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SITE CERTIFICATION APPLICATION
AND
ENVIRONMENTAL ANALYSIS

SEMINOLE PLANT UNITS NO. 1 & NO. 2

SEMINOLE ELECTRIC COOPERATIVE, INC.

VOLUME III
APPENDICES
2

GEOLOGY/SOILS

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GEOLOGY/SOILS

E.1 INTRODUCTION

The objective of this Appendix is to provide a broad geotechnical description of the materials underlying the Putnam Site and to present sufficient data to support this description. Although a preliminary evaluation is made of the suitability of these materials for potential foundation support, it may be emphasized that the level of effort expended was aimed at addressing those issues of relevance to an environmental analysis, and consequently should not be misconstrued as being sufficiently definitive to permit an initiation of foundation design.

It is also stressed that although the general geology of the region was taken into account in analyzing local subsurface conditions, the geologic setting of the site is not addressed in this Appendix, and the reader is referred for this information to Section 2.2 in the main body of the text.

The main emphasis of this work relates to the following:

1. the engineering nature of subsurface materials, in particular with respect to variation both vertically and horizontally of unconsolidated materials; any anticipated foundation problems and the relative suitability of existing subsurface conditions for the proposed facilities,

2. the identification of any mitigating measures that could be implemented to either reduce environmental impacts, or improve, from a geotechnical standpoint, the design layout of major plant facilities.

E.2 GEOTECHNICAL PROGRAM

The description of the subsurface conditions of the site is based on 5 exploratory test borings ranging in depth from approximately 100 to 200 feet below existing grade and by a number of hand auger holes to a maximum depth of 8 feet.

Samples were taken at intervals of 5 feet to 100 feet and at either 5 or 10 feet between 100 feet and 200 feet below surface, and all unconsolidated materials were described in terms of the Unified Soil Classification System (Figure E-1). Standard Penetration tests furnished the bulk of samples for identification and provided the main source of quantitative data. The laboratory program consisted predominantly of index-type testing including Atterberg limit tests, moisture and density determinations, and particle size analyses. These assisted in the engineering classification of materials. A few relatively undisturbed samples were taken at selected locations for more sophisticated testing (triaxial compression, direct shear, and consolidation tests).

Boring logs presenting the data collected during the program described above are included in Figures E-2 through E-9. Legend is shown on Figure E-10.

Boring 2-1 was located in a shallow semi-circular depression to assess the depression's possible association with collapsed cavern activity at depth. No such association was found. Further, an aerial photograph analysis showed no sinkhole-related features in the immediate vicinity of the site.

E.3 DESCRIPTION OF SOILS

The surficial soil characteristics of the site are shown in a surface soil map prepared by the U. S. Soil Conservation Service (1973) (Figure E-11). Beneath surficial deposits, the area sampled showed three broad geotechnically distinguishable and horizontally continuous layers (Figure 2.2-15). The geotechnical characteristics of these layers are described below:

1. Layer 1 consists of a clean fine to medium sand extending over most of the high ground of the site, to a depth of approximately 40 feet below surface. Based on typical standard penetration test 'N' values, this sand may be described for the most part as "medium dense" to "dense."

The gradational characteristics of the layer are shown in Figure E-12. Sieve analysis showed a silt and clay size fraction of up to 15 percent. Based on typical gradational characteristics, the coefficient of permeability of these sands is estimated to be on the order of 10^{-3} cm/sec. A preliminary evaluation of a field pumping test, however, suggests a somewhat higher value of 2 x 10^{-2} cm/sec.

The natural moisture content of samples tested ranged from about 14 percent to 25 percent (with corresponding natural dry densities of 121 and 99 pcf). Laboratory direct shear tests on samples taken from 11 feet and 22 feet below surface in Boring 2-1 showed shear strengths of 900 and 1550 psf under normal pressures of 1000 and 2000 psf, respectively. Shear strengths, in general, may be expected to increase with depth or with increasing confining pressures.

This sand layer constitutes an upper, unconfined, or water table aquifer, with the water table existing at about 8 feet below surface at the time of drilling.

2. Layer 2 is an interbedded layer extending typically between about 40 feet and 100 feet below surface. This layer is distinguished from the clean sands overlying it, by its increasing content of fines and from the layer underlying it, by that layer being more cohesive in makeup.

   The unit characteristically contains interbedded silty and clayey sands and clean sands with 'N' values on the order of 15 to 50 and, as with the overlying clean sand above, may again be best described as "medium dense" to "dense." As is apparent from the logs, however, anomalies do exist in the form of low blow count materials, (less than 10 blows per foot) generally between 60 and 80 feet below surface. These few areas of low blow count material should be looked at in more detail in the foundation investigation, but may well be the result of a "quick" condition which can exist at the tip of the split spoon during driving, rather than an indication of "very loose/soft" material.

Based on limited classification tests, this layer appears to consist predominantly of granular (non-plastic) materials. With the exception of a clay lens at approximately 50 feet below surface (Figure E-5) the soils comprising Layer 2 tended to show a fine fraction (material passing the number 200 seive) of up to 25 percent (Figure E-13). The natural moisture content ranged from 22 to 41 percent (with corresponding dry densities of 104 and 80 pcf, respectively).

3. Layer 3, the lowest overburden layer identified, extends from approximately 100 feet below surface to the top of the limestone intersected at approximately 200 feet. This unit is characterized by interbedded layers containing an overall higher percentage of fines, a notable lack of clean sands and significant thicknesses of cohesive materials. Materials within unit 3 were described typically as hard sandy clays grading with lenses of clayey and silty sands, clayey silts and occasionally with hard inorganic clays. 'N' values of these materials ranged from about 30 to approximately 100 suggesting consistencies of "very stiff" to "hard" for cohesive soils and "medium dense" to "dense" for granular soils.

   Once again the individual beds within this unit appear to be lenticular and gradational in a lateral direction.

   Sieve analyses from Layer 3 typically show approximately 50 percent of material finer than the number 200 sieve (Figure E-14). These materials may be expected to show an average coefficient of permeability on the order of 10^{-8} cm/sec and are therefore relatively impermeable. Tests showed the natural water content to range from 35 to 57 percent with corresponding dry densities of 86 pcf and 68 pcf, respectively. The high 'N' values throughout the thickness of this layer should correspond with high unconfined compressive strengths in the clay zones.

Unit 3 corresponds with the Miocene Hawthorn Formation discussed in Section 2.2.4. It constitutes the major confining layer or aquiclude to the underlying limestones which comprise the Floridan Aquifer. Its effectiveness as an aquiclude demonstrates, on a large scale, its overall low permeability.

Deep borings on site show the top of the Eocene limestone dipping to the northwest as approximately 50 feet per mile. This corresponds with the direction of the near-regional trend. It is, however, somewhat steeper than average dips over the area depicted in Figure 2.2-6. In addition, a microscopic examination of the limestone sampled suggests that the uppermost limestones underlying the site belong to the Crystal River Formation. This means that the contact between the Crystal River Formation and the Williston Formation extends slightly to the south of the contact shown in Figure 2.2-6.

E.4 FOUNDATION SUITABILITY

Liquefaction Potential

An assessment of liquefaction potential is not a requirement for the licensing of a steam-electric generating plant. However, good engineering practice dictates that any condition which might reasonably be expected to affect the stability of the foundation materials should be examined. Thus, the liquefaction potential of the soils at the site has been reviewed, using the simplified Seed & Idriss approach.

This approach, first presented in Seed & Idriss (1971) was updated and modified slightly as more data became available (Seed, 1976). This is an empirical method based on field observations of the performance of sites at which liquefaction has, or has not occurred during previous earthquakes. Briefly, the procedure is to compare blow counts from the standard penetration tests, which have been corrected to an effective overburden pressure of 1 ton/sq. ft., with an empirical relationship of corrected blow count for which liquefaction may occur. This empirical relationship is a function of peak ground acceleration and earthquake magnitude.

As described in Section 2.2.6, the Florida peninsula is one of the least seismically active regions in the United States. For the purpose of the analysis of liquefaction potential, a conservative peak ground acceleration of 0.1g was assumed.

The variation of blow count with depth is shown in Figure E-15. This plot shows overall high values, a few low values and a general scatter of results. Figure E-16, a plot of 'N' values against elevation, shows a similar trend, with the scatter of results indicating neither high nor low value material showing lateral continuity.

Since Boring 1 is nearest to the probable location of major foundation bearing structures, the standard penetration values from this bore hole were corrected to allow for effective overburden pressure, and plotted against depth below surface (Figure E-17). The fact that corrected blow counts to a depth of 50 feet (the range of depth for which the empirical relationship is valid) plotted outside of the zone where liquefaction is likely to take place, shows that liquefaction will not occur. Consequently, it is Dames & Moore's opinion that foundation stability will not be affected by the loss of shear strength due to liquefaction of the fine sand material at the site due to a 0.1g peak ground acceleration.

Foundation Assessment

The type of foundation most appropriate for a given structure depends upon several factors: (1) the function of the structure and its size; (2) the type and magnitude of the imposed load; (3) the subsurface conditions; (4) the tolerance of the structure to differential settlements; and (5) relative costs of foundation types.

Using preliminary information provided by Burns and Roe, Inc. as to the anticipated size and loading conditions of the structures in the power plant complex, the generalized soil profile, and the basic engineering properties determined during the field and laboratory program discussed previously, the suitability of different foundation types was assessed for the support of these structures.

Based on present knowledge, it is Dames & Moore's opinion that, with perhaps one exception to be discussed later in this section, the structures in the power plant complex may be supported on shallow foundations at economical bearing pressures and that construction may be undertaken with minimal dewatering.

For a given soil profile, the anticipated performance of a particular building foundation type and size is evaluated by considering both bearing capacity and settlement. In almost all cases, the allowable contact pressure is governed by settlement considerations rather than bearing capacity. A preliminary evaluation of the foundation conditions of this site indicates this to be the case; that is, the design allowable bearing pressure will be a function of the allowable settlement. The permissible contact stress will depend also on the size of the foundation, but will probably range from 6.0 kips/sq. ft. to 10.0 kips/sq. ft.

The settlement of the structures may be divided into two categories; namely, elastic settlement and consolidation settlement. The distinction between these two components of the total settlement is important because the elastic settlement is essentially "built out" during the construction process, while the consolidation settlement can be expected to continue after the plant is operational. For a given soil profile, the magnitude of both types of settlement increases with increasing contact pressure, and for equal contact pressure with increasing foundation size.

It is anticipated that the more heavily loaded structures in the plant complex will undergo elastic settlements on the order of 2 to 4 inches. It is again emphasized that this settlement will take place during construction and should not affect the integrity of structures. Consolidation settlement under the major structures on the order of one inch or less may be expected. This is within the tolerance of all but the most sensitive structures.

Depending on the preferred plant grade and final foundation design elevations, it may be necessary to densify the surficial soils (upper 5 to 8 feet) to reduce the contribution of this upper material to the total settlement. This may be accomplished by in situ compaction or by excavation and replacement with compacted fill. Densification may also be required to a slightly greater depth under foundations which are subject to vibration; for instance, the turbine mat.

On the basis of this preliminary assessment, there is one loading condition for which a shallow foundation may not be adequate, or, if adequate, not economical. It is very possible that piles may be necessary to provide uplift resistance sufficient to withstand the high overturning moments due to wind loading on the stacks.

Alternate Foundation Types

The information presented in this section is based on the relatively small body of data available at this time. If subsequent analyses of field and laboratory data gathered for the actual foundation design indicated conditions less suitable than those encountered in this set of borings, other foundation types may have to be considered. Such alternative foundations include piles (friction or end bearing), caissons, or, perhaps, some form of soil stabilization in conjunction with deep foundations. It is emphasized that deeper foundations do have several inherent drawbacks, including, for example, the need for engineering data at proportionally greater depths. Also, if the centroid of loads in pile groups is in, or quite close to, the limestone (causing an increase in stress in the limestone), the question of possible solution features in the rock mass becomes a significant consideration.

E.5 REFERENCES

Seed, H. and Idriss, I. M., 1971, Simplified procedure for evaluating soil liquefaction potential, Journal of the Soil Mechanics and Foundations Division, ASCE, vol. 97, no. SM9, p. 1249-1273.

Seed, H., 1976, Evaluation of soil liquefaction effects on level ground during earthquakes, Speciality Session on Liquefaction Problems in Geotechnical Engineering, ASCE National Convention, Philadelphia, p. 1-104.

Soil Conservation Service, 1973, Soil survey for west river road site-3744. Unpublished soil survey, U. S. Department of Agriculture, Soil Conservation Service, Putnam County.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50 % OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50 % OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

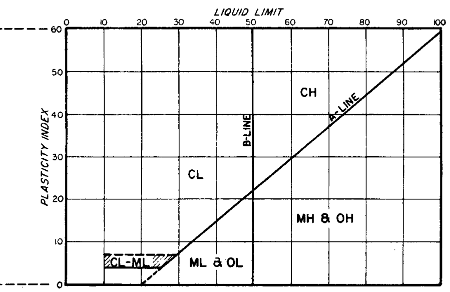
FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

SOIL CLASSIFICATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE	MILLIMETERS	SIEVE SIZE*
SAND	FINE	.074	#200*	0.42	#40*
	MEDIUM	0.42	#40*	2.00	#10*
	COARSE	2.00	#10*	4.76	#4*
GRAVEL	FINE	4.76	#4*	19.1	3/4"•
	COARSE	19.1	3/4"•	76.2	3"•
COBBLES		76.2	3"•	304.8	12"•
BOULDERS		304.8	12"•	914.4	36"

* U.S. STANDARD   • CLEAR SQUARE OPENINGS

GRADATION CHART



PLASTICITY CHART

NOTES:

1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
2. WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

COHESIVE SOILS	(APPROXIMATE SHEARING STRENGTH IN KSF)	COHESIONLESS SOILS	
VERY SOFT	LESS THAN .25	VERY LOOSE	THESE ARE USUALLY BASED ON AN EXAMINATION OF SOIL SAMPLES, PENETRATION RESISTANCE, AND SOIL DENSITY DATA.
SOFT	0.25 TO 0.5	LOOSE	
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	
STIFF	1.0 TO 2.0	DENSE	
VERY STIFF	2.0 TO 4.0	VERY DENSE	
HARD	GREATER THAN 4.0		

KEY TO TEST DATA

TESTS AT FIELD MOISTURE — TESTS AT ARTIFICIALLY CHANGED MOISTURE

2500 - 20.4% - 104 — 22.9% - 104 - 20.4%

- TEST NORMAL PRESSURE IN POUNDS PER SQUARE FOOT
- PERCENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
- DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
- PERCENT MOISTURE WHEN TESTED EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
- SHEARING STRENGTH IN POUNDS PER SQUARE FOOT
- FRICTION OF SOIL ON STEEL IN POUNDS PER SQUARE FOOT
- FRICTION OF SOIL ON WOOD IN POUNDS PER SQUARE FOOT
- FRICTION OF SOIL ON CONCRETE IN POUNDS PER SQUARE FOOT

DIRECT SHEAR AND FRICTION TESTS

20.4% - 104

- PERCENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
- DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
- SHEARING STRENGTH IN POUNDS PER SQUARE FOOT (1/2 UNCONFINED COMPRESSIVE STRENGTH AT FAILURE)

UNCONFINED COMPRESSION TESTS

2500-22.9%-104-20.4%

- CELL PRESSURE IN POUNDS PER SQUARE FOOT
- FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT
- DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
- TEST MOISTURE CONTENT IN PERCENT OF DRY WEIGHT
- 1/2 DEVIATOR STRESS AT FAILURE IN POUNDS PER SQUARE FOOT

UU UNCONSOLIDATED UNDRAINED
CU CONSOLIDATED UNDRAINED
CD CONSOLIDATED DRAINED

TRIAXIAL COMPRESSION TESTS

YIELD, PEAK OR ULTIMATE STRENGTHS ARE IDENTIFIED ON SHEAR TEST DATA ON THE BORING LOGS AS FOLLOWS:

* YIELD STRENGTH
** PEAK STRENGTH
*** ULTIMATE STRENGTH

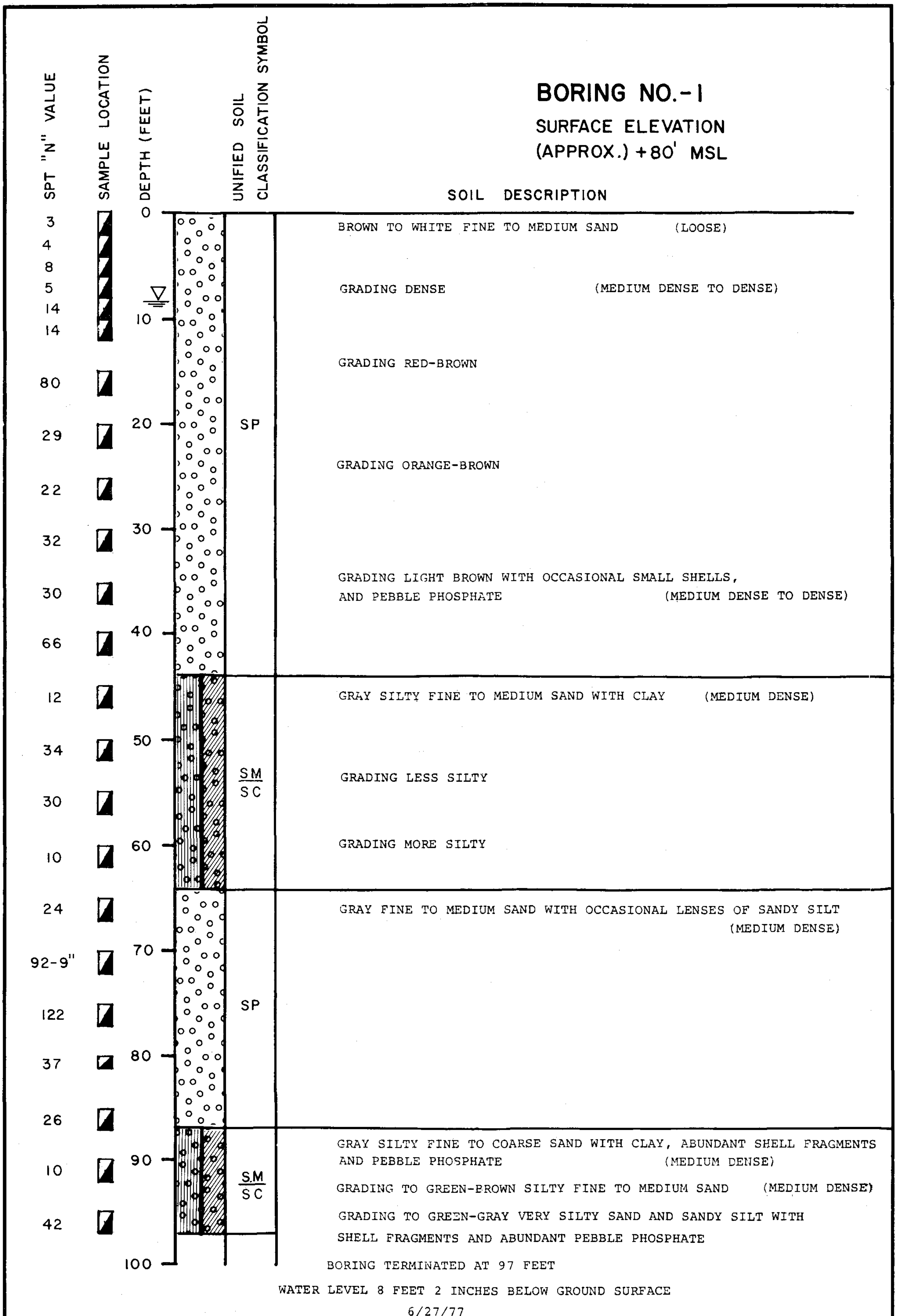
SHEAR TEST RESULTS

■ INDICATES UNDISTURBED SAMPLE
☒ INDICATES DISTURBED SAMPLE
□ INDICATES SAMPLING ATTEMPT WITH NO RECOVERY
I INDICATES LENGTH OF CORING RUN

NOTE: DEFINITIONS OF ANY ADDITIONAL DATA REGARDING SAMPLES ARE ENTERED ON THE FIRST LOG ON WHICH THE DATA APPEAR.

SAMPLES

Figure E-1. Unified Soil Classification System and Key to Test Data.



BORING NO.-1
SURFACE ELEVATION
(APPROX.) +80' MSL
SPT "N" VALUE
SAMPLE LOCATION
DEPTH (FEET)
UNIFIED SOIL CLASSIFICATION SYMBOL
SOIL DESCRIPTION
3
4
8
5
14
14
80
29
22
32
30
66
12
34
30
10
24
92-9"
122
37
26
10
42
0
10
20
30
40
50
60
70
80
90
100
SP
SM
SC
SP
SM
SC
BROWN TO WHITE FINE TO MEDIUM SAND (LOOSE)
GRADING DENSE (MEDIUM DENSE TO DENSE)
GRADING RED-BROWN
GRADING ORANGE-BROWN
GRADING LIGHT BROWN WITH OCCASIONAL SMALL SHELLS,
AND PEBBLE PHOSPHATE (MEDIUM DENSE TO DENSE)
GRAY SILTY FINE TO MEDIUM SAND WITH CLAY (MEDIUM DENSE)
GRADING LESS SILTY
GRADING MORE SILTY
GRAY FINE TO MEDIUM SAND WITH OCCASIONAL LENSES OF SANDY SILT
(MEDIUM DENSE)
GRAY SILTY FINE TO COARSE SAND WITH CLAY, ABUNDANT SHELL FRAGMENTS
AND PEBBLE PHOSPHATE (MEDIUM DENSE)
GRADING TO GREEN-BROWN SILTY FINE TO MEDIUM SAND (MEDIUM DENSE)
GRADING TO GREEN-GRAY VERY SILTY SAND AND SANDY SILT WITH
SHELL FRAGMENTS AND ABUNDANT PEBBLE PHOSPHATE
BORING TERMINATED AT 97 FEET
WATER LEVEL 8 FEET 2 INCHES BELOW GROUND SURFACE
6/27/77

Figure E-2.

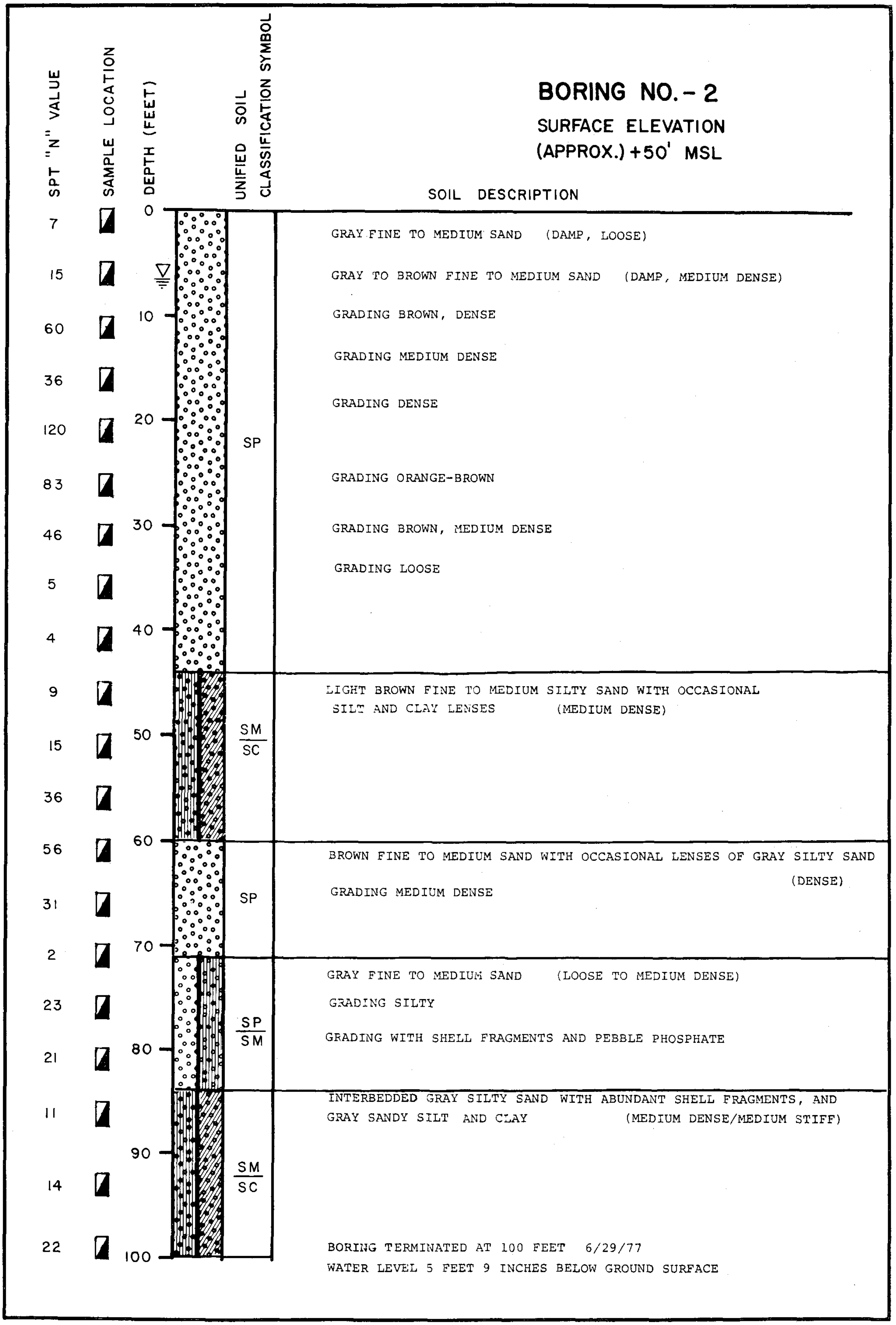

BORING NO.-2
SURFACE ELEVATION
(APPROX.) +50' MSL
SPT "N" VALUE
SAMPLE LOCATION
DEPTH (FEET)
UNIFIED SOIL CLASSIFICATION SYMBOL
SOIL DESCRIPTION
7
15
60
36
120
83
46
5
4
9
15
36
56
31
2
23
21
11
14
22
0
10
20
30
40
50
60
70
80
90
100
SP
SM/SC
SP
SP/SM
SM/SC
GRAY FINE TO MEDIUM SAND (DAMP, LOOSE)
GRAY TO BROWN FINE TO MEDIUM SAND (DAMP, MEDIUM DENSE)
GRADING BROWN, DENSE
GRADING MEDIUM DENSE
GRADING DENSE
GRADING ORANGE-BROWN
GRADING BROWN, MEDIUM DENSE
GRADING LOOSE
LIGHT BROWN FINE TO MEDIUM SILTY SAND WITH OCCASIONAL SILT AND CLAY LENSES (MEDIUM DENSE)
BROWN FINE TO MEDIUM SAND WITH OCCASIONAL LENSES OF GRAY SILTY SAND (DENSE)
GRADING MEDIUM DENSE
GRAY FINE TO MEDIUM SAND (LOOSE TO MEDIUM DENSE)
GRADING SILTY
GRADING WITH SHELL FRAGMENTS AND PEBBLE PHOSPHATE
INTERBEDDED GRAY SILTY SAND WITH ABUNDANT SHELL FRAGMENTS, AND GRAY SANDY SILT AND CLAY (MEDIUM DENSE/MEDIUM STIFF)
BORING TERMINATED AT 100 FEET 6/29/77
WATER LEVEL 5 FEET 9 INCHES BELOW GROUND SURFACE

Figure E-3.

BORING NO.-3

SURFACE ELEVATION
(APPROX.) + 75' MSL

SPT "N" VALUE	SAMPLE LOCATION	DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION SYMBOL	SOIL DESCRIPTION
2 12 31 44 132 111 140 52 34		0 10 20 30 40	SP	GRAY FINE TO MEDIUM SAND (LOOSE) GRADING WHITE, MEDIUM DENSE GRADING DARK BROWN GRADING DENSE GRADING ORANGE-BROWN GRADING DARK BROWN GRADING MEDIUM DENSE
13 14 36 7 21		50 60	SM / SC	GREEN-BROWN SILTY FINE TO MEDIUM SAND (MEDIUM DENSE) GRAY SILTY FINE SAND WITH OCCASIONAL LENSES OF GRAY SANDY SILT AND CLAY (MEDIUM DENSE) GRADING FINE TO MEDIUM GRADING GRAY-BROWN
27 32 7		70 80	SP	BROWN FINE TO MEDIUM SAND (MEDIUM DENSE) GRADING GRAY, LOOSE TO MEDIUM DENSE
25 80 76		90 100	SM / SC	GRAY SILTY FINE TO COARSE SAND WITH ABUNDANT SHELL FRAGMENTS (MEDIUM DENSE) GRADING WITH INTERBEDDED GRAY SILTY FINE SAND AND GRAY SANDY CLAYEY SILT WITH OCCASIONAL PEBBLE PHOSPHATE (DENSE/MEDIUM STIFF) GRADING GRAY-GREEN

BORING TERMINATED AT 100 FEET 6/30/77
WATER LEVEL 8 FEET BELOW GROUND SURFACE

Figure E-4.

BORING NO. 2-1

SURFACE ELEVATION (APPROX.) + 67' MSL

DEPTH BELOW GRADE	TYPE OF STRENGTH TEST	SHEAR STRENGTH TEST RESULTS, TSF τ	SHEAR STRENGTH TEST RESULTS, TSF σ_3 OR σ_N	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	MOISTURE CONTENT, %	DRY DENSITY, PCF	% PASSING 200 SIEVE	TYPE AND DEPTH OF SAMPLE	SPT 'N' VALUE	D&M (BLOWS/FT)		SOIL DESCRIPTION
0						18.4	113.3	15	■		11	SP	BROWN FINE SAND WITH LITTLE SILT (LOOSE TO MEDIUM DENSE)
									■		18		
									◪	5			GRADING DARK BROWN, SOME ORGANICS PRESENT
10	DS-UU	.456	.5			13.5	121.1	15	■		47		
									◪	22			
20	DS-UU	.784	1			23.7	99.2		■		46		GRADING LIGHT BROWN (DENSE)
									◪	42			
30						25.3	98.6	2	■		75		
									◪	30			
40													GRADING WITH STRINGERS OF CLAY AND ORGANIC SILTY SAND
						22.0	103.4	5	■		41		
									◪	23			GRADING LESS SILT
												CH	GRAY CLAY, TRACE OF FINE SAND
50				147	35	66	60		■		7		
												SM/SC	BROWN SILTY SAND WITH CLAY LENSES
				NON-PLASTIC		39.4		20	■		P		
						22.6	102.4		■ TW				
60									◪	26		SP	BROWN FINE TO MEDIUM SAND WITH TRACES OF PEBBLE PHOSPHATE (MEDIUM DENSE TO DENSE)
						21.6	104.1	1	■		53		
70	TV	1.5				40.6	80		◪	2		SM/SC	BROWN CLAYEY SILTY SAND WITH LENSES OF FINE TO MEDIUM SAND
	PP	.25		NON-PLASTIC		34.7	86.2		■ TW		P		
									◪	3			
												SP/SM	GRAY FINE TO MEDIUM SAND WITH PEBBLE PHOSPHATE
80						36.6	86.4	15	■		19		GRADING SILTY AND WITH SHELL FRAGMENTS
									◪	100/5"		SM/SC	GRAY SILTY SAND AND CLAYEY SAND WITH FINE TO MEDIUM SAND AND PEBBLE PHOSPHATE
90				NON PLASTIC		24.8		25	■		190/9"		
									◪	35			ABUNDANT SHELL FRAGMENTS AND THIN BEDDED STRUCTURE OF LIMESTONE PRESENT
100													

Figure E-5A.

BORING NO. 2-1 (cont.)

SURFACE ELEVATION (APPROX.) + 67' MSL

DEPTH BELOW GRADE	TYPE OF STRENGTH TEST	SHEAR STRENGTH TEST RESULTS, TSF: τ	SHEAR STRENGTH TEST RESULTS, TSF: σ_3 OR σ_N	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	MOISTURE CONTENT, %	DRY DENSITY, PCF	% PASSING 200 SIEVE	TYPE AND DEPTH OF SAMPLE	SPT 'N' VALUE	DBM (BLOWS/FT)		SOIL DESCRIPTION
100													
	PP	2.75		80	24			25	◪	30		SM/SC	GRADING WITH MORE SILT
									◪	30			
												ML	GRAY CLAYEY SILT AND FINE SAND WITH AN ABUNDANCE OF FINE TO COURSE QUARTZ AND PEBBLE PHOSPHATE (VERY STIFF TO HARD)
110													
									◪	31			
									◪	38			
120													
				47	23				◪	43			GRADING WITH MORE CLAY
									■		151/10"		
												SM/SC	GRAY SILTY SAND WITH CALCAREOUS FOSSILS (DENSE)
130													
									◪	86			GRADING LIGHT GREEN WITH FINE TO MEDIUM SAND
						39	88	47	■		175/10"		GRADING CLAYEY
140													
									◪	57		CH	GRAY SANDY CLAY (STIFF TO VERY STIFF)
	TV PP	8 >4.5		84	26	57	68	47	■		185/8"		
												SM/SC	GRAY SILTY SAND WITH SOME CLAYEY SAND, STRINGERS OF QUARTZ AND PEBBLE PHOSPHATE (MEDIUM DENSE TO DENSE)
150													
									◪	66			
						35	86	48	■		166/11"		GRADING WITH MORE CLAYEY SAND
160													
									◪	112		CL	GRAY SILTY CLAY WITH FINE SAND (HARD)
									■		179/10"		GRADING WITH MORE SILT AND FINE SAND
170													
									◪	45		CL/ML	GRAY GREEN SILTY CLAY WITH FINE SAND, FINE TO COARSE QUARTZ AND PEBBLE PHOSPHATE (VERY STIFF TO HARD)
									■		160/9"		
180													
									◪				
				128	50			99	◪	74		CH	DARK GRAY SILTY CALCAREOUS CLAY WITH THIN IRREGULAR SEAMS OF FRACTURED LIMESTONE (HARD)
190													
									■		100/4"		
200													BORING TERMINATED AT 198 FEET 10/7/77

WATER LEVEL 1 FOOT 6 INCHES BELOW GROUND SURFACE 10/7/77

Figure E-5B.

BORING NO. 2-2

SURFACE ELEVATION
(APPROX.) + 72' MSL

SPT "N" VALUE	SAMPLE LOCATION
5	◪
10	◪
14	◪
17	◪
19	◪
72	◪
80	◪
24	◪
142	◪
74	◪
39	◪
123	◪
41	◪
50	◪
65	◪
74	◪
10	◪
42	◪
17	◪
15	◪

DEPTH (FEET): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

UNIFIED SOIL CLASSIFICATION SYMBOL	SOIL DESCRIPTION
SP	LIGHT BROWN FINE TO MEDIUM SAND (LOOSE) GRADING WHITE IN COLOUR (LOOSE TO MEDIUM DENSE) GRADING WITH TRACES OF PHOSPHATE GRADING DARK BROWN WITH LITTLE SILT GRADING SILTY (DENSE)
SM/SC	BROWN SILTY SAND WITH POORLY CEMENTED FRAGMENTS OF SANDSTONE (DENSE) GRADING WITH NO SANDSTONE FRAGMENTS GRADING TO CLAYEY SAND
SP	LIGHT BROWN FINE TO MEDIUM SAND WITH LITTLE SILT AND TRACES OF SILTY CLAY (DENSE) GRADING WITH MORE SILT GRADING WITH LESS SILT
SM/SC	BROWN SILTY SAND AND CLAYEY SAND (DENSE)
CL	GRAY CALCAREOUS SANDY CLAY WITH FINE TO COARSE QUARTZ, PHOSPHATE AND SOME SHELL FRAGMENTS (MEDIUM STIFF TO STIFF)

(cont. on next page)

Figure E-6A.

BORING NO. 2-2(cont.)

SURFACE ELEVATION
(APPROX.) + 72' MSL

SPT "N" VALUE	SAMPLE LOCATION	DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION SYMBOL	SOIL DESCRIPTION
21		100	CL	GRADING GRAYISH GREEN (STIFF) PP= 1.75 TSF TV= 5.5 TSF
34		110	CL	GRADING WITH PEBBLE PHOSPHATE (VERY STIFF) PP= 4.25 TSF TV= 10.0 TSF
37		120	ML	LIGHT GREEN CALCAREOUS CLAYEY SILTY FINE SAND WITH ABUNDANCE OF FINE TO COARSE QUARTZ AND PHOSPHATE (VERY STIFF) PP= 2.5 TSF TV= 4.5 TSF
44		130	ML	
41		140	CL	GRAYISH GREEN CALCAREOUS SILTY SANDY CLAY (HARD) PP= 3.5 TSF TV= 5.5 TSF
47		150	CL	PP= 4.0 TSF TV> 10.0 TSF
53		160	CL	PP> 4.5 TSF TV> 10.0 TSF
136/11"		170	CL	GRADING SANDY WITH PEBBLE PHOSPHATE
60		180	CL	PP> 4.5 TSF TV> 10.0 TSF LIMESTONE STRUCTURE PRESENT
121		190	CL	PP> 4.5 TSF TV>10.0 TSF
		200	LS	LIMESTONE (VERY HARD)

BORING TERMINATED AT 205 FEET 10/20/77

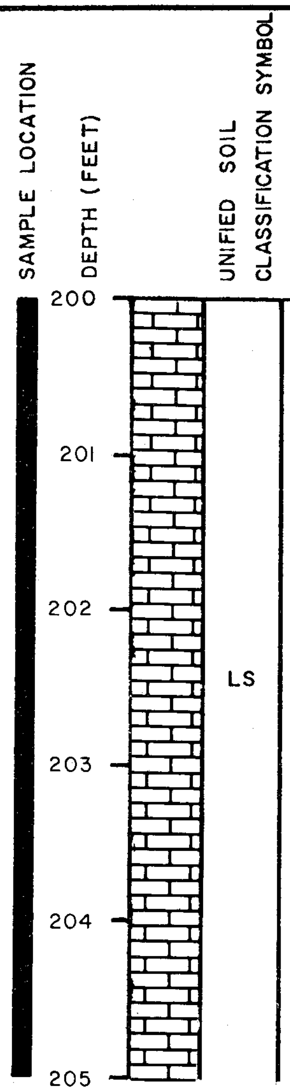
(cont. on next page)

WATER LEVEL 9 FEET BELOW GROUND SURFACE 10/20/77

Figure E-6B

DETAIL BORING NO. 2-2

SURFACE ELEVATION
(APPROX.) + 72' MSL



200-201' LIMESTONE, SANDY, DENSE, WITH ROCK FRAGMENT CASTS, INTERBEDDED WITH THIN BEDS OF SANDY **PHOSPHATIC CLAY** VARIEGATED GREENS AND BROWNS

201-201.7' LIMESTONE, SANDY, DENSE, ABUNDANT SHELL CASTS

201.7-203' LIMESTONE, SANDY, FRIABLE, INTERBEDDED WITH CALCAREOUS PHOSPHATIC, SANDY CLAY

203-204' LIMESTONE, SANDY, DENSE, ABUNDANT SHELL CASTS

204-204.6' LIMESTONE, SANDY, SOMEWHAT FRIABLE, FOSSILIFEROUS

204.6-205' LIMESTONE, SANDY, SOMEWHAT FRIABLE TO MODERATELY WELL CEMENTED, POROUS, ABUNDANTLY FOSSILIFERROUS, HIGH MICROFOSSIL CONTENT

BORING TERMINATED AT 205 FEET 10/20/77

Figure E-6C.

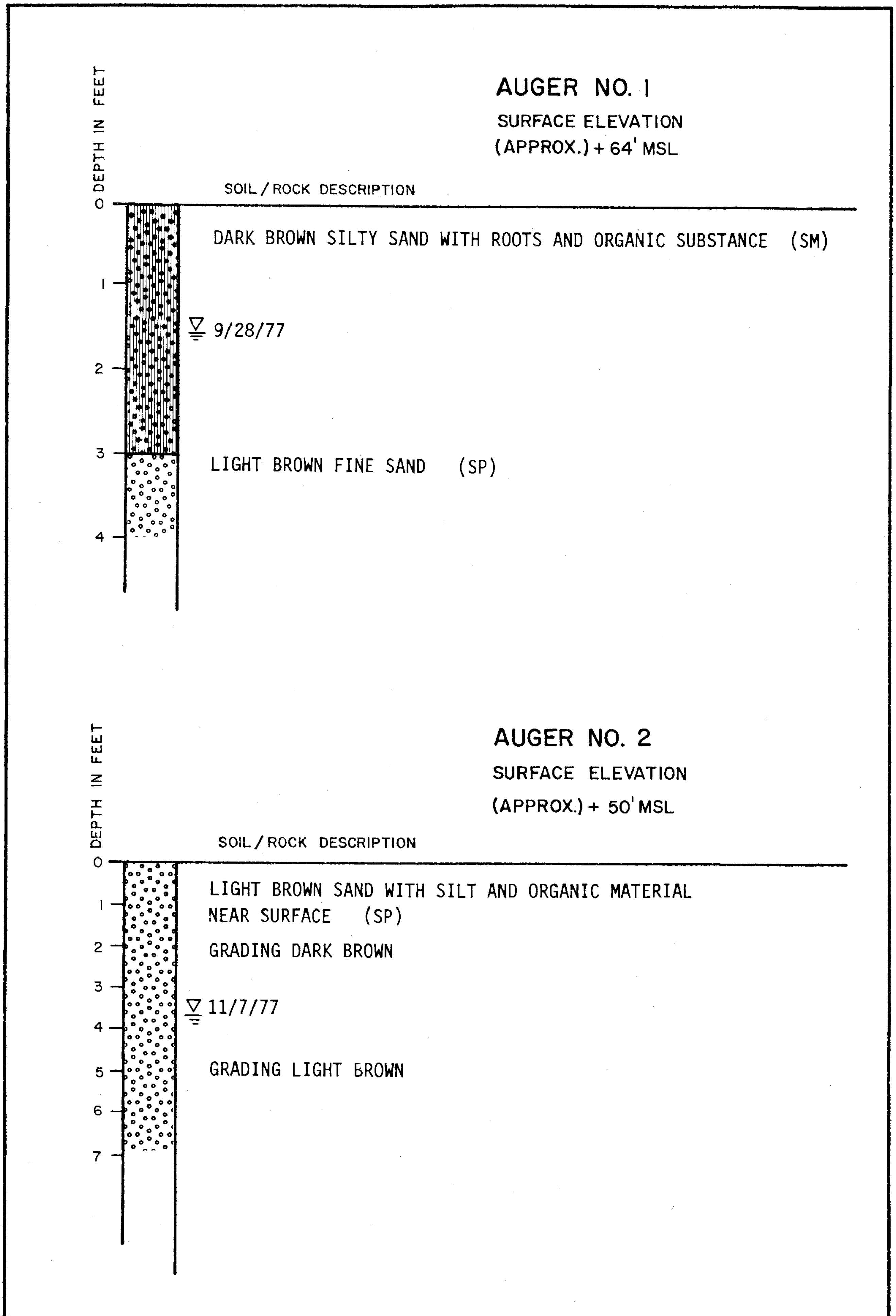

AUGER NO. 1
SURFACE ELEVATION
(APPROX.) + 64' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
DARK BROWN SILTY SAND WITH ROOTS AND ORGANIC SUBSTANCE (SM)
9/28/77
LIGHT BROWN FINE SAND (SP)
AUGER NO. 2
SURFACE ELEVATION
(APPROX.) + 50' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
7
LIGHT BROWN SAND WITH SILT AND ORGANIC MATERIAL
NEAR SURFACE (SP)
GRADING DARK BROWN
11/7/77
GRADING LIGHT BROWN

Figure E-7.

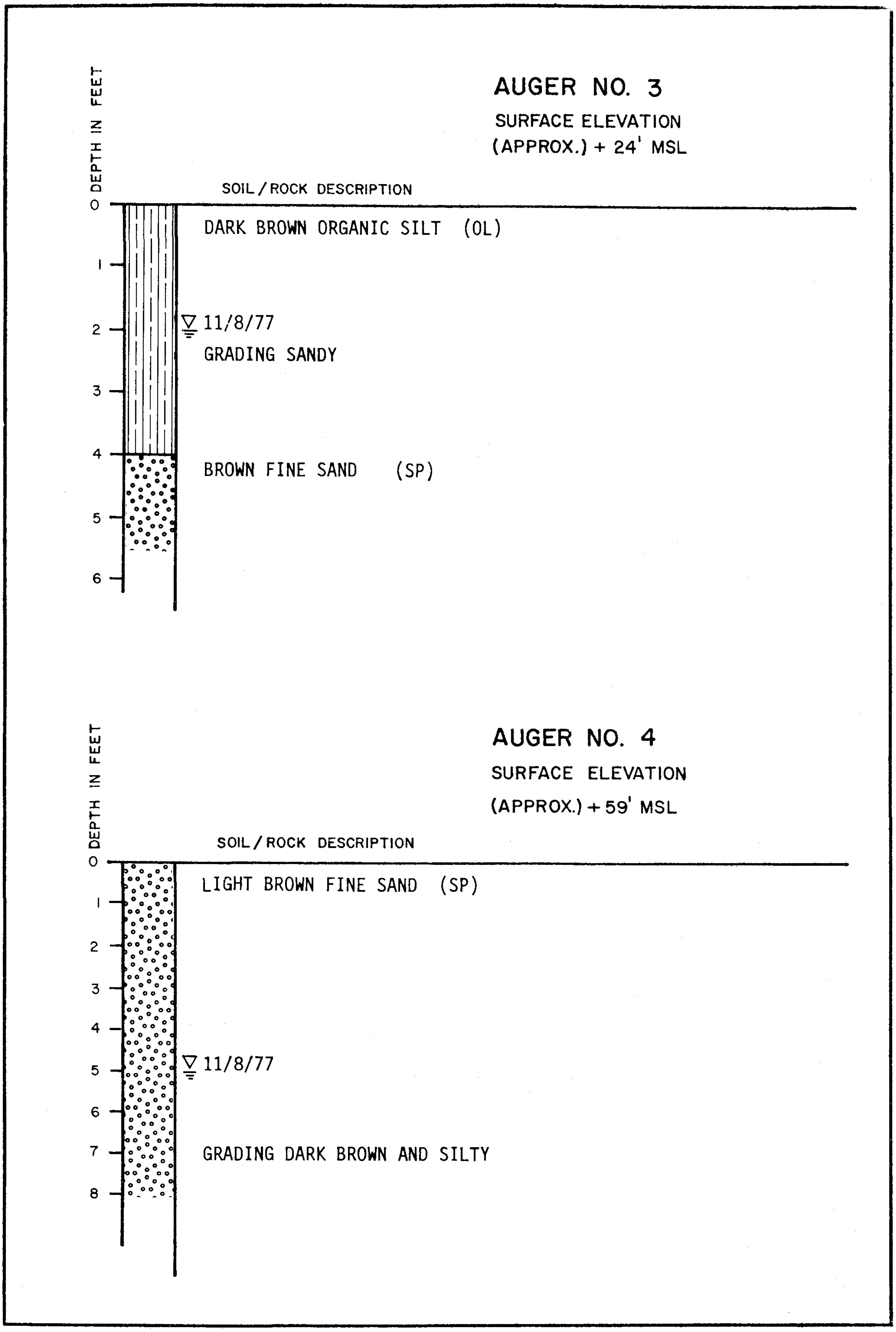

AUGER NO. 3
SURFACE ELEVATION
(APPROX.) + 24' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
DARK BROWN ORGANIC SILT (OL)
11/8/77
GRADING SANDY
BROWN FINE SAND (SP)
AUGER NO. 4
SURFACE ELEVATION
(APPROX.) + 59' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
7
8
LIGHT BROWN FINE SAND (SP)
11/8/77
GRADING DARK BROWN AND SILTY

Figure E-8.

