slope toward the creek below is rather steep, probably close to 1-1/2:1. The bedrock is locally exposed at the top by cuts made in the past for construction of Bunkerhill Road. No slope instability features are present. The surface soil cover is less than 2 feet, and consists of sandy clay of low plasticity.

Area of Lots 5 and 6 and the Access Road

This area is mostly underlain by light to medium brown, fine to medium grained sandstone and in a stable condition. These sandstones are extensively exposed on the high cut slopes along the existing service road to the water tanks. The surface soil cover is expected to vary from 2 feet or so on the ridge top to 5 feet or less in the lower elevations. No special instability problems exist in this area.

Area of Lots 7 through 19

Lots 7 through 18 are single-family lots, and are located in the upper elevations adjoining the existing residential area, and Lot 19, which is proposed for a townhome development, encompasses a 12-acre portion over the lower elevation below Lots 7 through 18.

This area is crossed by a rather broad drainage valley above the existing apartment complexes on Polhemus Drive. This drainage divides into two branches in the upper elevation, one extending through Lot 8 and the other extending through the area including Lots 11 through 14. This drainage area is expected to be underlain by alluvium deposits to various depth. Due to the lack of access to this area by drilling equipment, no borings were performed and the thickness and characteristics of the alluvium deposits could not be evaluated in sufficient detail at this time. However, judging from the changes in elevation relief along the drainage and rock outcrops present in and around the drainage area, the alluvium deposits are expected to range in thickness from several feet in the upper elevations to more than ten feet in the lower elevations, particularly behind the existing apartment complexes on Polhemus Drive.

Large sandstone boulders of more than 6 feet in diameter are abundantly present on the slope along the boundary with the residential area above the proposed extension of Cowpens Place. These boulders probably came from the grading work for the adjoining residential area in the past. Also, there are several, massive and hard sandstone outcrops present in the higher elevations. Outcrops of notable sizes are shown on the geologic map, Figure No. 2.

The upper elevations of this area is underlain by graywacke sandstone, and the lower half is underlain mostly by more extensively weathered and softer sandstone and highly sheared shale.

No existing landslides are present in this area. In a previous investigation, a prehistorical landslide was postulated by United Soil Engineering, Inc. to exist on the ridge slope to the south of the drainage area. However, a subsequent investigation by Berlogar, Long & Associates failed to find evidence to support this landslide postulation. Our test boring, B-3, located in this landslide area revealed approximately 7 feet of extensively weathered and soft shale and siltstone underlain by highly fractured and hard sandstone. This area is also crossed by a man-made dirt road, which gives a rise to a disrupted appearance resembling that of a landslide on a topographic map.

C) Potential Geologic and Geotechnical Hazards

The proposed development is constrained by a variety of potential geologic and geotechnical hazards. These hazards are identified and discussed below for each of the proposed development areas.

a) Lots 1 through 4:

This area is underlain by massive sandstone, and the natural slopes are in a stable condition. Other than the possible difficulty with the foundation pier drilling or footing excavations into the rock mass, no significant potential hazards are present for this area.

b) Lots 5 and 6:

This area situates on a broad ridge-top underlain by sandstone bedrock. No existing instability features are present in this area. It is possible to perform a fair amount of grading on these lots and shallow footings could be used. No significant slope instability hazards are anticipated with the construction of the proposed access road to these lots. However, there is a significant potential for surface erosion and rockfalls on the high cut slopes along the access road.

c) Lots 7 through 14 and Cowpens Place Extension:

This area will require grading for construction of the proposed extension of Cowpens Place. No mass grading is contemplated on lots in this area. The natural slope above the proposed extension of Cowpens Place will serve as a watershed collecting runoff to the new cut slopes along the roadway. Also, there are scattered boulders of various sizes sitting loosely on the natural slope. Therefore, the rockfall and erosion potential is high in this area. The proposed cut slopes are likely to expose the highly fractured and relatively unstable sandstone bedrock in the upper 10 feet or so. The rapid weathering of this sandstone, when exposed by the cut slopes, can be a potential cause for slope instability and rockfalls.

d) Lots 15 through 18 and Townhome Area (Lot 19):

Extensive grading is proposed in this area. Major filling is proposed over much of the drainage area below Lots 8 through 12 and over the area extending from the lower elevations in the southeast corner of the site to Lots 15 through 18. Cuts are proposed above and in between these fill areas.

