G407

Geotechnical Report

# INTERIM REPORT
# SOILS INVESTIGATION

230 KV
San Onofre - Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company

Project No. 71-12-22A
February 9, 1972

BENTON ENGINEERING, INC.

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# INTERIM REPORT
# SOILS INVESTIGATION

## Introduction

This is to present the results of a soils investigation conducted at certain tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California.

The objectives of the investigation were to determine the existing subsurface conditions and physical properties of the subsoils so that representative soil parameters could be recommended for the design of the proposed tower foundation. Also, the findings and log of soil conditions are to serve as a guide in determining the best probable type foundation to be used. It is understood that the preferable foundation is the drilled, cast-in-place belled pier type. The second alternative is the drilled, grouted in-place rock anchor type where the rock formations are suitable for such installations. The third alternative is the spread footing type, where conditions such as large boulders, preclude the use of the other foundation types. Also, at two tower sites, located in river bottom areas, where ground water may rise, driven pile design curves are to be presented. These designs are not included in this Interim Report.

In addition to the findings transmitted in this report, geological descriptions are being prepared for a number of additional tower sites inaccessible to the drill rig at this time for one reason or another. Also refraction seismograph lines are to be run at every tower site where single large diameter pier footings are being considered and at other selected locations. The supplemental geological descriptions and velocities of the hammer induced shock waves will be presented in a final report to be prepared at a later date.

In order to accomplish the objectives of this interim report, twenty-four borings were drilled at the tower sites as authorized, undisturbed samples were obtained, where possible, and laboratory tests were performed on these samples.

## Field Investigation

Twenty-four borings were drilled with a truck-mounted rotary bucket-type drill rig. The locations of the borings, relative to the staked centerline of the various tower locations, are described individually on Drawing Nos. 1 to 34, inclusive, each entitled "Summary Sheet." The borings were drilled to depths of 3.5 to 40.0 feet below the existing ground surface. A continuous log of the soils encountered in the borings was recorded at the time of drilling and is also shown in detail on the Summary Sheets.

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density and moisture content. The results of these tests are presented on Drawing Nos. 1 to 34, inclusive. Direct shear tests were performed on representative samples in order to determine the angle of internal friction and apparent cohesion of the soils. The samples were allowed to saturate and drain prior to being tested. The exceptions are the samples from Boring 245 which were tested both under field moisture condition, and saturated and drained conditions. Subsequent tests, before the final report is prepared may be conducted on saturated samples, with the normal loads reduced due to the bouyant effect of a higher ground water level if this is determined to be a likelihood, at sometime in the future. These variations in tests are conducted to stimulate various conditions of water fluctuations in the river bottom areas which directly effect the shearing resistances of the soils in contact with driven piles. The general procedures used for the laboratory tests are described briefly in Appendix B. The results of these tests are presented in the "Table of Shear Test Results" which are presented on pages 12 to 15, inclusive.

## DISCUSSION AND RECOMMENDATIONS

### 1. Soil Strata

Brief descriptions of the subsurface conditions pertaining to each tower are presented below: (Numbering systems for both boring and tower are the same.)

#### Tower No. 1

A total of three holes were drilled at this location. The first hole was located 5 feet west of the tower centerline. This was stopped at 14.2 feet on a boulder (12"+ diameter). The second hole was moved 5 feet to the south from Hole 1 and penetrated to 19.5 feet. A third hole was drilled 5 feet south of the second hole and again penetrated to 19.5 feet. A ripper bar was used for 30 minutes at this depth and no greater penetration was achieved so drilling was stopped at this location.

A composite log of the soils at the three holes is as follows: Medium loose silty sand was underlain at 3.8 feet by a medium firm sandy clay to 7.0 feet. A compact very fine to fine slightly silty sand with medium to coarse grains of weathered gneiss was encountered between depths of 7.0 and 19.5 feet, the depth of exploration. Lenses of fine to medium sand saturated with perched water was encountered between 7.0 feet to 8.0 feet. Boulders to 12 inches in diameter were encountered at a depth of 14.35 feet.

Perched water was encountered at 7 to 8 feet and rose to 3 feet in approximately 1 1/2 hours.

Tower No. 6

A total of three holes were drilled at this location. The first hole was drilled 5 feet west of the tower centerline. The second hole was 10 feet south of the first hole and the third hole 20 feet west of the second. All holes were terminated at 7.0 feet where no further penetration was achieved. The soil conditions at all three locations is described as loose porous silty very fine to fine sand containing rootlets to a depth of 2.0 feet and firm silty clay with some very fine sand and rootlets was found between 2.0 and 3.0 feet. This was underlain by compact to very compact silty sand to 7.0 feet, the depth of exploration. The soils below 4.8 feet were the residual material of weathered gneiss. It was estimated that boulders to 48 inches in diameter exist below the depths of exploration.

No ground water was encountered at these locations. No saturated-drained tests were performed because of the lack of undisturbed samples. However, it is recommended that the data obtained from Tower No. 1 be used because of the similarity of materials encountered in the two locations.

Tower No. 11

Loose, porous very fine to fine sand with some rootlets was underlain at a depth of 2.5 feet by a firm sandy clay to a depth of 3.5 feet. Very compact slightly silty very fine to fine sand with some medium to coarse grains was encountered between depths of 3.5 and 10.0 feet, the end of the hole. The silty sand is a residual material of weathered quartz diorite.

No ground water was encountered in this hole.

### Tower No. 20

A 3.5 feet thickness of soft silty clay with occasional rootlets and very fine to fine sand was underlain by a compact silty sand to the depth of 6.5 feet and then merged to a very compact slightly silty very fine to fine sand with occasional medium grains to the limit of the exploration at 24.6 feet.

No ground water was encountered.

### Tower No. 22

Loose porous silty very fine to fine sand with rootlets and occasional medium to coarse grains was underlain at a depth of 1.3 feet by a porous very firm silty clay with occasional very fine to fine sand with rootlets to a depth of 3.0 feet. Below this depth was a very compact silty very fine sand to the bottom of the hole at 20 feet. A ripper bar was used to penetrate below 13.0 feet and the rate of drilling with the bucket auger was approximately 2 feet per hour to the depth of exploration. The silty sand was a residual soil of weathered quartz diorite and became more resistant to penetration with depth. Occasional fine to medium grains of weathered rock was encountered at the depth of 8.3 feet.

No ground water was encountered in this boring.

### Tower No. 33

The soils consisted primarily of the silty sand of granitic origin. The upper 1.5 feet was loose, very fine to fine grained and porous with rootlets and cobbles up to 12 inches in diameter. This merged to very compact below 4.0 feet to the limit of exploration at 11.5 feet where slow progress was being made with the gad and ripper bar.

No ground water was encountered in this hole.

### Tower No. 50

A soft, porous silty very fine to medium sand with rootlets was underlain at a depth of 1.0 foot by a compact to very compact slightly clayey very fine to coarse sand to a depth of

5.0 feet. This layer was the residual soil of weathered granodiorite. Below 5.0 feet, the soils graded to a very firm silty very fine to medium sand to the end of the hole at 6.5 feet where slow progress was being made with a gad and ripper bar.

No ground water was encountered. Attempts were made to prepare testing specimens from this hole but failed because of the rocky nature of the samples.

### Tower No. 52

The soils encountered in the boring consisted primarily of slightly clayey very fine to coarse sand derived from weathered quartz diorite. The upper 1.0 foot of the soils were loose to medium firm and merged to firm below 1.7 feet and very firm from 4.0 feet to 12.0 feet where the hole was terminated due to slow progress using the ripper bar.

No ground water was encountered.

### Tower No. 56

The soils encountered in the hole were essentially of silty sand of granitic origin with varying contents of silt in alternating sequences. The upper 1.8 feet was loose, porous, and very fine to fine grained with some rootlets. This soil merged to a coarser and compact to very compact weathered quartz diorite below that depth to the end of the hole at 20 feet where no progress was being made with the ripper bar.

No ground water was encountered in this hole.

### Tower No. 60

The soils encountered in this boring consisted primarily of slightly clayey very fine to medium sand derived from weathered quartz diorite. The upper 3.5 feet was loose, porous, and micaceous with some rootlets and became firm, compact to very compact, at the depths of 3.5 feet, 5.7 feet and 7.0 feet, respectively. The weathered quartz diorite became increasingly more indurated to 9.5 feet then stayed relatively uniform to the depth of exploration at 25.5 feet.

No ground water was encountered.

Tower No. 67

The soils encountered in this hole consisted primarily of silty very fine to coarse sand which was medium firm for the upper 3.7 feet, and graded to firm to very firm at 3.7 feet, and very firm below 8.0 feet to the end of the hole at 12.5 feet where slow progress was being made using the ripper bar. The gad was used intermittently to penetrate last 0.5 foot.

No ground water was encountered.

Tower No. 82

The soils consisted primarily of medium firm gravelly silty clay with approximately 25 to 30 percent of gravel, cobbles and boulders to 30 inches. Because of the rocky nature of the materials encountered, the hole was terminated at 4.0 feet. It is unlikely any type of auger drill rig could penetrate this type of formation that includes large boulders in a silty clay matrix.

No samples were taken from this hole.

Tower No. 101

A medium loose silty very fine to fine sand with a few coarse grains and rootlets was underlain at 3.5 feet by a highly weathered quartz diorite, medium firm in consistency between 3.5 feet and 4.5 feet, and then merged to very firm to the end of the hole at 6.0 feet where no progress with the gad was being achieved.

Some water seepage was encountered in this hole at 4.5 feet.

Tower No. 109

A medium loose and porous silty very fine to fine sand with a few medium grains and rootlets was encountered to the depth of 5.7 feet. This contained approximately 20 percent of cobbles to 12 inches and boulders estimated to be up to 36 inches in diameter. Between 5.7 and 7.0 feet, a firm clayey silt with organic material was encountered. This was underlain by a very compact silty very fine to fine sand with medium and coarse grains of granitic origin to the limit of exploration at 16.5 feet. In spite of some surface boulders at this site to 8 feet in diameter drilling could be accomplished, when boulders do not occur at the footing location.

No ground water was encountered.

Tower No. 115

A loose, porous silty very fine to fine sand with roots and rootlets was underlain by a weathered to highly weathered gneissic formation at a depth of 3.0 feet and to the limit of exploration at 8.5 feet. The gneissic formation is medium firm between 3.0 and 4.0 feet and then merged to firm below 4.0 feet, and firm to very firm below 6.5 feet. Drilling was terminated due to no progress using a gad. The contact between the colluvial soils and the gneiss slopes approximately 30 degrees downward in a northerly direction at this site.

No ground water was encountered.

Tower No. 133

A compact, porous clayey fine to medium sand with a few rootlets was underlain at 3.5 feet by a firm silty fine to medium sand with a slight clay binder to the depth of 6.0 feet. Below the depth of 6.0 feet, a very compact slightly silty fine to medium sand was encountered to the end of the hole at 20.0 feet.

No ground water was encountered.

Tower No. 136

A very firm and porous silty fine to medium sand was underlain at 3.5 feet by a very compact slightly silty fine to medium sand to the end of exploration at 20.0 feet.

No ground water was encountered in this hole.

Tower No. 159

A medium loose silty fine to medium sand with occasional coarse grains, rootlets and granitic fragments to 4 inches in diameter was encountered to the depth of 8.5 feet and merged to medium firm between 8.5 feet and 10.0 feet. Below 10 feet, the soils consisted primarily of decomposed granite with varying degrees of weathering and its residual products of silty fine to medium sand, to the end of the boring at 40.0 feet. Slickensided clay in fractures was found between 24.8 feet and 33.5 feet.

No ground water was encountered.

Tower No. 174

The upper 3.5 feet of soils consisted of a soft and very porous silty fine to medium sand with 10 to 20 percent of gravel up to 0.5 inch in diameter. It contained some rootlets and had a clay binder. This was underlain by a porous firm clayey fine to coarse sand with approximately 10 to 20 percent of gravel to 0.5 inch in diameter to a depth of 6.0 feet. Below this depth, the soils were combinations of silty fine to medium sand, clayey fine to medium sand and fine sandy silt to 12.0 feet. Below this was very compact highly weathered granitic bedrock that fractured into 40 to 50 percent gravel sized fragments with clayey fine sand and became less weathered with depth to 30 feet.

No ground water was encountered.

Tower No. 184

The soils encountered in this boring consisted primarily of very compact highly weathered bedrock that fractures into 20 to 40 percent gravel sized fragments with clayey fine to medium sand to 8.0 feet in depth. Between 8.0 and 25.0 feet, the limit of exploration, approximately 40 to 50 percent gravel sized rock fragments were removed by the bucket auger.

No ground water was encountered.

Tower No. 191

The upper 4.0 feet of soil consisted of fine to medium sandy clay with was soft to the depth of 2.5 feet and merged to firm from that depth to 4.0 feet. Below 4.0 feet, a very compact clayey fine to medium sand was encountered, which was a weathered metavolcanic bedrock to the limit of exploration at 25.0 feet.

No ground water was encountered during exploration.

Tower No. 230

A soft, porous gravelly clayey fine to medium sand with roots and about 25 percent gravel and cobbles to 4 inches was underlain by a medium firm to firm silty clay to a depth of 9.8 feet. Firm silty fine sand with a clay binder and about 5.0 percent shells was encountered between 9.8 and 13.0 feet. This layer contained lenses of black fine to medium sand. Below this layer was a 4.0 feet thickness of very firm clayey fine to medium sandy silt with fossils and lenses of silty fine sand underlain by a very firm silty fine sand with clay binder to the depth of 22.0 feet, and then merged to a very compact slightly silty fine to medium sand to the end of the hole at 25.0 feet.

No ground water was encountered.

Tower No. 233

A soft porous fine sandy silty clay was underlain at 1.0 foot by a firm silty clay with thin layers of white caliche and rootlets to the depth of 14.8 feet. A firm, fine sandy silt was found below that depth and was underlain by a firm fine sandy silty clay with caliche and veins of gypsum to the end of the hole at 30.0 feet.

No ground water was encountered.

Tower No. 245

A soft fine sandy silt and a loose silty fine to medium sand was underlain at 4.0 feet by a firm silty fine to medium sand with approximately 10 to 15 percent gravel to the depth of 8.0 feet. A compact and slightly silty fine to coarse sand was encountered between 8.0 feet and 18.0 feet. This layer contained approximately 25 percent gravel and cobbles to 8 inches in diameter. Below 18 feet, intermittent layers of fine to medium sand and gravelly fine to coarse sand of various thickness were found with different gravel contents to the end of the hole at 40.0 feet.

Ground water was encountered at the depth estimated to be 37.0 feet. Direct shear tests on samples from this hole were conducted under both field moisture and saturated and drained conditions. This is to stimulate various conditions of water fluctuations in the ground water conditions.

2. Soil Parameters

In plotting the direct shear test data, the peak values of all tested specimens were used. The test angle of internal friction and apparent cohesion values were determined from the average of the possible combinations of two or three tested peak values if the three tested specimens did not fall on the same resistance envelope. In some instances, where the direct shear test results were unusually high or quite inconsistent, the causes of variations were analyzed, and the recommended values for the angle of internal friction and cohesion presented in the "Table of Shear Test Results" have been reduced on the basis of the analyses and judgement to safe design values. The possible causes of the variations arose from the differences in the density, degree of induration and cementation, gravel contents, grain sizes and their distribution, type of rock minerals, the natural fracture planes in the samples, degrees of weathering and decomposition, stress history of soil deposition, field moisture contents and degree of disturbances during sampling. Some of these factors, but not all of them, have been used in the analyses to arrive conclusions for the recommended values. The "Table of Shear Test Results" are tabulated on the attached pages 12 to 15, inclusive, and the unit weights of the soils can be found from the Summary Sheets, Drawing Nos. 1 to 34, inclusive, at the end of this report.

Respectfully submitted,

BENTON ENGINEERING, INC.

By S-H. Shu
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SHS/PHB/ew

# TABLE OF SHEAR TEST RESULTS

| Tower No. | Sample No. | Depth in Feet | Soil Description | Shear Resistance in kips/sq ft. Under Normal Load of 0.5 | 1.0 | 2.0 (Kips per sq. ft.) | Apparent Cohesion (lb/sq. ft.) Tested | Recommended | Angle of Internal Friction (Degrees) Tested | Recommended |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 5.0 | Sandy clay, some gravel and sand | 0.85 | 1.45 | 1.98 | 910 | 910 | 28.0 | 28.0 |
|  | 3 | 10.0 | Slightly silty very fine to fine sand. Gneissic origin | 2.79 | 6.85 | - | 1300 | 1300 | 71.0 | 43.0 |
|  | 4 | 15.0 | Slightly silty very fine to fine sand. Gneissic origin | 0.90 | 2.23 | 2.70 | 1045 | 1045 | 37.5 | 37.5 |
| 11 | 2 | 4.5 | Slightly silty very fine sand. Granitic origin | 5.93 | 4.62 | 6.98 | 2250 | 2250 | 35.0 | 35.0 |
|  | 3 | 9.5 | Slightly silty very fine sand. Granitic origin | 1.40 | - | 4.87 | 930 | 930 | 66.5 | 43.0 |
| 20 | 2 | 5.0 | Very silty sand, very fine to fine grained. Porous | 0.40 | 0.43 | 0.89 | 275 | 275 | 17.0 | 17.0 |
|  | 3 | 10.0 | Slightly silty very fine to fine sand with medium sands | 1.77 | 3.81 | 5.18 | 1300 | 1300 | 54.0 | 43.0 |
|  | 4 | 14.5 | Slightly silty very fine to fine sand with medium sands | Beyond Machine Capacity |  |  | - | 1565 | - | 43.0 |
|  | 5 | 19.5 | Slightly silty very fine to fine sand with medium sands | 2.22 | - | 5.99 | 1010 | 1010 | 67.5 | 43.0 |
| 22 | 2 | 5.0 | Silty very fine sand of granitic origin | 0.52 | 1.98 | 1.73 | 120 | 120 | 39.0 | 39.0 |
| 33 | 1 | 4.5 | Silty very fine to fine sand of granitic origin | 0.60 | 2.34 | 2.10 | 150 | 150 | 44.5 | 43.0 |
|  | 2 | 9.0 | Silty very fine to fine sand of granitic origin | 3.96 | 5.99 | 3.72 | 2000 | 2000 | 53.0 | 43.0 |
| 50 | 2 | 4.5 | Slightly clayey very fine to fine sand. Granitic | Too Rocky to Test |  |  | - | - | - | - |
| 52 | 2 | 5.5 | Slightly clayey very fine to fine sand with coarse grains | 3.34 | - | 7.14 | 2100 | 2100 | 68.5 | 43.0 |

# TABLE OF SHEAR TEST RESULTS

| Tower No. | Sample No. | Depth in Feet | Soil Description | Shear Resistance in kips/sq ft. Under Normal Load of 0.5 (Kips per sq. ft.) | 1.0 | 2.0 | Apparent Cohesion (lb/sq. ft.) Tested | Recommended | Angle of Internal Friction (Degrees) Tested | Recommended |
|---|---|---|---|---|---|---|---|---|---|---|
| 56 | 2 | 5.0 | Silty very fine to medium sand with coarse grains | 0.59 | 1.72 | 1.97 | 150 | 150 | 42.5 | 42.5 |
|  | 3 | 10.0 | Silty very fine to medium sand with coarse grains | 2.60 | - | 7.50 | 1200 | 1200 | 72.0 | 43.0 |
|  | 4 | 15.0 | Slightly silty very fine to medium sand | 1.63 | 3.35 | 7.50 | 1200 | 1200 | 72.0 | 43.0 |
| 60 | 2 | 6.0 | Slightly clayey very fine to fine sand. Silty and micaceous | 0.64 | 2.35 | 3.14 | 1600 | 1600 | 37.0 | 37.0 |
|  | 3 | 10.5 | Slightly clayey very fine to fine sand. Granitic and very micaceous | 1.47 | 1.46 | 6.37 | 0 | 1000 | 72.5 | 43.0 |
|  | 4 | 15.5 | Slightly clayey very fine to fine sand. Granitic and very micaceous | 2.52 | - | 5.31 | 1600 | 1600 | 62.0 | 43.0 |
|  | 5 | 20.5 | Slightly clayey very fine to fine sand. Granitic and very micaceous | 4.55 | - | 3.55 |  | 1450 |  | 43.0 |
| 67 | 2 | 6.0 | Silty very fine to fine sand. Granitic and micaceous | 1.98 | 3.37 | 4.68 | 1050 | 1050 | 61.5 | 43.0 |
|  | 3 | 11.0 | Silty very fine to fine sand. Granitic and micaceous | 1.29 | 1.83 | 4.04 | 730 | 800 | 48.0 | 43.0 |
| 101 | 2 | 5.5 | Silty very fine to fine sand. Granitic and micaceous | 5.15 | 6.70 | 7.50 | 4400 | 4400 | 57.0 | 43.0 |
| 109 | 2 | 7.0 | Very clayey silt with organic matter | 1.41 | 2.06 | 2.24 | 1150 | 1150 | 29.0 | 29.0 |
|  | 3 | 11.5 | Silty very fine to fine sand. Granitic | 1.85 | - | 4.10 | 1100 | 1100 | 56.5 | 43.0 |
| 115 | 2 | 5.0 | Silty very fine to fine sand. Gneissic | 2.08 | 2.33 | 7.43 | 1850 | 1850 | 26.0 | 26.0 |

# TABLE OF SHEAR TEST RESULTS

| Tower No. | Sample No. | Depth in Feet | Soil Description | Shear Resistance in kips/sq ft. Under Normal Load of (Kips per sq. ft.) | | | Apparent Cohesion (lb/sq. ft.) | | Angle of Internal Friction (Degrees) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.5 | 1.0 | 2.0 | Tested | Recommended | Tested | Recommended |
| 133 | 2 | 5.0 | Silty fine to medium sand with clay binder | 0.85 | 1.12 | 2.60 | 260 | 260 | 28.0 | 28.0 |
| | 3 | 10.0 | Slightly silty fine to medium sand. Granitic | 1.47 | 5.13 | 5.10 | 260 | 1030 | 67.5 | 43.0 |
| | 4 | 15.0 | Slightly silty fine to medium sand. Granitic | 3.80 | 2.42 | 4.38 | 420 | 1450 | 63.0 | 43.0 |
| 136 | 2 | 5.0 | Slightly silty fine to medium sand. Granitic | 1.77 | 2.33 | 5.63 | 1220 | 1220 | 48.0 | 43.0 |
| | 3 | 10.0 | Slightly silty fine to medium sand. Granitic | 2.00 | 4.33 | 5.20 | 910 | 1560 | 53.5 | 43.0 |
| | 4 | 15.0 | Slightly silty fine to medium sand. Granitic | 3.24 | 7.50 | 7.50 | 1840 | 1840 | 61.0 | 43.0 |
| 159 | 2 | 5.0 | Silty fine to medium sand | 0.74 | 0.97 | 2.80 | 500 | 500 | 25.0 | 25.0 |
| | 3 | 10.0 | Silty fine to medium sand | 0.77 | 1.48 | 2.17 | 300 | 300 | 42.5 | 42.5 |
| | 4 | 15.0 | Residual soils of decomposed granite | 2.29 | 7.30 | 7.25 | 600 | 1800 | 73.0 | 43.0 |
| 174 | 2 | 5.0 | Clayey fine to coarse sand with lenses of gravel. Porous | 1.14 | 2.24 | 2.20 | 800 | 800 | 35.0 | 35.0 |
| | 3 | 10.0 | Mixed silty sand, clayey sand and sandy silt with gravel, granitic rock | 1.14 | 2.60 | 5.89 | 0 | 700 | 70.0 | 43.0 |
| | 4 | 15.0 | Silty and clayey sand matrix of granitic rock | 4.41 | 5.13 | 6.27 | 3800 | 3800 | 51.0 | 43.0 |
| 184 | 2 | 5.0 | Gravelly clayey fine to medium sand mixed in granitic rock | 3.62 | 3.52 | 4.28 | 2730 | 2730 | 37.5 | 37.5 |

# TABLE OF SHEAR TEST RESULTS

| | | | | Shear Resistance in kips/sq ft. Under Normal Load of | | | Apparent Cohesion (lb/sq. ft.) | | Angle of Internal Friction (Degrees) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Tower No. | Sample No. | Depth in Feet | Soil Description | 0.5 (Kips per sq. ft.) | 1.0 | 2.0 | Tested | Recommended | Tested | Recommended |
| 191 | 2 | 5.0 | Clayey and silty fine to medium sand. Metavolcanic | 7.50 | 4.64 | 7.50 | 1750 | 1750 | 71.0 | 40.0 |
| | 3 | 10.0 | Clayey and silty fine to medium sand. Metavolcanic | 3.54 | 4.36 | 3.89 | 3090 | 3090 | 35.3 | 35.3 |
| | 4 | 15.0 | Clayey and silty fine to medium sand. Metavolcanic | 2.08 | 2.70 | 5.47 | 910 | 910 | 52.5 | 40.0 |
| 230 | 2 | 7.0 | Silty clay from weathered rock | 1.18 | 1.98 | 3.41 | 450 | 450 | 56.0 | 40.0 |
| | 3 | 10.0 | Silty fine sand with clay binder | 0.53 | 1.00 | 2.31 | 110 | 110 | 43.0 | 40.0 |
| | 4 | 15.0 | Clayey sandy silt. | 1.43 | 2.82 | 2.31 | 1120 | 1120 | 31.0 | 31.0 |
| 233 | 3 | 10.0 | Silty clay. Residual soils of shale | 1.74 | 2.40 | 2.23 | 1570 | 1570 | 18.0 | 18.0 |
| | 4 | 15.0 | Sandy silt. Residual soils of shale | 3.98 | 2.65 | 3.44 | 1870 | 1870 | 37.5 | 37.5 |
| 245 | 1-4 | 2 to 20 | Mixed fine sandy silt and silty fine to medium sand | Sheared at normal load under field moisture condition | | | 270 | 270 | 38.0 | 38.0 |
| | 1-4 | 2 to 20 | Mixed fine sandy silt and silty fine to medium sand | Sheared at normal load under saturated and drained condition | | | 110 | 110 | 38.0 | 38.0 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 1

5' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐1 | ▨ | Brown, Moist, Loose, Porous, Roots (Topsoil) | SILTY VERY FINE TO FINE SAND | | | | | * ALLUVIUM-COLLUVIUM |
| 2<br>3 | ① | ▨ | Light Brown, Moist, Loose, Slightly Micaceous | SLIGHTLY SILTY VERY FINE TO FINE SAND | 0.8 | 16.3 | 101.8 | | |
| 4<br>5<br>6 | ☐2<br>② | ▤ | Gray-black, Moist, Medium Firm, Some Light Gray Clayey Very Fine to Fine Sand, Occasional Gravel to 1/2 Inch | VERY FINE TO MEDIUM SANDY CLAY | 3.2 | 19.5 | 108.2 | | |
| 7<br>8<br>9 | ☐3 | ▨ | Gray-brown, Slightly Moist, Compact, Lenses of Saturated Fine to Medium, Water Bearing Sand from 7 to 8 Feet. ** | SLIGHTLY SILTY VERY FINE TO COARSE SAND | | | | | WEATHERED GNEISS |
| 10<br>11 | ③ | ▨ | Very Compact | | 32.5 | 9.0 | 138.0 | | |

Continued on Drawing No. 2

☐ - Indicates Loose Bag Sample

○ - Indicates Undisturbed Drive Sample

* - Colluvium is used in this report to include topsoils, residual soils, and other weathering products and deposits which have formed in situ or have moved only a very short distance, chiefly by gravity. In general, it is the soil mantle overlying weathered bedrock.