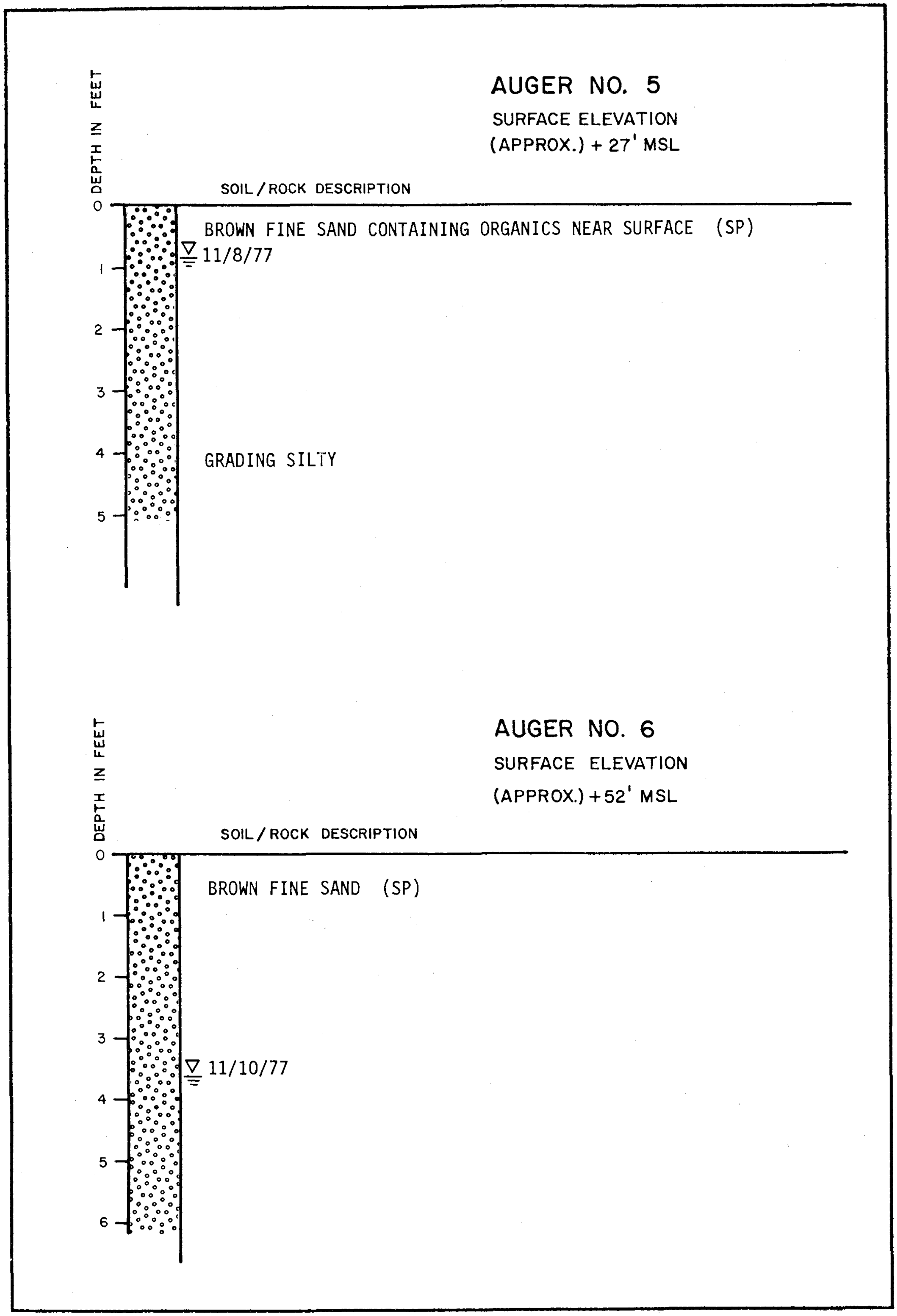

AUGER NO. 5
SURFACE ELEVATION
(APPROX.) + 27' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
BROWN FINE SAND CONTAINING ORGANICS NEAR SURFACE (SP)
11/8/77
GRADING SILTY
AUGER NO. 6
SURFACE ELEVATION
(APPROX.) +52' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
BROWN FINE SAND (SP)
11/10/77

Figure E-9.

LEGEND TO BORING LOGS

■ D&M SAMPLE	100/5" — BLOW COUNT / DISTANCE DRIVEN
◪ SPT SAMPLE	
▨ BLANK SPT SAMPLE	▽ NATURAL GROUND WATER TABLE
TW ■ THIN WALL SAMPLE	
P ■ D&M SAMPLE PUSHED	LIMESTONE STRUCTURE

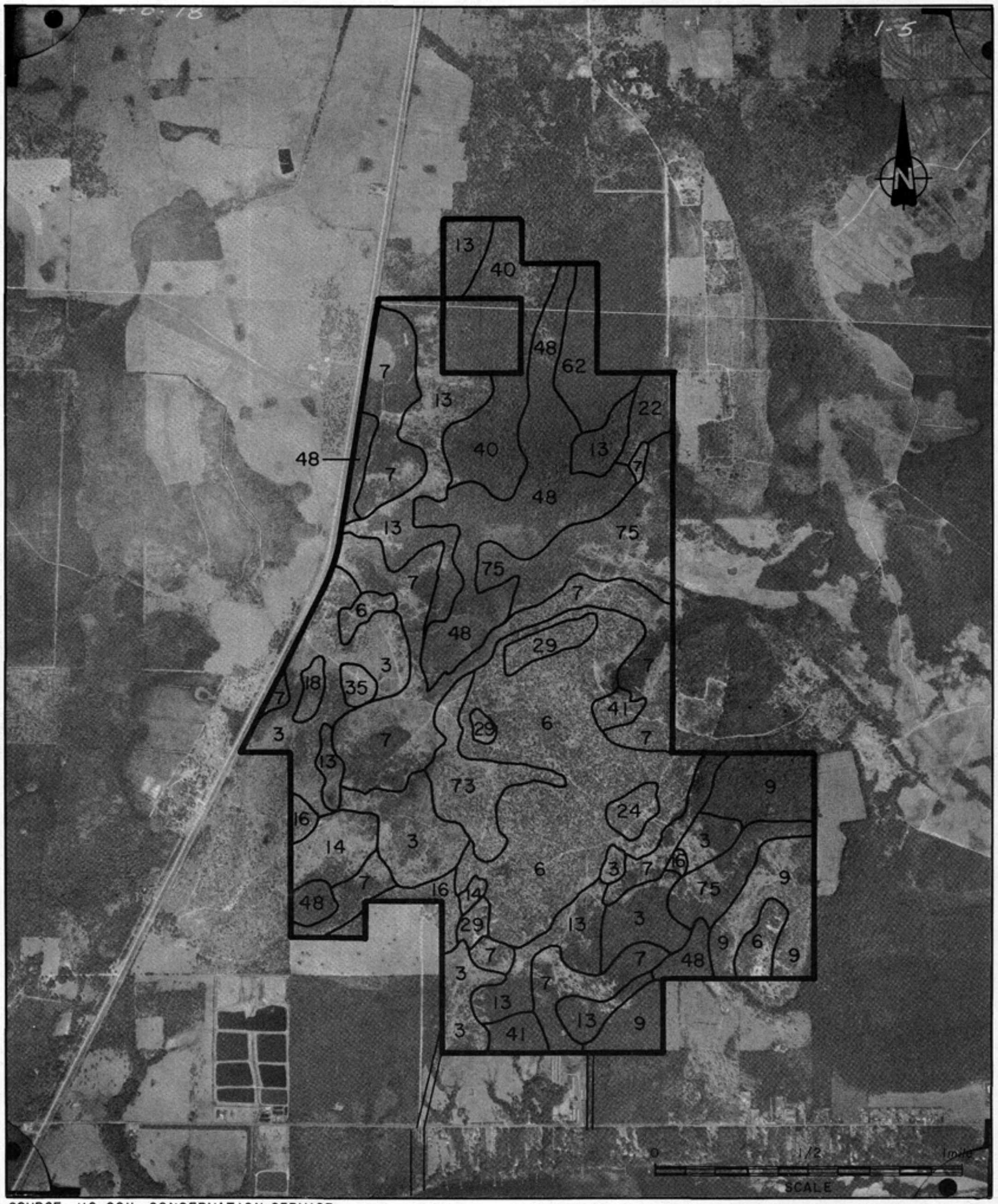
DEPTH OF SAMPLE TESTED

THE FIGURES IN THE COLUMN LABELED "D&M SAMPLER BLOW COUNTS" REFER TO THE NUMBER OF BLOWS REQUIRED TO DRIVE THE DAMES & MOORE SOIL SAMPLER A DISTANCE OF ONE FOOT USING A 140-POUND HAMMER FALLING 30 INCHES. THE DAMES & MOORE SAMPLER IS 3¼"O.D. AND APPROXIMATELY 2½" I.D. THE STANDARD SPLIT-SPOON SAMPLER IS 2" O.D. AND 1-3/8" I.D.

SA	=	SIEVE ANALYSIS
HA	=	HYDROMETER ANALYSIS
AL	=	ATTERBERG LIMIT (LL=LIQUID LIMIT, PL=PLASTIC LIMIT, PI=PLASTICITY INDEX)
M/D	=	MOISTURE CONTENT (%)/DRY DENSITY (PCF) (NATURAL)
CONSL	=	CONSOLIDATION TEST
DS-UU	=	UNCONSOLIDATED UNDRAINED DIRECT SHEAR TEST AT NATURAL MOISTURE CONTENT
TxL-UU	=	UNCONSOLIDATED TRIAXIAL TEST AT NATURAL MOISTURE CONTENT
SA(-#200)	=	SIEVE ANALYSIS ONLY DETERMINE PORTION OF MATERIAL PASSING #200
τ	=	SHEAR STRENGTH (TSF)
$\sigma_1-\sigma_3$	=	DEVIATOR STRESS IN TRIAXIAL TEST (TSF)
σ_3	=	CONFINING PRESSURE (TSF)
ε	=	AXIAL STRAIN DURING TRIAXIAL TESTING OF SOIL SAMPLES (%)
NON-PLASTIC	=	ATTERBERG LIMIT TEST INDICATED SOIL SAMPLE IS NON-PLASTIC

Figure E-10

REVISED 3/15/79



SOURCE: US SOIL CONSERVATION SERVICE

Figure E-11A. Surficial Soil Map of the Site.

Soil Mapping Unit Symbol and Name	BRIEF SOIL DESCRIPTION
3, Myakka fine sand	Nearly level to gently sloping, poorly drained, sandy soils. Dark organic pan less than 40 inches below the surface.
6, Tavares fine sand	Nearly level, moderately wet, acid, rapidly permeable deep sand.
7, Immokalee fine sand	Nearly level to gently sloping, poorly drained, rapidly permeable sandy layers to more than 72 inches. A weakly cemented organic layer is less than 40 inches below the surface.
9, Pomona fine sand	Nearly level, poorly drained sand over loamy soils.
13, St. Johns fine sand	Nearly level, poorly drained sandy layers to more than 72 inches. Weakly cemented organic layer within 30 inches of the surface.
14, Cassis fine sand	Nearly level, acid, deep sandy soils with organic stained pan at approximately 30 inches below the surface. Poorly to moderately well drained.
16, Adamsville fine sand	Nearly level and gently sloping, somewhat poorly drained, rapidly permeable, deep sand.
18, Ultic sideraouods	Nearly level, poorly drained, sandy soils 20-40 inches to moderately permeable loamy subsoil.
22, Arenic umbraquults	Deep, slightly acid to alkaline, nearly level, very poorly drained, sandy surface with loamy subsoil.

AFTER U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE (1978)
MAP LEGEND -- SURFICIAL SOIL TYPES

Figure E-11B

Soil Mapping Unit Symbol and Name	BRIEF SOIL DESCRIPTION
28, Entic Haplaquods	Same as No. 3
29, Astatula dark surface	Excessively drained, moderately steep to steep, sandy soils to depths of greater than 85 inches.
35, Entic haplohumods	Nearly level, somewhat poorly and moderately well drained soils. Sandy layers to more than 72 inches. Weakly cemented layer of organic material 20 to 60 inches below the surface.
40, Bluff fine sand	Very poorly drained, nearly level soils with sandy clay loam surface and sandy clay loam subsoil.
41, Bassinger sand	Poorly drained, rapidly permeable, sandy, nearly level soils.
48, Samsula muck	Nearly level, very poorly drained, rapidly permeable woody organic soils more than 40 inches deep.
62, Terra Ceia muck	Nearly level, very poorly drained, organic soils 16 to 40 inches thick.
73, Cassia fine sand	Same as 35
75, Wesconnett fine sand	Nearly level, very poorly drained sandy soils to depths of more than 72 inches. A weakly cemented organic layer about 30 inches thick begins just below the surface. Permeability is moderate to moderately rapid.

AFTER U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE (1978)
MAP LEGEND -- SURFICIAL SOIL TYPES

Figure E-11C

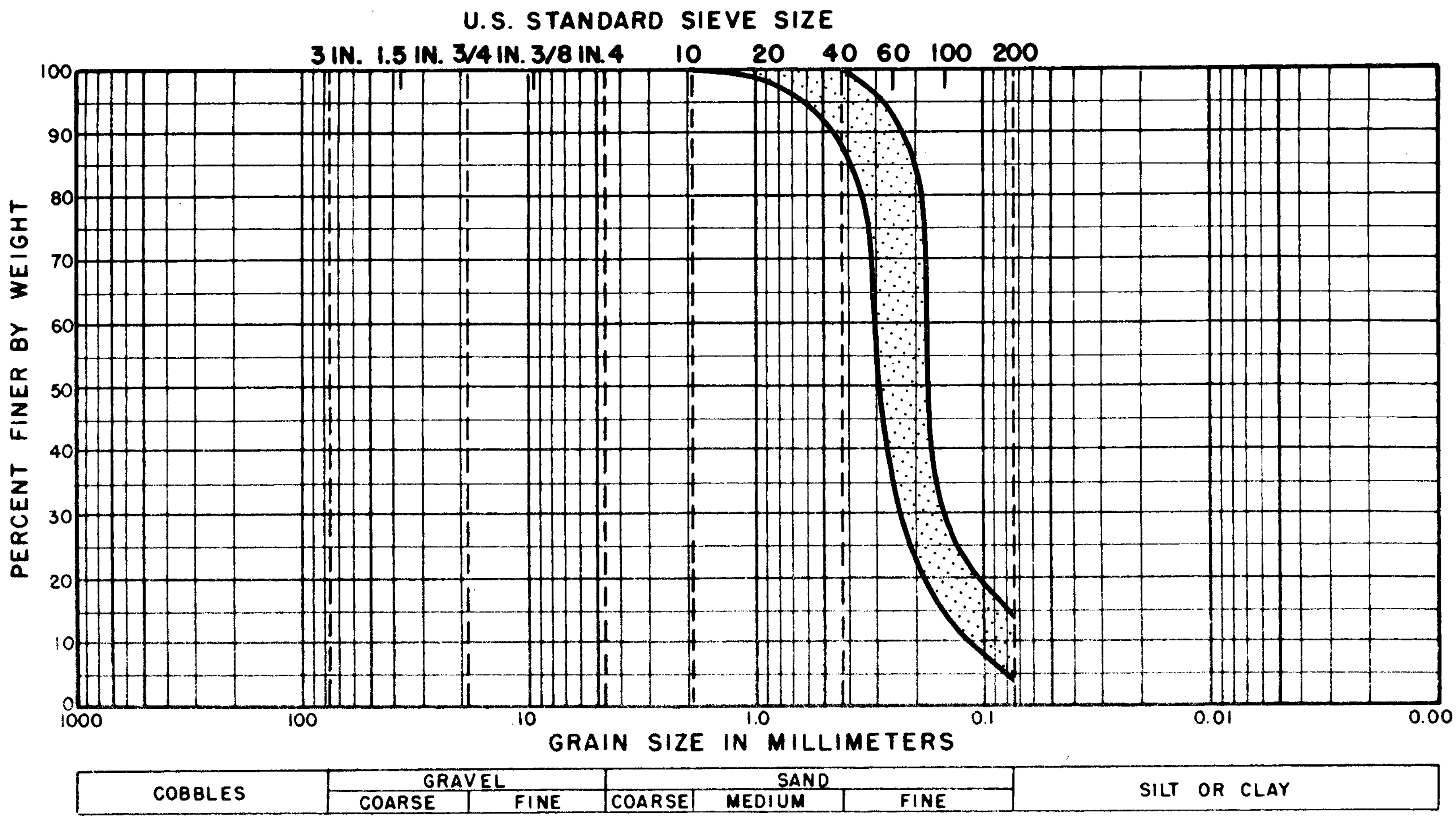


Figure E-12. Gradation Envelope - Layer 1.

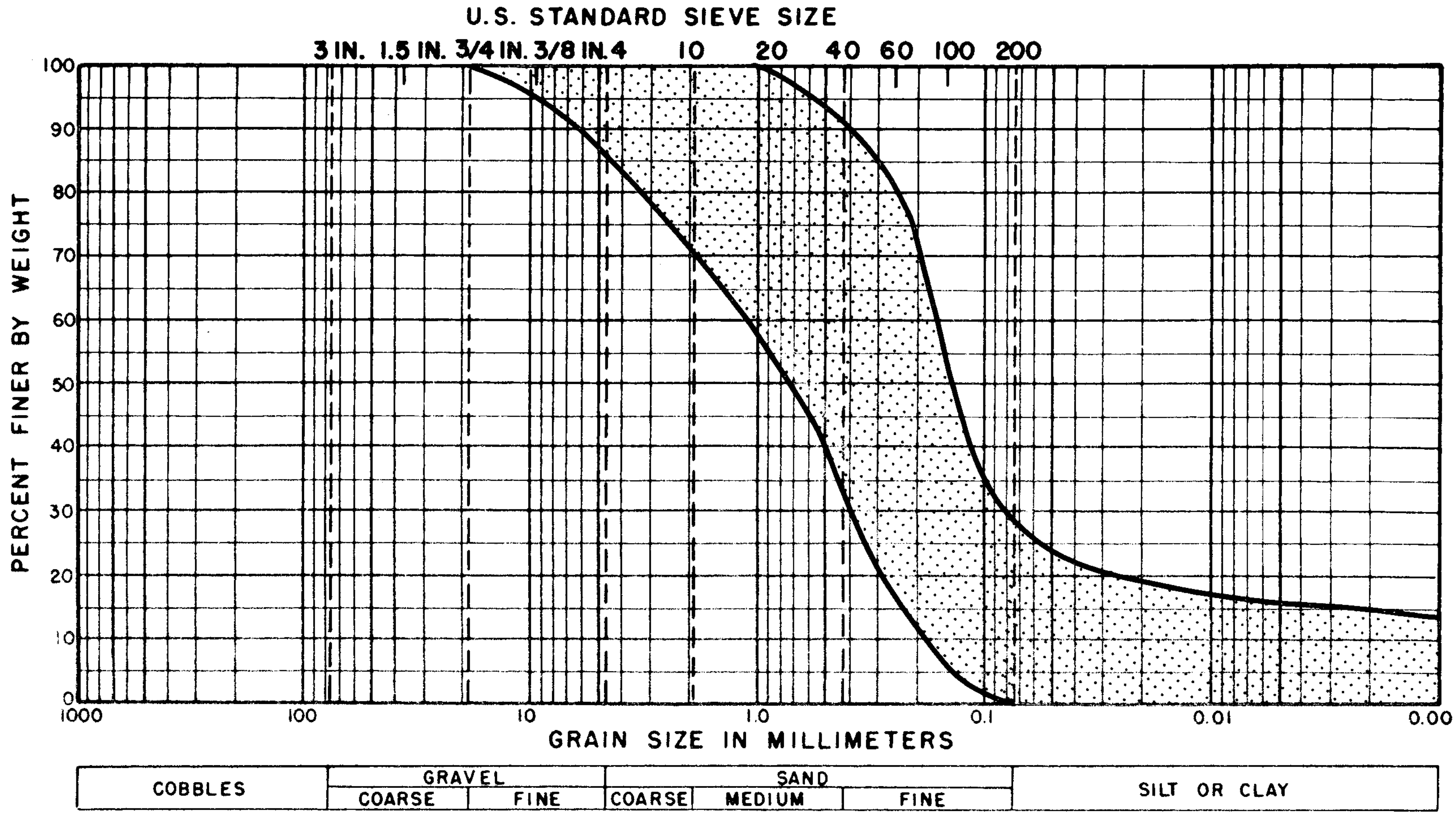


Figure E-13. Gradation Envelope - Layer 2.

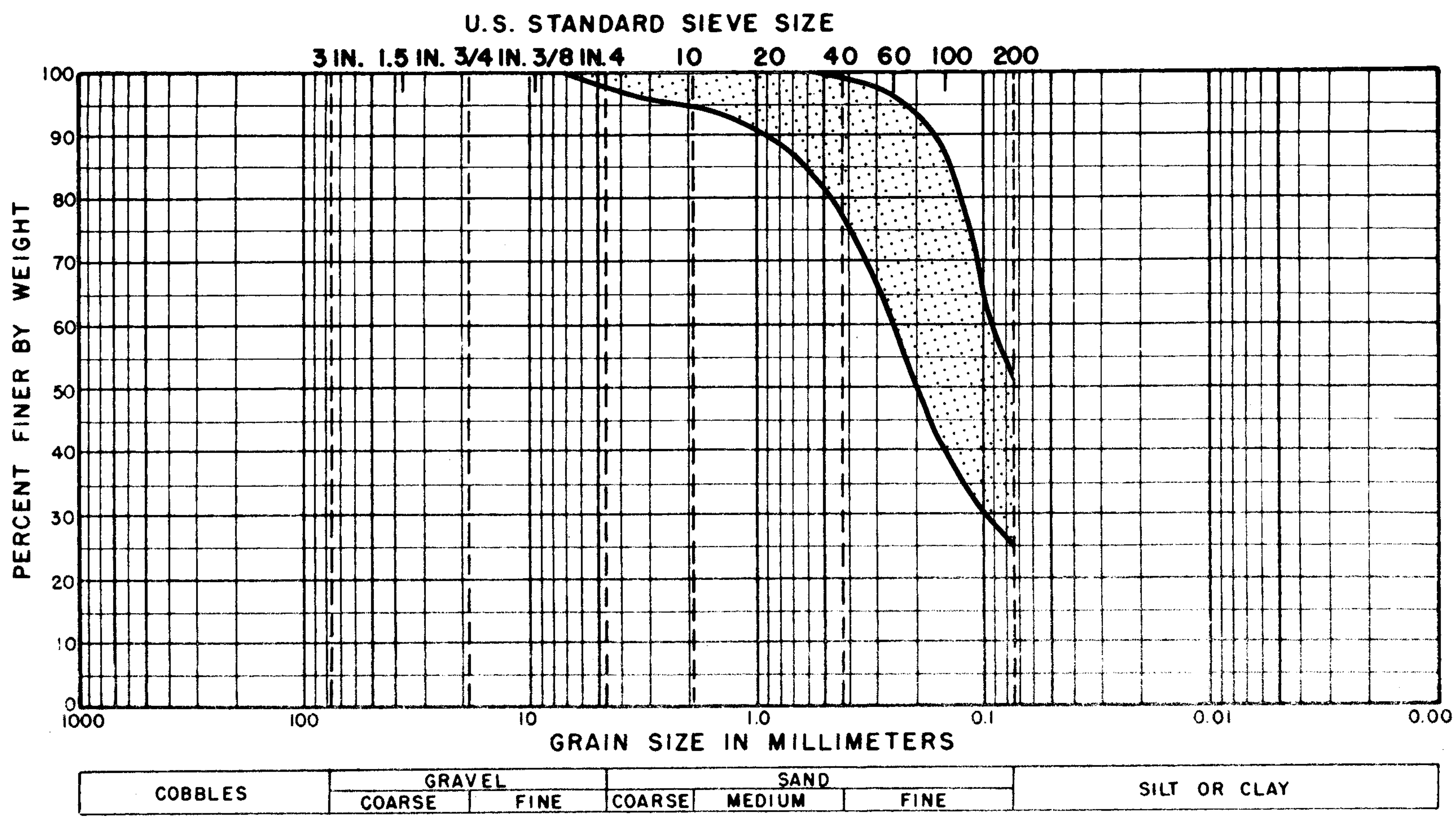


Figure E-14. Gradation Envelope - Layer 3.

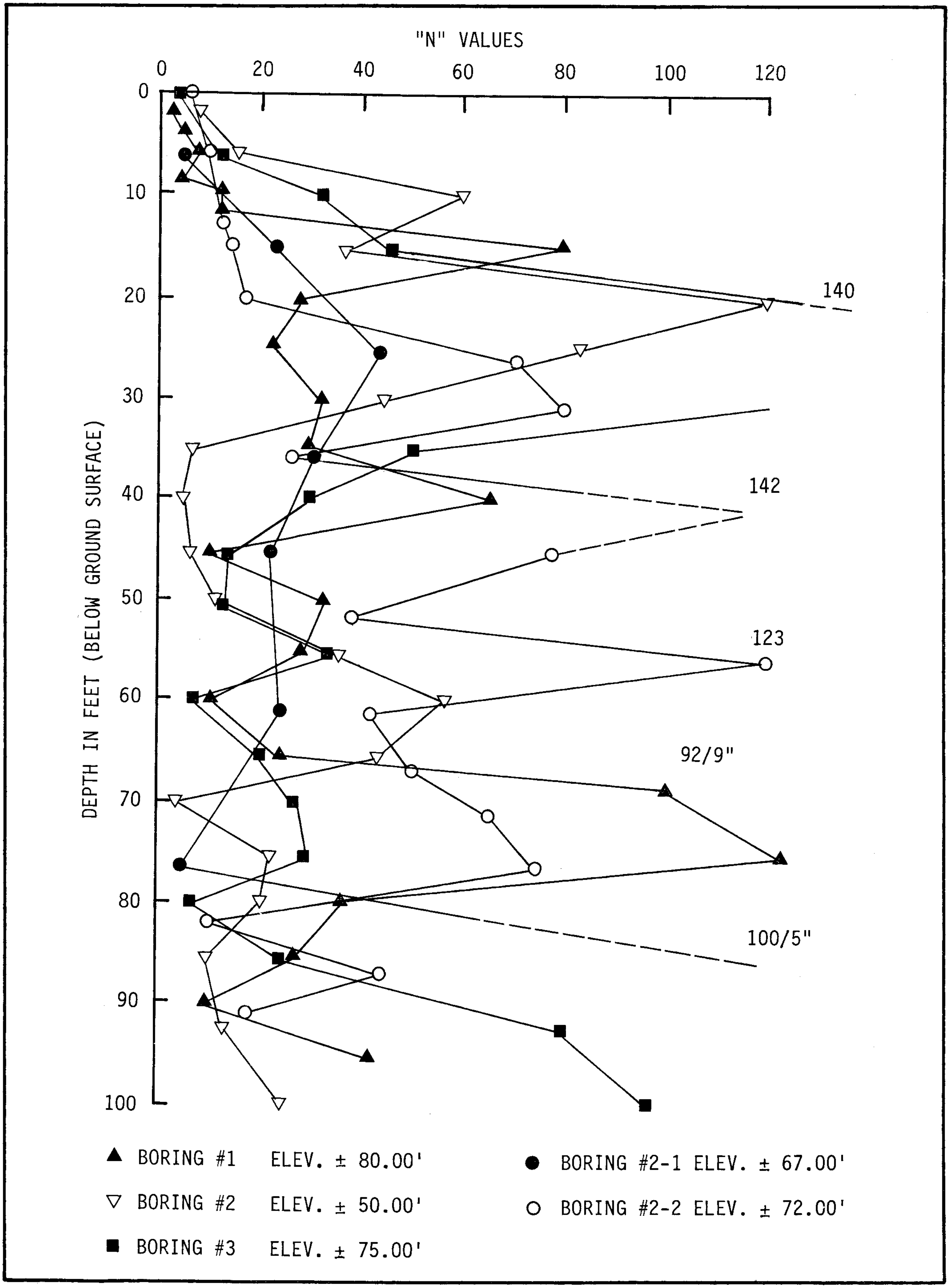


Figure E-15. Measured SPT Blow Counts vs Depth.

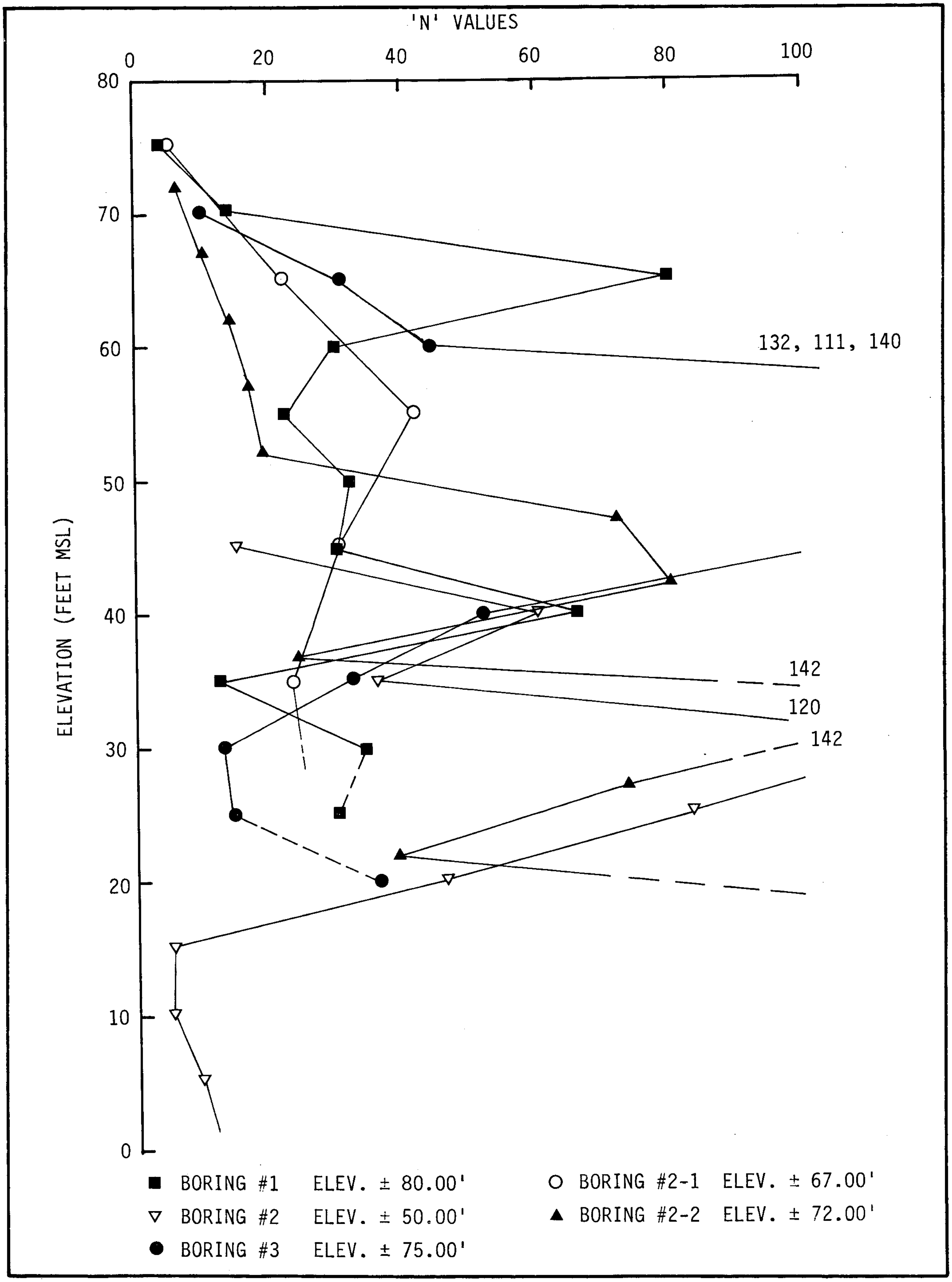


Figure E-16. Measured SPT Blow Counts vs Elevation.

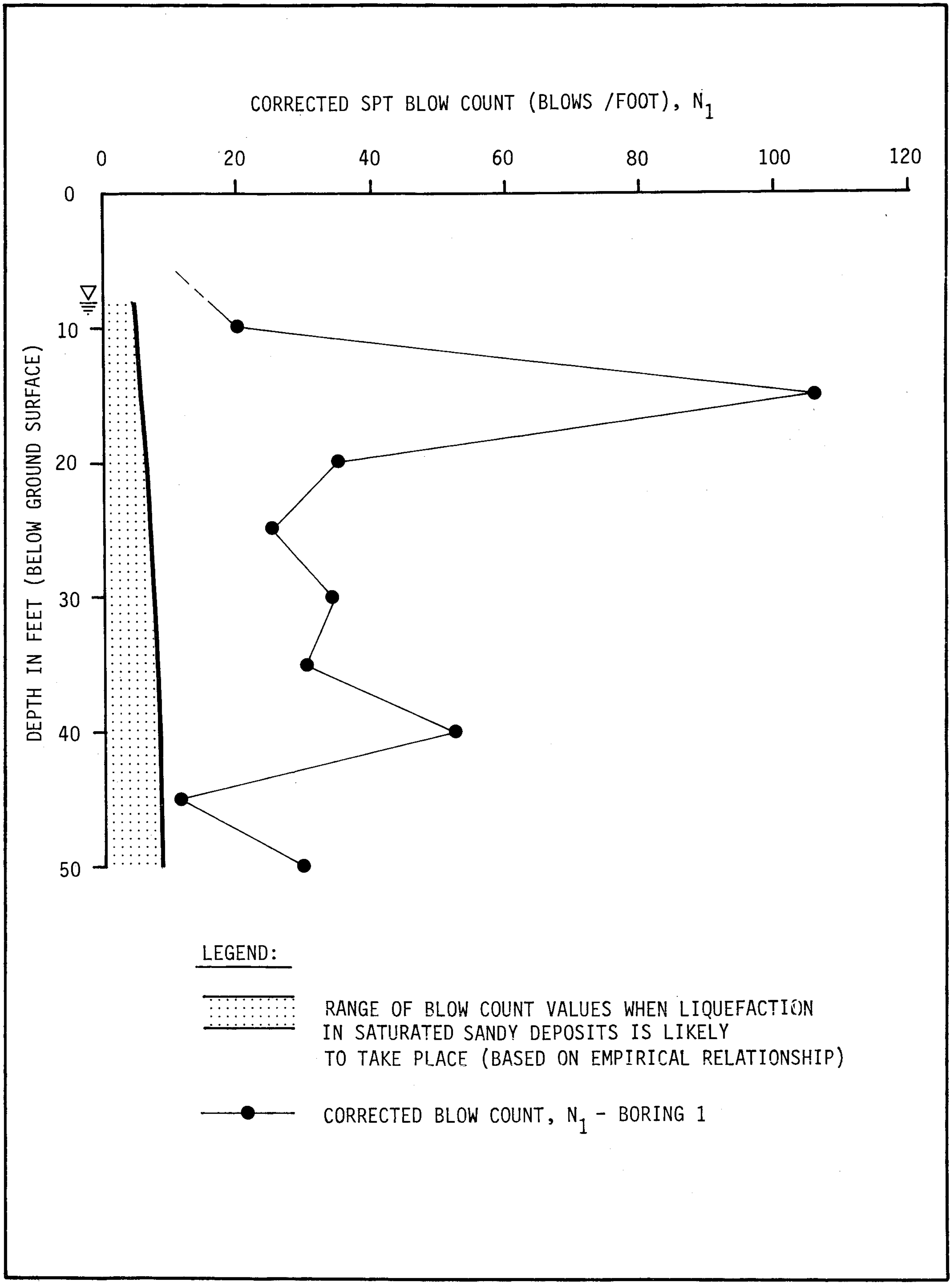


Figure E-17. Corrected Standard Penetration Resistance, N_1.

METEOROLOGY/AIR QUALITY

APPENDIX F

TABLE OF CONTENTS

APPENDIX F

METEOROLOGY/AIR QUALITY

APPENDIX F

METEOROLOGY/AIR QUALITY

F.1 INTRODUCTION

To assist in better understanding of discussions on air quality presented in preceding chapters, this appendix contains relevant excerpts from the Prevention of Significant Deterioration permit application which was submitted to the U.S. Environmental Protection Agency (with copies to the Florida Department of Environmental Regulation) on 19 May 1978 and later amended on 15 December 1978.

F.2 EXCERPTS FROM PREVENTION OF SIGNIFICANT DETERIORATION PERMIT APPLICATION

The PSD permit application excerpts provided consist of the following selections:

- ° Cover letter accompanying the amended application submitted on 15 December 1978.
- ° Modeling analysis overview.
- ° Modeling analysis results.
- ° Consideration of impacts due to associated growth and impacts on visibility, soils, and vegetation.
- ° A portion of the chapter presenting a Best Available Control Technology analysis.
- ° A list of references.
- ° Selected support material.

The lengthy exhibits and detailed engineering drawings which appear in the Best Available Control Technology chapter of the permit application are not included in this appendix. Numbering of sections, pages, tables, and figures are as they appear in the amended application.

Seminole Electric Cooperative, Incorporated

Suite 108 2410 East Busch Boulevard (813) 933-7406

Tampa, Florida 33612

December 15, 1978

Mr. Winston Smith
Chief, Air Programs Branch
Region IV
U. S. Environmental Protection Agency
345 Courtland Street
Atlanta, Georgia 30305

Re: Seminole Plant Units No. 1 and No. 2
PSD Permit Application Amendment
File: 620-S.11

Dear Mr. Smith:

We are herewith amending our Prevention of Significant Deterioration Application for a new power station in Putnam County, Florida:

(1) to include detailed engineering design data for all air pollution control devices pursuant to your letter of October 10, 1978;

(2) to conform to the proposed New Source Performance Standards published in the Federal Register on September 9, 1978; and

(3) to address the requirements for determining Best Available Control Technology (BACT).

We understand that since we were not advised of the requirements to submit detailed engineering design specifications within 30 days of the original application date, the official date of application for purposes of the PSD regulations shall still be May 19, 1978.

Since there may be a mistaken assumption that Seminole based its original application of 90% sulfur dioxide removal on an analysis of BACT, we would like to explain the basis of our application. At the time the application was filed on May 19, 1978, the known and anticipated federal requirements relating to sulfur dioxide included:

(1) Sections 111 and 112 of the Act which required compliance with New Source Performance Standards, and

(2) the draft New Source Performance Standards (first circulated in the fall of 1977) which contained a ninety percent reduction requirement for potential sulfur dioxide emission.

Mr. Winston Smith
re: PSD Permit Application Amendment

December 15, 1978

The ninety percent reduction requirement of the draft New Source Performance Standard was discussed by Seminole and the EPA staff prior to the filing of the initial application. During those discussions, in addition, EPA staff advised that the BACT determination would be made on a case-by-case basis; that it would require "scrubbers or other flue gas desulfurization methods"; that sufficient design specification information would have to be submitted to support this judgment; and that if final design specification was submitted, EPA would issue a conditional permit based on the bid specifications which would be either confirmed or withdrawn at such time as final design data was evaluated and a final permit issued.

It was the understanding of Seminole that, in all probability, the ninety percent reduction requirement set forth in the draft Standards would be incorporated into the final New Source Performance Standards and that nothing less would satisfy the anticipated requirements. Its design and initial application were accordingly based on that conclusion. This is made clear by Section 6.3 of Seminole's initial application which states:

> Station design is based on the assumption that a 90% removal efficiency for SO_2 .....will be required by revised New Source Performance Standards....

In view of the above, we feel it should not be presumed that Seminole's May 19, 1978 application was based on an analysis of BACT. However, the best available control technology achievable by Seminole at its proposed Putnam County site has now been properly demonstrated in the enclosed amended application and the EPA's determination of adequacy should be based solely on factors described in the Act and the regulations.

We shall anticipate working closely with your staff throughout its review of the amended application to achieve a "preliminary determination" for inclusion by February 15, 1979 in the draft Environmental Impact Statement being prepared by the Rural Electrification Administration.

Sincerely,

T. E. Crumlish

T. E. Crumlish
Project Director

TEC:ld

cc : H. Oven
G. Broyles

8.0 MODELING ANALYSIS OVERVIEW

8.1 INTRODUCTION

There are four primary objectives on which the modeling analysis performed for this application are based.

(a) Evaluate compliance with PSD Class II increments.

(b) Evaluate compliance with NAAQS and FAAQS.

(c) Determine effect of Seminole Plant Units No. 1 & No. 2 particulate emissions on the Jacksonville TSP nonattainment area.

(d) Verify to the extent allowed by modeling distance limitations that Class I increments will not be exceeded within the nearest Class I area.

Because of the nature of other sources in the Putnam Site area of interest as discussed in Section 7.2, analysis in terms of PSD increments was accomplished using a single-source model considering only projected emissions from the Seminole station. The same is true for the evaluation used to determine impacts on the Jacksonville TSP nonattainment area. Multiple-source modeling was used to assess compliance with ambient air quality standards. A description of modeling techniques and input data is provided in the following section.

8.2 MODELS AND INPUT DATA

8.2.1 Annual Average Model

8.2.1.1 Calculation Concepts

The primary program used to calculate annual average concentrations is the Air Quality Display Model (AQDM), a model which was originally developed for regional air quality evaluations and one which has been widely used (U. S. Public Health Service, 1969). This model estimates annual arithmetic average ground-level concentrations at specified receptor points resulting from the emissions of one or more pollutant sources, based on Gaussian diffusion concepts.

A modification of the original AQDM program was made in the treatment of mixing height in recognition of the higher than average height at which emissions will be released from Seminole Plant Units No. 1 & No. 2. In the original program, a mixing height of 100 meters is assumed for all Class E occurrences. With a stack height of over 150 meters, this would mean no ground-level concentrations calculated for stable (E) cases. The program was modified to allow specification of any desired mixing height value to be associated with Class E rather than a fixed value of 100 meters. (This is the same procedure employed in EPA's Climatological Dispersion Model.) Other than this modification, mixing height is treated the same as in the original program.

The only other change from the original AQDM is in the substitution of Briggs' (1971, 1972) plume rise equations in place of the Holland equation. The form of these equations incorporated into the code is a duplicate of the EPA plume rise calculation subroutine often referred to as BEH072.

8.2.1.2 Meteorological Input

The meteorological input required for running AQDM consists of a normalized annual joint frequency distribution of wind speed, wind direction, and atmospheric stability. Average annual mixing height and temperature values are also required.

The ambient temperature value used for each run is 294 K, and mixing height values selected are 1424 m and 444 m (from Holzworth, 1972). The required joint frequency distribution was derived from Jacksonville surface observations made every 3 hours over a 5-year period from 1970 to 1974. The well-known STAR method, based on techniques developed by Turner (1964), was used to construct distribution tables. The distributions used for modeling purposes are reproduced in Appendix A. These distributions were obtained from the National Climatic Center (NCC). As received from NCC, stable cases were split into three classes (E, F, and G). For computation purposes, all stable cases are lumped into one class (E). The resulting stability class distribution for the 5-year Jacksonville data set is as follows:

Class	Percent Frequency
A	.9
B	7.1
C	13.7
D	20.5
E	57.8

8.2.1.3 Receptor Orientation and Terrain

The receptors used for annual average concentration calculations are represented by a rectangular grid array with up to 225 grid points. The grid pattern is defined by the location of its lower left hand corner and distance between the adjacent rows and columns. Specifying different grid spacings allows investigation of both long- and short-range impacts of a given source. Receptor spacings of 1, 3 and 5 km were utilized for the analyses presented in this application. The greatest distance considered was approximately 50 km.

AQDM was not originally designed to calculate annual concentrations at receptor points of varying elevations. However, the lack of significant terrain differences within a 50 km radius of the Putnam Site precludes the necessity of considering varying terrain.

8.2.1.4 Emissions Data Input

To calculate annual average concentrations attributable to the Seminole station, an operating level of 75 percent of rated capacity was modeled. Emissions input data for this level are shown in Tables 5.1-1 and 5.1-2 assuming coal characteristics producing maximum emission rates.

A multiple-source annual average concentration analysis was also performed to estimate ambient concentrations based on Seminole's proposed emissions and current emissions within the Putnam Site area of interest. The emissions input data used for sources other than the Seminole station are as shown in Table 7.2-2. In some cases, sources with similar stack characteristics within a cluster of emission points located at the same point were treated as a single source having pollutant emission rates equal to the total combined emissions of each individual source. This step was taken to simplify input data setup, and has no effect on the results obtained.

8.2.2 Model for 24-Hour and 3-Hour Concentrations

8.2.2.1 Calculation Concepts

Ambient concentrations for 24-hour and 3-hour averaging periods were estimated through use of the CRSTER program developed for EPA and recommended for application to single-source modeling evaluations (EPA, 1977d). This model incorporates Gaussian diffusion concepts and calculates ground-level concentrations using hourly values of meteorological variables.

Two versions of the CRSTER Model were used, the first to evaluate compliance with PSD increments due to Seminole station emissions alone, and the second to evaluate compliance with ambient air quality standards allowing for possible interactions among Seminole and the other two major emission sources in its area - Hudson Pulp and Paper Company and Florida Power & Light Company. The first version is the CRSTER code in its most widely used form (consisting of a meteorological preprocessor program and a ground-level concentration calculation program). The only change made in this form of the model was to incorporate a listing of random numbers supplied by EPA Region IV for the purpose of achieving a standardized method of randomizing wind directions as required before final calculations can be completed. The previous randomization method consisted of applying the random number generator function of whatever computer system a particular analyst might have available.

Interactions among multiple emission sources were analyzed using a multiple source version of EPA's CRSTER model developed by Dames & Moore known as MLTCRS. MLTCRS utilizes input information similar to that required by CRSTER (including the standardized random number modification) with the only additional information required being the spatial location of the point sources of emission. The output format is identical to that of CRSTER. The modifications to CRSTER to facilitate multiple source contributions to ground-level concentrations essentially involve utilizing selected calculation procedures that are presently employed by EPA's RAM programs (i.e., allowances were made for bent-over plume rise and a different method of calculating off-centerline distances). MLTCRS has been compared in detail with RAM, CRSTER and PTMTP-W to ensure similarity to approved EPA models. Verbal approval for its use in routine modeling applications has already been given by EPA Regions V, VI and X. For reference purposes, quantitative comparisons between MLTCRS, CRSTER, PTMTP-W and versions of RAM (as supplied to Regions IV, V, VI and X) are included in Appendix B. The results of these comparisons illustrates the validity of MLTCRS as an adequate multiple source dispersion model.

