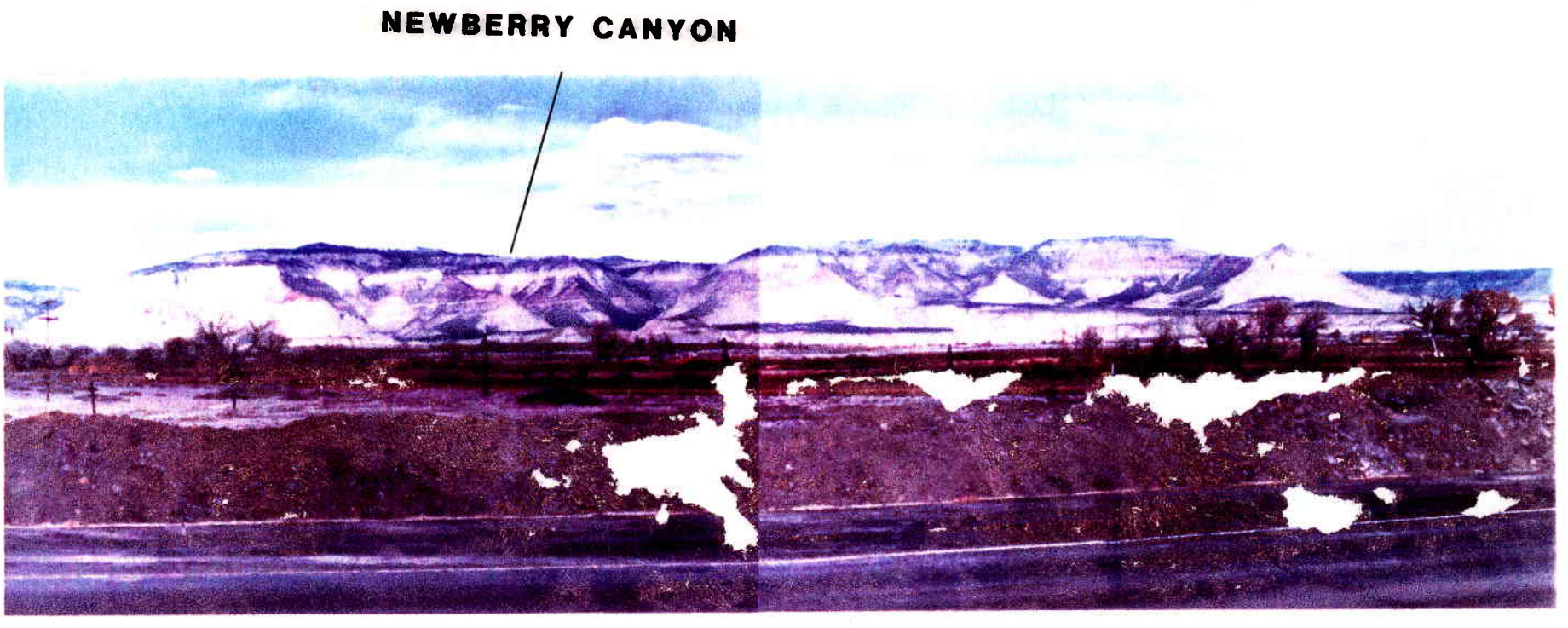
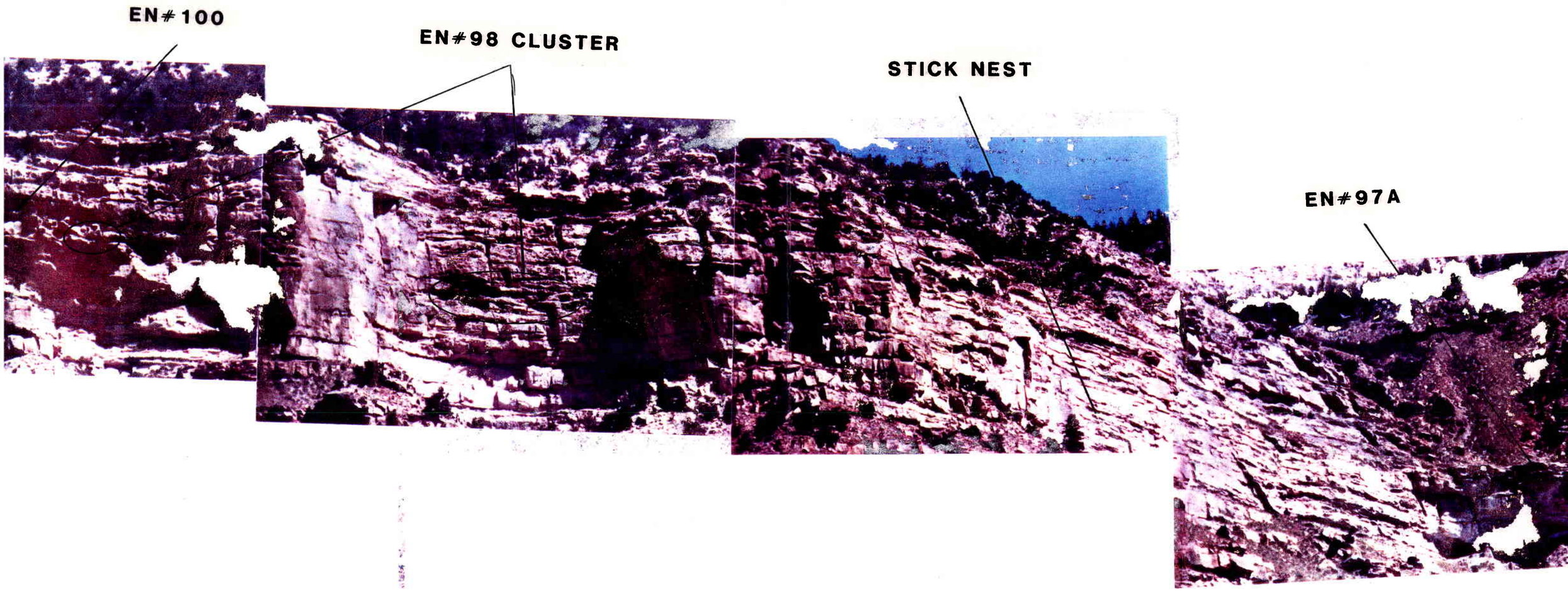

NEWBERRY CANYON


NEWBERRY CANYON



MILLER CANYON

APPENDIX E

SEEGMILLER INTERNATIONAL

SURFACE STABILITY EVALUATION

6E/7E & 9W/10W PANELS

COTTONWOOD MINE

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
143 South 400 East
Salt Lake City, Utah 84111 U.S.A.
Phone: (801)- 363-0606 Cable: ROCKENGR
TELEX: 5106008248 (SEEGMILLER SLC)

SURFACE STABILITY EVALUATION

6E/7E AND 9W/10W PANELS

COTTONWOOD MINE

Emery County, Utah

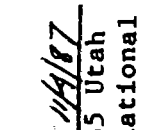
PREPARED FOR

UTAH POWER & LIGHT COMPANY
Huntington, Utah

By

Dr. Ben L. Seegmiller
Principal Consultant

November 1987

Approved: 
11/9/87
Ben L. Seegmiller, P.E. #3485 Utah
President, Seegmiller International

Copy 4 of 6

CONTENTS

LIST OF FIGURES

SUMMARY/CONCLUSIONS

An evaluation of surface stability above the 6E/7E and 9W/10W longwall panels at the Cottonwood Mine is made in this report. Specifically, the past stability of the Castle Gate Sandstone cliffs above the presently mined 6E/7E panels and the future stability of this cliff sandstone above the 9W/10W panels are addressed. Field data, including geologic discontinuity and geotechnical characteristics of the subject areas, were collected during two site visits, one in August and one in September of 1987. A complete data evaluation was made and the following have been concluded:

- The 6E/7E panels had many adverse characteristics, relative to surface displacements.
- Best surface stability areas are [1] located where probable surface compression exists, such as in canyon heads and [2] obtained by orienting the panels perpendicular to adjacent cliff areas.
- The 9W/10W panels are properly located and oriented such that surface damage in the sandstone cliffs should be minimal to non-existent.
- A surface displacement monitoring program is needed for the 9W/10W panels to check on any possible surface movements during the mining of the first 1000 feet of panel.

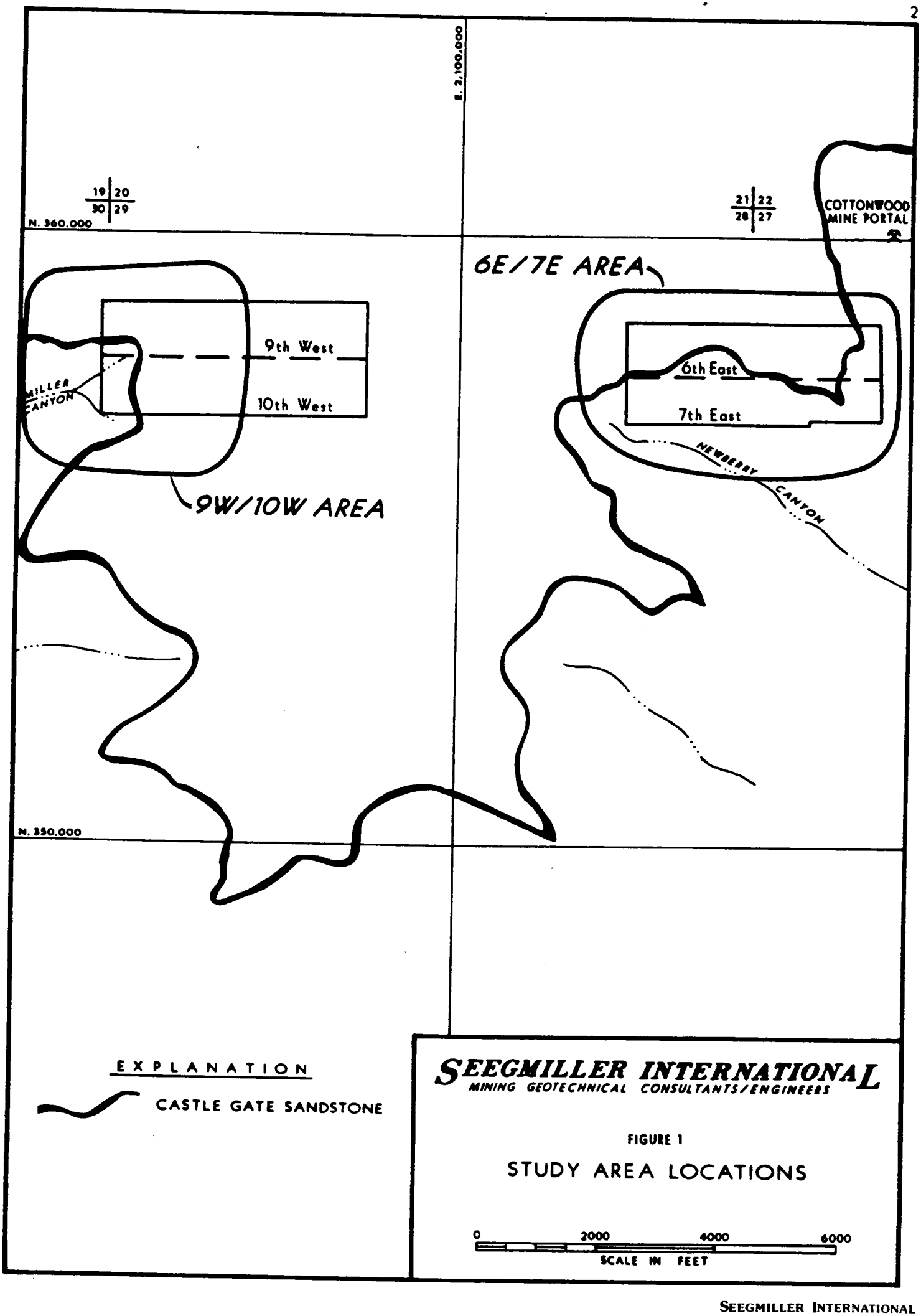
INTRODUCTION

A surface stability evaluation for the 6th East/7th East and 9th West/10th West longwall panels at the Cottonwood Mine, Emery County, Utah is the subject of this report. The study was originally requested by Mr. James Hislop, Chief Mining Engineer, Utah Power & Light Company.

The Cottonwood Mine is located on the west side of Grimes Wash and longwall mining is taking place under East Mountain. Since September of 1986, mining has been concentrated in the 6th East(6E) panel and subsequently, in 1987, in the 7th East(7E) panel. The longwall mining has resulted in surface subsidence along the north side of Newberry Canyon. The subsidence is particularly pronounced in the Castle Gate Sandstone cliffs, which are located approximately 800 feet vertically above the Hiawatha coal seam and the mining panels. Failures along the sandstone cliffs are of particular concern to Utah Power & Light Company (UP&L) because eagle nesting sites are known to exist in certain of the cliff areas. If possible, it is desired that such eagle nesting sites remain undisturbed. Near-future mining is planned in longwall panels designated 9th West(9W) and 10th West(10W), which are located adjacent to Miller Canyon approximately 2 miles west of the 6E/7E panels as shown in Figure 1. Owing to the fact that the 9W/10W panels will be under and adjacent to Castle Gate Sandstone cliffs in Miller Canyon, the possibility of surface subsidence in the cliffs and any related eagle nesting areas exists. In order to evaluate the present mining plans and the related surface stability, Seegmiller International(SEEGMILLER) was retained to perform an analysis of the situation. The present report is the culmination of that analysis.

The basic purposes of the study and of this report are to [1] assess the mining plans, [2] analyze surface geologic discontinuities and related geotechnical characteristics, [3] compare similarities/differences between 6E/7E panels and 9W/10W panels, [4] predict/evaluate future surface stability in the 9W/10W panel area and [5] make any necessary remedial modifications/recommendations to improve future surface stability. The study has involved two site visits, computer analysis of field data and the evaluation of probable field tensile/compression zones, panel orientation and geotechnical characteristics.

The report first presents the field data and their analyses. Prediction/evaluation, relative to mine layout, potential problem zones and minimal damage zones, is then given. Recommended remedial measures complete the report. Discontinuity computer analyses examples are appended.


E. 2,100,000
19 20
30 29
N. 360,000
21 22
28 27
COTTONWOOD MINE PORTAL
6E/7E AREA
9th West
10th West
MILLER CANYON
9W/10W AREA
6th East
7th East
NEWBERRY CANYON
N. 350,000
EXPLANATION
CASTLE GATE SANDSTONE
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 1
STUDY AREA LOCATIONS
0
2000
4000
6000
SCALE IN FEET

MINING PLANS

6E/7E Panels

A general plan view of the 6E/7E Panels, showing the approximate surface expression of Castle Gate Sandstone in the Newberry Canyon area, is given in Figure 2. The 6E/7E longwall panels were located such that the surface exposure of the Castle Gate Sandstone is approximately parallel to the panel lengths and is above the central portion of these panels. A north-south section across the panels is shown in Figure 3.