** - NOTE: Water level rose from 7.0' to 3.0' in approximately 1 1/2 hours.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 1 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 1 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 12 | | ▨ | Gray-brown, Slightly Moist, Very Compact, Lenses of Saturated Fine to Medium Sand, Cobbles to 12 Inches | SLIGHTLY SILTY VERY FINE TO COARSE SAND | | | | | WEATHERED GNEISS |
| 13 | | ▨ | | | | | | | |
| 14 | ④ | ▨ | Fragments from Drilling to 12 Inches | | 196.0<br>** | 14.7 | 121.1 | | |
| 15 | | ▨ | | | | | | | |
| 16 | | ▨ | | | | | | | |
| 17 | | ▨ | | | | | | | |
| 18 | | ▨ | | | | | | | |
| 19 | ⑤ | ▨ | | | 97.4 | 11.6 | 132.6 | | |
| 20 | | | Practical refusal at 19 1/2 feet *** | | | | | | |

** Sample tube able to penetrate only 3 inches.

*** "Practical Refusal" indicates that progress with the bucket-type drilling rig used for this project was slowed to less than one foot per hour and therefore considered economically impractical to continue drilling efforts.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 2 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 6

5' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2 | 1<br>① | ▨ | Red-brown, Moist, Loose, Slightly Micaceous, Porous, Roots, (Topsoil) | SILTY VERY FINE TO FINE SAND | 1.6 | 4.4 | 115.2 | | Colluvium |
| 3 | | ▤ | Red-brown, Moist, Firm, with Some Very Fine Sand, Rootlets | SILTY CLAY | | | | | |
| 4<br>5<br>6 | ② | ▨ | Light Brown, Slightly Moist, Very Compact, Weathered | SILTY VERY FINE TO COARSE SAND | 64.9 | - | - | | Weathered Gneiss |
| 7 | | ▨ | Light Gray-brown, Boulders to 48 Inches (Estimated) | | | | | | |

Practical refusal at 7.0 feet

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 3 |

JOB NAME S.D.G.&E. 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 11

10' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Red-brown, Moist, Loose, Porous, Rootlets, Slightly Micaceous, (Topsoil) | SILTY VERY FINE TO FINE SAND | 1.6 | 11.3 | 102.1 | | Colluvium |
| | | ▤ | Light Red-brown, Slightly Moist, Medium Compact | | | | | | |
| 4 | | ▤ | Red-brown, Moist, Firm | FINE SANDY CLAY | | | | | |
| 5<br>6<br>7<br>8<br>9 | ② | ▨ | Light Brown, Slightly Moist, Very Compact, With Some Coarse Grains, Weathered | SLIGHTLY SILTY VERY FINE TO SAND | 55.7 | 1.8 | 115.8 | | Weathered Quartz Diorite |
| 10 | ③ | ▨ | Less Weathered | | 97.4 | 2.8 | 120.4 | | |

Practical refusal at 10.5 feet

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 4 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 20

5' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2 | 1<br>① | | Red-brown, Moist, Soft, Some Very Fine to Fine Sand, Porous, Roots and Rootlets (Topsoil) | SILTY CLAY | 1.6 | 15.8 | 105.5 | | Colluvium |
| 3 | | | With Medium Grains | | | | | | |
| 4<br>5 | ② | | Light Red-brown, Slightly Moist, Loose to Medium Compact, Porous, Rootlets | SILTY VERY FINE TO FINE SAND | 9.7 | 6.0 | 97.0 | | Weathered Quartz Diorite |
| 6 | | | Light Brown, Very Compact | | | | | | |
| 7<br>8<br>9<br>10<br>11<br>12 | ③ | | Light Gray-brown, Slightly Moist, Very Compact, with Medium Grains | SLIGHTLY SILTY VERY FINE TO FINE SAND | 39.0 | 2.8 | 129.4 | | |
| 13<br>14<br>15<br>16<br>17<br>18 | ④ | | | | 97.4 | 2.8 | 141.8 | | |
| 19<br>20 | ⑤ | | | | 64.9 | 3.5 | 126.9 | | |

Continued on Drawing No. 6

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 5 |

# SUMMARY SHEET

TOWER **NO.** 20 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | | ▨ | Light Gray-brown, Slightly Moist, Very Compact, with Medium Grains | SLIGHTLY SILTY VERY FINE TO FINE SAND | | | | | Weathered Quartz Diorite |
| 22 | | ▨ | | | | | | | |
| 23 | | ▨ | | | | | | | |
| 24 | ⑥ | ▨ | | | 85.0 | - | - | | |
| 25 | | | | | | | | | |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

**PROJECT NO.** 71-12-22A

**BENTON ENGINEERING, INC.**

**DRAWING NO.** 6

# SUMMARY SHEET

TOWER NO. 22

5' East of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | ↓ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | ▨ | Dark Red-brown, Moist, Loose, with Few Coarse Grains, Porous, Rootlets | SILTY VERY FINE TO MEDIUM SAND | | | | | Colluvium |
| 2 | ① | ▤ | Red-brown, Moist, Very Firm, Some Very Fine to Fine Sand, Slightly Porous, Rootlets | SILTY CLAY | 13.0 | 8.0 | 105.5 | | |
| 3 | | ▨ | Light Brown, Slightly Moist | | | | | | Weathered Quartz Diorite |
| 5 | ② | ▨ | Light Yellow-brown, Slightly Moist, Very Compact, Highly Weathered | SILTY VERY FINE SAND | 19.5 | 7.6 | 108.2 | | |
| 9 | ③ | ▨ | Light Yellow-brown and Gray, Few Fine to Medium Grains, Weathered | | 97.4 | 6.9 | 112.8 | | |
| 14 | ④ | ▨ | Slightly Weathered | | 116.9 | 1.4 | - | | |
| 20 | ⑤ | ▨ | | | 146.1 | - | - | | |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 7 |

# SUMMARY SHEET

TOWER NO. 33

15' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| | | ▨ | Dark Red-brown, Moist, Loose, Porous, Rootlets, 10 Percent Granitic Cobbles to 12 Inches (Topsoil) | SILTY VERY FINE TO FINE SAND | | | | | Colluvium |
| 1 | | | | | | | | | |
| 2 | | ▨ | Light Yellow-brown, Medium Compact, Highly Weathered | | | | | | |
| 3 | | | | | | | | | |
| 4 | ① | ▨ | Light Yellow-brown, Slightly Moist, Very Compact, Weathered With Some Coarse Grains | SILTY VERY FINE TO MEDIUM SAND | 8.1 | 4.7 | 108.5 | | Weathered Quartz Diorite |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | ② | | | | 43.3 | 1.6 | 132.7 | | |
| 10 | | | | | | | | | |
| 11 | | ▨ | Light Gray-brown, Slightly Weathered | | | | | | |
| 12 | | | | | | | | | |

Practical refusal at 11.5 feet.

JOB NAME S.D.G.&E. 230 KV Line

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 8 |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 50

10' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ① | ▨ | Brown, Moist, Soft, Porous, Rootlets | SILTY VERY FINE TO MEDIUM SAND | 3.2 | 6.7 | 108.3 | | Colluvium |
| 2 | | ▤ | Light Red-brown, Moist, Compact | SLIGHTLY CLAYEY VERY FINE TO COARSE SAND | | | | | Weathered Granodiorite |
| 3<br>4 | ② | ▤ | Very Compact | | 129.8 | 2.7 | - | | |
| 5<br>6 | | ▨ | Light Red and Light Brown, Slightly Moist, Very Firm, Cemented | SILTY VERY FINE TO MEDIUM SAND | | | | | |
| 7 | | | | | | | | | |

Practical refusal at 6.5 feet.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 9 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 52

10' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | Dark Brown, Moist, Loose, Porous, Micaceous, (Topsoil) | SLIGHTLY CLAYEY VERY FINE TO COARSE SAND<br>(Decomposed Granite) | | | | | Colluvium |
| | | | Red-brown, Medium, Firm | | | | | | |
| 2 | ① | | Slightly Moist, Firm, Highly Weathered | | 6.5 | 9.0 | 119.5 | | |
| 3 | | | | | | | | | Weathered Quartz Diorite |
| 4 | | | | | | | | | |
| 5 | ② | | Light Red-brown, Very Firm, Weathered | | 55.6 | 2.4 | 129.1 | | |
| 6 | | | | | | | | | |
| 7 | | | Light Yellow-brown and Gray | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | ③ | | | | 116.9 | - | - | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |

Practical refusal at 12.0 feet.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 10 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 56

15' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | Description | Classification | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1–2 | ① | | Dark Gray-brown, Moist, Loose, Slightly Micaceous, Porous, Rootlets with Some Medium Grains (Topsoil) | SILTY VERY FINE TO FINE SAND (Merges) | 0.8 | 7.8 | 99.0 | | Colluvium |
| 2–4 | | | Light Red-brown, Slightly Moist, Compact, Porous, Rootlets, with Some Coarse Grains Highly Weathered | SLIGHTLY SILTY VERY FINE TO MEDIUM SAND | | | | | Weathered Quartz Diorite |
| 5 | ② | | Light Red-brown, Slightly Moist, Very Compact, Weathered with Some Coarse Grains | SILTY VERY FINE TO MEDIUM SAND | 35.4 | 3.5 | 110.6 | | |
| 10 | ③ | | | | 64.9 | 2.5 | 134.4 | | |
| 12–14 | | | Light Brown and Gray, Slightly Moist, Very Compact, Weathered | SLIGHTLY SILTY VERY FINE TO MEDIUM SAND | | | | | |
| 15–17 | ④ | | Light Brown and Gray, Slightly Moist, Very Compact, Weathered | SILTY VERY FINE TO COARSE SAND | 48.7 | 2.2 | 145.0 | | |
| 18 | | | Practical refusal at 17.5 feet. | | | | | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 11 |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 60

10' East of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0–3½ | | | Dark Brown, Moist, Loose, Porous, Micaceous, Rootlets (Topsoil) | CLAYEY VERY FINE TO MEDIUM SAND | | | | | Colluvium |
| 2 | ① | | | | 0.8 | 10.4 | 105.9 | | |
| 3½–6 | | | Red-brown, Moist, Compact | SLIGHTLY CLAYEY VERY FINE TO MEDIUM SAND | | | | | Weathered Quartz Diorite |
| 6 | ② | | | | 8.1 | 3.4 | 116.9 | | |
| 6–7½ | | | Light Red-brown, Slightly Moist, Compact to Very Compact | | | | | | |
| 7½–9½ | | | Light Yellow-brown and Gray, Very Compact | | | | | | |
| 9½–21 | | | Light Gray, Very Micaceous, Less Clayey | | | | | | |
| 10 | ③ | | | | 55.6 | 2.1 | 138.3 | | |
| 15 | ④ | | | | 81.2 | 9.3 | 138.1 | | |
| 20 | ⑤ | | | | - | * | * | | |

Continued on Drawing No. 13

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 12 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 60 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22<br>23<br>24<br>25 | ⑥ | | Light Gray, Slightly Moist, Very Compact, Very Micaceous | SLIGHTLY CLAYEY VERY FINE TO MEDIUM SAND | 120.0 | 5.3 | 113.1 | | Weathered Quartz Diorite |
| 26 | | | | | | | | | |

* No representative results were obtained

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 13 |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 67

12' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | ▨ | Dark Brown, Moist, Soft (Topsoil) | SILTY VERY FINE TO COARSE SAND | | | | | Colluvium |
| 2 | ① | ▨ | Red-brown, Moist, Medium Firm, Highly Weathered | SLIGHTLY SILTY VERY FINE TO COARSE SAND | 0.8 | 12.0 | 104.1 | | |
| 3 | | ▨ | | | | | | | Weathered Quartz Diorite |
| 4 | | ▨ | Light Yellow-brown, Slightly Moist, Firm to Very Firm | | | | | | |
| 5 | | ▨ | | | | | | | |
| 6 | ② | ▨ | | | 21.1 | 3.0 | 112.9 | | |
| 7 | | ▨ | | | | | | | |
| 8 | | ▨ | | | | | | | |
| 9 | | ▨ | Light Yellow-brown and Gray, Very Firm, Weathered | | | | | | |
| 10 | | ▨ | | | | | | | |
| 11 | ③ | ▨ | Light Gray, Slightly Weathered | | 41.0 | 2.1 | 123.6 | | |
| 12 | | ▨ | | | | | | | |

Practical refusal at 12.5 feet

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 14 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 82

15' South of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | Description | Classification | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2 | | ▨ | Dark Brown, Moist, Medium Firm, 25 to 30 Percent Gravel, Cobbles, and Boulders to 24 Inches, Some Fine to Medium Sand | GRAVELLY SILTY CLAY | | | | | Colluvium * |
| 3 | | ▨ | Red-brown, Firm, with Boulders to 30 Inches | | | | | | |
| 4 | | | Slightly Moist | | | | | | |

Practical refusal at 3.5 feet

* This material is essentially a boulder conglomerate with a clay matrix and is fairly typical of weathered gabbro surfaces. Because of the 1 to 3 foot diameter of these unweathered floating boulders, it is doubtful that a conventional soil-type drill rig will make much progress in this terrain.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 15 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 101

5' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1–2 | ① | ▨ | Dark Brown, Moist, Loose, With Few Coarse Grains, Slightly Micaceous, Roots and Rootlets (Topsoil) | SILTY VERY FINE TO MEDIUM SAND | 0.8 | 10.3 | 102.0 | | Colluvium |
| 3 | | Water* ▽ | | | | | | | |
| 4 | | ▨ | Light Yellow-brown, Saturated, Medium Firm, Highly Weathered | | | | | | Weathered Quartz Diorite |
| 5 | ② | ▨ | Moist, Firm | | 64.9 | 10.4 | 129.9 | | |
| 6 | | ▨ | Very Firm | | | | | | |

Practical refusal at 6.0 feet

* Very slight water seepage, hole is at north edge of meadow

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 16 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 109

15' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | DESCRIPTION | CLASSIFICATION | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Dark Brown, Moist, Loose, Porous, Roots and Rootlets, with Some Medium Grains (Topsoil) | SILTY VERY FINE TO FINE SAND | 0.8 | 9.0 | 106.1 | | Colluvium |
| 4<br>5 | | ▨ | 35 Percent Cobbles and Boulders to 36 Inches * | | | | | | |
| 6<br>7 | ② | ▤ | Yellow-brown, Moist, Firm, Organic Matter | CLAYEY SILT | 11.4 | 32.9 | 76.9 | | |
| 8<br>9<br>10<br>11<br>12<br>13<br>14<br>15 | ③ | ▨ | Light Red-brown, Slightly Moist, Very Firm, Weathered with Some Coarse Grains | SILTY VERY FINE TO MEDIUM SAND | 64.9 | 3.5 | 115.0 | | Weathered Granodiorite |
| 16 | ④ | ▨ | Slightly Weathered | | 116.9 | – | – | | |
| 17 | | | | | | | | | |

Practical refusal at 16.5 feet

* At the center point of the tower site boulders up to 6 feet in diameter are present at the surface as part of a talus-slope wash deposit in a broad swale. This surficial material should not be considered suitable for footings.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 17 |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 115

10' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Gray-brown and Light Gray-brown, Moist, Loose, Slightly Micaceous, Porous, Roots and Rootlets, ± 10 Percent Gneissic Cobbles to 12 Inches, (Topsoil) | SILTY VERY FINE TO FINE SAND | 1.6 | 13.1 | 108.4 | | Colluvium |
| 4<br>5 | ② | ▨ | Light Brown and Light Gray, Medium Firm, Highly Weathered, Thin Foliation | | 13.0 | 6.3 | 120.3 | | Weathered Gneiss |
| 6 | | ▨ | Slightly Moist, Firm | | | | | | |
| 7<br>8 | | ▨ | Dry, Firm to Very Firm, Weathered | | | | | | |
| 9 | | | Practical refusal at 8.5 feet | | | | | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 18 |

# SUMMARY SHEET

TOWER NO. 133

33' N 50° E from Tower Centerline, and
3' above Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| | | ▤ | Brown to Slightly Red-brown, Moist, Firm, Few Rootlets, Porous (Topsoil) | CLAYEY FINE TO MEDIUM SAND | | | | | Colluvium |
| 1 | | ▤ | | | | | | | |
| 2 | ① | ▤ | Light Brown, Dry, Less Organic Material | | 9.7 | 6.7 | 106.6 | | |
| 3 | | ▤ | | | | | | | |
| 4 | | ▨ | Light Gray to Light Brown and Light Brown-gray, Dry, Firm with Slight Clay Binder, Slightly Porous, Highly Weathered | SILTY FINE TO MEDIUM SAND<br>(Merges) | | | | | Weathered Quartz Diorite |
| 5 | ② | ▨ | | | 19.5 | 4.7 | 117.2 | | |
| 6 | | ▨ | Light Gray, Dry, Very Compact | | | | | | |
| 7 | | ▨ | | | | | | | |
| 8 | | ▨ | | | | | | | |
| 9 | | ▨ | | | | | | | |
| 10 | ③ | ▨ | | | 35.4 | 4.6 | 140.6 | | |
| 11 | | ▨ | | | | | | | |
| 12 | | ▨ | | SLIGHTLY SILTY FINE TO MEDIUM SAND | | | | | |
| 13 | | ▨ | | | | | | | |
| 14 | | ▨ | | | | | | | |
| 15 | ④ | ▨ | | | 45.8 | 3.8 | 140.0 | | |
| 16 | | ▨ | | | | | | | |
| 17 | | ▨ | | | | | | | |
| 18 | | ▨ | | | | | | | |
| 19 | | ▨ | | | | | | | |
| 20 | ⑤ | ▨ | | | 55.6 | 3.5 | 135.8 | | |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 19 |

# SUMMARY SHEET

TOWER NO. 136

94' S 48° E from Tower Centerline and
23' above Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | ▨ | Light Brown to Gray-brown, Slightly Moist, Firm with Clay Binder, Fine Rootlet, Porous, Highly Weathered | SILTY FINE TO MEDIUM SAND | | | | | Weathered Quartz Diorite |
| 2 | ① | ▨ | | | 11.4 | 8.3 | 123.2 | | |
| 3 | | ▨ | | | | | | | |
| 4 | | ▨ | Light Brown-gray, Dry, Very Compact, Very Firm | | | | | | |
| 5 | ② | ▨ | | | 24.3 | 5.9 | 134.9 | | |
| 6 | | ▨ | | | | | | | |
| 7 | | ▨ | Becomes More Firm | | | | | | |
| 8 | | ▨ | | | | | | | |
| 9 | | ▨ | Gray | | | | | | |
| 10 | ③ | ▨ | | | 43.3 | 4.1 | 137.0 | | |
| 11 | | ▨ | | SLIGHTLY SILTY FINE TO MEDIUM SAND | | | | | |
| 12 | | ▨ | | | | | | | |
| 13 | | ▨ | NOTE: Hole drilled on cut pad. 3 feet high cut bank adjacent to hole showed 1.5 feet of dark brown, moist, soft, silty fine to medium sand, (Topsoil), porous with rootlets; underlain by silty fine to medium sand as above at 0-3 1/2 feet. | | | | | | |
| 14 | | ▨ | | | | | | | |
| 15 | ④ | ▨ | | | 64.9 | 3.5 | 142.7 | | |
| 16 | | ▨ | | | | | | | |
| 17 | | ▨ | | | | | | | |
| 18 | | ▨ | | | | | | | |
| 19 | | ▨ | | | | | | | |
| 20 | ⑤ | ▨ | | | 64.9 | 2.8 | 123.7 | | |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 20 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 159

211' S 84° E of Tower Centerline and
103' Below Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Dark Brown, Slightly Moist, Loose, Rootlets, 10 Percent Gravel and Cobbles to 4 Inches (Topsoil) | SILTY FINE TO COARSE SAND | 0.8 | 7.3 | 95.7 | | Colluvium |
| 4<br>5<br>6<br>7<br>8 | ② | ▨ | Brown, Slightly Moist, Loose, Rootlets, 15 to 20 Percent Gravel<br>NOTE: This hole is approximately 103 feet lower and easterly from the Tower site, and soil conditions from 0-10 feet are not typical of the actual Tower site. At most, we anticipate 1 to 3 feet of topsoil before reaching weathered granite as at 10 to 40 feet in this boring. | GRAVELLY SILTY FINE TO COARSE SAND | 1.6 | 5.5 | 104.6 | | |
| 9 | | ▨ | Yellow-brown, Medium Firm | | | | | | |
| 10 | ③ | ▨ | | | 4.9 | 10.4 | 107.9 | | |
| 11<br>12<br>13<br>14<br>15<br>16 | ④ | ▨ | Light Yellow-brown, Dry, Firm, Highly Weathered, 2 to 3 Inch Seams of Hard Fractured Quartz | SILTY FINE TO COARSE SAND<br>(Decomposed Granite) | 66.5 | 5.2 | 127.9 | | Weathered Granite |
| 17<br>18<br>19 | | ▨ | Very Firm, Weathered | | | | | | |
| 20<br>21 | ⑤ | ▨ | Yellow and Light Gray | | 55.6 | 4.4 | 131.0 | | |

Continued on Drawing No. 22

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 159 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22<br>23<br>24 | | ▨ | Yellow and Light Gray, Dry, Very Firm, Weathered and Fractured | SILTY FINE TO COARSE SAND<br><br>(Decomposed Granite) | | | | | Weathered Granite |
| 25 | ⑥ | ▨ | Light Gray, Moist, Highly Weathered and Intensely Fractured, Clayey Slickensides in Fractures | | 100.0 | 5.2 | 122.1 | | |
| 26<br>27<br>28<br>29 | | ▨ | | | | | | | |
| 30 | ⑦ | ▨ | | | 54.5 | 9.2 | 122.9 | | |
| 31<br>32<br>33 | | ▨ | | | | | | | |
| 34 | | ▨ | Slightly Moist, Fractured | | | | | | |
| 35 | ⑧ | ▨ | | | 100.0 | 3.9 | 113.1 | | |
| 36<br>37<br>38<br>39 | | ▨ | | | | | | | |
| 40 | ⑨ | ▨ | | | 109.1 | - | - | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 22 |

# SUMMARY SHEET

TOWER NO. 174

13' S 20° W of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Dark Brown, Very Moist, Soft, with Clay Binder, Very Porous Rootlets, Lenses of 10 to 20 Percent Gravel to 1/2 Inch (Topsoil) | SILTY FINE TO MEDIUM SAND<br>(Merges) | 0.8 | 15.7 | 104.1 | | Colluvium |
| 4<br>5<br>6 | ② | ▤ | Orange to Red-brown and Gray-brown, Very Moist, Firm, Very Porous, Lenses of 10 to 20 Percent Gravel to 1/2 Inch | CLAYEY FINE TO COARSE SAND | 6.5 | 13.5 | 122.1 | | |
| 7<br>8<br>9<br>10<br>11 | ③ | ▨ | Mixed Light Brown, Light Gray, and Light Yellow-brown, Moist, Firm, with Lenses of 5 to 20 Percent Gravel to 1/2 Inch, Occasional Cobbles to 4 Inches, Highly Weathered and Fractured Bedrock | MIXED SILTY FINE TO MEDIUM SAND AND CLAYEY FINE TO MEDIUM SAND AND FINE SANDY SILT<br>(Merges) | 9.7 | 14.7 | 114.0 | | Weathered Hypabyssal Granitic Bedrock |
| 12<br>13<br>14<br>15<br>16<br>17<br>18 | ④ | ● | Mixed Light Brown, Light Gray and Light Yellow-brown, Slightly Moist, Very Compact, Less Weathered but Highly Fractured Bedrock, 40 to 50 Percent Gravel | GRAVELLY CLAYEY FINE TO MEDIUM SAND | 19.5 | 7.6 | 131.3 | | |
| 19<br>20<br>21 | ⑤ | ● | | | 22.7 | 14.4 | 123.1 | | |

Continued on Drawing No. 24

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 23 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 174 (Cont.)