Part of the output available from the CRSTER Model is a listing of maximum 24-hour and 3-hour concentrations at each receptor point. Another available listing consists of the highest, second-highest 24-hour and 3-hour concentrations at each receptor. These two types of output will be distinguished in subsequent discussion by referring to the first as "maximum" concentrations and to the other as "second-high" concentrations. Since the model processes only one year of meteorological data at a time, there can be different maximum and second-high concentrations for each year analyzed.

8.2.2.2 Meteorological Input

The hourly meteorological input data required for the CRSTER model must be created from two separate data base files through application of a preprocessor program. One data base consists of hourly surface observations of wind speed, wind direction (to the nearest ten degrees), temperature, and cloud cover specifications. Based on these data, the preprocessor program reformats the wind and temperature and determines a stability class for each hour based on the STAR method developed by Turner (1964).

The second primary data base required to execute the preprocessor program consists of a morning and an afternoon mixing height for each day considered. These heights are determined from twice-daily upper air soundings using the Holzworth method (Holzworth, 1972). From these morning and afternoon mixing heights, a mixing height for each hour is assigned based on an interpolation technique. Actually two techniques are used, one for urban sites and one for rural sites. Only rural mixing heights were considered in this analysis.

For the Putnam Site PSD Class II analysis, hourly surface observations from Jacksonville for the years 1964, 1970, 1971, 1972, 1973, and 1974 were used. Mixing heights for the year 1964 were taken from observations made at the Jacksonville upper air sounding station. Waycross, Georgia, upper air data were used for the years 1970-1974 because the Jacksonville upper air station was discontinued prior to 1970. All of the data listings required were supplied on magnetic tape by NCC.

A different method of meteorological data selection was adopted for applying the multiple-source CRSTER Model variation to an evaluation of compliance with short-term ambient air quality standards. After assessing the impact of Seminole station emissions on all 6 years of meteorological data, it became evident that the year 1972 was particularly significant. Of all the years considered, data for this year produced the greatest second-high 3-hour concentration (see Section 9.1). Because analysis of several years of data can be very complex when multiple sources are involved, only the year 1972 was used to evaluate attainment of ambient standards, based on the recognition that this would at least focus on a year which produced high concentrations resulting from projected Seminole station emissions.

Meteorological data resulting in maximum 3-hour and 24-hour concentrations and second-high 3-hour and 24-hour concentrations attributable to Seminole station emissions alone are listed in the Appendix.

8.2.2.3 <u>Emissions Data Input</u>

SO_2 and TSP concentrations attributable to the Seminole station were calculated for operating levels of 50 percent, 75 percent, and 100 percent of operating capacity using maximum emission rates developed from the extremes of the coal characteristics range. Stack conditions used in the modeling anaylsis are listed in Tables 5.1-1 and 5.1-2. As previously mentioned, there will be only one stack with dual flues at the Seminole station, with one flue for each boiler. Calculations were made assuming total pollutant emissions from both boilers exit through a single stack. Exhaust gases from each flue are assumed to merge into a single plume immediately upon entering the atmosphere.

Emission characteristics used for currently operating Hudson Pulp and Paper Company and Florida Power & Light Company emission sources are as shown in Table 7.2-2. Since these sources operate on an essentially continuous basis, emission rates on a per second basis were obtained from tons per year emissions assuming a constant emission rate thoughout the year. Seminole station emission characteristics selected for use in the multiple-source analysis are those representative of a 100 percent load level since single-source modeling indicates this operating level produces highest ground-level concentrations.

8.2.2.4 Receptor Orientation and Terrain

The receptor array used in CRSTER is a concentric grid with receptors spaced along each of 36 10-degree azimuths. Five distances are analysed for each program run, allowing calculations to be made at a total of 180 receptor points per run. For determining compliance with PSD increments, sufficient runs were made for the year of meteorological data which was found to produce the greatest concentrations in order to determine the point of maximum second high concentration within 100 meters. (An initial screening was made with receptors spaced 250 m apart, and in some cases it could be determined from the lack of change in concentration that a finer receptor spacing would not be necessary.) The nearest distance considered was 1.0 km from the Seminole station stacks. Closer distances are within the boundaries of the Putnam Site except for two very small offsite areas to the south and east which are within 0.8 km of the stacks. Based on past modeling experience with tall-stack power generating stations, primary attention was directed toward receptors located between 1.0 and 5.0 km from the emission source. However, calculations were made to a distance of 10.0 km to verify that concentrations did indeed decrease at distances beyond 5.0 km. Receptors 50 km to the north of the site were also modeled to determine impacts on the Jacksonville TSP nonattainment area and to verify that concentrations attributable to Seminole station emissions are near the level of the PSD Class I increments at this distance.

When performing multiple-source modeling to assess compliance with short-term ambient air quality standards, three receptor grids were used - one centered on the Putnam Site, one centered on Hudson Pulp and Paper Company, and one centered on Florida Power & Light Company. It is not necessary to consider all directions around each grid center since for most directions there will be no short-term interactions between the Seminole station and the other two major sources in the immediate area. For example, with an east wind there would be interaction between Hudson and Florida Power, but the Seminole station would not contribute to this interaction, making it unnecessary to consider receptors lying in a westward direction. The directions and distances considered for each grid are as follows:

Grid Center	Directions (clockwise)	Distances (km)
Seminole	320° thru 70°	1.0, 1.2, 1.5, 1.7, 2.0
Hudson	200° thru 320°	1.0, 1.2, 1.5, 1.7, 2.0
Florida Power	90° thru 190°	1.0, 1.2, 1.5, 1.9, 2.0

Because of the flat terrain within the Putnam Site area of interest, no terrain height differences were considered when applying the CRSTER Model.

9.0 MODELING ANALYSIS RESULTS

9.1 COMPLIANCE WITH PSD INCREMENTS

As discussed in previous sections, a review of regional emission source data supplied by DER indicates that the only facility which must be considered in assessing compliance with PSD increments is Seminole Plant Units No. 1 & No. 2. The PSD analysis results contained in this section are therefore in reference only to Seminole station emissions.

9.1.1 Annual Average Concentrations

Annual average SO_2 and TSP concentrations have been calculated using the AQDM model based on a load level of 75 percent of rated capacity with both units in operation. Concentrations were determined to a distance of 50 km from the Putnam Site. Maximum concentrations computed are shown in Table 9.1-1 together with applicable PSD Class II increments. As can be seen, these highest concentrations are negligible in comparison with the increments.

The pattern of annual concentrations, as is typical of tall stack sources, consists of almost no effect at close distances and a slight increase in concentrations at distances of about 40 to 50 km, in this case to the east of the site. However, the concentrations calculated are so low in relation to the accuracy of the model that the only firm conclusion which can be drawn regarding geographical distribution is that concentrations are uniformly low for all directions and distances.

9.1.2 24-Hour Concentrations

SO_2 and TSP 24-hour concentrations were calculated using 6 years of meteorological data based on operating levels of 50, 75, and 100 percent. Inasmuch as Federal regulations express allowable ground-level concentrations of a given contaminant as "not to be exceeded more than once per year" the greatest second-high SO_2 concentrations for each of the six years of meteorological data are presented in Table 9.1-2 and equivalent TSP results are shown in Table 9.1-3. (The modeling was actually conducted using SO_2 emission rates and the results used to obtain TSP concentrations by applying the ratio of TSP to SO_2 emission rates.) These tables also show the operating level, distance, and direction associated with points of highest concentration.

As can be seen from Table 9.1-2, the greatest second-high 24-hour SO_2 concentration is 60 $\mu g/m^3$ which represents 66 percent of the Class II increment. It will also be noted that the distances at which these concentrations are calculated are very close to the Putnam Site. At greater distances (and in different directions), a lower percentage of the increment would be consumed by Seminole station emissions. Furthermore, it should be remembered that emissions used for modeling are based on the extremes of the coal characteristics range (lowest heat value and highest sulfur content). Figure 9.1-1 illustrates the percentage consumption of the 24-hour PSD Class II increment consumed by the Seminole Plant under 100 percent load as predicted by CRSTER using meteorological data for the year 1972. As can be seen in the figure, over the majority of Seminole's area of impact less than 50 percent of the SO_2 increment is consumed. Also, the area in which the highest concentration can be expected to occur is generally to the northeast of the proposed site. This indicates that there is a low probability of plume interaction between Seminole and any new sources which may locate between the proposed Seminole site and the Jacksonville area.

Additional information related to 24-hour SO_2 modeling results is contained in Appendix C. This Appendix material consists of (a) a listing of the meteorological conditions producing the greatest second-high 24-hour concentrations, and (b) CRSTER Model concentration printouts for runs showing both the greatest maximum and second-high concentrations. It will be seen from the tables of meteorological data that highest 24-hour concentrations result predominantly from a few hours of unstable conditions. This explains why highest concentrations occur near the Putnam Site and also implies that the results obtained are somewhat conservative since unstable conditions are basically found near the surface and do not often extend to the level of a buoyant plume emitted from a tall stack.

Table 9.1-3 shows that predicted highest 24-hour TSP concentrations are well below the Class II increment. The greatest second-high concentration, 2 $\mu g/m^3$, is only 5 percent of the increment. Again, this result is based on emission rates assuming extremes of coal characteristics (lowest heat value and highest ash content). The meteorological data in Appendix C which apply to greatest 24-hour SO_2 concentrations also apply to greatest 24-hour TSP concentrations.

In addition to the standard 24-hour analyses performed by CRSTER, the effect of "running average" concentrations were investigated. This essentially involved examining the 72-hour periods that centered on the three or four worst case 24-hour meteorological periods defined by CRSTER (for each year analyzed). These periods were then qualitatively assessed to determine if any 24-hour periods within the 72-hour periods would result in significantly higher concentrations than would be predicted by CRSTER. The results of this assessment indicated that 24-hour running average calculations of concentrations would not result in significantly higher concentrations. All associated meteorological data necessary for the assessment of running averages is contained in Appendix C.

9.1.3 3-Hour Concentrations

As mentioned earlier, the greatest second-high 3-hour concentrations were determined by using CRSTER. Once all calculations were made, the predicted concentrations were examined in conjunction with their associated meteorology to determine whether or not they were indeed representative of realistic conditions. Specifically, second-high 3-hour concentrations were rejected which were based on any 3-hour period which contained two calms; either two consecutive calms or two calms which wind directions which caused contribution to the final concentration. If a maximum 3-hour concentration resulted from two calms, the second-high value was not automatically moved up to take its place. In other words, the initial test for calms applied only to second-high values. In all cases, concentrations based on 3-hour periods containing only one calm were retained. However, it is felt that even the existence of a single hour of calm conditions, particularly when associated with Class A stability, may lead to unrealistically high concentrations because of the CRSTER method of assigning wind direction and wind speed to calm winds.

Second-high 3-hour SO_2 concentrations calculated initially for each of the six years of meteorological data are shown in Table 9.1-4 along with the operating level, distance, and direction associated with each concentration. Because the greatest second-high concentration initially calculated (511 $\mu g/m^3$, year 1972) is so close to the allowable increment, the CRSTER run was subjected to closer examination. The first point noted was that the 3-hour period in question (day 186, time period 4) included two Class A occurrences, one of which was associated with a calm wind. It was next discovered that the maximum (i.e., high rather than second-high) concentration for the receptor point in question was produced by day 186, time period 5 when there were two consecutive calm winds coincident with Class A stability. Such conditions can be rejected as invalid for modeling purposes, with the result that the 511 $\mu g/m^3$ second-high concentration (day 186, time period 4) then becomes the maximum rather than the second-high concentration. Re-running CRSTER with day 186 excluded, the greatest second-high concentration for year 1972 is 319 $\mu g/m^3$ and the greatest second-high for all years is then 437 $\mu g/m^3$ for year 1973. (It is questionable if even this concentration should be considered a second-high rather than a maximum concentration. The maximum concentration for the same receptor point is produced by a 3-hour period with unstable conditions and two calm winds, although the calms are not consecutive.) The conclusion drawn from this closer analysis of initial CRSTER results is that the appropriate concentration for comparison with the PSD increment is 437 $\mu g/m^3$, representing 85 percent of the increment.

The variation of these second-high concentrations from year to year is fairly large, but in every case are calculated for close receptor points (i.e., within 1.30 km of the site). This can be explained by reference to the meteorological conditions which produce these concentrations. Listed in Appendix C are meteorological conditions associated with greatest maximum and second-high 3-hour concentrations. It can be seen that unstable atmospheric stability classes, which result in highest levels at close distances, produce these concentrations. Also included in Appendix C are CRSTER Model concentration printouts containing the greatest maximum and second-high 3-hour concentrations.

Qualifying remarks included in the discussion of 24-hour SO_2 concentrations above also apply to 3-hour SO_2 concentrations. That is, the largest consumption of the increment pertains only to a specific distance and direction and is based on emissions derived from the lowest heat value and highest sulfur content of the coal characteristics range.

Figure 9.1-2 shows the percentage consumption of the 3-hour PSD Class II increment consumed by the Seminole Plant for year 1973 meteorological data based on second-high concentrations. The majority of Seminole's area of impact can be seen to exhibit less than 50 percent increment consumption, and the area of greatest consumption is very close to the site. In addition, the predicted location of the greatest second-high concentration has enough of an easterly component to indicate that extensive plume interaction between Seminole and any new SO_2 emission sources that may locate between the Putnam Site and the Jacksonville area to the north is unlikely.

Running averages were also considered by examining the 9-hour meteorological period that centered on the three or four worst-case periods defined by CRSTER for each year analyzed. These periods were then qualitatively assessed to determine if <u>any</u> 3-hour period within the 9-hour period would result in a significantly higher concentration than would be predicted by CRSTER. For all of the greatest second-high 3-hour concentrations listed in Table 9.1-4, a running average calculation would not have resulted in higher predicted concentrations.

9.2 COMPLIANCE WITH AMBIENT AIR QUALITY STANDARDS

9.2.1 Annual Average Concentrations

Compliance with annual standards was assessed by modeling all of the sources within the Putnam Site area of interest using the AQDM model. Maximum annual SO_2, TSP, and NO_2 concentrations obtained by this method, in comparison with the FAAQS, are as follows (all concentrations in $\mu g/m^3$):

Pollutant	Maximum Calculated Annual Concentration	Florida Ambient Standard	Distance/Direction from Putnam Site
SO_2	28	60	6 km/170°
TSP	3	60	10 km/10°
NO_2	11	100	14 km/140°

In the case of TSP, comparison of calculated concentrations with the Florida ambient standard is not completely adequate since no background concentration resulting from sources other than those modeled is included in the calculated value. Adding a geometric annual average background value of about 35 $\mu g/m^3$ as suggested by the measured concentrations listed in Table 7.1-1, the total maximum annual average TSP concentration would be 40 $\mu g/m^3$ (assuming the calculated arithmetic average to be equivalent to a geometric average). Annual average background concentrations of SO_2 and NO_2, as indicated by Tables 7.1-2 and 7.1-3, are very low and need not be added to modeled concentrations since the sources included in the modeling analysis are probably largely responsible for measured background concentrations.

An important point to emphasize in this discussion is that the annual concentrations attributable to Seminole station emissions alone are practically negligible in comparison with ambient standards. The highest SO_2, NO_2, and TSP concentrations estimated to result from Seminole emissions alone are 5, 3, and 1 $\mu g/m^3$, respectively.

In conclusion, it appears very probable that all annual average standards are currently being achieved and that construction and operation of Seminole Plant Units No. 1 and No. 2 will not interfere with maintaining standards compliance.

9.2.2 24-Hour and 3-Hour Concentrations

In performing a modeling evaluation of short-term concentrations resulting from more than one emission source, it is important that time and space factors be kept consistent. In other words, the interactive effects of each source should be calculated at the same receptor points under the same meteorological conditions.

An inspection of the existing SO_2 and TSP emission sources within the Putnam Site area of interest from the standpoint of location and emission source strength indicates that the only sources which could have significant interaction with the Seminole station are Hudson Pulp and Paper Company and Florida Power & Light Company. The other existing sources are either too far away, have emission rates that are too small, or both.

To assure that time and space considerations would be treated consistently, interactions among Seminole, Hudson, and Florida Power & Light were computed using a multiple-source variation of the CRSTER Model as described in Section 8.2.2. For reasons previously discussed, this analysis was performed using 1972 meteorological data, assuming the Seminole station is operating at 100% of rated capacity, and keying on directions within about 30 degrees on either side of the direct angle between the Seminole station and the other two sources, i.e., directions along which significant short-term interactions could be expected.

The resulting second-high 24-hour and 3-hour SO_2 and 24-hour TSP concentrations from this interaction analysis are presented in Table 9.2-1. The maximum SO_2 concentrations occur near the Seminole station and are almost entirely due to Seminole emissions. This can be seen by referring to the second-high 3-hour value of 511 $\mu g/m^3$ shown in Table 9.1-4 that resulted from Seminole alone (year 1972) and comparing it with the value of 514 $\mu g/m^3$ that results from multiple source modeling (i.e., Hudson Pulp and Paper and Florida Power and Light Sources). One can then conclude from these results that close in to the Seminole Plant (i.e., within approximately 2.0 km), effects on ground level concentrations from emissions other than those that originate from the Seminole Plant are negligible. In comparison with ambient standards, the second-high 24-hour SO_2 concentration calculated is 23 percent of the Florida standard (and 16 percent of the national standard), and the second-high 3-hour SO_2 concentration is 40 percent of the Florida (and national) standard.

The second-high 24-hour TSP concentration is predicted to occur in the vicinity of Florida Power & Light and is largely attributable to Florida Power & Light emissions. This concentration represents only 4 percent of the Florida ambient standard (and national secondary standard). However, if a background concentration of, say, 35 $\mu g/m^3$ were added to the calculated maximum interactive concentration of 5 $\mu g/m^3$, the combined concentration would be 26 percent of the standard.

9.3 IMPACT ON JACKSONVILLE TSP NONATTAINMENT AREA

To evaluate the impact of Seminole station particulate emissions on the Jacksonville TSP nonattainment area, calculations of 24-hour and annual average concentrations were made using the CRSTER Model at receptor points 50 km north of the Putnam Site. A distance of 50 km was selected since this is the distance to the southern boundary of Duval County and also the generally accepted range limit of the CRSTER Model. All six years of meteorological data were considered, and it was conservatively assumed that the station was operating at 100 percent of capacity at all times.

For all six years, both the maximum 24-hour and annual average TSP concentrations attributable to Seminole station emissions are predicted to be less than 1 $\mu g/m^3$. These concentrations are below the level of significant impact recommended by EPA (see Section 6.2 for significant impact levels), and it is therefore concluded that Seminole Plant Units No. 1 & No. 2 will not significantly affect the Jacksonville TSP nonattainment area if a condition of nonattainment still remains when the Seminole station begins operations.

9.4 IMPACTS IN RELATION TO NEAREST PSD CLASS I AREA

The PSD Class I area nearest the Putnam Site is the Okefenokee National Wilderness Area located approximately 105 km north-northwest of the site. Since this distance is beyond the limit of 50 km normally considered appropriate for standard Gaussian models, no attempt was made to calculate concentrations attributable to the Seminole station directly within the Okefenokee Class I Area. Instead, calculations were made at a distance of 50 km and compared with applicable Class I increments. These increments are as follows (in $\mu g/m^3$):

	SO_2	TSP
Annual	2	5
24-Hour	5	10
3-Hour	25	--

The 3-hour and 24-hour increments are increases in concentrations which can be exceeded once a year.

Concentrations were calculated with the CRSTER Model at receptors located north-northwest and north of the site (directions 320° through 10°) using all six years of meteorological data. The station was assumed to be operating at 100 percent of rated capacity at all times.

All annual average and 24-hour calculated TSP concentrations are less than the Class I increment. Annual average SO_2 concentrations are also estimated to be less than 1 $\mu g/m^3$. The greatest second-high 24-hour and 3-hour SO_2 concentrations are 9 and 31 $\mu g/m^3$, respectively, at 50 km from the Putnam Site. (Second-high concentrations are cited because short-term increments can be exceeded once a year.) Since these concentrations are only slightly greater than the Class I increments, no problem is anticipated at 105 km from the Putnam Site.

Based on the results of calculations at a distance of 50 km, it is concluded that Seminole station emissions will have only a minor impact on the Okefenokee PSD Class I Area, an impact which is in compliance with the increases in ambient concentrations allowed in such areas.

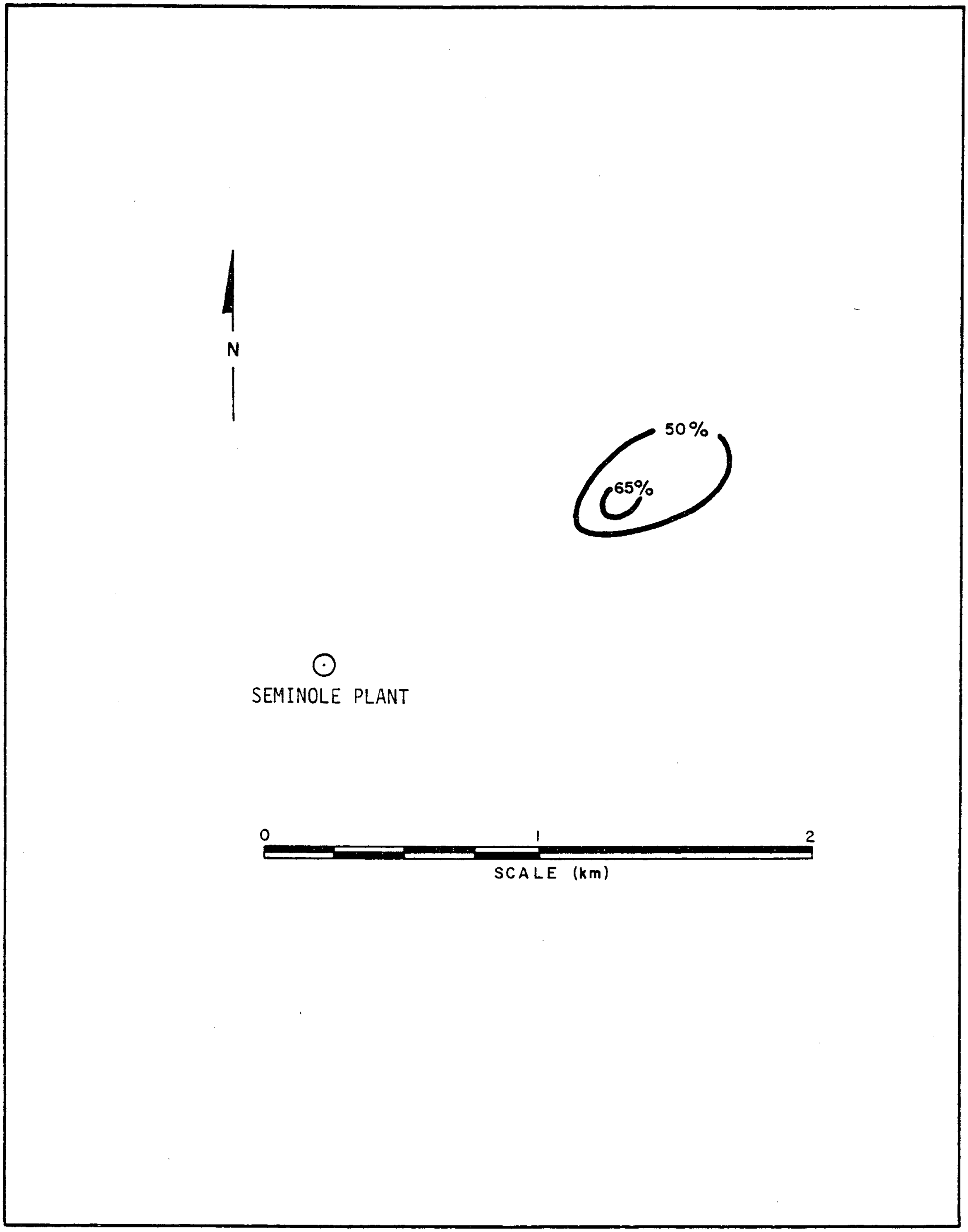


Figure 9.1-1. Predicted Second-High 24-hour SO_2 Concentrations Expressed as Percentage Consumption of the Class II 24-hour Increment. Seminole Plant at 100% Load, Meteorology for Year 1972.

TABLE 9.1-2

SECOND-HIGH 24-HOUR SULFUR DIOXIDE CONCENTRATIONS ATTRIBUTABLE TO SEMINOLE PLANT UNITS NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 24-Hour Concentration ($\mu g/m^3$)
1964	100%	53 (1.0 km/20°)[a]
1970	100%	49 (2.5 km/50°)
1971	100%	54 (1.5 km/130°)
1972	100%	60 (1.25 km/60°)
1973	75%	55 (1.25 km/140°)
1974	100%	60 (1.25 km/60°)

PSD Class II Area 24-Hour SO_2 Increment: 91 $\mu g/m^3$

[a]Distance and direction from Putnam Site at which concentration shown is calculated.

TABLE 9.1-3

SECOND-HIGH 24-HOUR PARTICULATE MATTER CONCENTRATIONS
ATTRIBUTABLE TO SEMINOLE PLANT UNITS
NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 24-Hour Concentration ($\mu g/m^3$)
1964	100%	2 (1.0 km/20°)[a]
1970	100%	2 (2.5 km/50°)
1971	100%	2 (1.5 km/130°)
1972	100%	2 (1.25 km/60°)
1973	75%	2 (1.25 km/140°)
1974	100%	2 (1.25 km/60°)

PSD Class II Area 24-Hour TSP Increment: 37 $\mu g/m^3$

[a]Distance and direction from Putnam Site at which concentration shown is calculated.

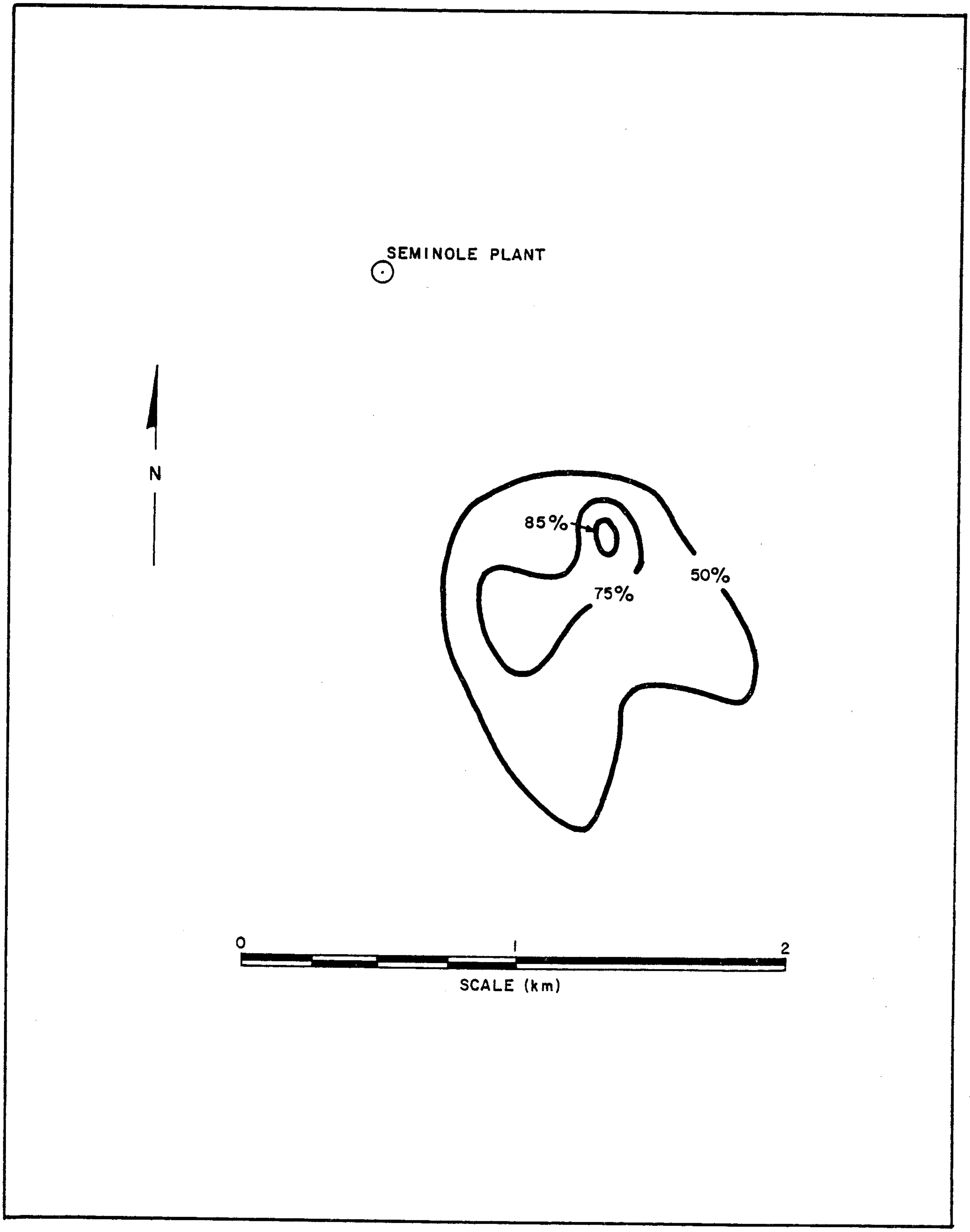


Figure 9.1-2. Predicted Second-High 3-hour SO_2 Concentrations Expressed as Percentage Consumption of the Class II 3-hour Increment. Seminole Plant at 75% Load, Meteorology for Year 1973.

TABLE 9.1-1

MAXIMUM PREDICTED ANNUAL AVERAGE CONCENTRATIONS
ATTRIBUTABLE TO SEMINOLE PLANT UNITS
NO. 1 & NO. 2 EMISSIONS

Maximum SO_2 Concentration ($\mu g/m^3$)	Maximum TSP Concentration ($\mu g/m^3$)	Distance/Direction of Maximum Concentration From Putnam Site
5	<1	45 km/90°

PSD Class II Area Annual Average SO_2 Increment: 20 $\mu g/m^3$

PSD Class II Area Annual Average TSP Increment: 19 $\mu g/m^3$

TABLE 9.1-4

SECOND-HIGH 3-HOUR SULFUR DIOXIDE CONCENTRATIONS
ATTRIBUTABLE TO SEMINOLE PLANT UNITS
NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 3-Hour Concentration ($\mu g/m^3$)
1964	100%	386 (1.25 km/20°)[a]
1970	100%	253 (1.0 km/310°)
1971	75%	391 (1.25 km/130°)
1972	100%	511[b] (319)[c] (1.30 km/40°)
1973	75%	437 (1.25 km/140°)
1974	100%	388 (1.25 km/30°)

PSD Class II Area 3-Hour SO_2 Increment: 512 $\mu g/m^3$

[a]Distance and direction from Putnam Site at which concentration shown is calculated.

[b]The highest concentration for this distance and direction was predicted by CRSTER to be 525 $\mu g/m^3$ and could be rejected due to the occurrence of two consecutive calms coincident with Class A stability in a three-hour period. The indicated second-high concentration (511) would then become the highest concentration with the new second-high becoming considerably lower (see footnote c).

[c]Parenthetical value indicates the greatest second high that results when day 186 of 1972 is excluded from the analysis. The distance and direction of occurrence of this value is 1.5 km at 70° from the Putnam Site.

TABLE 9.2-1

SECOND-HIGH 24-HOUR AND 3-HOUR CONCENTRATIONS RESULTING FROM INTERACTION OF SEMINOLE, HUDSON PULP AND PAPER, AND FLORIDA POWER & LIGHT

Second-High 24-Hour TSP Concentration ($\mu g/m^3$)	Grid Center Point	Distance/Direction from Grid Center
5	Florida Power & Light	1.0 km/140°

Second-High 24-Hour SO_2 Concentration ($\mu g/m^3$)	Grid Center Point	Distance/Direction from Grid Center
60[a]	Seminole	1.2 km/ 60°

Second-High 3-Hour SO_2 Concentration ($\mu g/m^3$)	Grid Center Point	Distance/Direction from Grid Center
514[b]	Seminole	1.3 km/ 40°

Florida 24-Hour TSP Ambient Standard: 150 $\mu g/m^3$

Florida 24-Hour SO_2 Ambient Standard: 260 $\mu g/m^3$

Florida 3-Hour SO_2 Ambient Standard: 1300 $\mu g/m^3$

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[a] No contribution from either Hudson Pulp and Paper or Florida Power & Light is expected in this figure.

[b] A negligible contribution of approximately 3 $\mu g/m^3$ is expected to have resulted from Hudson Pulp and Paper emission sources.

10.0 ADDITIONAL CONSIDERATIONS

10.1 ASSOCIATED GROWTH

The PSD preconstruction review requirements of the Clean Air Act Amendments of 1977 include an assessment of the air quality aspects of growth projected to result from a proposed facility. EPA's proposed PSD regulations express an intention to restrict this review to immediate, well defined indirect or secondary emissions which can be accurately quantified.

The permanent staff required to operate Seminole Plant Units No. 1 & No. 2 will amount to a work force of less than 200 employees. Furthermore, no major manufacturing facilities will have to be added locally to support the operating power generator station. The immediate secondary emissions expected to be associated with the station will, therefore, be minor emissions created by increases in automobile, truck, and rail traffic. These emissions are not expected to have a significant effect on ambient air quality conditions.

10.2 VISIBILITY, SOILS, AND VEGETATION

The requirement that an assessment be made of impacts on visibility, soils, and vegetation is particularly relevant when an emission source is located near a PSD Class I area. As has been previously stated, the Class I area nearest the Putnam Site is the Okefenokee National Wilderness Area located more than 100 km from the site. The remoteness of this area will serve to diminish any impacts attributable to Seminole station emissions.

The visibility effects of any coal-fired generating station can be divided into three major categories: (a) plume opacity at the point of release due to direct particulate emissions; (b) plume discoloration at some distance downwind due primarily to conversion of NO to NO_2; and (c) long-range visibility impairment resulting primarily from the conversion of gaseous sulfur oxides to aerosol sulfates.

Plume opacity is regulated by state and federal new source performance standards. The efficiency of the electrostatic precipitators which will be used for particulate control should assure that opacity is maintained within allowable limits (disregarding the opacity due to any water vapor condensation which may result from the use of wet scrubbers).

Plume discoloration and long-range visibility impairment are difficult to analyze quantitatively because of the secondary atmospheric chemical reactions which are involved in these processes. Factors which complicate determining the visibility impact of a single new source locating in the eastern United States are the occurrence of high relative humidities and the existence of substantial background aerosol concentrations resulting from both natural sources and previous industrial development. EPA has underway at this time a research program aimed at developing visibility impact assessment methods for various sections of the country; but according to the present development schedule, the results of this program will not be available for general use within the next several months.

The emission control design features of the Seminole station will serve as a definite mitigative measure to reduce visibility impacts. Sulfur dioxide removal in particular will act to diminish the subsequent formation of aerosol sulfates which are thought to be key ingredients in the impairment of visual range.

Predicting the effects of a single source of emissions on vegetation and soil conditions is also difficult to accomplish quantitatively. One yardstick for gauging the probability of avoiding adverse impacts on soil and vegetation is the degree of compliance with national secondary ambient air quality standards. These secondary standards, particularly the 3-hour SO_2 standard, were established to prevent non-health related effects such as vegetation damage.

Information available on existing air quality conditions in the Putnam Site area (Section 7.0) and the results obtained through a modeling analysis of emissions from the Seminole station and other sources (Section 9.0) indicate that all secondary standards will be maintained by a wide margin. Therefore, the probability of adverse impacts on vegetation and soils resulting from operation of Seminole Plant Units No. 1 & No. 2 is slight.

Additional impact analysis information is contained in the environmental assessment now being prepared for submittal to the Rural Electrification Administration (acting as lead Federal agency) and to DER in satisfaction of Florida's power plant site certification procedures. EPA will be one of the reviewing agencies. Included in this assessment are descriptions of soil, vegetation, and land use patterns in the vicinity of the site, as well as a further discussion of such issues as sulfate formation and visibility effects.

11.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

11.1 INTRODUCTION

This section presents a discussion of those control systems proposed as representing Best Available Control Technology (BACT) for Seminole Plant Units No. 1 and No. 2. Included is a description of boiler emission controls and controls of other operations which are potential particulate emission sources. With regard to boiler emissions, BACT proposed for this source is consistent with recently proposed New Source Performance Standards (NSPS) for Electric Utility Steam Generating Units and furthermore represents control technology which is economically reasonable and technically feasible from the standpoint of offering control efficiencies which can be achieved and maintained on a reliable, continuing basis. Sulfur dioxide control will be achieved through a combination of coal washing and limestone slurry flue gas desulfurization (FGD) which will result in an overall sulfur removal efficiency of 85 percent. Boiler particulate matter emissions will be controlled at an efficiency rating of 99.6 percent using electrostatic precipitators. Oxides of nitrogen control will result from furnace design features which will limit NO_x emissions to an emission rate no higher than 0.6 lb per million Btu heat input. Dust control of specific materials handling points will be achieved through use of water sprays and bag filters.

11.2 PROPOSED CONTROL SYSTEM

11.2.1 Sulfur Dioxide Controls - Boiler Emissions

The Best Available Control Technology proposed to reduce boiler SO_2 emissions will achieve an 85 percent reduction, consisting of 79 percent reduction in a Flue Gas Desulfurization (FGD) system plus 6 percent credit derived from removal of 30 percent of coal sulfur in a mine washing process. (This combination will hereafter be referred to as 79 percent FGD, 6 percent washing.) This degree and method of control will comply with provisions of the recently proposed NSPS for Electric Utility Steam Generating Units. It will also provide a technically feasible system which is capable of satisfying the intent of the proposed performance standards to require a method of emission reduction which can be reliably maintained at a continuous high level of control.

11.2.1.1 Coal Availability and Coal Washing

One aspect of the proposed SO_2 control system is to start with a coal which can be upgraded by available, demonstrated treatment methods (washing) to yield an as received coal satisfying the range of coal characteristics specified in Section 4.0. There are therefore two subjects to be addressed in evaluating this aspect of the proposed control system: availability of coal with required characteristics, and ability of conventional treatment methods to achieve the percent sulfur reduction needed.

These subjects are covered in the attached letter report prepared by Dames & Moore consultants labeled Exhibit 11.2-1. This report contains a general analysis of coal availability, and more detailed analysis based on two specific coal fields owned by MAPCO. Comments conerning these specific fields should not be construed to mean that coal supply sources have been definitely narrowed to these two choices or that a coal supply contract has been awarded to MAPCO. The reason for including reference to these two specific fields is that test information is available for these fields, and this information is considered to be representative of coal quality and coal processing techniques applicable to Seminole Plant Units No. 1 and No. 2.

For further assistance in evaluating the coal aspect of the proposed SO_2 control system, Exhibit 11.2-2 is presented. This exhibit contains calculations, again based on MAPCO coal field data, to demonstrate that the proposed coal washing sulfur removal efficiency of 30 percent is not only achievable but is probably a conservatively low estimate.

11.2.1.2 Flue Gas Desulfurization System

Seminole Electric proposes to install a limestone slurry spray tower FGD system consisting of five parallel absorber modules per boiler. At design conditions (full load) four modules will operate and the fifth will be available as a spare. It is Semonole's intention to operate these modules with two slurry recirculation pumps. Provisions will be made for another pump to be operated only when the proposed overall 85 percent sulfur removal (79 percent FGD, 6 percent washing) is not being obtained due to equipment malperformance. With this additional pump in operation, an expected overall removal of 91 percent (85 percent FGD, 6 percent washing) can be obtained. The availability of this third pump should therefore assure maintenance of the 24-hour average overall 85 percent removal (79 percent FGD, 6 percent washing) required. It should also be noted that the design of the FGD system does not assume any removal efficiency credit due to the presence of elements such as magnesium, sodium, and aluminum which act as reagents. Omitting credit for these substances is a conservative assumption and results in a design efficiency which may be lower than that actually achieved during station operation. An additional feature of the FGD design is a start-up bypass for bypassing gas flow when burning fuel oil in order not to introduce hydrocarbons into the system.

For assistance in evaluating the proposed FGD system, material obtained from a prospective vendor is enclosed. Although no contract for an FGD system has yet been awarded, the material attached is specific to Seminole Plant Units No. 1 and No. 2 and is representative of the system to be installed. Included for review are the following items:

Exhibit 11.2-3	-	FGD Proposed System
Exhibit 11.2-4	-	FGD Process Description
Exhibit 11.2-5	-	FGD Control Philosophy
Exhibit 11.2-6	-	FGD Process Chemistry
Drawing E-I00104-0102	-	Process Flow Diagram, FGD w/Limestone Storage & Delivery, 85 percent removal (79 percent FGD, 6 percent washing)
Drawing E-I00104-0101	-	Process Flow Diagram FGD w/Limestone Storage & Delivery, 91 percent removal (85 percent FGD, 6 percent washing)
Drawing E-I00104-0301	-	General Arrangement, SO_2 Removal Area

Design data, including L/G ratios, are included in Drawings E-I00104-0102 and E-I00104-0101.

11.2.2 Particulate Matter Controls - Boiler Emissions

Boiler particulate matter emissions will be controlled through the use of electrostatic precipitators. The design plan at this stage proposes the use of two cold-side precipitators, one for each generating unit. Each precipitator will be capable of providing a collection efficiency of 99.6 percent. Precipitators will be of the rigid frame discharge electrode type and are sized such that the design efficiency will be maintained with 10 percent of the collection surface de-energized in parallel.

Each precipitator will contain four 12-ft deep electrical fields and one 9-ft deep field in series with four bus stations in parallel, giving a total of 20 bus sections per precipitator. Power will be supplied to each precipitator by 20 full wave transformer/rectifiers rated at 55 kV (average). Each precipitator casing will contain five pyramidal type hoppers in series with eight in parallel, giving a total of 40 hoppers per casing. Each hopper will have a minimum 55° valley angle.

Additional precipitator data are provided in the following attachments:

Exhibit 11.2-7	-	Data Specifications for Electrostatic Precipitators
Exhibit 11.2-8	-	Summary of Electrostatic Precipitator Design Parameters
Exhibit 11.2-9	-	Electrostatic Precipitator Efficiency Calculation

Again it should be understood that a precipitator contract has not yet been awarded, and the information supplied in this application is representative, not final.

11.2.3 Oxides of Nitrogen Controls - Boiler Emissions

Control of nitrogen oxides emissions will be achieved through boiler furnace design. A boiler contract has already been awarded to Foster Wheeler Energy Corporation. Foster Wheeler guarantees that maximum NO_x emissions in the flue gas leaving the air heater will not exceed 0.6 lb/10^6 Btu for loads between 20 and 100 percent of Maximum Continuous Rating, the upper end of this range being equivalent to 110 percent of guaranteed station rating. A description of the NO_x control design which will be implemented by Foster Wheeler is provided in Exhibit 11.2-10.

11.2.4 Particulate Matter Controls - Other Than Boiler Emissions

A brief discussion on dust control appears in Section 3.4.4 The information below amplifies the previous discussion, particularly by providing additional data on control measures at those points with the greatest potential for dust generation - coal unloading, coal transfer house, coal crusher house, coal silos, limestone unloading, limestone day storage silo, lime unloading/storage bin, and fly ash storage silos.

Coal Unloading

A dust supression system will be designed for the coal unloading facility which will be either a rotary car dumper or a continuous bottom dump trestle type as determined later. The purpose of the dust supression system is to prevent fugitive coal dust escaping from the coal as it is unloaded by applying a water spray, including a wetting agent, to the coal.

The dust supression system will contain a proportioning system with metering pumps to accurately mix a wetting agent and station water. Spray header pressure will be 100-300 psi with nozzles rated 1 gpm at 100 psi placed on 2'-0" centers. An aggregate of 1-2 gallons of wet water will be applied for each ton of coal. Pumps will be oversized and latitude built into the system to add or delete nozzles as determined by field tests. A trestle unloader will require two (2) spray headers spraying continuously 1 gpm per foot of trestle length. Three (3) headers are required to spray 250-300 gpm. Spraying is required only during dumping.

Coal Transfer House

The transfer house receives coal from storage or an unloader and sends the coal to the plant or to the storage pile. Dust generated at each coal transfer point is collected by air hoods and vents and this air is processed through bag filters. Filters will be sized to handle 36,000 CFM with an air-to-cloth ratio of 7.5 to 1.

Coal Crusher House

The crusher house receives coal from the transfer house, crushes it, and sends it to day silos at the unit. There will be two crushers and two conveyor belts to the day silos. Either crusher can feed either conveyor belt. Air collection using bag filters will be provided at each transfer point. Filters will be sized to handle 30,000 CFM with an air-to-cloth ratio of 7.8 to 1.

Coal Silos

Crushed coal is transported to the day silos and stored. The coal is carried to the silos on two belts and then transferred to the unloading belts (unloading belts can be fed by either transport belt). There are two rows of 6 storage silos for each unit. It is assumed that only one silo in each row is being loaded at any time or two silos per unit. The end silo of each row is always open to collect the fines at the end of the belt run. The end silo is partially vented when collecting fines and fully vented when loading coal. Unit 2 has a similar arrangement of silos but the unloading belts are fed by Unit 1's unloading belts. Each unit will have its own air collection and treatment system. Unit 1 coal silo will be equipped with a bag filter capable of handling 38,000 CFM at an air-to-cloth ratio of 7.9 to 1. Unit 2 coal silo will be equipped with a bag filter having a capacity of 24,000 CFM and an air-to-cloth ratio of 8.1 to 1.

Limestone Unloading Facility

The limestone unloading facility is designed to accept truck loads of limestone or limestone from storage. The truck can be backed into the shed, sealed from the outside with a cover and emptied into a temporary storage bin before it is conveyed to the day storage silo. A front end loader is used to bring limestone from bulk storage to the temporary storage bin. A minimum air velocity (approximately 250 fpm) is maintained down through the grating to keep any dust generated by dumping down in the storage bin. The air is taken off the top of the storage bin and processed through bag filters with a capacity of 35,000 CFM and an air-to-cloth ratio of 7.3 to 1.

Limestone Day Storage Silo

The limestone is transported from the unloading facility to the day storage silo on a belt conveyor. Air is collected at the discharge of the belt and the vent of the silo. Since only one silo will be loaded at a time, one air unit will service all silos and will be valved accordingly. The bag filter unit will be located over one silo and will discharge collected fines into that silo. The air volume capacity of the filter will be 8,000 CFM, and it will have an air-to-cloth ratio of 6.3 to 1.