The anticipated fill thickness is generally 30 to 40 feet, and locally reaches up to 55 feet. Cuts are mostly in the range of 15 to 20 feet in depth, and locally become as deep as 30 feet. Retaining walls are proposed at various locations, mostly along the roadways. Walls in the interior of the project are generally less than 10 feet in height, but locally become approximately 20 feet high. These interior walls will support both cut and fill slopes. High retaining walls, ranging up to 35 feet in height, are proposed along the periphery of the project on the Tigonderoga Drive side in the southeast corner. These retaining walls will support fill slopes. Also, retaining walls will be extensively utilized within the proposed buildings to accommodate the differences in the pad elevations.

The grading scheme discussed above presents special concerns on several items which are discussed below.

The global stability of the major slopes supported by retaining walls depends critically on both the integrity of the slope itself and performance of the retaining wall. Therefore, special attention will be required for selection of the retaining wall types and construction that are most suitable for and compatible with the local topographic and geotechnical conditions.

The proposed massive fills will experience differential settlements, partially due to compression of the ground beneath the fill, particularly in the alluvium filled drainage area, and partially due to compression of the fill itself. Differential settlements of the fills from these sources can adversely affect the foundations, unless properly controlled. The expansion characteristics of the native soils are favorable and should not be a critical factor for determination of the foundations.

High cut slopes are expected to expose highly fractured sandstone bedrock. Further weathering of these rocks could generate rockfalls. Also, the presence of a mixture of scattered boulders, loose rocks and soils in the upper 10 feet of the sandstone area, combined with the presence of the highly fractured sandstones beneath, is expected to adversely affect the local stability of the high cut slopes.

Surface erosion potential is very significant in this area, as much of the area will be involved in constructed slopes and will receive runoff from areas at higher elevations.

D) Hazard Mitigation Options

As discussed above, the proposed development as outlined in the present Tentative Map is constrained by a variety of hazards as related to geologic and geotechnical occurrences, especially in the proposed Townhome Development area. However, many of these hazards can be mitigated to lower levels of risk. These hazard mitigation measures are discussed below.

a) Mitigation of Rock Fall Hazard

Rocks on the site that are susceptible to fall or downhill movements include the large boulders sitting loosely on the slope above the proposed Cowpens Place extension, in-place boulders and isolated rocks loosely mixed in the upper 10 feet of the natural slopes in the proposed high cut slopes, and the fractured sandstone bedrock expected to be exposed on high cut slopes.

The rockfall hazard can be practically eliminated by removing the loose surface boulders and overexcavating the cut slopes containing loosely embedded rocks or boulders and the highly fractured sandstone bedrock. Careful scrunity will be required over the natural slopes above the proposed development limits to locate boulders loosely sitting on the slopes. Large size boulders may be incorporated in the lower portion of deep fills.

Heavy-duty chain-link fences can be an effective measure to deal with the rockfall problems locally.

b) Mitigation of Fill Settlement Problems

Deep fills placed on sloping ground will differentially settle and this can adversely affect the foundations and underground pipelines. This concern exists in the proposed Townhome Development area. The most practical means of mitigating this settlement problem is a delayed construction. Delayed construction allows some of the settlement to have taken place before the foundation construction begins. The necessary delay periods for the construction can be reliably determined when more complete subsurface information becomes available from the proposed supplemental investigation at a later date.

Settlement of deep fills can be reduced by proper preparation of the ground on which the fill is to be placed and proper placement of the fill. We will develop complete earthwork specifications to attain this end upon completion of the final grading plan.