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22 | | | Mixed Light Brown, Light Gray, and Light Yellow-brown, Slightly Moist, Very Compact, Fractured Bedrock Less Weathered with Depth, 40 to 50 Percent Gravel | GRAVELLY CLAYEY FINE TO MEDIUM SAND | | | | | Weathered Hypabyssal Granitic Bedrock |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| 25 | ⑥ | | | | 41.6 | 8.8 | 130.0 | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | ⑦ | | | | 46.6 | 5.0 | 129.3 | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 24 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET

TOWER **NO.** 184
29' N 25 W of Tower Centerline and
4.0' Lower Than Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | Light Brown to Gray-brown to Olive-brown, Slightly Moist, Very Compact, 20 to 40 Percent Gravel, Highly Fractured and Highly Weathered Bedrock | | | | | | Highly Weathered Hypabyssal Granitic Rock |
| 2 | ① | | | | 22.7 | 12.0 | 119.4 | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | ② | | | | 17.8 | 11.6 | 122.1 | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | GRAVELLY CLAYEY FINE TO MEDIUM SAND | | | | | |
| 9 | | | Light Gray-brown, Dry, 40 to 50 Percent Gravel, Weathered and Fractured Bedrock | | | | | | Weathered Hypabyssal Granitic Rock |
| 10 | ③ | | | | 35.7 | 3.9 | - | | |
| 11 | | | | | | | | | |
| 12 | | | NOTE: Drilled on cut pad. 4 feet high cut bank adjacient to the hole showed 2 feet of dark brown, slightly moist, loose silty fine to medium sand with clay binder, (Topsoil); underlain by gravelly clayey fine to medium sand as at 0 to 8 feet above. | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | ④ | | | | 64.9 | 4.7 | - | | |
| 16 | | | | | | | | | |
| 17 | ⑤ | | | | 35.7 | 5.6 | 133.0 | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 25 |

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 184 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22<br>23<br>24<br>25 | ⑥ | ▨ | Light Gray-brown, Dry, Very Compact, 40 to 50 Percent Gravel, Weathered and Fractured Bedrock | GRAVELLY CLAYEY FINE TO MEDIUM SAND | 44.2 | 7.3 | 135.1 | | Weathered Hypabyssal Granitic Rock |

| **PROJECT NO.** | | **DRAWING NO.** |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 26 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 191
220' N 6° E from Tower Centerline
53' Lower Than Tower

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | Red, Orange and Yellow-brown, Moist, Soft | FINE TO MEDIUM SANDY CLAY | | | | | Colluvium |
| 2 | ① | | | | 3.2 | 22.9 | 100.0 | | |
| 3 | | | Light Brown, Yellow-brown, and Brown, Firm | (Merges) | | | | | |
| 5 | ② | | Light Brown to Gray-brown, Slightly Moist, Very Firm, Fractured | CLAYEY FINE TO MEDIUM SAND | 39.0 | 5.6 | 125.4 | | Highly Weathered Santiago Peak Metavolcanic Rock |
| 10 | ③ | | | | 16.2 | 21.4 | 105.2 | | |
| 15 | ④ | | | | 14.6 | 10.3 | 125.7 | | |
| 18 | | | Brown to Gray, Dry, Fractured | | | | | | Weathered Santiago Peak Metavolcanic Rock |
| 20 | ⑤ | | | | 39.0 | 5.0 | - | | |
| 21 | | | | | | | | | |

Continued on Drawing No. 28

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 27 |

# SUMMARY SHEET

TOWER **NO.** 191 (Cont.)

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22<br>23<br>24<br>25 | ⑥ | ▤ | Brown to Gray, Dry, Very Firm, Fractured | CLAYEY FINE TO MEDIUM SAND | 66.6 | - | - | | Weathered Santiago Peak Metavolcanic Rock |

| **PROJECT NO.** | | **DRAWING NO.** |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 28 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER NO. 230

14' N 45° E of Tower Centerline and
1.5 feet Higher Than Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | ↓ |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2 | | | Dark Gray-brown, Moist, Soft, Roots, Porous, Topsoil, 25 Percent Gravel and Cobbles to 4 Inches (Topsoil) | GRAVELLY CLAYEY FINE TO MEDIUM SAND | | | | | Colluvium |
| 3<br>4 | ① | | Red-brown, Yellow-brown, and Gray-brown, Mixed, Moist, Firm, Granulated Pieces 1/8 to 1/4 Inch | SILTY CLAY | 4.9 | 37.9 | 86.7 | | Highly Weathered Eocene Marine Sedimentary Rock |
| 5 | | | Light Brown, Orange, Yellow-brown, and Gray-brown, Medium Firm | | | | | | |
| 6<br>7<br>8<br>9 | ② | | Light Gray with Mottled Yellow, Orange, Yellow-brown, and Brown, Slightly Moist, Firm, Some Roots, Fractured | | 11.4 | 22.2 | 102.3 | | |
| 10<br>11<br>12 | ③ | | Yellow-brown, Slightly Moist, Firm, with Clay Binder, 5 Percent Shells, Lenses of Black Fine to Medium Sand | SILTY FINE SAND | 11.4 | 17.4 | 106.1 | | Weathered Eocene Marine Sedimentary Rock |
| 13<br>14<br>15<br>16 | ④ | | Yellow, Yellow-brown, Brown, and Gray, Slightly Moist, Very Firm, Fossils, Chunky, Thin Bedded Layers, with Lenses of Silty Fine Sand | CLAYEY FINE TO MEDIUM SANDY SILT<br>(Merges) | 19.5 | 17.8 | 110.9 | | |
| 17<br>18<br>19<br>20 | ⑤ | | Yellow, Yellow-brown, and White, Slightly Moist, Very Firm, with Clay Binder | SILTY FINE SAND | 35.7 | 9.7 | 124.2 | | |

Continued on Drawing No. 30

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 29 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

# SUMMARY SHEET

TOWER **NO.** 230 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | | ▨ | Yellow, Yellow-brown, and White, Slightly Moist, Very Firm, with Clay Binder | SILTY FINE SAND | | | | | Weathered Eocene Marine Sedimentary Rock |
| 22<br>23 | | ▨ | Light Yellow and White, Slightly Moist, Very Compact, Occasional Coarse Sand | SLIGHTLY SILTY FINE TO MEDIUM SAND | | | | | |
| 24<br>25 | ⑥ | ▨ | Yellow-brown, Orange, Gray and Brown | | 60.0 | 8.6 | 128.6 | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 30 |

# SUMMARY SHEET

TOWER NO. 233

13' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | DESCRIPTION | SOIL CLASS | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|
| 0–1 | | Brown and Gray, Slightly Moist, Soft, Roots, Porous | FINE SANDY SILTY CLAY | | | | | FILL |
| 2 | ① | Gray with Mixed Browns and Brown-Gray, Slightly Moist, Firm, Thin Layers of White, Caliche, Rootlets, Fractured, with Lenses of Fine Sandy Silty Clay, Locally Micaceous | SILTY CLAY (Shale) | 4.9 | 32.0 | 78.1 | | Weathered Capistrano Formation, Mid-Pliocene Marine Sedimentary Rocks |
| 5 | ② | | | 6.5 | 17.9 | 94.4 | | |
| 10 | ③ | | | 13.0 | 27.0 | 92.8 | | |
| 15 | ④ | | | 9.7 | 22.9 | 99.0 | | |
| 15–20 | | Yellow to Yellow-brown, Slightly Moist, Firm, Fractured | FINE SANDY SILT | | | | | |
| 20 | ⑤ | | (Merges) | 14.6 | 26.7 | 99.4 | | |

Continued on Drawing No. 32

JOB NAME San Diego Gas & Electric Co., 230 KV Line

PROJECT NO. 71-12-22A

**BENTON ENGINEERING, INC.**

DRAWING NO. 31

# SUMMARY SHEET

TOWER **NO.** 233 (Cont.)

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 21<br>22<br>23<br>24 | | ▨ | Gray and Brown-gray, Slightly Moist, Firm, Some Caliche and Gypsum Veins, Locally Micaceous | FINE SANDY SILTY CLAY | | | | | Weathered Capistrano Formation<br>Mid-Pliocene Marine Sedimentary Rocks |
| 25 | ⑥ | ▨ | | | 23.3 | 19.3 | 101.7 | | |
| 26<br>27 | | ▨ | | | | | | | |
| 28<br>29 | | ▨ | Dark Gray to Black | | | | | | Unweathered Capistrano Formation |
| 30 | ⑦ | ▨ | | | 22.5 | 29.0 | 96.7 | | |

| **PROJECT NO.** | | **DRAWING NO.** |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 32 |

# SUMMARY SHEET

TOWER NO. 245

10' West of Tower Centerline, And 165' N64E
From Existing Tower No. 223133

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | DESCRIPTION | CLASSIFICATION | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | ① | ▨ | Brown to Dark Brown, Moist, Loose, Soft, Porous, Rootlets, (Topsoil) | FINE SANDY SILT AND SILTY FINE TO MEDIUM SAND<br>(Merges) | 0.8 | 18.8 | 82.0 | | River Floodplain Terrace Deposits |
| 4<br>5<br>6<br>7 | ② | ▧ | Brown, Moist, Firm, Occasional Lenses of 10 to 15 Percent Gravel | SILTY FINE TO MEDIUM SAND | 1.6 | 15.1 | 91.4 | | |
| 8<br>9<br>10<br>11<br>12 | | ▩ | Light Brown to Light Gray-brown, Moist, Compact, 25 Percent Gravel and Cobbles to 6 Inches (Hole Sloughing Below 8 feet) | GRAVELLY SLIGHTLY SILTY FINE TO COARSE SAND<br>(Merges) | | | | | Older Alluvium, Pleistocene Floodplain Deposits Not Being Actively Transported |
| 13<br>14<br>15<br>16<br>17 | ③ | ▩ | 25 Percent Gravel and Cobbles to 8 Inches, with Lenses of Fine to Medium Sand and Occasional Gravel to 1/2 Inch (Hole Caving Below 15 Feet) (Added Drilling Mud at 15 Feet) | | 19.5 | 3.5 | - | | |
| 18<br>19<br>20<br>21 | ④ | ░ | Light Brown to Light Gray-brown, Moist, Compact, 5 to 10 Percent Gravel | FINE TO MEDIUM SAND | 6.5 | 24.8 | 103.1 | | |

Continued on Drawing No. 34

# SUMMARY SHEET

TOWER **NO.** 245 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASS SYMB. | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 22<br>23 | | | Light Brown to Light Gray-brown, Moist, Compact, 5 to 10 Percent Gravel | FINE TO MEDIUM SAND<br>(Merges) | | | | | Older Alluvium, Pleistocene Floodplain Deposits Not Being Actively Transported |
| 24<br>25<br>26<br>27 | ⑤ | | Light Brown to Light Gray-brown, Moist, Compact, 30 to 40 Percent Gravel to 2 Inches with Lenses of Fine to Coarse Sand | GRAVELLY FINE TO COARSE SAND<br>(Merges) | 25.0 | 18.1 | 109.6 | | |
| 28<br>29<br>30<br>31<br>32 | ⑥ | | Light Brown to Light Gray-brown, Moist, Compact, 10 to 15 Percent Gravel to 2 Inches, with Lenses of Silty Clay and Lenses of Fine to Medium Sand | | 10.0 | 29.8 | 91.7 | | |
| 33<br>34<br>35<br>36 | ⑦ | Water * ▽ | | FINE TO COARSE SAND<br>(Merges) | 10.0 | 21.6 | 108.0 | | |
| 37<br>38<br>39<br>40 | ⑧ | | Light Brown to Light Gray-brown, Saturated, Compact, 20 to 40 Percent Gravel and Cobbles to 5 Inches | GRAVELLY FINE TO COARSE SAND | 16.7 | 11.1 | 127.0 | | |

(Stopped at 40.0 feet due to caving conditions and drilling progress of less than one foot per hour.)

* Water table estimated, due to addition of drilling mud at 15.0 feet.

**JOB NAME** San Diego Gas & Electric Co., 230 KV Line

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | 34 |

# SECOND INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER NO. 81
# AND
# GEOLOGIC DESCRIPTIONS FOR TOWER
# NOS. 25, 50, 79 and 85

230 KV
San Onofre-Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company

Project No. 71-12-22A
March 11, 1972

BENTON ENGINEERING, INC.

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APPENDICES

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
6741 EL CAJON BOULEVARD
SAN DIEGO, CALIFORNIA 92115

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

SAN DIEGO: 583-5654
LA MESA: 469-5654

# SOILS INVESTIGATION FOR TOWER NO. 81 AND GEOLOGIC DESCRIPTIONS FOR TOWER NOS. 25, 50, 79 and 85

## Introduction

This is to present the results of a soils investigation and a geological investigation conducted at certain tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California. More specifically, this completes the investigation for the Escondido-Rainbow portion of the Transmission Line.

This investigation included field boring and laboratory testing of the subsoils underlying the site of Tower No. 81 which is located in the channel area of San Luis Rey River. Two driven pile design curves have been calculated for the design of the tower foundation support in that the fluctuating water level makes this the best type of foundation support in alluvial sand deposits in the river bottom.

Also included in this report are the geologic descriptions of the sites of Tower Nos. 25, 50, 79 and 85. This report serves as a supplement to our first interim report dated February 9, 1972, under Project No. 71-12-22A, entitled "Interim Report, Soils Investigation, 230 KV, San Onofre-Escondido Line, San Diego County, California."

## Field Investigation

One boring was drilled with a truck-mounted rotary bucket-type drill rig at a location 10 feet north of the proposed Tower No. 81 centerline. The boring was drilled to a depth of 47.0 feet below the existing ground surface. A continuous log of the soils encountered in the boring was recorded at the time of drilling and is shown in detail on Drawing Nos. 35 to 37, inclusive, each entitled "Summary Sheet."

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density, moisture content, and shearing strength except for samples too rocky to test. The shearing strengths of the soils above water table were sheared under their existing overburden pressures, and for those below water, sheared under saturated and undrained conditions and under normal loads allowing for submerged densities below the water level. The results of these tests are presented on Drawing Nos. 35 to 37, inclusive.

The general procedures used for the laboratory tests are described briefly in Appendix B.

## Soil Strata

Loose and slightly silty fine to medium sand soils with lenses and layers of fine sand were underlain at the depth of 3.0 feet by a loose fine sand to the depth of 4.8 feet. Between 4.7 and 13.0 feet was a loose fine to coarse sand which merged to a gravelly fine to coarse sand between 13.0 and 19.0 feet. Approximately 20 to 25 percent gravel was encountered between the depths of 13.0 and 16.0 feet and approximately 30 to 35 percent gravel and cobbles to 5 inches in diameter were encountered between 16.0 and 19.0 feet. Below 19.0 feet, a 6.0 feet thickness of medium compact fine to coarse sand with approximately 2 inch layers of fine sand

and occasional gravel was underlain at the depth of 25.0 feet by a medium compact gravelly fine to coarse sand to the end of boring at 47.0 feet. The gravelly fine to coarse sand layer contained approximately 15 to 20 percent gravel and cobbles to 10 inches in diameter between 25.0 feet and 29.5 feet and increased to 20 to 30 percent gravel, and cobbles between 29.5 feet and 41.5 feet. Thin layers of fine sand up to 0.5 foot in thickness were also found below a depth of 34.0 feet and to the end of the boring.

Ground water was encountered below a depth of 8.5 feet below existing ground surface on March 1, 1972. It should be noted that the rainfall for January and February, 1972 was the lowest ever recorded locally at only 0.17 inch for these two months.

## Foundation, Tower No. 81

The best probable type of foundation to be used in the Tower No. 81 site would be driven piles. Two pile design curves for 12 inch by 12 inch concrete piles and 12 inch steel H-piles are presented on the attached Drawing No. A. The pile design curves shown are based on calculations using the minimum shear strength of the soils in contact with the perimeter areas of the piles, divided by a factor of safety of 2.0 to determine the safe allowable supporting capacities of single pile. It is assumed that both H-pile and concrete piles have the same perimeter areas. Therefore the curves are applicable to both types of pile. If smaller perimeter piles are used, then the supporting capacities would be reduced in direct proportion to the ratios of the shortest outside perimeters. Due to the presence of cobbles to 10 inches below 25 feet in depth it will be easier to drive "non-displacement" "H" type steel piles than any displacement type piles.

The upper pile design curve presented on the attached Drawing No. A and B, entitled "Vertical Supporting Capacities of Driven Piles," presents the safe allowable downward load supporting capacities for existing ground water conditions. The lower design curve presents the safe allowable downward load supporting capacities for an water level at the ground water surface. It is recommended that the potential maximum elevation of the water should also be taken into consideration in the design. For example, if the river at this location may have 10 feet of free flowing water above the ground surface at some time during the life of the tower, then a depth of scour of 10 feet should also be assumed. This would subtract 10.6 kips supporting capacity for the upper 10 feet of pile, therefore, to compensate for this loss, the length of pile for the lower design curve for a downward load of 80 kips, should be increased by 1.5 feet.

For uplift forces, it is recommended that only one half the downward allowable load capacity be used.

Respectfully submitted,

BENTON ENGINEERING, INC.

By S. H. Shu
S. H. Shu, Civil Engineer

Reviewed by Philip H. Benton
Philip H. Benton, Civil Engineer

SHS/PHB/ew

## GEOLOGIC CONDITIONS FOR TOWER NOS. 25, 50, 79 and 85

A brief description of the geological conditions observed at each site is presented as follows:

### Tower No. 25

On February 4 and 18, 1972 the site of Tower No. 25 was inspected to determine the suitability of using the existing rock outcrops for rock anchor footings. The first visit was made after the center point had been established and the second visit was made after each of the four footing points had been established. Leg No. 1 (southwest corner) and Leg No. 4, (southeast corner) are each founded upon a partly-buried relatively flat solid granodiorite boulder which measures about 30 feet in an east-west direction by about 15 feet in a north-south direction. There is a north-south trending joint near the center of the boulder dividing it into unequal parts, and except for minor surface spalling, the two portions appear to be solid massive boulders capable of adequately supporting the proposed tower legs with no additional site preparation other than drilling and setting anchor bolts.

The northeast Leg, No. 3, is located on what is probably a large mostly-buried granodiorite boulder of unknown dimensions. Thin surface soil and debris should be removed from the surface of this boulder to determine if it has lateral dimensions of six or more feet in diameter and if so, it may be drilled and tested for use as a rock anchor footing. Unfortunately, this footing is located down between two very large boulders exposed on the surface. The boulder on the westerly side extends vertically up from the ground surface about six feet and in its present position will interfer with the bottom angle support structure for this leg, and will need to be removed prior to tower construction. The large boulders present easterly of the tower leg will probably not need to be removed unless they interfer with construction equipment.

The northwest Leg, No. 2, is in a location free of large surface boulders. Colluvium and rock debris cover the surface. It is possible that removal of surface debris may expose a large boulder which could be used for a rock anchor footing.

In the case of footings for both Legs 2 and 3, if large enough boulders are encountered to be used for rock anchor footings, these should be inspected to insure that no joints or cracks exist which would effectively reduce the mass of rock acting together to properly support and to serve as adequate anchorage for each leg.

## Tower No. 50

On January 4, 1972, the site of Tower No. 50 was inspected and it was determined at that time that a rotary bucket drilling rig could be moved in on existing roads with no difficulty. During a brief surface geological inspection, the site was found to be underlain by topsoils and colluvium with occasional outcrops of three to five feet diameter granodiorite boulders. Subsequently, the boring drilled at Tower No. 50, disclosed one foot of colluvium, followed by weathered granodiorite from 1.0 to 6.5 feet where the drill rig met practical refusal (drilling progress slowed to less than one foot per hour). If a rotary auger type drill rig capable of exerting hydraulic down pressure is not able to penetrate the dense very compact weathered granodiorite the required depth for concrete pier footings, a rock anchor testing program may be initiated to determine the suitability of this material for rock anchor footings.

## Tower No. 79

On January 5, 1972, the site of Tower No. 79 was viewed with binoculars from Pala Road, Highway 76, at a position about one mile to the north-northwest. The approximately located site is on a 28° westerly facing rugged slope with many 10 feet and more diameter boulders on the surface. Access is by foot only with no trails, and it was therefore concluded that a binocular look would be the most economical means of site investigation at this point in planning. The site appears to be located in an area of dark gray to black outcrop boulders about half way up the mountain slope. On the State Geologic Map (Santa Ana sheet, 1965) these outcrops are identified as Upper Jurassic marine. Similarly identified rocks crop out at Tower No. 115, which was visited on January 6, 1972. The outcrop at Tower No. 115 is a classic example of a metasedimentary gneiss with well developed foliation. The Upper Jurassic marine at Tower No. 79 is most likely similar to that found at Tower No. 115.

We anticipate that rock anchor foundations may be possible at Tower No. 79 if large partially buried boulders are present under the footing legs. This situation would be similar to that encountered at Tower No. 25 were individual tower legs were staked prior to a final inspection and decision as to the type of footing to be used.

Tower No. 85

On January 7, 1972, the site of Tower No. 85 was viewed with binoculars from a private dirt road in the SE 1/4, 20/T9S, R2W, SBBM, at a position about one half mile north-northwest. The site is located on the crest of an easterly sloping ridge which is covered with a thick mat of brush and occasional rock outcrops. Access is by foot only with no trails, and it was therefore concluded that a binocular look would be the most economical means of investigation at this point in planning. The site is located in an area of dark gray to black outcrop boulders which on the State Geologic Map (Santa Ana sheet, 1965) are identified as Mesozoic basic intrusive rocks. Similarly identified rocks crop out at Tower No. 82 which was visited on January 7, 1972. The outcrop at Tower No. 82 is a gabbro, and the boring at Tower No. 82 disclosed very dense massive gabbro boulders up to 2.5 feet in diameter floating in a silty clay matrix. Drilling was stopped at 3.5 feet due to the size and number of boulders. The Mesozoic intrusive rocks at Tower No. 85 are most likely similar to those found at Tower No. 82.

We anticipate that drilling auger holes for concrete pier footings may be extremely difficult due to the presence of hard dense floating gabbro boulders at Tower Nos. 82 and 85. Perhaps this type of footings may be attempted first, if it is usual to make an attempt, but with the probability that spread or mat type footing would be more feasible to construct by dozing out a footing below the ground surface.

Respectfully submitted,

BENTON ENGINEERING, INC.

By W. J. Elliott
W. J. Elliott, R.G. 1101

Distr: San Diego Gas & Electric Company
(3) Attention: Mr. John Burton
(2) Attention: Mr. C. Hjalmarson

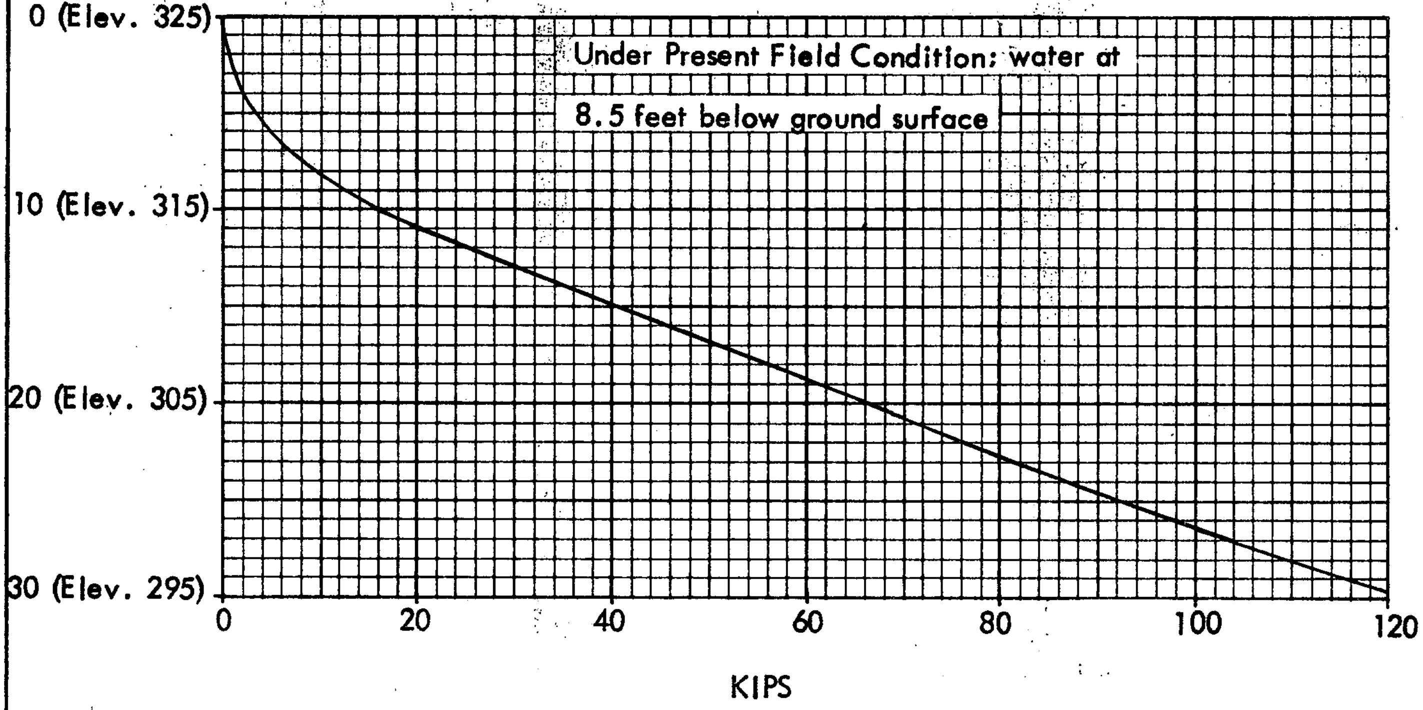
WJE/PHB/ew

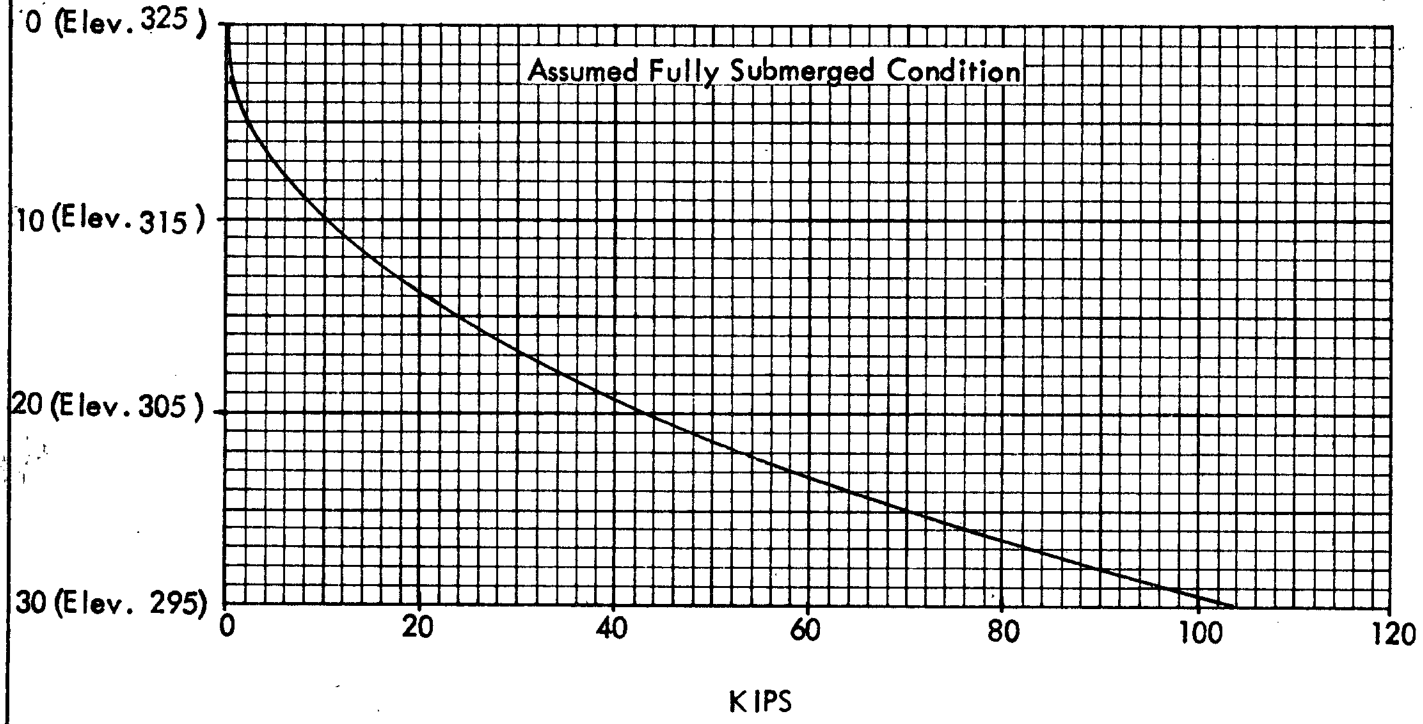
# VERTICAL SUPPORTING CAPACITIES OF DRIVEN PILES

(12" × 12" Concrete Piles and 12" Steel H Piles)