Lime Unloading/Storage Bin

Lime is unloaded from the truck by a pneumatic conveying system mounted on the truck. The lime is discharged into a storage bin. Air is vented from the storage bin and processed through a bag filter mounted over the bin. The collected fines are returned to the storage bin. The bag filter will have a capacity of 2,000 CFM and an air-to-cloth ratio of 5.5 to 1.

Fly Ash Storage Silo/Day Storage Silo

Fly ash is transported pneumatically from a collection point below the boiler to a storage silo. From the storage silo, it is again pneumatically transported to the day storage silo at the sludge stabilization facility. Each silo will be vented and the air processed through a bag filter. Since only one storage silo or one day storage silo will be loaded at a time, all vents for the storage silos will be processed by another single unit. The bag filter for the collector to storage bin system will have a capacity of 9,000 CFM and an air-to-cloth ratio of 5.7 to 1. For the storage silo to day storage silo system, dust control will also be achieved with a bag filter capable of handling 9,000 CFM and having an air-to-cloth ratio of 5.7 to 1.

In concluding this section on dust control, it should be noted that 40 CFR 60.250, the NSPS for coal preparation plants, stipulates that emissions from coal processing and conveying equipment, coal storage systems, and coal transfer and loading systems shall not exhibit an opacity of 20 percent or greater. Although it is not certain that the coal handling system to be used at the Seminole station will fall within the definition of coal preparation plants subject to NSPS, the controls planned for this system should result in compliance with the opacity regulation.

11.3 ALTERNATIVE CONTROL SYSTEMS

11.3.1 Sulfur Dioxide Control - Boiler Emisisons

The Clean Air Act Amendments (CAAA) of 1977 define best available control technology in terms of "degree of reduction" of pollutants in question. There are a number of FGD system types commercially available or under development, but there is little difference in the degree of emission reduction achievably by major systems. Seminole Electric proposes to install a limestone scrubbing process for sulfur dioxide control, presently the most widely used and proposed system for U. S. electric utilities. Rather than consider other types of control systems, the alternatives which have been evaluated are different degrees of emission reduction conceptually (not necessarily realistically) achievable through application of a limestone scrubbing FGD system.

11.3.1.1 Sulfur Emission Reduction

Specifically, two emission reduction alternatives in addition to the proposed system have been considered: (1) a system which achieves an overall 24-hour average sulfur reduction of approximately 91 percent (consisting of 85 percent reduction in the FGD system and 6 percent credit for a 30 percent sulfur reduction resulting from coal washing at the mine), and (2) a system which achieves an overall 24-hour average sulfur reduction of approximately 96 percent (consisting of 90 percent reduction in the FGD system and 6 percent credit from coal washing at the mine). This second emission reduction alternative (further qualified below) is considered neither technically feasible over a long period of time, nor economically feasible. The technical infeasibility argument is supported by the recently proposed NSPS which requires only 85 percent removal (including credit for fuel treatment), and by EPA's recent decision in the Indianapolis Power and Light Company (IPALCO) PSD permit application case reported in the October 17, 1978 issue of the Federal Register. Cost comparisons are presented in Section 11.4.1.

11.3.1.2 Reheat

Another point which can be considered when reviewing effects of coal fired steam-electric generating stations equipped with an FGD system is the amount of reheat added to exhaust gases after passing through the FGD device. Reheat enhances plume dispersion by increasing plume rise and effective stack height, thereby decreasing ground-level concentrations. However, under the CAAA definition of BACT, reheat is not within the scope of BACT alternatives since it does nothing to reduce emission rates. (In fact, the addition of reheat can result in greater emissions since reheat is normally accomplished either by burning more fuel or bypassing a portion of the exhaust gas flow around the FGD system.) The modeling analysis discussed previously indicates that the proposed Seminole station design should comply with ground-level concentration limits without using reheat. Reheat alternatives are therefore included in anticipation of questions arising during the application review process regarding reheat, despite the fact that reheat will not reduce emissions and is not properly a BACT alternative.

11.3.1.3 List of Alternatives

Including the added factor of reheat, alternatives evaluated can be summarized as follows:

	Proposed	Alt. A	Alt. B	Alt. C
Percent Reduction in FGD System	79%	85%	79%	90%
Percent Reduction Credit from Coal Washing	6%	6%	6%	6%
Total Reduction	85%	91%	85%	96%
Reheat	No	No	Yes	Yes
Exit Temperature	128°F	128°F	160°F	170°F
SO_2 Emission Rate ($lb/10^6$ Btu)	1.15	0.82	1.15	0.55
Number of Stacks	1	1 or 2	2	2

11.3.2 Particulate Matter Controls - Boiler Emissions

The proposed electrostatic precipitator control method will achieve a high removal efficiency and will result in compliance with the proposed NSPS emission limitation of 0.03 $lb/10^6$ Btu. An alternative means of particulate removal would be the use of baghouse filters. For this installation, however, precipitator and baghouse controls would be roughly equivalent, and therefore detailed assessment of alternatives has not been undertaken.

11.3.3 Oxides of Nitrogen Controls - Boiler Emissions

No available demonstrated technology exists to reduce oxides of nitrogen emission to a greater degree than the control method proposed.

11.3.4 Particulate Matter Controls - Other Than Boiler Emissions

The methods proposed to reduce dust emissions associated with handling of coal, limestone, lime, and fly ash are expected to achieve a degree of emission reduction which constitutes BACT.

11.4 IMPACTS OF PROPOSED BACT SYSTEM IN COMPARISON WITH ALTERNATIVE SYSTEMS

The alternatives of chief concern are those involving variations in sulfur removal and reheat. These alternatives are compared below in terms of economic, energy, and environmental impacts.

11.4.1 Economic Impacts

The cost factors involved in a comparison of sulfur removal/reheat alternatives are capital and operating costs. Capital costs are required for the FGD system itself and for the sludge stabilization and fixation process involved in sludge disposal. Operating costs include those for reagents, energy consumption, maintenance, and other items. A cost comparision of the proposed system versus Alternatives A, B, and C (defined in Section 11.3.1) is presented in Table 11.4-1. This table displays a differential cost analysis, expressed in 1983 dollars, covering the assumed 35-year lifetime of the generating station. Including each alternative in the cost comparison is not meant to imply that each is equally feasible or reliable from a technical standpoint. In particular, Alternative C involves a scrubber sulfur removal efficiency for which there is little evidence to indicate achievability on a long-term, routine basis. This alternative is presented to deomonstrate the penalty which would have to be borne by consumers to pay for an alternative which differs considerably from the proposed system.

The figures shown in Table 11.4-1 require little in the way of supplementary explanation. A factor which is not evident in the table, but which has economic implications, is the confidence or risk factor which can be assigned to different sulfur reduction rates. Based on information supplied by prospective vendors, it can be predicted with a much greater degree of confidence that a limestone system designed to achieve an overall 85 percent sulfur removal (79 percent FGD, 6 percent washing) will in fact achieve this removal on a reliable long-term basis than can be predicted for a system designed for an average of 91 percent (85 percent FGD, 6 percent washing) or higher. In other words, given that the propsed case and each alternative will all satisfy proposed

NSPS emission reduction provisions, the lowest cost option (the proposed base) has the least risk of failing to meet design objectives throughout the lifetime of the project.

11.4.2 Energy Impact

Each of the alternatives considered will require greater energy consumption than the proposed system. Energy increases would be due to increased pumping power, gas pressure drop, and reheat steam (for those alternatives involving reheat). Energy consumption differentials for both generating units combined using the proposed system as a base would be as follows:

	Proposed	Alt. A	Alt. B	Alt. C
1) Btu/Hour	Base	7.7×10^6	267×10^6	369×10^6
2) Btu/Year @ 70% Load Factor	Base	47.2×10^9	1637×10^9	2263×10^9
3) Tons of Coal Over 35 Years	Base	7.6×10^4	2.6×10^6	3.6×10^6

11.4.3 Environmental Impact

11.4.3.1 Solid Waste Disposal

Alternatives which require a greater degree of sulfur removal than the proposed design will result in a proportionately larger sludge volume to be disposed of. The major impact would be on the amount of land required to accommodate varying sludge volumes. Greater scrubber efficiency and consequent greater sludge quantities would result in a larger area of land being covered by scrubber sludge.

The increase in quantity of solid waste generated for each alternative, in comparison with the proposed design as a base case, is estimated as follows:

	Proposed	Alt. 1	Alt. 2	Alt. 3
1) Percent Increase	Base	7.6%	6.6%	24%
2) Acre-Ft Increase	Base	1,400	1,200	4,300

11.4.3.2 Air Quality

Particulate Matter and Oxides of Nitrogen

With respect to impact on ground-level concentrations of total suspended particulate matter (TSP) and nitrogen dioxide, differences between the base case and alternatives should be insignificant. For all options, maximum TSP concentrations attributable to Seminole emissions alone are expected to be insignificant according to the definition of significance established by EPA cited in Section 6.2. Maximum annual average NO_2 concentrations computed for option extremes (proposed base case and Alternative C) differ by less than 1 $\mu g/m^3$ and furthermore are only a small fraction (about 2 percent) of the national and Florida ambient air quality standard.

Sulfur Dioxide - Ambient Air Quality Standards

The greatest difference between the proposed BACT design and alternatives considered is in regard to impact on SO_2 concentrations. This difference can best be illustrated by comparing the proposed design with the most extreme of the alternatives, Alternative C, again keeping in mind that Alternative C is not considered technically feasible on a long-term basis or cost effective. The impacts of other alternatives would fall within the range defined by the proposed case and Alternative C.

With respect to SO_2 ambient air quality standards, neither the proposed case nor Alternative C should result in concentrations which equal even as much as 50 percent of governing standards. (This also takes into account interaction with existing sources.) Maximum concentrations due to Seminole alone, as a percent of Florida ambient SO_2 standards, are computed to be as follows:

Averaging Period	Proposed	Alt. C
Annual	8%	3%
2d High 24-Hour	23%	12%
2d High 3-Hour	34%	18%

Sulfur Dioxide - PSD Increments

With regard to PSD increments, the first question to ask is whether or not SO_2 increments in the nearest Class I area would be exceeded. In answer to this question, modeling evaluations indicate that compliance would be achieved by both the proposed design and Alternative C.

Turning next to compliance with Class II increments, SO_2 modeling results as a percentage of respective increments can be summarized as follows:

Averaging Period	Proposed	Alt. 3
Annual	25%	10%
2d High 24-Hour	66%	33%
2d High 3-Hour	85%	46%

When evaluating short-term concentrations, it is imperative to remember the time and space dependency factors which apply. The 85 percent consumption value, for example, represents a specific concentration at a specific point for a specific time period (or specific set of meteorological conditions). As discussed in Section 9.0, throughout the great majority of its impact area, the proposed design should consume much less than 50 percent of the available increment. Furthermore, the modeling analysis indicates highest short-term concentrations occuring very close to the Seminole site where there would be very little probability of significant interaction with new SO_2 emission sources locating nearer the heavily industrialized Jacksonville area to the north. The conclusion reached, then, is that the proposed design would not unreasonably interfere with future industrial growth either on its own merits or in comparison with alternative station designs.

TABLE II.4-I

DIFFERENTIAL COST COMPARISON
FOR PROPOSED SULFUR
REMOVAL SYSTEM
VERSUS ALTERNATIVES, IN 1983 DOLLARS

ITEM	PROPOSED	ALT. A	ALT. B	ALT. C
A. FGD SYSTEM				
1. Capital Cost Differential-	Base	Base	Base	$ 1,000,000
a. Including scrubber, limestone storage and handling, ductwork and stack				
b. Reheat System	Base	Base	3,760,000	4,000,000
2. Differential/Reagent Costs 35 Years	Base	2,000,000	1,724,000	6,300,000
3. Differential-Present Worth of Combined Energy and Capability Costs	Base	8,550,000	5,700,000	22,800,000
4. Differential - Average Steam Costs	Base	Base	74,670,000	99,300,000
5. Differential - Estimated Maintenance	Base	Base	Base	Base
6. Differential - Material Handling Costs	Base	Base	Base	Base
7. Differential - Operating Labor Cost	Base	Base	Base	Base
8. Total Differential - FGD	Base	10,550,000	85,854,000	133,400,000
B. SLUDGE STABILIZATION & FIXATION				
1. Differential - Capital Cost	Base	Base	Base	1,500,000
2. Differential - Present Worth of Combined Energy and Capability Costs	Base	Base	Base	330,000
3. Differential - Additive Costs 35 Years	Base	1,760,000	1,530,000	5,600,000
4. Differential - Operating Labor	Base	Base	Base	Base
5. Differential - Land Fill Equipent	Base	Base	Base	Base
6. Differential - Maintenance	Base	Base	Base	Base
7. Total Differential - Sludge Stabilization & Fixation	Base	1,760,000	1,530,000	7,430,000
C. TOTAL SYSTEM DIFFERENTIAL	Base	12,310,000	87,384,000	140,830,000

LIST OF REFERENCES

Briggs, G.A., 1971, Some recent analyses of plume rise observation, in Proceedings of the Second International Clean Air Congress, H.M. Englund and W.T. Beery (ed.), Academic Press, New York, p. 507-510.

_____, 1972, Discussion on chimney plumes in neutral and stable surroundings. Atmospheric Environment, vol. 6, p. 507-510.

Federal Register (42 FR 57479), 3 November 1977, Approval and promulgation of implementation plans, prevention of significant air quality deterioration (40 CFR Part 52), proposed.

Federal Register (43 FR 8961), 3 March 1978, National ambient air quality standards, states attainment status.

Holzworth, G.C., 1972, Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. U.S. Environmental Protection Agency, Office of Air Programs, Publication No. AP-101.

Turner, D.B., 1964, A diffusion model for an urban area. Journal of Applied Meteorology, vol. 3, p. 83-91.

U.S. Environmental Protection Agency, 1977, Good engineering stack height, technical support document for proposed regulation to implement Section 123 (Stack Heights) of the Clean Air Act Amendments of 1977, draft copy. Office of Air Quality Planning and Standards.

_____, 1977b, Interim guidelines on air quality models. Office of Air Quality Planning and Standards, Publication OAQPS No. 1.2-080, p. A-1.

_____, 1977c User's manual for single-source (CRSTER) model. Office of Air Quality Planning and Standards, Publication No. EPA-450/2-77-013.

U.S. Public Health Service, 1969, Air quality display model. Prepared for National Air Pollution Control Administration by TRW Systems Group, Contract No. PH-22-68-60.

APPENDIX A

TABLES A-1 THROUGH A-5
JOINT FREQUENCY DISTRIBUTION OF WIND SPEED,
WIND DIRECTION, AND STABILITY
CLASS USED IN AQDM ANALYSIS

JACKSONVILLE, 1970-1974
(8 OBSERVATIONS/DAY)

Note: Windspeed class numbers have following interpretation:

1 = 0.67 m/s

2 = 2.46 m/s

3 = 4.47 m/s

4 = 6.93 m/s

5 = 9.61 m/s

6 = 12.52 m/s

TABLE A-1

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS A

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.0002	.0002	0.0000	0.0000	0.0000	0.0000
NNE	.0001	.0001	0.0000	0.0000	0.0000	0.0000
NE	.0003	.0002	0.0000	0.0000	0.0000	0.0000
ENE	.0003	.0003	0.0000	0.0000	0.0000	0.0000
E	.0003	.0003	0.0000	0.0000	0.0000	0.0000
ESE	.0005	.0006	0.0000	0.0000	0.0000	0.0000
SE	.0002	.0004	0.0000	0.0000	0.0000	0.0000
SSE	.0000	.0001	0.0000	0.0000	0.0000	0.0000
S	.0003	.0003	0.0000	0.0000	0.0000	0.0000
SSW	.0003	.0004	0.0000	0.0000	0.0000	0.0000
SW	.0001	.0002	0.0000	0.0000	0.0000	0.0000
WSW	.0002	.0005	0.0000	0.0000	0.0000	0.0000
W	.0003	.0007	0.0000	0.0000	0.0000	0.0000
WNW	.0001	.0002	0.0000	0.0000	0.0000	0.0000
NW	.0002	.0003	0.0000	0.0000	0.0000	0.0000
NNW	.0004	.0003	0.0000	0.0000	0.0000	0.0000

TABLE A-2

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS B

	WINDSPEED CLASS					
WIND DIRECTION	1	2	3	4	5	6
N	.0022	.0024	.0008	0.0000	0.0000	0.0000
NNE	.0008	.0011	.0009	0.0000	0.0000	0.0000
NE	.0006	.0010	.0011	0.0000	0.0000	0.0000
ENE	.0009	.0016	.0012	0.0000	0.0000	0.0000
E	.0007	.0026	.0018	0.0000	0.0000	0.0000
ESE	.0006	.0013	.0014	0.0000	0.0000	0.0000
SE	.0012	.0022	.0014	0.0000	0.0000	0.0000
SSE	.0004	.0010	.0009	0.0000	0.0000	0.0000
S	.0013	.0024	.0015	0.0000	0.0000	0.0000
SSW	.0009	.0014	.0009	0.0000	0.0000	0.0000
SW	.0017	.0025	.0023	0.0000	0.0000	0.0000
WSW	.0012	.0029	.0019	0.0000	0.0000	0.0000
W	.0017	.0027	.0024	0.0000	0.0000	0.0000
WNW	.0010	.0023	.0012	0.0000	0.0000	0.0000
NW	.0014	.0027	.0012	0.0000	0.0000	0.0000
NNW	.0012	.0014	.0009	0.0000	0.0000	0.0000

TABLE A-3

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS C

	WINDSPEED CLASS					
WIND DIRECTION	1	2	3	4	5	6
N	.0012	.0027	.0034	.0001	0.0000	0.0000
NNE	.0006	.0014	.0021	.0005	0.0000	0.0000
NE	.0006	.0013	.0039	.0005	0.0000	0.0000
ENE	.0005	.0016	.0064	.0018	0.0000	0.0000
E	.0003	.0010	.0092	.0028	.0001	0.0000
ESE	.0002	.0009	.0062	.0019	0.0000	0.0000
SE	.0006	.0016	.0055	.0017	0.0000	0.0000
SSE	.0009	.0011	.0024	.0003	0.0000	0.0000
S	.0012	.0023	.0041	.0006	0.0000	0.0000
SSW	.0006	.0017	.0040	.0009	.0001	0.0000
SW	.0010	.0025	.0051	.0012	.0001	0.0000
WSW	.0012	.0027	.0079	.0012	0.0000	0.0000
W	.0010	.0037	.0074	.0019	.0002	0.0000
WNW	.0009	.0014	.0037	.0010	.0001	0.0000
NW	.0011	.0020	.0042	.0006	0.0000	.0001
NNW	.0007	.0010	.0022	.0002	0.0000	0.0000

TABLE A-4

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS D

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.0027	.0053	.0121	.0047	.0001	.0001
NNE	.0009	.0030	.0075	.0084	.0005	.0001
NE	.0007	.0033	.0092	.0156	.0023	.0003
ENE	.0009	.0034	.0094	.0125	.0011	0.0000
E	.0013	.0042	.0103	.0125	.0007	0.0000
ESE	.0006	.0027	.0077	.0077	.0003	.0001
SE	.0007	.0021	.0090	.0108	.0006	.0001
SSE	.0007	.0027	.0064	.0042	.0005	.0001
S	.0016	.0048	.0122	.0075	.0005	0.0000
SSW	.0010	.0030	.0088	.0055	.0003	0.0000
SW	.0008	.0041	.0130	.0101	.0012	0.0000
WSW	.0009	.0032	.0089	.0094	.0010	.0002
W	.0011	.0044	.0079	.0123	.0026	.0005
WNW	.0011	.0032	.0040	.0084	.0023	.0003
NW	.0011	.0027	.0060	.0075	.0017	.0001
NNW	.0009	.0027	.0051	.0041	.0002	0.0000

TABLE A-5

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS E

	WINDSPEED CLASS					
WIND DIRECTION	1	2	3	4	5	6
N	.0147	.0149	.0048	0.0000	0.0000	0.0000
NNE	.0048	.0051	.0011	0.0000	0.0000	0.0000
NE	.0062	.0069	.0013	0.0000	0.0000	0.0000
ENE	.0086	.0121	.0017	0.0000	0.0000	0.0000
E	.0076	.0104	.0036	0.0000	0.0000	0.0000
ESE	.0068	.0085	.0045	0.0000	0.0000	0.0000
SE	.0087	.0124	.0050	0.0000	0.0000	0.0000
SSE	.0075	.0077	.0024	0.0000	0.0000	0.0000
S	.0149	.0178	.0034	0.0000	0.0000	0.0000
SSW	.0102	.0138	.0020	0.0000	0.0000	0.0000
SW	.0126	.0165	.0038	0.0000	0.0000	0.0000
WSW	.0124	.0156	.0062	0.0000	0.0000	0.0000
W	.0176	.0164	.0062	0.0000	0.0000	0.0000
WNW	.0149	.0118	.0036	0.0000	0.0000	0.0000
NW	.0112	.0113	.0040	0.0000	0.0000	0.0000
NNW	.0096	.0082	.0032	0.0000	0.0000	0.0000

Table 2.4-1

Atmospheric Temperature (°F) at Jacksonville, Florida
1940 - 1974

	Averages			Extremes	
Month	Daily Max	Daily Min	Mean	Highest	Lowest
Jan	64.6	44.5	54.6	85	19
Feb	66.9	45.7	56.3	88	19
Mar	72.2	50.1	61.2	91	25
Apr	79.0	57.1	68.1	95	35
May	84.6	63.9	74.3	100	45
June	88.3	70.0	79.2	103	56
Jul	90.0	72.0	81.0	105	61
Aug	89.7	72.3	81.0	102	64
Sep	86.0	70.4	78.2	100	50
Oct	79.2	61.7	70.5	96	38
Nov	71.4	51.0	61.2	88	21
Dec	65.6	45.1	55.4	84	12
Annual	78.1	58.7	68.4	105	12

Source: USDC, 1974.

Table 2.4-2

Mean Monthly and Annual Relative Humidity at Jacksonville, Florida 1936 - 1974

Month	Hour of the Day 0100	0700	1300	1900
Jan	85	87	57	74
Feb	82	85	52	68
Mar	81	85	49	65
Apr	83	85	47	64
May	84	84	49	66
Jun	87	86	56	72
Jul	88	87	58	75
Aug	90	90	60	78
Sep	89	91	62	79
Oct	88	90	58	78
Nov	86	89	55	77
Dec	86	88	58	77
Annual	86	87	55	73

Source: USDC, 1974

Table 2.4-3

Wind Conditions at Jacksonville, Florida
1941 - 1974

Month	Average Speed (mph)	Most Common Direction	Fastest Mile
Jan	8.5	NW	41
Feb	9.7	WSW	52
Mar	9.6	NW	44
Apr	9.3	SE	48
May	8.9	WSW	52
Jun	8.6	SW	76
Jul	7.7	SW	49
Aug	7.4	SW	52
Sep	8.5	NE	82
Oct	8.8	NE	72
Nov	8.4	NW	62
Dec	8.3	NW	62
Annual	8.6	NW	82

Source: USDC, 1974

Table 2.4-4

Average Frequency Distribution of
Stability Classes at Jacksonville, Florida
1970 - 1974

Pasquill Stability Class	Description	Percent Frequency by Season Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Annual
A	Extremely Unstable	0	1	2	1	1
B	Unstable	4	6	15	5	7
C	Slightly Unstable	9	14	22	11	14
D	Neutral	48	40	20	33	35
E	Stable	39	39	41	50	43

Source: USDC, 1974

Table 2.4-5

Average Mixing Height and Episodes of Limited Dispersion at Jacksonville, Florida
1960 - 1964

	Morning		Afternoon	
	Average Mixing Height (m)	Average Mixing Layer Wind Speed (m/s)	Average Mixing Height (m)	Average Mixing Layer Wind Speed (m/s)
Winter	345	5.2	1058	6.7
Spring	447	5.3	1639	7.1
Summer	567	4.3	1681	5.6
Autumn	418	4.7	1321	6.5
Annual	444	4.9	1424	6.5

Number of Episodes Lasting Two or More Days

Mixing Height (m)	Mixing Layer Wind Speed (m/s)		
	≤2	≤4	≤6
≤ 500	0	0	1
≤1000	0	2	12
≤1500	0	12	43

Source: Holzworth, 1972

Table 2.4-6

Average Rainfall at Palatka, Florida,
1941 - 1970

Month	Average Amount (Inches)
Jan	2.54
Feb	3.42
Mar	4.05
Apr	3.00
May	3.32
Jun	6.49
Jul	7.74
Aug	7.56
Sep	7.58
Oct	4.88
Nov	1.85
Dec	2.41
Annual	54.84

Source: USDC, 1973

APPENDIX G

ACOUSTICS

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ACOUSTICS

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ACOUSTICS

G.1 NOMENCLATURE

The range of sound pressures that can be heard by humans is very large. This range varies from two ten-thousand-millionths (2×10^{-10}) of an atmosphere for sounds barely audible to humans, to two thousandths (2×10^{-5}) of an atmosphere for sounds which are so loud as to be painful. The decibel notation system is used to present sound levels over this wide physical range. Essentially, the decibel system compresses this range to a workable one using logarithms. Sound level is defined as:

$$\text{Sound level in decibels (dB)} = 20 \text{ Log}_{10} \left(\frac{P}{P_o}\right)$$

where P_o is a reference sound pressure required for a minimum sensation of hearing, and P is the measured sound pressure.

Zero decibel (dB) is assigned to the minimum level and 140 dB to sound which is painful. Thus, a range of more than one million is expressed in a scale of zero to 140.

The human ear does not perceive sounds at low frequencies in the same manner as those at higher frequencies. Sounds at low frequency do not seem as loud as those of equal intensity at higher frequencies. To simulate human hearing, the A-weighting network is provided in sound analysis systems. A-weighted sound levels are expressed in units of dB. These levels in dB are used by the engineer to evaluate hearing damage risk (OSHA) or community annoyance impact. These values are also used in federal, state, and local noise ordinances.

Sound is not constant in time. Statistical analysis is used to describe the temporal distribution of sound and to compute single number descriptors for the time-varying sound. This report contains the following statistical A-weighted sound levels:

L_{95} - This is the sound level exceeded 95 percent of the time during the measurement period.

L_{90} - This is the sound level exceeded 90 percent of the time during the measurement period and is often used to represent the "residual" sound level.

L_{50} - This is the sound level exceeded 50 percent of the time during the measurement period and is used to represent the "median" sound level.

L_{10} - This is the sound level exceeded 10 percent of the time during the measurement period and is often used to represent the "intrusive" sound level.

L_5 - This is the sound level exceeded 5 percent of the time during the measurement period.

L_{eq} - This is the equivalent steady sound level which provides an equal amount of acoustic energy as the time-varying sound.

L_d - Average sound level, L_{eq}, for the daytime period (0700-2200) only.

L_n - Average sound level, L_{eq}, for the nighttime period (2200-0700) only.

L_{dn} - Average day/night sound level, defined as:

$$L_{dn} = 10 \text{ Log}_{10}([15 \times 10^{L_d/10} + 9 \times 10^{(L_n+10)/10}]/24)$$

Note: A 10 dB correction factor is added to the nightime average sound level.

G.2 DATA ACQUISITION AND ANALYSIS

This section describes the instrumentation, data acquisition and analysis, used for the ambient sound survey conducted at the Putnam Site.

The data acquisition system consisting of a General Radio omnidirectional one-inch electret condenser microphone with windscreen, a General Radio Type 1933 Sound Level Meter and Octave Band Analyzer, and a Nagra 4.2L single track magnetic tape recorder. The General Radio Type 1933 Sound Level Meter and Octave Band Analyzer were used as a linear amplifier and step attenuator. Ambient sound was recorded on Scotch 177 magnetic tape. The data acquisition system is shown schematically in Figure G-1.

The above system was calibrated before each recording by means of a reference signal of 114 dB at 1000 Hertz generated by a General Radio Type 1652A Sound Level Calibrator.

The microphone was mounted on a tripod four feet above the ground surface and, in order to avoid major interference with sound propagation, at least ten feet from any sizable sound reflecting surfaces. Most recordings of the background ambient sound were 21 minutes in length.

Meteorological parameters such as wet bulb and dry bulb temperatures, humidity, barometric pressure, and wind speed and direction were noted during each recording period. If high relative humidity or excessive wind speed (over 12 miles per hour) occurred during the measurement period, the recording session was terminated. The tape recorded data were returned to the acoustic laboratory at Dames & Moore for analysis, using a General Radio Real-Time Analyzer and a Digital Equipment Corporation mini-computer (shown schematically in Figure G-2).

During the recording session, any unusual intrusions, such as wind pop over the microphone or clipping due to overloads, were noted by the engineer monitoring the signal input to the tape. Such intrusions are not characteristic of the acoustic environment, and are deleted during the analysis phase. Each sample tape is used to obtain a cumulative distribution at each octave band center frequency, a histogram and cumulative distribution of A-weighted sound levels.

G.3 RESULTS

The detailed results of the ambient sound level survey conducted in the study area during November 17 to November 19, 1977 are presented in Figures G-3 to G-36. Each figure contains the A-weighted sound level histogram, indicating the number of times a particular sound level occurred during the measurement period, and the cumulative distribution of A-weighted sound levels, indicating the percentage of time a sound level is exceeded. Also included are the L_{95}, L_{90}, L_{50}, L_{10}, L_5, and L_{eq} of the sound pressure levels at octave band center frequencies.

Table G-1 presents a summary of the meteorological conditions during the measurement periods.

G.4 DESCRIPTION OF USAGE FACTOR

In the course of a typical work cycle, construction equipment spends part of its cycle idling or preparing to perform tasks. During some part of its work cycle, the noise the individual machine emits is higher than it is at any other time. Since L_{eq} is an average value representing the total sound energy emitted during the period of interest, the maximum sound level, L_p,* and the duration of maximum noise as a fraction of the total period must be known to determine the equivalent (energy average) sound level emitted by the machine during a total work period: for example, a typical work day. The fraction of this period that the equipment operates in its noisiest mode is designated as the Usage Factor (UF). The usage factor is considered to consist of two component elements; an operating factor (F_1) and a utilization factor (F_2). UF = $F_1 \times F_2$. The operating factor is that portion of the typical work cycle that the equipment is emitting its maximum noise. This factor is illustrated in Figure G-37 where $F_1 = T_1/T_2$. Three possible time-varying modes of equipment noise emission are possible. They are listed below:

Mode 1: The equipment works cyclically; for example, a backhoe or front end loader may generate maximum sound while trenching but significantly less sound while using its loader.

Mode 2: The equipment moves throughout the site.

Mode 3: An operation is performed sporadically, possibly only once during the observation period.

The utilization factor is that portion of the work period (e.g., 8-hour work day) that the equipment is on the site and is being used. Thus, the utilization factor considers the number of work cycles for the equipment during typical operations during the work period. Figure G-38

*The maximum sound level, L_p, is the average sound level of the equipment in its noisiest mode. To better illustrate L_p, Figure G-37 shows a typical work cycle for a unit of construction equipment illustrates possible time histories applicable to each mode. The operating factor (F_1) is computed from the fraction of time the equipment is in its noisiest mode. The utilization factor is then multiplied by the operating factor to yield the usage factor.

Stationary equipment may not be operating, may be idling while other preparatory activities are in process, or may be operating at full load (and maximum noise level). These operations may be repeated often during a typical construction day. This activity is shown in Figure G-38 as Mode 1.

Mobile equipment may be operating at maximum noise levels for a short duration; for example, a front end loader while loading. The equipment (the loader) may travel a considerable distance to place this load. At a receiver, sound levels drop significantly as the loader leaves the scene even though the source noise level has not diminished. Mode 2 of Figure G-38 illustrates this activity.

A single event is illustrated by Mode 3 of Figure G-38. The total period T_2 is assumed to be the construction duration, perhaps an 8-hour day.

The maximum sound level of the equipment and its usage factor are used to evaluate L_{eq} as shown below:

$$L_{eq} = 10 \log_{10} (U.F. \times 10^{(Lp/10)})$$

Operating factors and utilization factors are best determined from measurements at a construction site where operations similar to those at the site under study are occurring.

G.5 FEDERAL GUIDELINES AND STATE AND LOCAL NOISE REGULATIONS

The EPA has established guidelines for limits of L_{dn} requisite for the protection of public health and welfare.*

---

*Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, USEPA 550/9-74-004, March 1974.

According to EPA guidelines, outdoor ambient sound levels, L_{dn}, below 55 dB will not degrade public health and welfare. A summary of noise levels, identified as requisite to protect public health and welfare with an adequate margin of safety is present in Table G-2.

The state of Florida has no noise regulations for steam-powered generating power plants.

Putnam County has no noise regulations for steam-powered generating power plants.

TABLE G-1

METEOROLOGICAL CONDITIONS DURING AMBIENT MEASUREMENT PERIODS

Location	Date	Time	Temperature (°C)	Humidity (%)	Wind (m/sec)
			Weekdays		
1	11/18/77	1125	24.5	56	0-1.8
2	11/18/77	1215	22.5	56	0-2.7
3	11/18/77	1255	23.0	56	0-2.7
4	11/18/77	1338	24.0	46	1.8-3.6
5	11/18/77	1430	22.0	42	1.8-3.6
6	11/18/77	1511	24.5	40	1.8-3.6
1	11/17/77	1800	21.5	82	0- .9
2	11/17/77	1855	21.5	82	0- .9
3	11/17/77	1931	21.0	82	0- .9
4	11/17/77	2009	19.0	84	0- .9
5	11/17/77	2054	19.5	82	0- .9
6	11/17/77	2133	19.5	84	0- .9
1	11/17/77	2227	19.5	88	0- .9
2	11/17/77	2311	19.0	88	0- .9
3	11/17/77	2347	17.0	84	0- .9
4	11/18/77	0024	18.0	84	0- .9
5	11/18/77	0104	18.0	84	0- .9
6	11/18/77	0139	18.0	84	0- .9
			Weekend		
1	11/19/77	1053	23.5	60	0-1.8
2	11/19/77	1142	26.0	66	1.8-2.7
3	11/19/77	1216	27.0	66	1.8-3.6
4	11/19/77	1403	28.0	56	1.8-3.6
5	11/19/77	1329	27.0	62	2.7-3.6
6	11/19/77	1249	27.0	62	1.8-2.7
1	11/18/77	1800	19.0	52	0- .9
2	11/18/77	1845	16.5	66	0- .9
3	11/18/77	1925	13.0	68	0- .9
4*					
5	11/18/77	2105	12.0	68	0- .9
6	11/18/77	2000	13.5	74	0- .9
1	11/18/77	2238	14.0	80	0- .9
2	11/18/77	2326	14.0	80	0- .9
3	11/19/77	0002	12.0	88	0- .9
4*					
5	11/19/77	0150	11.0	78	1.8-2.7
6	11/19/77	0037	11.5	90	0- .9

*No measurements were taken.

TABLE G-2

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

Effect	Level	Area
Hearing Loss	$L_{eq(24)} \leq 70$ dB	All areas
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities such as schools, etc.

$L_{eq(24)}$ represents the sound energy averaged over a 24-hour period. L_{dn} represents the L_{eq} with a 10 dB nighttime weighting.

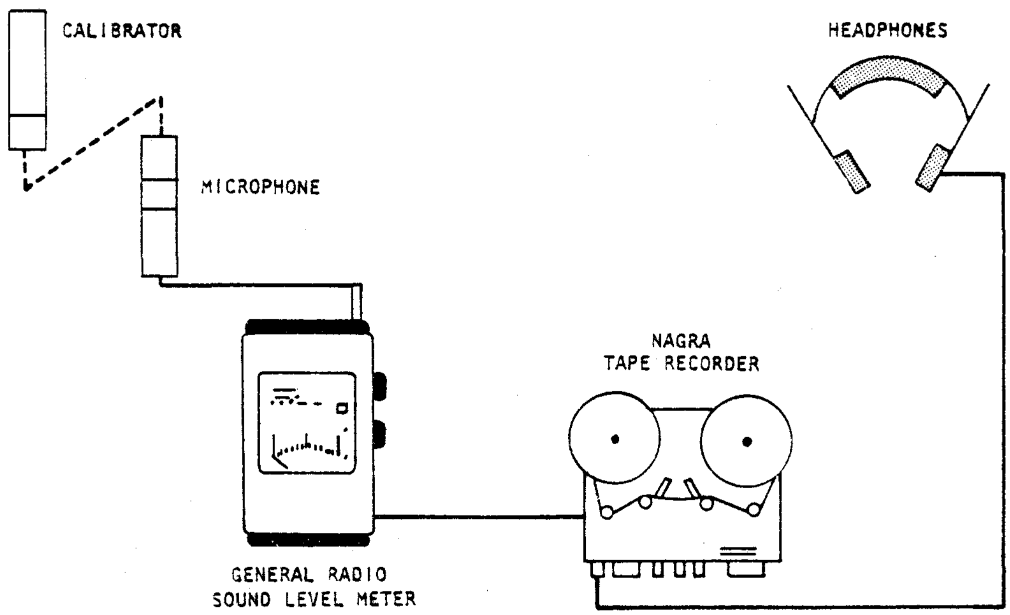


Figure G-1. Data Aquisition System.

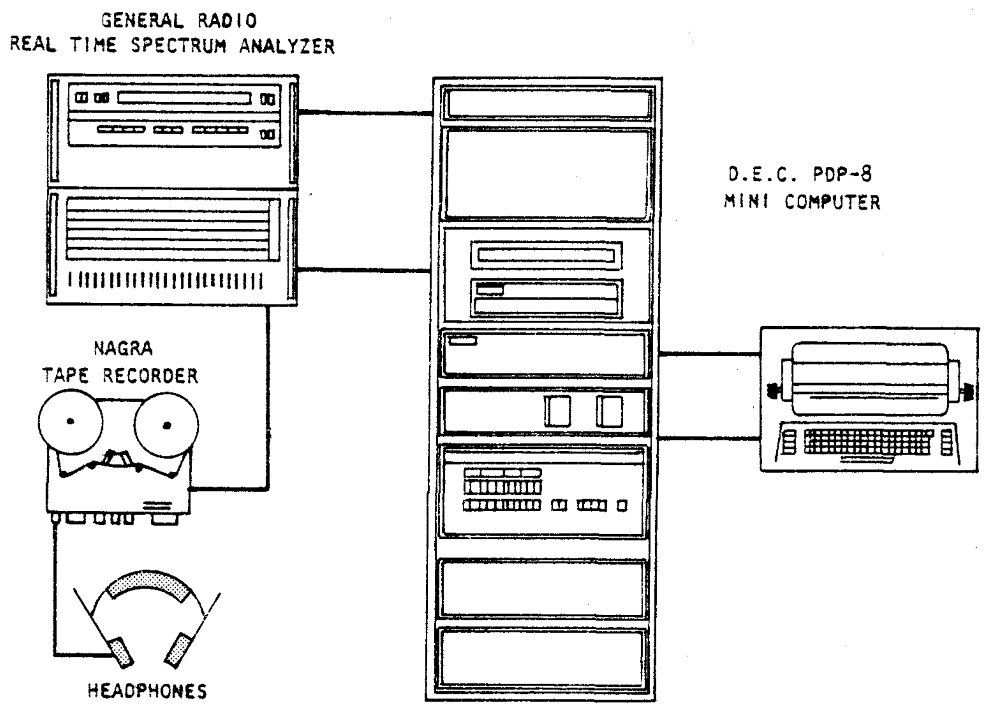


Figure G-2. Computer Controlled Data Analysis System.

FILE SEM013. DA

OCTAVE BAND HZ.	LEQ DB	L_{5}	L_{10}	L_{50}	L_{90}	L_{95}
31. 5	45. 4	50	48	44	41	41
63	45. 2	49	47	44	43	42
125	40. 3	45	42	36	33	33
250	33. 8	40	37	28	26	25
500	34. 1	40	38	28	27	26
1000	35. 7	41	38	31	30	29
2000	33. 5	40	36	31	29	29
4000	29. 6	35	31	27	26	25
8000	28. 9	33	32	26	24	24
A-WT.	40. 8	47	43	37	36	35

FILE SEM013. DA
A-WT. SOUND LEVELS

A-Weighted Sound Level - dB re: 20 µPa

```
34  *  0. 3 %
35  **********  5. 6 %
36  ***********************************************  26. 1 %
37  **************************************************  28 %
38  **********************  12. 3 %
39  ***************  8. 3 %
40  *****  2. 5 %
41  ******  3 %
42  *****  2. 8 %
43  ***  1. 5 %
44  **  1 %
45  ****  2. 1 %
46  *  0. 6 %
47  **  1. 1 %
48  ****  2 %
49  **  0. 7 %
50  **  0. 7 %
51  **  0. 9 %
52  *  0. 6 %
53  *  0. 2 %
```

EQUIVALENT SOUND LEVEL = 40. 8 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	35
90	36
85	36
80	36
75	36
70	36
65	37
60	37
55	37
50	37
45	37
40	38
35	38
30	38
25	39
20	39
15	41
10	43
5	47

Location: 1
Date: 11/18/77
Time: 1125

Figure G-3. Background Ambient Sound Level Data.

FILE SEM014.DA

OCTAVE BAND HZ.	LEQ DB	L_5	L_{10}	L_{50}	L_{90}	L_{95}
31.5	58.4	64	62	55	51	50
63	61.5	66	64	57	54	53
125	58.7	64	62	53	46	45
250	51.4	57	54	45	38	37
500	45.6	52	48	39	35	34
1000	46.3	53	49	41	35	34
2000	43.2	49	47	39	34	34
4000	38.3	42	40	34	34	34
8000	34.6	36	35	34	34	34
A-WT.	52.1	58	56	47	41	40

FILE SEM014.DA
A-WT. SOUND LEVELS

Location: 2
Date: 11/18/77
Time: 1215

A-Weighted Sound Level - dB re 20µPa

```
37  *  0.1 %
38  ****  0.7 %
39  ******************  2.9 %
40  *************************************  6.1 %
41  ****************************  4.6 %
42  *******************************************  7.2 %
43  ****************************************  6.7 %
44  ************************************  6 %
45  *********************************  5.5 %
46  *********************************  5.4 %
47  ******************************  5 %
48  **********************************  5.6 %
49  ****************************************  6.7 %
50  *********************************  5.5 %
51  **********************************  5.7 %
52  *********************************  5.5 %
53  ****************************  4.7 %
54  ***************  2.5 %
55  *************  2.1 %
56  ******************  2.9 %
57  *************  2.1 %
58  ***********  1.8 %
59  **********  1.7 %
60  *******  1.1 %
61  ******  1 %
62  ***  0.5 %
63  **  0.3 %
64  **  0.3 %
65  *  0.1 %
66  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 52.1 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	40
90	41
85	42
80	42
75	43
70	44
65	45
60	46
55	46
50	47
45	48
40	49
35	50
30	51
25	52
20	53
15	54
10	56
5	58

Figure G-4. Background Ambient Sound Level Data.

FILE SEM015.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	61.3	67	65	55	48	46
63	59.9	64	61	56	54	53
125	53.7	59	56	48	42	41
250	46.9	51	48	40	36	35
500	41.8	47	45	37	34	34
1000	43.7	49	47	39	34	34
2000	39.1	44	41	35	34	34
4000	35.7	39	36	34	34	34
8000	34.4	35	34	34	34	34
A-WT.	48.3	54	52	44	37	36

FILE SEM015.DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/18/77
Time: 1255

A-Weighted Sound Level - dB re 20 μPa

34	**********	1.7 %
35	****************	2.7 %
36	**************	2.3 %
37	**********************	3.7 %
38	***************************	4.5 %
39	************************************	5.9 %
40	******************************	4.9 %
41	*******************************	5.1 %
42	**	7.6 %
43	***	7.2 %
44	**	6.7 %
45	*********************************	5.4 %
46	**	7.3 %
47	*************************************	6.1 %
48	*****************************	4.8 %
49	***********************************	5.8 %
50	*******************************	5.1 %
51	*******************	3.2 %
52	******************	3 %
53	***********	1.8 %
54	************	1.9 %
55	*******	1.1 %
56	*******	1.1 %
57	**	0.3 %
58	*	0.1 %
59	**	0.3 %
60	*	0.1 %
61	**	0.3 %
62	*	0.2 %
63	**	0.3 %

EQUIVALENT SOUND LEVEL = 48.3 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	37
85	39
80	39
75	40
70	41
65	42
60	43
55	43
50	44
45	45
40	46
35	47
30	47
25	48
20	49
15	50
10	52
5	54

Figure G-5. Background Ambient Sound Level Data.

FILE SEM016.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	56.8	62	59	50	45	44
63	55.1	57	56	53	53	52
125	50.1	53	50	45	42	41
250	40.4	44	41	36	35	35
500	40.2	44	42	37	35	35
1000	37.6	41	39	34	34	34
2000	36	35	35	34	34	34
4000	36.1	34	34	34	34	34
8000	35.6	35	34	34	34	34
A-WT.	43.7	46	44	39	36	36

FILE SEM016.DA
A-WT. SOUND LEVELS

Location: 4
Date: 11/18/77
Time: 1338

A-Weighted Sound Level - dB re: 20μPa

```
34  *  0.3 %
35  **********  3.2 %
36  *************************  8.3 %
37  *******************************************  14.1 %
38  **********************************************  15.2 %
39  ******************************************  13.8 %
40  ****************************************  13.1 %
41  *************************  8.1 %
42  ***********************  7.5 %
43  ********************  6.4 %
44  ********  2.6 %
45  *****  1.6 %
46  *****  1.4 %
47  ****  1.1 %
48  **  0.6 %
49  **  0.5 %
50  **  0.4 %
51  *  0.3 %
52  **  0.5 %
53  *  0.3 %
54  *  0.2 %
55  *  0.1 %
56
57
58  *  0.2 %
59
60
61
62  *  0.1 %
63  *  0.1 %
64  *  0.1 %
65
66  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	36
85	37
80	37
75	37
70	38
65	38
60	38
55	39
50	39
45	40
40	40
35	40
30	41
25	41
20	42
15	43
10	44
5	46

EQUIVALENT SOUND LEVEL = 43.7 DB

Figure G-6. Background Ambient Sound Level Data.

FILE SEM017. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	53. 6	59	57	50	46	45
63	54. 8	58	56	54	53	52
125	48. 7	53	52	47	43	42
250	41. 6	47	45	38	35	35
500	37. 6	43	40	35	34	34
1000	35	38	37	34	34	34
2000	34. 8	35	34	34	34	34
4000	34. 3	34	34	34	34	34
8000	34	34	34	34	34	34
A-WT.	41	46	44	39	36	35

FILE SEM017. DA
A-WT. SOUND LEVELS

Location: 5
Date: 11/18/77
Time: 1430

A-Weighted Sound Level - dB re: 20 µPa

```
34  ***  0. 8 %
35  **********************  6. 8 %
36  ***********************************************  14. 6 %
37  *********************************************  13. 9 %
38  ************************************  11. 3 %
39  *********************************  10. 3 %
40  ************************************  11. 1 %
41  ***************************  8. 5 %
42  *****************  5. 3 %
43  *******************  5. 8 %
44  ************  3. 7 %
45  ******  1. 8 %
46  ********  2. 6 %
47  ***  1 %
48  ****  1. 3 %
49  **  0. 5 %
50  *  0. 2 %
51  *  0. 2 %
52  *  0. 2 %
53  *  0. 2 %
54
55  *  0. 1 %
```

EQUIVALENT SOUND LEVEL = 41 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	35
90	36
85	36
80	36
75	37
70	37
65	37
60	38
55	38
50	39
45	39
40	40
35	40
30	41
25	41
20	42
15	43
10	44
5	46

Figure G-7. Background Ambient Sound Level Data.