With the measures discussed above, the potential hazards of deep fill settlement can be adequately mitigated.

c) Retaining Walls and Constructed Slopes

The proposed tentative grading scheme contemplates using retaining walls to support both fill and cut slopes in the townhome development area. Therefore, the overall stability of the slope being supported by retaining walls depends critically on the performance characteristics of both the retaining walls and the slope itself, and thus selection of a proper type of the wall construction becomes of utmost importance.

A variety of wall types and construction techniques are available today that would be suitable for the subject project. Typically these include cantilever walls of conventional construction, gravity element walls (such as interlocking cribs), tie-back walls using anchors or deadmans, and reinforced soil walls.

High retaining walls are proposed to support fill slopes along Ticonderoga Drive and the southeast corner perimeter. Wall heights reach up to 35 feet. For walls of this height, cantilever walls of conventional construction would be impractical from the cost standpoint. More practical wall construction for this area would be either gravity element walls, such as "Evergreen" retaining walls of Geo Concrete Systems, Inc. and "Criblock" walls of Retaining Walls Company, or reinforced soil walls, notably "Reinforced Earth" retaining walls of the Reinforced Earth Company, as an example. Deformability should be an important consideration in the final selection of the wall, because large deformations of the wall can be detrimental to the fill slopes and the road being directly supported by the wall.

Interior retaining walls to support fills or fill slopes are generally less than 10 feet in height. These walls in the northeast corner section of the townhome area will be located close to the buildings. This situation will require a tighter control of the wall deformation or movements. Cantilever walls combined with tiebacks or reinforced soil walls would be more suitable and appropriate for this area.

Retaining walls are proposed to support up-hill cut slopes in the upper elevations of the townhome area. These walls are also generally less than 10 feet in height, but become as high as 15 to 20 feet for a short distance at one location. These cut slopes, where they require retaining walls, are expected to expose mostly the graywacke sandstone. It is our opinion that cantilever walls of conventional construction or combined with anchored tie-backs and gravity element walls would be most suitable for support of these cut slopes.

The proposed retaining walls inside of the buildings are expected to be generally less than 10 feet in height and to be an integral part of the building. Cantilever walls of conventional construction, or combined with tiebacks, will provide the necessary performance characteristics.

Placement of fills or construction of fill slopes over the natural slopes will require keying the fill section deep into the bedrock or stable material to attain stable foundations for support of the fills. This is a typical practice with construction of fill slopes on sloping ground. In the drainage area through the central portion of the townhome area, underdrains would be required to stabilize the fill foundation.

Cut slopes will require overexcavation to improve stability and to reduce the rockfall potential over much of the proposed cut slope area.

d) <u>Seismic Considerations</u>

Liquefaction and seismically induced ground settlement problems are not significant within the site. Also, the hazards of ground displacements associated with direct faulting are not significant as the site is not crossed by any known active faults.

Seismic effects at the site are mostly related to strong ground shaking. Seismic motions imparted to structures, constructed slopes and retaining walls at a site are influenced by the stiffness and type of the material underlying the site. The presence of the bedrock at shallow depths would render the site to respond favorably to seismic motions. More specific analysis will be undertaken to determine stability of constructed slopes and retaining walls under seismic loading as part of our final investigation in the future.

e) Foundation Stability

As discussed earlier, it is necessary to consider the effect of differential settlements of deep fills on sloping ground to ensure stable performance of the foundations.

The locally variable subsurface conditions will require consideration of the specific local subsurface conditions at each location in determining the foundation design. We anticipate that the foundations will range from shallow strip footings of conventional construction to deep piers connected by tie beams or grade beams, depending on the topographic and geotechnical conditions at the specific locations. Determination of the specific foundation conditions and design recommendations will be included in the final geotechnical investigation report.

f) Erosion Control

The most important undertaking for erosion control, and also for stability of slopes and foundations, is proper control of the surface drainage. This will require providing lined gutters on either side of new roads, concrete V-ditches on slope benches and along top of constructed slopes, sloping the ground away from the slopes and buildings where possible, connecting roof drains into storm drain facilities, and grading the site to attain the most desirable drainage pattern to minimize the adverse affect of the surface runoff.