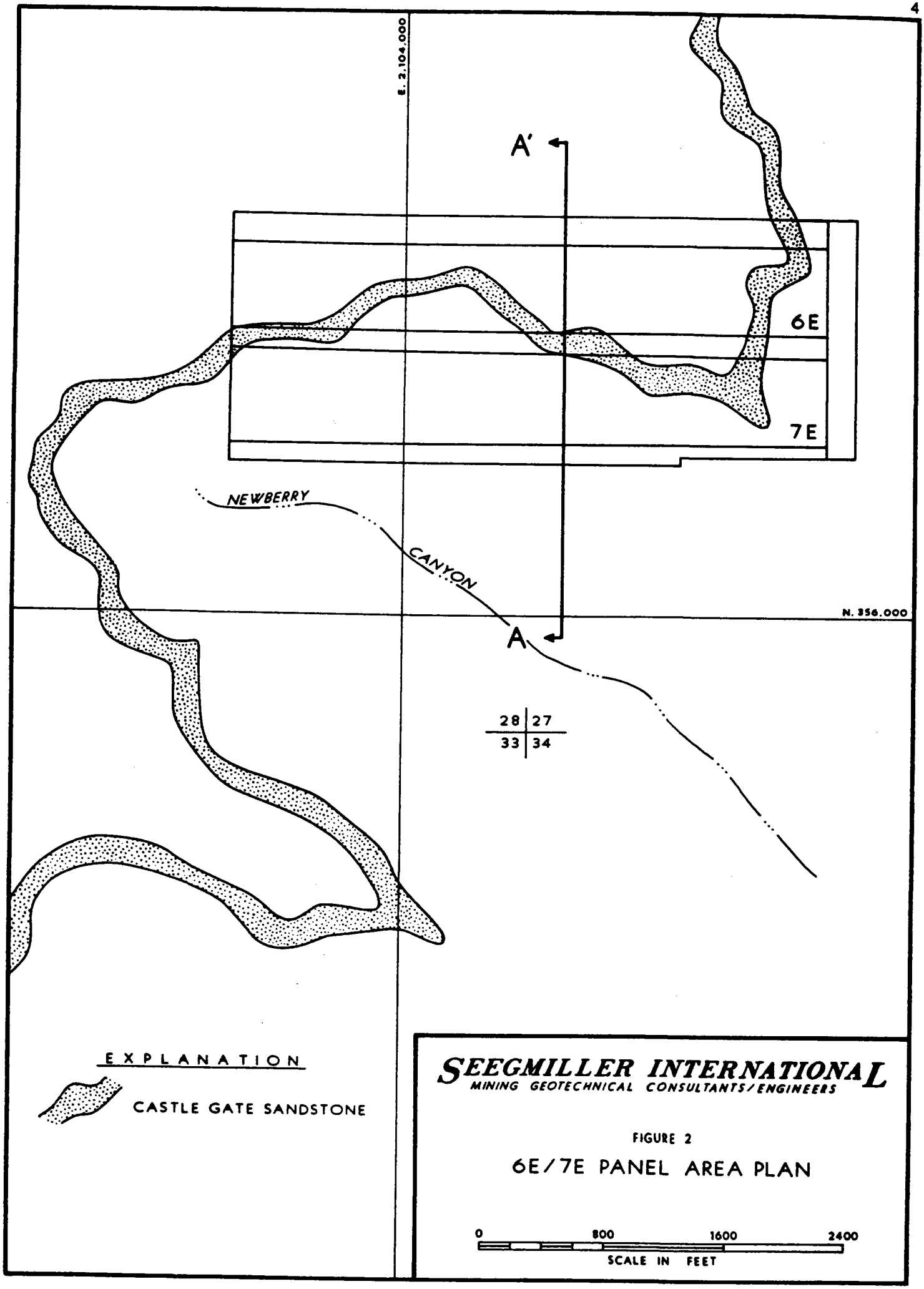
9W/10W Panels

The general relationship of the 9W/10W panels and the surface expression of the Castle Gate Sandstone is shown in Figure 4. The original plan for these panels called for them to continue in the west direction under Miller Canyon for some 1100 additional feet. However, recent evaluations of coal quality dictated that the panels be ended at Crosscut 49. Crosscuts 50 and 51 now form the bleeders on the west end, as shown in the plan view and in Section BB', which is presented in Figure 5.

FIELD DATA REVIEW/ANALYSIS

Mapping Program

Seegmiller Data. Over a two-day period geological discontinuities were examined in the field. One day was spent in the 6E/7E area where discontinuities and geotechnical characteristics were noted in two distinct sites. The first site was on the west slope


E. 2,104,000
A'
6E
7E
NEWBERRY
CANYON
N. 356,000
A
28 | 27
33 | 34
EXPLANATION
CASTLE GATE SANDSTONE
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 2
6E/7E PANEL AREA PLAN
0
800
1600
2400
SCALE IN FEET

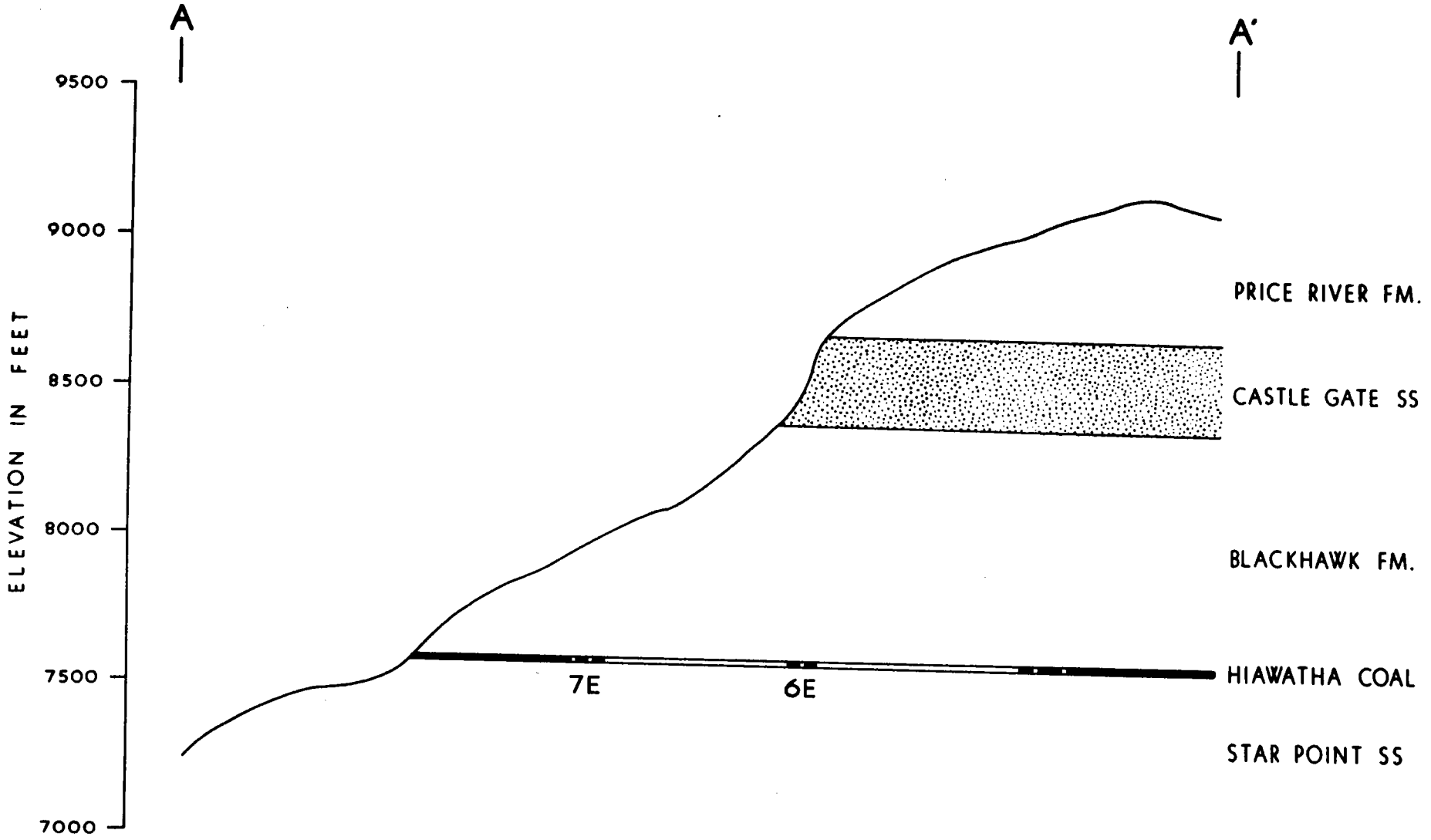
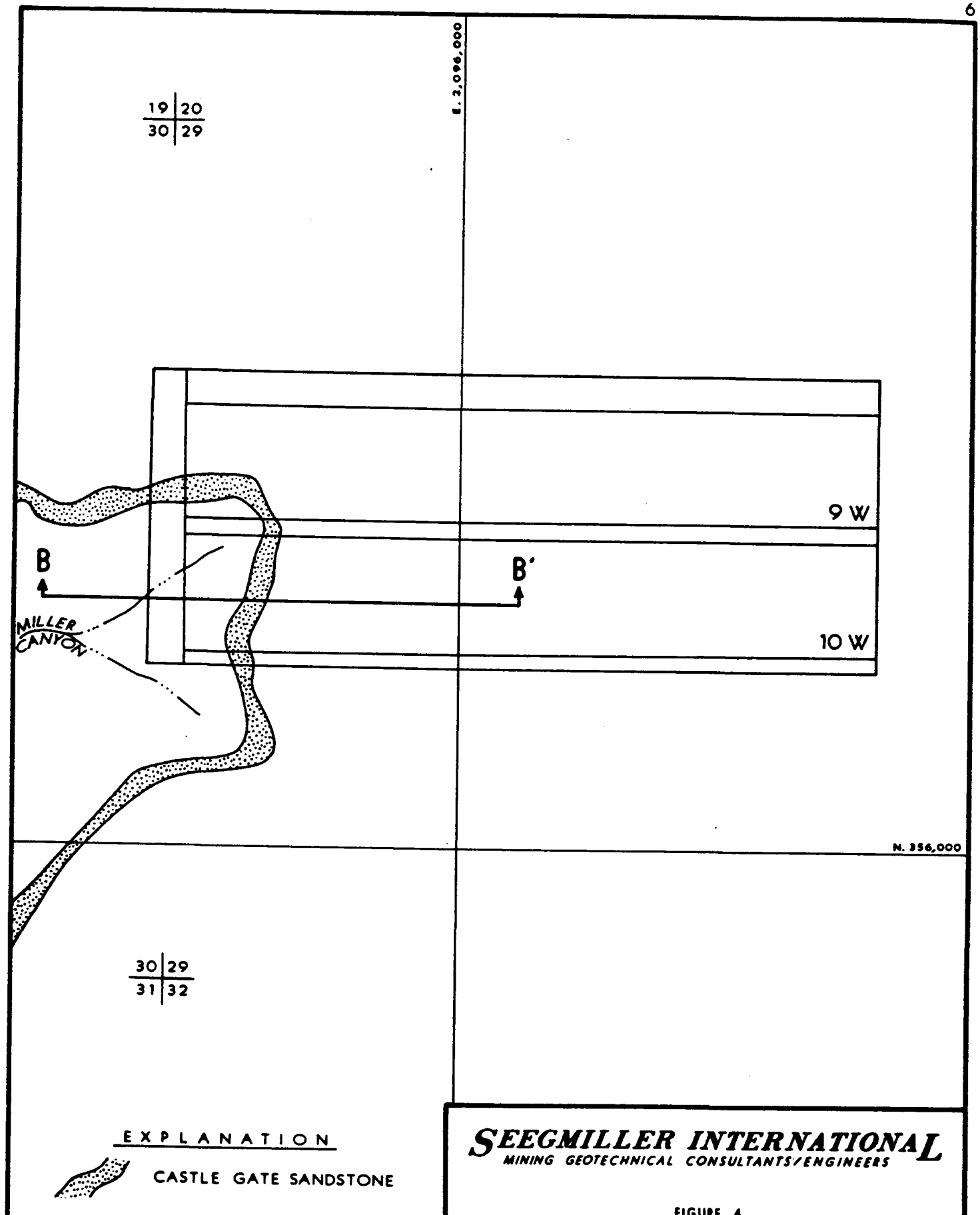


FIGURE 3

6E / 7E PANEL AREA SECTION AA'



SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

FIGURE 4

9W/10W PANEL AREA PLAN

0 800 1600 2400
SCALE IN FEET

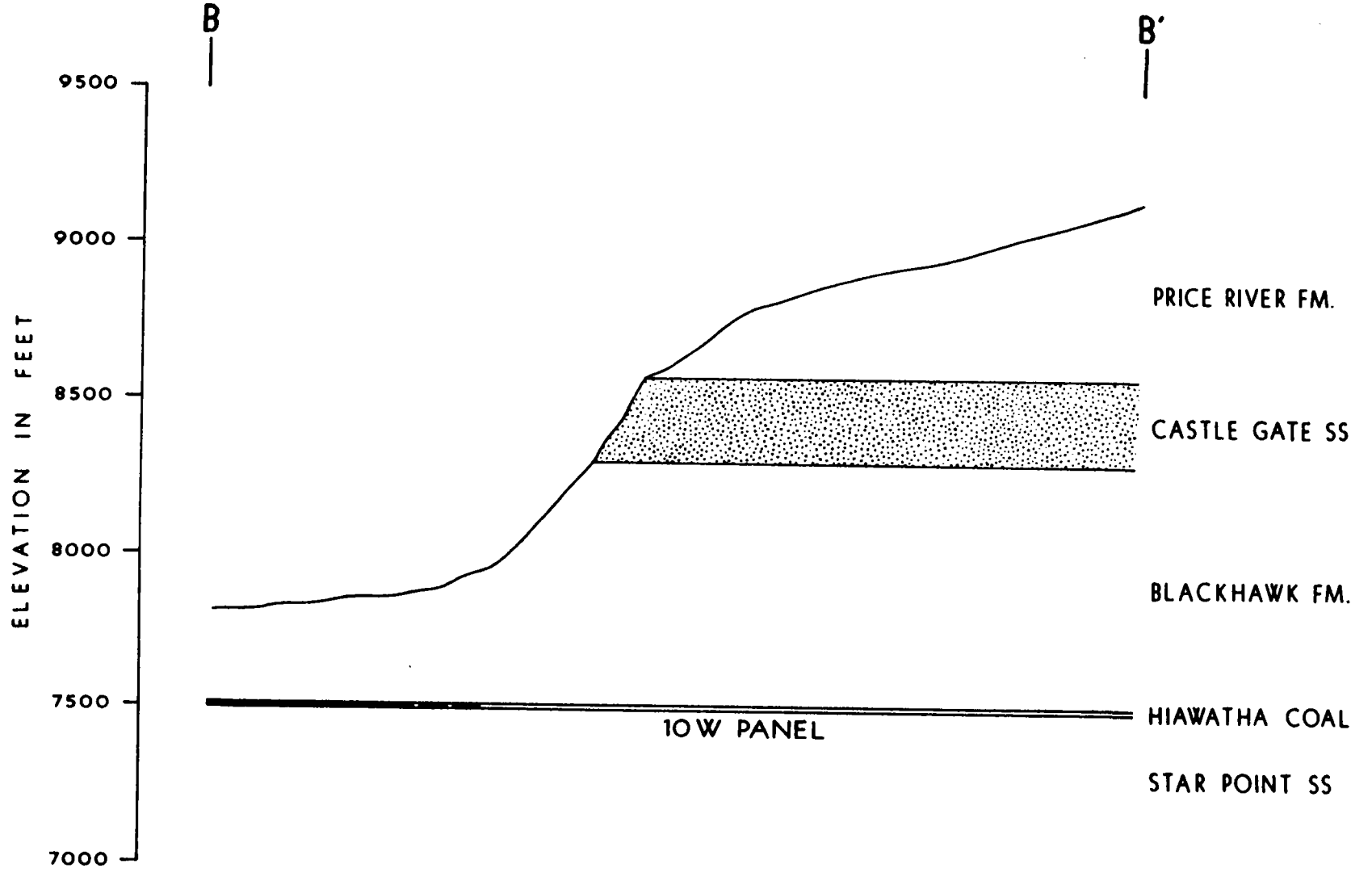


FIGURE 5

9W/10W PANEL AREA SECTION BB'

of Grimes Wash and was designated Site 1. The second site, Site 2, was located along the Castle Gate Sandstone cliff areas on the north slope of Newberry Canyon. A second day was spent in Miller Canyon above the proposed 9W/10W panel area. Discontinuities and related geotechnical characteristics were noted in the general area designated as Site 3. The three sites are located as shown in Figure 6. Specific data collected, relative to geologic discontinuities, included spacial orientation, discontinuity type, strike and dip continuity, relative roughness, Joint Roughness Coefficient(JRC) and spacing.

Cottonwood Data. Discontinuity data were collected by UP&L geologists using the SEEGMILLER format. The data came from six mapping sites along the Castle Gate Sandstone exposures on the south end of East Mountain, as shown in Figure 7. Specific items noted for each discontinuity included spacial orientation, discontinuity type, strike and dip continuity, relative roughness, spacing and rock hardness.