(F.S.=2)

(Assume Existing Ground Surface Elevation = 325' From Topo. Map)

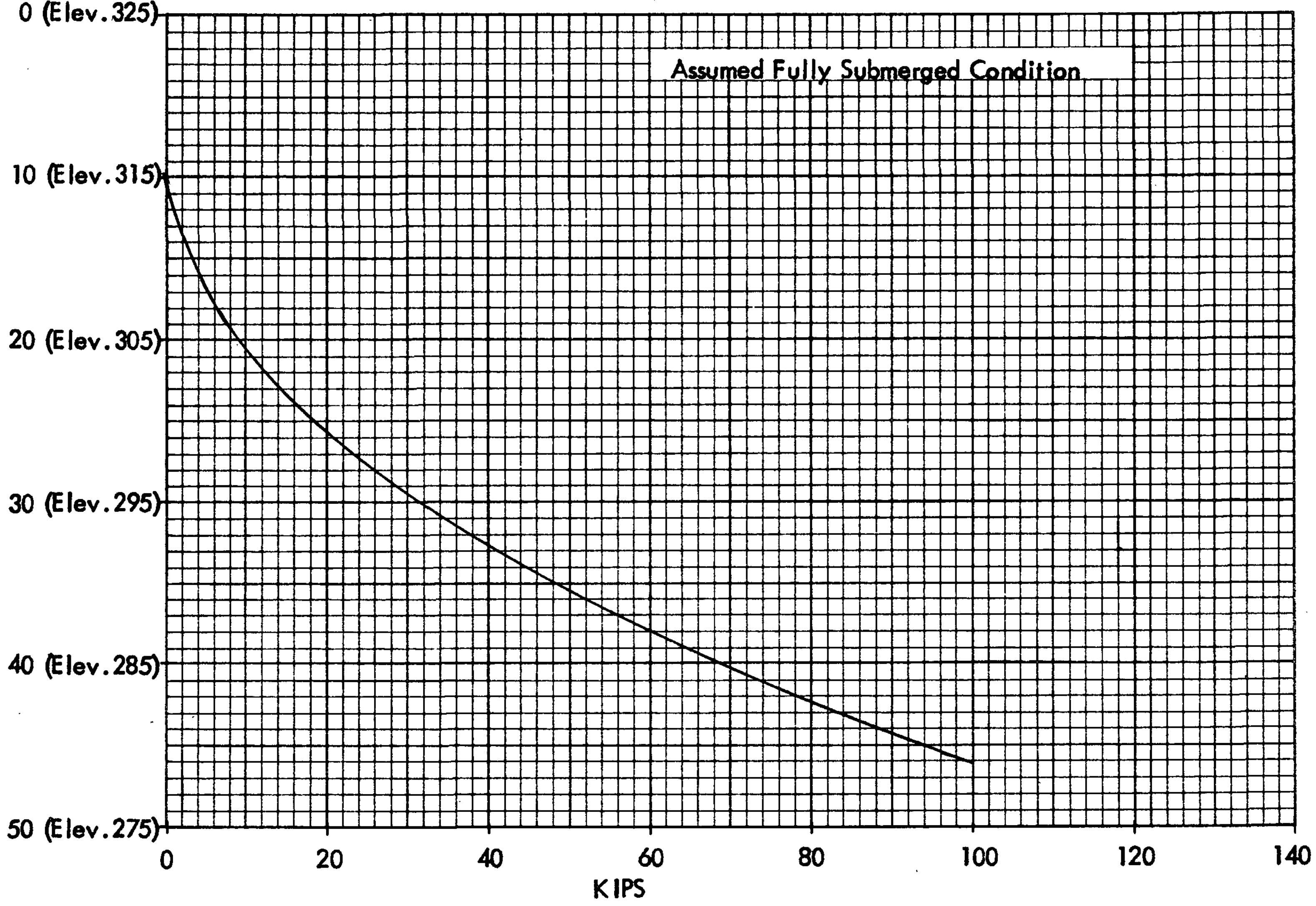




| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | A |

## 8" STEEL H PILES
## VERTICAL SUPPORTING CAPACITY OF DRIVEN PILES

### TOWER 81
### (F.S.=2)



PROJECT NO.
71-12-22A

BENTON ENGINEERING, INC.

DRAWING NO.
B

JOB NAME San Diego Gas & Electric Company - 230 KV Line

# SUMMARY SHEET

TOWER NO. 81

ELEVATION 325' *

Drilled 10' North of Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 0–3 | ① | ▨ | Light Gray, Slightly Moist, Loose, with Lenses and Layers of Fine Sand | SLIGHTLY SILTY FINE TO MEDIUM SAND | 0.8 | 6.1 | 83.0 | 0.26 |
| 3–5 | | ░ | Light Gray, Slightly Moist, Loose | FINE SAND | | | | |
| 5 | ② | ░ | | | 0.8 | 5.3 | 90.4 | 0.52 |
| 5–8½ | | ░ | Light Gray, Slightly Moist, Loose, Occasional Small Gravel | FINE TO COARSE SAND | | | | |
| 8½ | | Water ▽ | | | | | | |
| 8½–13 | | ░ | Saturated | | | | | |
| 10 | ③ | ░ | | | 0.8 | 17.2 | 113.8 | 1.95 |

Continued on Drawing No. 36

○ - Indicates undisturbed drive sample

* - The elevation shown was estimated from contour map. U.S.G.S. Map. (Scale: 1" = 2,000 Feet)

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 35 |

JOB NAME San Diego Gas & Electric Company - 230 KV Line

## SUMMARY SHEET
## TOWER NO. 81 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 13 | | | Light Gray, Saturated, Loose, 20 to 25 Percent Gravel | GRAVELLY FINE TO COARSE SAND | | | | |
| 15 | 4 | | | | 1.6 | 16.4 | 119.1 | 3.05 |
| 16 | | | 30 to 35 Percent Gravel and Cobbles to 5 Inches | | | | | |
| 19 | | | Gray, Saturated, Medium Compact, with 2 Inch Layers of Fine Sand, Occasional Gravel | FINE TO COARSE SAND | | | | |
| 20 | 5 | | | | 6.5 | 21.0 | 104.8 | 2.47 |
| 25 | 6 | | Gray, Saturated, Medium Compact, 15 to 20 Percent Gravel and Cobbles to 10 Inches, with 2 Inch Layers of Fine Sand | GRAVELLY FINE TO COARSE SAND | 5.0 | 16.3 | 114.0 | 3.54 |
| 29 | | | 20 to 30 Percent Gravel and Cobbles to 10 Inches | | | | | |
| 30 | 7 | | | | 3.3 | 9.9 | 125.4 | -* |
| 34 | | | | | | | | |

Continued on Drawing No. 37

* Too rocky to test.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 36 |

JOB NAME San Diego Gas & Electric Company - 230 KV Line

## SUMMARY SHEET
TOWER NO. 81 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 34 | | ▨ | Gray, Saturated, Medium Compact, 20 to 30 Percent Gravel and Cobbles to 10 Inches, with Thin Layers of Fine Sand | GRAVELLY FINE TO COARSE SAND | | | | |
| 35 | | | | | | | | |
| 36 | | | | | | | | |
| 37 | | | | | | | | |
| 38 | | | | | | | | |
| 39 | | | | | | | | |
| 40 | | | | | | | | |
| 41 | ⑧ | | | | 4.2 | 14.6 | 108.6 | 4.72 |
| 42 | | | 4 Inch Layer of Clayey Fine Sand | | | | | |
| 43 | ⑨ | | 6 Inch Layer of Fine Sand | | 4.2 | 17.4 | 113.4 | 5.59 |
| 44 | | | 5 Inch Layer of Fine Sand | | | | | |
| 45 | ⑩ | | | | 5.8 | 13.6 | 119.2 | -* |
| 46 | | | | | | | | |
| 47 | | | | | | | | |

* Too rocky to test.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 37 |

# THIRD INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER STATIONS 2364+26.70 AND 2400+63.03

230 KV
San Onofre - Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company

Project No. 71-12-22A
May 5, 1972

BENTON ENGINEERING, INC.

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
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PRESIDENT - CIVIL ENGINEER

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LA MESA: 469-5654

# SOILS INVESTIGATION FOR TOWER STATIONS 2364+26.70 AND 2400+63.03

## Introduction

This is to present the results of a soils investigation conducted at the subject tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California.

This report serves as a supplement to our previous interim reports dated February 9, 1972, February 28, 1972, March 11, 1972 and March 17, 1972, all under Project No. 71-12-22A.

The objectives of this investigation were to determine the existing subsurface conditions and physical properties of the soils in order that appropriate soil parameters could be presented for designing the tower foundation along a portion of the Rainbow-Talega segment of the Transmission Line.

In order to accomplish these objectives, two borings were drilled and undisturbed samples were obtained, where possible, for laboratory testing.

## Field Investigation

Two borings were drilled with a truck-mounted rotary bucket-type drill rig supplemented by manual excavations at the locations 15 feet northerly of the tower centerline at Station 2364+26.70 and at 15 feet westerly of the tower centerline at Station 2400+63.03. The borings were drilled with great difficulty due to the presence of large boulders to depths of 7.0 feet to 11.5 feet below the existing ground surface. Upon completion of drilling, our field engineer was lowered inside the open borings to check the properties of the matrix soils around the cobbles and boulders encountered.

A continuous log of the soils encountered in the borings was recorded at the time of drilling and is shown in detail on Drawing Nos. 38 and 39.

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density and moisture contents. The results of these tests are presented on Drawing Nos. 38 and 39. Saturated and drained direct shear tests were also performed on selected undisturbed samples in order to determine strength parameters of the soils for foundation design. The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion.

For samples containing too large gravel to be sheared in regular undisturbed manner, the matrix portion of the soils was remolded to a density of 110 pounds per cubic foot under field moisture condition in the brass liner, and the remolded sample was then sheared three separate times under saturated and drained conditions at three various normal loads. The first point of the strength envelope was sheared under a small normal load of 0.5 kips per square foot. The shear specimen was remolded to its original state, saturated, drained, and a higher normal load

of 1.0 kips per square foot applied and then sample was again sheared. The sheared sample was again remolded to its original state, saturated, drained and the sample again sheared under higher normal loads of 2.0 kips per square foot. The results of the shear tests are tabulated below:

| Tower Sites | Sample No. | Depth in Feet | Soil Description | Shear Resistance in kips/sq ft Under Normal Load of 0.5 (Kips per sq. ft.) | 1.0 | 2.0 | Apparent Cohesion (lb/sq ft) Tested | Recommended | Angle of Internal Friction (Degrees) Tested | Recommended |
|---|---|---|---|---|---|---|---|---|---|---|
| 2364+ 26.70 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.47 | 0.34 | 0.61 | 100 | 100 * | 15 | 15 * |
| 2400+ 63.03 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.46 | 0.54 | 0.77 | 350 | 350 * | 12 | 12 * |
| | 2 | 6.5 | Clayey very fine to fine sandy gravel | 5.35 | ** | 7.28 | 4700 | 350 | 52 | 36 |
| | 3 | 11.0 | Clayey sandy Gravel. | Sample too rocky and too intact to be sheared. | | | | | | |

Note: * Strength parameters obtained from the test of matrix portion of soils around gravel and cobbles recovered in the field.

** Sample too rocky and too intact to be sheared.

## Soil Strata

At the Station 2364+26.70 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 7.0 feet. This layer was grayish-brown medium firm, and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 36 inches in diameter. The boring was terminated at a depth of 7.0 feet due to slow progress in drilling through many large boulders.

No ground water was encountered in this boring.

At the Station 2400+63.03 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 11.5 feet. This layer was grayish-brown in color and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 26 inches in diameter. The upper 1.5 feet of the layer is medium firm and porous and graded to very firm below 1.5 feet to the end of boring.

No ground water was encountered in this boring.

Because of the large boulders encountered at both tower sites, which would cause difficult drilling conditions for deep foundation construction, it may be desirable to consider the use of conventional spread footings for foundation support. A bearing value of 4500 pounds per square foot may be used for a 3 feet wide square footing placed at a minimum depth of 1 foot into the lowest adjacent undisturbed ground surface. For each additional foot below this depth, an increase of 900 pounds per square foot may be used up to a maximum bearing value of 8000 pounds per square foot.

Respectfully submitted,

BENTON ENGINEERING, INC.

By S. H. Shu
S. H. Shu, Civil Engineer

Reviewed by Philip H. Benton
Philip H. Benton, Civil Engineer

Distr: San Diego Gas & Electric Company, San Diego
(3) Attention: Mr. John Burton
San Diego Gas & Electric Company, Chula Vista
(2) Attention: Mr. Lloyd Wilson

SHS/PHB/ew

JOB NAME San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET
## STATION 2364+26.70
15' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | Gray-brown, Slightly Moist, Medium Firm, Some Medium and Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulder to 36 Inches | CLAYEY VERY FINE TO FINE SANDY GRAVEL | | | | | |
| 1 | ① | | | | 9.7 | 6.3 | * (168.0) | | |
| 2 | | | | | | | | | |
| | | | 24 Inch Boulder | | | | | | |
| 3 | | | Light Brown | | | | | | |
| | | | 20 Inch Boulder | | | | | | |
| 4 | | | 36 Inch Boulder | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | 24 Inch Boulder | | | | | | |
| | | | 20 Inch Boulder | | | | | | |
| 7 | | | | | | | | | |

* Too rocky and disturbed. The figure in the parenthesis was the unit weight of the rock portion only.

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 38 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET
## STATION 2400+63.03
15' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0<br>1<br>2 | ① | ▨ | Gray-brown, Dry, Medium Firm, Some Medium to Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulders to 26 Inch, Porous to 1.5 Feet | CLAYEY VERY FINE TO FINE SANDY GRAVEL | 9.7 | 7.4 | 108.9 | | |
| 3 | | ▨ | 20 Inch Boulder | | | | | | |
| | | ▨ | Light Brown, Slightly Moist, Very Firm | | | | | | |
| 4<br>5 | | ▨ | 26 Inch Boulder | | | | | | |
| 6<br>7<br>8<br>9 | ② | ▨ | 20 Inch Boulder | | 65.0 | 7.6 | 136.8 | | |
| 10 | | ▨ | 25 Inch Boulder | | | | | | |
| 11 | ③ | ▨ | 26 Inch Boulder | | 42.5 | 7.3 | 118.9 | | |

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

PROJECT NO. 71-12-22A

BENTON ENGINEERING, INC.

DRAWING NO. 39

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
5540 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

TELEPHONE (714) 565-1955

## APPENDIX A

### Unified Soil Classification Chart*

| SOIL DESCRIPTION | | GROUP SYMBOL | TYPICAL NAMES |
|---|---|---|---|
| I. COARSE GRAINED, More than half of material is larger than No. 200 sieve size.** | | | |
| GRAVELS<br>More than half of coarse fraction is larger than No. 4 sieve size but smaller than 3 inches | CLEAN GRAVELS | GW | Well graded gravels, gravel-sand mixtures, little or no fines. |
| | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. |
| | GRAVELS WITH FINES (Appreciable amount of fines) | GM | Silty gravels, poorly graded gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, poorly graded gravel-sand-clay mixtures. |
| SANDS<br>More than half of coarse fraction is smaller than No. 4 sieve size | CLEAN SANDS | SW | Well graded sand, gravelly sands, little or no fines. |
| | | SP | Poorly graded sands, gravelly sands, little or no fines. |
| | SANDS WITH FINES (Appreciable amount of fines) | SM | Silty sands, poorly graded sand-silt mixtures. |
| | | SC | Clayey sands, poorly graded sand-clay mixtures. |
| II. FINE GRAINED, More than half of material is smaller than No. 200 sieve size.** | SILTS AND CLAYS | ML | Inorganic silts and very fine sands, rock flour, sandy silt or clayey-silt-sand mixtures with slight plasticity. |
| | Liquid Limit<br>Less than 50 | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILTS AND CLAYS | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | Liquid Limit<br>Greater than 50 | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of medium to high plasticity |
| III. HIGHLY ORGANIC SOILS | | PT | Peat and other highly organic soils. |

* Adopted by the Corps of Engineers and Bureau of Reclamation in January, 1952.

** All sieve sizes on this chart are U. S. Standard.

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TELEPHONE (714) 565-1955

# APPENDIX B

## Sampling

The undisturbed soil samples are obtained by forcing a special sampling tube into the undisturbed soils at the bottom of the boring, at frequent intervals below the ground surface. The sampling tube consists of a steel barrel 3.0 inches outside diameter, with a special cutting tip on one end and a double ball valve on the other, and with a lining of twelve thin brass rings, each one inch long by 2.42 inches inside diameter. The sampler, connected to a twelve inch long waste barrel, is either pushed or driven approximately 18 inches into the soil and a six inch section of the center portion of the sample is taken for laboratory tests, the soil being still confined in the brass rings, after extraction from the sampler tube. The samples are taken to the laboratory in close fitting waterproof containers in order to retain the field moisture until completion of the tests. The driving energy is calculated as the average energy in foot-kips required to force the sampling tube through one foot of soil at the depth at which the sample is obtained.

## Shear Tests

The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Each sample is sheared under a normal load equivalent to the weight of the soil above the point of sampling. In some instances, samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion. Where considered necessary, samples are saturated and drained before shearing in order to simulate extreme field moisture conditions.

## Consolidation Tests

The apparatus used for the consolidation tests is designed to receive one of the one inch high rings of soil as it comes from the field. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. Generally, each increment of load is maintained on the sample until the rate of deformation is equal to or less than 1/10000 inch per hour. Porous stones are placed in contact with the top and bottom of each specimen to permit the ready addition or release of water.

## Expansion Tests

One inch high samples confined in the brass rings are permitted to air dry at 105° F for at least 48 hours prior to placing into the expansion apparatus. A unit load of 500 pounds per square foot is then applied to the upper porous stone in contact with the top of each sample. Water is permitted to contact both the top and bottom of each sample through porous stones. Continuous observations are made until downward movement stops. The dial reading is recorded and expansion is recorded until the rate of upward movement is less than 1/10000 inch per hour.

G407

Geotechnical Report

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February 28, 1972

San Diego Gas & Electric Company
P. O. Box 1831
San Diego, California 92112

Attention: Mr. John Burton

Subject: Project No. 71-12-22A
Report of Seismic Investigation
230 KV San Onofre-Escondido Line
San Diego County, Claifornia

Gentlemen:

This is to transmit to you three copies of Mr. T. Funnekotter's report entitled "Subsurface Investigation, Tower Sites, 230 KV Line, San Diego County, California," dated February 21, 1972, and his addenda entitled, "Subsurface Investigation, Tower Sites, 230 KV Line, Stations 112, 113, and 114," dated February 25, 1972. Mr. Funnekotter's subsurface seismic investigation of selected tower sites was made in conjunction with our report of Project No. 71-12-22A entitled, "Interim Report, Soils Investigation, 230 KV San Onofre-Escondido Line, San Diego County, California," dated February 9, 1972.

We are transmitting under separate cover two copies to Mr C. Hjalmarson of the San Diego Gas & Electric Company, Chula Vista office.

Comments contained within the body of Mr. Funnekotter's report describe the relationships between seismic velocities determined with a portable engineering seismograph and rock types observed during his reconnaissance of each site. According to our agreement, the following tower sites were investigated: 1 through 19, 32, 59, 108, 109, 110, 112, 113, 114, 120 and 160. Tower No. 108 was visited by Mr. Funnekotter and observed to be an outcrop of solid grantic rock and therefore seismic velocities were not determined for that point. Also, Tower Nos. 111, 112, and 113 as per original agreement have apparently been changed to Nos. 112, 113, and 114, respectively.

In general, he found velocities of 1200 to 1500 feet per second in soil and alluvium, 2000 to 3800 feet per second in decomposed and fractured grantic and metamorphic rocks, and 7000 to 9000 feet per second in dense massive fresh granitic and metamorphic bedrock. He further suggested that materials with a velocity up to 3800 feet per second may be drillable with a "drilling machine".

We have made our own correlations between the seismic velocities vs. penetration of our bucket-type rotary drilling rig, at individual towers, or adjacent towers in a similar rock formation, which were investigated by both seismic and drilling methods and feel that the following may be used as a reasonable guide:

Up to 2500 feet per second - Drillable
2500 to 3200 feet per second - Marginal
More than 3200 feet per second - Little or no penetration, practical refusal, less than 1 foot per hour.

Certainly a rotary auger type drill rig capable of exerting hydraulic down pressure could penetrate formations which would stop a bucket-type rig, and in that case the limits set above could be increased. Encounters with fresh dense boulder floaters within otherwise drillable materials will of course stop either a rotary bucket or auger type of drill rig.

If you have any question after reviewing Mr. Funnekotter's report, please do not hesitate to contact this office.

This opportunity to be of service is sincerely appreciated.

Respectfully submitted,

BENTON ENGINEERING, INC.

By William J. Elliott
William J. Elliott, R.G. 1101

Distr: (3) Addressee
(2) San Diego Gas & Electric Co., Chula Vista
Attention: Mr. C. Hjalmarson

**T. FUNNEKOTTER**
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**ENGINEERING GEOLOGY**

GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines - Roads
Seismic Rippability Studies

# SUBSURFACE INVESTIGATION
# TOWER SITES 230 KV LINE

San Diego County, California
February 21, 1972

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GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines · Roads
Seismic Rippability Studies

Purpose: To evaluate subsurface conditions at selected tower sites for a 230 KV line in order to determine what excavation and drilling problems may be anticipated.

Method: Refraction Seismography. Geologic reconnaissance.

Discussion: The tower sites are situated primarily on two types of rock units, metamorphosed sedimentary strata and granitics. The metamorphosed sedimentary strata is mainly argillite, schist, and quartzite. The high line crosses the contacts of these two units at several locations. The velocity profile identifies at each location the visible surface material as follows:

GR - granitics
M - metamorphosed sedimentary strata

Fifty three Seismic traverses were run between station number 1 and station 160. Most runs were made at 45 degrees to the line - exceptions are noted on the location plat. From one to three layers were mapped in the following velocity ranges:

1200 to 1500 ft/sec - soil and alluvium
2000 to 3800 ft/sec - decomposed and fractured granitic and metasedimentary strata
7000 to 9000 ft/sec - dense, massive parent rock.

The soil and alluvium is up to 12 feet deep and the

Discussion: (con't)

decomposed material is from 6 feet to over 36 feet deep High velocity material was located on stations 1,2,3,5, 6,9,16,18,19,32 from 6 feet to 35 feet deep. The rest of the lines indicate that the intermediate velocity zone has a range of 2000 ft/sec to 3800 ft/sec from a minimum depth of 25 feet to over 34 feet. Virtually all runs indicate boulders either scattered or heavily concentrated as indicated on the profile. Very large boulders are also indicated on the profile.

On site 5 there is a large outcrop immediately upslope from the runs. At site 16 the traverse is entering an outcrop at the end of run 16B. At site 109, a very heavy concentration of large boulders exists in the first 40 feet of the run (0 to .4). In the vicinity of station 113 at the top of the mountain a test was made directly on top of the rock - this showed a veloci of 9000 ft/sec. Station 160 is a unique situation in that the velocity is very low to a considerable depth. The material appears to be depositional in nature with rounded small rock fragments up to boulders. This area appears to be severely eroded water deposits.

Conclusion: The project exhibits a wide range of Seismic velocities from very soft to very hard material. The material is also highly varied - from stream deposits to decomposed to rigid igneous and metamorphic rock. Most of the sites appear to be rippable with a D-9 Cat. In terms of rippability, the following schedule should apply for the types of material encountered:

| Velocity (ft/sec) | Excavation Method |
|---|---|
| 0 to 2000 | Scraper |
| 2000 to 5000 | Ripper |
| 5000 to 5500 | Marginal |
| Over 5500 | Drill & Shoot. |

In order to correlate a drilling machine to the Seismic velocities to determine its capability, the following selection is made:

| Station | Velocity (ft/sec) |
|---|---|
| 160 | 2100 |
| 120 | 2400 |
| 59 | 2500 |
| 8 | 3000 |
| 7 | 3100 |
| 12 | 3300 |
| 14 | 3600 |
| 10 | 3800 |

The entire project has a considerable amount of rock fragments contained in the overburden - the above selection appears to be most free of rubble. This should make for better correlations.

Conclusion: (con't)

These stations also show good Seismic evidence. So this selection is a compromise between avoiding rubble and boulders and good Seismic information.

Submitted by

T. Funnekotter

T. Funnekotter

# SEISMIC - RIPPABILITY INFORMATION

The following points should be considered when evaluating Seismic information:

1. All velocities, depths, and thicknesses are averages and qualified according to the following schedule:

   G - good
   F - fair
   P - poor
   VP - very poor
   ? - questionable

   Grades of G, F, and P can be considered reliable; VP and ? should be considered as indications only.

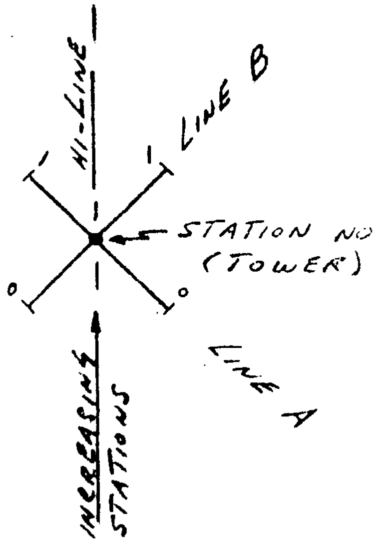
2. Each profile provides information in the immediate area of that profile - extrapolation outward from this area must be considered speculative unless additional information is available.