Also, the constructed slopes should be provided with suitable planting to reduce the erosion damage.

RECOMMENDATIONS

Our subsurface explorations to date were limited due to various constraints including the inaccessibility of much of the site to the heavy drilling equipment and the restriction by the County of San Mateo for destroying the vegetation. The variable subsurface conditions so far disclosed by our explorations and by previous investigations done by others require a supplemental subsurface exploration over the area proposed for the Townhome Development.

The supplemental subsurface exploration requires access roads through the steep sections of the area to mobilize heavy equipment. We recommend that this supplemental investigation be scheduled for completion prior to commencing development of the construction plans that are related to geotechnical engineering aspects.

Various alternate grading schemes for the townhome area were studied in great detail by the project design team, including the Architect, Civil Engineer and Geotechnical Engineer. The proposed tentative grading scheme discussed in this report represents one that is most practical from geotechnical engineering considerations among the alternate schemes studied. However, it is quite possible that our final analysis of the subsurface conditions through the supplemental investigation may recommend further modifications to the tentative grading scheme presently chosen.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

This evaluation, consisting of professional opinions and recommendations, has been made in accordance with generally accepted principles and practices in the field of engineering geology and geotechnical engineering. This acknowledgement is in lieu of all warranties either express or implied.

It is noted that a supplemental geotechnical investigation will be required to obtain sufficient amount of the subsurface data for development of specific geotechnical recommendations that may be used in the development and design of the final construction plans.

In the event that the proposed construction scheme or plan will significantly differ from the preliminary plan cited above, our conclusions and recommendations presented in this report may become invalidated, partially or wholly.

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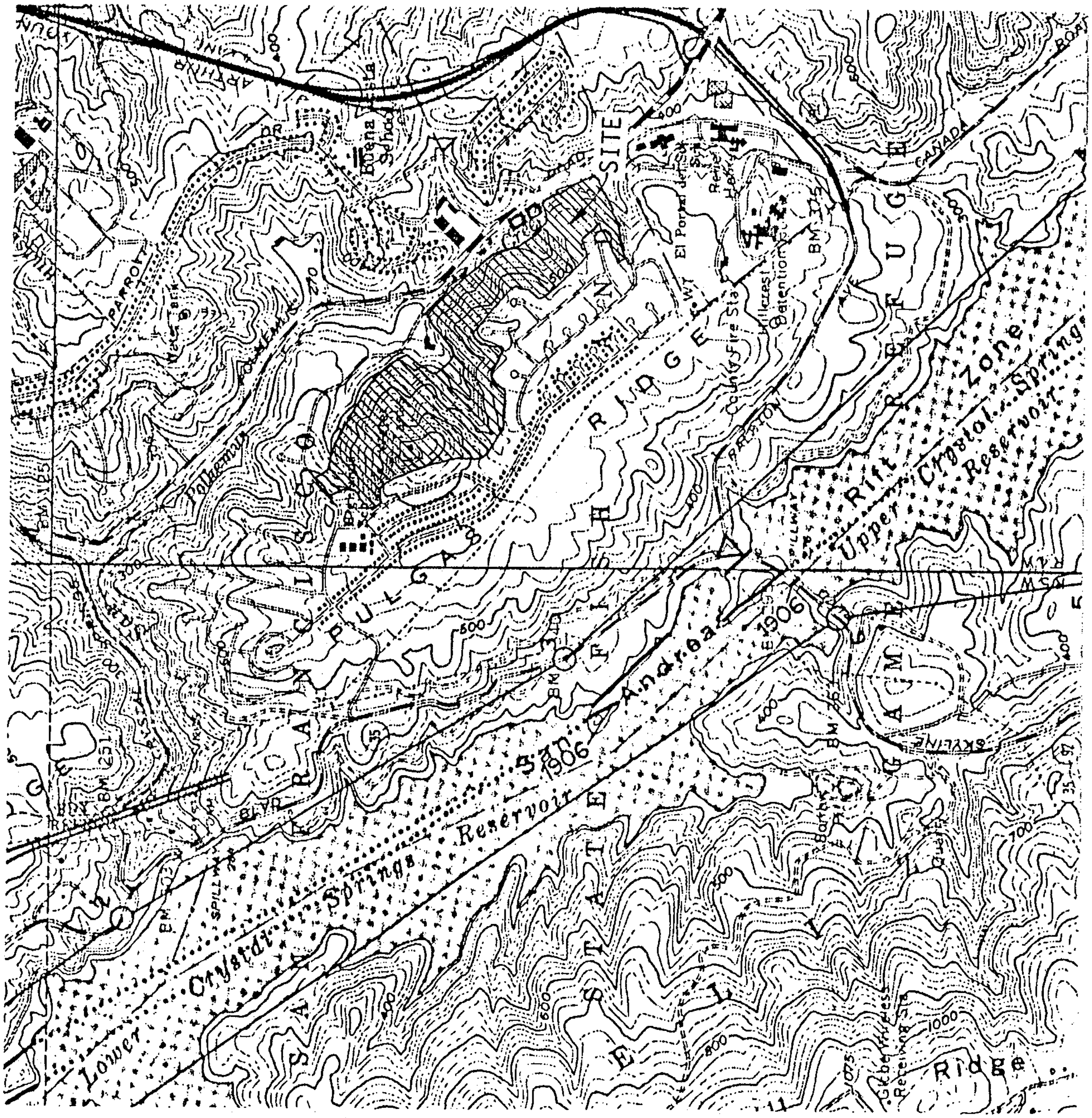
APPENDIX A