FILE SEM018. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	58. 9	63	61	54	47	46
63	61. 4	65	62	55	53	52
125	63. 2	69	.65	53	45	44
250	57. 2	64	60	44	36	35
500	52. 1	58	54	40	35	34
1000	52. 5	58	56	44	36	34
2000	51	56	54	41	34	34
4000	46. 2	50	48	35	34	34
8000	39. 2	43	40	35	34	34
A-WT.	58. 5	64	62	49	42	40

FILE SEM018. DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/18/77
Time: 1511

A-Weighted Sound Level - dB re: 20μPa

```
37  *  0. 2 %
38  ********  1. 3 %
39  **************  2. 3 %
40  ******************  2. 9 %
41  ****************  2. 7 %
42  *****************************  4. 8 %
43  *****************************  4. 8 %
44  ************************************  6 %
45  ******************************************  7 %
46  *************************************************  8. 2 %
47  **********************************  5. 6 %
48  ************************  4 %
49  ******************************  4. 9 %
50  ***********************  3. 8 %
51  *****************  2. 8 %
52  *******************  3. 2 %
53  **************  2. 3 %
54  ********************  3. 3 %
55  *****************  2. 8 %
56  *******************  3. 1 %
57  **************  2. 3 %
58  ******************  3 %
59  ****************  2. 6 %
60  ******************  3 %
61  ****************  2. 7 %
62  *************  2. 2 %
63  ************  1. 9 %
64  **********  1. 7 %
65  ******  0. 9 %
66  ***  0. 5 %
67  ********  1. 3 %
68  ***  0. 4 %
69  ***  0. 4 %
70  **  0. 3 %
71  ***  0. 5 %
72  *  0. 1 %
73  **  0. 3 %
74  *  0. 1 %
75  **  0. 3 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	40
90	42
85	43
80	44
75	45
70	45
65	46
60	46
55	47
50	49
45	50
40	51
35	53
30	55
25	56
20	58
15	60
10	62
5	64

EQUIVALENT SOUND LEVEL = 58.5 DB

Figure G-8. Background Ambient Sound Level Data.

FILE SEM001.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	52.5	55	55	52	48	47
63	49.8	53	51	49	47	47
125	45.4	48	46	42	39	39
250	34.6	39	38	33	30	30
500	37.1	40	37	33	30	30
1000	30.1	35	31	28	26	26
2000	39.9	42	41	41	35	35
4000	37.1	38	38	37	35	34
8000	35	37	36	35	33	32
A-WT.	44.7	46	46	45	42	41

FILE SEM001.DA
A-WT. SOUND LEVELS

Location: 1
Date: 11/17/77
Time: 1800

A-Weighted Sound Level - dB re 20μPa

```
40  **  1.3 %
41  ********  6.6 %
42  *****************  13.8 %
43  ********  6.1 %
44  *****************  13.8 %
45  **********************************************  37.9 %
46  *******************  15.7 %
47  ***  2.3 %
48  *  0.8 %
49  *  0.6 %
50  *  0.5 %
51  *  0.4 %
52  *  0.1 %
53  *  0.1 %
54  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 44.7 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	41
90	42
85	42
80	42
75	43
70	44
65	44
60	44
55	45
50	45
45	45
40	45
35	45
30	45
25	45
20	46
15	46
10	46
5	46

Figure G-9. Background Ambient Sound Level Data.

FILE SEMØØ2. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	53. 5	56	55	53	5Ø	5Ø
63	54. 5	59	57	52	5Ø	5Ø
125	55. 2	59	57	51	49	49
25Ø	46. 2	52	5Ø	43	4Ø	39
5ØØ	42. 7	47	45	4Ø	37	37
1ØØØ	43. 3	48	47	41	36	34
2ØØØ	41. 6	48	46	38	33	32
4ØØØ	36. 6	42	4Ø	34	28	27
8ØØØ	28. 2	33	31	25	24	24
A-WT.	49. 1	54	53	46	43	42

FILE SEMØØ2. DA
A-WT. SOUND LEVELS

Location: 2
Date: 11/17/77
Time: 1855

A-Weighted Sound Level - dB re: 20μPa

```
40  *  Ø. 1 %
41  *****  1. 6 %
42  **********************  7. 2 %
43  *****************************  9. 6 %
44  ***********************************  11. 4 %
45  ****************************************  13. 3 %
46  *************************************  12. 2 %
47  ***********************  7. 6 %
48  *******************  6. 1 %
49  ***************  4. 8 %
5Ø  **************  4. 6 %
51  ****************  5. 2 %
52  *************  4. 3 %
53  *************  4. 3 %
54  *********  3 %
55  *******  2. 3 %
56  *****  1. 4 %
57  **  Ø. 5 %
58  *  Ø. 3 %
59  *  Ø. 3 %
6Ø  *  Ø. 2 %
```

EQUIVALENT SOUND LEVEL = 49. 1 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	42
9Ø	43
85	43
8Ø	44
75	44
7Ø	45
65	45
6Ø	45
55	46
5Ø	46
45	46
4Ø	47
35	48
3Ø	49
25	5Ø
2Ø	51
15	52
1Ø	53
5	54

Figure G-10. Background Ambient Sound Level Data.

FILE SEM003.DA

OCTAVE BAND HZ.	LEQ DB	L_5	L_{10}	L_{50}	L_{90}	L_{95}
31.5	52	56	53	50	48	47
63	49.3	54	52	46	45	44
125	49.1	56	53	41	38	37
250	41.5	49	45	32	29	28
500	36.3	42	41	33	25	24
1000	40.1	47	45	35	24	24
2000	37.1	43	41	32	27	26
4000	32.9	36	34	31	30	30
8000	25.2	28	25	24	24	24
A-WT.	44.9	52	49	41	35	35

FILE SEM003.DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/17/77
Time: 1931

A-Weighted Sound Level - dB re 20 µPa

```
33  *  0.1 %
34  *******  1.8 %
35  *********************************************  11.1 %
36  ***********************************************  11.7 %
37  ***************************  6.6 %
38  ***********************  5.8 %
39  **********************  5.4 %
40  *******************  4.7 %
41  ***************************  6.8 %
42  **************************  6.5 %
43  ******************************  7.5 %
44  *********************  5.2 %
45  ***********************  5.8 %
46  ****************  4 %
47  *****************  4.1 %
48  *************  3.2 %
49  ***********  2.6 %
50  *****  1.1 %
51  ******  1.3 %
52  *********  2.1 %
53  *****  1.3 %
54  ***  0.6 %
55  ***  0.8 %
56  *  0.3 %
57  *  0.2 %
```

EQUIVALENT SOUND LEVEL = 44.9 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	35
90	35
85	36
80	36
75	37
70	37
65	38
60	39
55	40
50	41
45	42
40	42
35	43
30	44
25	45
20	46
15	47
10	49
5	52

Figure G-11. Background Ambient Sound Level Data.

FILE SEM004. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	49. 9	56	51	43	39	38
63	45. 3	51	47	39	36	35
125	38. 3	45	41	33	28	27
250	37. 8	47	40	28	21	20
500	42. 8	50	42	31	18	17
1000	36. 6	44	40	30	15	14
2000	31. 3	37	34	27	24	23
4000	23. 6	26	24	22	21	20
8000	20. 8	25	23	20	16	15
A-WT.	42. 9	50	44	35	29	29

FILE SEM004. DA
A-WT. SOUND LEVELS

A-Weighted Sound Level - dB re: 20 µPa

```
28  ************  2. 8 %
29  ******************************************  10. 7 %
30  ***********************************************  11. 8 %
31  ********************************  8 %
32  ********************  4. 9 %
33  *******************  4. 8 %
34  ****************  3. 9 %
35  *****************  4. 3 %
36  ******************  4. 4 %
37  *********************  5. 3 %
38  **********************  5. 4 %
39  ********************  4. 8 %
40  *****************  4. 3 %
41  ***********************  5. 6 %
42  *******************  4. 7 %
43  **********  2. 4 %
44  *********  2. 3 %
45  *****  1. 2 %
46  ***  0. 8 %
47  ***  0. 7 %
48  *****  1. 1 %
49  **  0. 4 %
50  ****  0. 8 %
51  *****  1. 1 %
52  ****  0. 9 %
53  *****  1. 1 %
54  **  0. 4 %
55  ***  0. 8 %
56  *  0. 2 %
57  *  0. 3 %
58  *  0. 1 %
59
60  *  0. 1 %
```

EQUIVALENT SOUND LEVEL = 42. 9 DB

Location: 4
Date: 11/17/77
Time: 2009

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	29
90	29
85	30
80	30
75	30
70	31
65	32
60	33
55	34
50	35
45	36
40	37
35	38
30	39
25	40
20	41
15	42
10	44
5	50

Figure G-12. Background Ambient Sound Level Data.

FILE SEM005.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	48.5	54	53	44	40	39
63	47.6	53	52	43	39	38
125	47.7	54	51	43	36	35
250	40.1	47	44	34	27	25
500	40.5	48	45	33	22	20
1000	38.7	46	43	34	23	21
2000	32.3	38	36	29	26	25
4000	23.2	27	25	21	20	20
8000	21.6	23	22	20	17	17
A-WT.	43.4	50	48	39	32	31

FILE SEM005.DA
A-WT. SOUND LEVELS

Location: 5
Date: 11/17/77
Time: 2054

A-Weighted Sound Level - dB re: 20 μPa

```
29  ** 0.3 %
30  ****************** 2.9 %
31  *************************** 4.5 %
32  ***************************** 4.8 %
33  **************************** 4.7 %
34  *************************** 4.5 %
35  ********************************** 5.7 %
36  ***************************************** 6.8 %
37  *************************************** 6.5 %
38  *********************************************** 7.8 %
39  ************************************************ 8 %
40  ******************************** 5.3 %
41  ************************************* 6.1 %
42  ******************************* 5.2 %
43  *************************** 4.4 %
44  *********************** 3.8 %
45  ****************** 2.9 %
46  ************* 2.2 %
47  ****************** 2.9 %
48  ************** 2.3 %
49  *********** 1.8 %
50  ************* 2.1 %
51  ************* 2.2 %
52  ******** 1.3 %
53  *** 0.4 %
54  ** 0.3 %
55
56  ** 0.3 %
```

EQUIVALENT SOUND LEVEL = 43.4 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	31
90	32
85	33
80	34
75	35
70	36
65	37
60	37
55	38
50	39
45	39
40	40
35	41
30	42
25	43
20	44
15	46
10	48
5	50

Figure G-13. Background Ambient Sound Level Data.

FILE SEM006. DA

OCTAVE BAND HZ.	LEQ DB	L_{5}	L_{10}	L_{50}	L_{90}	L_{95}
31. 5	50. 6	58	54	43	40	39
63	53. 5	57	54	45	42	42
125	53. 2	58	54	42	32	31
250	48. 9	53	49	34	25	25
500	47. 8	53	49	37	26	25
1000	51. 9	55	53	41	26	24
2000	46. 8	54	50	36	24	24
4000	37. 9	45	40	24	24	24
8000	32. 1	37	35	26	24	24.
A-WT.	55. 1	61	57	45	32	30

FILE SEM006. DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/17/77
Time: 2133

A-Weighted Sound Level - dB re: 20 μPa

```
26  *  0. 1 %
27  *********  1. 5 %
28  **  0. 3 %
29  ***********  1. 8 %
30  **************  2. 3 %
31  **************  2. 3 %
32  **************  2. 3 %
33  ****************  2. 7 %
34  *********************  3. 4 %
35  ******************  2. 9 %
36  ********************  3. 3 %
37  *****************  2. 8 %
38  *********************  3. 4 %
39  *********************  3. 5 %
40  **********************  3. 6 %
41  ************  1. 9 %
42  ******************  2. 9 %
43  ****************  2. 7 %
44  ***********************  3. 8 %
45  ************************  4 %
46  ****************************  4. 6 %
47  *******************************  5. 1 %
48  *************************  4. 2 %
49  ***********************  3. 8 %
50  ******************  3 %
51  ********************  3. 3 %
52  **********************  3. 6 %
53  **************  2. 3 %
54  ***************  2. 4 %
55  ***************  2. 5 %
56  ************  2 %
57  **************  2. 3 %
58  *******  1. 2 %
59  ***********  1. 8 %
60  ******  1 %
61  *********  1. 5 %
62  *******  1. 2 %
63  ****  0. 6 %
64  ****  0. 7 %
65  **  0. 3 %
66
67  *  0. 1 %
68  **  0. 3 %
69  *  0. 2 %
70  **  0. 3 %
71  *  0. 1 %
72  *  0. 1 %
73  *  0. 1 %
74
75  *  0. 2 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	30
90	32
85	34
80	36
75	37
70	39
65	40
60	42
55	44
50	45
45	46
40	47
35	48
30	50
25	51
20	53
15	55
10	57
5	61

EQUIVALENT SOUND LEVEL = 55. 1 DB

Figure G-14. Background Ambient Sound Level Data.

FILE SEM007. DA

OCTAVE BAND HZ.	LEQ DB	L_{5}	L_{10}	L_{50}	L_{90}	L_{95}
31. 5	53. 7	58	57	52	49	48
63	48. 7	51	50	48	46	46
125	43. 5	46	45	43	41	41
250	34	38	37	33	30	30
500	33. 7	40	37	30	27	27
1000	34. 1	42	35	30	29	29
2000	31. 7	36	32	30	29	29
4000	32. 7	34	33	33	32	30
8000	24. 4	25	25	24	23	23
A-WT.	40. 5	46	42	39	38	38

FILE SEM007. DA
A-WT. SOUND LEVELS

A-Weighted Sound Level - dB re 20µPa

```
37  *  0. 8 %
38  ***********************************************  38. 6 %
39  ***********************************************  38. 7 %
40  ***********  8. 8 %
41  ****  2. 9 %
42  *  0. 8 %
43  *  0. 8 %
44  **  1. 2 %
45  ***  2. 2 %
46  ***  2. 1 %
47  *  0. 8 %
48  **  1. 7 %
49  *  0. 5 %
50  *  0. 1 %
51  *  0. 1 %
52
53
54  *  0. 1 %
```

EQUIVALENT SOUND LEVEL = 40. 5 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	38
90	38
85	38
80	38
75	38
70	38
65	38
60	39
55	39
50	39
45	39
40	39
35	39
30	39
25	39
20	40
15	40
10	42
5	46

Location: 1
Date: 11/17/77
Time: 2227

Figure G-15. Background Ambient Sound Level Data.

FILE SEM008.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	58.4	62	61	58	53	52
63	54.8	57	56	53	51	51
125	55.5	59	55	51	48	48
250	46.9	52	48	42	40	39
500	42.1	45	43	39	36	35
1000	41.7	48	45	37	32	31
2000	40.7	47	44	32	27	26
4000	47.3	51	51	47	25	24
8000	27.4	31	29	25	24	24
A-WT.	51.8	56	54	51	43	42

FILE SEM008.DA
A-WT. SOUND LEVELS

Location: 2
Date: 11/17/77
Time: 2311

A-Weighted Sound Level - dB re: 20µPa

```
38  *  0.1 %
39  *  0.3 %
40  **  0.8 %
41  ****  1.5 %
42  *************  5.2 %
43  **************  5.7 %
44  ***********  4.3 %
45  ************  5 %
46  *********  3.5 %
47  *****************  6.8 %
48  ***************  5.9 %
49  *******  2.9 %
50  *******  2.7 %
51  ***************  6.2 %
52  *******************************************  17.3 %
53  *******************************************  17.3 %
54  *****************  6.8 %
55  ******  2.3 %
56  ****  1.5 %
57  ***  1.2 %
58  ***  1.3 %
59  *  0.3 %
60  **  0.5 %
61  *  0.2 %
62  *  0.3 %
63
64  *  0.1 %
65  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 51.8 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	42
90	43
85	44
80	45
75	46
70	47
65	48
60	49
55	51
50	51
45	52
40	52
35	52
30	53
25	53
20	53
15	53
10	54
5	56

Figure G-16. Background Ambient Sound Level Data.

FILE SEM009. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	48. 7	52	51	48	44	43
63	46. 3	50	48	45	42	42
125	43. 6	47	42	39	37	36
250	35. 9	40	35	30	28	27
500	34. 7	40	37	28	23	23
1000	34. 2	41	36	21	17	17
2000	30. 1	36	31	17	15	15
4000	23. 7	27	22	16	15	15
8000	20. 2	22	21	17	15	15
A-WT.	39	45	41	31	28	28

FILE SEM009. DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/17/77
Time: 2347

A-Weighted Sound Level - dB re: 20 μPa

27	*****	1. 9 %
28	**********************************	13. 7 %
29	*************************************	14. 8 %
30	******************	7. 3 %
31	***	18. 8 %
32	***********************	9. 3 %
33	***************	6 %
34	*********	3. 8 %
35	********	3. 2 %
36	******	2. 4 %
37	*******	2. 9 %
38	*****	2 %
39	******	2. 2 %
40	****	1. 6 %
41	***	1. 3 %
42	****	1. 3 %
43	***	1. 1 %
44	**	0. 8 %
45	***	1. 2 %
46	***	1. 2 %
47	**	0. 5 %
48	*	0. 3 %
49	**	0. 5 %
50	**	0. 7 %
51	*	0. 4 %
52	**	0. 5 %
53	*	0. 2 %
54	*	0. 2 %
55	*	0. 1 %
56		
57	*	0. 2 %

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	28
90	28
85	28
80	29
75	29
70	29
65	30
60	31
55	31
50	31
45	31
40	32
35	32
30	33
25	34
20	36
15	38
10	41
5	45

EQUIVALENT SOUND LEVEL = 39 DB

Figure G-17. Background Ambient Sound Level Data.

FILE SEM010.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	41	44	42	39	35	34
63	37.3	40	39	36	34	34
125	30.8	34	33	30	27	26
250	28.9	33	29	24	19	18
500	34.3	39	34	19	16	15
1000	30.7	37	32	14	14	14
2000	24.4	31	26	15	14	14
4000	18.1	20	19	17	16	16
8000	20.7	22	22	21	19	19
A-WT.	35.7	41	36	26	24	24

FILE SEM010.DA
A-WT. SOUND LEVELS

Location: 4
Date: 11/18/77
Time: 0024

A-Weighted Sound Level - dB re 20 μPa

```
23  ****  2.3 %
24  ************************  13.3 %
25  **************************************************  27.7 %
26  ****************************************  21.8 %
27  **********  5.8 %
28  *****  2.8 %
29  ****  1.8 %
30  ****  2.3 %
31  ****  2 %
32  ******  3.4 %
33  *****  2.4 %
34  ***  1.3 %
35  ****  1.9 %
36  **  1.2 %
37  **  1.2 %
38  **  1 %
39  **  1.1 %
40  **  0.9 %
41  **  1 %
42  **  1 %
43  **  0.9 %
44  *  0.4 %
45  **  0.7 %
46  *  0.3 %
47  *  0.3 %
48  *  0.2 %
49  *  0.1 %
50  *  0.1 %
51  *  0.2 %
52  *  0.5 %
53  *  0.2 %
54  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	24
90	24
85	24
80	25
75	25
70	25
65	25
60	25
55	26
50	26
45	26
40	26
35	26
30	27
25	29
20	32
15	33
10	36
5	41

EQUIVALENT SOUND LEVEL = 35.7 DB

Figure G-18. Background Ambient Sound Level Data.

FILE SEM011.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	39.7	45	44	37	33	33
63	39.1	44	43	37	35	34
125	36.9	42	41	34	30	30
250	29.2	33	32	27	26	25
500	27.8	34	33	20	16	15
1000	29.3	36	34	20	18	18
2000	24.9	31	29	20	18	18
4000	18.2	20	19	18	17	17
8000	20.8	22	22	21	20	20
A-WT.	33.6	40	38	29	27	27

FILE SEM011.DA
A-WT. SOUND LEVELS

A-Weighted Sound Level - dB re: 20 μPa

```
26  *******  3.9 %
27  ***************************************************  28.9 %
28  *********************  11.8 %
29  *************  7.4 %
30  *************  7.4 %
31  ***********  6.1 %
32  *********  5.2 %
33  ********  4.4 %
34  *******  4.1 %
35  ******  3.4 %
36  *****  2.5 %
37  ****  2.3 %
38  ********  4.5 %
39  ******  3 %
40  ***  1.6 %
41  ****  1.8 %
42  *  0.6 %
43  *  0.4 %
44  *  0.4 %
45  *  0.3 %
```

EQUIVALENT SOUND LEVEL = 33.6 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	27
90	27
85	27
80	27
75	27
70	27
65	28
60	28
55	29
50	29
45	30
40	31
35	31
30	32
25	33
20	35
15	36
10	38
5	40

Location: 5
Date: 11/18/77
Time: 0104

Figure G-19. Background Ambient Sound Level Data.

FILE SEM012. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	39. 2	43	41	37	34	33
63	43. 1	44	44	42	42	42
125	36. 9	36	34	31	29	29
250	32. 6	26	25	24	24	24
500	28. 6	27	26	25	24	24
1000	30. 4	30	26	24	24	24
2000	35	37	36	34	28	27
4000	28. 2	30	29	26	24	24
8000	24. 7	24	24	24	24	24
A-WT.	38. 8	40	39	36	31	30

FILE SEM012. DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/18/77
Time: 0139

A-Weighted Sound Level - dB re: 20µPa

```
28  ***  0. 8 %
29  ****  1. 3 %
30  ********************  6. 3 %
31  ********************************  10 %
32  ******************************  9. 3 %
33  ******************************  9. 2 %
34  ******  1. 9 %
35  *********  3 %
36  ********************************  9. 8 %
37  **********************************************  14. 7 %
38  *******************************************  13. 7 %
39  *****************************************  12. 8 %
40  ********  2. 5 %
41  *****  1. 5 %
42  ****  1. 1 %
43  *  0. 3 %
44  *  0. 1 %
45  *  0. 2 %
46  **  0. 4 %
47
48  *  0. 2 %
49  *  0. 1 %
50
51  *  0. 2 %
52  *  0. 1 %
53  *  0. 2 %
54
55  *  0. 1 %
56  *  0. 1 %
57  *  0. 1 %
58  *  0. 2 %
```

EQUIVALENT SOUND LEVEL = 38. 8 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	30
90	31
85	31
80	32
75	32
70	33
65	33
60	35
55	36
50	36
45	37
40	37
35	37
30	38
25	38
20	38
15	39
10	39
5	40

Figure G-20. Background Ambient Sound Level Data.

FILE SEM031.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	48.5	53	51	46	42	42
63	51	55	54	49	46	45
125	49	55	53	44	39	38
250	44.1	51	47	33	28	27
500	40.1	46	42	29	27	27
1000	36.3	42	40	31	30	29
2000	35.1	40	39	31	30	30
4000	32.5	38	36	26	25	25
8000	28.5	33	31	25	24	24
A-WT.	44.1	51	48	39	36	36

FILE SEM031.DA
A-WT. SOUND LEVELS

Location: 1
Date: 11/19/77
Time: 1053

A-Weighted Sound Level - dB re: 20 μPa

```
35  ***  1.5 %
36  ************************  11.2 %
37  ********************************************  21.1 %
38  *********************************  15.7 %
39  **********************  10.5 %
40  ****************  7.2 %
41  *********  4.3 %
42  ********  3.6 %
43  *******  3.2 %
44  *****  2.3 %
45  *******  3.2 %
46  *****  2.1 %
47  ********  3.6 %
48  *****  2.2 %
49  ****  1.8 %
50  ****  1.6 %
51  ****  1.7 %
52  ***  1.1 %
53  **  0.7 %
54  ***  1.1 %
55  *  0.3 %
56  *  0.1 %
57  *  0.3 %
58  *  0.2 %
```

EQUIVALENT SOUND LEVEL = 44.1 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	36
85	37
80	37
75	37
70	37
65	38
60	38
55	38
50	39
45	39
40	40
35	40
30	41
25	43
20	44
15	46
10	48
5	51

Figure G-21. Background Ambient Sound Level Data.

```
FILE SEM032.DA

OCTAVE BAND   LEQ      L       L       L       L       L
   HZ.        DB       5       10      50      90      95

   31.5       57.5     62      60      54      50      50
   63         58.7     64      62      56      54      53
   125        57.6     63      60      53      46      45
   250        54       56      54      45      39      38
   500        48.4     55      51      43      40      39
   1000       48.7     54      51      43      37      36
   2000       45.5     50      48      41      37      36
   4000       40.8     44      42      35      34      34
   8000       36       38      36      34      34      34
   A-WT.      53.7     59      56      49      44      43
```

```
FILE SEM032.DA
A-WT. SOUND LEVELS
```

Location: 2
Date: 11/19/77
Time: 1142

A-Weighted Sound Level - dB re 20 μPa

```
40 *** 0.8 %
41 ** 0.4 %
42 ****** 1.4 %
43 ***************** 4.3 %
44 ************************* 6.3 %
45 ************************************ 9 %
46 **************************************** 10 %
47 *************************************** 9.8 %
48 *************************** 6.8 %
49 ************************* 6.2 %
50 *********************** 5.8 %
51 ***************************** 7.3 %
52 *************************** 6.7 %
53 *********************** 5.8 %
54 ******************* 4.8 %
55 *************** 3.8 %
56 ************* 3.3 %
57 ***** 1.2 %
58 ******* 1.6 %
59 ***** 1.1 %
60 **** 0.8 %
61 **** 1 %
62 *** 0.7 %
63 ** 0.5 %
64 * 0.2 %
65 * 0.3 %
66 * 0.2 %
67 * 0.2 %
68
69 * 0.1 %
70 * 0.1 %
71
72 * 0.1 %
73 * 0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	43
90	44
85	45
80	45
75	46
70	46
65	47
60	47
55	48
50	49
45	50
40	50
35	51
30	52
25	53
20	53
15	54
10	56
5	59

EQUIVALENT SOUND LEVEL = 53.7 DB

Figure G-22. Background Ambient Sound Level Data.

FILE SEM033.DA

OCTAVE BAND HZ.	LEQ DB	L_5	L_{10}	L_{50}	L_{90}	L_{95}
31.5	59.4	66	63	52	45	44
63	56.1	60	58	54	52	52
125	56.6	62	57	48	44	43
250	47.9	52	48	38	35	35
500	41.1	47	44	36	34	34
1000	41	47	45	35	34	34
2000	38.2	44	41	34	34	34
4000	35.5	39	36	34	34	34
8000	34.4	36	35	34	34	34
A-WT.	47.3	53	50	42	37	36

FILE SEM033.DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/19/77
Time: 1216

A-Weighted Sound Level - dB re: 20 μPa

```
34  *  0.2 %
35  ***************  3.1 %
36  ***********************  4.9 %
37  *****************************  6.5 %
38  ***********************************  8 %
39  *************************************  8.2 %
40  *****************************************  9 %
41  *************************************  8.1 %
42  ***********************************  7.8 %
43  *********************************  7.2 %
44  *****************************  6.1 %
45  ************************  5.3 %
46  ************************  5.3 %
47  ***************  3.3 %
48  *************  2.8 %
49  *************  2.8 %
50  **********  2.1 %
51  **********  2.2 %
52  *********  1.8 %
53  ******  1.2 %
54  *****  0.8 %
55  *****  1 %
56  **  0.3 %
57  ***  0.7 %
58  **  0.4 %
59  ***  0.7 %
60  *  0.2 %
61  **  0.3 %
62  *  0.1 %
63  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 47.3 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	37
85	38
80	38
75	39
70	39
65	40
60	41
55	41
50	42
45	42
40	43
35	44
30	45
25	46
20	47
15	48
10	50
5	53

Figure G-23. Background Ambient Sound Level Data.

FILE SEM036.DA

OCTAVE BAND HZ.	LEQ DB	L_{5}	L_{10}	L_{50}	L_{90}	L_{95}
31.5	63.2	70	66	57	52	50
63	56.6	61	59	55	53	53
125	48.6	53	52	47	43	43
250	40.3	46	44	36	34	34
500	35.9	38	37	35	34	34
1000	34.5	36	35	34	34	34
2000	34.1	35	34	34	34	34
4000	36.8	39	38	37	34	34
8000	34.4	35	35	34	34	34
A-WT.	42.1	45	44	41	40	39

FILE SEM036.DA
A-WT. SOUND LEVELS

Location: 4
Date: 11/19/77
Time: 1403

A-Weighted Sound Level - dB re: 20μPa

```
37  *  0.3 %
38  ****  1.8 %
39  ************  6.6 %
40  ******************************  17.2 %
41  *********************************************  26.3 %
42  **************************************  22.2 %
43  *********************  12.1 %
44  **********  5.8 %
45  *******  4.1 %
46  ****  1.9 %
47  **  0.9 %
48  *  0.6 %
49  *  0.3 %
50  *  0.1 %
51  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 42.1 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	39
90	40
85	40
80	40
75	40
70	41
65	41
60	41
55	41
50	41
45	42
40	42
35	42
30	42
25	43
20	43
15	43
10	44
5	45

Figure G-24. Background Ambient Sound Level Data.

FILE SEM035.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	61.2	68	65	55	50	49
63	56.8	61	59	55	53	53
125	54.8	60	58	51	47	45
250	47.6	53	51	44	37	36
500	45.7	48	45	38	35	34
1000	40.7	45	42	36	34	34
2000	43.6	45	41	34	34	34
4000	36.3	38	36	34	34	34
8000	34.1	34	34	34	34	34
A--WT.	52.2	52	50	44	40	39

FILE SEM035.DA
A-WT. SOUND LEVELS

Location: 5
Date: 11/19/77
Time: 1329

A-Weighted Sound Level - dB re: 20µPa

```
38  ******  1.8 %
39  ************  3.4 %
40  ******************  5.4 %
41  *************************  7.7 %
42  *********************************  10.2 %
43  *******************************************  13.2 %
44  *************************************  11.1 %
45  *****************************  8.8 %
46  ********************************  9.7 %
47  ***********************  6.8 %
48  ***************  4.6 %
49  ****************  4.9 %
50  ************  3.6 %
51  *******  2.3 %
52  *****  1.7 %
53  ****  1.3 %
54  **  0.6 %
55  **  0.6 %
56  **  0.5 %
57  *  0.3 %
58
59  *  0.1 %
60  *  0.1 %
61  *  0.2 %
62
63
64  *  0.2 %
65  *  0.3 %
66
67  *  0.2 %
68  *  0.2 %
69  *  0.2 %
70  *  0.1 %
71  *  0.1 %
72
73  *  0.2 %
74  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	39
90	40
85	41
80	42
75	42
70	43
65	43
60	43
55	44
50	44
45	45
40	45
35	46
30	46
25	47
20	48
15	49
10	50
5	52

EQUIVALENT SOUND LEVEL = 52.2 DB

Figure G-25. Background Ambient Sound Level Data.

FILE SEM034.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	64.3	70	68	60	52	50
63	58.9	64	62	56	54	53
125	59.9	65	62	54	47	46
250	53.4	58	55	46	39	37
500	48.6	53	51	43	38	37
1000	50.1	55	54	46	40	38
2000	47.8	54	52	43	36	35
4000	45.5	49	47	42	38	36
8000	39.9	43	41	38	37	36
A-WT.	55.7	61	59	52	47	46

FILE SEM034.DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/19/77
Time: 1249

A-Weighted Sound Level - dB re 20 µPa

```
43  **  0.5 %
44  ****  0.8 %
45  *******  1.8 %
46  ******************  4.3 %
47  ********************  5 %
48  ***********************  5.8 %
49  ***************************************  9.4 %
50  ******************************************  10.3 %
51  ********************************************  10.6 %
52  *************************************  9 %
53  **********************************  8.1 %
54  **************************  6.1 %
55  *******************  4.7 %
56  ********************  4.8 %
57  ****************  4 %
58  ***************  3.6 %
59  ************  2.8 %
60  *************  3.2 %
61  *******  1.7 %
62  ********  2 %
63  *  0.3 %
64  **  0.4 %
65  *  0.2 %
66  *  0.1 %
67  *  0.1 %
68  *  0.1 %
69  *  0.2 %
70  *  0.3 %
71
72
73  *  0.2 %
```

EQUIVALENT SOUND LEVEL = 55.7 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	46
90	47
85	48
80	49
75	49
70	50
65	50
60	51
55	51
50	52
45	52
40	53
35	53
30	54
25	55
20	56
15	57
10	59
5	61

Figure G-26. Background Ambient Sound Level Data.

FILE SEM019.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	49.4	56	53	46	43	42
63	47.9	54	52	45	41	41
125	49	54	52	41	37	36
250	42	49	46	30	25	24
500	32.5	37	34	28	26	25
1000	31.4	33	32	31	30	30
2000	33.6	32	31	30	29	29
4000	35.4	32	32	27	24	24
8000	23.6	22	21	19	18	17
A-WT.	42.3	45	43	37	36	36

FILE SEM019.DA
A-WT. SOUND LEVELS

Location: 1
Date: 11/18/77
Time: 1800

A-Weighted Sound Level - dB re: 20 µPa

```
35  *****  2.8 %
36  ******************************  18.2 %
37  *************************************************  30.2 %
38  ************************************  22.5 %
39  ***********  6.1 %
40  *****  2.8 %
41  *****  3.2 %
42  ******  3.6 %
43  ****  2.6 %
44  ****  2.3 %
45  ***  1.7 %
46  **  0.8 %
47  **  0.8 %
48  *  0.4 %
49  *  0.4 %
50  *  0.3 %
51  *  0.3 %
52  *  0.5 %
53  *  0.5 %
54
55
56
57
58
59
60
61  *  0.1 %
62  *  0.1 %
63  *  0.1 %
64  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	36
85	36
80	36
75	37
70	37
65	37
60	37
55	37
50	37
45	38
40	38
35	38
30	38
25	39
20	40
15	41
10	43
5	45

EQUIVALENT SOUND LEVEL = 42.3 DB

Figure G-27. Background Ambient Sound Level Data.

FILE SEM020.DA

OCTAVE BAND HZ.	LEQ DB	L_{5}	L_{10}	L_{50}	L_{90}	L_{95}
31.5	53.8	58	57	51	48	47
63	60.1	66	63	53	48	47
125	59.8	66	63	52	44	43
250	50.5	56	54	42	36	34
500	42.8	48	46	40	35	34
1000	46	51	50	43	36	34
2000	44.7	50	49	39	31	29
4000	37.2	43	41	30	24	24
8000	29.6	32	31	29	26	24
A-WT.	52.2	58	56	48	41	40

FILE SEM020.DA
A-WT. SOUND LEVELS

Location: 2
Date: 11/18/77
Time: 1845

A-Weighted Sound Level - dB re: 20µPa

```
37  **  0.3 %
38  *****  0.8 %
39  ****************  2.6 %
40  **********************  3.6 %
41  **********************************  5.6 %
42  **************************************  6.3 %
43  ***********************  3.8 %
44  *********************************  5.5 %
45  **************************************  6.3 %
46  ****************************************  6.6 %
47  ****************************************  6.6 %
48  **************************************  6.3 %
49  ************************************  5.9 %
50  **********************  3.7 %
51  ****************************  4.6 %
52  *****************************  4.8 %
53  *****************************************  6.8 %
54  ********************  3.3 %
55  **************************  4.3 %
56  **************************  4.3 %
57  ****************  2.7 %
58  **************  2.3 %
59  ******  1 %
60  ****  0.7 %
61  *****  0.8 %
62  ***  0.4 %
63  **  0.3 %
64  **  0.3 %
65  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 52.2 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	40
90	41
85	42
80	43
75	44
70	45
65	46
60	46
55	47
50	48
45	49
40	49
35	51
30	52
25	53
20	54
15	55
10	56
5	58

Figure G-28. Background Ambient Sound Level Data.

FILE SEM021.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	49.6	54	52	48	45	44
63	52.2	56	53	47	45	44
125	50.8	57	53	41	37	36
250	41.1	48	44	33	30	29
500	39.4	45	43	36	29	27
1000	40.9	48	45	35	26	25
2000	37.2	44	40	29	24	24
4000	30.2	36	32	24	24	24
8000	25.2	28	25	24	24	24
A-WT.	45.6	52	49	40	32	32

FILE SEM021.DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/18/77
Time: 1925

A-Weighted Sound Level - dB re 20µPa

```
30 *****  0.8 %
31 *********************  3.4 %
32 *************************************  6.1 %
33 ************************************  5.9 %
34 ******************************  5 %
35 ***************************  4.5 %
36 ***********************************  5.8 %
37 ************************  4 %
38 ***********************************  5.8 %
39 ************************************  5.9 %
40 *******************************  5.2 %
41 *************************************  6.1 %
42 **************************************  6.3 %
43 ****************************  4.7 %
44 *********************************  5.5 %
45 **********************  3.6 %
46 *********************  3.5 %
47 *********************  3.4 %
48 *******************  3.2 %
49 **************  2.3 %
50 ********  1.3 %
51 ********  1.3 %
52 ***********  1.8 %
53 ******  1 %
54 ******  1 %
55 *******  1.1 %
56 *****  0.8 %
57 ***  0.5 %
58 **  0.3 %
59 *  0.1 %
```

EQUIVALENT SOUND LEVEL = 45.6 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	32
90	32
85	33
80	34
75	35
70	36
65	37
60	38
55	39
50	40
45	41
40	42
35	43
30	44
25	45
20	46
15	47
10	49
5	52

Figure G-29. Background Ambient Sound Level Data.

FILE SEM024.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	49.9	55	52	47	43	42
63	50.3	54	53	47	41	40
125	50.8	55	54	46	38	36
250	43.2	49	47	38	31	30
500	42	48	45	38	31	30
1000	41.3	47	45	38	32	30
2000	40.2	42	40	32	27	26
4000	34.7	35	32	21	16	16
8000	24.4	25	22	18	15	15
A-WT.	47.2	52	50	43	38	36

FILE SEM024.DA
A-WT. SOUND LEVELS

Location: 5
Date: 11/18/77
Time: 2105

A-Weighted Sound Level - dB re: 20 μPa

```
32  *  0.2 %
33  ***  0.6 %
34  ****  1 %
35  *******  1.8 %
36  ************  3 %
37  ************  3 %
38  **************  3.5 %
39  *****************  4.3 %
40  ****************************  6.9 %
41  *************************************  9.1 %
42  **********************************  8.3 %
43  **************************************  9.4 %
44  ***********************************  8.7 %
45  *******************************  7.6 %
46  ***************************  6.7 %
47  *************************  6.3 %
48  **********************  5.4 %
49  *****************  4.2 %
50  *************  3.2 %
51  ********  2 %
52  *****  1.3 %
53  ******  1.3 %
54  ***  0.7 %
55  ***  0.8 %
56  *  0.2 %
57  **  0.3 %
58  *  0.3 %
59  *  0.2 %
60
61
62
63
64  *  0.1 %
65
66
67
68
69
70  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	36
90	38
85	39
80	40
75	41
70	41
65	42
60	42
55	43
50	43
45	44
40	45
35	45
30	46
25	47
20	47
15	48
10	50
5	52

EQUIVALENT SOUND LEVEL = 47.2 DB

Figure G-30. Background Ambient Sound Level Data.

FILE SEM022.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	52.9	57	54	45	42	41
63	54.1	59	56	45	43	42
125	58.9	64	59	45	34	32
250	49.9	55	51	35	25	24
500	48.7	53	51	40	28	26
1000	51.4	57	55	43	29	24
2000	48.7	55	53	38	25	24
4000	41.1	47	45	24	24	24
8000	33.2	38	35	25	24	24
A-WT.	56	62	60	46	33	28

FILE SEM022.DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/18/77
Time: 2000

A-Weighted Sound Level - dB re: 20 μPa

```
26  ****  0.6 %
27  ***************  2.5 %
28  ***************  2.4 %
29  ****  0.6 %
30  ***  0.4 %
31  *******  1.2 %
32  *********  1.5 %
33  *************  2.2 %
34  ***************  2.5 %
35  *************  2.1 %
36  *************  2.2 %
37  ************  2 %
38  ****************  2.6 %
39  *******************  3.2 %
40  ****************  2.6 %
41  *************  2.2 %
42  *********************  3.6 %
43  *****************  2.8 %
44  *************************  4.3 %
45  ******************************  5.1 %
46  ************************  4.2 %
47  **********************  3.8 %
48  ******************  2.9 %
49  *****************  2.8 %
50  *******************  3.1 %
51  ************************  4.1 %
52  **********************  3.8 %
53  ******************  3 %
54  ******************  2.9 %
55  ****************  2.6 %
56  **************  2.3 %
57  *************  2.1 %
58  *******************  3.2 %
59  ****************  2.7 %
60  ***************  2.5 %
61  ***********  1.8 %
62  **********  1.7 %
63  *****  0.8 %
64  *********  1.4 %
65  ***  0.4 %
66  *  0.2 %
67  **  0.3 %
68  *  0.2 %
69  *  0.2 %
70  *  0.1 %
71  *  0.2 %
72  *  0.2 %
73  **  0.3 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	28
90	33
85	35
80	37
75	39
70	41
65	43
60	44
55	45
50	46
45	48
40	49
35	51
30	52
25	54
20	56
15	58
10	60
5	62

EQUIVALENT SOUND LEVEL = 56 DB

Figure G-31. Background Ambient Sound Level Data.

FILE SEM025. DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31. 5	45. 6	49	48	45	41	41
63	43. 6	48	47	42	37	36
125	44. 2	51	48	39	33	32
250	36. 8	43	41	33	24	22
500	32. 7	38	35	27	25	24
1000	29. 5	31	29	27	26	26
2000	27. 8	29	28	27	26	26
4000	23. 6	25	24	23	22	22
8000	19. 5	21	21	19	18	17
A-WT.	37. 1	41	40	35	33	33

FILE SEM025. DA
A-WT. SOUND LEVELS

A-Weighted Sound Level - dB re: 20µPa

```
32  *****  2. 8 %
33  *****************************  16. 4 %
34  *********************************************  26 %
35  ******************************  17. 3 %
36  ***************  8. 6 %
37  *************  7. 3 %
38  ************  6. 6 %
39  *********  4. 8 %
40  *****  2. 5 %
41  ******  3. 5 %
42  ****  1. 9 %
43  **  0. 8 %
44  **  0. 8 %
45  *  0. 5 %
46  *  0. 1 %
47
48  *  0. 1 %
49
50
51
52  *  0. 1 %
53  *  0. 2 %
```

EQUIVALENT SOUND LEVEL = 37. 1 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	33
90	33
85	33
80	34
75	34
70	34
65	34
60	34
55	34
50	35
45	35
40	35
35	36
30	36
25	37
20	38
15	39
10	40
5	41

Location: 1
Date: 11/18/77
Time: 2238

Figure G-32. Background Ambient Sound Level Data.

FILE SEM026.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	48.4	52	51	48	44	43
63	50.5	53	52	49	46	46
125	48.7	55	52	45	42	42
250	43.1	49	46	37	34	33
500	38.9	44	42	35	31	31
1000	41.2	48	46	35	29	29
2000	39.4	47	45	29	25	25
4000	31.6	39	35	24	24	24
8000	24.9	28	25	24	24	24
A-WT.	46.3	53	51	40	36	35

FILE SEM026.DA
A-WT. SOUND LEVELS

Location: 2
Date: 11/18/77
Time: 2326

A-Weighted Sound Level - dB re: 20 µPa

```
34 *********  1.8 %
35 **************************  5.5 %
36 *******************************************************  11.6 %
37 ******************************************************  11.3 %
38 ******************************************  8.8 %
39 *****************************************  8.6 %
40 ***********************************  7.4 %
41 *********************  4.5 %
42 *************************  5.3 %
43 ******************  3.9 %
44 ****************  3.4 %
45 ***************  3.2 %
46 *********  1.9 %
47 ***********  2.4 %
48 ***********  2.4 %
49 ****************  3.3 %
50 ***********  2.3 %
51 ****************  3.3 %
52 **************  2.9 %
53 **********  2.1 %
54 *********  1.9 %
55 ****  1 %
56 **  0.5 %
57 **  0.3 %
58 *  0.1 %
59
60 *  0.1 %
61 *  0.1 %
```

EQUIVALENT SOUND LEVEL = 46.3 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	35
90	36
85	36
80	37
75	37
70	37
65	38
60	39
55	39
50	40
45	40
40	42
35	43
30	44
25	45
20	48
15	49
10	51
5	53

Figure G-33. Background Ambient Sound Level Data.

FILE SEM027.DA

OCTAVE BAND HZ.	LEQ DB	L_5	L_{10}	L_{50}	L_{90}	L_{95}
31.5	43.9	47	44	39	37	36
63	47.3	55	52	38	36	35
125	45.2	52	48	37	33	32
250	36.5	42	37	29	23	22
500	33.4	40	37	28	21	20
1000	34.8	41	37	27	19	18
2000	30.7	37	34	19	15	15
4000	25.1	32	27	14	14	14
8000	19.5	24	20	16	15	14
A-WT.	39.6	45	43	32	26	25

FILE SEM027.DA
A-WT. SOUND LEVELS

Location: 3
Date: 11/19/77
Time: 0002

A-Weighted Sound Level - dB re 20μPa

```
23  *  0.1 %
24  **************  3.3 %
25  ******************  4.5 %
26  *************  3.2 %
27  *********************  5.1 %
28  **********************************  8.4 %
29  *********************************  8.2 %
30  ***************************  6.8 %
31  *************************  6.1 %
32  *********************************  8.3 %
33  *******************************  7.6 %
34  ***************************  6.7 %
35  ***************  3.7 %
36  *************  3.2 %
37  **************  3.3 %
38  *********  2.3 %
39  ********  2 %
40  *******  1.7 %
41  *********  2.2 %
42  **********  2.5 %
43  ********  2 %
44  ***********  2.6 %
45  *******  1.7 %
46  ***  0.6 %
47  ****  1 %
48  ***  0.8 %
49  *  0.3 %
50  ***  0.6 %
51  ****  0.8 %
52  **  0.3 %
53  *  0.1 %
54  **  0.3 %
55
56  *  0.1 %
57  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	25
90	26
85	27
80	28
75	29
70	29
65	30
60	31
55	31
50	32
45	33
40	33
35	34
30	35
25	37
20	38
15	41
10	43
5	45

EQUIVALENT SOUND LEVEL = 39.6 DB

Figure G-34. Background Ambient Sound Level Data.