3. As the velocity of the material increases, ripping becomes progressively more difficult until at some point it is more economical to drill and shoot the material prior to excavation. This point occurs within the marginal zone. Rippability figures vary with the type of material, however, in general, D-9 ripper performance is as follows:

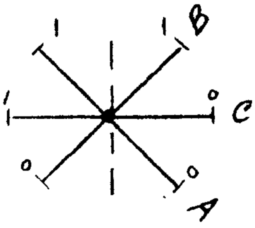
| Velocity Range (ft/sec) | Excavation Method |
|---|---|
| 0 to 2000 | Scraper |
| 2000 to 5000 | Ripper |
| 5000 to 5500 | Marginal |
| Over 5500 | Blasting |

   These figures are based on several hundred job studies.

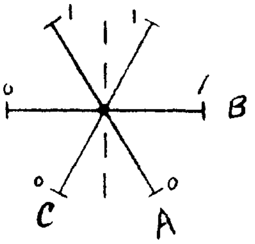
4. For trencher and backhoe operations the rippability figures must be adjusted downward, i.e., velocities as low as 3500 ft/sec may indicate material that is not rippable, depending on the homogeneity of that material, whereas material measuring over 4300 ft/sec almost certainly would require explosive work. As an average, materials measuring over 3800 ft/sec would mean difficult trenching and the economics of the situation would probably dictate explosive work first. The above figures are based on a machine similar to the Kohring 505.



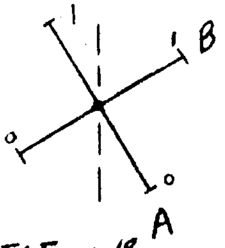
ALL RUNS EXCEPT THOSE INDICATED BELOW ARE ORIENTED AS SHOWN ON LEFT – APPROXIMATELY 45° TO LINE OF STATIONS. IF LINE TURNS, THE RUN IS 45° TO NEW (INCREASING STATION) DIRECTION.



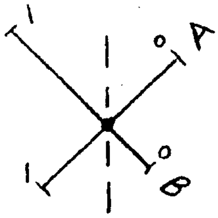
STATION 2,5



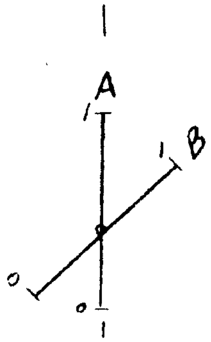
STATION 16



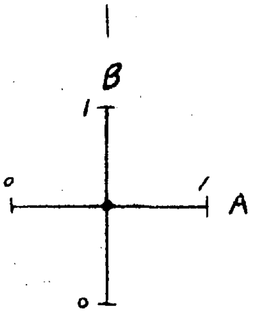
STATION 19



STATION 7



STATION 17

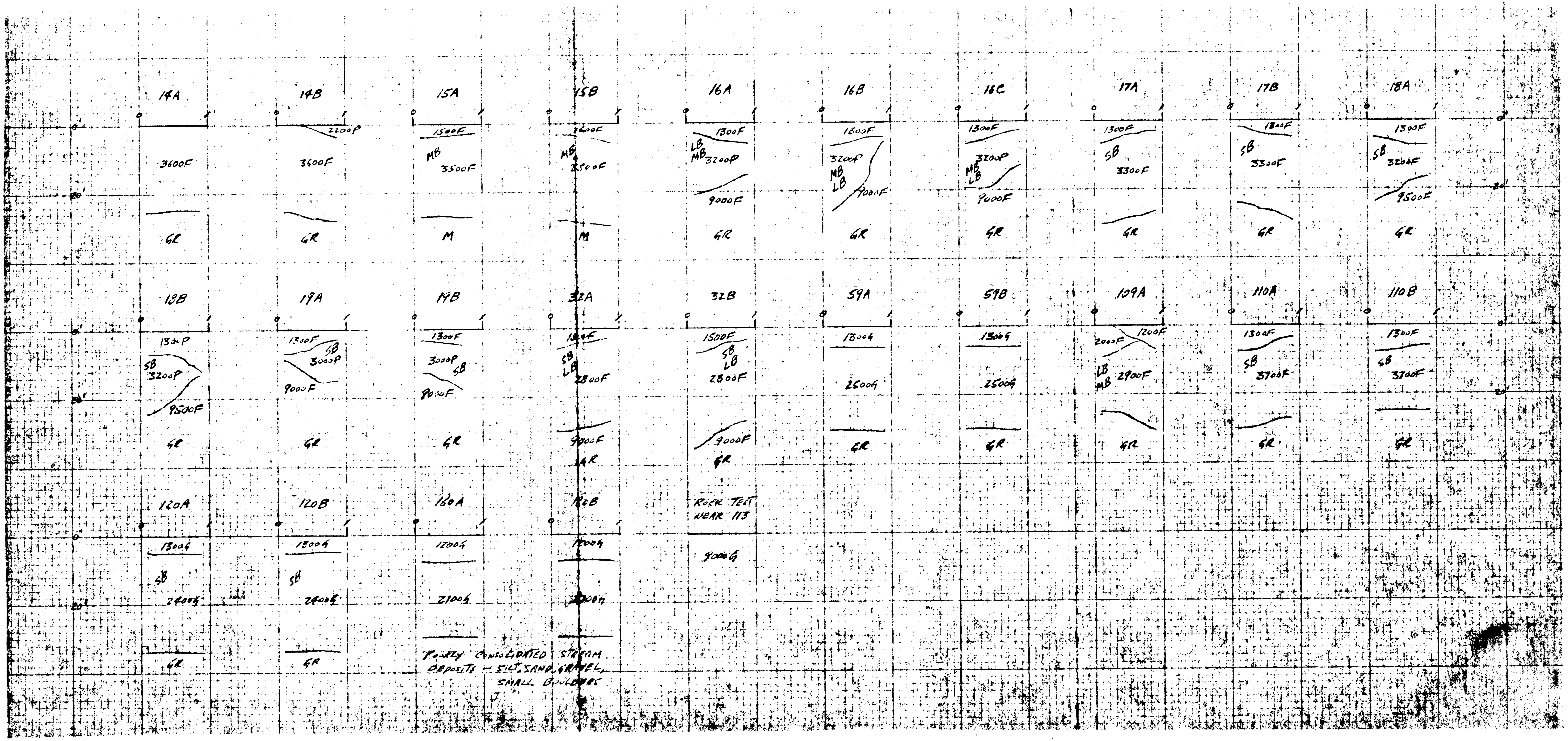


STATION 160

1" = 100'

# VELOCITY PROFILE

SB SCATTERED BOULDERS
MB MANY BOULDERS
LB LARGE BOULDERS
GR GRANITE
M METAMORPHOSED SEDIMENTARY



ROCK TEST
NEAR 113

9000G

POORLY CONSOLIDATED STREAM
DEPOSITS – SILT, SAND, GRAVEL,
SMALL BOULDERS

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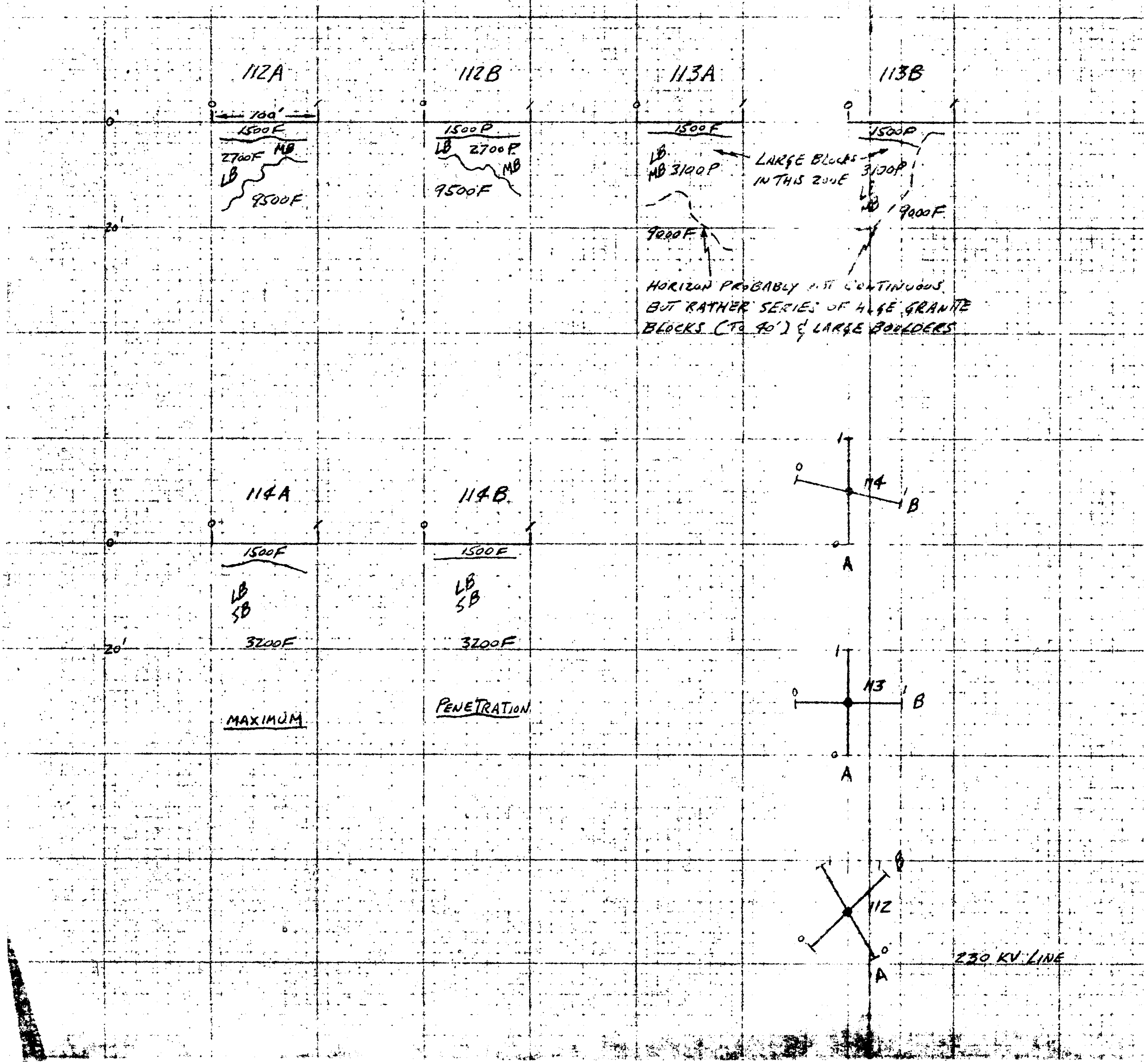
# ADDENDA

## SUBSURFACE INVESTIGATION
## TOWER SITES 230 KV LINE
## Stations 112,113,&114

Discussion: All these stations are west of Highway 395 - 114 is at the very top of the mountain. The material is granitic. The higher reaches are solid granite outcrops - the flanks are composed of decomposed granite and huge blocks (up to 40 and 50 feet) and boulders that have drifted down. This appears to be the major condition of the slopes although granite outcrops can also be seen here.

High velocity granite was located at station 112 from 6 feet to 17 feet deep with large boulders within the overburden. Station 113 appears to be comprised of hug blocks and boulders rather than a clearly defined high velocity horizon. Station 114 is in a saddle on top of the mountain and appears to be large boulders scattere within a softer decomposed granite matrix. No high velocity horizon was located here to approximately 34 feet. This is especially interesting since a large northerly plunging outcrop is present just to the sout of line B.

Conclusion: A most distinctive feature of these locations are the size of the boulders and blocks - the boulders are from a few feet in diameter to over 20 feet, the blocks are upwards of 40 and 50 feet. A high velocity horizon was located on station 112 at 6 feet to 17 feet deep. The granite horizon was also located on station 113 but her it is ill defined - probably a series of huge granite blocks. The thickest overburden was located at station 114 at the top of the mountain.


112A
112B
113A
113B
0
100'
1500F
2700F
MB
LB
9500F
20'
1500P
LB
2700P
MB
9500F
1500F
LB
MB 3100P
LARGE BLOCKS
IN THIS ZONE
9000F
1500P
3100P
LB
MB
9000F
HORIZON PROBABLY NOT CONTINUOUS
BUT RATHER SERIES OF HUGE GRANITE
BLOCKS (TO 40') & LARGE BOULDERS
114A
114B
1500F
LB
SB
3200F
1500F
LB
SB
3200F
20'
MAXIMUM
PENETRATION
114
A
B
113
A
B
112
A
B
230 KV LINE

**G407**

**Geotechnical Report**

# SECOND INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER NO. 81
# AND
# GEOLOGIC DESCRIPTIONS FOR TOWER NOS. 25, 50, 79 and 85

230 KV
San Onofre-Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company
~~Project 12-7274~~

Project No. 71-12-22A
March 11, 1972

BENTON ENGINEERING, INC.

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DRAWINGS — Drawing No.

APPENDICES

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71-12-22A

# SOILS INVESTIGATION FOR TOWER NO. 81
# AND
# GEOLOGIC DESCRIPTIONS FOR TOWER NOS. 25, 50, 79 and 85

## Introduction

This is to present the results of a soils investigation and a geological investigation conducted at certain tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California. More specifically, this completes the investigation for the Escondido-Rainbow portion of the Transmission Line.

This investigation included field boring and laboratory testing of the subsoils underlying the site of Tower No. 81 which is located in the channel area of San Luis Rey River. Two driven pile design curves have been calculated for the design of the tower foundation support in that the fluctuating water level makes this the best type of foundation support in alluvial sand deposits in the river bottom.

Also included in this report are the geologic descriptions of the sites of Tower Nos. 25, 50, 79 and 85. This report serves as a supplement to our first interim report dated February 9, 1972, under Project No. 71-12-22A, entitled "Interim Report, Soils Investigation, 230 KV, San Onofre-Escondido Line, San Diego County, California."

## Field Investigation

One boring was drilled with a truck-mounted rotary bucket-type drill rig at a location 10 feet north of the proposed Tower No. 81 centerline. The boring was drilled to a depth of 47.0 feet below the existing ground surface. A continuous log of the soils encountered in the boring was recorded at the time of drilling and is shown in detail on Drawing Nos. 35 to 37, inclusive, each entitled "Summary Sheet."

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density, moisture content, and shearing strength except for samples too rocky to test. The shearing strengths of the soils above water table were sheared under their existing overburden pressures, and for those below water, sheared under saturated and undrained conditions and under normal loads allowing for submerged densities below the water level. The results of these tests are presented on Drawing Nos. 35 to 37, inclusive.

The general procedures used for the laboratory tests are described briefly in Appendix B.

## Soil Strata

Loose and slightly silty fine to medium sand soils with lenses and layers of fine sand were underlain at the depth of 3.0 feet by a loose fine sand to the depth of 4.8 feet. Between 4.7 and 13.0 feet was a loose fine to coarse sand which merged to a gravelly fine to coarse sand between 13.0 and 19.0 feet. Approximately 20 to 25 percent gravel was encountered between the depths of 13.0 and 16.0 feet and approximately 30 to 35 percent gravel and cobbles to 5 inches in diameter were encountered between 16.0 and 19.0 feet. Below 19.0 feet, a 6.0 feet thickness of medium compact fine to coarse sand with approximately 2 inch layers of fine sand

and occasional gravel was underlain at the depth of 25.0 feet by a medium compact gravelly fine to coarse sand to the end of boring at 47.0 feet. The gravelly fine to coarse sand layer contained approximately 15 to 20 percent gravel and cobbles to 10 inches in diameter between 25.0 feet and 29.5 feet and increased to 20 to 30 percent gravel, and cobbles between 29.5 feet and 41.5 feet. Thin layers of fine sand up to 0.5 foot in thickness were also found below a depth of 34.0 feet and to the end of the boring.

Ground water was encountered below a depth of 8.5 feet below existing ground surface on March 1, 1972. It should be noted that the rainfall for January and February, 1972 was the lowest ever recorded locally at only 0.17 inch for these two months.

## Foundation, Tower No. 81

The best probable type of foundation to be used in the Tower No. 81 site would be driven piles. Two pile design curves for 12 inch by 12 inch concrete piles and 12 inch steel H-piles are presented on the attached Drawing No. A. The pile design curves shown are based on calculations using the minimum shear strength of the soils in contact with the perimeter areas of the piles, divided by a factor of safety of 2.0 to determine the safe allowable supporting capacities of single pile. It is assumed that both H-pile and concrete piles have the same perimeter areas. Therefore the curves are applicable to both types of pile. If smaller perimeter piles are used, then the supporting capacities would be reduced in direct proportion to the ratios of the shortest outside perimeters. Due to the presence of cobbles to 10 inches below 25 feet in depth it will be easier to drive "non-displacement" "H" type steel piles than any displacement type piles.

The upper pile design curve presented on the attached Drawing No. A, entitled "Vertical Supporting Capacities of Driven Piles," presents the safe allowable downward load supporting capacities for existing ground water conditions. The lower design curve presents the safe allowable downward load supporting capacities for an water level at the ground water surface. It is recommended that the potential maximum elevation of the water should also be taken into

71-12-22A

consideration in the design. For example, if the river at this location may have 10 feet of free flowing water above the ground surface at some time during the life of the tower, then a depth of scour of 10 feet should also be assumed. This would subtract 10.6 kips supporting capacity for the upper 10 feet of pile, therefore, to compensate for this loss, the length of pile for the lower design curve for a downward load of 80 kips, should be increased by 1.5 feet.

For uplift forces, it is recommended that only one half the downward allowable load capacity be used.

Respectfully submitted,

BENTON ENGINEERING, INC.

71-12-22A

By S. H. Shu

S. H. Shu, Civil Engineer

Reviewed by Philip H. Benton

Philip H. Benton, Civil Engineer

SHS/PHB/ew

## GEOLOGIC CONDITIONS FOR TOWER NOS. 25, 50, 79 and 85

A brief description of the geological conditions observed at each site is presented as follows:

### Tower No. 25

On February 4 and 18, 1972 the site of Tower No. 25 was inspected to determine the suitability of using the existing rock outcrops for rock anchor footings. The first visit was made after the center point had been established and the second visit was made after each of the four footing points had been established. Leg No. 1 (southwest corner) and Leg No. 4, (southeast corner) are each founded upon a partly-buried relatively flat solid granodiorite boulder which measures about 30 feet in an east-west direction by about 15 feet in a north-south direction. There is a north-south trending joint near the center of the boulder dividing it into unequal parts, and except for minor surface spalling, the two portions appear to be solid massive boulders capable of adequately supporting the proposed tower legs with no additional site preparation other than drilling and setting anchor bolts.

71-12-22A

The northeast Leg, No. 3, is located on what is probably a large mostly-buried granodiorite boulder of unknown dimensions. Thin surface soil and debris should be removed from the surface of this boulder to determine if it has lateral dimensions of six or more feet in diameter and if so, it may be drilled and tested for use as a rock anchor footing. Unfortunately, this footing is located down between two very large boulders exposed on the surface. The boulder on the westerly side extends vertically up from the ground surface about six feet and in its present position will interfer with the bottom angle support structure for this leg, and will need to be removed prior to tower construction. The large boulders present easterly of the tower leg will probably not need to be removed unless they interfer with construction equipment.

The northwest Leg, No. 2, is in a location free of large surface boulders. Colluvium and rock debris cover the surface. It is possible that removal of surface debris may expose a large boulder which could be used for a rock anchor footing.

In the case of footings for both Legs 2 and 3, if large enough boulders are encountered to be used for rock anchor footings, these should be inspected to insure that no joints or cracks exist which would effectively reduce the mass of rock acting together to properly support and to serve as adequate anchorage for each leg.

### Tower No. 50

On January 4, 1972, the site of Tower No. 50 was inspected and it was determined at that time that a rotary bucket drilling rig could be moved in on existing roads with no difficulty. During a brief surface geological inspection, the site was found to be underlain by topsoils and colluvium with occasional outcrops of three to five feet diameter granodiorite boulders. Subsequently, the boring drilled at Tower No. 50, disclosed one foot of colluvium, followed by weathered granodiorite from 1.0 to 6.5 feet where the drill rig met practical refusal (drilling progress slowed to less than one foot per hour). If a rotary auger type drill rig capable of exerting hydraulic down pressure is not able to penetrate the dense very compact weathered granodiorite the required depth for concrete pier footings, a rock anchor testing program may be initiated to determine the suitability of this material for rock anchor footings.

### Tower No. 79

On January 5, 1972, the site of Tower No. 79 was viewed with binoculars from Pala Road, Highway 76, at a position about one mile to the north-northwest. The approximately located site is on a 28° westerly facing rugged slope with many 10 feet and more diameter boulders on the surface. Access is by foot only with no trails, and it was therefore concluded that a binocular look would be the most economical means of site investigation at this point in planning. The site appears to be located in an area of dark gray to black outcrop boulders about half way up the mountain slope. On the State Geologic Map (Santa Ana sheet, 1965) these outcrops are identified as Upper Jurassic marine. Similarly identified rocks crop out at Tower No. 115, which was visited on January 6, 1972. The outcrop at Tower No. 115 is a classic example of a metasedimentary gneiss with well developed foliation. The Upper Jurassic marine at Tower No. 79 is most likely similar to that found at Tower No. 115.

We anticipate that rock anchor foundations may be possible at Tower No. 79 if large partially buried boulders are present under the footing legs. This situation would be similar to that encountered at Tower No. 25 were individual tower legs were staked prior to a final inspection and decision as to the type of footing to be used.

Tower No. 85

On January 7, 1972, the site of Tower No. 85 was viewed with binoculars from a private dirt road in the SE 1/4, 20/T9S, R2W, SBBM, at a position about one half mile north-northwest. The site is located on the crest of an easterly sloping ridge which is covered with a thick mat of brush and occasional rock outcrops. Access is by foot only with no trails, and it was therefore concluded that a binocular look would be the most economical means of investigation at this point in planning. The site is located in an area of dark gray to black outcrop boulders which on the State Geologic Map (Santa Ana sheet, 1965) are identified as Mesozoic basic intrusive rocks. Similarly identified rocks crop out at Tower No. 82 which was visited on January 7, 1972. The outcrop at Tower No. 82 is a gabbro, and the boring at Tower No. 82 disclosed very dense massive gabbro boulders up to 2.5 feet in diameter floating in a silty clay matrix. Drilling was stopped at 3.5 feet due to the size and number of boulders. The Mesozoic intrusive rocks at Tower No. 85 are most likely similar to those found at Tower No. 82.

We anticipate that drilling auger holes for concrete pier footings may be extremely difficult due to the presence of hard dense floating gabbro boulders at Tower Nos. 82 and 85. Perhaps this type of footings may be attempted first, if it is usual to make an attempt, but with the probability that spread or mat type footing would be more feasible to construct by dozing out a footing below the ground surface.

Respectfully submitted,

BENTON ENGINEERING, INC.

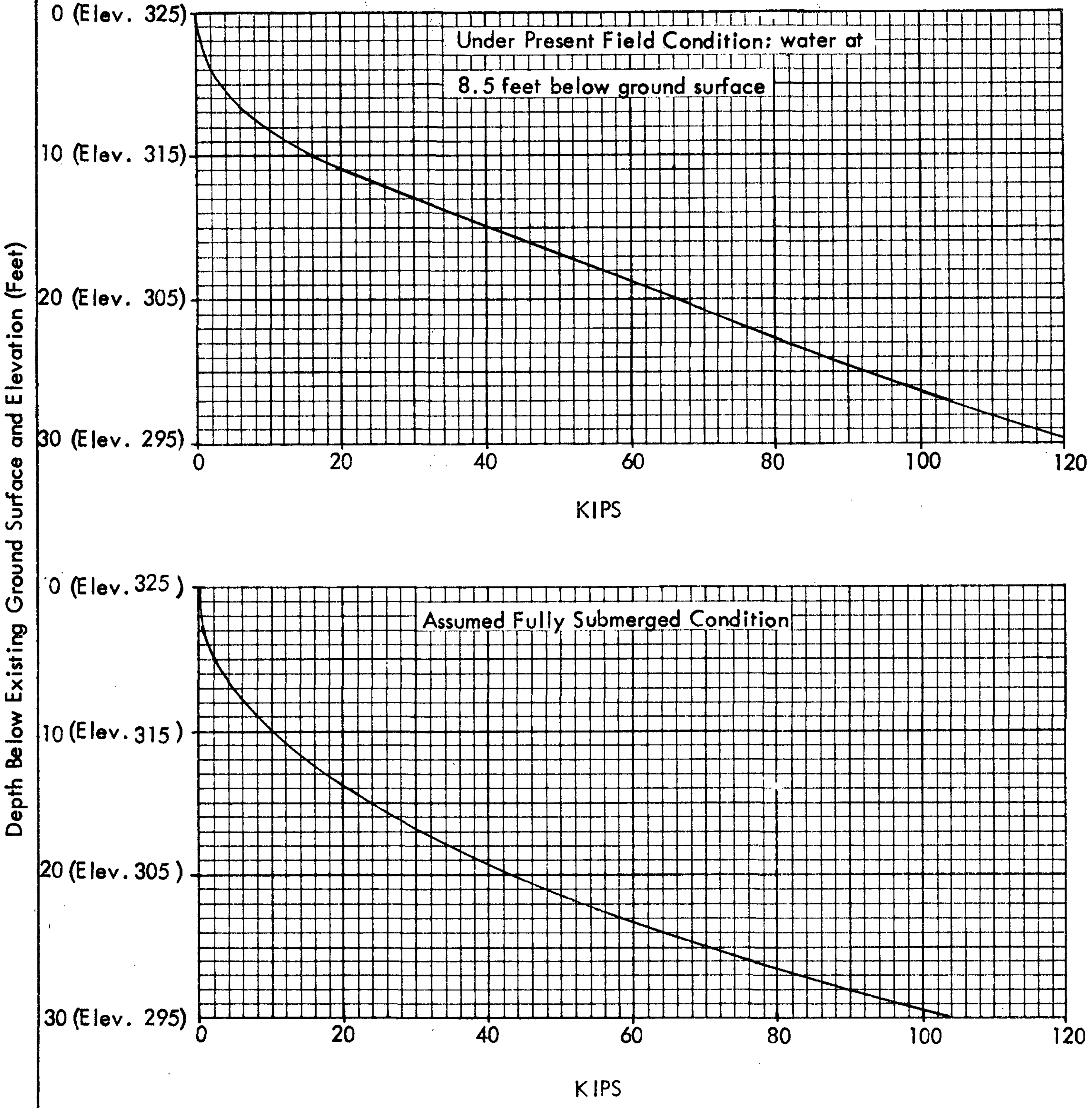
By W. J. Elliott

W. J. Elliott, R.G. 1101

Distr: San Diego Gas & Electric Company
(3) Attention: Mr. John Burton
(2) Attention: Mr. C. Hjalmarson

WJE/PHB/ew

# VERTICAL SUPPORTING CAPACITIES OF DRIVEN PILES
(12" × 12" Concrete Piles and 12" Steel H Piles)
(F.S.=2)
(Assume Existing Ground Surface Elevation = 325' From Topo. Map)



| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | A |

San Diego Gas & Electric Company - 230 KV Line

JOB NAME

# SUMMARY SHEET

TOWER NO. 81

ELEVATION 325' *

Drilled 10' North of Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0<br>1<br>2<br>3 | ① | ▨ | Light Gray, Slightly Moist, Loose, with Lenses and Layers of Fine Sand | SLIGHTLY SILTY FINE TO MEDIUM SAND | 0.8 | 6.1 | 83.0 | 0.26 | |
| 4 | | ░ | Light Gray, Slightly Moist, Loose | FINE SAND | | | | | |
| 5 | ② | | | | 0.8 | 5.3 | 90.4 | 0.52 | |
| 6<br>7<br>8 | | ░<br>Water ▽ | Light Gray, Slightly Moist, Loose, Occasional Small Gravel | FINE TO COARSE SAND | | | | | |
| 9<br>10<br>11<br>12<br>13 | ③ | ░ | Saturated | | 0.8 | 17.2 | 113.8 | 1.95 | |

Continued on Drawing No. 36

○ - Indicates undisturbed drive sample

* - The elevation shown was estimated from contour map. U.S.G.S. Map. (Scale: 1" = 2,000 Feet)

JOB NAME San Diego Gas & Electric Company - 230 KV Line

## SUMMARY SHEET
## TOWER NO. 81 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 13 | ④ | | Light Gray, Saturated, Loose, 20 to 25 Percent Gravel | GRAVELLY FINE TO COARSE SAND | 1.6 | 16.4 | 119.1 | 3.05 |
| 16 | | | 30 to 35 Percent Gravel and Cobbles to 5 Inches | | | | | |
| 19 | ⑤ | | Gray, Saturated, Medium Compact, with 2 Inch Layers of Fine Sand, Occasional Gravel | FINE TO COARSE SAND | 6.5 | 21.0 | 104.8 | 2.47 |
| 25 | ⑥ | | Gray, Saturated, Medium Compact, 15 to 20 Percent Gravel and Cobbles to 10 Inches, with 2 Inch Layers of Fine Sand | GRAVELLY FINE TO COARSE SAND | 5.0 | 16.3 | 114.0 | 3.54 |
| | ⑦ | | 20 to 30 Percent Gravel and Cobbles to 10 Inches | | 3.3 | 9.9 | 125.4 | -* |

Continued on Drawing No. 37

* Too rocky to test.