Source of Map: California State Division of Mines & Geology
Special Studies Zones Map

Sacle: 1:24,000

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Figure No. 1 - Site Location Map

Figure No. 2 - Geologic Map (placed in envelope at end of report).

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EXPLORATORY BORING LOG						LABORATORY TESTS								
Sample Number	Depth, feet	Boring Log	Unified Soil Classification System Symbols	Description	Standard Penetration Test, blows/foot	Moisture Content, %	Dry Density, p. c. f.	Unconfined Compressive Strength, k. s. f.	Direct Shear Test "C", k. s. f.	Direct Shear Test "φ", degrees	Liquid Limit, %	Plasticity Index, %		
				Hole B-1		Date of Drilling: 4/3/90								
	2		CL - ML	FILL: Mixture of silty to sandy Clay and rock fragments, failry stiff										
1-1	4			(moist and soft at base)	24*	39.8	73.8							
1-2	6			Colluvium - mixture of clayey sand and rock fragments and boulders, fairly dense	40*/5"	11.4	103.8		0.3	15				
	8													
	10													
	12			(sandstone/serpentine)		9.9								
1-3				Medium to dark gray rock	30*/4"		121.8	7.2 @ 6.2% strain						
				Bottom at 13 feet										
				Hole B-2		Date of Drilling: 4/3/90								
			CL	Sandy Clay w/Rock fragments										
	2													
	4			Sandstone, very hard refusal to drilling										
				Bottom at 5 feet										

Figure No. 3 - Logs of Test Borings

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EXPLORATORY BORING LOG						LABORATORY TESTS								
Sample Number	Depth, feet	Boring Log	Unified Soil Classification System Symbols	Description	Standard Penetration Test, blows/foot	Moisture Content, %	Dry Density, p. c. f.	Unconfined Compressive Strength, k. s. f.	Direct Shear Test "C", k. s. f.	Direct Shear Test "ϕ", degrees	Liquid Limit, %	Plasticity Index, %	Compaction Test	
				Hole B-3		Date of Drilling: 4/3/90								
3-A	2		ML	Dark brown clayey Silt, fairly stiff					(2.0	8)	32	10	x	
3-1	4			Light gray Shale, highly sheared, silty, interbedded w/sandstone	35*	14.0	113.1		0.8	14				
	6													
	8													
3-2	10			Medium brown Sandsonte, highly fractures, hard										
3-B	12												X	
	14													
3-3														
				Bottom at 15 feet										

Notes: • * penetration resistance for $2\frac{1}{2}$" I.D. split-tube sampler.
• Numbers in ( ) are for recompacted samples.