DISCONTINUITIES ANALYSIS

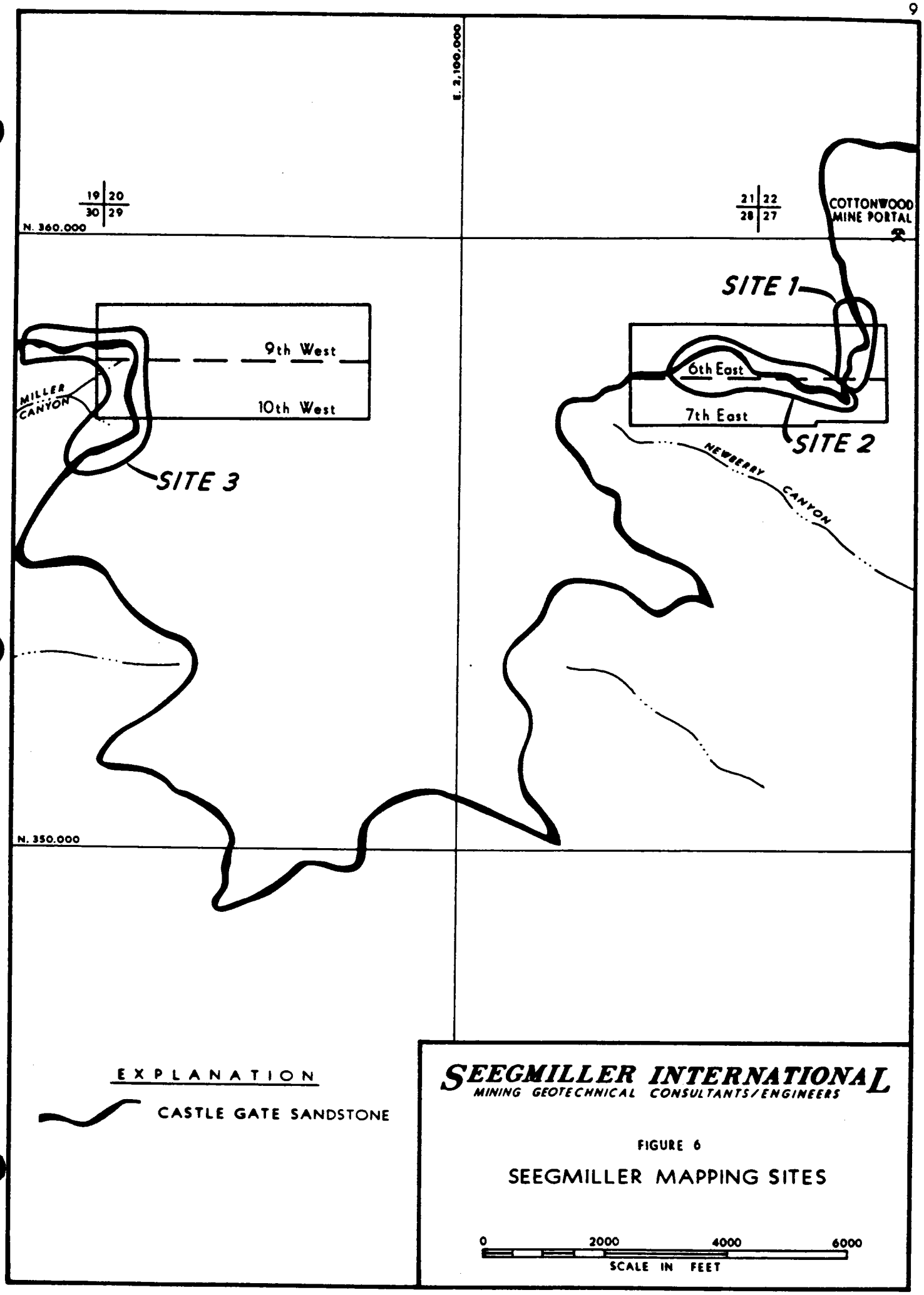
Seegmiller Data. The data from the 6E/7E area(Sites 1 and 2) have been analyzed and compared to the data from the 9W/10W area (Site 3). For each area, a Schmidt net and a characteristic data analysis were produced. The 6E/7E area had one major discontinuity set and one moderate/minor discontinuity set as follows:

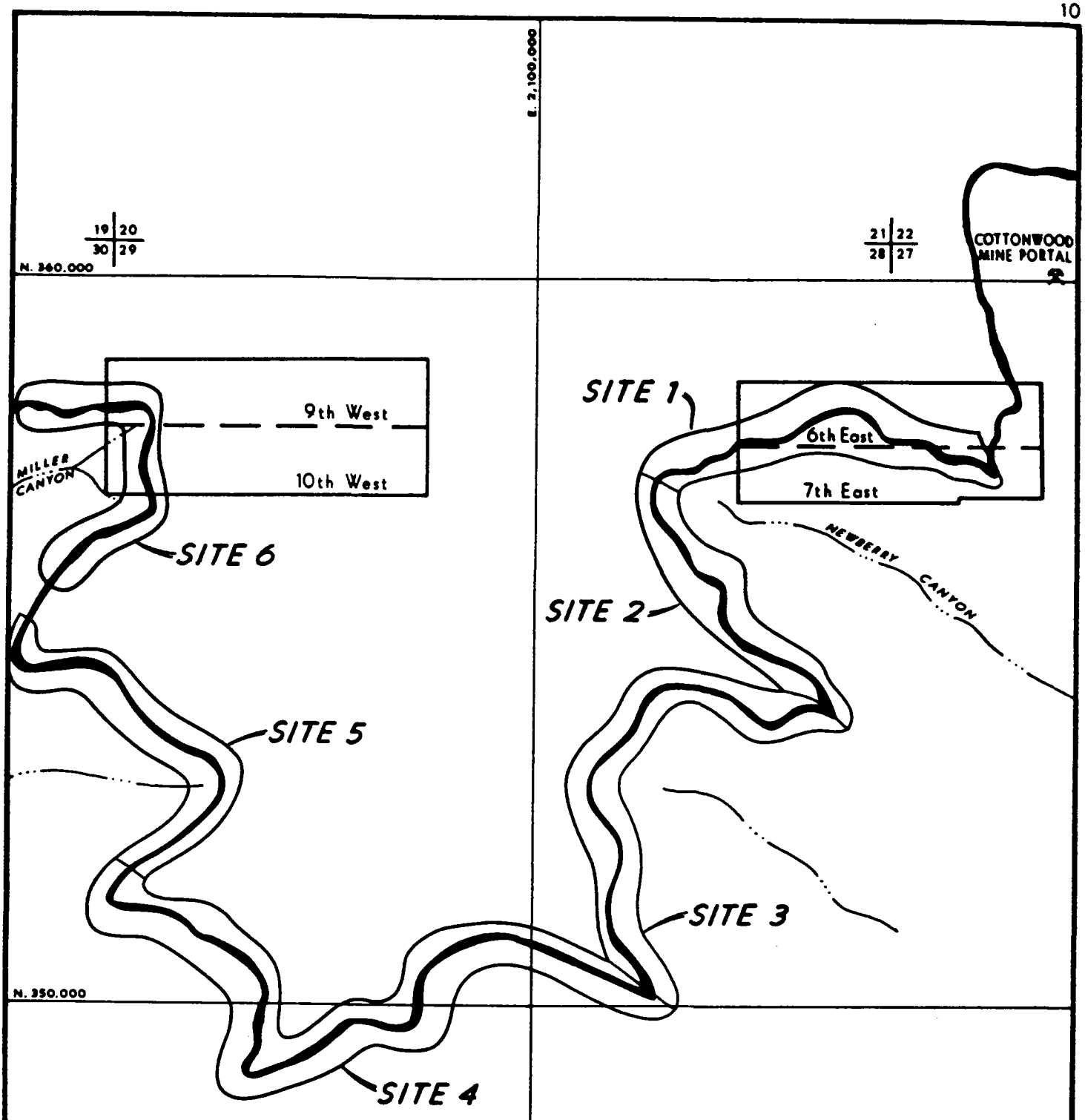
Major	—	N 75° ± 20° W;	90° ± 10°
Moderate/Minor	—	N 07° ± 05° E;	90° ± 03°

The 9W/10W area had a much smaller data base, but had one distinct major set as follows:

N 22° ± 10° E; 90° ± 07°

The characteristic analysis shows only one significant difference, and that is in the strike continuity. The 6E/7E area has approximately a 50% greater strike continuity than the 9W/10W area. The Schmidt nets and characteristic analyses details are presented


E. 2,100,000
19 | 20
30 | 29
N. 360,000
21 | 22
28 | 27
COTTONWOOD MINE PORTAL
SITE 1
9th West
10th West
MILLER CANYON
6th East
7th East
SITE 2
NEWBERRY CANYON
SITE 3
N. 350,000
EXPLANATION
CASTLE GATE SANDSTONE
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 6
SEEGMILLER MAPPING SITES
0
2000
4000
6000
SCALE IN FEET



EXPLANATION

CASTLE GATE SANDSTONE

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

FIGURE 7

COTTONWOOD MAPPING SITES

0 2000 4000 6000
SCALE IN FEET

in Appendix I.

Cottonwood Data —Site 1 versus Site 6. The data from Site 1 were the closest to the 6E/7E area, and they were analyzed by Schmidt net and for geotechnical characteristics. The results show that one major set and one minor set exist as follows:

Major — N 05° ± 10° W; 90° ± 05°
Minor — N 90° ± 25° E; 85° ± 10° S

The 9W/10W area was located in the area of Site 6. It has one major set as follows:

N 22° ± 10° E; 90° ± 10°

The characteristics from both areas were very similar and no significant differences were noted. The details of the computer analyses are presented in Appendix II.

Cottonwood Data – Sites 1 & 2 versus Sites 5 & 6. Sites 1 and 2 represent data collected in the eastern area near 6E/7E and, together, have a variety of slope strikes. Sites 5 and 6 represent data collected in the western area near 9W/10W and, together, have slope strikes which are quite variable. Such a comparison of sites may help to eliminate possible mapping bias that always exists when mapping on a slope striking in one direction only. Sites 1 and 2 have one major set and one minor set as follows:

Major — N 05° ± 10° W; 90° ± 07°
Minor — N 90° ± 25° E; 85° ± 07° S

The discontinuities of Sites 5 and 6 indicate one major set and one minor set as follows:

Major — N 25° ± 12° E; 90° ± 10°
Minor — N 85° ± 20° W; 85° ± 10° W

The geotechnical characteristics evaluation shows that the continuities of Sites 1 and 2 are approximately 60% greater than those of Sites 5 and 6. The spacings of Sites 1 and 2 are more than twice the spacings of Sites 5 and 6. Further, the sandstone at Sites 1 and 2 is distinctly softer than those sandstones examined at Sites 5 and 6. Analyses details in terms of the computer output are presented in Appendix III.

Cottonwood Data – South-Dipping Slopes versus West-Dipping Slopes. A comparison of slopes, which have south dips, was made with slopes having west dips. The south-dipping slopes have two major sets which are as follows:

N 10° ± 10° W; 90° ± 07°
N 82° ± 20° E; 87° ± 03° E

The west-dipping slopes have one major set and one moderate set as follows:

Major — N 25° ± 15° E; 90° ± 10°
Moderate — N 25° ± 10° W; 77° ± 04° W

Comparing characteristics of the two, it is found that the only significant difference exists in the spacing. The west-dipping slopes have a spacing which is approximately 50% larger than the south-dipping slopes. Details of the analyses are given in Appendix IV.

Analysis Discussion. The Schmidt net analyses show that almost all data have essentially vertical dips. In very minor cases, some discontinuities dip very steeply to the south. The SEEGMILLER data show that a major N 75° W discontinuity set is found in the 6E/7E area, whereas the Cottonwood data indicate a major N 05° W set. The reason for this difference is not completely understood and, such a difference may be due to mapping method or to actual mapping site differences. The SEEGMILLER data were, in part, collected on the east dipping slope in Grimes Wash and high angle discontinuities such as the N 75° W set would have been more predominant. The Cottonwood data were collected along the south dipping slope of Newberry Canyon where again high angle discontinuities such as the N 05° W set would have been more predominant. In the 9W/10W area, excellent agreement is found between SEEGMILLER data and Cottonwood data. The only

major discontinuity set, which is found, is the N 22°-25° E set. The west-dipping slopes agree well with the data found in the 9W/10W area. The south-dipping slopes show two major orthogonal sets, which loosely approximate other data found in the 6E/7E area. The geotechnical characteristics of 6E/7E discontinuities are similar in many ways to the south-dipping slopes, but 6E/7E discontinuities may have greater continuities, spacings and the host sandstones may be softer. West-dipping slopes apparently have greater discontinuity spacings than south-dipping slopes. In summary, the following may be stated about the discontinuities analyses:

- The N 22° E discontinuity set found to predominate in the 9W/10W areas exists only as a very minor set in the 6E/7E area.
- The two major discontinuity sets, N 75° W and N 05° W, found above 6E/7E do not appear to exist above 9W/10W.
- The geotechnical characteristics of the discontinuities appear to present a mixed-bag of results. Little can be stated with certainty, relative to strength differences from the 6E/7E area to the 9W/10W area, except that the discontinuities above the 6E/7E panels probably have greater continuities and could more easily be involved with surface instability.

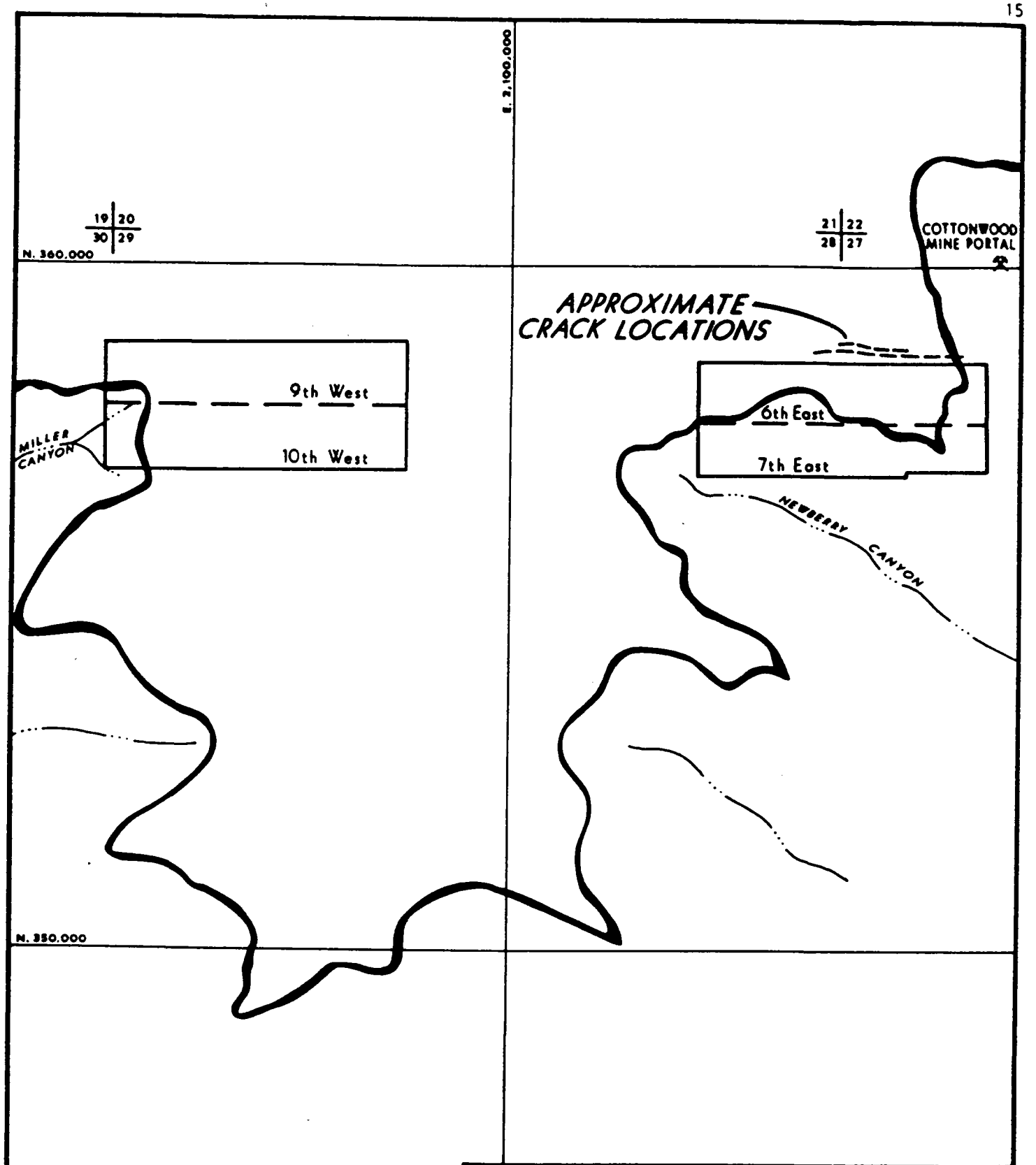
OBSERVATIONAL DATA: 6E/7E AREA

Discontinuities. The geologic discontinuities of concern are the joints, which occur at relatively high angles to the flat-lying stratigraphic bedding planes. A site examination along the top of the Castle Gate Sandstone in August of 1987 indicated that the joints typically were of two sets. The first set, a major set, had a strike of approximately N 75° W, while the second, a minor set, had a strike of approximately N 10° E. Both sets

had approximately vertical dips. Spacings were on the order of 10 to 20 feet and continuities of 20 feet or more were common. In general, the discontinuities combined to give the area a definite and distinct large blocky appearance.