JOB NAME San Diego Gas & Electric Company - 230 KV Line

# SUMMARY SHEET

TOWER NO. 81 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 34 | | | Gray, Saturated, Medium Compact, 20 to 30 Percent Gravel and Cobbles to 10 Inches, with Thin Layers of Fine Sand | GRAVELLY FINE TO COARSE SAND | | | | |
| 35 | | | | | | | | |
| 36 | | | | | | | | |
| 37 | | | | | | | | |
| 38 | | | | | | | | |
| 39 | | | | | | | | |
| 40 | | | | | | | | |
| 41 | ⑧ | | | | 4.2 | 14.6 | 108.6 | 4.72 |
| 42 | | | 4 Inch Layer of Clayey Fine Sand | | | | | |
| 43 | ⑨ | | 6 Inch Layer of Fine Sand | | 4.2 | 17.4 | 113.4 | 5.59 |
| 44 | | | 5 Inch Layer of Fine Sand | | | | | |
| 45 | ⑩ | | | | 5.8 | 13.6 | 119.2 | -* |
| 46 | | | | | | | | |
| 47 | | | | | | | | |

* Too rocky to test.

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | BENTON ENGINEERING, INC. | 37 |

**G407**

**Geotechnical Report**

BENTON ENGINEERING, I
APPLIED SOIL MECHANICS — FOUNDATIO
6741 EL CAJON BOULEVARD
SAN DIEGO, CALIFORNIA 92115

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

SAN DIEGO: 583-5654
LA MESA: 469-5654

March 17, 1972

Pioneer Service & Engineering Company
2 North Riverside Plaza
Chicago, Illinois 60606

Attention: Mr. Stefan Trausch

Gentlemen:

In compliance with Mr. Burton's request, we have added a pile design curve of 8 inches steel H-pile under full submergence condition for Tower 81 foundation design and also assumes the existing upper 10 feet of soil either in complete suspension or washed away from the piles.

Please add this drawing, as Drawing B, to our report entitled "Second Interim Report, Soils Investigation for Tower No. 81 and Geologic Descriptions for Tower Nos. 25, 50, 79 and 85, 230 KV San Onofre-Escondido Line, San Diego County, California," under Project No. 71-12-22A and dated March 11, 1972.

If you have any questions concerning any of the data presented, please contact us.

Very truly yours,

BENTON ENGINEERING, INC.

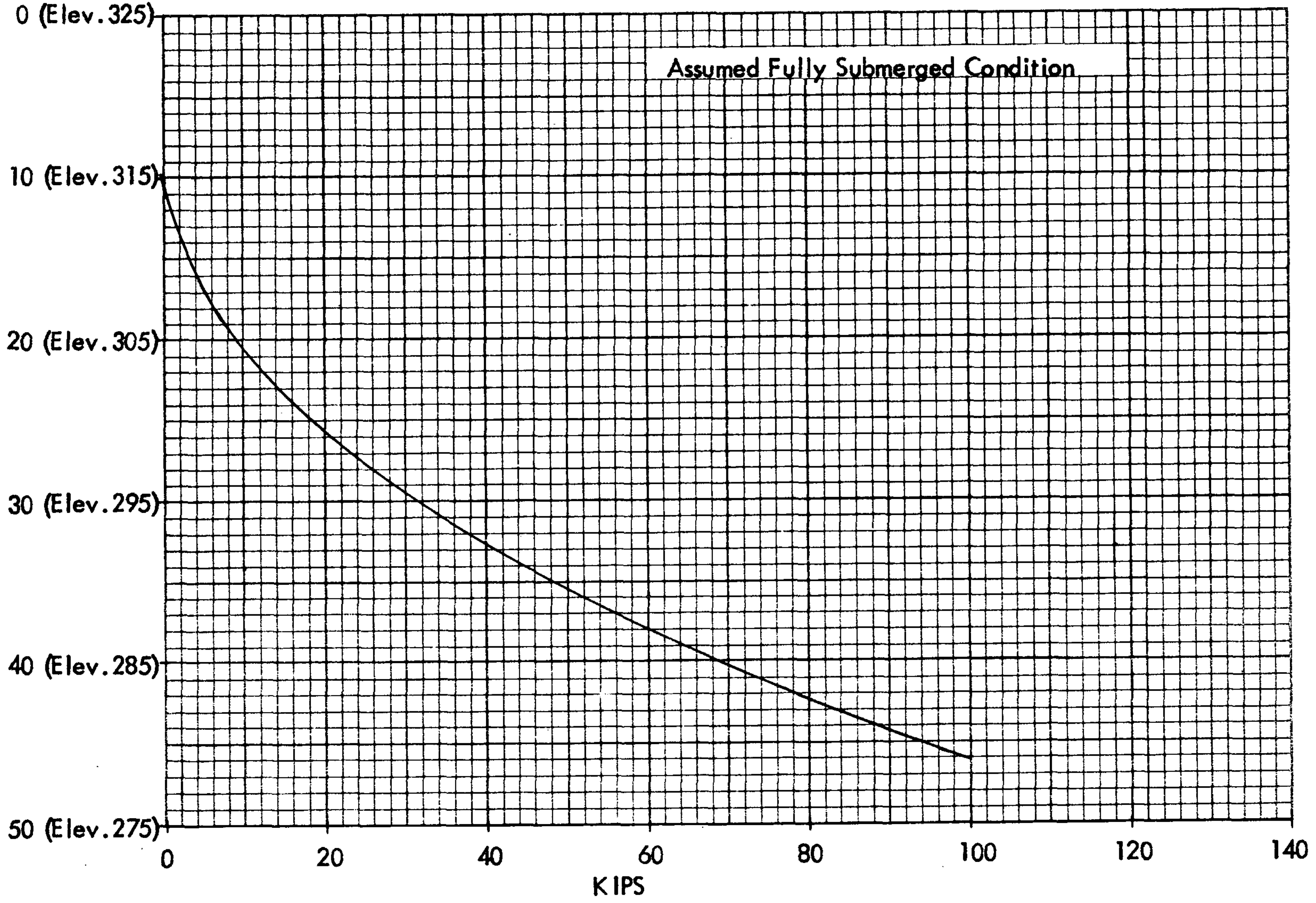
Philip H. Benton

Philip H. Benton, Civil Engineer

Distr:
(2) Addressee
(3) San Diego Gas & Electric Company, San Diego
Attention: Mr. John Burton
(2) San Diego Gas & Electric Company, Chula Vista
Attention: Mr. C. Hjalmarson

## 8" STEEL H PILES
## VERTICAL SUPPORTING CAPACITY OF DRIVEN PILES

TOWER 81
(F.S.=2)



| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 71-12-22A | **BENTON ENGINEERING, INC.** | B |

G407

Geotechnical Report

# SOILS INVESTIGATION

Proposed Steel Towers
Stations 2840+00 and 2345+76.29
San Onofre - Escondido Transmission Line
San Diego County, California

For The
San Diego Gas & Electric Company

Project No. 73-8-25A
September 20, 1973

BENTON ENGINEERING, INC.

402

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
6717 CONVOY COURT
SAN DIEGO, CALIFORNIA 92111

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

TELEPHONE (714) 565-1955

# SOILS INVESTIGATION

## Introduction

This is to present the results of a soils investigation conducted at certain proposed steel tower sites of San Onofre - Escondido Transmission Line of San Diego Gas & Electric Company. The proposed steel tower sites will be located at Stations 2840+00 and 2345+76.29 in accordance with the stationing system established by the San Diego Gas & Electric Company. A previous boring was drilled at Station 2364+26.70 and was included as part of our Project No. 71-12-22A in our report dated May 5, 1972. This report is reproduced and included as Appendix C of this report.

73-8-25A

The objectives of this investigation were to determine certain physical properties of the soils so that soil parameters could be presented for designing the steel tower foundations.

In order to accomplish these objectives, three borings were drilled as part of both this and a previous investigation and both undisturbed and loose soil samples were obtained for laboratory testing.

## Field Investigation

Two borings were drilled with a truck-mounted rotary bucket-type drill rig in the vicinity of the proposed tower locations at Stations 2840+00 and 2345+76.29. Boring 1 was drilled 50 feet south of Station 2840+00 and Boring 2 was drilled 25 feet south and 20 feet west of Station 2345+76.23. The borings were drilled to depths of 12.5 to 30.0 feet below the existing ground surface. A continuous log of the soils encountered in the two recently drilled borings was recorded at the time of drilling and is shown in detail on Drawing Nos. 1 to 3, inclusive, each entitled "Summary Sheet."

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals where possible in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

In drilling Boring 1, driller's mud was added below a depth of 2.0 feet in order to maintain a greater pressure inside the hole than that of outside and thereby prevent the sides of the boring from caving in. Also, a ripper was used in drilling below a depth of 10.5 feet at Boring 2 because of the presence of gravel and cobbles in the very firm fine to medium sandy clay matrix.

73-8-25A

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density and moisture content. The results of these tests are presented on Drawing Nos. 1 to 3, inclusive.

In addition to the above laboratory tests, an expansion test was performed on one sandy clay soils encountered to determine its volumetric change characteristics with change in moisture content. The recorded expansion of the sample is presented as follows:

| Boring No. | Sample No. | Depth of Sample, in Feet | Soil Description | Percent Expansion Under Unit Load of 500 Pounds per Square Foot from Field Moisture to Saturation |
|---|---|---|---|---|
| 2 | 1 | 3.0-4.0 | Fine to medium sandy clay | 0.83 |

Direct shear tests were performed on selected undisturbed samples that were all saturated prior to testing. The results of these tests are presented below:

| | Normal Load in kips/sq ft | Maximum Shear Load kips/sq ft | Angle of Internal Friction Degrees | Apparent Cohesion lb/sq ft |
|---|---|---|---|---|
| Boring 1, Sample 1* | 0.5 | 0.78 | 40* | 100 |
| Depth: 6.0 Feet | 1.0 | 1.46 | | |
| | 2.0 | 2.84 | | |
| Boring 1, Sample 2 | 0.5 | 0.68 | 29 | 450 |
| Depth: 10.0 Feet | 1.0 | 1.02 | | |
| | 2.0 | 1.57 | | |
| Boring 1, Sample 3 | 0.5 | 1.44 | 39 | 400 |
| Depth: 15.0 Feet | 1.0 | 1.20 | | |
| | 2.0 | 2.65 | | |
| Boring 2, Sample 1 | 0.5 | 1.28 | 35* | 430 |
| Depth: 4.0 Feet | 1.0 | - | | |
| | 2.0 | 3.80 | | |
| Boring 2, Sample 2 | 0.5 | 2.29 | 37 | 1910 |
| Depth: 9.0 Feet | 1.0 | 3.07 | | |
| | 2.0 | 3.82 | | |

* - Arbitrarily Reduced.

73-8-25A

Unconfined compression tests were performed on three clayey silt soils derived from clayey siltstone formation in Boring 1 in order to evaluate the cohesive components of the formation. The results of the tests are presented below:

| Boring No. | Sample No. | Depth in Feet | Soil Description | Unconfined Compressive Strengths lb/sq ft | Cohesive Strenghs lb/sq ft |
|---|---|---|---|---|---|
| 1 | 5 | 25.0 | Clayey siltstone | 25,300 | 12,560 |
| 1 | 6 | 30.0 | Clayey siltstone | 1,560 | 780 |

* - Failed along bedding plane.

## DISCUSSION AND RECOMMENDATIONS

### Soil Strata

At Boring 1, a loose gravelly fine to coarse sand was found to a depth of 1.0 foot. This was underlain by a medium firm gravelly silty fine to medium sand to 2.0 feet, and then merged to very compact gravelly slightly silty fine to coarse sand to 8.5 feet. Below 8.5 feet, a clayey silt (or clayey siltstone) was encountered to the end of boring at 30.0 feet. This clayey siltstone stratum was medium firm to firm between 8.5 and 13.0 feet of depth and then merged to very firm to the limit of exploration at 30.0 feet.

Ground water was found below a depth of 2.0 feet below existing ground surface and caving was encountered to a depth of 3.0 feet.

At Boring 2, a fine to medium sandy clay was found to a depth of 4.0 feet. This layer was firm to very firm to 2.0 feet and merged to very firm between 2.0 and 4.0 feet. Below 4.0 feet, a very firm gravelly fine sandy clay was found to a depth of 6.0 feet and then merged to very firm fine to medium sandy clay to the end of boring at 12.5 feet where large boulders prevented deeper exploration.

No ground water was encountered in this boring.

73-8-25A

### Recommendations

1. Pile Design Curve - Tower at Station 2840+00

In that the proposed tower in Boring 1 area is to be located in a stream, and in that ground water and caving of soils in the boring occurred, the best probable type of foundation support for this tower would be to use driven piles. Two design curves for 8 inch steel H piles were prepared as shown on the attached Drawing No. A. The derived allowable supporting capacities of the piles presented in Drawing No. A were based on the minimum shearing shearing strength of the soils in contact with the perimeter areas of the piles divided by a factor of safety of 2.0. Curves 1 and 2 were based on the assumption that the upper 2.0 and 8.5 feet, respectively, of the existing soils in the area of Boring 1 will be either in complete suspension or washed away from the piles sometime in the future. For other sizes of steel H piles, the supporting capacities may be computed by a ratio of the minimum perimeters of the piles times capacities shown on the drawing. The uplift capacity may be assumed to one half of the downward supporting capacity.

## 2. Soil Parameters for Foundation Design

The recommended strength parameters of soils for tower design in Boring 2 area are presented below:

| Depth Below Existing Ground Surface (Feet) | Angle of Internal Friction Degrees | Apparent Cohesion (lb/sq ft) | Moist Unit Weight of Soils (lb/cu ft) |
|---|---|---|---|
| 0- 4.0 | 35 | 430 | 133 |
| 4.0-12.5 | 37 | 1910 | 144 |

The upper sandy clay soils exhibit some volumetric change with change in moisture content, however, for foundations placed at a depth of 4 feet or greater below the lowest adjacent natural ground surface, the vertical movements are estimated to be minimal.

Respectfully submitted,

BENTON ENGINEERING, INC.

By
S. H. Shu, Civil Engineer

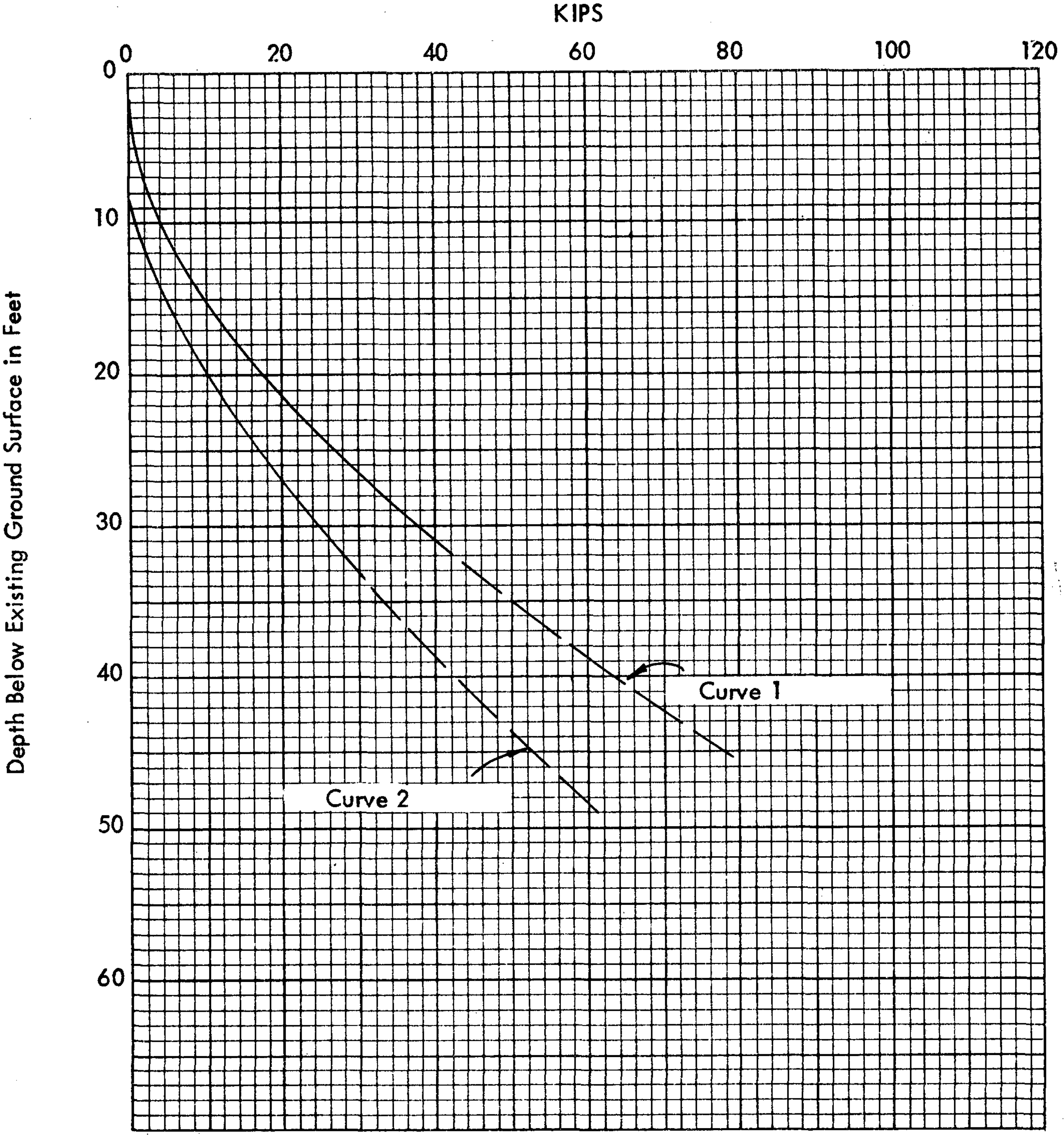
Reviewed by
Philip H. Benton, Civil Engineer

Distr: San Diego Gas & Electric Company, San Diego
(2) Attention: Mr. E. J. Brancheau
San Diego Gas & Electric Company, Carlsbad
(3) Attention: Mr. Lloyd Wilson,
Plant Construction

SHS/PHB/meg

## VERTICAL SUPPORTING CAPACITIES OF 8 INCH STEEL H PILE

(Factor of Safety 2)



Note: (1) Curve 1 assumes that the upper 2.0 feet of existing soils will be washed away sometime in the future.
Curve 2 assumes that the upper 8.5 feet of existing soils will be washed away sometime in the future.

(2) For other size of Steel H Piles, the supporting capacities may be proportioned with the perimeter of the piles.

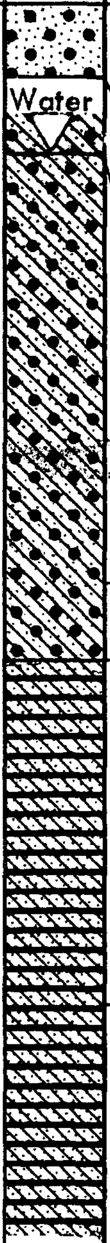
(3) Uplift capacity may be assumed to be one half of the downward capacity.

| PROJECT NO.<br>73-8-25A | BENTON ENGINEERING, INC. | DRAWING NO.<br>A |
|---|---|---|

JOB NAME S.D.G.&.E. San Onofre - Escondido Line

## SUMMARY SHEET

BORING NO. 1



| DEPTH/FEET | SAMPLE NUMBER | DESCRIPTION | SOIL CLASSIFICATION | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|
| 0 | | Gray-brown, Dry, Loose, 30 to 40 Percent Gravel and Cobbles to 4 Inches | GRAVELLY FINE TO COARSE SAND | | | | |
| | | Water | | | | | |
| | | Dark Gray-brown, Moist, Medium Firm, 20 to 30 Percent Gravel | GRAVELLY SILTY FINE TO MEDIUM SAND | | | | |
| 3 | | Gray-brown, Saturated, Very Compact, 40 to 50 Percent Gravel and Cobbles to 8 Inches | GRAVELLY SLIGHTLY SILTY FINE TO COARSE SAND | | | | |
| 5 | □ 1 | | | | | | |
| 6 | ① | | | 13.0 | 14.5 | 123.2 | - |
| | | 6 Inch Layer with Cobbles to 12 Inches | | | | | |
| | | Gray to Gray-brown, Saturated, Medium Firm to Firm, Slightly Micaceous | CLAYEY SILT LAMINATED WITH THIN LAYERS OF CLAYEY FINE SAND AND SILTY CLAY (CLAYEY SILTSTONE) | | | | |
| 10 | ② | | | 4.9 | 52.5 | 73.1 | - |
| 13 | | Dark Gray and Dark Gray-brown, Very Firm | | | | | |
| 15 | ③ | | | 11.4 | 40.4 | 82.1 | - |
| 16 | | | | | | | |

Continued on Drawing No. 3

□ - Indicates Loose Bag Sample

○ - Indicates Undisturbed Drive Sample

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 73-8-25A | BENTON ENGINEERING, INC. | 1 |

JOB NAME S.D.G.&E. San Onofre - Escondido Line

## SUMMARY SHEET

**BORING NO.** 1 (Cont.)

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 16 | | ▨ | Dark Gray and Dark Gray-brown Saturated, Very Firm | CLAYEY SILT LAMINATED WITH THIN LAYERS OF CLAYEY FINE SAND AND SILTY CLAY (CLAYEY SILTSTONE) | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |
| | ④ | | | | 26.0 | 32.9 | 85.1 | - | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| | ⑤ | | | | 60.0 | 36.1 | 81.6 | - | |
| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| | ⑥ | | | | 60.0 | 37.8 | 80.7 | - | |
| 30 | | | | | | | | | |

PROJECT NO.
73-8-25A

BENTON ENGINEERING, INC.

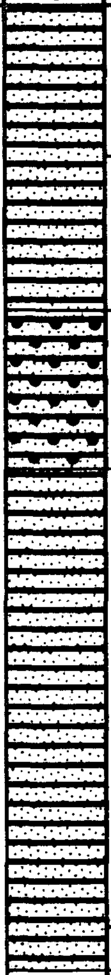
DRAWING NO.
2

JOB NAME S.D.G.&.E. San Onofre - Escondido Line

## SUMMARY SHEET

BORING NO. 2

ELEVATION 536.5'



| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS/CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | Brown, Dry, Firm to Very Firm, Occasional Rock Fragments to 24 Inches, Occasional Boulders | FINE TO MEDIUM SANDY CLAY | | | | | |
| 2 | ① | | Yellow-brown and Brown, Slightly Moist, Very Firm | (Merges) | 16.2 | 8.8 | 122.4 | - | |
| 4 | | | Light Red-brown, Slightly Moist, Very Firm, 20 to 30 Percent Gravel and Cobbles to 12 Inches | GRAVELLY FINE SANDY CLAY<br>(Merges) | | | | | |
| 6 | ② | | Brown and Red-brown, Moist, Very Firm, Occasional Gravel and Cobbles to 6 Inches | FINE TO MEDIUM SANDY CLAY | 13.0 | 9.8 | 131.0 | - | |
| 12 | | | Large Boulders | | | | | | |

| PROJECT NO. | | DRAWING NO. |
|---|---|---|
| 73-8-25A | BENTON ENGINEERING, INC. | 3 |

**BENTON ENGINEERING, INC.**
APPLIED SOIL MECHANICS — FOUNDATIONS
5840 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT · CIVIL ENGINEER

TELEPHONE (714) 565-1955

## APPENDIX A
### Unified Soil Classification Chart*

| SOIL DESCRIPTION | | GROUP SYMBOL | TYPICAL NAMES |
|---|---|---|---|
| I. COARSE GRAINED, More than half of material is larger than No. 200 sieve size.** | | | |
| GRAVELS More than half of coarse fraction is larger than No. 4 sieve size but smaller than 3 inches | CLEAN GRAVELS | GW | Well graded gravels, gravel-sand mixtures, little or no fines. |
| | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. |
| | GRAVELS WITH FINES (Appreciable amount of fines) | GM | Silty gravels, poorly graded gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, poorly graded gravel-sand-clay mixtures. |
| SANDS More than half of coarse fraction is smaller than No. 4 sieve size | CLEAN SANDS | SW | Well graded sand, gravelly sands, little or no fines. |
| | | SP | Poorly graded sands, gravelly sands, little or no fines. |
| | SANDS WITH FINES (Appreciable amount of fines) | SM | Silty sands, poorly graded sand-silt mixtures. |
| | | SC | Clayey sands, poorly graded sand-clay mixtures. |
| II. FINE GRAINED, More than half of material is smaller than No. 200 sieve size.** | SILTS AND CLAYS Liquid Limit Less than 50 | ML | Inorganic silts and very fine sands, rock flour, sandy silt or clayey-silt-sand mixtures with slight plasticity. |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILTS AND CLAYS Liquid Limit Greater than 50 | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of medium to high plasticity |
| III. HIGHLY ORGANIC SOILS | | PT | Peat and other highly organic soils. |

* Adopted by the Corps of Engineers and Bureau of Reclamation in January, 1952.
** All sieve sizes on this chart are U. S. Standard.