Figure No. 4 - Log of Test Boring

SOIL FOUNDATION SYSTEMS, INC.

File No. S20-634-1
September 17, 1990

EXPLORATORY BORING LOG						LABORATORY TESTS								
Sample Number	Depth, feet	Boring Log	Unified Soil Classification System Symbols	Description	Standard Penetration Test, blows/foot	Moisture Content, %	Dry Density, p. c. f.	Unconfined Compressive Strength, k. s. f.	Direct Shear Test "C", k. s. f.	Direct Shear Test "ϕ", degrees	Liquid Limit, %	Plasticity Index, %		
				Hole B-4		Date of Drilling: 4/6/90								
	2		CL	FILL: Mixture of sandy Clay and rock fragments (serpentine), stiff										
	4													
4-1	6		-		29*	13.5	117.3	2.4 @ 3.2% strain						
	8		ML											
4-2	10				84*	9.8	126.7							
	12													
	14					18.3	112.0							
4-3	16			Black to dark brown silty Clay with fine rock frgments, scattered tree roots	21*	14.5	114.3		0.5	20				
	18		CH											
	20					22.9	103.6							
4-4				becoming sandy and rocky	44*	19.9	109.9		0.5	14				
	22													
	24			Dark gray Serpentine, hard										
	26													
	28													
				Bottom at 30 feet										

Note: * penetration resistnace of 2½-inch I.D. split-tube sampler

Figure No. 5 - Log of Test Boring

SOIL FOUNDATION SYSTEMS, INC.