FILE SEM030.DA

OCTAVE BAND HZ.	LEQ DB	L 5	L 10	L 50	L 90	L 95
31.5	44.5	48	44	41	39	38
63	39.3	44	42	37	35	34
125	40	46	41	34	31	31
250	33.1	40	37	26	24	24
500	33.5	40	37	22	16	16
1000	33.6	40	37	24	17	17
2000	28.7	35	32	18	16	16
4000	16.1	20	17	14	14	14
8000	21.4	26	25	20	17	16
A-WT.	37.8	44	41	30	25	25

FILE SEM030.DA
A-WT. SOUND LEVELS

Location: 5
Date: 11/19/77
Time: 0150

A-Weighted Sound Level - dB re: 20 µPa

```
24  *  0.4 %
25  ****************************************  16.4 %
26  *********************************************  18.8 %
27  ****************  6.7 %
28  **********  4.2 %
29  *******  2.9 %
30  *********  3.7 %
31  ***********  4.3 %
32  *********  3.7 %
33  ********  3.3 %
34  **************  5.6 %
35  ***********  4.3 %
36  **********  3.9 %
37  ********  3 %
38  *******  2.9 %
39  *******  2.8 %
40  *****  1.8 %
41  ******  2.4 %
42  ****  1.7 %
43  ***  1.3 %
44  ****  1.5 %
45  ****  1.4 %
46  **  0.8 %
47  **  0.6 %
48  *  0.4 %
49  **  0.7 %
50  *  0.2 %
51  *  0.1 %
52  *  0.2 %
53  *  0.3 %
54
55
56  *  0.1 %
```

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	25
90	25
85	25
80	26
75	26
70	26
65	26
60	27
55	28
50	30
45	31
40	32
35	34
30	35
25	36
20	37
15	39
10	41
5	44

EQUIVALENT SOUND LEVEL = 37.8 DB

Figure G-35. Background Ambient Sound Level Data.

FILE SEM028. DA

OCTAVE BAND HZ.	LEQ DB	L_5	L_{10}	L_{50}	L_{90}	L_{95}
31.5	48.5	54	51	42	37	37
63	51.7	57	54	44	42	42
125	57.1	62	58	43	34	33
250	48.8	54	48	36	25	24
500	45.3	50	48	38	25	24
1000	48.7	55	53	43	24	24
2000	46.9	53	51	38	24	24
4000	39.9	47	43	24	24	24
8000	31.8	39	34	24	24	24
A-WT.	53.8	60	58	46	27	26

FILE SEM028. DA
A-WT. SOUND LEVELS

Location: 6
Date: 11/19/77
Time: 0037

A-Weighted Sound Level - dB re 20µPa

```
24  *  0.1 %
25  *********************  3.4 %
26  **************************  4.3 %
27  ******************  2.9 %
28  *************  2.2 %
29  *************  2.1 %
30  *******  1.1 %
31  ******  1 %
32  ******  0.9 %
33  ********  1.3 %
34  *******  1.1 %
35  *****  0.8 %
36  ****  0.6 %
37  ******  1 %
38  ************  2 %
39  ****************  2.7 %
40  ********************  3.3 %
41  *****************  2.8 %
42  **********************  3.7 %
43  ****************  2.6 %
44  *******************  3.1 %
45  ****************************  4.6 %
46  *****************************  4.8 %
47  ***********************  3.8 %
48  ********************  3.3 %
49  *********************  3.5 %
50  **********************  3.7 %
51  ****************************  4.7 %
52  ***********************  3.8 %
53  ************************  4 %
54  ******************  3 %
55  *******************  3.2 %
56  ****************  2.6 %
57  ***********  1.8 %
58  ****************  2.6 %
59  **********  1.7 %
60  *********  1.4 %
61  ******  0.9 %
62  ********  1.3 %
63  ****  0.7 %
64  ******  0.9 %
65  *  0.2 %
66  **  0.3 %
67  *  0.1 %
68  *  0.2 %
69  *  0.2 %
70  *  0.1 %
```

EQUIVALENT SOUND LEVEL = 53.8 DB

CUMULATIVE DISTRIBUTION

(%) EXCEEDED	SOUND PRESSURE LEVEL-DB
95	26
90	27
85	29
80	34
75	39
70	40
65	42
60	44
55	45
50	46
45	47
40	49
35	50
30	51
25	52
20	54
15	55
10	58
5	60

Figure G-36. Background Ambient Sound Level Data.

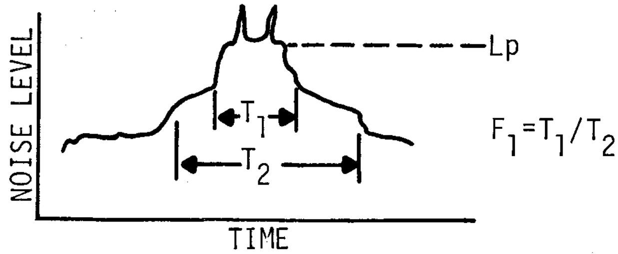
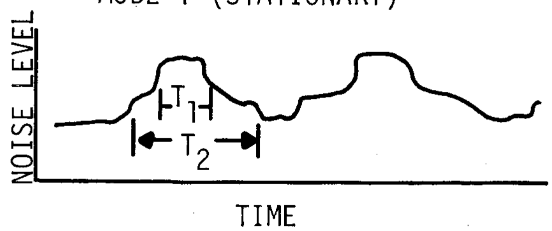
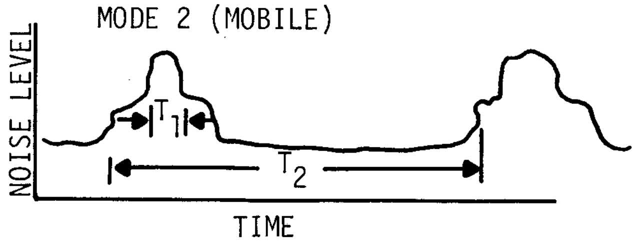


Figure G-37 Operating Factor-Time History
Construction Equipment

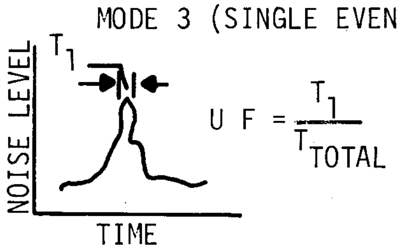
MODE 1 (STATIONARY)



MODE 2 (MOBILE)



MODE 3 (SINGLE EVENT)



Operating Factor $F_1 = T_1/T_2$

Utilization Factor $F_2 = T_2/T_{Total}$

T_{Total} might be construction duration (an 8-hour day)

Figure G-38. Usage Factor - Examples of Time Histories.

APPENDIX H

SOCIOECONOMICS

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SOCIOECONOMICS

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APPENDIX H

SOCIOECONOMICS

H.1 ECONOMIC BASE ANALYSIS METHODOLOGY

Perhaps the most widely used measure of the basic and non-basic sectors is the location quotient. The underlying notion of location quotients is that if a given community is highly specialized relative to the nation as a whole in the production of a particular commodity, then the product is presumed to be an export item produced by the basic sector. The key assumption underlying such analysis is that demand patterns for the local residents are the same as the national demand patterns. In the aggregate, this assumption appears to be reasonable.

Table H-1 was constructed by utilizing the location quotient methodology. The column entitled "Basic Putnam Employment" identifies what industries are most important in the economy of Putnam County. Whenever a positive entry appears in this column, it indicates that the given sector is basic in the Putnam County economy. A negative entry in this column signifies the degree to which Putnam County has to import the product of the given sector in order to satisfy its non-basic demand. For example, basic Putnam wage and salary employment in the agricultural sector was 576 in 1974 (Table H-1). This indicates that 576 wage and salary agricultural employees were involved in producing agricultural commodities for the export market. Non-basic employment in this sector totaled 167 employees, who were theoretically involved in producing agricultural commodities for the local demands of Putnam County. Summing up the basic and non-basic employment in this sector gives a total of 743 workers (Table H-1).

In the finance, insurance, and real estate sector, actual total Putnam County employment in 1974 was 297 (Table H-1)). The number 592 in the "Non-Basic Putnam Employment" column indicates the number of employees that Putnam County would have to have in this sector in order to satisfy local, or non-basic demand, assuming that Putnam County's demand for these types of services are similar to national demand patterns. Obviously, Putnam County does not employ 592 employees in this sector since actual employment is only 297. Therefore, the entry of -295 in the "Basic Putnam Employment" column represents the quantity of services imported by Putnam County, measured in terms of employees, to satisfy its local demands for finance, insurance, and real estate services. The essence of this analysis so far, therefore, is that Putnam County is strong in the agricultural sector and weak in the finance, insurance, and real estate sector.

H.2 EMPLOYMENT PROJECTIONS

It must be stressed that these projections reflect only one possible scenario for growth in Putnam County. In the view of the Jacksonville Area Planning Board, these projections represent the most probable case. Nevertheless, different sets of assumptions will lead to different projections. For the purposes of this impact report, the goal is not to formulate a "definitive" set of baseline projections, but rather to present a set of reasonable baseline projections that can then be used as a guide in determining the impact of the proposed project. It is the difference between the baseline and impact projections that is of primary interest, as opposed to a choice of a specific set of baseline projections.

One additional comment is in order concerning the interpretaton of these employment projections. In making projections, the confidence interval on any given point estimate becomes larger as the projection moves onward in time. The projection of 15,610 for total employment in 1980 from Table 2.10-6 should perhaps be interpreted as 15,610 plus or minus 20 percent with 80 percent confidence. When projecting to the year 2000, however, uncertainty increases and the number of possible scenarios expands rapidly. Therefore, the point estimate of 20,347 for the year 2000 for Putnam County total employment should perhaps be interpreted as 20,347 plus or minus 40 percent with 60 percent confidence. The specific choice of a confidence interval and significance level is a function of the projection methodology utilized. The confidence intervals and significance levels used in the preceding example are for illustrative purposes only and in no way indicate what the actual confidence and significance parameters should be.

H.3 METHODOLOGY FOR ESTIMATING COMMUTER COMPOSITION OF SEMINOLE CONSTRUCTION LABOR FORCE

The following assumptions were used in the preparation of Table 6.2-2 Commuter Composition of Seminole Construction Labor Force:

Manual Labor

Based on personal interviews with Florida construction officials that:

1) 85 percent of the manual labor force will be commuters, primarily from the Jacksonville area;

2) 5 percent of the manual labor force will be relocaters;

3) 10 percent of the manual labor force will be local residents.

Supervisory Labor

Based on personal interviews with Florida construction officials that:

1) 75 percent of the supervisory labor force will be commuters;

2) 20 percent of the supervisory labor force will be relocaters;

3) 5 percent of the supervisory labor force will be local residents.

H.4 METHODOLOGY FOR ESTIMATING DEMOGRAPHIC IMPACTS

The methodology used in producing the Seminole Project Population Projects of Table 6.2-5 assumes that the primary cause of population change in Putnam County will be the influx of construction workers and operation phase employees who relocate to Putnam County. Table H-5 illustrates this methodology in more detail.

The data in the second column of Table H-5, Incremental Construction Phase Relocaters, are derived from the data in the next to last column of Table 6.2-2 that represent the aggregate number of construction phase temporary residents in any given year. The data in Column 2 of Table H-5, however, represents the incremental number of construction phase Relocaters in any given year. As an example, the incremental number for 1980 (14) equals the aggregate number for 1980 (19) minus the aggregate number for 1979 (5).

The data in the third column of Table H-5, Incremental Operation Phase Relocaters, is derived from the data in Column 2 of Table 6.2-4, Number of Employees. Once again, the data in Column 3 of Table H-5 is incremental, while the data in Column 2, Table 6.2-4, is aggregate in nature. In making the derivations from aggregate data to incremental data, it was assumed that 50 per cent of the operation phase labor would be relocaters. It was also assumed that the Seminole project would have a 30-year life, that construction phase relocaters would leave Putnam County after construction has been completed, and that operation phase relocaters would remain in Putnam County when the power station is retired.

The data in Column 4 of Table H-5, Incremental Total Relocaters, is simply the sum of incremental construction phase and incremental operation phase Relocaters. In the notation of Table H-5,

$$C_t = A_t + B_t$$

where

C_t = incremental total relocaters in year t

A_t = incremental construction phase temporary residents in year t, and

B_t = incremental operation phase temporary residents in year t.

Column 5 of H-5 gives data for the number of incremental total relocaters plus family members. This data can also be interpreted as the direct population increase in Putnam County due to the Seminole project. In calculating the direct population increase, D_t, it was assumed that each relocating worker is a member of a household with an average size of 3 persons. (U.S. Dept. of Commerce, 1974, Statistical Abstract of the U.S., page xiii.) In the notation of Table H-5,

$$D_t = 3.0\ (C_t)$$

where

D_t = direct population increase in year t,

C_t = incremental total temporary residents in year t, and

3.0 = the average family size per relocater.

There will also be an indirect population increase associated with the Seminole project. The indirect population increase represents those individuals and their families who will move into Putnam County to provide support services for the families directly associated with the Seminole project. This direct plus indirect population increase is represented by the data in column six of Table H-5. This direct plus indirect population increase is also known as "Incremental Population Change Due to the Seminole Project", as illustrated in Column 3 of Table 6.2-5.

In calculating this incremental population change due to the Seminole project, a demographic multiplier of 2.5 was used to reflect the indirect population changes. This multiplier was obtained by using gross output multipliers for the heavy construction industry (to represent the construction phase) and the utility industry (to represent the operation phase). In calculating a value for the demographic multiplier, it was assumed that a direct relationship exists between demographic changes and gross output changes. Thus, it appears reasonable to use gross output multipliers as indices for demographic multipliers. The value for the demographic multiplier used in this analysis is 2.5, which represents an average of the heavy construction industry gross output multiplier (2.616) and the utility industry gross output multiplier (2.312) for the Jacksonville, Florida Bureau of Economic Analysis economic area. (U.S. Water Resources Council, Jan. 1977, Guideline 5, Regional Multipliers, Washington, D.C.) This multiplier analysis assumes that all multipliers take their full effect over a twelve month period.

Thus, in the notation of Table H-5,

$$E_t = 2.5(D_t)$$

where

E_t = direct plus indirect population increase in year t,

D_t = direct population increase in year t, and

2.5 = the demographic multiplier used to reflect indirect population changes in Putnam County associated with the Seminole project.

Finally, the aggregate population change due to the Seminole project, as illustrated in Column 6 of Table H-5, and Column 4 of Table 6.2-5, can be calculated by summing the incremental population changes of column six in Table H-5. In the notation of the table,

$$F_t = \sum_{t = 1978}^{t = t} E_t$$

where

F_t = aggregate population change due to Seminole project in year t, and

E_t = incremental population change due to the Seminole project in year t.

H.5 METHODOLOGY FOR ESTIMATING EMPLOYMENT IMPACTS

Table H-6, Employment Impact Methodology, outlines the procedures used in deriving the values for incremental and aggregate employment changes due to the Seminole project as illustrated in Columns 3 and 4 of Table 6.2-6. The data in Columns 3 and 4 of Table 6.2-6 are identical to the data in Columns 11 and 12 of Table H-6.

By progressively defining each of the variables in Table H-6, the methodology for deriving employment impacts will become evident. The definitions and assumptions used in the derivation of the variables presented in Table H-6 are as follows:

A_t = aggregate employment of local residents due to construction in year t. This data comes from Column 13 of Table 6.2-2.

B_t = incremental employment of local residents due to construction in year t. In mathematical notation,

$$B_t = A_t - A_{t-1}$$

C_t = aggregate employment of relocaters due to construction in year t. This data comes from Column 12 of Table 6.2-2.

D_t = incremental employment of relocaters due to construction in year t. In mathematical notation,

$$D_t = C_t - C_{t-1}$$

E_t = incremental employment of relocaters and local residents due to construction in year t. E_t can also be thought of as incremental direct employment due to construction in year t. In mathematical notation,

$$E_t = B_t + D_t$$

F_t = incremental direct and induced employment due to construction in year t. Induced employment refers to the employment that is generated due to the increased spending in Putnam County by the construction phase personnel and their families. A value of 2.616 was used as the multiplier for induced employment during the construction phase. (U.S. Water Resources Council, Jan. 1977, Guideline 5, Regional Multipliers) In mathematical notation,

$$F_t = 2.616(E_t)$$

G_t = aggregate employment of relocaters and local residents due to operation in year t. In deriving values for G_t, it was assumed that all operating personnel would be either relocaters or local residents. This data comes from Column 2 of Table 6.2-4.

H_t = incremental employment of relocaters and local residents due to operation in year t. H_t can also be thought of as incremental direct employment due to operation in year t. In mathematical notation,

$$H_t = G_t - G_{t-1}$$

I_t = incremental direct and induced employment due to operation in year t. A value of 2.313 was used as the multiplier for induced employment during the operation phase. (U.S. Water Resources Council, Jan. 1977, Guideline 5, Regional Multipliers). In mathematical notation,

$$I_t = 2.313(H_t)$$

J_t = incremental direct and induced employment due to construction and operation in year t. It can also be thought of as the incremental employment change due to the Seminole project as illustrated in column three of Table 6.2-6. In mathematical notation,

$$J_t = F_t + I_t$$

K_t = aggregate direct and induced employment due to construction and operation in year t. K_t can also be thought of as aggregate employment change due to the Seminole project as illustrated in Column 4 of Table 6.2-6. In mathematical notation,

$$K_t = \sum_{t = 1978}^{t = t} J_t$$

H.6 METHODOLOGY FOR ESTIMATING INCOME IMPACTS

The first task in formulating Seminole project income projections involved aggregation of quarterly labor cost data for the construction phase manual and supervisory workers from Table 6.2-3 into annual data. Total labor cost data for the operation phase, as supplied by SECI in Table 6.2-4, was already aggregated on an annual basis, and thus required no further aggregation.

Total labor cost (TLC) was then broken down into three components, wages (W), fringe benefits (F), and travel allowances (TA) based on cross sectional data for fourteen Jacksonville area trade unions. In breaking the total labor costs into component parts, it was assumed that manual workers who commute from Jacksonville to the Putnam Site will travel an average of 100 miles per round trip. It is necessary to make an assumption about commuting distances in order to calculate travel allowance, which is often based on distance travelled, as a percentage of total labor cost. Fringe benefits include health and welfare and pension plans. Travel allowances, for some unions, include subsistence.

After taking averages for the fourteen crafts for which data was available, it was determined that total labor cost consists of 79 percent wages, 11 percent travel allowance, and 10 percent fringe benefits. Thus, the following three relationships have been determined:

$$W = 0.79\ TLC$$
$$TA = 0.11\ TLC$$
$$\text{and } F = 0.10\ TLC$$
$$\text{Thus, } W + TA + F = TLC$$

Personal income (PI) was then calculated for each of the three categories of labor: 1) construction phase manual labor, 2) construction phase supervisory personnel, and 3) operation phase personnel. Personal income (PI) is defined as wages (W) plus travel allowance (TA). Thus,

$$PI = W + TA, \text{ and}$$

$$PI = 0.79\ TLC + 0.11\ TLC$$

$$\text{Hence, } PI = 0.9\ TLC$$

Disposable personal income (DPI) equals personal income (PI) minus taxes (T). Assuming that taxes (T) equal 30 percent of personal income (PI), the following relationships emerge:

$$DPI = PI - T$$

$$T = 0.3\ PI$$

$$DPI = PI - 0.3\ PI$$

$$DPI = 0.7\ PI$$

Upon calculating values for disposable personal income (DPI) for the three labor categories for all the years of interest, it is then appropriate to calculate values for consumption expenditure (CE). Assuming that the average propensity to consume out of disposable personal income (DPI) is 0.7, it follows that CE = 0.7 DPI. Assuming that none of the fringe benefits are injected back into the local economy of Putnam County, it is the consumption expenditure by the three classes of labor that will cause increases in Putnam County income through a multiplier effect.

Upon calculating values for consumption expenditure (CE), it is necessary to disaggregate consumption expenditure into local and non-local components. The local component of consumption expenditure is that portion spent by workers in Putnam County. It is this portion that triggers income changes in Putnam County. Non-local consumption expenditure is spent outside of Putnam County and is treated as a leakage. This portion has no direct impact on the income of Putnam County.

For manual construction personnel, it was assumed that direct local consumption expenditure (DLCE) equals 15 percent of consumption expenditure since 15 percent of the manual construction workers are expected to reside in Putnam County. (Recall from Appendix H.3 that it was assumed that 5 percent of the manual construction workers would be relocaters and 10 percent of the manual construction workers would be local residents, thus giving 15 percent of the manual construction workers residing in Putnam County.)

In a similar manner it was assumed that direct local consumption expenditure (DLCE) for supervisory construction personnel equals 25 percent of consumption expenditure for supervisory construction personnel. Thus, for manual construction labor:

1. DLCE = 0.15 CE

   and for supervisory construction personnel

2. DLCE = 0.25 CE

For construction phase commuters, whether they be manual or supervisory personnel, it was assumed that 50 percent of their travel allowance (TA) would be spent locally in Putnam County as direct local consumption expenditure (DLCE). Since 85 percent of the manual construction workers are assumed to be commuters, it follows that for manual construction commuters,

DLCE = 0.5(0.85)(TA)

or

3. DLCE = 0.425(TA)

For supervisory construction personnel, it was assumed that 75 percent would be commuters. Thus, for supervisory construction commuters,

DLCE = 0.5(0.75)(TA)

or

4. DLCE = 0.375(TA)

The sum of the four DLCE's for construction phase manual and supervisory personnel is total direct local consumption expenditure due to construction activities (TDLCEC).

In order to calculate the direct and induced income change due to the construction phase activities, it is necessary to multiply TDLCEC by the multiplier 2.616. Thus,

$$PIIC = 2.616\ (TDLCEC)$$

where

PIIC = personal income impact due to construction phase as illustrated in column three of Table 6.2-7.

In order to disaggregate consumption expenditure into local and non-local components for the operation phase personnel, it was assumed that all operating personnel are either relocaters or local residents. Thus, in this case, consumption expenditure equals direct local consumption expenditure. Hence, CE = DLCE for operating phase personnel.

In order to calculate the direct and induced income change due to the operation phase activities, it is necessary to multiply DLCE for operating phase personnel by the multiplier 2.313. Thus, PIIO = 2.313 (DLCE) where PIIO = personal income impact due to operation phase as illustrated in column four of Table 6.2-7.

Finally, the baseline income projections of Table 2.10-12 are given in terms of 1967 dollars. The baseline income projections of Table 6.2-7, however, have been converted to nominal dollars by inflating the projections of Table 2.10-12 by the consumer price index for the years 1967 to 1977, and then arbitrarily inflating the projections at a rate of 6 percent per year thereafter.

TABLE H-1

PUTNAM COUNTY BASIC AND NON-BASIC EMPLOYMENT BY SECTOR
1974

Sector	Total Putnam Employment	Total National Employment	Basic Putnam Employment	Non-Basic Putnam Employment
Total Employment	12,941	94,090,500	0	12,941
Proprietors	1,701	9,948,000	333	1368
I. Agriculture	440	3,028,000	23	417
II. Non-Agriculture	1,261	6,920,000	310	951
Wage and Salary	11,240	84,142,500	-333	11,573
I. Agriculture	743	1,208,000	576	167
II. Non-Agriculture	10,497	82,934,500	-909	11,406
A Private, Non-agric. Sector	8,295	67,094,000	-932	9227
1. Mining	D	707,000	D	97
2. Construction	553	3,984,000	5	548
3. Trans., Comm., and Pub. Util.	301	4,709,000	-346	647
4. Manufacturing	3,206	20,117,000	439	2,767
5. Wholesale & Retail Trade	2,063	17,144,000	-295	2,358
6. Finance, Insurance, and Real Estate	297	4,306,000	-295	592
7. Services	1,803	15,850,000	-377	2,180
8. Other	D	277,000	D	38
B. Government Sector	2202	15,840,000	23	2,179
1. Federal Civilian	156	2,861,000	-238	394
2. Federal Military	54	1,613,000	-168	222
3. State and Local	1,992	11,366,000	429	1,563

Note: Basic and non-basic employment is derived via the location quotient methodology as described in Tiebout, Dec. 1962, The Community Economic Base Study. The location quotient methodology utilizes the following formula:

$$\frac{x_i}{\text{Total Putnam Employment}} = \frac{\text{National Employment in Sector i}}{\text{Total National Employment}}$$

where x_i = non-basic employment in sector i in Putnam County. Non-basic employment is that employment required in sector i in a given community to produce just enough output from sector i to supply the local demands of the given community. The difference between total employment and non-basic employment gives basic employment, which is that employment required to satisfy the export demand for the output from sector i. This type of analysis assumes that local residents have the same basic demand patterns that prevail on a national Level. D = non-disclosure industry.

Source: U. S. Department of Commerce, Bureau of Economic Analysis, Unpublished Data, as cited in Florida Dept. of Commerce, Division of Economic Development, Bureau of Economic Analysis, April 1977, and Dames & Moore, 1977.

TABLE H-2

NATIONAL INDICES OF INFLATION

Period	Percent Change in Wholesale Prices	Percent Change in Consumer Prices
1968	2.8	4.7
1969	4.8	6.1
1970	2.2	5.5
1971	4.1	3.4
1972	6.3	3.4
1973	15.4	8.8
1974	20.9	12.2
1975	4.2	7.0
1976	4.7	4.8

Notes: Percent changes are from preceding period and are seasonally adjusted, Changes are from December to December and apply to all commodities.

Source: Department of Labor, Bureau of Labor Statistics, as cited in Council of Economic Advisors, September 1977, Economic Indicators.

TABLE H-3

IMPLICIT PRICE DEFLATORS FOR INCOME
(1972 = 100)

Year	Price Deflator
1966	76.76
1967	79.02
1968	82.57
1969	86.72
1970	91.36
1971	96.02
1972	100.00
1973	105.80
1974	116.02
1975	127.18
1976	133.88

Source: U. S. Department of Commerce, Bureau of Economic Analysis, as cited in Council on Economic Advisors, August 1977, Economic Indicators.

TABLE H-4
PROPOSED COSTS OF GENERATION
(IN MILLIONS OF CURRENT DOLLARS)
SEMINOLE PLANT UNITS NO. 1 AND NO. 2

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fixed Charges											
Capital Recovery	25.25	43.29	68.82	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06
Insurance	16.10	16.10	32.38	32.38	32.38	32.38	32.38	32.38	32.38	32.38	32.38
Total Fixed Charges	41.35	59.39	101.20	119.44	119.44	119.44	119.44	119.44	119.44	119.44	119.44
Present Value	38.11	50.45	79.23	86.18	79.43	73.21	67.47	62.19	57.32	52.83	48.69
Variable Costs											
Fuel	44.62	80.32	134.10	178.63	189.35	200.71	212.75	225.52	239.05	253.39	268.59
Present Value	41.12	68.23	104.99	128.89	125.92	123.02	120.19	117.42	114.71	112.07	109.49
Operation and Maintenance	9.05	16.44	26.07	34.18	36.23	38.40	40.71	43.15	45.74	48.48	51.39
Present Value	8.34	13.97	20.41	24.66	24.09	23.54	23.00	22.47	21.95	21.44	20.95
Working Capital	2.36	2.20	4.02	5.02	5.32	5.64	5.98	6.34	6.72	7.12	7.55
Present Value	2.18	1.87	3.14	3.62	3.54	3.46	3.38	3.30	3.22	3.15	3.08
Taxes - Property	4.90	4.74	9.53	9.21	8.88	8.56	8.24	7.91	7.59	7.27	6.94
Present Value	4.52	4.03	7.46	6.65	5.91	5.25	4.65	4.12	3.64	3.22	2.83
Gross Receipts	1.53	2.62	4.41	5.90	6.25	6.63	7.03	7.45	7.90	8.37	8.87
Present Value	1.41	2.23	3.45	4.26	4.16	4.06	3.97	3.88	3.79	3.70	3.62
Total Variable Costs	62.46	106.32	178.13	232.94	246.03	259.94	274.71	290.37	307.00	324.63	343.34
Present Value	57.57	90.31	139.46	168.08	163.62	159.33	155.19	151.19	147.32	143.58	139.96
Total Capital and Operating Costs	103.81	165.71	279.33	352.38	365.47	379.38	394.15	409.81	426.44	444.07	462.78
Present Value	95.68	140.76	218.69	254.26	243.05	232.54	222.66	213.38	204.64	196.41	188.65

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Fixed Charges											
Capital Recovery	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06
Insurance	32.38	32.38	32.38	32.3	32.38	32.38	32.38	32.38	32.38	32.38	32.38
Total Fixed Charges	119.44	119.44	119.44	119.4	119.44	119.44	119.44	119.44	119.44	119.44	119.44
Present Value	44.87	41.36	38.12	35.13	32.38	29.84	27.51	25.35	23.36	21.53	19.85
Variable Costs											
Fuel	284.71	301.79	319.90	339.09	359.44	381.00	403.87	428.10	453.78	481.01	509.87
Present Value	106.97	104.50	102.09	99.74	97.44	95.20	93.00	90.86	88.77	86.72	84.72
Operation and Maintenance	54.47	57.74	61.21	64.88	68.77	72.90	77.27	81.91	86.82	92.03	97.55
Present Value	20.47	19.99	19.53	19.08	18.64	18.21	17.79	17.38	16.98	16.59	16.21
Working Capital	8.00	8.48	8.99	9.53	10.10	10.71	11.35	12.03	12.75	13.52	14.33
Present Value	3.01	2.94	2.87	2.80	2.74	2.67	2.61	2.55	2.49	2.44	2.38
Taxes - Property	6.62	6.30	5.98	5.65	5.33	5.01	4.69	4.37	4.05	3.73	3.41
Present Value	2.49	2.18	1.91	1.66	1.44	1.25	1.08	0.93	0.79	0.67	0.57
Gross Receipts	9.40	9.97	10.57	11.20	11.87	12.58	13.34	14.14	14.99	15.89	16.84
Present Value	3.53	3.45	3.37	3.29	3.22	3.14	3.07	3.00	2.93	2.86	2.80
Total Variable Costs	363.20	384.28	406.65	430.35	455.51	482.20	510.52	540.55	572.39	606.18	642.00
Present Value	136.45	133.06	129.78	126.58	123.49	120.48	117.56	114.73	111.97	109.29	106.68
Total Capital and Operating Costs	482.64	503.72	526.09	549.79	574.95	601.64	629.96	659.99	691.83	725.62	761.44
Present Value	181.32	174.42	167.90	161.71	155.87	150.32	145.07	140.08	135.33	130.82	126.53

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL	Annual Equivalent Amount Per Year	Annual Equivalent Amount mils per kwh
Fixed Charges														
Capital Recovery	87.06	87.06	87.06	87.06	87.06	87.06	87.06	87.06	69.02	43.77	18.24	2,619.01		
Insurance	32.38	32.38	32.38	32.38	32.38	32.38	32.38	32.38	32.38	16.28	16.28	1,003.78		
Total Fixed Charges	119.44	119.44	119.44	119.44	119.44	119.44	119.44	119.44	101.40	60.05	34.52	3,622.79		
Present Value	18.29	16.86	15.54	14.32	13.20	12.17	11.21	10.33	8.09	4.41	2.34	1,161.17	105.87	14.81
Variable Costs														
Fuel	540.46	572.89	607.26	643.70	682.32	723.26	766.66	812.66	682.92	459.07	202.78	12,983.57		
Present Value	82.77	80.86	79.00	77.18	75.40	73.67	71.97	70.31	54.46	33.74	13.74	2,929.18	267.07	37.36
Operation and Maintenance	103.41	109.61	116.19	123.16	130.55	138.38	146.69	155.49	130.66	87.83	38.80	2,486.16		
Present Value	15.84	14.60	15.12	14.77	14.43	14.09	13.77	13.45	10.42	6.46	2.63	561.28	51.18	7.16
Working Capital	15.19	16.10	17.06	18.09	19.17	20.32	21.54	22.83	19.19	12.90	5.70	366.13		
Present Value	2.33	2.77	2.22	2.17	2.12	2.07	2.02	1.98	1.53	0.95	0.39	83.49	7.61	1.06
Taxes - Property	3.09	2.77	2.45	2.14	1.82	1.50	1.19	0.87	0.44	0.29	0	155.47		
Present Value	0.47	0.39	0.32	0.26	0.20	0.15	0.11	0.08	0.04	0.02	0	69.27	6.32	0.88
Gross Receipts	17.85	18.92	20.06	21.26	22.54	23.89	25.32	26.84	20.15	15.08	6.66	426.31		
Present Value	2.73	2.67	2.61	2.55	2.49	2.43	2.38	2.32	1.61	1.11	0.45	96.54	8.80	1.23
Total Variable Costs	680.00	720.29	763.02	808.35	856.40	907.35	961.40	1019.19	853.36	575.17	253.94	16,418.17		
Present Value	104.14	101.67	99.26	96.92	94.64	92.41	90.25	88.18	68.05	42.27	17.20	3,740.69	341.06	47.70
Total Capital and Operating Costs	799.44	839.73	882.46	927.79	975.84	1026.79	1080.84	1138.63	954.76	635.22	288.46	20,040.96		
Present Value	122.43	118.53	114.80	111.24	107.84	104.58	101.46	98.51	76.14	46.68	19.54	4,901.86	446.93	62.52

Totals may not add exactly due to rounding
Present values computed at 8.5% discount rate
Mils/kwh on basis of 7,148.16 x 10^6 kwh per year, both units in full operation (with 68% capacity factor).

TABLE H-5

DEMOGRAPHIC IMPACT METHODOLOGY

Year	Incremental Construction Phase Relocaters (A_t)	Incremental Operation Phase Relocaters (B_t)	Incremental Total Relocaters (C_t)	Incremental Total Relocaters Plus Family Members (Direct Population Increase (D_t)	Incremental Population Change Due to Seminole Project (Direct Plus Indirect Population Increase) (E_t)	Aggregate Population Change Due to Seminole Project (F_t)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1978	0	0	0	0	0	0
1979	5	0	5	15	38	38
1980	14	0	14	42	105	143
1981	24	0	24	72	180	323
1982	22	0	22	66	165	488
1983	-15	50	35	105	263	751
1984	-2	0	-2	-6	-15	736
1985	-32	20	-12	-36	-90	646
1986	-16	0	-16	-48	-120	526

Source: Burns and Roe, Inc., April 24, 1978; U. S. Dept. of Commerce, 1974, Statistical Abstract of the U. S., page xiii; U. S. Water Resources Council, January 1977, Guideline 5, Regional Multipliers, Washington, D.C.; Seminole Electric Cooperative, Inc., May 2, 1978; and Dames & Moore, June 1978.

TABLE H-6

EMPLOYMENT IMPACT METHODOLOGY

	CONSTRUCTION PHASE						OPERATION PHASE			CONSTRUCTION AND OPERATION PHASES	
	Locals		Relocaters		Locals and Relocaters		Locals and Relocaters			Locals and Relocaters	
Year	Aggregate Direct Employment (A_t)	Incremental Direct Employment (B_t)	Aggregate Direct Employment (C_t)	Incremental Direct Employment (D_t)	Incremental Direct Employment (E_t)	Incremental Direct and Induced Employment (F_t)	Aggregate Direct Employment (G_t)	Incremental Direct Employment (H_t)	Incremental Direct and Induced Employment (I_t)	Incremental Direct and Induced Employment (J_t)	Aggregate Direct and Induced Employment (K_t)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1978	0	0	0	0	0	0	0	0	0	0	0
1979	5	5	5	5	10	26	0	0	0	26	26
1980	25	20	19	14	34	89	0	0	0	89	115
1981	61	36	43	24	60	157	0	0	0	157	272
1982	92	31	65	22	53	139	0	0	0	139	411
1983	70	-22	50	-15	-37	-97	99	99	229	132	543
1984	68	-2	48	-2	-4	-11	99	0	0	-11	532
1985	17	-51	16	-32	-83	-217	140	41	95	-122	410
1986	0	-17	0	-16	-33	-86	140	0	0	0	410
1987	0	0	0	0	0	0	140	0	0	0	410
1988	0	0	0	0	0	0	140	0	0	0	410
1989	0	0	0	0	0	0	140	0	0	0	410
1990	0	0	0	0	0	0	140	0	0	0	410

Source: Jacksonville Area Planning Board, June 1976B, Regional Employment Study; Bureau of the Census,1970, U. S. Census of Population; Burns and Roe, April 24, 1978; Seminole Electric Cooperative, Inc., May 2, 1978; U. S. Water Resources Council, January 1977, Guideline 5, Regional Multipliers; and Dames & Moore, June 1978.

TABLE H-7
HYPOTHETICAL PUTNAM COUNTY PROPERTY TAXES
SEMINOLE PLANT UNITS NO. 1 AND NO. 2

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Unit 1 Non-exempt value[1]	368.0	355.7	343.5	331.2	318.9	306.7	294.4	282.1	269.9	257.6	245.3	233.1	220.8	208.5	196.3	184.0	171.7
Unit 2 Non-exempt value[2]	0	0	372.1	359.7	347.3	334.9	322.5	310.1	297.7	285.3	272.9	260.5	248.1	235.7	223.3	210.9	198.5
TOTAL, Plant and Equipment	368.0	355.7	715.6	690.9	666.2	641.6	616.9	592.2	567.6	542.9	518.2	493.6	468.9	444.2	419.6	394.9	370.2
Coal stockpile non-exempt value[3]	1.5	1.6	3.4	3.6	3.8	4.0	4.3	4.5	4.8	5.1	5.4	5.7	6.1	6.4	6.8	7.2	7.7
TOTAL, Assessed Value	369.5	357.3	719.0	694.5	670.0	645.6	621.2	596.7	572.4	548.0	523.6	499.3	475.0	450.6	426.4	402.1	377.9
Estimated Putnam County Ad Valorem Taxes @ 16.326 mils (1978)	6.03	5.83	11.74	11.34	10.94	10.54	10.14	9.74	9.35	8.95	8.55	8.15	7.75	7.36	6.96	6.56	6.17

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Unit 1 Non-exempt value[1]	159.5	147.2	134.9	122.7	110.4	98.1	85.9	73.6	61.3	49.1	36.8	24.5	12.3	0	0	0	
Unit 2 Non-exempt value[2]	186.1	173.7	161.3	148.9	136.4	124.0	111.6	99.2	86.8	74.4	62.0	49.6	37.2	24.8	12.4	0	
TOTAL, Plant and Equipment	345.6	320.9	296.2	271.6	246.8	222.1	197.5	172.8	148.1	123.5	98.8	74.1	49.5	24.8	12.4	0	
Coal stockpile non-exempt value[3]	8.1	8.6	9.1	9.7	10.3	10.9	11.5	12.2	13.0	13.8	14.6	15.5	16.4	8.7	9.2	0	
TOTAL, Assessed Value	353.7	329.5	305.3	281.3	257.1	233.0	209.0	185.0	161.1	137.3	113.4	89.6	65.9	33.5	21.6	0	
Estimated Putnam County Ad Valorem Taxes @ 16.326 mils (1978)	5.79	5.38	4.98	4.59	4.20	3.80	3.41	3.02	2.63	2.24	1.85	1.46	1.08	0.55	0.35	0	191.43

NOTES:

1 $460 million less 20% for estimated value of tax exempt pollution control equipment. Depreciated straightline over 30 years. Assume unit is "substantially" completed for commercial use as of 1/1/83 (on line 6/1/83), and that assessment ratio on non-exempt property is 100%.

2 $465.17 million less 20% for pollution control equipment. Depreciated straightline 30 years. Assume unit is substantially complete 1/1/85 (on line 6/1/85).

3 Coal stockpile of 75 days supply. On basis of 1.5 mtpy per unit, stockpile equals 308,219.2 tons. Use 310,000 ton/unit average. Value of coal based on 1978 cost of $1.60 per million Btu, escalates to 1986 at 5.3% per year and 6.0% thereafter (per SECI letter dated 5/2/78). Assume coal average heat value of 12,000 Btu per pound. Thereafter, gross value of inventory =

310,000 tons x 2,000 lbs x 12,000 Btu/lb x $1.60/million Btu = $11,904,000 (1978) x $(1.053)^5$ = $15,411,140 (1983)
= $16,227,931 (1984)
(x 2) = $34,176,022 (1985)
= $35,987,351 (1986)
@ 6.0% ___ = $38,146,592 (1987)

Assume assessment ratio of 10%

Source: SECI

APPENDIX J

ARCHEOLOGY

APPENDIX J

ARCHEOLOGY

CULTURAL RESOURCE ASSESSMENT OF THE SEMINOLE ELECTRIC PROPERTY PUTNAM COUNTY, FLORIDA

Performed under contract by
Cultural Resource Management, Inc.

for

DAMES AND MOORE
ATLANTA, GEORGIA

Mildred L. Fryman
John W. Griffin
James J. Miller

May 19, 1978

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INTRODUCTION

The present report details methods, results and recommendations of an archeological and historical survey of some 3260 acres in Putnam County, Florida, performed under contract by Cultural Resource Management, Inc. The property, proposed site of an electric generating plant, was surveyed under the direction of Dames and Moore, Atlanta, as part of an environmental impact analysis. The study was designed to meet current federal standards set forth in 36 C.F.R. 800, "Procedures for the Protection of Historic and Cultural Properties," in order that compliance could be achieved with requirements of the National Environmental Policy Act and the Florida Electric Power Plant Siting Act. Information from such varied sources as personal interviews, county tax and deed records, United States General Land Office survey records, early aerial photography, museum files of recorded sites, and an archeological field survey was assembled to document all sites found on the property and assess their significance and endangerment.

The project area was defined to include a roughly rectangular tract covering some 2380 acres as well as three alternate outfall corridors totalling 880 acres. The property is situated in northeast Putnam County about 5 miles north of Palatka near, but not on, the St. Johns River (Figure 1). Altogether some 25 person-days were spent on the project -- slightly more than half of these in the field.

The tract was found to have been sparsely inhabited in both historic and prehistoric times. At the river terminus of one of the alternate corridors two prehistoric shell midden sites were found in locations similar to those known for other sites in the area. These can be avoided by eliminating the corridor from further consideration. On the rectangular property three historic homesteads were identified dating no earlier than 1880. These are not considered eligible for inclusion in the National Register of Historic Places, and if Corridor B is not utilized no impact upon cultural resources is anticipated by the project.

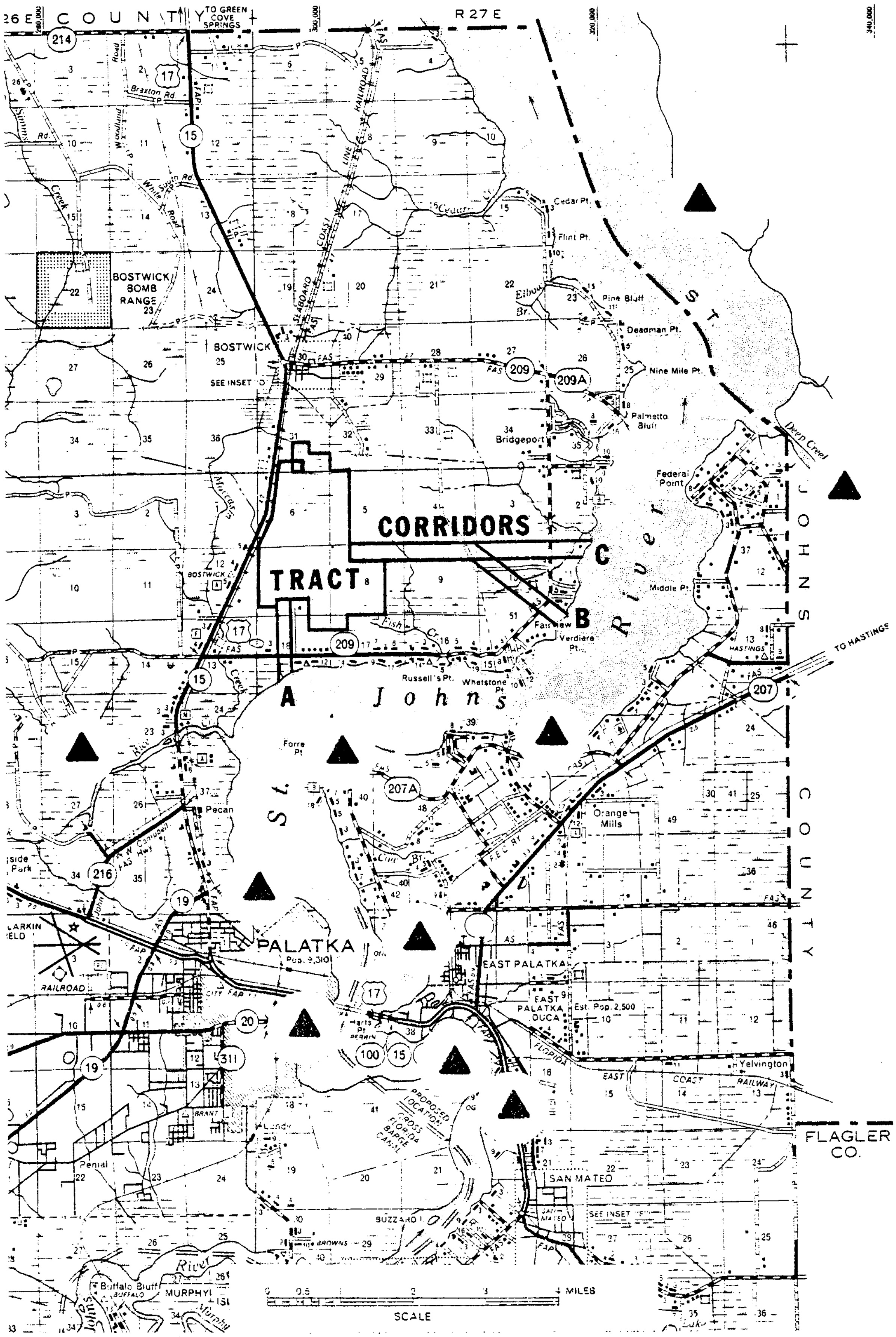


Figure 1. Tract Location Map showing general distribution of recorded archeological sites by approximate location.

PLAN OF STUDY

The study was designed to enable the applicant to comply with federal and state historic preservation mandates. Objectives were stated in the proposal as follows:

1. Identify and locate all archeological and historical sites on the property.

2. Gather sufficient data to assess the significance, integrity, and National Register eligibility of each site.

3. Prepare a report of results suitable for inclusion in the applicant's environmental statements.

The project was divided into three phases: background and literature survey, field work, and interpretation and presentation of results. The first phase involved investigation by a historian and archeologist into published and file sources to determine current knowledge of the project area. The historical documentary study, results of which are presented in Section 4, focused on land use and ownership of the subject property within the context of regional historical development. Federal, state, and county property records were investigated along with standard published historical sources. Early surveyor's and travellers' accounts proved valuable, as did a soil survey of Putnam County detailing natural and cultural features by text and map as of 1914. The study was valuable in suggesting what types of historic sites were known or could be expected on the tract and in which locations. Moreover, during the field survey historical remains discovered on the property could be identified with the information at hand, then assessed for significance on the basis of historical as well as archeological value.

Before field work the regional archeological literature was thoroughly reviewed (Section 3) to determine the extent and results of past work and to provide a context within which sites on the property could be evaluated. A check of the Florida Master Site File at the Division of Archives, History and Records Management revealed 13 prehistoric sites within an 8-mile radius of the center of the tract. The nearest was some 3 miles away on the other side of the St. Johns. Without exception these sites were all directly on the St. Johns River or a major tributary. No sites were recorded in inland locations similar to the survey property (excluding corridor termini). Based on these data, then, the tract was considered to have low site probability.