**BENTON ENGINEERING, INC.**
APPLIED SOIL MECHANICS — FOUNDATIONS
5540 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

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# APPENDIX B

## Sampling

The undisturbed soil samples are obtained by forcing a special sampling tube into the undisturbed soils at the bottom of the boring, at frequent intervals below the ground surface. The sampling tube consists of a steel barrel 3.0 inches outside diameter, with a special cutting tip on one end and a double ball valve on the other, and with a lining of twelve thin brass rings, each one inch long by 2.42 inches inside diameter. The sampler, connected to a twelve inch long waste barrel, is either pushed or driven approximately 18 inches into the soil and a six inch section of the center portion of the sample is taken for laboratory tests, the soil being still confined in the brass rings, after extraction from the sampler tube. The samples are taken to the laboratory in close fitting waterproof containers in order to retain the field moisture until completion of the tests. The driving energy is calculated as the average energy in foot-kips required to force the sampling tube through one foot of soil at the depth at which the sample is obtained.

## Shear Tests

The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Each sample is sheared under a normal load equivalent to the weight of the soil above the point of sampling. In some instances, samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion. Where considered necessary, samples are saturated and drained before shearing in order to simulate extreme field moisture conditions.

## Consolidation Tests

The apparatus used for the consolidation tests is designed to receive one of the one inch high rings of soil as it comes from the field. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. Generally, each increment of load is maintained on the sample until the rate of deformation is equal to or less than 1/10000 inch per hour. Porous stones are placed in contact with the top and bottom of each specimen to permit the ready addition or release of water.

## Expansion Tests

One inch high samples confined in the brass rings are permitted to air dry at 105° F for at least 48 hours prior to placing into the expansion apparatus. A unit load of 500 pounds per square foot is then applied to the upper porous stone in contact with the top of each sample. Water is permitted to contact both the top and bottom of each sample through porous stones. Continuous observations are made until downward movement stops. The dial reading is recorded and expansion is recorded until the rate of upward movement is less than 1/10000 inch per hour.

# APPENDIX C

# THIRD INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER STATIONS
# 2364+26.70 AND 2400+63.03

Project No. 71-12-22A
May 5, 1972

**Project No. 73-8-25A**
**September 20, 1973**

# THIRD INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER STATIONS
# 2364+26.70 AND 2400+63.03

230 KV
San Onofre - Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company

Project No. 71-12-22A
May 5, 1972

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS -- FOUNDATIONS
6741 EL CAJON BOULEVARD
SAN DIEGO, CALIFORNIA 92115

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

SAN DIEGO 583-5654
LA MESA 469-5654

# SOILS INVESTIGATION FOR TOWER STATIONS 2364+26.70 AND 2400+63.03

## Introduction

This is to present the results of a soils investigation conducted at the subject tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California.

This report serves as a supplement to our previous interim reports dated February 9, 1972, February 28, 1972, March 11, 1972 and March 17, 1972, all under Project No. 71-12-22A.

The objectives of this investigation were to determine the existing subsurface conditions and physical properties of the soils in order that appropriate soil parameters could be presented for designing the tower foundation along a portion of the Rainbow-Talega segment of the Transmission Line.

In order to accomplish these objectives, two borings were drilled and undisturbed samples were obtained, where possible, for laboratory testing.

## Field Investigation

Two borings were drilled with a truck-mounted rotary bucket-type drill rig supplemented by manual excavations at the locations 15 feet northerly of the tower centerline at Station 2364+26.70 and at 15 feet westerly of the tower centerline at Station 2400+63.03. The borings were drilled with great difficulty due to the presence of large boulders to depths of 7.0 feet to 11.5 feet below the existing ground surface. Upon completion of drilling, our field engineer was lowered inside the open borings to check the properties of the matrix soils around the cobbles and boulders encountered.

A continuous log of the soils encountered in the borings was recorded at the time of drilling and is shown in detail on Drawing Nos. 38 and 39.

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density and moisture contents. The results of these tests are presented on Drawing Nos. 38 and 39. Saturated and drained direct shear tests were also performed on selected undisturbed samples in order to determine strength parameters of the soils for foundation design. The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion.

For samples containing too large gravel to be sheared in regular undisturbed manner, the matrix portion of the soils was remolded to a density of 110 pounds per cubic foot under field moisture condition in the brass liner, and the remolded sample was then sheared three separate times under saturated and drained conditions at three various normal loads. The first point of the strength envelope was sheared under a small normal load of 0.5 kips per square foot. The shear specimen was remolded to its original state, saturated, drained, and a higher normal load

of 1.0 kips per square foot applied and then sample was again sheared. The sheared sample was again remolded to its original state, saturated, drained and the sample again sheared under higher normal loads of 2.0 kips per square foot. The results of the shear tests are tabulated below:

| | | | | Shear Resistance in kips/sq ft Under Normal Load of | | | Apparent Cohesion (lb/sq ft) | | Angle of Internal Friction (Degrees) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Tower Sites | Sample No. | Depth in Feet | Soil Description | 0.5 | 1.0 | 2.0 (Kips per sq. ft.) | Tested | Recommended | Tested | Recommended |
| 2364+ 26.70 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.47 | 0.34 | 0.61 | 100 | 100 * | 15 | 15 * |
| 2400+ 63.03 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.46 | 0.54 | 0.77 | 350 | 350 * | 12 | 12 * |
| | 2 | 6.5 | Clayey very fine to fine sandy gravel | 5.35 | ** | 7.28 | 4700 | 350 | 52 | 36 |
| | 3 | 11.0 | Clayey sandy Gravel | Sample too rocky and too intact to be sheared. | | | | | | |

Note: * Strength parameters obtained from the test of matrix portion of soils around gravel and cobbles recovered in the field.
** Sample too rocky and too intact to be sheared.

Soil Strata

At the Station 2364+26.70 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 7.0 feet. This layer was grayish-brown medium firm, and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 36 inches in diameter. The boring was terminated at a depth of 7.0 feet due to slow progress in drilling through many large boulders.

No ground water was encountered in this boring.

At the Station 2400+63.03 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 11.5 feet. This layer was grayish-brown in color and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 26 inches in diameter. The upper 1.5 feet of the layer is medium firm and porous and graded to very firm below 1.5 feet to the end of boring.

No ground water was encountered in this boring.

Because of the large boulders encountered at both tower sites, which would cause difficult drilling conditions for deep foundation construction, it may be desirable to consider the use of conventional spread footings for foundation support. A bearing value of 4500 pounds per square foot may be used for a 3 feet wide square footing placed at a minimum depth of 1 foot into the lowest adjacent undisturbed ground surface. For each additional foot below this depth, an increase of 900 pounds per square foot may be used up to a maximum bearing value of 8000 pounds per square foot.

Respectfully submitted,

BENTON ENGINEERING, INC.

By S. H. Shu
S. H. Shu, Civil Engineer

Reviewed by Philip H. Benton
Philip H. Benton, Civil Engineer

Distr: San Diego Gas & Electric Company, San Diego
(3) Attention: Mr. John Burton
San Diego Gas & Electric Company, Chula Vista
(2) Attention: Mr. Lloyd Wilson

SHS/PHB/ew

San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET

## STATION 2400+63.03

15' West of Tower Centerline

| DEPTH/FE | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENER FT. KIPS/F | FIELD MOISTUR % DRY W | DRY DENSI LBS./CU. F | SHEAR RESISTANC KIPS/SQ. F |
|---|---|---|---|---|---|---|---|---|
| 0<br>1 | ① | | Gray-brown, Dry, Medium Firm, Some Medium to Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulders to 26 Inch, Porous to 1.5 Feet | CLAYEY VERY FINE TO FINE SANDY GRAVEL | 9.7 | 7.4 | 108.9 | |
| 2 | | | 20 Inch Boulder | | | | | |
| 3 | | | Light Brown, Slightly Moist, Very Firm | | | | | |
| 4<br>5 | | | 26 Inch Boulder | | | | | |
| 6<br>7<br>8 | ② | | 20 Inch Boulder | | 65.0 | 7.6 | 136.8 | |
| 9<br>10 | | | 25 Inch Boulder | | | | | |
| 11 | ③ | | 26 Inch Boulder | | 42.5 | 7.3 | 118.9 | |

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

| PROJECT NO. 71-12-22A | BENTON ENGINEERING INC. | DRAWING NO 39 |
|---|---|---|

San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET

STATION 2364+26.70

15' North of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 0<br>1<br>2 | ① | | Gray-brown, Slightly Moist, Medium Firm, Some Medium and Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulder to 36 Inches | CLAYEY VERY FINE TO FINE SANDY GRAVEL | 9.7 | 6.3 | *(168.0) | |
| | | | 24 Inch Boulder | | | | | |
| 3 | | | Light Brown | | | | | |
| | | | 20 Inch Boulder | | | | | |
| 4<br>5 | | | 36 Inch Boulder | | | | | |
| 6 | | | 24 Inch Boulder | | | | | |
| 7 | | | 20 Inch Boulder | | | | | |

* Too rocky and disturbed. The figure in the parenthesis was the unit weight of the rock portion only.

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

PROJECT NO. 71-12-22A

BENTON ENGINEERING, INC.

DRAWING NO. 38

G407

Geotechnical Report

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
6741 EL CAJON BOULEVARD
SAN DIEGO, CALIFORNIA 92115

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

SAN DIEGO: 583-5654
LA MESA: 469-5654

May 5, 1972

San Diego Gas & Electric Company
P. O. Box 1831
San Diego, California 92112

Attention: Mr. John Burton

Gentlemen:

Twr # 184 Twr 187

This is to transmit to you three copies of our report of Project No. 71-12-22A entitled, "Third Interim Report, Soils Investigation For Tower Stations, 2364+26.70 And 2400+63.03, 230 KV San Onofre - Escondido Line, San Diego County, California," dated May 5, 1972.

We are transmitting under separate cover two copies to San Diego Gas & Electric Company, Chula Vista office, Attention: Mr. Lloyd Wilson.

If you should have any questions concerning any of the data presented in this report, please contact us.

Very truly yours,

BENTON ENGINEERING, INC.

Philip H. Benton, Civil Engineer

# THIRD INTERIM REPORT
# SOILS INVESTIGATION FOR TOWER STATIONS 2364+26.70 AND 2400+63.03

230 KV
San Onofre - Escondido Line
San Diego County, California

for the
San Diego Gas & Electric Company

Project No. 71-12-22A
May 5, 1972

BENTON ENGINEERING, INC.

BENTON ENGINEERING, INC.
APPLIED SOIL MECHANICS — FOUNDATIONS
6741 EL CAJON BOULEVARD
SAN DIEGO, CALIFORNIA 92115

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

SAN DIEGO: 583-5654
LA MESA: 469-5654

# SOILS INVESTIGATION FOR TOWER STATIONS 2364+26.70 AND 2400+63.03

## Introduction

This is to present the results of a soils investigation conducted at the subject tower sites for the proposed San Diego Gas & Electric Company Transmission Line from the San Onofre Power Plant to the Escondido Operating Center in San Diego County, California.

This report serves as a supplement to our previous interim reports dated February 9, 1972, February 28, 1972, March 11, 1972 and March 17, 1972, all under Project No. 71-12-22A.

The objectives of this investigation were to determine the existing subsurface conditions and physical properties of the soils in order that appropriate soil parameters could be presented for designing the tower foundation along a portion of the Rainbow-Talega segment of the Transmission Line.

In order to accomplish these objectives, two borings were drilled and undisturbed samples were obtained, where possible, for laboratory testing.

71-12-22A

## Field Investigation

Two borings were drilled with a truck-mounted rotary bucket-type drill rig supplemented by manual excavations at the locations 15 feet northerly of the tower centerline at Station 2364+26.70 and at 15 feet westerly of the tower centerline at Station 2400+63.03. The borings were drilled with great difficulty due to the presence of large boulders to depths of 7.0 feet to 11.5 feet below the existing ground surface. Upon completion of drilling, our field engineer was lowered inside the open borings to check the properties of the matrix soils around the cobbles and boulders encountered.

A continuous log of the soils encountered in the borings was recorded at the time of drilling and is shown in detail on Drawing Nos. 38 and 39.

The soils were visually classified by field identification procedures in accordance with the Unified Soil Classification Chart. A simplified description of this classification system is presented in the attached Appendix A at the end of this report.

Undisturbed samples were obtained at frequent intervals, where possible, in the soils ahead of the drilling. The drop weight used for driving the sampling tube into the soils was the "Kelly" bar of the drill rig which weighs 1623 pounds, and the average drop was 12 inches. The general procedures used in field sampling are described under "Sampling" in Appendix B.

## Laboratory Tests

Laboratory tests were performed on all undisturbed samples of the soils in order to determine the dry density and moisture contents. The results of these tests are presented on Drawing Nos. 38 and 39. Saturated and drained direct shear tests were also performed on selected undisturbed samples in order to determine strength parameters of the soils for foundation design. The shear tests are run using a direct shear machine of the strain control type in which the rate of deformation is approximately 0.05 inch per minute. The machine is so designed that the tests are made without removing the samples from the brass liner rings in which they are secured. Samples are sheared under various normal loads in order to obtain the internal angle of friction and cohesion.

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of 1.0 kips per square foot applied and then sample was again sheared. The sheared sample was again remolded to its original state, saturated, drained and the sample again sheared under higher normal loads of 2.0 kips per square foot. The results of the shear tests are tabulated below:

| Tower Sites | Sample No. | Depth in Feet | Soil Description | Shear Resistance in kips/sq ft Under Normal Load of 0.5 (Kips per sq. ft.) | 1.0 | 2.0 | Apparent Cohesion (lb/sq ft) Tested | Recommended | Angle of Internal Friction (Degrees) Tested | Recommended |
|---|---|---|---|---|---|---|---|---|---|---|
| 2364+ 26.70 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.47 | 0.34 | 0.61 | 100 | 100 * | 15 | 15 * |
| 2400+ 63.03 | 1 | 1.0 | Clayey very fine to fine sandy gravel | 0.46 | 0.54 | 0.77 | 350 | 350 * | 12 | 12 * |
| | 2 | 6.5 | Clayey very fine to fine sandy gravel | 5.35 | ** | 7.28 | 4700 | 350 | 52 | 36 |
| | 3 | 11.0 | Clayey sandy Gravel. | Sample too rocky and too intact to be sheared. | | | | | | |

Note: * Strength parameters obtained from the test of matrix portion of soils around gravel and cobbles recovered in the field.

** Sample too rocky and too intact to be sheared.

## Soil Strata

At the Station 2364+26.70 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 7.0 feet. This layer was grayish-brown medium firm, and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 36 inches in diameter. The boring was terminated at a depth of 7.0 feet due to slow progress in drilling through many large boulders.

No ground water was encountered in this boring.

At the Station 2400+63.03 Tower site, clayey very fine to fine sandy gravel was encountered throughout to the limit of exploration at 11.5 feet. This layer was grayish-brown in color and contained approximately 50 to 60 percent gravel, cobbles and boulders up to 26 inches in diameter. The upper 1.5 feet of the layer is medium firm and porous and graded to very firm below 1.5 feet to the end of boring.

No ground water was encountered in this boring.

Because of the large boulders encountered at both tower sites, which would cause difficult drilling conditions for deep foundation construction, it may be desirable to consider the use of conventional spread footings for foundation support. A bearing value of 4500 pounds per square foot may be used for a 3 feet wide square footing placed at a minimum depth of 1 foot into the lowest adjacent undisturbed ground surface. For each additional foot below this depth, an increase of 900 pounds per square foot may be used up to a maximum bearing value of 8000 pounds per square foot.

Respectfully submitted,

BENTON ENGINEERING, INC.

71-12-22A

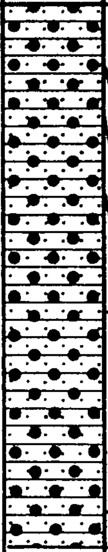
By S. H. Shu
S. H. Shu, Civil Engineer

Reviewed by Philip H. Benton
Philip H. Benton, Civil Engineer

Distr: San Diego Gas & Electric Company, San Diego
(3) Attention: Mr. John Burton
San Diego Gas & Electric Company, Chula Vista
(2) Attention: Mr. Lloyd Wilson

SHS/PHB/ew

JOB NAME San Diego Gas & Electric Co., 230 KV Line

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | SUMMARY SHEET<br>STATION 2364+26.70<br>15' North of Tower Centerline | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. | |
|---|---|---|---|---|---|---|---|---|---|
| 0<br>1<br>2 | ① |  | Gray-brown, Slightly Moist, Medium Firm, Some Medium and Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulder to 36 Inches | CLAYEY VERY FINE TO FINE SANDY GRAVEL | 9.7 | 6.3 | *<br>(168.0) | | |
| | | | 24 Inch Boulder | | | | | | |
| 3 | | | Light Brown | | | | | | |
| | | | 20 Inch Boulder | | | | | | |
| 4<br>5 | | | 36 Inch Boulder | | | | | | |
| 6 | | | 24 Inch Boulder | | | | | | |
| 7 | | | 20 Inch Boulder | | | | | | |

* Too rocky and disturbed. The figure in the parenthesis was the unit weight of the rock portion only.

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

| | | |
|---|---|---|
| PROJECT NO.<br>71-12-22A | BENTON ENGINEERING, INC. | DRAWING NO.<br>38 |

JOB NAME San Diego Gas & Electric Co., 230 KV Line

## SUMMARY SHEET
## STATION 2400+63.03
15' West of Tower Centerline

| DEPTH/FEET | SAMPLE NUMBER | SOIL CLASSIFICATION SYMBOL | | | DRIVE ENERGY FT. KIPS/FT. | FIELD MOISTURE % DRY WT. | DRY DENSITY LBS./CU. FT. | SHEAR RESISTANCE KIPS/SQ. FT. |
|---|---|---|---|---|---|---|---|---|
| 0–2.5 | ① | | Gray-brown, Dry, Medium Firm, Some Medium to Coarse Grains, 50 to 60 Percent Gravel, Cobbles and Boulders to 26 Inch, Porous to 1.5Feet | CLAYEY VERY FINE TO FINE SANDY GRAVEL | 9.7 | 7.4 | 108.9 | |
| 2.5–3 | | | 20 Inch Boulder | | | | | |
| 3–4 | | | Light Brown, Slightly Moist, Very Firm | | | | | |
| 4–6 | | | 26 Inch Boulder | | | | | |
| 6–9 | ② | | 20 Inch Boulder | | 65.0 | 7.6 | 136.8 | |
| 9–10.5 | | | 25 Inch Boulder | | | | | |
| 10.5–11.5 | ③ | | 26 Inch Boulder | | 42.5 | 7.3 | 118.9 | |

Note: Boring was terminated due to very slow progress in removing large, oversized boulders by hand.

PROJECT NO. 71-12-22A

BENTON ENGINEERING, INC.

DRAWING NO. 39

G407

**T. FUNNEKOTTER**
REGISTERED GEOLOGIST
CERTIFIED ENGINEERING GEOLOGIST
P. O. BOX 575 - ESCONDIDO, CALIF. 92025
746-2793

**ENGINEERING GEOLOGY**

GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines - Roads
Seismic Rippability Studies

June 28,1976

San Diego Gas & Electric Co.
P.O.Box 1831
San Diego,Calif. 92112
Attn: J.C.Burton Civil Engineer

Dear Sir,

Enclosed is the Subsurface Investigation Report of the 69 KV Undergrounding Project in Escondido. The primary excavation problem that I see is the boulder situation - very few areas exhibit near surface rock structures, at least along the lines investigated. High velocity massive rock was located on many lines but appears to be mostly near a depth of 20 feet. A few exceptions exist as noted.

Very truly yours,

Ted Funnekotter

Ted Funnekotter

**T. FUNNEKOTTER**
REGISTERED GEOLOGIST
CERTIFIED ENGINEERING GEOLOGIST
P. O. BOX 575 - ESCONDIDO, CALIF. 92025
746-2793

**ENGINEERING GEOLOGY**

GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines - Roads
Seismic Rippability Studies

# SUBSURFACE INVESTIGATION

## 69 KV UNDERGROUNDING PROJECT
## ESCONDIDO, CALIFORNIA
## SAN DIEGO GAS & ELECTRIC CO.

JUNE 28,1976

**T. FUNNEKOTTER**
REGISTERED GEOLOGIST
CERTIFIED ENGINEERING GEOLOGIST
P. O. BOX 575 - ESCONDIDO, CALIF. 92025
746-2793

**ENGINEERING GEOLOGY**

GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines - Roads
Seismic Rippability Studies

PURPOSE: To evaluate subsurface conditions along fourteen select areas for a 69 KV undergrounding project in order to determine what excavation problems may be expected.

METHOD: Geologic reconnaissance. Refraction Seismography.

DISCUSSION: The areas investigated are composed of two basic materials, i.e., granite (GR) and metamorphic (M) materials and their decomposed and fractured products. The metamorphic rock is principally argillite, schist, and quartzite. These two major classifications are used to identify the materials on each line - either GR or M or combination of both.

Fourteen Seismic traverses were run - these are 100 to 150 feet long - their approximate locations are shown on the enclosed maps.

Two to three velocity layers were located, i.e., soil and alluvium, decomposed and fractured material, and the high velocity material. These layers fall within the following velocity ranges: 1100 - 2000 ft/sec, 2600 - 4000 ft/sec, and 7000 - 9000 ft/sec. For reference each location is noted from the beginning station number of that run, i.e., line 96 is the run from station 96 to 97, etc. The following are the more pertinent results of each run:

DISCUSSION: Lines 96 and 101 - soil layer 3 to 5 feet - middle zone velocity 2600 to 3000 ft/sec - many boulders and large as noted.

Lines 107 and 112+50 - soil layer 3 to 9 feet - intermediate zone velocity 3800 to 4000 ft/sec - note high velocity material rising on line 112+50.

Lines 124+50 and 129+50 - approximately 3 feet soil - 2700 to 3000 ft/sec intermediate zone velocity.

Lines 143+50, 145+50, and 151+50 - 3 to 5 feet of soil - middle zone velocity 3100 to 3500 ft/sec - no high velocity material encountered. Probably fractured rock and boulders near hill.

Line 162+70 - soil 5 feet - maximum velocity is 3500 ft/sec to 15 feet.

Line 166 - soil with boulders 3 to 4 feet thick - many large boulders in 3400 ft/sec material.

Line 168+50 - soil 3 feet thick - maximum velocity of 3000 ft/sec to 21 feet.

Line 171+50 - thick soil and alluvium to 9 feet - 3600 ft/sec material to 20 feet.

Line 174+20 - thick alluvium and soil 8 to 12 feet - high velocity granite at 8 to 12 feet deep.