Geotechnical Characteristics. The area, as a whole, has fairly strong sandstone with estimated intact compressive strengths on the order of 6000 to 8000 psi. The rock mass, however, has the appearance in many places of being blocky and possibly more open and loose. This is due, in part, to the probable tensile condition prevailing along the cliffs in the 6E/7E area. A tensile zone commonly occurs in plateau cliffs which form a convex shape. In effect, there are no confining stresses on the sides of the cliffs on a convex point and the rock mass tends to be in a more open and loose state, as a whole.

Failure Modes. The observed failure modes along the Castle Gate Sandstone cliffs on the north side of Newberry Canyon appear to include [1] rock falls, [2] toppling failure and [3] foundation failure and related slumping/toppling. In addition, major surface tension cracks have formed above the 6E/7E panel area and are located as shown in Figure 8. The rock fall failures have occurred where blocks of rock have been bounded by discontinuities. Subsurface movements have allowed these blocks to be freed on all sides, and they have simply fallen as a result of gravity. The toppling failures have occurred where relatively long and slender blocks of rock existed. These long and slender blocks are the result of relatively continuous vertical joints with spacings on the order of 5 to 10 feet. The blocks remain stable as long as their weight vectors pass through their lowermost horizontal surface. When a subsurface movement occurs and the weight vector is shifted to the interface of the base and a vertical joint, located on the canyon side of the block, the block tilts and topples into the canyon. Foundation failure and related slumping/toppling can occur where a shale is found at the base of the Castle Gate Sandstone or where a major shaly interbed exists within the sandstone. In effect, a subsurface movement causes a large block of rock to lose the previously existing shear resistance from adjacent blocks or the in-place rock that held it in place. The block then exerts a larger bearing load on the underlying shale and eventually a foundation failure occurs in the shale. Once the foundation failure begins, the block may simply slump to a more stable position or it could rotate either outward or to the side and toppling could occur. The major surface tension cracks were formed as a result of classical subsidence as the underlying longwall panels were pulled. Of particular importance is that these major surface tension cracks form parallel to the long direction of the panel.


E. 2,100,000
19 20
30 29
N. 360,000
21 22
28 27
COTTONWOOD MINE PORTAL
APPROXIMATE CRACK LOCATIONS
9th West
10th West
MILLER CANYON
6th East
7th East
NEWBERRY CANYON
N. 350,000
EXPLANATION
CASTLE GATE SANDSTONE
SURFACE TENSION CRACK
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 8
TENSION CRACKS ABOVE 6E/7E
0
2000
4000
6000
SCALE IN FEET

No similar surface cracks are known to have occurred perpendicular to the panels in the north-south direction. Displacements of up to 5 feet were noted toward the central and west end of the cracks. Minimum displacements of only inches were noted toward the east end of the cracks in the Castle Gate Sandstone.

OBSERVATIONAL DATA: 9W/10W AREA

Discontinuities. The cliff discontinuities on the north side of Miller Canyon appear to predominantly strike N 20° E and have essentially vertical dips. They have spacings on the order of 20 to 50 feet and continuities in excess of 50 feet. A few discontinuities striking N 70° W were observed toward the west end of the north canyon side. The east and south cliff slopes of Miller Canyon have far fewer observable discontinuities. The only major set noted strikes about N 15° E and has an approximately vertical dip. Spacings are on the order of 10 feet and continuities are up to 50 feet, but only in one direction. In the other direction, the rock is solid and massive.

Geotechnical Characteristics. The north side of Miller Canyon has a gross blocky nature to the cliffs in some areas and yet appears quite massive in others. The Castle Gate Sandstone has portions which are very solid for hundreds of vertical feet and no shaly interbeds are found. The east and south slopes have portions which are very massive with essentially no joints cutting them. Weathering has caused irregular erosion to occur in several large areas and the sandstone has a carved and sculptured appearance. Small, and even large blocks are not obvious when looking perpendicular to these slopes. Some slabs are noted, however, when a view parallel to the slope strike is made. General compressive strengths of intact cliff sandstone are estimated to be on the order of 7500 psi. The rock mass tends to generally appear tight and solid. This would be due, in part, to the fact that the head of Miller Canyon has a probable compressive condition prevailing along the cliffs adjacent to the 9W/10W panels. A compressive condition is commonly found where a concave zone exists in plateau cliffs. In effect, the surrounding rocks are all giving confining stresses to the plateau cliffs because yielding cannot occur except along a single plateau face. The rock is, therefore, tighter and more compact as a whole.

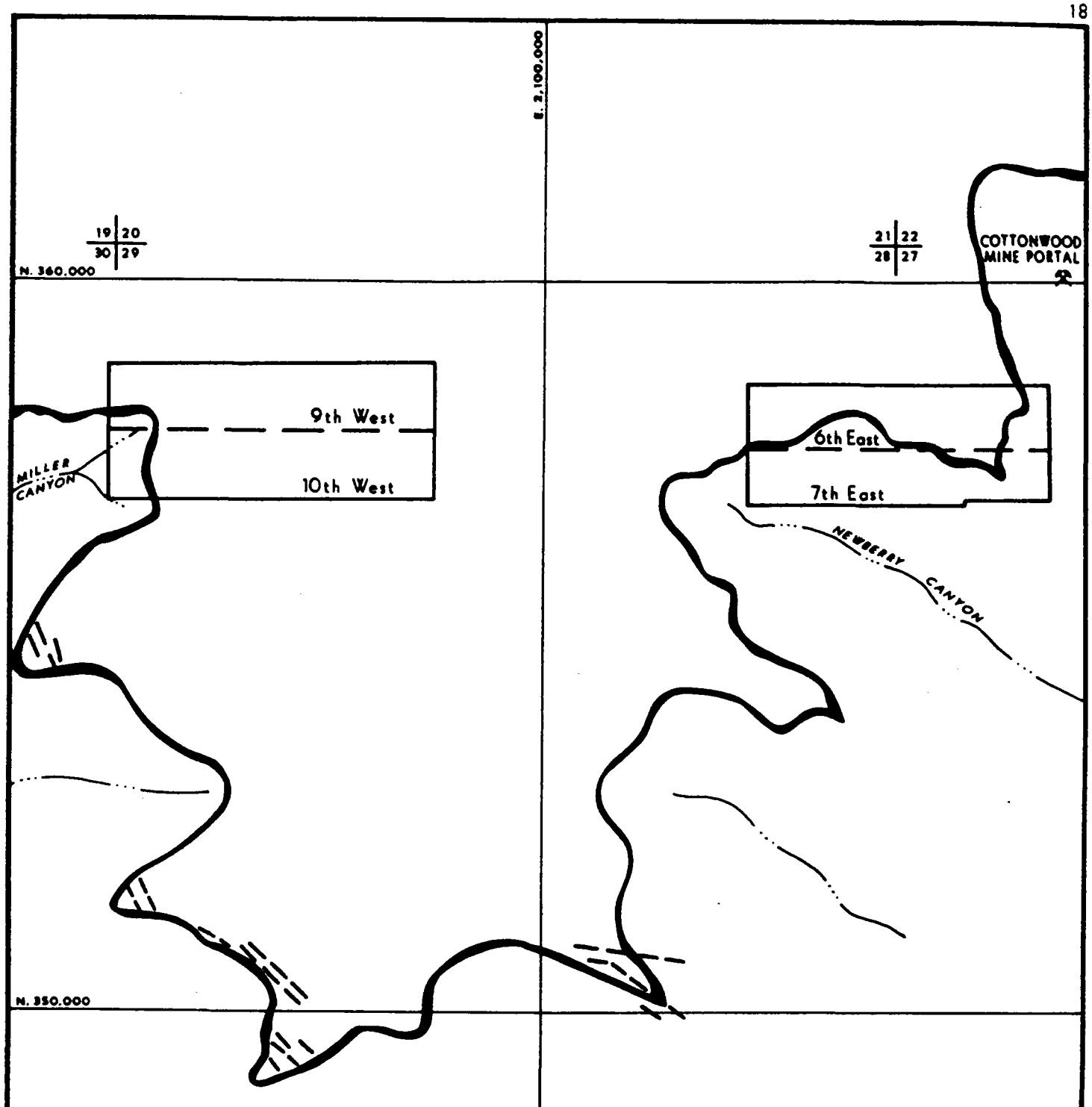
EAST MOUNTAIN - SOUTH END(UNMINED AREAS)

In September, a second field visit was made to the study areas. The second visit involved viewing the Castle Gate Sandstone cliffs from a helicopter. In addition to viewing the two study areas, the entire cliff area along the south end of the East Mountain plateau was observed in some detail. The most important observation made was that major tension cracks already exist along much of the convex cliff areas where a probable tensile condition prevails. General zones where tension cracks were observed are shown in Figure 9. The tension cracks generally trend northwest-southeast. They have continuities on the order of up to hundreds of feet. In effect, what is being observed is the natural geologic phenomenon of mountain erosion and breakup that goes on constantly throughout the world. The heads of the canyons, where a probable compressive condition prevails, were observed to generally be more solid, massive and stable.

PREDICTION/EVALUATION

MINE LAYOUT EFFECTS

6E/7E Panels. The layout of 6E/7E could not really have been much worse for surface stability. Most importantly, a major portion of these panels is under a probable tension zone on a convex Castle Gate Sandstone cliff area. Further, the long direction of the panels is almost parallel to the strike of the cliff. Classic subsidence theory predicts that maximum surface subsidence will be noted down the length of the panel as opposed to the zone beyond the start-up room at the end of the panel. The major surface tension crack noted above the panels is evidence of subsidence parallel to the panel length. No subsidence was noted beyond the end of the panel eastward in Grimes Wash. Another problem with the layout is that a major discontinuity set(N 75° W) essentially parallels the panels and the cliff. These relatively long discontinuities have formed two sides of almost all toppling mode failures found on the north side of Newberry Canyon. The blocky nature of the cliff sandstones also has contributed to their expansion and subsequent failure by one or more modes. Consequently, the surface disturbance in the Castle Gate Sandstone



EXPLANATION

CASTLE GATE SANDSTONE

TENSION CRACK ZONES

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

FIGURE 9

EAST MOUNTAIN - SOUTH END
TENSION CRACKS

0 2000 4000 6000
SCALE IN FEET

cliffs above the 6E/7E panels was easily triggered by the subsurface subsidence, as longwall mining took place.

9W/10W Panels. The layout of these panels is very good for minimal disturbance to the Castle Gate Sandstone cliffs. The reasons for this include the fact that the panels are located at the head of Miller Canyon under a probable compression, or concave, cliff area. The cliff sandstones are relatively tight and massive at the canyon head indicating lateral confinement. Secondly, the panels are oriented directly away from the cliff area. Classical subsidence theory indicates that the maximum subsidence will occur down the length of the panels with very little subsidence over the panel ends where good buttressing and lateral resistance are located. Mining of 6E/7E panels showed that very little subsidence occurred at the east panel end, even when the sandstone cliff zone was located in a probable tensile zone. Therefore, very little, if any, surface disturbance should occur in the 9W/10W zone adjacent to the panel end. The tight, massive nature of the Castle Gate Sandstone in the Miller Canyon area should keep it together, as a single unit, much better than the blocky cliff zones above the 6E/7E panel. Only one major discontinuity set appears in the east and south slopes of Miller Canyon. That discontinuity set strikes N 25° E and should be perpendicular to the major direction of mining and subsidence. Displacements on the major discontinuity set are expected to be relatively minor.

POTENTIAL PROBLEM ZONES

Potential future problem zones will be those in probable tensile zones or convex cliff areas. Mining should be avoided under such zones, if sandstone cliff zones are to have minimal damage. These probable tensile zones already have major tension cracks in most of them. Any subsurface displacement will likely cause surface movements and possible cliff failures. In addition, panels oriented parallel to any cliff zone, particularly if it is inside the surface trace of a 20° draw angle, will likely have surface displacement and related sandstone cliff damage. The 20° angle of draw generally exceeds actual past angles of draw found to exist in the area. An additional aggravating factor is to have a major discontinuity set paralleling the panel length when that panel is parallel to the adjacent slope. The worst problem areas will probably be those in convex cliff zones oriented parallel to the cliffs with major discontinuity sets parallel to the panel.

Minimal Damage Zones

The best surface stability will occur adjacent to probable compressive zones where the cliff area is concave-shaped, such as at the head of a canyon. Minimal damage should prevail in the surface sandstone cliffs when the panels are oriented perpendicular to the cliffs. Such perpendicular orientation should be especially good if the panel is less than about 500 feet out beyond the vertical projection of the sandstone cliff. Major discontinuity sets oriented perpendicular to the panel may have less disturbing effects on sandstone cliffs also oriented perpendicular to the panel. Exceptions may be found as to the best orientation for a major discontinuity set because other factors, including panel orientation and panel location, may outweigh the discontinuity orientation factor.

RECOMMENDED REMEDIAL MEASURES

The remedial measures for the 9W/10W panel area are few, because the present location and orientation are already very good for minimizing damage to the surface cliff exposures of Castle Gate Sandstone. The general location under the head of a canyon, where a probable surface compression zone exists, is very good. In addition, the orientation is also very good because it is perpendicular to the cliff sandstone at the head of the canyon. Also favorable is the orientation of the major discontinuity set, which is perpendicular to the length of the panel. Only one improvement could be made and that would be to have careful surface monitoring of the Castle Gate Sandstone shortly before and during the pulling of the first 1,000 feet of panel. Such monitoring would apply to both the 9W and 10W panels. The recommended monitoring means are twofold. First, it is recommended that detailed visual monitoring be used, as well as recording the sandstone cliff conditions with still photography. A series of photos of the area should be taken periodically from several fixed points. Secondly, it is recommended that several glass prisms be strategically placed on key cliff areas. These glass prisms may be located in X, Y and Z coordinates to the nearest 1/10 inch using a light-ranging instrument. Periodic measurements would give a very accurate measurement of any movements as a function of mining advances. Such documented monitoring would serve to provide hard evidence to back up the conclusions of the present study.

APPENDIX I

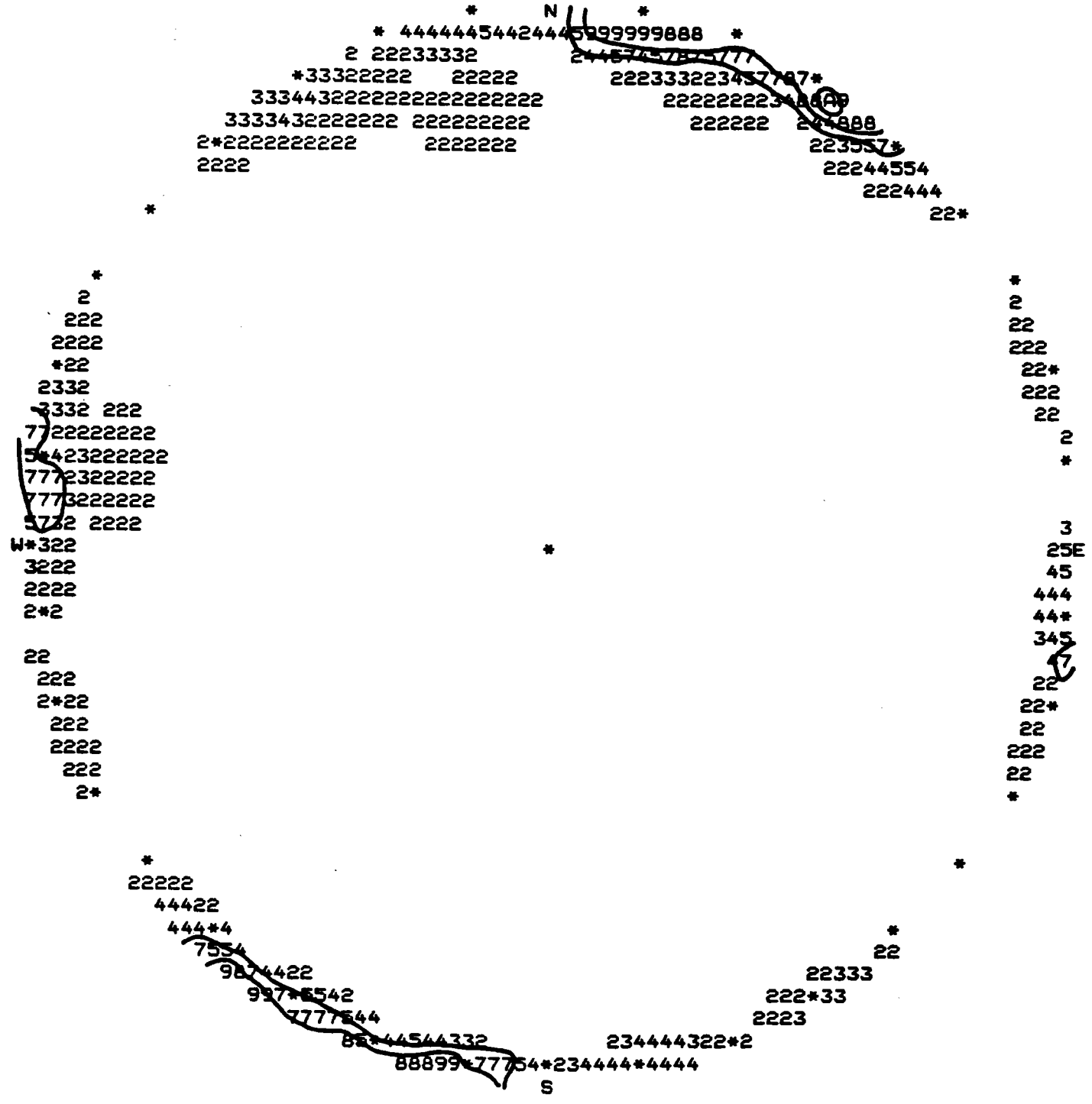
SEEGMILLER DISCONTINUITY ANALYSIS

Schmidt Nets & Characteristic Statistics

6E / 7E AREA

SEEGMILLER DATA - SITES 1&2: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
34 OBSERVATIONS. HIGHEST LEVEL COUNT IS 8