Attention was also paid to environmental characteristics of the study area since it is by now well known that site distribution is closely dependent upon natural features such as drainage, elevation, slope, proximity to water and food resources, soil fertility and so on. The 1914 soil survey already mentioned was most helpful in delineating soil zones with potential vegetation. Further information was obtained from the Jacksonville Area Planning Board Land Use/Cover Analysis of Northeast Florida. Aerial photography from 1943, 1972, and 1975 provided accurate and detailed information about distribution of vegetation types and cultural features. By this type of analysis it was possible to identify areas likely or unlikely to contain cultural resources, based upon experience from other similar areas as well as knowledge of requirements for habitation.

Phase II of the study involved a comprehensive field survey to locate and assess sites on the property. Three archeologists spent three days on the tract; corridors were covered by one archeologist requiring three additional days. Standard survey techniques were used, particular attention being paid to hammocks, river banks, and ecotones. All available soil exposures were walked, or driven at slow speed, and test holes were dug in areas judged to have site potential and in areas where the ground surface was not visible enough to reveal artifacts had they been present. Additional tests were made on the St. Johns where two unrecorded shell mounds were found.

Results that were summarized in preliminary form are reported here in full, and a final summary appears in the Environmental Impact Statement. No artifacts were collected during the project. Field notes, maps, aerial photographs and administrative files are maintained by the contractor (Cultural Resource Management, Inc., P. O. Box 1313, Tallahassee, FL 32302). Project personnel included James J.

Miller, John W. Griffin, and David Swindell, Archeologists; historical research was completed by Mildred L. Fryman, Ph.D.

ARCHEOLOGICAL BACKGROUND

As early as 1834 antiquarians were beginning to investigate sites along the St. Johns River. In that year Dr. John Durkee, a New Hampshire physician, described in some detail a large sand burial mound some 12 miles below Jacksonville (Hoole 1974:305-307). Slightly later, during the Seminole War, other Indian mounds were explored by military men.

In 1853 Louis Agassiz reported on a discovery made a few years earlier by Count F. D. Portales of fossilized human bones in a shell conglomerate from the shores of Lake Monroe, which he regarded as being 10,000 or more years old (Haven 1856:87). This find was later given broader exposure by Sir Charles Lyell. Wyman (1875:15) noted that the finds were from a midden and that Portales himself had recognized the artificial nature of the deposit, although Agassiz had not. The find was rejected by Hrdlicka (1907:19) with the comment, "Fossilization itself means in Florida but little, as the process is even now going on in many portions of the peninsula." Concreted basal levels below present water levels are known from a number of sites both of the St. Johns River and along the coasts, and cannot be accepted as evidence of vast antiquity, although most are probably from the Archaic period.

Brinton (1859:166-181) devoted one chapter of his book to the antiquities of the state, and while he found no difficulty in ascribing the coastal shell heaps to aboriginal times he regarded the fresh-water shell heaps of the St. Johns as "a geological enigma . . . not to be mistaken for those of artificial construction."

Within a very few years, however, Jeffries Wyman (1868) produced convincing evidence from his examination of a number of sites that these deposits were indeed "the works of man." Further he noted that some sites contained no pottery, while yet others did. His larger, final report (1875) carried the same arguments forward, indicated more clearly his division into sequential non-pottery and pottery periods, and suggested numerous avenues of inquiry.

J. Francis LeBaron (1884:772) in his overall survey of Florida archeology had the following to say about sites near Palatka:

> . . . The next mound that we found was situated on the west bank of the river, about 2 miles north of Pilatka. It was a shell heap about 12 feet high, the eastern edge abraded by the waters of the river into a steep bluff. A large part of this shell-heap had been carried away in boats to form walks and drive-ways in Pilatka and for fertilizing purposes.
>
> This practice is very common throughout the state, and is working the speedy destruction of these interesting remains.

> The shells in this mound were mostly fresh-water species. The bottom of the mound is washed by the river, and the part that has been exposed to the continued action of the water has formed a kind of calcareous conglomerate, which is thickly interspersed with human and other bones, broken in all cases that came under my notice . . . .

LeBaron (Ibid.) was informed that there was a mound in the swamp a half mile west of the shell heap, but he did not visit it. At Palatka he found the remains of a small mound in town, and midden remains all along the shore.

From 1892 to 1895 Clarence B. Moore worked extensively in both the sand and shell mounds of the St. Johns River, from which resulted a long series of publications (Moore, 1892:128-143; 1892:568-579; 1892:912-122; 1893:8-13, 113-117, 604-624, 709-733; 1894:5-105; 1894:129-246; 1894:15-26; 1895:449-502; 1895:503-516; 1895:518-543). Goggin (1952:33) correctly assesses Moore's work in this area as "perhaps the most significant of all his work in the Southeast." Despite the fact that it has been popular for several decades to denigrate Moore's contributions, a careful re-reading of his work on the shell mounds in particular (Moore, 1892:912-922; 1893:8-13, 113-117, 604-624, 709-733; 1894:15-26) engenders considerable respect for his work, given "the state of the art" at the time. He demonstrates a sequence from preceramic, through fiber-tempered pottery, to chalky pottery; he is concerned with size differences of the shells in the deposits at different time periods; he touches on settlement pattern and subsistence, and on many other facets of interest to the modern scholar.

Moore (1894:212) clearly recognizes the major cultural blocks of St. Johns prehistory when, in speaking of the fiber-tempered pottery, he says, ". . . we are still inclined to the belief that the presence of this pottery marks the earlier shell-heaps, though not the earliest which are characterized by an absence of pottery, the latest class holding sherds similar to the commoner varieties met with in the sand mounds." This latter reference would be to chalky wares. Additionally, Moore (1892:916) notes that, "in other shell heaps pottery, plain and ornamented, is found in association for a time, after which unornamented pottery alone is found." This statement was not picked up by Goggin (1952:39) who attributes the recognition of a plain pottery period (St. Johns I) to Nelson (1918). It is true that Moore does not say whether he is referring to chalky or fiber-tempered pottery in this statement, but the plain fiber-tempered period in Florida was not recognized until much later in excavations at the Bluffton midden (Bullen 1955).

Following the work of Moore there was virtually no scientific excavation along the St. Johns River until after the conclusion of World War II, although pot-hunting and commercial shell removal took their toll of sites.

James B. Griffin (1945) became interested in the area while engaged in preparing several syntheses of eastern archeology, and provided a formal definition of the fiber-tempered Orange Incised and also named several other types including St. Johns Plain and St. Johns Check Stamp (sic). This was followed shortly by Goggin's (1947) preliminary definition of archeological areas and periods of Florida, and his significant paper on ecological relations (Goggin 1948). Rouse's (1951) survey volume organized the known data for the headwaters of the St. Johns, and Goggin (1952) did the same for northeast Florida.

While there exists a considerable literature on the central St. Johns from this time forward, only a small portion of it relates to controlled excavation. Bullen (1955) reported on stratigraphic excavations at Bluffton, while Sears (1960) excavated a nearby burial mound. A number of burials were recovered in a salvage operation on Tick Island (Bullen 1961). Neill (1958) dealt with an early stratified site near Silver Springs. Bullen and Bryant (1965) tested three Archaic shell middens in the Ocala National Forest, and Cumbaa and Gouchnour (1970) worked the Colby site on the Oklawaha River. Other site reports include Aten (1961), Carlson (1961) and Willis' (1972) paper on excavations at Alexander Springs.

Both before and after the publication of Goggin's synthesis, he and his students continued site survey and collection in the St. Johns area, and the results became part of the statewide archeological survey files. More recent surveys of portions of the Ocala National Forest will be found in Willis' (1972) inventory and Willis and Wells (1977).

Interest in archeozoology and subsistence patterns was, as we have seen, not absent in many early investigations. This has found expression in more recent years in such studies as those of Neill, Gut, and Brodkorb (1956) and Cumbaa (1976). Several graduate students at the University of Florida are currently continuing studies of a similar nature.

The framework of periods which has emerged from this work is presented in Figure 2.

The area near Palatka forms a dividing line insofar as the composition of the archeological sites is concerned, as Moore (1892:919) makes clear:

> The most northerly fresh-water shell heap is presumably near Whetstone Point, nine miles north of Palatka. Prof. Wyman, though thoroughly acquainted with the river below, failed to find any shell deposits farther north, and the writer during sixteen seasons spent in Florida, of which much time was passed upon the river, has

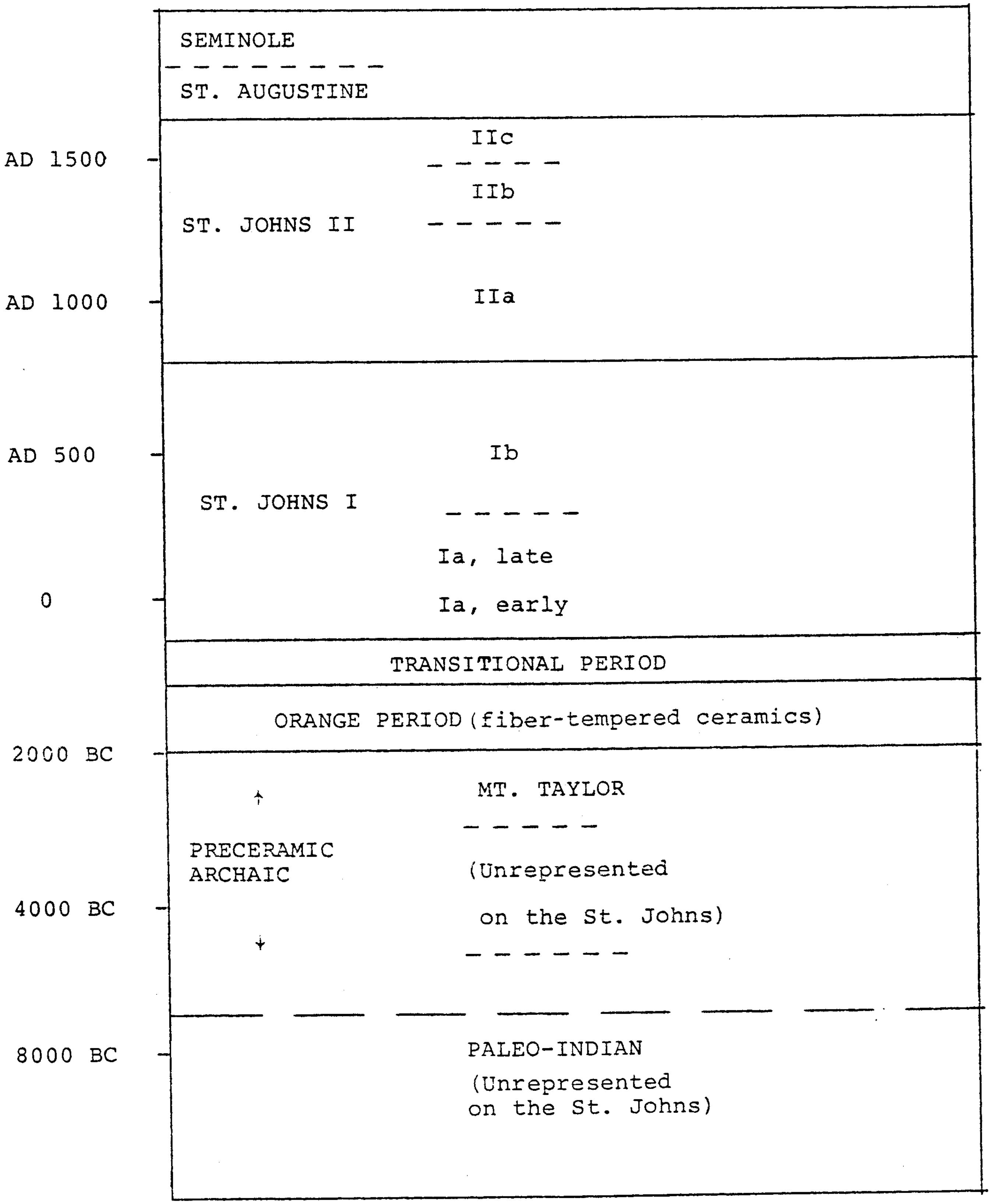


Figure 2. St. Johns River Chronology

> been unable to discover or to hear of any fresh-water shell deposits lower than Whetstone Point. A large number of persons familiar with the river in every capacity have been questioned; some perfectly acquainted with the shell heaps farther south, but no clue as to the existence of more northerly shell heaps has been gained.

Moore (Ibid.:920) was inclined to explain this lack as due to an insufficient supply of "their staple article of diet," rather than the absolute absence of shellfish. There are certainly sites on the St. Johns River north of Palatka (Goggin 1952:fig. 9), and the cultural inventory is not dissimilar to that from sites south of Palatka. Obviously, a somewhat different subsistence pattern was being followed in these two portions of the river.

It should be noted, however, that the intensity of occupation of the lower St. Johns in Archaic times (including the Orange Period) is not known. This earlier range of time is apparently responsible for the vast bulk of the shell heaps along the river, although levels from the St. Johns periods are also known. Therefore there may be a time difference as well as a space difference involved in the shell heap distribution. The majority of recorded sites in the area from Palatka to Jacksonville are sand burial mounds, dating from the St. Johns periods. Obviously, village sites must also exist, but they are relatively unknown.

Summary of Archeological Periods

Paleo-Indian Period: ?-8000 B.C.

There are no remains which can be attributed to the Paleo-Indian Period in the St. Johns River Valley. A distributional study of Paleo-Indian projectile points by Waller and Dunbar (1977) discloses only two locations near the St. Johns River, both of which are in Lake County at some little distance from the river. Near Silver Springs, Neill (1958) tested a stratified site which contained Suwanee Points (Clovis-like) in its lowest level.

The absence of such material in the river valley proper, and in those parts of the peninsula which lie to the east of it, may be attributed to a vastly different topography at approximately 10,000 years ago, related to a much lower sea-level and concomitant differences in stream gradients, water-tables, and vegetation.

Preceramic Archaic (Mt. Taylor Period): 3000-2000 B.C.

That portion of the preceramic Archaic before 5000 years ago is unrepresented for essentially the same reasons.

However, about 5000 years ago, or perhaps somewhat earlier, conditions in the St. Johns River had become conducive to human settlement and use. The first evidences of such occupancy are in the form of shell heaps or middens largely composed of the shells of the small univalve mollusc *Viviparus georgianus*. Smaller quantities of other shellfish also occur, particularly the apple snail, *Pomacea paludosa*, and bivalve mussels, *Elliptio* sp. But despite the tremendous mass of shells, at least 47 species of vertebrates were also consumed (Neill, Gut, and Brodkorb 1956).

Cumbaa (1976) has carried the study even further by calculating dietary percentages for the Kimball Island midden, adding to the visible faunal remains a thirty percent figure for plant foods. He concludes that only about 24 percent of the diet may be assigned to the shellfish component. From this point of view, shellfish form an important, but not a dominant or overwhelming, element in the subsistence pattern of these sites.

The surviving material culture of the Mt. Taylor Period is meager in variety and quantity. Projectile points are medium to large, often asymmetrical, stemmed points, not too unlike Late Archaic points from other parts of the Southeast. One stemmed scraper or "bunt" is noted. Although flakes and chips are mentioned in some accounts we do not know the extent to which these were utilized or whether they were all debitage. Bone was worked into awls and pins; some of the latter were peg-topped. Both *Busycon* gouges and *Strombus* celts are known; while some additional fragmentary marine shells are found, these artifacts probably reached the inland sites in completed form. One fragmentary steatite bannerstone is known. Conspicuously absent are cups, ladles, picks and hammers of Busycon.

It is little wonder with an inventory such as this that Moore (1894:26) was led to remark, ". . . little is found in comparison with the vast quantities of debris to be handled, and the relics of the wretched makers of the shell-heaps offer but a poor incentive in comparison to the more alluring results to be attained in other portions of the country." Even with a shift of interest in the problems which the shell heaps may cast light upon, they are still discouraging, labor consuming, sites.

Ceramic Archaic (Orange Period): 2000-1000 B.C.

The appearance of fiber-tempered pottery marks the beginning of this period, but "despite this new trait . . . the over-all cultural picture appears to be little changed and the subsistence pattern is identical" (Goggin 1952:79).

Fiber-tempered pottery is the earliest pottery in the eastern United States and is found on the coastal plain from Louisiana to South Carolina, with a small pocket occurring in the Tennessee Valley as well (Bullen and Stoltman 1972). As the age of this pottery became apparent it raised once more the old anthropological question, diffusion or independent invention?

Bullen (1960) argued for independent invention, while Ford (1966, 1969) believed that a case could be made for deriving the southeastern fiber-tempered ware from South America. The question remains open.

Goggin (1947) originally called this the Tick Island Period, but finding that the curvilinear Tick Island Incised was a minority type in fiber-tempered period sites and that the rectilinear Orange Incised ranged farther in both time and space, he changed the name to the Orange Period (Goggin 1952).

As the Orange Period became better known, and sites on both the Atlantic and Gulf coasts were explored, additional traits were added to the cultural inventory, altering in detail but not necessarily in any basic sense the summation of Goggin with which we opened this section. Bullen (1972) has summarized a vast amount of information. Some of the additional traits are shell picks and hammers, columella chisels, fishhooks, and sherds of steatite vessels.

Within the approximately 1000 years covered by the Orange Period, Bullen (1972) distinguishes four sub-periods, Orange 1 through Orange 4. Orange 1 is marked by plain fiber-tempered pottery. Orange 2 sees the addition of Tick Island Incised and Orange Incised. In Orange 3, Tick Island Incised disappears, Orange Incised undergoes elaboration including wide decorated lips, and sherds of steatite vessels are found. Orange 4 witnesses a simplification of Orange Incised designs, and near its end the first appearance of chalky pottery.

In northeast Florida, Orange 1 and Orange 2 seem to be confined to the St. Johns River valley, while Orange 3 marks the first appearance of the material on the Atlantic coast. Orange 3 is not heavily represented in the river valley, but it is not absent. Characteristic wide decorated lips from Tick Island are on exhibit in the museum of the Halifax Historical Society, Daytona Beach, Florida.

Orange 4 is nowhere well known. Bullen (1972:17) defines it from the Sunday Bluff site (Bullen 1969).

Transitional Period: 1000-500 B.C.

Bullen (1959) coined the term Transitional Period to cover a span of time, perhaps 500 years, immediately following the Orange Period and before the firm establishment of the regional traditions which characterize the remainder of Florida prehistory.

In the St. Johns area this period is most easily recognized by the presence of St. Johns Incised pottery. This is a chalky ware decorated primarily with incised designs which are clearly degenerate carry-overs from fiber-tempered times. There are, however, other design elements which suggest influence from other areas of the southeast.

While sites and levels of sites representing "pure" components of this period are known from Florida, none, so far, have been isolated in the St. Johns River valley. This is probably merely a function of the relative lack of controlled excavation. Sherds of St. Johns Incised pottery have been found in a number of sites, clearly indicating the presence of manifestations of the period in this area.

St. Johns I: 500 B.C.-A.D. 800

Chalky pottery already dominated the ceramics of the St. Johns River in the Transitional Period. The marker for the beginning of the St. Johns I period may be taken as the disappearance of St. Johns Incised. Dominantly the pottery of this period is St. Johns Plain, but Dunns Creek Red, a red-filmed or slipped chalky type, appears as the most frequent minority type. There is some local incised ware, very rare, and obviously inspired by decorated types from outside the area. Most decorated sherds found in St. Johns I context are trade sherds, and serve to establish cross-dating with other Florida and southeastern horizons.

Beginning in this period we find low sand burial mounds. In fact, most of our information comes from the burial mounds; they attracted early investigation whereas the middens did not. As Goggin (1952:47) says, "the distinctive ceramic types are so scarce that they were not obtained in the desultory midden collecting of Wyman and Moore."

On the basis of the cultural traits reported from excavated burial mounds, Goggin (1952:48-50) divided the

St. Johns I Period into three sub-periods, as discussed below.

St. Johns Ia, early. In addition to the dominant St. Johns Plain and Dunns Creek Red pottery, trade sherds from the Deptford complex of Georgia are found. Local copies of tetrapods and stamping occur on chalky paste, particularly at the Tick Island mound and midden. Shell beads, bone pins, pendants, copper ornaments, elbow pipes, mica and galena bespeak of a developed ceremonialism and a wide network of contacts.

St. Johns Ia, late. Goggin (1952:49) found this the most difficult of his units to isolate. Most of the pottery types of the earlier sub-period persist, but early Swift Creek Complicated Stamped pottery is added. The strongest Hopewellian influences on the St. Johns valley occur at this time level (Ibid.). Copper discs, conjoined copper tubes, cymbal-shaped ear-spools are among the artifacts suggesting this relationship.

St. Johns Ib. "Late occupation in St. Johns I times is distinguished by trade wares from the west, mainly late variety Swift Creek Complicated Stamped and Weeden Island pottery, including Tucker Ridge Pinched. Together with the lack of check stamped these forms suggest that this period can be equated with Weeden Island I. St. Johns Plain and Dunns Creek Red are the local forms of pottery" (Goggin 1952:50). There is little to add to this characterization.

During St. Johns I times there is an apparent shift in population density from the upper reaches of the river to the lower river (Goggin 1952:48). The reason for this is not obvious, but it may relate to the increasing importance of horticulture during the period.

St. Johns II: A.D. 800-1650

This period is a continuation of the preceding, marked primarily by the introduction of St. Johns Check Stamped pottery. Goggin (1952:53-56) summarized the period and defined three sub-periods on the basis of seriation and cross-correlation. This was difficult because of the relative lack of foreign trade sherds. He found (Goggin 1952:53) that, "neither a well rounded picture of the whole period nor of the subperiods is available." The situation has not improved since 1952.

St. Johns IIa marks a time coeval with Weeden Island II and includes sites containing trade wares of that time. St. Johns IIb equates with early Fort Walton of northwest Florida and includes sites containing Mississippian traits. St. Johns IIc includes sites with European contact materials prior to the mid-seventeenth century. It is mainly known from intrusive burials and represents Timucua culture of the contact period.

St. Augustine Period

As originally defined by Smith (1948) this period is characterized by a ceramic complex originating on the Georgia coast and appearing in Florida about the middle of the seventeenth century. Goggin (1952:59) retains this limited definition as setting aside a definite historical segment of the Spanish-Indian tradition. Some recent authors have failed to recognize this restricted usage, and have used the term as a synonym for First Spanish Period historical sites in general.

Seminole Period

Goggin (1952:62-63) recognizes a Seminole Period for the area, but readily admits that there is little archeological evidence for it. Several historical sites have been located and tested, including the Spanish site of Fort Pupo (Goggin, 1951) and the site of Spalding's Upper Store from the British Period (Goggin 1949).

HISTORICAL NARRATIVE

Introduction

Documentary research yielded sufficient information to evaluate the historical significance of sites within the project tract. Within the subject area, including the three tentative pipeline corridors, eight indentifiable sites or locales of significance deserve attention, including two homestead sites which were noted during field work. Two "old fields," presumably linked with Indian habitation referenced in documents, seemed worthy of further investigation. Both are associated with tentative pipeline corridors rather than with the main portion of the projects tract. Near, but evidently not within, the survey tract, the site of a Second Seminole War (1835-42) encampment or fortification appeared on period maps. Three small nineteenth century settlements located outside, but in the vicinity of, the tract also deserved attention. In addition, roads trafficked in the nineteenth and early twentieth century crossed the project area and a railroad that contributed significantly to the post Civil War development of the region ran along the tract's western boundary. Finally, the area's proximity to Palatka, a community with deep historical roots, merits mention. Figure 3 shows those features in the study area. Further documentary investigation of these eight sites indicated that none are eligible for inclusion in the National Register of Historic Places on the basis of historical significance.

Historical Context

Exploration and settlement of Florida during the first period of Spanish occupation (1513-1763) focused elsewhere than in the project area. Discovery of the St. Johns River, an important interior water route, and of Indian trails across Florida meant that Spaniards in those two centuries became aware of the region in general terms. However, they made no attempt to establish in this area the missions which were the Spanish way of exploiting the interior resources and aboriginal inhabitants of Florida's interior.

With British occupation of Florida (1763-83) came the first true attempts at colonization of the peninsula. The St. Johns River attracted British travellers. Botanists John and William Bartram, father and son, visited Florida in the 1760's and recorded the flora along that waterway and in lands lying to the west of its middle portion. William did not go ashore in the tract area but commented on the vegetation along the west bank not far from the project area. He observed palm, beech, ash, sweetgum, magnolia,and hickory (Bartram 1958: Section 90, p. 58). Indian traders of the British period transported goods by river to store houses located on the St. Johns both above and below what is now Palatka, and familiarity with old Indian trails in that area increased. One Britisher about whom little information could be found claimed lands at

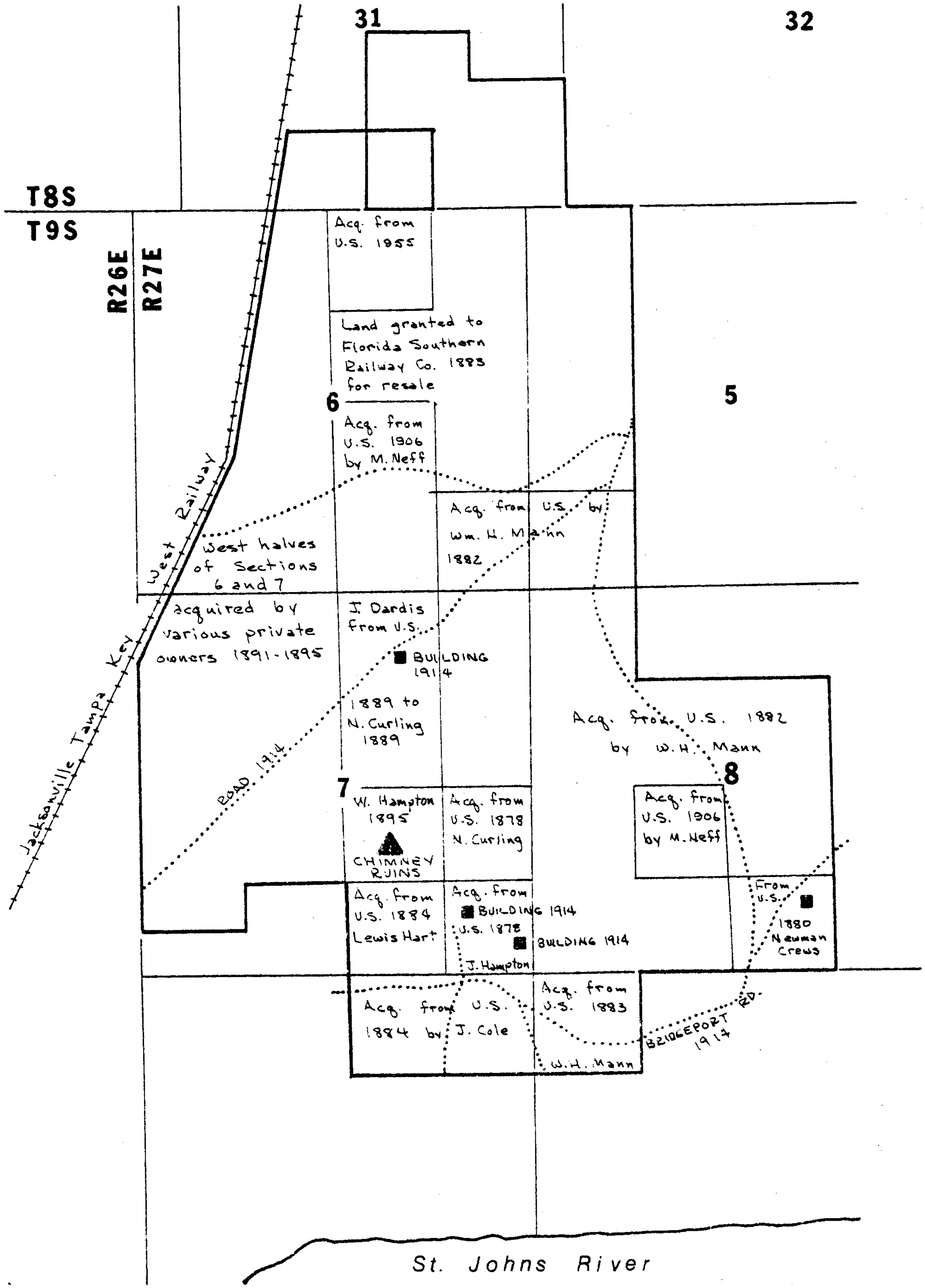


Figure 3: Historical Features showing first private land ownership, cultural features from 1914 map, and location of Hampton homestead chimney.

what is now Verdiere Point. Between 1766 and 1781, Langley Bryan, or Bryant, obtained from the British crown survey warrants and grants for several hundred acres of land (Siebert 1929:2, 115, n.85).

Interest in the fertile, heavily timbered lands along the St. Johns in the Palatka region continued after the Spanish regained possession of Florida in 1783. During the later years of the Second Spanish Period (1783-1821), the Spanish crown granted to Britishers and Americans many sizeable tracts of land along the river as plantations, cattle grazing lands, or timber tracts. Not all of them settled on their lands, but many retained possession of grants in their estates through adjudication after Florida became an American territory in 1821. Such a grant, comprising Section 51, Township 9 South, Range 27 East in the survey area, was awarded to George Fleming.

Fleming emigrated from Ireland to the American colonies in the mid-eighteenth century. He was employed by an established mercantile firm in his new home, Charleston, but was sent to St. Augustine and remained in Florida. Dates for these activities remain unclear, but apparently he lived in St. Augustine during the Revolutionary War period. After the Spanish government reestablished authority in Florida in 1783, George Fleming joined the Royal Spanish Colonial Army with the rank of captain. In return for such services, the Spanish crown granted military men land in the colony (Biddle 1974:20).

Fleming received several tracts of land in this way (Spanish Land Grants 3:125; Florida DNR, Land Records Section, Confirmed Land Grant File F 54). One of them -- Section 51 -- coincided with the Langley Bryan grant mentioned above. Several decades later, the American government confirmed Fleming's heirs in possession of his 1816 grant of "780 acres on the St. Johns River at Langley Bryan opposite Buena Vista fort" (Confirmed Land Grant File F 54). That small Spanish fortification served as a landmark on the east bank of the St. Johns along the Alachua ferry trail (see Spanish Land Grants 3:339, Con. C 80; 2:332, Con. C 70 and 333, Con. C 71; 1:304, Unc. T 2; 2:132, Con. A 45; 4:183, Con. P 25).

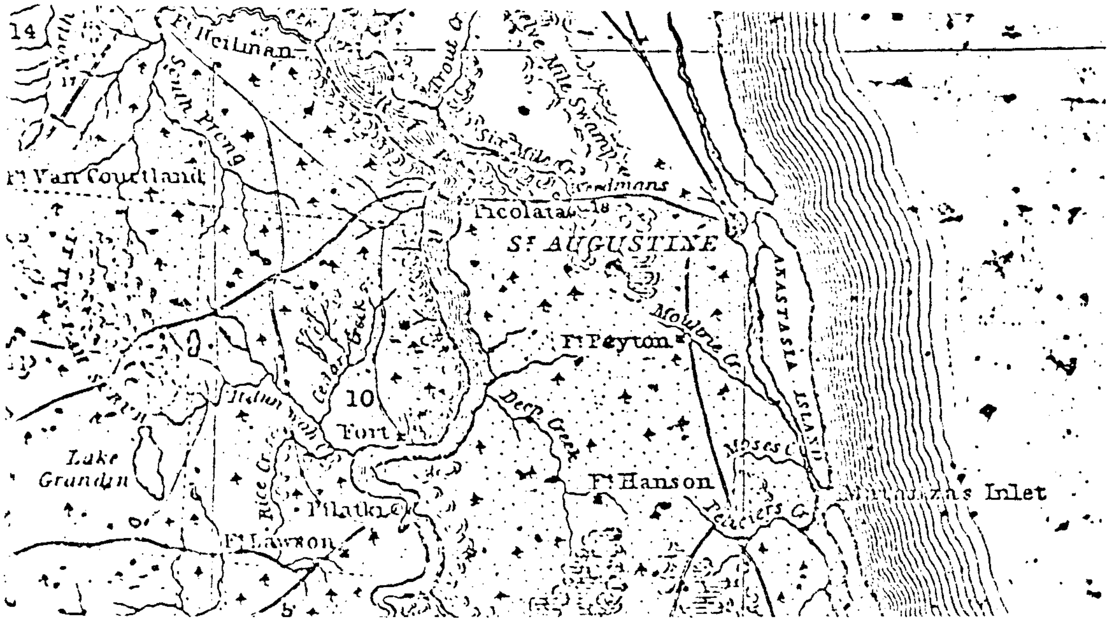
Documentation provides no evidence that Fleming ever visited his land. A plantation called Hibernia, located closer to the mouth of the St. Johns, which he obtained in 1790 served as the major rural estate of Fleming and his wife, a daughter of Don Francisco Fatio of St. Augustine, whom he married in 1791 (Biddle 1974:20, 23-24; Confirmed Land Grant F 54). Possibly his military service took him to the Buena Vista area along the trail from St. Augustine to the St. Johns crossing near present day Palatka. If so, he could well have noted the land he later received as a land grant.

The favored river crossing and the notable forest resources of the Palatka-Buena Vista area attracted others in the early nineteenth century. At the beginning of the Territorial Period in Florida history (1821-45), illegal cedar and live oak timbering occurred there; shipbuilders regarded the latter wood as indispensable to their craft (_Florida Territorial Papers_, 22:363, 378-79). A federally sponsored road from St. Augustine to Pensacola laid out in the mid-1820's failed to utilize the Palatka crossing, but travellers so preferred that route that it soon became even the official mail road (_Florida Territorial Papers_, 23:625-26, 735). Palatka received its post office in 1827, signifying the increase of activity in that area (_Florida Territorial Papers_, 24:782-83).

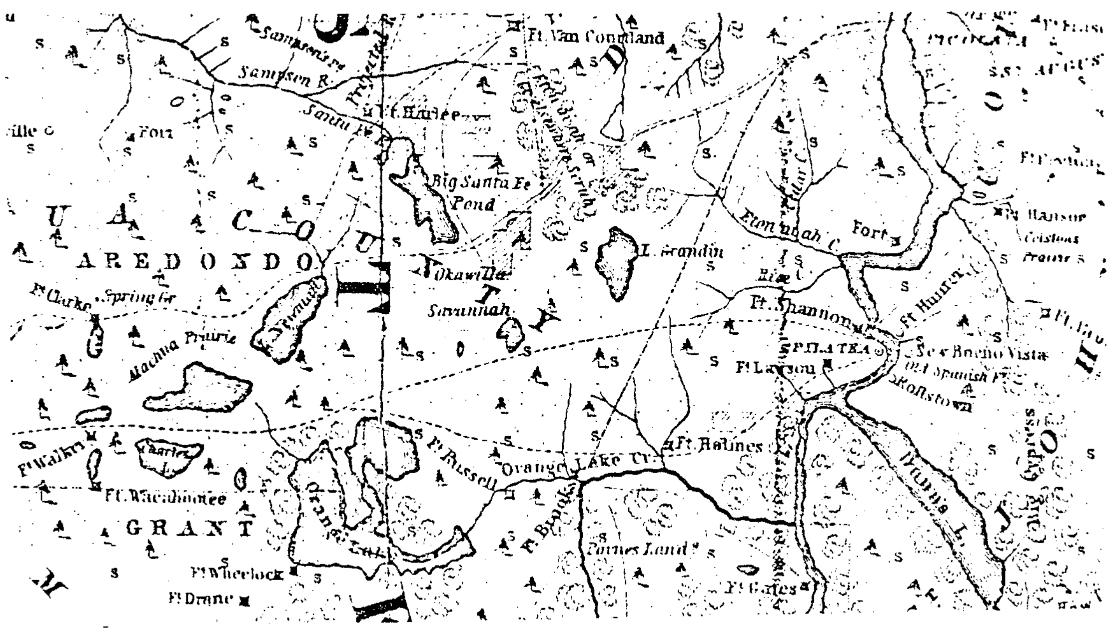
During the 1820's, the accelerated influx of white settlers to the northern part of the new territory resulted in the displacement of the region's Seminole Indian inhabitants to a reservation in central Florida. The Seminoles not only resented this action but also found the new environment unsuited to their accustomed way of life. Many American settlers desired the removal of the Indians to reservations west of the Mississippi River, an attitude supported by some U.S. government authorities. Tension between Seminoles and settlers heightened during the 1830's. Open warfare began at the end of 1835. In December of that year, Seminoles attacked and burned Palatka, causing its inhabitants to desert the community (_Florida Territorial Papers_, 25: 232-33). Although the focal point of the Second Seminole

War soon moved southward, the Palatka area remained involved in the hostilities -- a situation which affected settlement of the area.

A military post at Palatka itself, constructed, but perhaps temporarily abandoned, in 1838, served as an ordnance depot from 1840 to the war's end in 1842 ("Returns from U.S. Military Posts," Roll 1531; "Historical Information Relating to Military Posts," Roll 6). At the beginning of 1839, General Zachery Taylor, who at the time commanded U.S. troops in Florida, received approval for the establishment of a defensive network for northern and north central Florida. His plan, which called for the laying out of a number of squares eighteen miles to the side in the area to be defended was quickly implemented. In or near the middle of each square, a fortification was established as a base for a small garrison force responsible for that square. Square number ten included the project tract area. Its garrison encampment, referred to only as Fort Number Ten in military records, apparently stood on the banks of the St. Johns south of the project tract near Whetstone Point. Period maps indicate that it was located either just to the west of the mouth of Fish Creek or just east of that creek nearer Whetstone Point. (See "Historical Information Relating to Military Posts," Roll 7, and Figure 4).



Source: McKay, John and J. E. Blake, 1839. Map of the Seat of War in Florida.



Source: Bruff, J. B. and D. McClelland, 1846. The State of Florida.

Figure 4. Map References to Fort Ten

During 1839, the year in which Fort Number Ten presumably was established, public lands in the townships occupied by the project tract became available for purchase by individuals (Florida Territorial Papers, 25:594-96). However, land sales to individuals within the tract area actually began fifteen years later due to the upheavals of the Indian war. In 1854 and 1857, individuals obtained lands at the terminal points of alternate Corridors A and C, respectively (Florida DNR, Land Records Section, Tract Book 23:175-178). Documentation provides no evidence of any development of those tracts in that period; in both cases, the original owner apparently held the land idle until the 1880's before selling (Putnam County Deed Records, Book M: 297; Putnam County Tax Sales Lists, Book 1:80).

The major government survey plats for the project lands, completed in 1848-50, provide some data of interest. The plat maps of Township 9 South, Ranges 26 and 27 East and of Township 8 South, Range 27 East indicate no roads, no structures, nor any other man-made features of interest within the main section of the project tract. At the terminus of Corridor C, however, the 1848-50 plat of T 9 S, R 27 E depicts "old fields" presumably related to a former Indian habitation. Field notes (Florida DNR, Land Records Section, Field Notes, Vol. 181:366) made by surveyor Alexander McKay in 1849 while running section lines in that township document another "old field" located at about the point where the shared section line between Sections 10 and 11 (T 9 S, R 27 E) intersects the northern boundary of Section 51 (the old Fleming land grant). This locale is near, but not in, Corridor B. No further documentary evidence relating to these "old fields" was found.

In general, the surveyor described lands within the project tract as third rate pine lands interspersed with swamps which often contained cypress, or as second rate pine lands. No hammock lands occurred along the section lines in the relevant townships falling within the project tract (Florida DNR, Field Notes, Vol. 178:310, 317-18, 325-26, 333; Vol. 181:336-39, 352, 362, 364-66, 370-80).

With the exception of lands bordering the St. Johns River and one or two other tracts, no land within T 9 S, R 27 E, Sections 2-11, and 15-18 or T 8 S, R 27 E, Section 31 passed out of government ownership until 1879. In 1856, numerous unsold tracts of public land in those sections were patented to the state of Florida for sale under terms of an 1850 U.S. Congressional act. The patent granted Florida "all the 'swamp and overflowed lands' made unfit thereby for cultivation within the State of Florida which remained unsold [in 1850]." Similar patents in 1890 and 1894 made other lands in the area available to the state for sale. (See Florida DNR, Land Records Section, Patents to Swamp Lands, St. Augustine Series, Vol. 3, Patent 4 and Patents to Swamp Lands, Gainesville Series, Vol. 1, Patents 51 and 99).

The Civil War and resulting decade of social, political, and economic reconstruction slowed population growth and resource development all over Florida. Around 1880, the pace of economic life and immigration to Florida quickened. Investment of capital in railroad construction contributed greatly to this change. To encourage such activities, the state of Florida granted to railroad companies, sizeable amounts of land, the resale of which was expected to increase their capital. Florida Southern Railway, incorporated in 1879, received over two and a half million acres of land, about a section of which lay within the project tract area. Construction on that railroad, located outside the study area, began in 1881; its land sale offices were located in Palatka (Pettengill 1952:68; A Home in Florida 1883:21). Three years later, the Jacksonville, Tampa, and Key West Railway (incorporated 1881) came into Palatka, running just west of the project tract area (Pettengill 1952:80-81). Other area railroads drew traffic to the Palatka region during the 1880's, and steamboat activity on the St. Johns, of which Palatka was a focal point, increased during that decade (Pettengill 1952:103; Prince 1966:31).

In this region as in many parts of north central Florida, increased transportation facilities helped attract settlers. Land for citrus groves, utilization of forest resources (timber and naval stores, especially turpentine), and land for cattle grazing provided the main attractions. Palatka grew from a population of about 500 in 1869 to a population of about 800 in 1882 (Bill 1869:109; Barbour 1882:113).

Interest in the region northeast of Palatka, in which the project tract is located, mounted quickly reflecting peripheral activity related to the growth of Palatka and the region west of that community. Much of the land lying between the west boundary of the project area and the St. Johns River passed into private ownership between 1881 and 1885 (Tract Books).

Development focused on the river's banks where there was access to steamboat transportation. A traveller's guide published in 1879 listed Whetstone (variously, Whitestone) as a recognized steamer landing (Whitney's 1879:18, 20). At Verdier Point in 1883 could be found a post office, a store, a wharf or landing, and several "settlements" or houses (A Home in Florida 1883:39). At the same time, just a few miles to the north at about the point where the line between Township 8 and Township 9 South intersects the St. Johns River stood the new community of Bridgeport. The land there, first settled by Henry Henderson in 1847 (the appropriate 1848-50 survey plats depict Henderson's homestead), changed hands frequently during the mid-nineteenth century until Michael Renz of Bridgeport, Connecticut, bought "Henderson's" and surrounding lands, and platted lots for a town.

He made extensive plans for attracting industries, primarily those which would utilize local resources. In addition to a furniture factory, Renz also planned a "moss factory," probably a plant where mattresses and cushions were stuffed with Spanish moss. (A Home in Florida 1883:39; Webb 1885:92). These plans evidently failed, but Bridgeport remained an identifiable place until at least 1914 (See "Soil Map, Florida, Putnam County Sheet").

The timber and stock raising resources of the area continued to be exploited. In addition, Verdiere Point in 1885 was depicted as being the "centre of a fruit growing section" by a Florida gazeteer editor who usually presented a generous interpretation of Florida's resources (Webb 1885:92, 96; see also A Home in Florida 1883:39). The activities of a major buyer of land in the area, William H. Mann, reflect the pattern of speculative land investments operative in central Florida in the late nineteenth century. Mann acquired rather extensive acreage in Putnam County (created 1847) and established a little town, Mannville, on the Florida Southern Railway fifteen miles west of Palatka. He sold land there in 10-acre tracts for orange groves and also operated a sawmill (Webb 1885:94). Presumably he foresaw similar development opportunities in the project tract area, for in the early 1880's he acquired from the state lands there amounting to almost a section (see Florida DNR, Tract Books). He failed to achieve his goal of attracting settlers to that area.

Turpentining, lumbering, and stock raising appear to have been the main pursuits in the late nineteenth century in the region. Putnam County official records reflect instances of leases granted by tract owners for turpentining or lumbering privileges. The well known freeze of 1894-95 forced citrus growers to seek a more moderate climate farther south in Florida for their groves; if there were any groves in the tract area (documents consulted contain no evidence), they too would have suffered. County deed and tax records too numerous to itemize indicate that land in the area tended to change hands without significant development, especially in terms of structures. In numerous cases, properties simply appear on the county's lists of lands to be sold to meet delinquent taxes. Often the state of Florida repurchased them; in other cases, a single buyer acquired numerous such tracts at low prices. In a few cases, family members redeemed properties lost by relatives through failure to pay taxes. World War I resulted in disruptions in Florida's forest industries. Predictably, tax sales became more numerous during the depression years which in Florida began in the late 1920's and stretched into the 1930's. During the last half century, nothing transpired which lent historical significance to the project tract area.

Field surveys conducted as part of this project located what appeared to be two homestead sites within the project area. Subsequent documentary research produced limited data about the sites in question.

One of the homestead sites is located in the southeast quarter of Section 7, Township 9 South, Range 27 East, evidently in the southeast quarter of that quarter section. A search of Putnam County deed and tax records indicated that John Hampton, the first private owner, obtained the SE¼ of the SE¼ of Section 7 in 1878 (Florida DNR, Tract Book 23:174). Apparently he retained the property until his death, which must have occurred about 1905. In that year, four persons named Hampton, presumably John Hampton's heirs, sold the land in question to Mrs. Emma McClain, at that time a resident of Putnam County but later a resident of St. Augustine. The conveyance listed tenements as part of the transaction (Putnam County Deed Records, Book 52:168). The property later appeared on a 1930 tax sale list; subsequent transactions were not researched (Putnam County Tax Sales Lists, Book 7, Sale of August 4, 1930). It seems highly probable that John Hampton made his home on the SE¼ of the SE¼, Section 7, which he purchased in 1878. Another reasonable assumption is that the property was not used as a homestead by subsequent owners.

Evidence concerning the chain of events on one adjacent tract, the NE¼ of the SE¼ of Section 7, is inconclusive. Newman D. Curling obtained the property in 1878; the next year, he sold it to John Steele. That deed references the presence of tenements, etc. on the property. However, since Curling paid a dollar an acre for the property, which was just shy of forty acres, but sold it to Steele for only $45.00, it seems unlikely that his improvements included a house (Florida DNR, Tract Book 23:174; Putnam County Deed Records, Book H:626 and Book I:613). Research failed to locate records of any further transactions related to that property. Another adjacent tract, the NW¼ of the SE¼, Section 7, finally passed out of public ownership in 1895. Wade Hampton (see above) acquired the tract in that year and sold it to Mrs. McClain in 1897 without constructing appurtenances (Florida DNR, Tract Book 23:174; Putnam County Deed Records, Book 34:123). In 1948, there still were no buildings on this property (Putnam County Official Records, Book 179:286). The remaining contiguous property in Section 7, the SW¼ of the SE¼, became the property of Lewis Hart in 1884 (Florida DNR, Tract Book 23:174). Apparently he retained the property, perhaps as a homestead, for some time. Putnam County deed and tax records contain little relevant evidence. In 1903 and again in 1913, Mary J. Hart, wife and by then perhaps widow of Lewis, leased the land to various interests (Putnam County Mortgage, Lease Records, Book D:261 and Putnam County Deed Records, Book 59:182). No other information could be found to elucidate this matter.