File No
Septemb

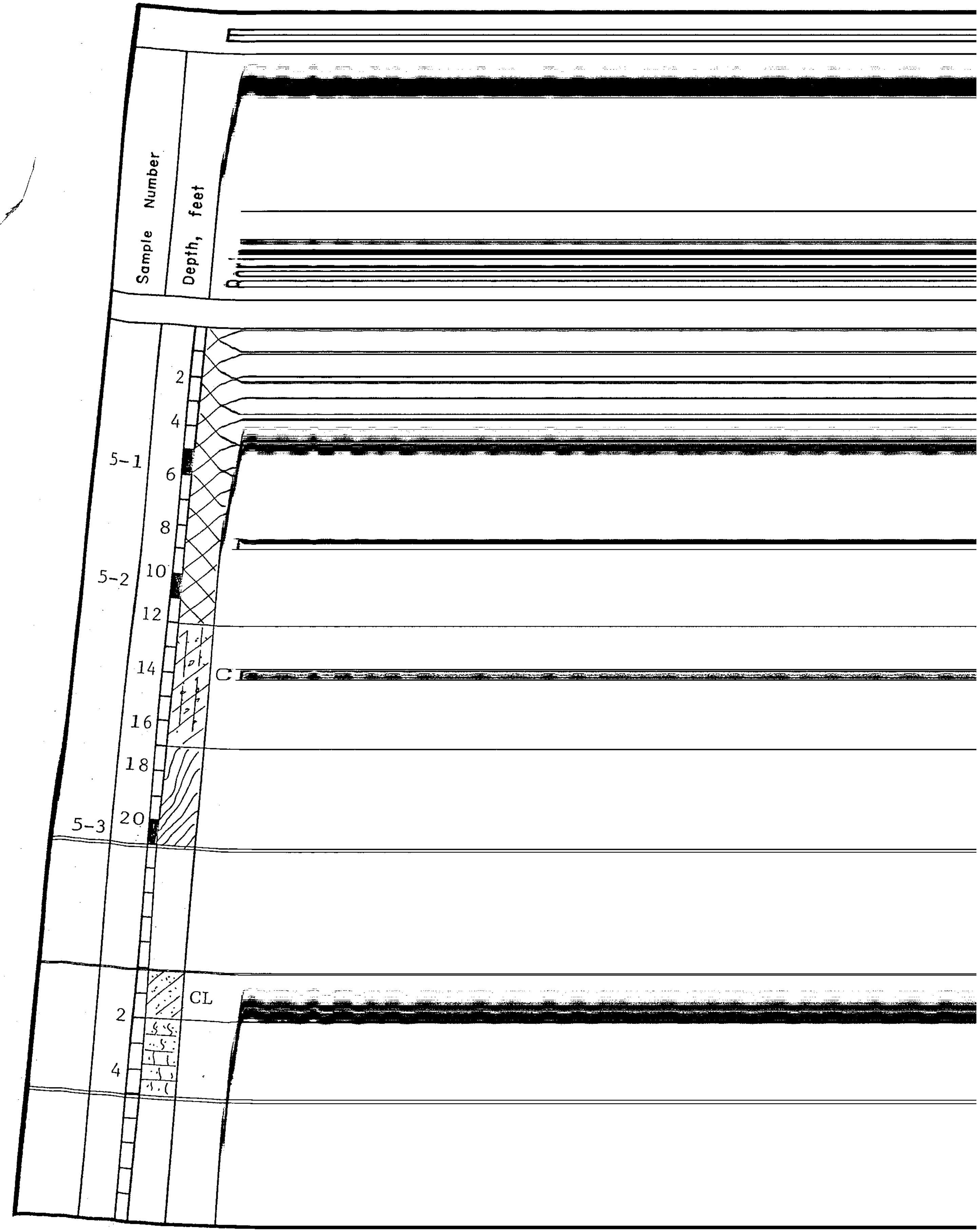
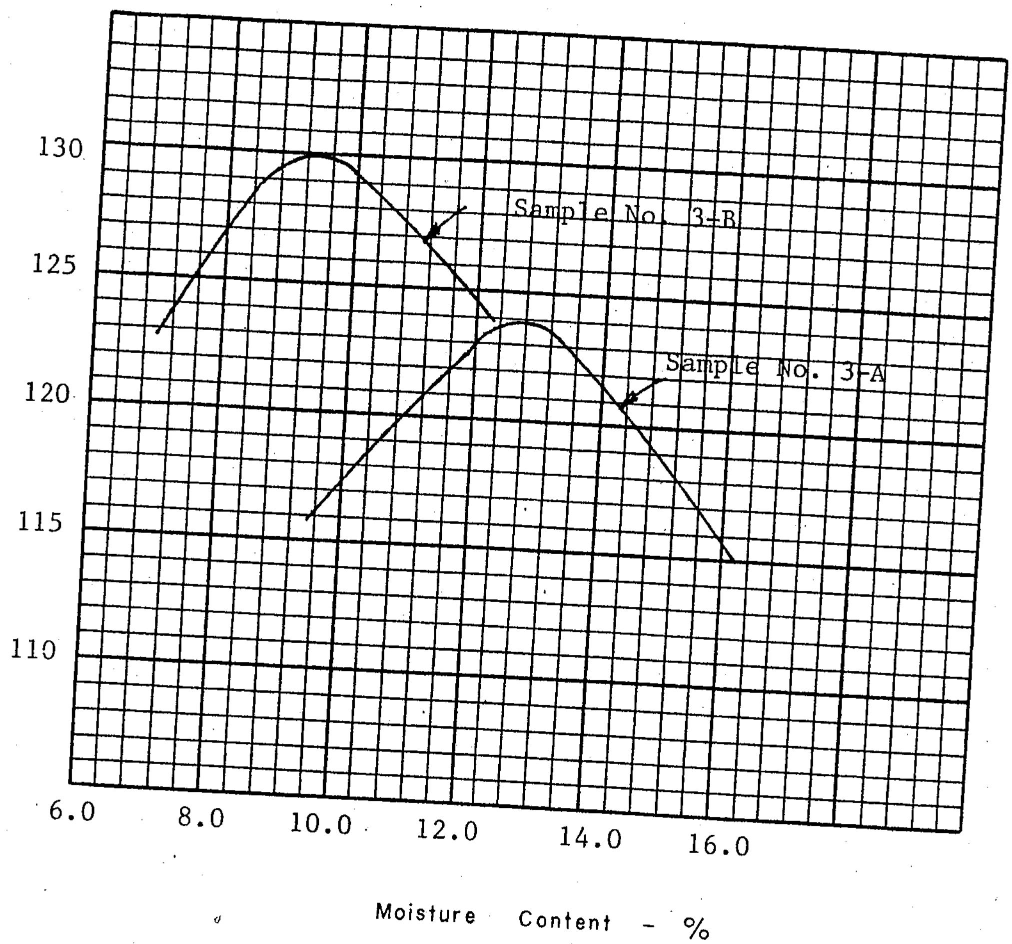