SEEGMILLER DATA - SITES 1&2: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 0	.00 - 2.35
2	1 - 1	2.35 - 4.71
3	2 - 2	4.71 - 7.06
4	3 - 3	7.06 - 9.41
5	4 - 4	9.41 - 11.76
6	5 - 4	11.76 - 14.12
7	5 - 5	14.12 - 16.47
8	6 - 6	16.47 - 18.82
9	7 - 7	18.82 - 21.18
A	8 - 8	21.18 - 23.53

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
34 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 32 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0 -	10.0	0	.0
2	10.0 -	20.0	0	.0
3	20.0 -	30.0	0	.0
4	30.0 -	40.0	0	.0
5	40.0 -	50.0	0	.0
6	50.0 -	60.0	0	.0
7	60.0 -	70.0	0	.0
8	70.0 -	80.0	2	5.9
9	80.0 -	90.0	32	94.1

DISCONTINUITY TYPE	
JOINT	70.6%
TENSION CRACK	29.4%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	29.4%
DEFINED RIDGES	47.1%
SMALL STEPS	5.9%
VERY ROUGH	5.9%
NO DATA	11.8%

ESTIMATED JRC	
0 - 2	.0%
3 - 4	.0%
5 - 6	.0%
7 - 8	26.5%
9 - 10	20.6%
11 - 12	23.5%
13 - 14	5.9%
15 - 16	.0%
17 - 18	5.9%
19 - 20	5.9%
20 (	.0%
NO DATA	11.8%
MEAN	11.1
STD. DEV.	3.5

SPACING (FT)	
(.50	.0%
.50- 1.00	.0%
1.00- 2.00	.0%
2.00- 3.00	2.9%
3.00- 4.50	.0%
4.50- 6.00	20.6%
6.00- 9.00	5.9%
9.00-12.00	17.6%
12.00(	41.2%
NO DATA	11.8%
MEAN	19.3
STD. DEV.	24.3

ROCK TYPE: SANDSTONE

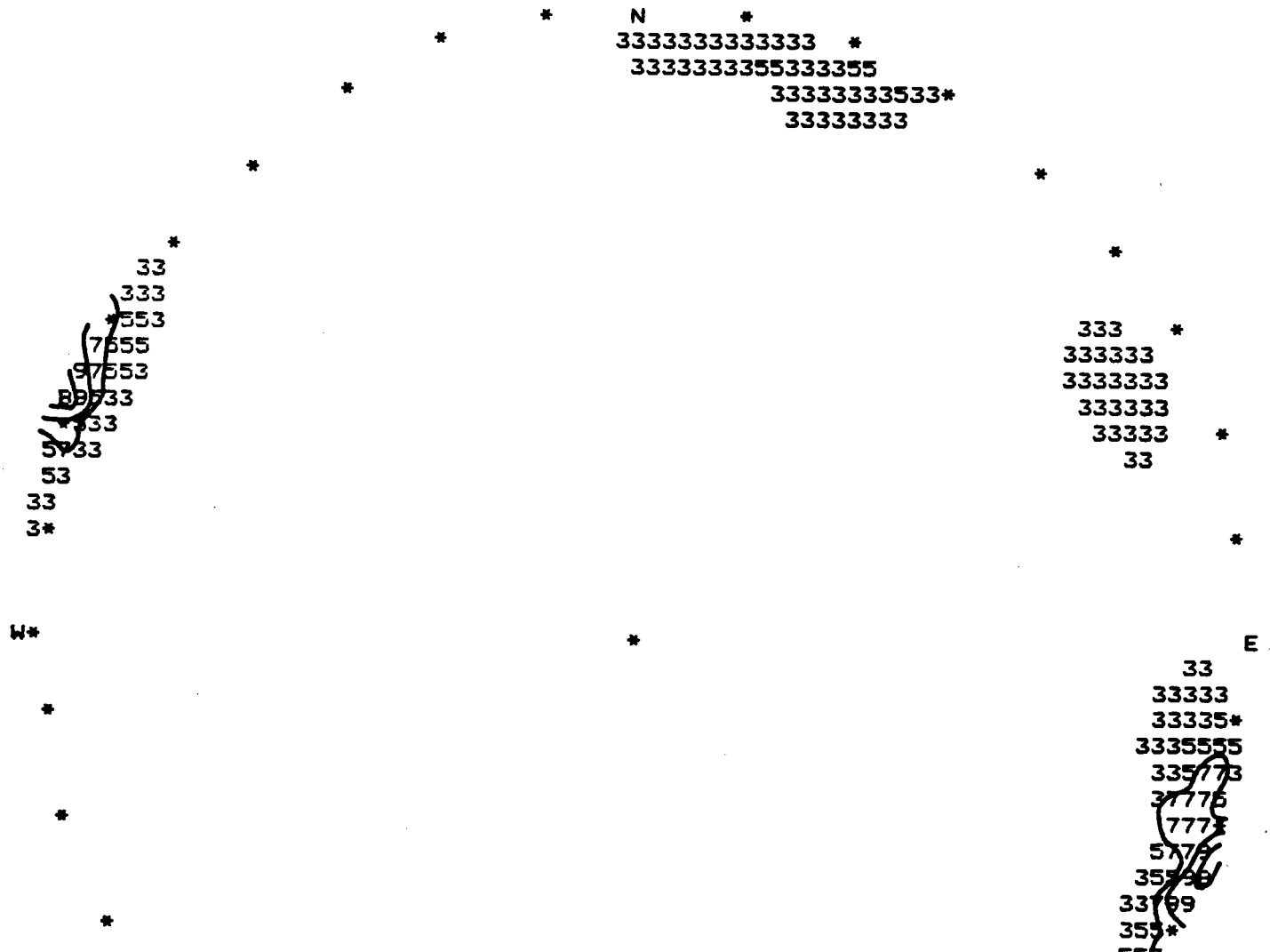
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY	
	STRIKE	DIP
(3	.0%	.0%
3- 6	8.8%	14.7%
6- 15	38.2%	52.9%
15- 30	29.4%	20.6%
30- 45	2.9%	.0%
45- 75	2.9%	.0%
75-150	5.9%	.0%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	11.8%	11.8%
MEAN	23.0	13.7
STD. DEV.	22.9	6.5

9 W / 10 W AREA

SEEGMILLER DATA - SITE 3: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
11 OBSERVATIONS. HIGHEST LEVEL COUNT IS 5



SEEGMILLER DATA - SITE 3: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT		PERCENTAGES		
1	1	- 0	.00	-	4.55
2	1	- 1	4.55	-	9.09
3	2	- 1	9.09	-	13.64
4	2	- 2	13.64	-	18.18
5	3	- 2	18.18	-	22.73
6	3	- 3	22.73	-	27.27
7	4	- 3	27.27	-	31.82
8	4	- 4	31.82	-	36.36
9	5	- 4	36.36	-	40.91
A	5	- 5	40.91	-	45.45
B	6	- 5	45.45	-	50.00

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
11 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 9 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0 -	10.0	0	.0
2	10.0 -	20.0	0	.0
3	20.0 -	30.0	0	.0
4	30.0 -	40.0	0	.0
5	40.0 -	50.0	0	.0
6	50.0 -	60.0	0	.0
7	60.0 -	70.0	0	.0
8	70.0 -	80.0	2	18.2
9	80.0 -	90.0	9	81.8

DISCONTINUITY TYPE	
JOINT	100.0%
TENSION CRACK	.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	54.5%
DEFINED RIDGES	45.5%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

ESTIMATED JRC	
0 - 2	.0%
3 - 4	.0%
5 - 6	.0%
7 - 8	54.5%
9 - 10	18.2%
11 - 12	27.3%
13 - 14	.0%
15 - 16	.0%
17 - 18	.0%
19 - 20	.0%
20 (	.0%
NO DATA	.0%
MEAN	9.3
STD. DEV.	2.0

SPACING (FT)	
(.50	.0%
.50- 1.00	.0%
1.00- 2.00	.0%
2.00- 3.00	.0%
3.00- 4.50	.0%
4.50- 6.00	.0%
6.00- 9.00	27.3%
9.00-12.00	36.4%
12.00(	36.4%
NO DATA	.0%
MEAN	15.0
STD. DEV.	12.2

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY	
	STRIKE	DIP
(3	.0%	.0%
3- 6	9.1%	.0%
6- 15	54.5%	72.7%
15- 30	27.3%	27.3%
30- 45	9.1%	.0%
45- 75	.0%	.0%
75-150	.0%	.0%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	.0%	.0%
MEAN	16.9	15.3
STD. DEV.	10.7	5.9

A P P E N D I X I I

COTTONWOOD DISCONTINUITY ANALYSIS

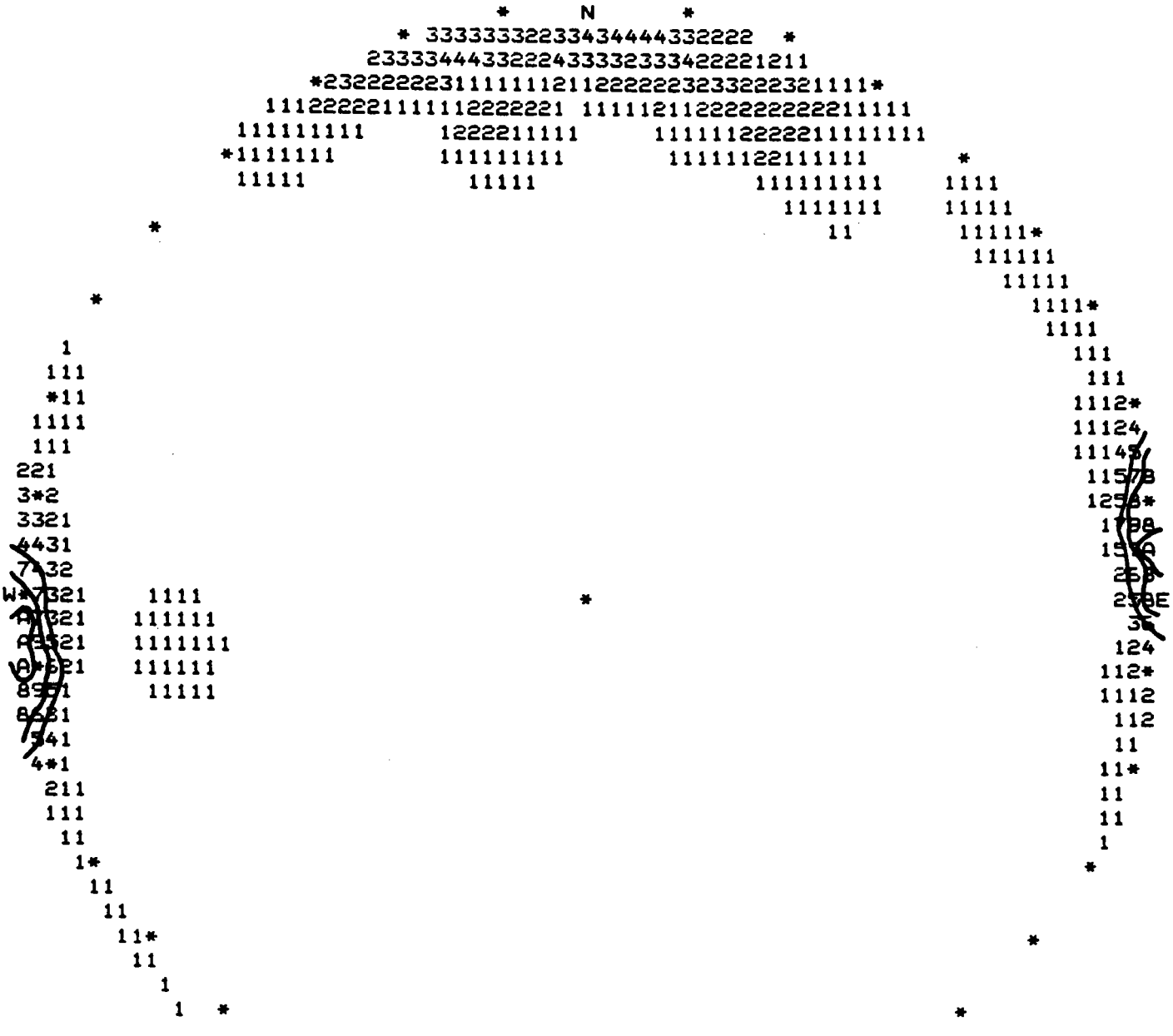
SITE 1 versus SITE 6

Schmidt Nets & Characteristic Statistics

SITE 1 – 6 E / 7E AREA

COTTONWOOD DATA - SITE 1: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
58 OBSERVATIONS. HIGHEST LEVEL COUNT IS 22



COTTONWOOD DATA - SITE 1: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 3.79
2	3 - 4	3.79 - 7.59
3	5 - 6	7.59 - 11.38
4	7 - 8	11.38 - 15.17
5	9 - 11	15.17 - 18.97
6	12 - 13	18.97 - 22.76
7	14 - 15	22.76 - 26.55
8	16 - 17	26.55 - 30.34
9	18 - 19	30.34 - 34.14
A	20 - 22	34.14 - 37.93

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
58 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 49 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	2	3.4
8	70.0 - 80.0	7	12.1
9	80.0 - 90.0	49	84.5

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	96.6%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	3.4%
NO DATA	.0%

SPACING (FT)	
(.50	1.7%
.50- 1.00	12.1%
1.00- 2.00	20.7%
2.00- 3.00	27.6%
3.00- 4.50	5.2%
4.50- 6.00	8.6%
6.00- 9.00	5.2%
9.00-12.00	10.3%
12.00(	5.2%
NO DATA	3.4%
MEAN	4.6
STD. DEV.	4.4