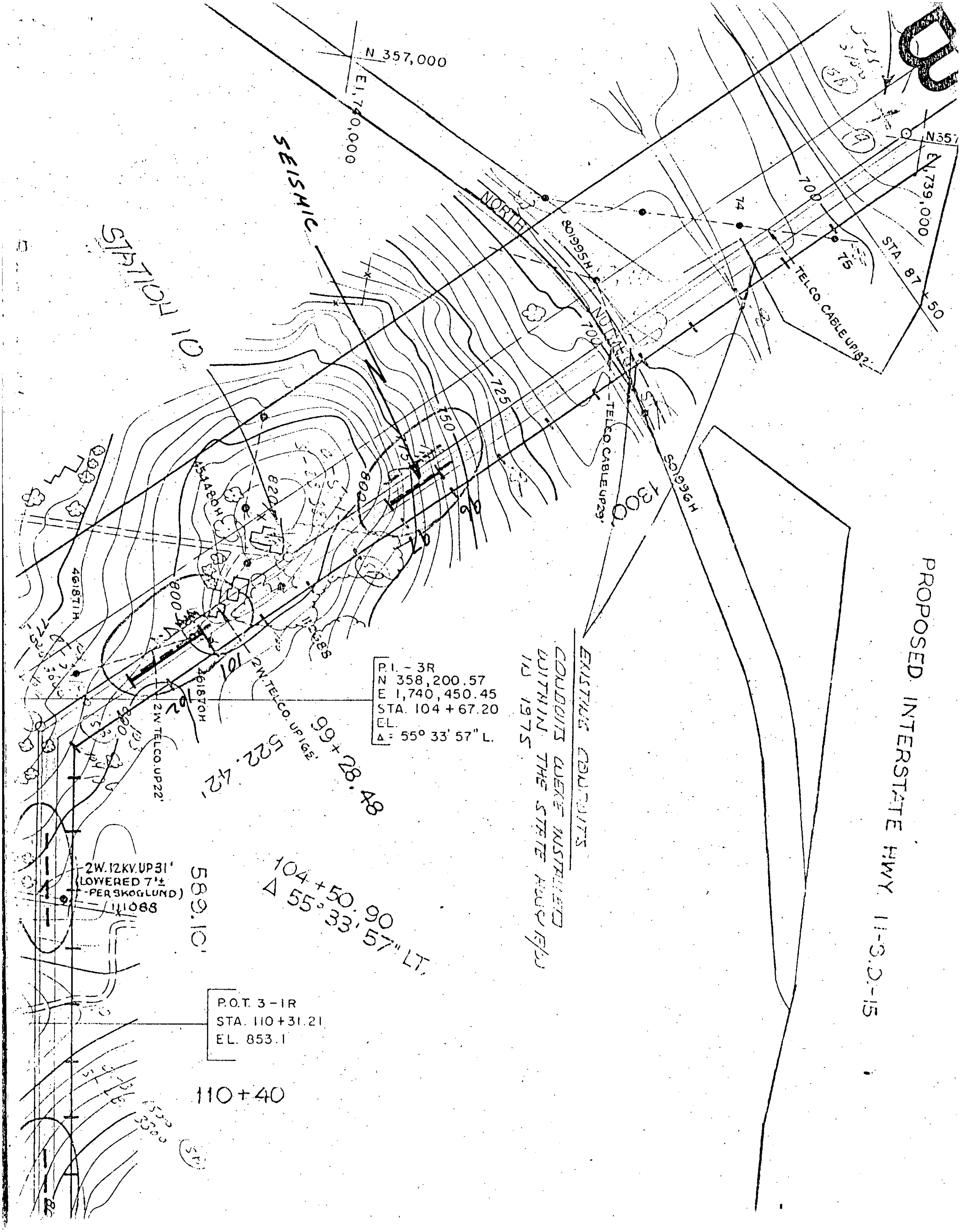
CONCLUSION: The main problem areas, mainly because of the presence, size and quantity of boulders/blocks are

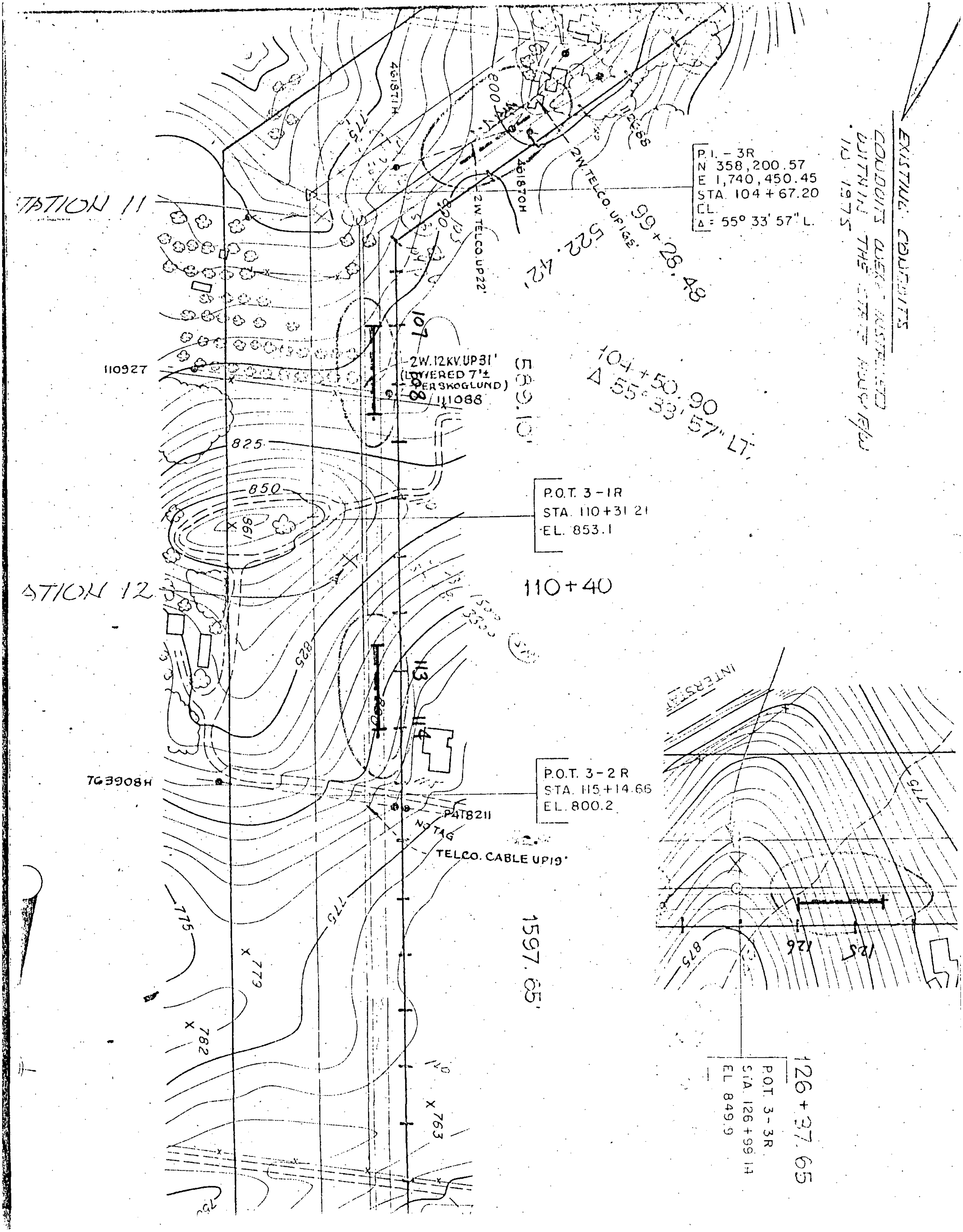
CONCLUSION: lines 96 and 101 and that immediate area, lines 145+50 and 151+50 and between, and lines 166 and 168+50 and vicinity. Boulders and broken rock are especially pronounced in the area of stations 166 to 169. High velocity structures were encountered on most lines, however they appear to be below the proposed cut depth. The most notable exception may be the rising trend of the high velocity layer near station 175+70. The soil and alluvium layer appears to average about 3 to 4 feet thick - at several sites it is about 8 feet thick. The intermediate zone layer is mostly in the 3000 to 3500 ft/sec range. This intermediate layer will be penetrated in most cases by the excavation.

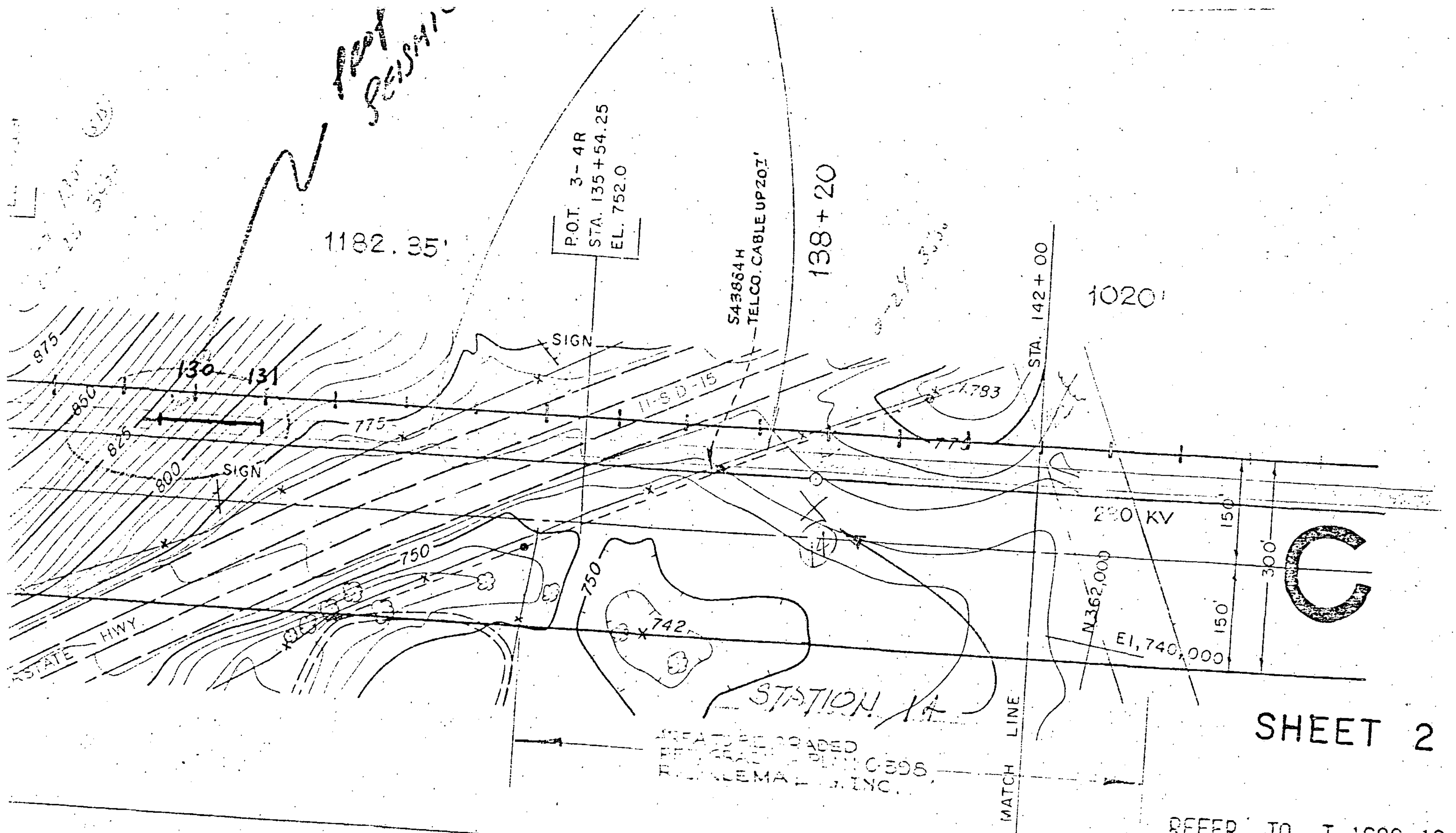
See appendix for additional Seismic - rippability information.

T. Funnekotter

Submitted by T. Funnekotter


N 357,000
E 1,740,000
N357
E 1,739,000
STA. 87+50
TELCO. CABLE UP18'
SEISMIC
STATION 10
NORTH
801995H
700
725
750
775
800
820
74
75
TELCO. CABLE UP29'
S01996H
1300'
4514804H
4618714
4618704
101
102
2W. TELCO. UP16'
2W. TELCO. UP22'
P.I. - 3R
N 358,200.57
E 1,740,450.45
STA. 104 + 67.20
EL.
Δ = 55° 33' 57" L.
99 + 28.48
522.42'
EXISTING CONDUITS
CONDUITS WERE INSTALLED
WITHIN THE STATE R/W
IN 1975
PROPOSED INTERSTATE HWY 11-3.0-15
2W. 12KV. UP31'
(LOWERED 7'±
-PER SKOGLUND)
111088
589.10'
104 + 50.90
Δ 55° 33' 57" LT.
P.O.T. 3-1R
STA. 110 + 31.21
EL. 853.1
110 + 40

EXISTING CONDUITS
CONDUITS WERE INSTALLED
WITHIN THE STATE HWY R/W
IN 1975
P.I. - 3R
N 358,200.57
E 1,740,450.45
STA. 104 + 67.20
CL
Δ = 55° 33' 57" L.
99 + 28.48
522.42'
2W. TELCO. UP 19'
2W. TELCO. UP 22'
4G187OH
4G187IH
800
775
820
TATION 11
107
108
2W. 12KV. UP 31'
(LOWERED 7'± PER SKOGLUND)
111088
110927
589.10'
104 + 50.90
Δ 55° 33' 57" LT.
825
850
861
P.O.T. 3 - 1R
STA. 110 + 31.21
EL. 853.1
110 + 40
ATION 12
825
113
114
P.O.T. 3 - 2R
STA. 115 + 14.66
EL. 800.2
7G3908H
P4T8211
NO TAG
TELCO. CABLE UP 19'
775
775
779
782
763
760
1597.65'
INTERSTATE
775
875
126
125
126 + 37.65
P.O.T. 3 - 3R
STA. 126 + 99.14
EL. 849.9



SHEET 2 0

REFER TO T-1600-10

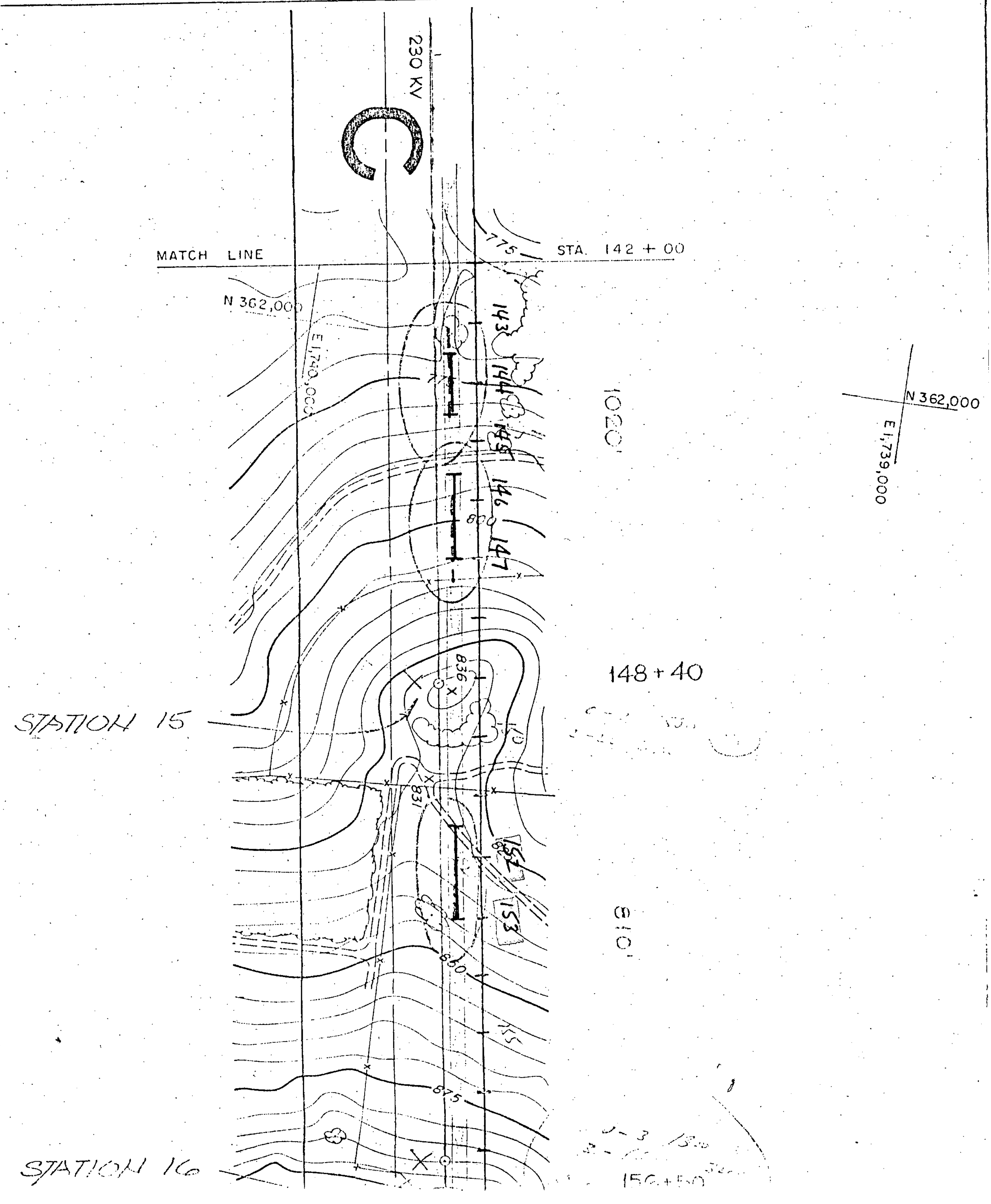
## REVISIONS

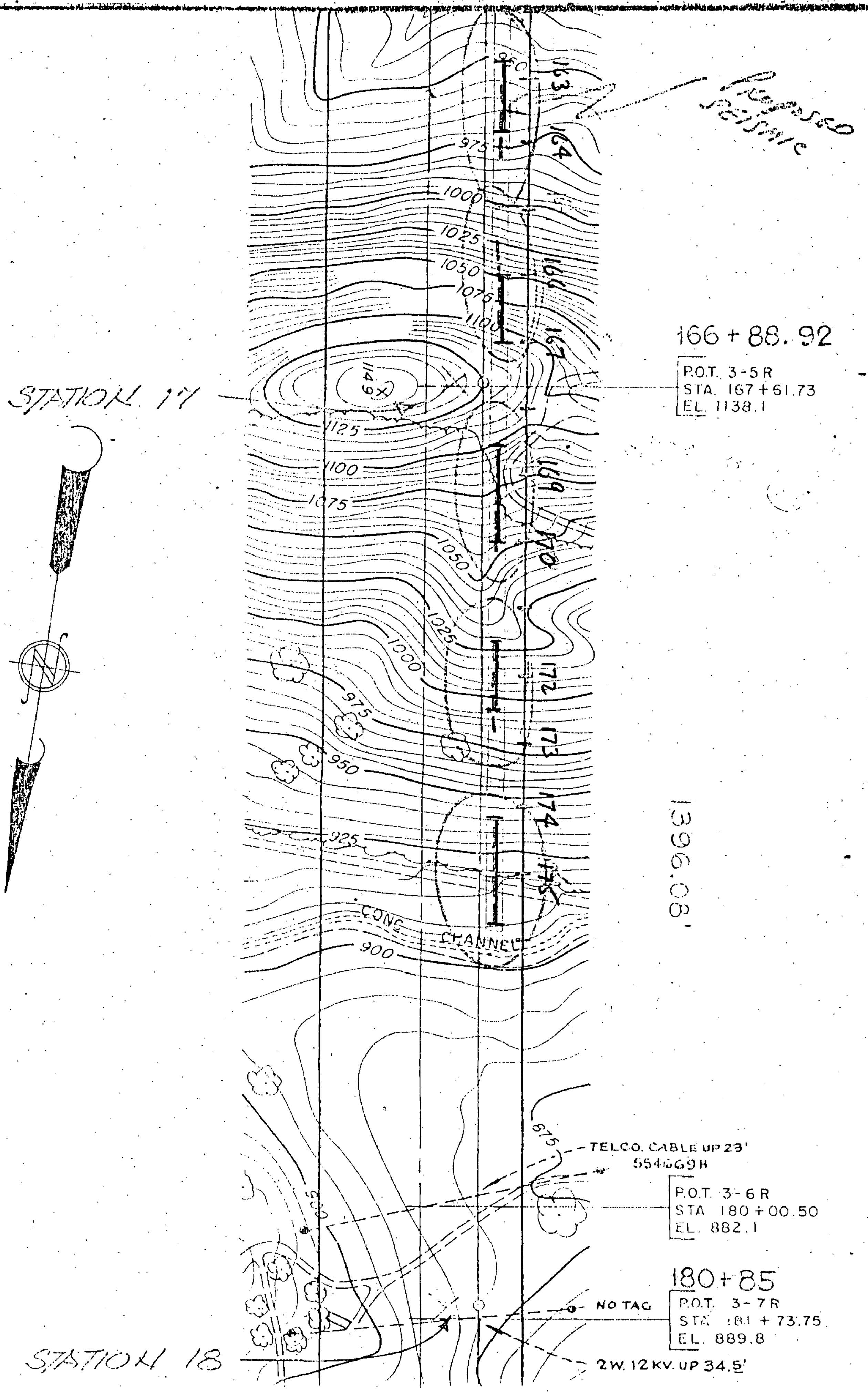
| | DATE | BY | APP'D |
|---|---|---|---|
| RELOCATED POLE 16 | 3-13-72 | DEA | |
| ADDED WIRE XINGS. "B" LINE | 3-16-72 | DEA | |
| RELOCATED POLE 18 (FROM 181+00) TO 180+85 - PER SKOGLUND | 3-23-72 | DEA | |
| LOWERED 12 KV. (7'±) BET. POLE 11 & 12 - PER SKOGLUND 3/22/72 | 3-23-72 | DEA | |
| UP DATED WIRE HEIGHTS PER SUR. DATA 3-24-72 | 3-27-72 | DEA | |

SAN DIEGO GAS & ELECTRIC
SAN DIEGO, CALIFORNIA

300' RIGHT OF WAY-ESCO
TO RIVERSIDE COUNTY

| | | |
|---|---|---|
| DRAWN BY: | SCALE: 1" = 200' | DATE: NOV. |
| SURVEYED BY: | R/W OK: | |
| OK TO INSTALL: | DATE: | TO |
| CO.-ORD.: 358-1753 & | | |


230 KV
MATCH LINE
STA. 142 + 00
775
N 362,000
E1,740,000
143
144
145
146
147
800
1020'
N 362,000
E1,739,000
148+40
836
STATION 15
831
152
153
810'
850
825
875
STATION 16
156+50


Proposed Seismic
163
164
975
1000
1025
1050
1075
1100
166
167
166 + 88.92
P.O.T. 3-5 R
STA. 167 + 61.73
EL. 1138.1
STATION 17
1149
1125
1100
1075
169
1050
170
1025
1000
172
975
173
950
174
925
1396.08'
175
CONC.
CHANNEL
900
875
TELCO. CABLE UP 23'
554669H
P.O.T. 3-6 R
STA. 180 + 00.50
EL. 882.1
180+85
NO TAG
P.O.T. 3-7 R
STA. 181 + 73.75
EL. 889.8
STATION 18
2 W. 12 KV. UP 34.5'

# VELOCITY PROFILE

MP — MAXIMUM PENETRATION LINE

SAN DIEGO GAS & ELECTRIC
69 KV UNDERGROUNDING PROJECT

**T. FUNNEKOTTER**
REGISTERED GEOLOGIST
CERTIFIED ENGINEERING GEOLOGIST
P. O. BOX 575 - ESCONDIDO, CALIF. 92025
746-2793

**ENGINEERING GEOLOGY**

GEOPHYSICAL INVESTIGATIONS
For
Subdivision Design
Pipelines - Roads
Seismic Rippability Studies

# RIPPABILITY SCHEDULE

The following schedules should apply for the type of material encountered in this report:

Based on a D-9 Cat

| Velocity (ft/sec) | Excavation Method |
|---|---|
| 0 to 2000 | Scraper |
| 2000 to 5000 | Ripper |
| 5000 to 5500 | Marginal |
| Over 5500 | Drill & Shoot |

For trenching, based on a Kohring 505 LARGE BACKHOE

| Velocity (ft/sec) | Excavation Method |
|---|---|
| 0 to 3800 | Ripper |
| 3800 to 4300 | Marginal |
| Over 4300 | Drill & Shoot |

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Pipelines - Roads
Seismic Rippability Studies

# SEISMIC - RIPPABILITY INFORMATION

The following points should be considered when evaluating Seismic information:

1. All velocities, depths, and thicknesses are averages and quafified as follows:
   G - good
   F - fair
   P - poor
   VP - very poor
   ? - questionable
   Grades of G,F, and P should be considered reliable; VP and ? should be considered as indications only.

2. Each profile provides information in the immediate area of that profile - extrapolation outward from this line must be considered speculative. In other words a velocity cross section is given along a specific line of investigation - 10 to 20 feet from this line the conditions could vary. In order to avoid any surprises between the Seismic lines additional Seismic lines would be in order.

3. As the velocity of material increases, ripping becomes progressively more difficult until at some point it is more economical to drill and shoot the material prior to excavation. Rippability also varies with the type of material; however, in general, D-9 Cat single ripper performance should be as follows: rippable to 5000 ft/sec, marginal from 5000 to 5500 ft/sec, and non-rippable over 5500 ft/sec. The changeover from a ripping to a blasting operation usually occurs within the marginal zone.

   To determine rippability is essentially an economic decision - whether to continue ripping at higher velocities or to blast at lower velocities depends on the type of job, type of equipment, expertise of the operators, amount of excavation, how the rock is to be disposed of, time factor, etc. For example, in fractured rock a trench type of operation is more difficult than a hillside job, especially if boulders are present. In a trench manuverability of the heavy equipment is limited and rock disposal is a bigger problem.

   The degree of fracturing is a factor in determining rippability, i.e., more fracturing, lower velocities, easier ripping. The same velocity could represent either decomposed or fractured rock.

4. Boulders are identified as scattered boulders (SB), many boulders (MB), and large boulders (LB). These notations can also mean hard angular blocks. Large boulders are considered to be over 10 feet in diameter and even possibly to 30 feet in diameter.

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## SEISMIC - RIPPABILITY INFORMATION

5. For trenching operations, the rippability figures must be adjusted downward, i.e., velocities as low as 3500 ft/sec may indicate difficult ripping depending on the degree of fracturing of the rock. Fractured rock and even small boulders can be very troublesome in a narrow trench. For example, decomposed granite is easier to dig than fractured granite even when the velocities are similar. However, in general, based on a machine comparable to a Kohring 505, most materials with velocities of approximately 3800 ft/sec or less should be rippable, over 4300 ft/sec non-rippable, and marginal in between. In a narrow trench a condition of many boulders can be almost as troublesome as solid rock so the above figures should be used with discretion.

G407

Geotechnical Report

**BENTON ENGINEERING, INC.**
APPLIED SOIL MECHANICS — FOUNDATIONS
5540 RUFFIN ROAD
SAN DIEGO, CALIFORNIA 92123

PHILIP HENKING BENTON
PRESIDENT - CIVIL ENGINEER

TELEPHONE (714) 565-1955

March 12, 1979

San Diego Gas & Electric Company
P. O. Box 1831
San Diego, California 92112

Attention: Mr. Craig Riker

Subject: Project No. 71-12-22A
Suggested Values of Modules of Horizontal Subgrade Reaction
For Tower No. 115 Design
230 KV San Onofre - Escondido Line
San Diego County, California

Gentlemen:

This is to present, pursuant to your request, our suggested modules of horizontal subgrade reaction values at proposed Tower No. 115 location for the subject project.

Upon evaluation of soil conditions encountered in the boring drilled at the tower site, it is our opinion that the following values are considered appropriate for the soil conditions encountered:

| Depth Below Existing Ground Surface, Feet | Soil Description | Suggested Values of Modulus of Horizontal Subgrade Reaction, Tons/Ft$^3$ |
|---|---|---|
| 0 to 3.0 | Silty fine sand, loose, porous and micaceous, colluvium deposit | 10 |
| 3.0 to 8.0 | Silty fine sand, medium firm to very firm with thin foliation, weathered Gneiss | 45 |

If you have questions concerning any of the data presented above, please contact us.

San Diego Gas & Electric Co.
MAR - 1979
Civil Engineering
Section

Respectfully submitted,

BENTON ENGINEERING, INC.

By S. H. Shu
S. H. Shu, Civil Engineer
RCE No. 19913

Reviewed by Philip H. Benton
Philip H. Benton, Civil Engineer
RCE No. 10332

Distribution: (3) Addressee