Figure No. 6 - L

EXPLORATORY BORING LOG						LABORATORY TESTS								
Sample Number	Depth, feet	Boring Log	Unified Soil Classification System Symbols	Description	Standard Penetration Test, blows/foot	Moisture Content, %	Dry Density, p. c. f.	Unconfined Compressive Strength, k. s. f.	Direct Shear Test "C", k. s. f.	Direct Shear Test "ϕ", degrees	Liquid Limit, %	Plasticity Index, %		
				Hole B-5		Date of Drilling : 4/6/90								
	2			FILL: Mixture of light to dark brown silty clay,										
	4		CL	sandy Clay and Serpentine rock fragments, stiff										
5-1	6		-		20*	16.5	102.5							
	8		ML											
5-2	10				51*	16.6	115.0		1.4	0				
	12													
	14		CL	Black to dark brown silty Clay with rock fragments, stiff, moist										
	16													
	18			Medium to dark gray Serpentine rock, hard		11.2	120.2							
5-3	20			(highly expansive)	45*	10.1	131.8		0.5	14				
				Bottom at 21 feet										
				Hole B-6		Date of Drilling : 4/6/90								
			CL	Brown sandy Clay										
	2			Massive Sandstone, very hard										
	4			(refusal to drilling)										
				Bottom at 5 feet										

LABORATORY COMPACTION TESTS



Sample Number	3-A	3-B	
Description	Med. brown clayey Silt w/rock fragments	Med. brown Sandstone	
Test Procedure	ASTM D1557-85	ASTM D1557-85	
Max. Dry Density, p. c. f.	124.0	130.0	
Opt. Moisture Content, %	12.5	9.5	

Figure No. 7 - Results of Compaction Tests

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September 17, 1990

TABLE I

RESULTS OF SOIL TESTS

(not reported on Figures No. 3 through 7)

Sample No.	Location	Description	Compaction Test: Max. Dry Density p.c.f.	Compaction Test: Opt. M/C %	Atterberg Limits: L.L. %	Atterberg Limits: P.I. %
1	Ridge below Woodcreek Ct.	Sandy Silt and rock fragments	120.0	13.5	28	5
2	Ridge above Apartments	Sandy to clayey to sandy Silt	119.0	14.0	31	7
3	Ridge top by upper water tank	Lt. brown sandy Clay	114.0	14.5	32	8
4	N.E. ridge at upper tank	sandy Silt	113.0	13.5	29	5
5	Gulley below water tank	Lt. brown silty	125.0	12.0	-	-
6	Ticonderoga	Mix of sheared shale and sandstone	135.0	9.0	30	10
7	Ticonderoga	same as No. 6	125.0	11.0	29	9

Sample No.	Direct Shear Test: Cohesion p.s.f.	Direct Shear Test: Friction Angle degrees	Notes
1	320	33	recompacted sample
2	500	24	recompacted sample
3	450	33	recompacted sample
4	750	31	recompacted sample
5	-	-	
6	330	24	recompacted sample
7	450	30	recompacted sample
8	330	19	core sample from gulley below water tank, Lt. brown sandy Siltstone
9	500	37	core sample, same location; silty Sandstone
10	450	33	core sample, same location; silty Sandstone