ROCK TYPE: SANDSTONE

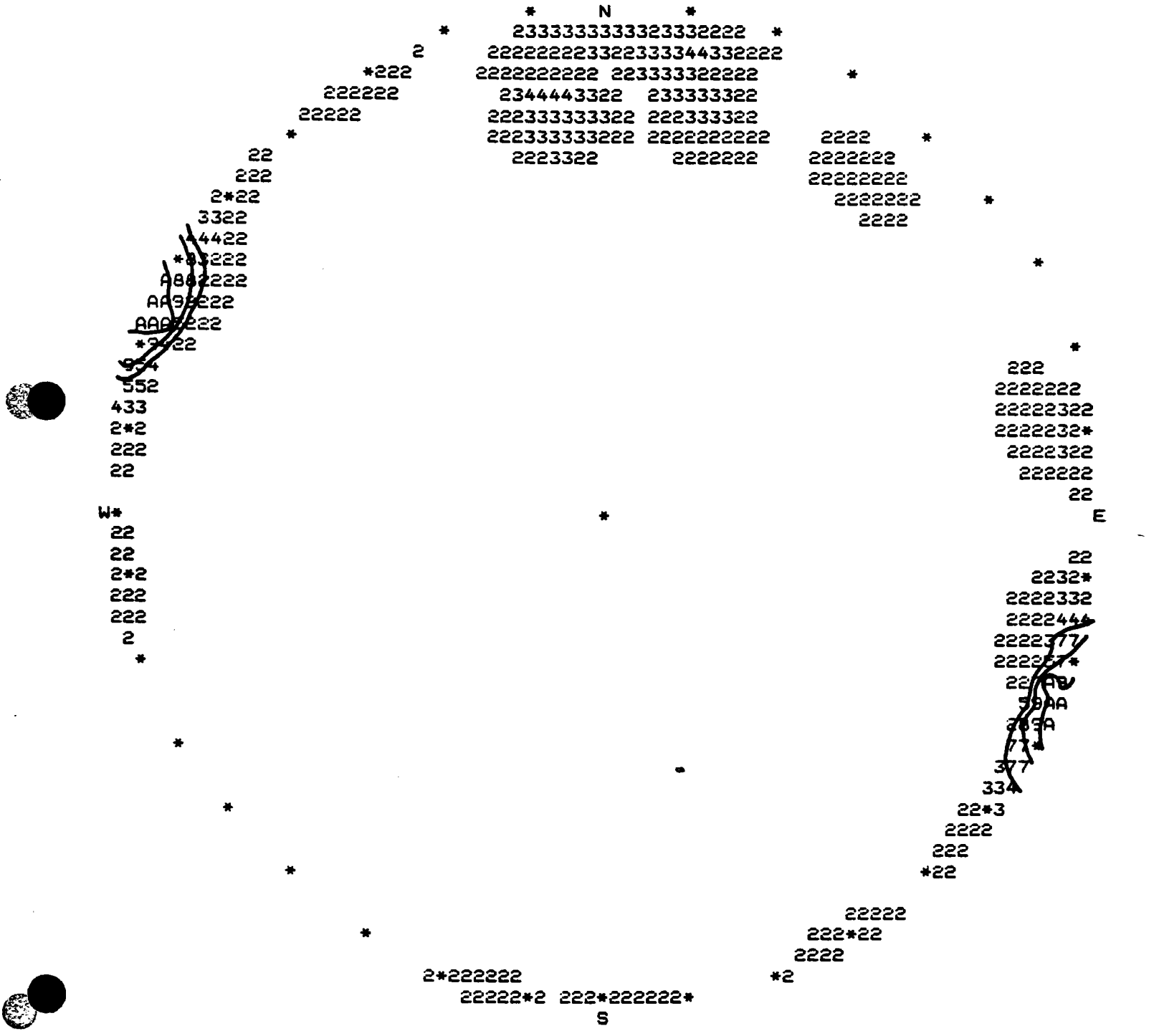
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	DIP
(3	13.8%	8.6%
3- 6	20.7%	25.9%
6- 15	43.1%	50.0%
15- 30	10.3%	10.3%
30- 45	1.7%	.0%
45- 75	.0%	1.7%
75-150	1.7%	1.7%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	8.6%	1.7%
MEAN	11.9	11.8
STD. DEV.	14.4	14.3

SITE 6 — 9 W / 10 W AREA

COTTONWOOD DATA - SITE 6: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
24 OBSERVATIONS. HIGHEST LEVEL COUNT IS 8



COTTONWOOD DATA - SITE 6: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT		PERCENTAGES	
1	1	0	.00	3.33
2	1	1	3.33	6.67
3	2	2	6.67	10.00
4	3	3	10.00	13.33
5	4	4	13.33	16.67
6	5	4	16.67	20.00
7	5	5	20.00	23.33
8	6	6	23.33	26.67
9	7	7	26.67	30.00
A	8	8	30.00	33.33

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
24 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 18 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0	10.0	0	.0
2	10.0	20.0	0	.0
3	20.0	30.0	0	.0
4	30.0	40.0	0	.0
5	40.0	50.0	0	.0
6	50.0	60.0	0	.0
7	60.0	70.0	3	12.5
8	70.0	80.0	3	12.5
9	80.0	90.0	18	75.0

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	100.0%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
(.50	.0%
.50- 1.00	20.8%
1.00- 2.00	20.8%
2.00- 3.00	4.2%
3.00- 4.50	12.5%
4.50- 6.00	12.5%
6.00- 9.00	4.2%
9.00-12.00	12.5%
12.00(	12.5%
NO DATA	.0%
MEAN	5.3
STD. DEV.	4.7

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	DIP
(3	16.7%	20.8%
3- 6	25.0%	8.3%
6- 15	45.8%	45.8%
15- 30	8.3%	16.7%
30- 45	.0%	4.2%
45- 75	4.2%	4.2%
75-150	.0%	.0%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	.0%	.0%
MEAN	11.1	14.1
STD. DEV.	10.6	13.5

APPENDIX III

COTTONWOOD DISCONTINUITY ANALYSIS

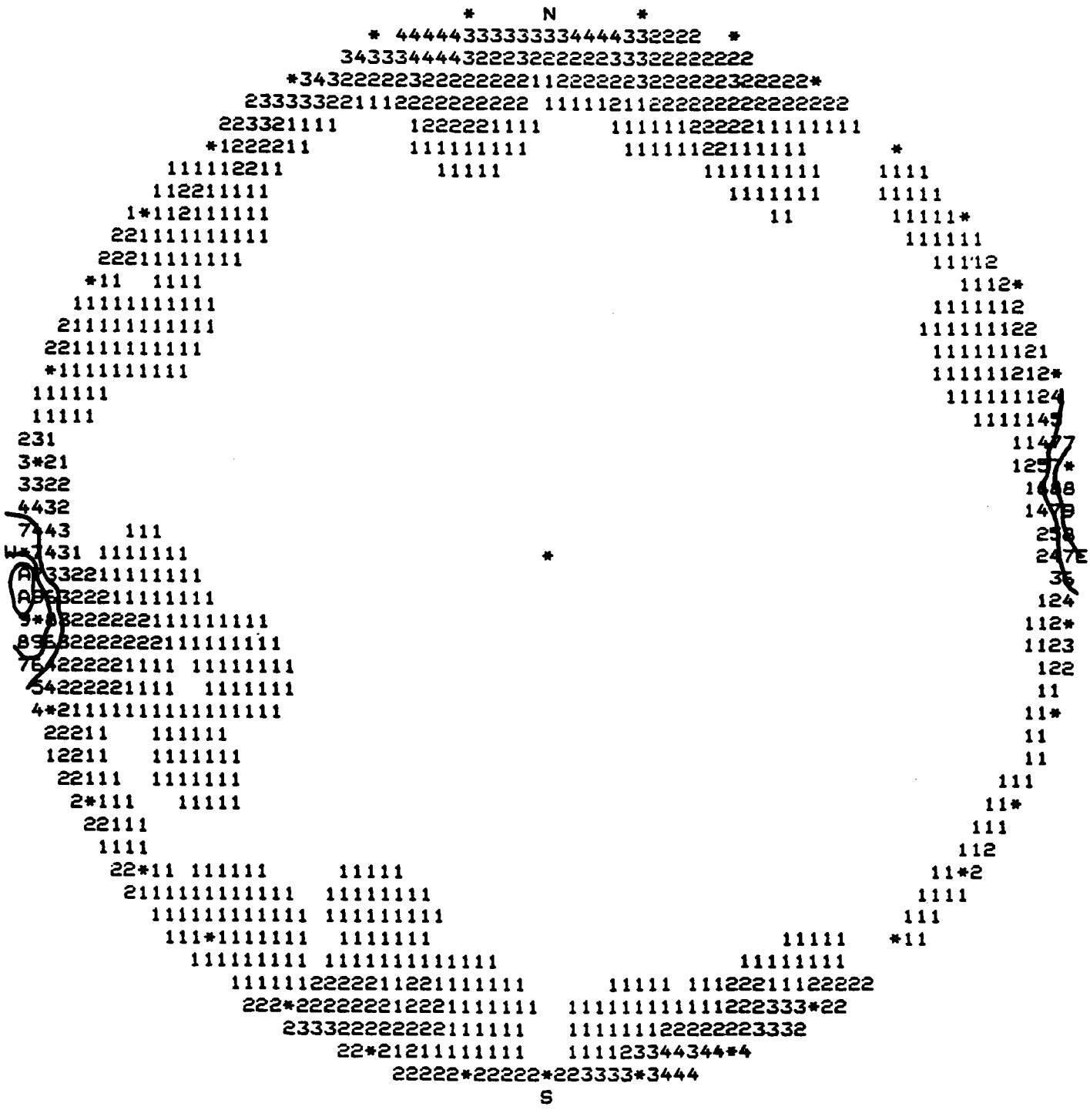
SITES 1 & 2 versus SITES 5 & 6

Schmidt Nets & Characteristic Analysis

SITES 1 & 2 — 6 E / 7E AREA

COTTONWOOD DATA - SITES 1&2: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
110 OBSERVATIONS. HIGHEST LEVEL COUNT IS 29



COTTONWOOD DATA - SITES 1&2: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 2.64
2	3 - 5	2.64 - 5.27
3	6 - 8	5.27 - 7.91
4	9 - 11	7.91 - 10.55
5	12 - 14	10.55 - 13.18
6	15 - 17	13.18 - 15.82
7	18 - 20	15.82 - 18.45
8	21 - 23	18.45 - 21.09
9	24 - 26	21.09 - 23.73
A	27 - 29	23.73 - 26.36

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
110 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 85 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0 -	10.0	0	.0
2	10.0 -	20.0	0	.0
3	20.0 -	30.0	0	.0
4	30.0 -	40.0	0	.0
5	40.0 -	50.0	0	.0
6	50.0 -	60.0	1	.9
7	60.0 -	70.0	5	4.5
8	70.0 -	80.0	19	17.3
9	80.0 -	90.0	85	77.3

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	50.9%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	1.8%
NO DATA	47.3%

SPACING (FT)	
< .50	.9%
.50- 1.00	8.2%
1.00- 2.00	10.9%
2.00- 3.00	15.5%
3.00- 4.50	2.7%
4.50- 6.00	10.0%
6.00- 9.00	3.6%
9.00-12.00	10.0%
12.00<	36.4%
NO DATA	1.8%
MEAN	17.0
STD. DEV.	24.6

ROCK TYPE: SANDSTONE

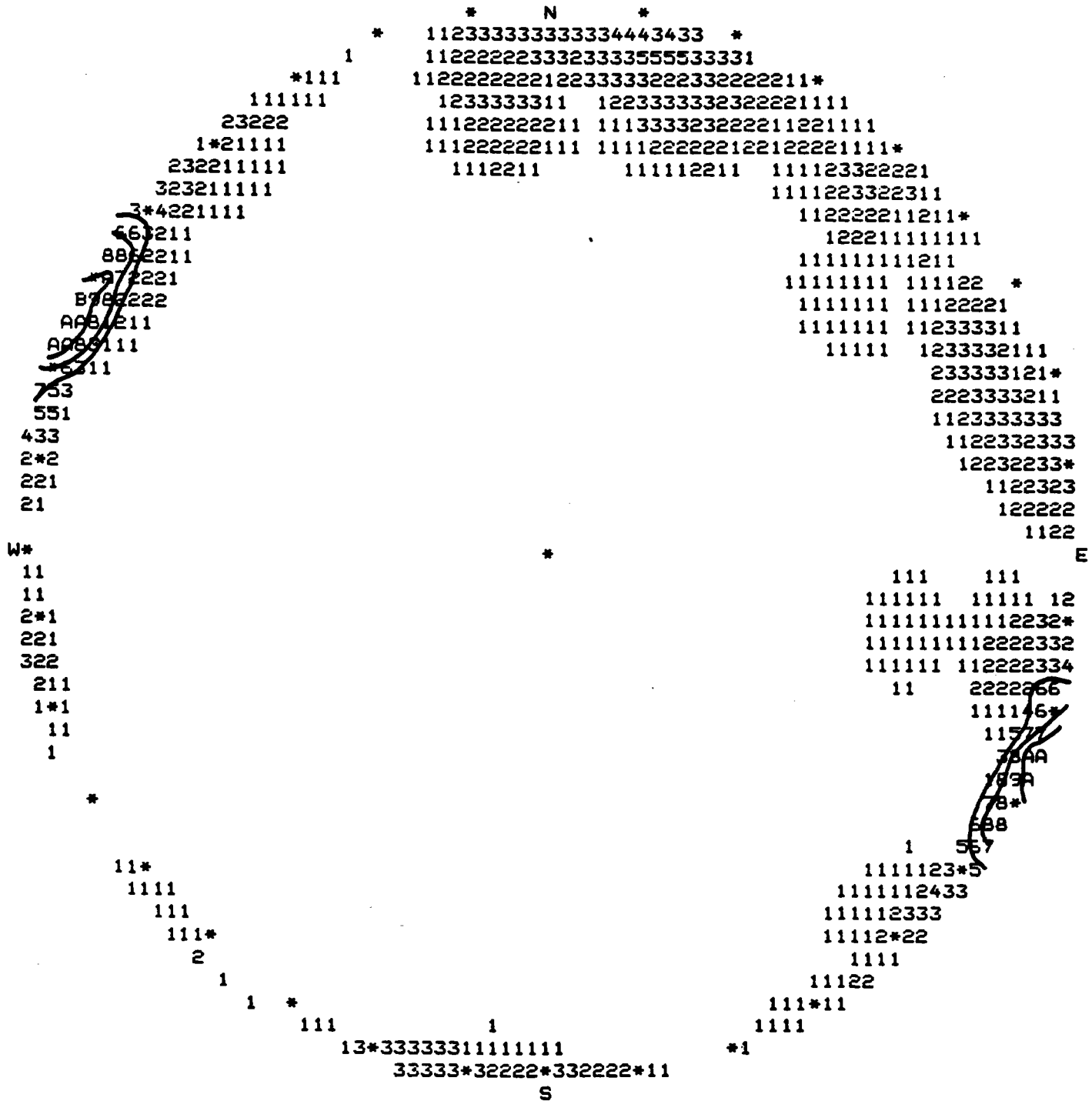
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	3.6%
SOFT ROCK	43.6%
HARD ROCK	52.7%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	DIP
< 3	7.3%	4.5%
3- 6	14.5%	19.1%
6- 15	35.5%	34.5%
15- 30	20.0%	24.5%
30- 45	2.7%	2.7%
45- 75	7.3%	9.1%
75-150	8.2%	4.5%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	4.5%	.9%
MEAN	24.2	21.3
STD. DEV.	27.4	21.6

SITES 5 & 6 — 9 W / 10 W AREA

COTTONWOOD DATA - SITES 5&6: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
57 OBSERVATIONS. HIGHEST LEVEL COUNT IS 14



COTTONWOOD DATA - SITES 5&6: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 1	.00 - 2.46
2	2 - 2	2.46 - 4.91
3	3 - 4	4.91 - 7.37
4	5 - 5	7.37 - 9.82
5	6 - 6	9.82 - 12.28
6	7 - 8	12.28 - 14.74
7	9 - 9	14.74 - 17.19
8	10 - 11	17.19 - 19.65
9	12 - 12	19.65 - 22.11
A	13 - 13	22.11 - 24.56
B	14 - 15	24.56 - 27.02

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
57 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 41 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	1	1.8
7	60.0 - 70.0	4	7.0
8	70.0 - 80.0	11	19.3
9	80.0 - 90.0	41	71.9

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	94.7%
DEFINED RIDGES	3.5%
SMALL STEPS	1.8%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
(.50	.0%
.50- 1.00	10.5%
1.00- 2.00	8.8%
2.00- 3.00	10.5%
3.00- 4.50	10.5%
4.50- 6.00	17.5%
6.00- 9.00	5.3%
9.00-12.00	14.0%
12.00(	17.5%
NO DATA	5.3%
MEAN	7.9
STD. DEV.	8.3

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	DIP
(3	8.8%	14.0%
3- 6	24.6%	12.3%
6- 15	49.1%	50.9%
15- 30	12.3%	17.5%
30- 45	1.8%	1.8%
45- 75	1.8%	1.8%
75-150	1.8%	1.8%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	.0%	.0%
MEAN	13.5	14.8
STD. DEV.	14.7	15.2

A P P E N D I X I V

COTTONWOOD DISCONTINUITY ANALYSIS

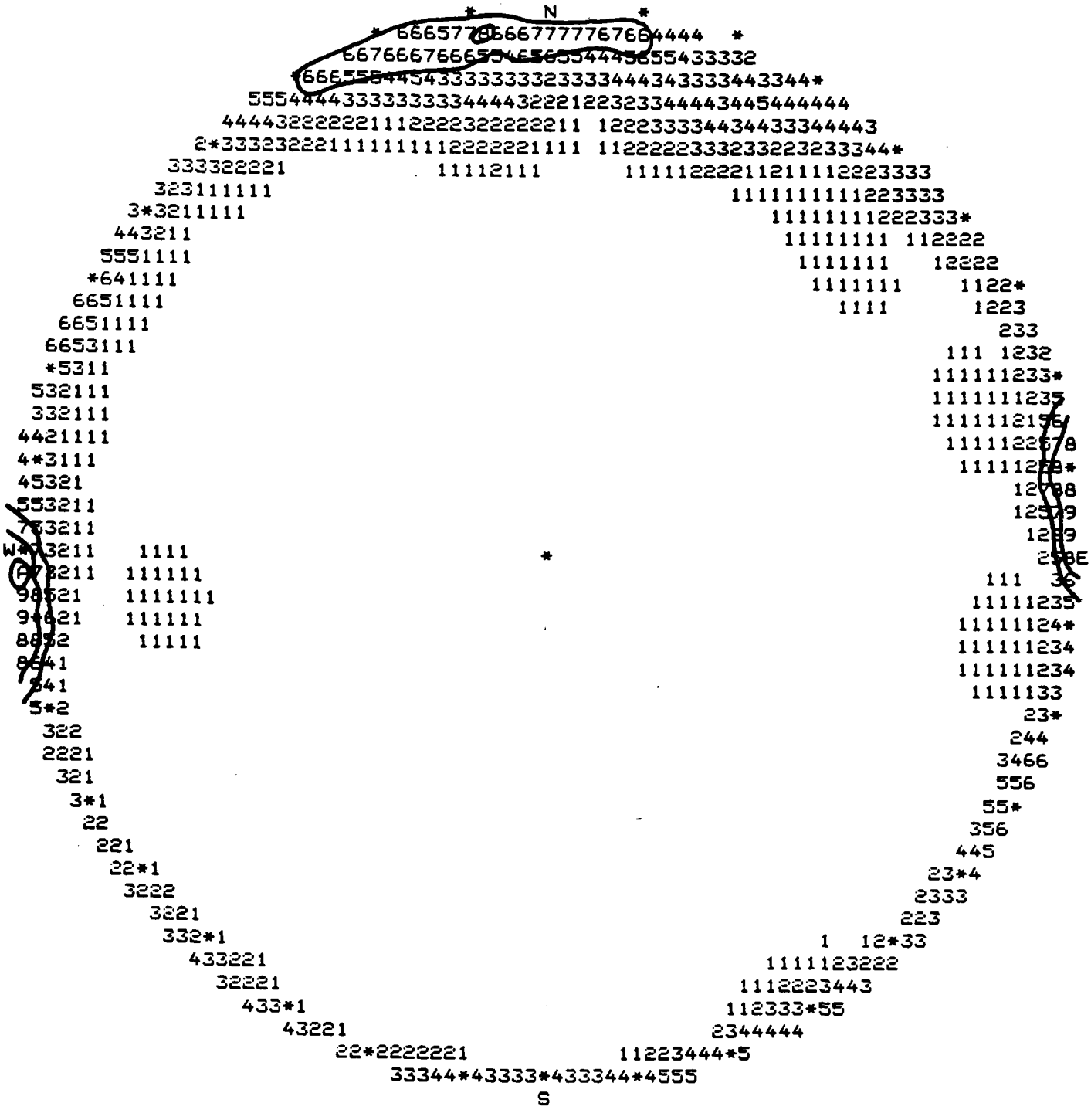
SOUTH-DIPPING versus WEST-DIPPING SLOPES

Schmidt Nets & Characteristic Analysis

ALL SOUTH-DIPPING SLOPES

COTTONWOOD DATA - ALL SOUTH DIPPING SLOPES

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
175 OBSERVATIONS. HIGHEST LEVEL COUNT IS 29



COTTONWOOD DATA - ALL SOUTH DIPPING SLOPES

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 1.66
2	3 - 5	1.66 - 3.31
3	6 - 8	3.31 - 4.97
4	9 - 11	4.97 - 6.63
5	12 - 14	6.63 - 8.29
6	15 - 17	8.29 - 9.94
7	18 - 20	9.94 - 11.60
8	21 - 23	11.60 - 13.26
9	24 - 26	13.26 - 14.91
A	27 - 29	14.91 - 16.57

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
175 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 150 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	6	3.4
8	70.0 - 80.0	19	10.9
9	80.0 - 90.0	150	85.7

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	79.4%
DEFINED RIDGES	12.0%
SMALL STEPS	6.9%
VERY ROUGH	1.7%
NO DATA	.0%

SPACING (FT)	
(.50	2.3%
.50- 1.00	8.6%
1.00- 2.00	15.4%
2.00- 3.00	16.6%
3.00- 4.50	9.7%
4.50- 6.00	16.0%
6.00- 9.00	5.1%
9.00-12.00	9.7%
12.00(	12.6%
NO DATA	4.0%
MEAN	6.3
STD. DEV.	6.8

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	DIP
(3	10.3%	15.4%
3- 6	24.0%	28.6%
6- 15	42.9%	36.0%
15- 30	13.7%	13.1%
30- 45	1.7%	.6%
45- 75	1.7%	2.9%
75-150	2.9%	2.3%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	2.9%	1.1%
MEAN	14.0	12.9
STD. DEV.	17.5	16.8

ALL WEST-DIPPING SLOPES

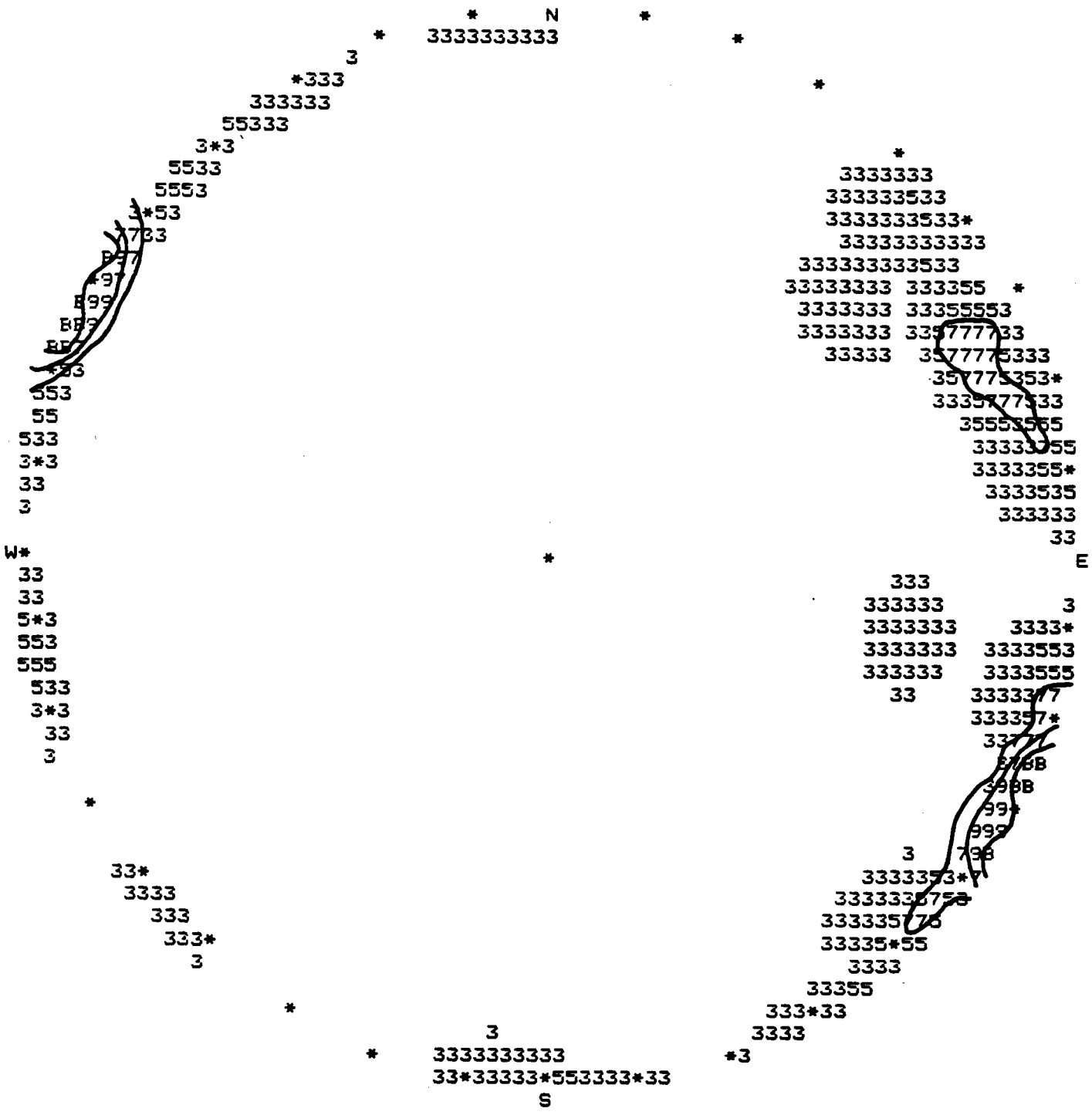
COTTONWOOD DATA - ALL WEST DIPPING SLOPES

----------POLAR EQUAL AREA PROJECTION----------

PLOTTING CIRCLE RADIUS IS 4.0 INCHES

----------LEVEL PLOT TYPE 1 ----------

23 OBSERVATIONS. HIGHEST LEVEL COUNT IS 5



COTTONWOOD DATA - ALL WEST DIPPING SLOPES

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 0	.00 - 2.17
2	1 - 1	2.17 - 4.35
3	2 - 1	4.35 - 6.52
4	2 - 2	6.52 - 8.70
5	3 - 2	8.70 - 10.87
6	3 - 3	10.87 - 13.04
7	4 - 3	13.04 - 15.22
8	4 - 4	15.22 - 17.39
9	5 - 4	17.39 - 19.57
A	5 - 5	19.57 - 21.74
B	6 - 5	21.74 - 23.91

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
23 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 16 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0 -	10.0	0	.0
2	10.0 -	20.0	0	.0
3	20.0 -	30.0	0	.0
4	30.0 -	40.0	0	.0
5	40.0 -	50.0	0	.0
6	50.0 -	60.0	1	4.3
7	60.0 -	70.0	1	4.3
8	70.0 -	80.0	5	21.7
9	80.0 -	90.0	16	69.6

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	91.3%
DEFINED RIDGES	8.7%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
(.50	.0%
.50- 1.00	8.7%
1.00- 2.00	4.3%
2.00- 3.00	4.3%
3.00- 4.50	4.3%
4.50- 6.00	17.4%
6.00- 9.00	4.3%
9.00-12.00	21.7%
12.00(	26.1%
NO DATA	8.7%
MEAN	10.8
STD. DEV.	10.6

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
(3	8.7%	17.4%
3- 6	17.4%	4.3%
6- 15	47.8%	56.5%
15- 30	17.4%	17.4%
30- 45	4.3%	.0%
45- 75	.0%	.0%
75-150	4.3%	4.3%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	.0%	.0%
MEAN	17.2	16.1
STD. DEV.	20.3	19.3

APPENDIX F

ARCHEOLOGICAL - ENVIRONMENTAL RESEARCH CORPORATION CULTURAL RESOURCE EVALUATION

ARCHEOLOGICAL - ENVIRONMENTAL RESEARCH CORPORATION

P.O. Box 853 Bountiful, Utah 84010
Tel: (801) 292-7061, 292-9668

November 16, 1987

Subject: **CULTURAL RESOURCE EVALUATION OF POTENTIAL SUBSIDENCE AND ESCARPMENT FAILURE AREAS IN THE EAST MOUNTAIN LOCALITY OF EMERY COUNTY, UTAH**

Project: Utah Power & Light Company - 1987-88 Wilberg Mine Development and Expansion Program

Project No.: UPL-87-6

Permit No.: Dept. of Interior U-87-54937
Utah State Project No. 87-AF-739bf

To: Mr. Ray Christensen, Utah Power & Light Company, P.O. Box 1005, Huntington, Utah 84528

Info: Utah State Preservation Office, Division of State History, 300 Rio Grande, Salt Lake City, Utah 84101

GENERAL INFORMATION:

On November 12, 1987, F.R. Hauck of AERC conducted cultural resource reconnaissance evaluations of a variety of locations associated with the proposed development zone in the Wilberg Mine permit area. This project was initiated for the mining and exploration section of the Utah Power and Light Company. The project area is situated on the southern portion of East Mountain in Emery County, Utah, and spans across the mountain from Cottonwood Canyon on the west, to Grimes Wash on the east (see attached maps).

The purpose of the investigations was two-fold: (1) to ascertain the potential for cultural resource disturbance on East Mountain as a result of any future subsidence resulting from the proposed expansion of the subsurface mine within the centers of Sections 27, 28, 29, and 30 of Township 17 South, Range 7 East; and (2) to determine within two tributary canyons, the potential for cultural resource disturbance resulting from any future escarpment failure associated with proposed and current mining operations conducted in the proximity of the canyon walls in Sections 27, 28, 30, and 34 of Township 17 South, Range 7 East.

The project area ranges from the 7200 foot elevation at the mouth of Miller Canyon in Cottonwood Canyon (see Map 1) up to the 9600 feet above sea level on the plateau of East Mountain and then down to the 7000 foot elevation at the canyon entrance in Grimes Wash (see Map 3). Pinyon-Juniper woodlands is the primary vegetation community on the canyon walls and drainages. This community is gradually replaced by mountain brush communities and then the aspen-fir communities associated with the higher elevations. Drainage in the western portion of the project area is to the west into Miller and Cottonwood Canyons. The eastern portion of the project area drains east into tributaries of Grimes Wash. Geological formations encountered on the canyon walls include the Flagstaff and North Horn formations on the East Mountain plateau. The Price River Group, Castlegate Sandstone, Black Hawk Group, Star Point Sandstone, and finally the Masuk member of the Mancos Shale are the various formations that comprise the canyon walls between the plateau and Cottonwood Creek on the south.

FILE SEARCH:

A records search was conducted at the Antiquities Section of the Utah State Division of History in Salt Lake City on November 16, 1987. No known National Register properties are situated in the project area, nor will the proposed development have any direct adverse affect on any known cultural resources in the general area.

PREVIOUS FIELD EVALUATIONS IN THE PROJECT AREA:

Drill Location and Access Route Examinations

A number of cultural resource clearance projects have been conducted on East Mountain since 1976 covering approximately 45 acres and involving about 28 miles of access routes. About five acres of these evaluations have been confined within the project area addressed within this report. These evaluations include the following drill locations and associated access roads: EM-2 (Hauck 1977B); EM-25 (Hauck 1978), EM-83 and EM-84 (Hauck 1981); EM-80, EM-81, EM-82, EM-90, and EM-91 (Hauck and Weder 1981); EM-92 and EM-93 (Hauck 1982A); EM-95 (Hauck 1982B); EM-96 and EM-97 (Hauck and Weder 1982B); EM-98 (Hauck 1983A); EM-105 (Hauck 1983D); EM-112 (Hauck 1984); and EM-139 (Hauck 1987).

No cultural resources were identified within the project area during these evaluations.

Seismic Corridor Examinations

Two seismic lines that pass through the project area have been examined for cultural resources. These lines were reported by Sagebrush Archaeological Consultants (see Montgomery 1984 and Montgomery 1985).

No cultural resources were identified during these evaluations within the project area.

Sample Survey Examinations

In 1980 AERC conducted sample surveys of 2705 acres on East Mountain to determine the area potential for cultural resource disturbance through subsidence (see Hauck and Weder 1980). This project was in addition to an earlier AERC sample survey on East Mountain that was conducted under government contract during the Central Coal Project (Hauck 1979A). Between these two large projects, a total of 3985 acres on the mountain were evaluated and some eight sites recorded.

Within the project area addressed by this present report, some 170 acres comprising five separate samples were intensively evaluated relative to the subsidence study. No cultural resources were identified within the project area.

Intensive Surface Examinations

Large-scale intensive surface evaluations have been conducted in the Cottonwood and Grimes Wash Canyons which flank the project area (see Hauck 1977A, Hauck 1979B, and Hauck and Smith

1979). Although outside the subsidence zone as defined by Maps 1 through 3, these evaluations extended short distances into the canyons where escarpment failure is occurring (above Grimes Wash) or may possibly occur in the future (above Miller Canyon adjacent to Cottonwood Canyon). These studies identified a higher concentration of cultural sites within these general canyon bottoms than was found on East Mountain. However, no cultural sites were found within the side canyons which are the present focus of the escarpment failure evaluations.

FIELD EVALUATIONS:

On November 12, 1987, the archaeologist first traveled to the top of East Mountain to evaluate cultural presence and/or the potential for significant cultural resources on those previously unexamined surfaces where future subsidence could occur as a result of the proposed mining expansion into this locality. A foot of snow cover on the plateau's upper slopes and terraces precluded the initiation of any intensive surface evaluations. It is unlikely that area will be free of snow until next spring.

Reconnaissance evaluations were also conducted in Miller Canyon (see Map 1). The unnamed canyon adjacent to Grimes Wash (see Maps 2 and 3) was examined in April 1987 by this archaeologist. The purpose of these non-intensive evaluations was to determine the cultural resource potential along the canyon walls and bottom where present and potential escarpment failure can occur. Mining operations within the mountain are loosening the exposed escarpments resulting in the development of new talus slopes in the Grimes Wash locality. These slides pose a threat to any cultural resource sites which may be in the talus path.

No cultural resource materials nor activity sites of any historic or prehistoric period were identified or recorded during these reconnaissance evaluations. No artifacts were observed or collected during the project.

DISCUSSION:

There is little probability that significant cultural resources exist on the East Mountain plateau and upper slopes and terraces within the potential subsidence zone addressed in this report. As summarized above, numerous archaeological evaluations have been conducted on the mountain and its adjacent canyons during the past ten years. These intensive evaluations have involved large-scale surface examinations, sample surveys, seismic line evaluations, and a large number of drill location-access route examinations (cf., bibliography). The information gathered through these various operations indicates both a prehistoric and historic preference for the canyon floors with a

reduction of activity on the highland plateau, sparse utilization of the upper canyon slopes and terraces, and very little activity on the canyon walls and steeper slopes. This pattern of prehistoric-historic activity was predicted in 1977 when site 42Em721 on Trail Mountain was the only known cultural resource existing in the higher elevations of this general region (see Hauck 1977C).

These patterns can be better appreciated by comparing the results of these numerous archaeological surveys. Intensive surveys of the canyon bottoms have resulted in a total of seven prehistoric sites in Grimes Wash where some 250 acres were evaluated (Hauck 1977A). A total of nine sites have been recorded in Cottonwood Canyon where about 440 acres were examined (Hauck 1979B and Hauck and Smith 1979). In contrast, some 4030 acres on East Mountain have been intensively evaluated by AERC since 1976 (Hauck 1979A, Hauck and Weder 1980, and various reports listed in bibliography between 1977B and 1987). A total of eight sites have been recorded on the mountain plateau and its upper slopes and terraces.

These figures roughly indicate that in the upper regions of Grimes Wash there is one site per 36 acres. In Cottonwood Canyon there is one site per 49 acres. East Mountain contains about one site per 504 acres. No sites or isolated artifacts have been found in the narrow canyons or on the steep but accessible canyon walls.

In addition, the most complex and significant sites found in this general area consist of three rock shelter occupations situated on the canyon floors. Two of these sites were subsequently excavated by AERC (see Hauck 1979B, and Hauck and Weder 1982A).

In contrast, only one culturally significant site has been discovered on East Mountain. This site consists of a large, prehistoric camp as reported by Hauck and Weder (1980:53). The remainder of the sites on the mountain consist of small lithic scatters and short-term campsites of low significance. Thus, not only is there a low potential for sites in the possible subsidence zone on the upper mountain slopes and plateau, but there is also marginal potential for this zone containing the types of complex sites that are presently perceived to be most susceptible to disruption through subsidence, i.e., occupations containing either standing architecture or stratified cultural deposits.

CONCLUSION AND RECOMMENDATIONS:

Based upon the cultural resource density and significance information summarized above, the following conclusions can be advanced:

a. No known cultural resource sites of historic or prehistoric use and/or occupation are situated within the project area as addressed within this report;

b. there is a low probability that significant cultural resources exist on the upper elevations of East Mountain within this project area that are threatened by future subsidence; and

c. there is very little to no probability that significant cultural resources exist on the accessible canyon walls and the tributary canyon floors adjacent to Cottonwood Canyon (Miller Canyon) and adjacent to Grimes Wash where escarpment failure is or possibly could occur.

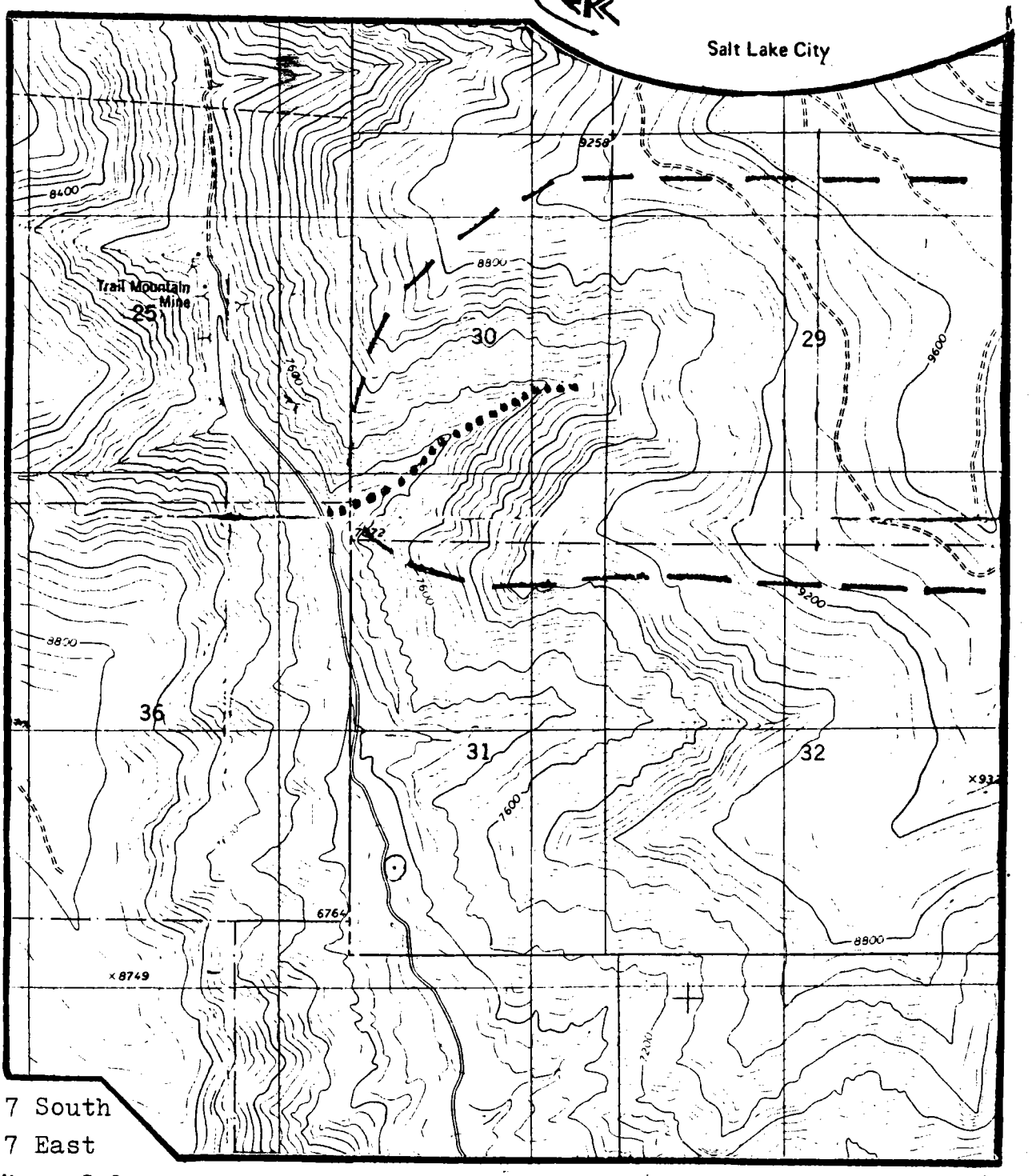
Therefore, AERC recommends that a cultural resource clearance be granted to the Utah Power and Light Company relative to the development of new portals and mining operations within the project area based upon the following recommendations:

a. When weather conditions permit, an intensive evaluation should be conducted of those limited surfaces within this project area on East Mountain which have a low probability for containing presently unidentified significant cultural resources; and

b. this evaluation should be associated with an examination of the present condition of known cultural resources situated within the existing subsidence zone on the mountain. Such an examination may provide pertinent information on cultural resource disturbance potential and extent as a result of subsidence action.

F. Richard Hauck, Ph.D.
President and Principal
Investigator

ARCHEOLOGICAL-ENVIRONMENTAL RESEARCH CORPORATION



T. 17 South
R. 7 East

Meridian: Salt Lake B. & M.

Quad: Mahogany Point, Utah 7.5 minute-USGS

Project: UPL-87-6
Series: Central Utah
Date: 11-16-87

MAP 1
Cultural Resource Survey of Potential Disturbance Areas in the East Mountain Locality of Emery County, Utah

Legend:
Potential Subsidence Area
Reconnaissance Route

2.64" = 1 mile

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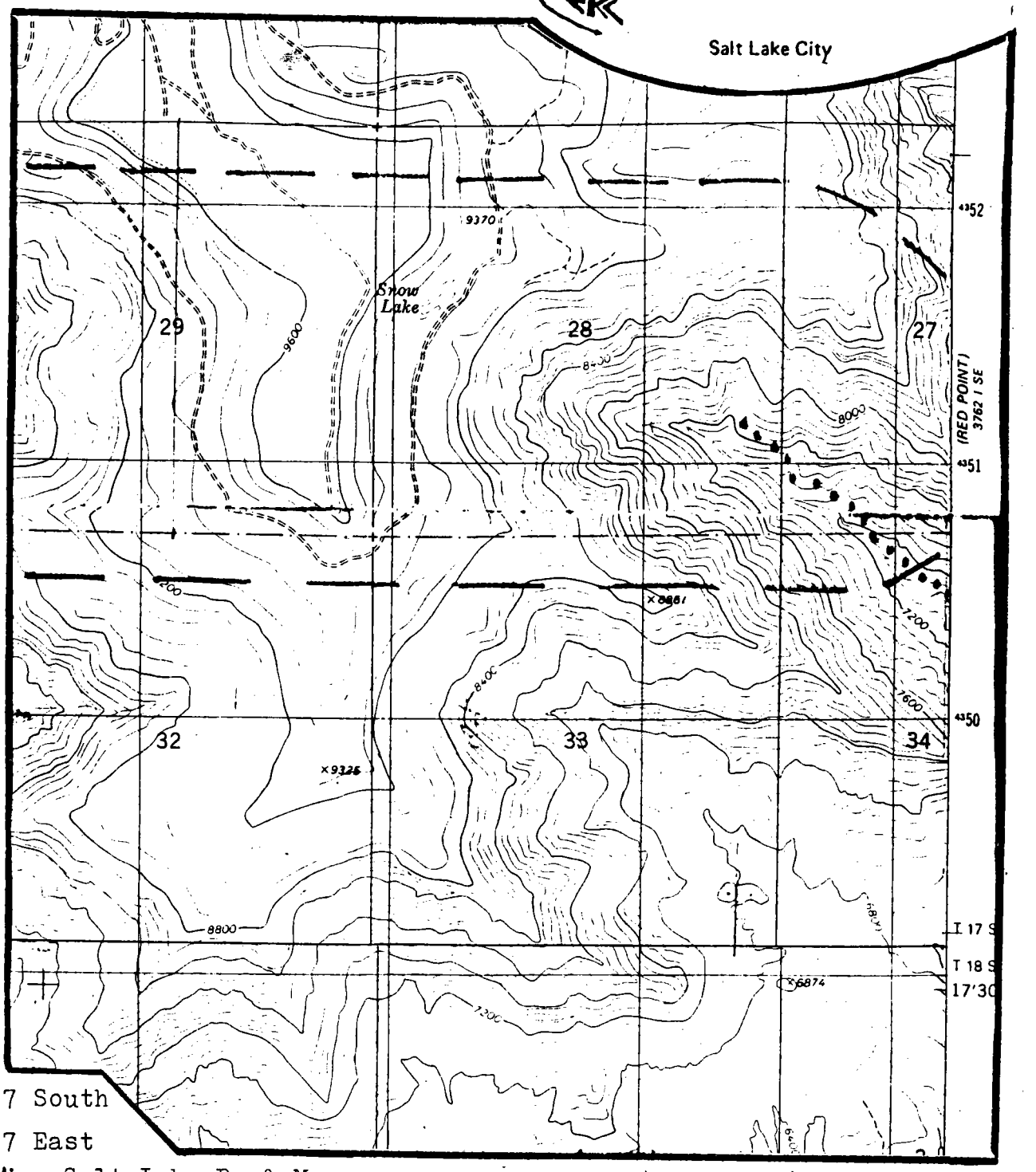


T. 17 South

R. 7 East

Meridian: Salt Lake B. & M.

Quad: Mahogany Point, Utah 7.5 minute-USGS

Project: UPL-87-6

Series: Central Utah

Date: 11-16-87

MAP 2
Cultural Resource Survey of Potential Disturbance Areas in the East Mountain Locality of Emery County, Utah

Legend:

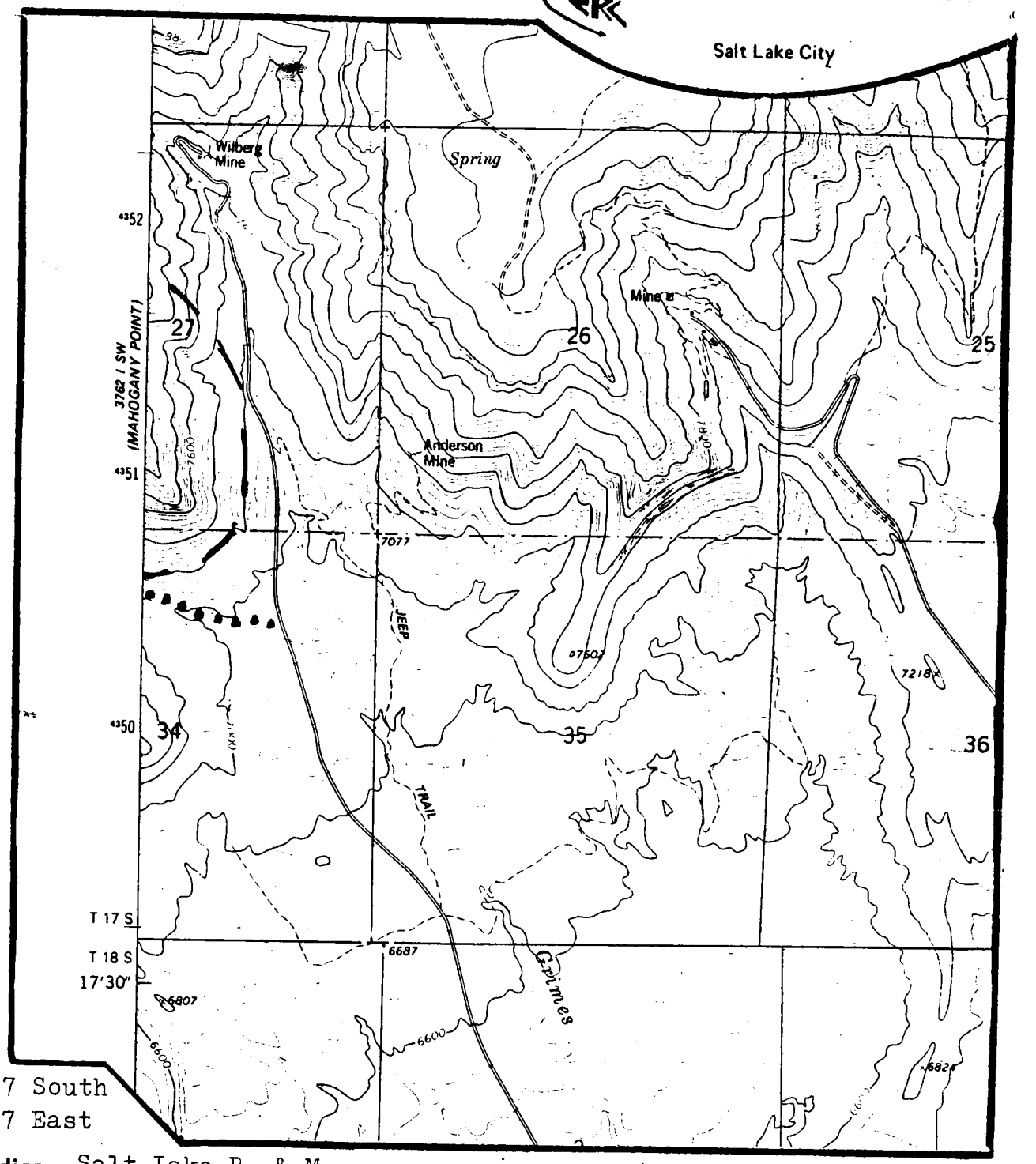
Potential Subsidence Area

Reconnaissance Route

N

2.64" = 1 mile

ARCHEOLOGICAL-ENVIRONMENTAL RESEARCH CORPORATION



T. 17 South
R. 7 East
Meridian: Salt Lake B. & M.

Quad: Red Point, Utah 7.5 minute-USGS

Project: UPL-87-6
Series: Central Utah
Date: 11-16-87

MAP 3
Cultural Resource Survey of Potential Disturbance Areas in the East Mountain Locality of Emery County

Legend:
Potential Subsidence Area
Reconnaissance Route

N

2.64" = 1 mile
Scale

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