The other homestead site located through field surveys apparently lay in the SW¼ of the SE¼ of Section 8, Township 9

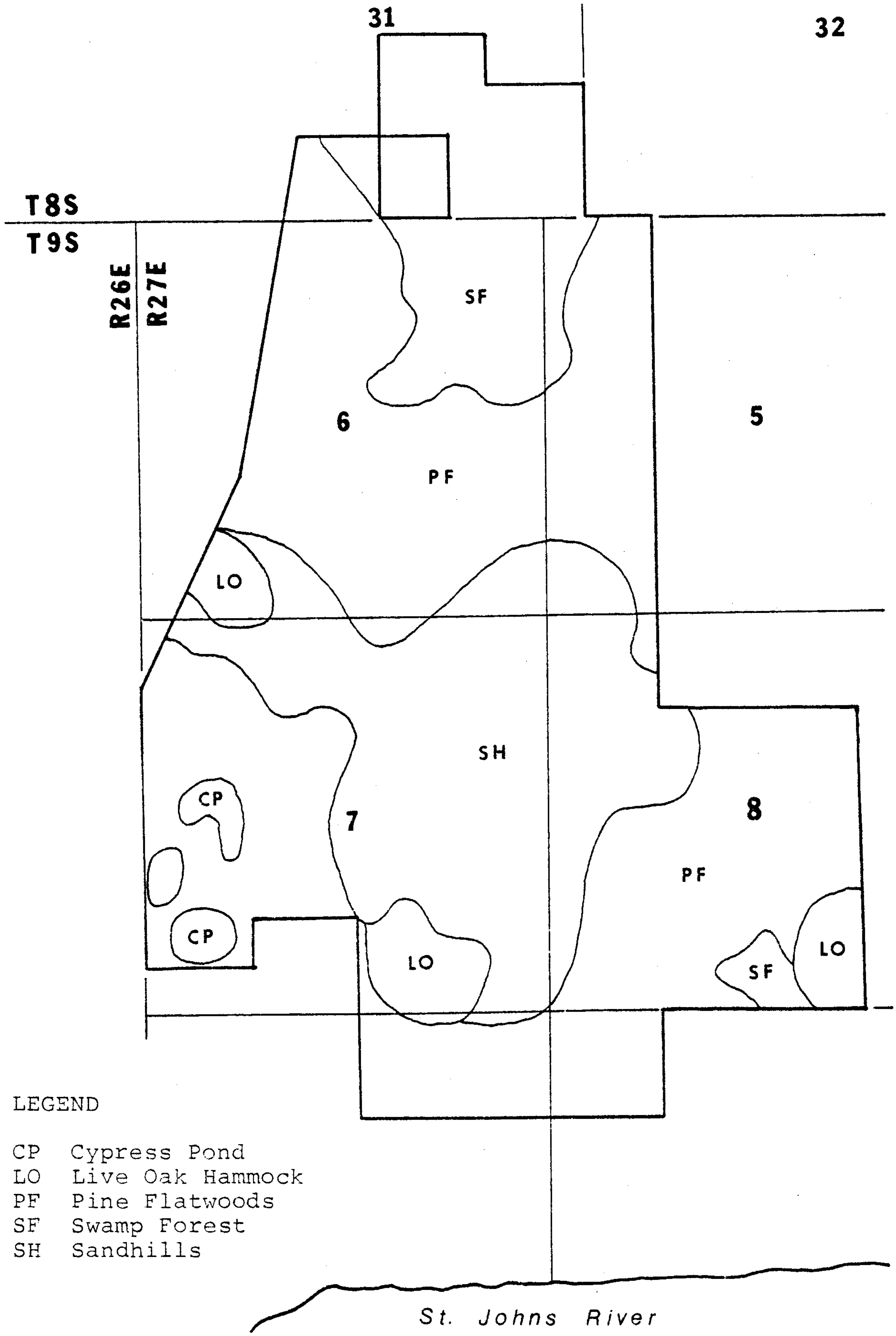
South, Range 27 East. Newman C. Crews obtained this property in 1880 as its first private owner (Florida DNR, Tract Book 23:174). Evidently it became his homestead. Crews died in 1911; his estate included a sizeable herd of cattle, so presumably he raised stock there (Putnam County Probate Records, File 1332). In 1920, Crews' heirs put the property up for tax sale (Putnam County Tax Sales List, Book 5:623). Contiguous properties in Section 8 were acquired by William H. Mann (see above) in 1882 (NW¼ of SE¼) and by Florida Southern Railway Company (see above) in 1883 (SE¼ of SE¼). The remaining quarter section (NE¼ of SE¼) remained public property until 1953 (Florida DNR, Tract Book 23:174).

ENVIRONMENT

While existing local and regional environmental conditions are assessed in other sections of the impact statement, it is worthwhile to review this information as it applies to the distribution of archeological and historical sites. We have already noted that all 13 recorded prehistoric sites known within a study area covering 50 square miles are situated on the banks of the St. Johns River or its major tributaries. However, there is some suggestion that horticulture may have been an important prehistoric adaptation on the lower river north of Palatka. Besides judging site potential of landscape types on the tract from the point of view of cultivation, we may also consider more general environmental characteristics such as drainage, microclimate, or relief.

Various classifications of environmental zones have been published; the following discussion is based on soil types, land use and cover, and interpretation of aerial photography. Figure 5 shows present distribution of vegetation types on the survey tract. Six gross categories can be recognized: sandhills, pine flatwoods, live oak hammock, swamp forest, and cypress ponds.

Sandhills comprise a single large area in the center of the tract having a well defined, steeply sloped boundary and elevations to 85 feet. Geologically this represents the the southern limit of the Duval Upland modified locally by



LEGEND

CP Cypress Pond
LO Live Oak Hammock
PF Pine Flatwoods
SF Swamp Forest
SH Sandhills

Figure 5. Vegetation Zones

the additional elevation of Teasdale Hill, a remnant of the Penholoway Terrace (White 1970:Pl. 1-B). The soil here is Norfolk fine sand, an excessively drained sandy type occurring on most of the ridges and rolling hills in the vicinity. Longleaf pine is the original vegetation with little or no undergrowth until the land is cleared; then blackjack oak becomes condominant with second growth pines. The soil is too dry for successful cultivation. This zone afforded excellent soil exposure during the survey since it had been recently timbered. Its site potential is usually considered low.

Pine flatwoods cover an approximately equal area distributed at elevations between the sandhills and low lying swamps. Portsmouth fine sand is the characteristic soil, occurring mostly in poorly drained areas. As the surface is flat it may have standing water for much of the year. Original vegetation is longleaf pine with some slash pine and much thick undergrowth consisting of scrub saw palmetto, gallberry, wire grass, and broom sedge. This vegetation is sometimes impenetrable but recent timbering allowed good access during the survey. Particular attention was paid to the narrow ecotone between the sandhills and flatwoods searching for evidence of occupation associated with moderate transitional drainage; none was found.

Live oak hammocks occur sporadically across the property. They are not mapped in the 1914 soil survey although equal or greater in size than mapped cypress ponds. Their distribution, one in the pine flatwoods, two in the sandhills, suggests that the community may develop in association with human occupation and prevention of fire. Soil is still dry and sandy, excessively drained. All evidence of historic occupation was found in live oak hammocks consisting of three possible homesteads.

Swamp forest occurs in low lying, permanently flooded locales usually associated with creek or river drainage. Muck is the characteristic soil reaching ten feet deep in the extreme case, but usually one to three feet deep. Hydrophytic hardwoods are the characteristic vegetation, particularly red bay, gum, red maple, and some cypress. Without extensive modification for drainage the soil is neither suitable for cultivation nor habitation. On the survey tract swamp forest covers a small area at the head of Fish Creek and occupies a 1/4 Section or so at the north end.

Cypress ponds are of two types: small circular depressions usually resulting from solution of underlying limestone, and larger stands occurring in association with drainage courses. Nearly a dozen of the smaller ponds are found on the sandhills along the west boundary. These have been found in other regions to have high site potential, representing, perhaps, valuable water sources during times of lower water tables. All of these ponds were examined for cultural material at their margins; some were even well exposed in the interior by logging trails, but no cultural material could be found.

In sum, it can be seen that the tract offered little in the way of desirable habitat for prehistoric Indians. Late nineteenth-early twentieth settlement is found today in association with one vegetation type, live oak hammock. Such locations were probably preferred, but it is also likely that human habitation served to maintain the fire susceptible association. Not surprisingly, most activity occurred along the St. Johns where transportation, soils, climate, and vegetation were more favorable.

SURVEY RESULTS

Field work on the Seminole tract and corridors resulted in the identification of three homesteads dating from the turn of the century and discovery of two previously unrecorded prehistoric shell middens.

In the NW¼ of SE¼ of Section 7 was found the most visible remains of historic occupation comprising the brick foundation of a house fireplace. Additional evidence consisted of scattered brick and metal, as well as a recently exposed trash pit dating from the early twentieth century. Property records suggest this land was occupied by W. Hampton no earlier than 1895. No building is shown in this location on the 1914 soil map, so it may be even younger.

In an adjacent 40-acre parcel, SE¼ of SE¼ of Section 7, the Hampton homestead was located. Like the previous one, this site is situated in a mature live oak hammock affording a pleasant surrounding and a somewhat moderate microclimate compared to nearby sandhills and pine flatwoods. Evidence for habitation was sparse consisting only of scattered artifacts typical of turn of the century farmsteads. Bottle glass, transfer ware ceramics, metal, and portions of a wood stove were located but not collected. The property was acquired from the U.S. government in 1878; two buildings and a short section of dirt road are indicated on the 1914 map.

The last homestead, located also in a live oak hammock, was found in the southeast corner of the tract in the SW¼ of SE¼ of Section 8. Newman Crews obtained a 40-acre parcel from the U.S. in 1880. One house and part of two roads are shown on the soil map. Artifacts were scarce; only metal fragments and a few bricks could be found. Remains of fencerows, and distribution of secondary vegetation seres, indicated old fields and some layout of the farmstead. Better information was obtained from the 1943 aerial photography which showed a cleared field but no structures.

None of the above properties are considered worthy of National Register nomination. Two prehistoric sites on the river, however, contain more tangible remains, and being likely to yield information important in prehistory, must be considered eligible for inclusion in the Register.

The first of these, called Walker Point and assigned the number 8Pu107 in the Florida Master Site File, was found exposed in the cut river bank. This freshwater shell midden is located at the obvious but unnamed point 1800 feet downstream from Verdiere Point. The site is named after the present owner of the property. Visible remains consist of 2 to 3 feet of shell midden consisting primarily of <u>Viviparous georgianus</u> shells at or just below the surface. The bank is actively eroding and, based on posthole tests and exposure in the banks, the site is estimated to be less than an acre in size. No artifacts were found during the survey, but a local collector, Mrs. Kelly Smith, reported finding plain and check stamped chalky pottery.

A similar, but larger, midden was found at the next point upriver long known as Verdiere Point. It is interesting that in this region at least points or projections of the river bank are absolutely correlated with shell mounds. Two explanations are likely: one, that such points existed as natural features during the prehistoric period and were favored as settlement locations, perhaps due to their elevation, exposure to breezes, or advantageous field of view. Alternatively, points may have been more recently formed due to the relative resistance of hard packed shell to erosion. While the latter explanation could be more likely applied to other sites upriver, especially where shell has been cemented into a hard basal zone, it does not seem to apply at Verdiere or Walker Points. Here the shell zone at the present time is as much as 10 feet above water level and would have no effect upon erosion of the underlying sediments. At Verdiere Point a nearly consolidated, dark red layer of sandy clay seems to be the resistant zone responsible for protection of the point.

The midden at Verdiere Point, 8Pu108, is again composed mostly of small snail shells with some larger

Pomacea sp. Two chalky, plain sherds were found but not collected. To prevent impact at either of these two sites it is recommended that alternative Corridor B not be used.

RECOMMENDATIONS

As has been evident in the preceding discussion little of historic or archeological interest was found on the subject tract. The historical survey revealed eight identifiable sites or locales meriting attention, two of which comprise the only historic remains on the tract discovered during the field survey. Finally, two additional prehistoric sites were found on the banks of the St. Johns near Verdiere Point in the path of Corridor B. All these resources are listed below with comments.

Nature	Location	Remarks
"old fields"	Corridor C	Not located; not significant.
Fort 10	Near Fish Creek	Not located; outside project area.
Whetstone	St. Johns River	Outside project area.
Verdiere Point	Corridor B	Reject Corridor.
Bridgeport	St. Johns River	Outside project area.
Hampton homestead	SE¼ of SE¼ Section 7	Little remaining evidence; not NR eligible.
Hart homestead	SW¼ of SE¼ Section 7	Little remaining evidence; not NR eligible.
Crews homestead	SW¼ of SE¼ Section 7	Little remaining evidence; not NR eligible.
early dirt roads		Obliterated; not significant.
Jacksonville, Tampa & Key West Railway	West boundary of tract	No impact; not NR eligible.

Nature	Location	Remarks
Verdiere Point Midden	Corridor B	NR eligible; reject Corridor.
Walker Point Midden	Corridor B	NR eligible; reject Corridor.

The only resources found during the study which may be considered eligible for inclusion in the National Register of Historic Places are two freshwater shell middens on the St. Johns River at Verdiere and Walker Points. On this basis it is recommended that Corridor B be removed from further consideration.

BIBLIOGRAPHY

Aten, Lawrence E. "Excavation and Salvage at Starks Hammock, Volusia County, Florida." Florida Anthropologist 14(1961): 37-45.

Barbour, George M. Florida for Tourists, Invalids, and Settlers... . New York: D. Appleton and Co., 1882. Facsimile edition. Floridiana Facsimile and Reprint Series. Gainesville: University of Florida Press, 1964.

Bartram, William. The Travels of William Bartram. Edited by Francis Harper. Naturalists Edition. New Haven: Yale University Press, 1958.

Biddle, Margaret Seton Fleming. Hibernia: The Unreturning Tide. New York: Vantage Press, 1974.

Bill, Ledyard. A Winter in Florida... . New York: Wood and Holbrook, 1869.

Brinton, Daniel G. Notes on the Floridian Peninsula, its Literary History, Indian Tribes and Antiquities. Philadelphia: Joseph Sabin, 1859.

Bullen, Ripley P. "The Earliest Pottery in Southeastern United States, 2000-1000 B.C., and Its Case as an Independent Invention." In Des Actes du VI° Congrès International des Sciences Anthropologiques et Ethnologiques, Tomo 2 (1960), (1er vol.) pp. 363-367.

Bullen, Ripley P. Excavations at Sunday Bluff, Florida. Contributions of the Florida State Museum, Social Sciences, no. 15. Gainesville: University of Florida, 1969.

Bullen, Ripley P. "Indian Burials at Tick Island." Yearbook of the American Philosophical Society, 1961, pp. 477-480.

Bullen, Ripley P. "The Orange Period of Peninsular Florida." In Fiber-tempered Pottery in Southeastern United States and Northern Colombia: Its Origins, Context, and Significance. Edited by Ripley P. Bullen and James B. Stoltman, pp. 9-33. Florida Anthropological Society Publications, no. 6. Gainesville: Florida Anthropological Society, 1972.

Bullen, Ripley P. "Stratigraphic Tests at Bluffton, Volusia County, Florida." Florida Anthropologist 8(1955):1-16.

Bullen, Ripley P. "The Transitional Period of Florida." Southeastern Archaeological Conference Newsletter 6(1959): 43-62.

Bullen, Ripley P., and William J. Bryant. Three Archaic Sites in the Ocala National Forest, Florida. William L. Bryant Foundation, American Studies Report, no. 6. Orlando: n.p., 1965.

Bullen, Ripley P., and James B. Stoltman, eds. Fiber-tempered Pottery in Southeastern United States and Northern Colombia: Its Origins, Context, and Significance. Florida Anthropological Society Publications, no. 6. Gainesville: Florida Anthropological Society, 1972.

Carlson, Charlie, Jr. "The Marshall Bluff Site." Florida Anthropologist 14(1961):81-83.

Carter, Clarence Edwin, ed. The Territorial Papers of the United States. Vol. 22-26. The Territory of Florida. Washington, D.C.: U.S. Government Printing Office, 1956-1962. Referenced in text as Florida Territorial Papers.

Chatelain, Verne E. The Defenses of Spanish Florida, 1565 to 1763. Carnegie Institute of Washington Publication 511. Washington, D.C.: Carnegie Institute of Washington, 1941.

Cumbaa, Stephen L. "A Reconsideration of Freshwater Shellfish Exploitation in the Florida Archaic." Florida Anthropologist 29(1976):49-59.

Cumbaa, Stephen L. and Thomas H. Gouchnour. "The Colby Site, Marion County, Florida." Florida Anthropologist 23(1970):43-56.

Ford, James A. A Comparison of Formative Cultures in the Americas, Diffusion or the Psychic Unity of Man. Smithsonian Contributions to Anthropology, vol. 2. Washington, D.C.: Smithsonian Institution Press, 1969.

Ford, James A. "Early Formative Cultures in Georgia and Florida." American Antiquity 31(1966):781-799.

Goggin, John M. "Florida Archeology and Recent Ecological Changes." Journal of the Washington Academy of Sciences 38(1948):225-233.

Goggin, John M. "A Florida Indian Trading Post, Circa 1763-1784." Southern Indian Studies 1(1949):35-38.

Goggin, John M. "Fort Pupo: A Spanish Frontier Outpost." Florida Historical Quarterly 30(1951):139-192.

Goggin, John M. "A Preliminary Definition of Archaeological Areas and Periods in Florida." American Antiquity 13(1947):114-127.

Goggin, John M. Space and Time Perspective in Northern St. Johns Archeology, Florida. Yale University Publications in Anthropology, no. 47. New Haven: Yale University Press, 1952.

Griffin, James B. "The Significance of the Fiber-tempered Pottery of the St. Johns Area in Florida." Journal of the Washington Academy of Sciences 35(1945):218-223.

Haven, Samuel B. Archaeology of the United States. Smithsonian Institution Contributions to Knowledge. Washington, D.C.: Smithsonian Institution, 1856.

A Home in Florida. Description of Putnam County, Florida... Palatka: Putnam County Journal, 1883.

Hoole, W. Stanley. "East Florida in 1834: Letters of Dr. John Durkee." Florida Historical Quarterly 52(1974): 294-308.

Hrdlicka, Ales. Skeletal Remains Suggesting or Attributed to Early Man in North America. Bureau of American Ethnology, Bulletin 33. Washington, D.C.: Bureau of American Ethnology, 1907.

Jacksonville Area Planning Board. Regional Land Use Element, Land Use/Cover Analysis, Northeast Florida. Jacksonville: Jacksonville Area Planning Board, 1977.

LeBaron, J. Francis. "Prehistoric Remains in Florida." Smithsonian Institution--Annual Report for 1882. Washington, D.C.: U.S. Government Printing Office, 1884.

Mahan, John K. History of the Second Seminole War, 1835-1842. Gainesville: University of Florida Press, 1967.

Moore, Clarence B. "A Burial Mound of Florida." American Naturalist 26(1892):128-143.

Moore, Clarence B. "Certain River Mounds of Duval County, Florida." Journal of the Academy of Natural Sciences, n.s., 10(1895):449-502.

Moore, Clarence B. "Certain Sand Mounds of the Ocklawaha River, Florida." Journal of the Academy of Natural Sciences, n.s., 10(1895):518-543.

Moore, Clarence B. "Certain Sand Mounds of the St. Johns River, Florida," Part 1. Journal of the Academy of Natural Sciences, n.s., 10(1894):5-105.

Moore, Clarence B. "Certain Sand Mounds of the St. Johns River, Florida," Part 2. Journal of the Academy of Natural Sciences, n.s., 10(1894):129-246.

Moore, Clarence B. "Certain Shell Heaps of the St. Johns River, Florida, Hitherto Unexplored." American Naturalist 26(1892):912-922.

Moore, Clarence B. "Certain Shell Heaps of the St. Johns River, Florida, Hitherto Unexplored." American Naturalist 27(1893):8-13, 113-117, 605-624, 709-733.

Moore, Clarence B. "Certain Shell Heaps of the St. Johns River, Florida, Hitherto Unexplored." American Naturalist 28(1894):15-26.

Moore, Clarence B. "Supplementary Investigation at Tick Island." American Naturalist 26(1892):568-579.

Moore, Clarence B. "Two Mounds on Murphy Island, Florida." Journal of the Academy of Natural Sciences, n.s., 10(1895):503-516.

Neill, Wilfred T. "A Stratified Early Site at Silver Springs, Florida." Florida Anthropologist 11(1958):33-49.

Neill, Wilfred T., H. James Gut, and Pierce Brodkorb. "Animal Remains from Four Preceramic Sites in Florida." American Antiquity 21(1956):383-395.

Nelson, N. C. "Chronology in Florida." Anthropological Papers of the American Museum of Natural History 22(1918): 73-103.

Palatka Board of Trade. Palatka, Putnam County, Florida: The Gem City. n.p., n.d.

Palatka, Florida. Office of County Court Clerk, Putnam County. Deed Records. Book H:626; Book I:613; Book M: 297; Book 34:123; Book 52:168; Book 59:182.

Palatka, Florida. Office of County Court Clerk, Putnam County. Mortgage, Lease Records. Book D:261.

Palatka, Florida. Office of County Court Clerk, Putnam County. Probate Records. File 1332.

Palatka, Florida. Office of County Court Clerk, Putnam County. Putnam County Official Records. Book 179:286.

Palatka, Florida. Office of County Court Clerk, Putnam County. Tax Sales Lists. Book 1:80; Book 5:623; Book 7.

Pettengill, George W.J. The Story of the Florida Railroads. The Railway and Locomotive Historical Society Bulletin, no. 86. Boston: The Railway and Locomotive Historical Society, 1952.

Prince, Richard E. Atlantic Coast Line Railroad: Steam Locomotives, Ships, and History. Green River, WY: Published by author, 1966.

Rouse, Irving. A Survey of Indian River Archeology, Florida. Yale University Publications in Anthropology, no. 44. New Haven: Yale University Press, 1951.

Sears, W.H. "The Bluffton Burial Mound." Florida Anthropologist 13(1960):55-60.

Siebert, Wilbur Henry. Loyalists in East Florida, 1774 to 1785. Volume 2. De Land, FL: The Florida State Historical Society, 1929.

Smith, Hale G. "Two Historical Archaeological Periods in Florida." American Antiquity 13(1948):313-319.

Spanish Land Grants in Florida. Vol. 1-5. Compiled by Works Projects Administration, Division of Community Service Program, Historical Records Survey. Jacksonville, 1941.

Tallahassee, Florida. Department of Natural Resources, Land Records Section. Field Notes. Vol. 178, 181. Located in Elliot Building.

Tallahassee, Florida. Department of Natural Resources, Land Records Section. Spanish Land Grant Files. File Confirmed F 54. Located in Elliot Building.

Tallahassee, Florida. Department of Natural Resources, Land Records Section. Survey Plats. Township 9 South, Range 26 East. Township 9 South, Range 27 East, Township 8 South, Range 27 East. Located in Elliot Building.

Tallahassee, Florida. Department of Natural Resources, Land Records Section. Tract Books. Vol. 22 and 23. Located in Elliot Building.

Tallahassee, Florida. Department of Natural Resources, Land Records Section. U.S. Patents to Swamp Lands. Gainesville Series, Vol. 1 and St. Augustine Series, Vol. 3. Located in Elliot Building.

Tolles, Zonira Hunter. Shadows on the Sand. Gainesville, FL:n.p., 1976. History of part of Putnam County.

U.S. National Archives. Historical Information Relating to Military Posts and Other Installations ca. 1700-1900. National Archives Microfilm Publications. Microcopy 661.

U.S. National Archives. Returns from U.S. Military Posts, 1800-1916. National Archives Microfilm Publication. Microcopy 617.

Vignoles, Charles. The History of the Floridas. . . . Brooklyn:n.p., 1824.

Waller, Ben I., and James Dunbar. "Distribution of Paleo-Indian Projectiles in Florida." Florida Anthropologist 30(1977):79-80.

Webb, Wanton S., editor and compiler. Webb's Florida: Historical, Industrial and Biographical. Part I. New York: W.S. Webb and Co., 1885.

White, William A. The Geomorphology of the Florida Peninsula. Geological Bulletin, no. 51. Tallahassee: Bureau of Geology, 1970.

Whitney's Florida Pathfinder. New York: John P. Whitney, 1879.

Willis, Raymond F. Archaeological Excavations in the Alexander Springs Recreation Area, Ocala National Forest. Miscellaneous Project Report Series, no. 1. Tallahassee: Division of Archives, History and Records Management, 1972.

Willis, Raymond F. Archaeological and Historical Inventory of the Ocala National Forest. Miscellaneous Project Report Series, no. 2. Tallahassee: Division of Archives, History and Records Management, 1972.

Willis, Raymond F. and Sharon Wells. Archaeological and Historical Survey of the Southeastern Portion of the Ocala National Forest, Marion and Lake Counties, Florida. Miscellaneous Project Report Series, no. 41. Tallahassee: Division of Archives, History and Records Management, 1977.

Wyman, Jeffries. An Account of the Fresh-Water Shell-Heaps of the St. Johns River, East Florida. Reprinted from the American Naturalist, vol. 2. Salem, MA: Essex Institute Press, 1868.

Wyman, Jeffries. Fresh-Water Shell Mounds of the St. Johns River, Florida. Peabody Academy of Science, Memoirs, no. 4. Salem MA: Peabody Academy of Science, 1875.

Maps

Bruff, J. Goldsborough, and D. McClelland. "The State of Florida." Compiled in the Bureau of Topographical Engineers from the best authorities. 1846.

MacKay, John and J. E. Blake. "Map of the Seat of War in Florida." Compiled by Order of Bvt. Brig. Genl. Z. Taylor, . . . Headquarters, Army of the South. U. S. Topographical Engineers. 1839.

U. S. Bureau of Soils. "Soil Map, Florida, Putnam County Sheet." 1914.

U. S. Coast Survey Office. "Northern Part of Florida." 1864.

U. S. Geological Survey. Quadrangle Sheets, 7.5', 1:24,000, "Bostwick, Fla." 1949 PR 1970; "Riverdale, Fla." 1949 PR 1970; "Hastings, Fla." 1968; "Palatka, Fla." 1968.

Aerial Photographs

Putnam County, 1943. Code CYZ, Scale 1:20,000, Flown by Abrams Aerial Surveys. Prints 1C-100 to 103; 120 to 123; 173 to 175; 193 to 196. Copies on file at Florida Dept. of Transportation, Tallahassee, Florida.

Putnam County, 1972. Scale 1:15,840, Soil Conservation Service. Print 12107 172-142. Copy on file, Dames and Moore, Atlanta.

Putnam County, 1975. Scale 1:2400 and 1:4800, Florida Dept. of Revenue. Prints VM-16 773 and 825. Copies available at Putnam County Courthouse.

SITE SELECTION STUDY

APPENDIX K

SITE SELECTION STUDY

EXECUTIVE SUMMARY

SEMINOLE ELECTRIC COOPERATIVE, INCORPORATED

APRIL, 1977

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STANLEY CONSULTANTS

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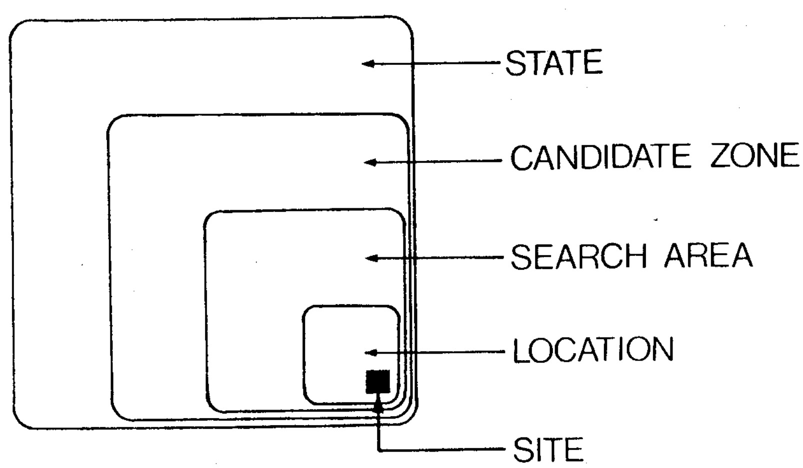
SYNOPSIS

Purpose

The purpose of this study is to identify and evaluate locations containing sites suitable for two 600 MW coal-fired generating units to be constructed by Seminole Electric Cooperative, Incorporated. With this location information, land options can be obtained and the final phase of identifying and evaluating a specific site for certification can begin.

The process by which the state of Florida is continually refined until a site acceptable for power plant construction is identified is graphically depicted below. This diagram will also serve as a key to the geographic units referred to in this report.



Summary

Starting with the entire state of Florida, information was gathered and analyzed that allowed identification of zones within the state that contained the positive factors of adequate water availability and reasonable transportation and transmission access necessary for power plant siting. Using a system of overlays for a base map of Florida, zones containing these positive factors were shown.

These zones were then reduced by applying information concerning the modifying factors of air quality, sensitive areas, prime agricultural lands and expected land use. The resulting areas, having reasonable access to the Seminole service area, became the search area within which further evaluations were conducted.

The search area was reviewed using detailed maps and information and 53 locations, defined as 36-square-mile areas, were identified. As the result of grouping and further detailed evaluations, 11 highly satisfactory locations were identified.

To provide discrimination between these 11 locations, or any other locations identified, the four basic criteria of water, transportation, transmission, and environment were expanded and weighted by a modified Delphi-structured decision-making process performed by discipline specialists within Stanley Consultants. The result was a highly quantifiable detailed criteria specifically suited to the Seminole site selection effort.

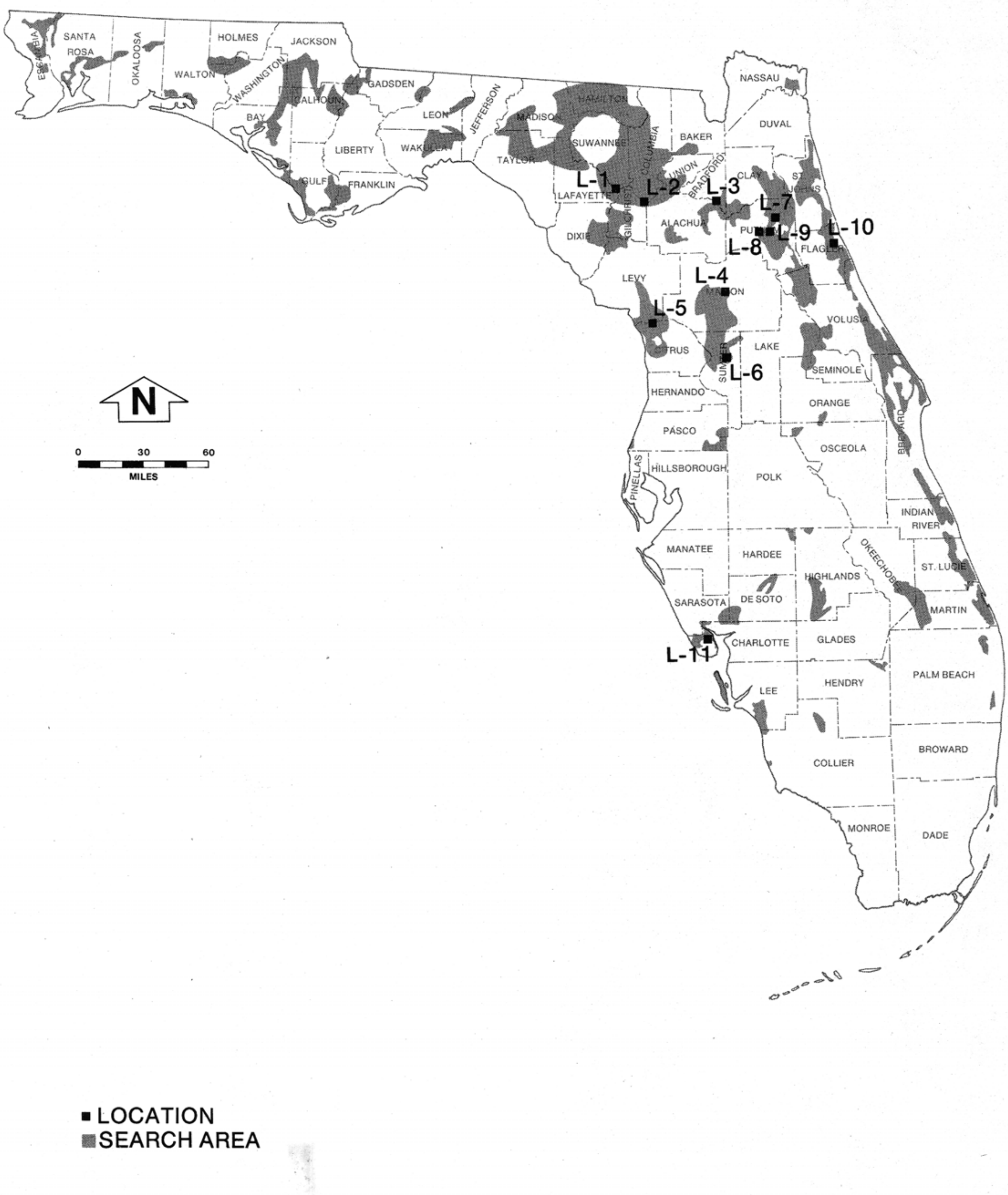
The 11 locations selected were then evaluated by applying the detailed criteria developed, cursory site inspections were performed, and an informal review of results obtained was conducted with the state of Florida, Department of State Planning, and Department of Environmental Regulation.

This overall evaluation process resulted in identification and grouping of the following 11 locations:

Group A	Group B	Group C
L-7 - Bostwick	L-2 - High Springs	L-11 - Charlotte Harbor
L-1 - Branford	L-5 - Lake Rousseau	L-10 - Flagler
L-6 - Bushnell	L-3 - Santa Fe	L-8 - Rodman
L-9 - Satsuma	L-4 - Silver Springs	

Figure 1 shows these locations within the defined search area. Appendix A provides further information for each of these locations, using detailed county maps.

Group A contains highly satisfactory locations encompassing 2-square-mile sites suitable for construction of the two 600 MW coal-fired generating units for Seminole Electric Cooperative, Incorporated. Further site selection action, as recommended in the next section of this report, should begin with this group of locations.



POWER PLANT LOCATIONS
FIGURE 1

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Recommendations

The proposed project schedule shown on Figure 2 was developed based on the objective of construction of a 600 MW unit in 1983 and another in 1985 as resolved by Seminole. This schedule establishes the major events necessary to move from the present position of having identified highly desirable site locations for construction of these units to commercial operation of the plant.

The objective, as contained in a resolution adopted by the Seminole Board of Directors, will require an aggressive approach under ideal circumstances. However, this objective is attainable and the following action is recommended to insure timely site evaluation, selection, and certification.

1. Obtain land options

   Land acquisition should begin as soon as possible within all locations identified in Group A to obtain 1,000 acre minimum sites. Since state requirements call for identification of a preferred and a preferred alternate site, three or four options should be obtained. It is suggested that these options be annually renewable for five years.

2. Begin detailed site evaluations

   As soon as an option is secured, proceed with the soil borings, environmental analyses, and other sampling, testing, and monitoring to satisfy the state's site certification requirements.

3. Initiate preparation of a site certification application

   Prepare a detailed scope of work and a related schedule based upon the site certification requirements of the state of Florida, and EPA and REA requirements as applicable. This application should be initiated with general information. Specific site information should be added as it becomes available.

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SEMINOLE ELECTRIC COOPERATIVE, INCORPORATED

PROPOSED PROJECT SCHEDULE

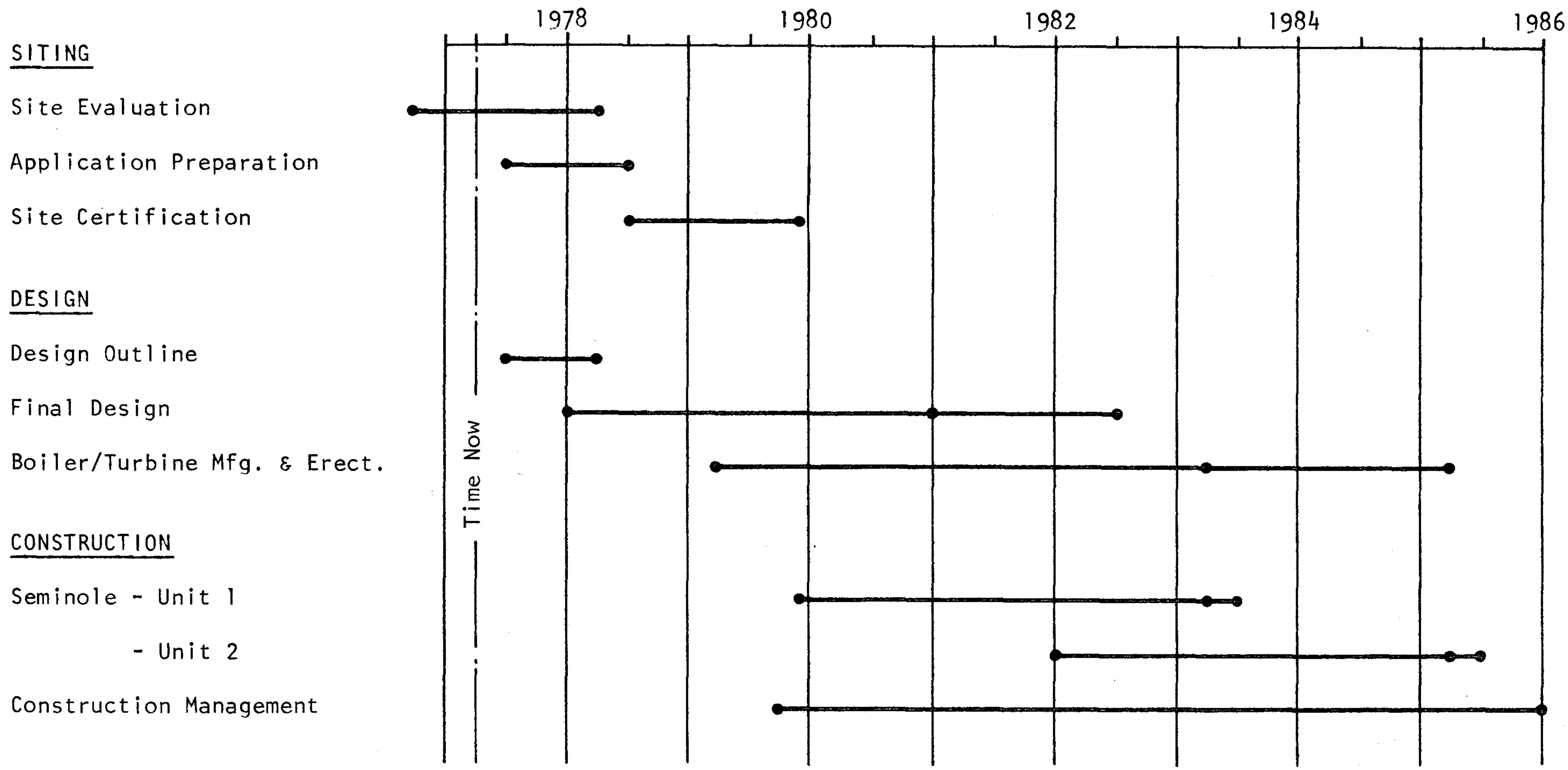


Figure 2

4. <u>Initiate preliminary plant design</u>

Specific plant cycle and arrangement information will be necessary for site certification application. A scope of work for design, contracts to be issued, and construction requirements should be prepared. A detailed project schedule and cost estimate should also be included.

5. <u>Initiate a coal supply study</u>

The type and source of coal to be used is one of the significant factors affecting site selection, plant design, and life cycle costs. The probable source and type of coal will dictate parts of the design process and a coal supply study should be initiated as early as practicable.

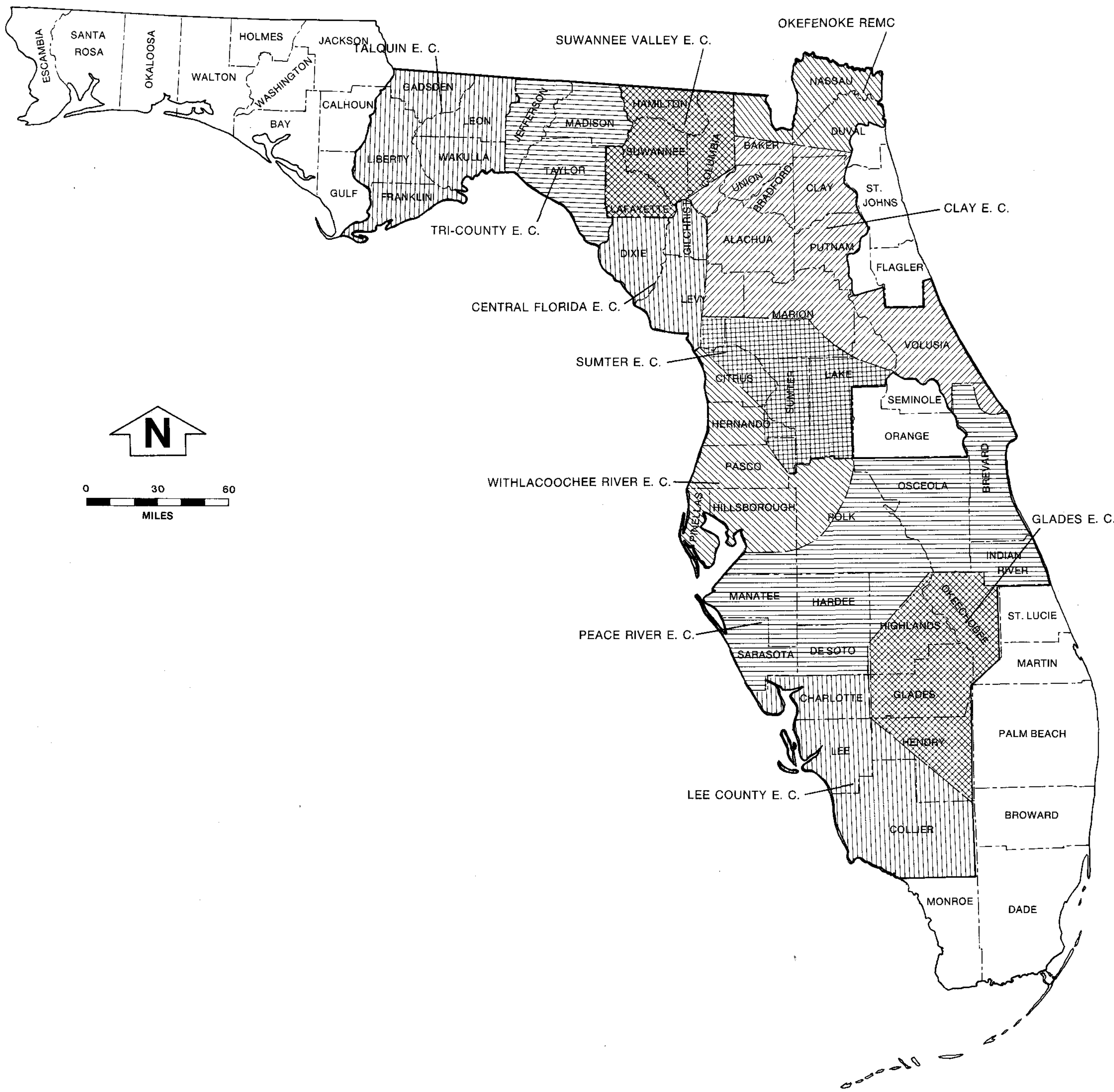
STUDY APPROACH

Introduction

As mentioned in the synopsis of this report, Seminole has passed a resolution to have two 600 MW coal-fired generating units in commercial operation by 1985. This resolution was based on a power requirements study conducted by Seminole. The general approach taken was to reduce the state of Florida to three groups of 36-square-mile locations with each location containing one or more 1,000 acre minimum sites having reasonable access to the Seminole service area (see Figure 3).

In this section of the report, a more detailed discussion of the methodology used in identifying and evaluating these locations is presented. Establishment of basic locational criteria, the approach taken for identification and gathering of information, the overlay system of mapping, and the development of detailed criteria for final location evaluation are covered.

For clarity of this report, which is intended for use as an executive summary, much of the detailed backup material, including calculations, meeting notes, data sources, and other supporting documents, has not been included but has been compiled and will be submitted as a separate supporting document.



SEMINOLE SERVICE AREA
FIGURE 3

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Methodology

Plant Criteria - One of the earliest tasks performed in this study was the description of a base plant and the establishment of plant criteria upon which site selection judgments could be made. A typical plant representative of Seminole objectives would consist of two 600 MW (net) 2400 psi/1000°F/1000°F, coal-fired units with precipitators and scrubbers and would

- Require 20,000 gpm of water
- Use 3,000,000 tons of coal per year
- Produce 425,000 tons of ash per year
- Produce up to 840,000 tons of sludge per year
- Require approximately 1,000 acres

For planning purposes, the criteria established reflect for siting severe site requirements, and final requirements are not expected to exceed these projections for two 600 MW units.

A summary of the plant criteria established for two 600 MW coal-fired units is shown on Table 1.

SEMINOLE ELECTRIC COOPERATIVE, INCORPORATED

SUMMARY OF PLANT CRITERIA

BASE PLANT

Two Units 600 MW (640 MW Gross)
Cooling Towers
Sulfur Removal Equipment
Turbine Driven Boiler Feed Pumps
Base Operating Conditions - 2400 psig/1000°F/1000°F
68% Annual Capacity Factor
  Availability - 85%
  Running Capacity Factor - 80%
Heat Rate - Average Gross - 9141 Btu/kWhr

WATER REQUIREMENTS (gpm)

Cooling Tower Make-Up	13,000	
Scrubber Make-Up	2,000	
Miscellaneous Plant Uses	2,000	
Total	17,000	- use 20,000 gpm for planning

COAL USE (Tons/Yr) 3,134,000

(1.25% sulfur, Alabama coal, 18% ash, 6% moisture, 11,200 Btu/lb heating value)

WASTE PRODUCTION (Tons/Yr)

Ash	425,000
Sludge	
1.25% Sulfur Coal	350,000
3.00% Sulfur Coal	840,000

AREA REQUIREMENTS (acres)

Main Plant	55	
Coal Handling Facilities	15	
Coal Storage (90 days - 1,000,000 Tons)	20	
Loop Track (14,000')	20	
Roads (3,000')	5	
Drainage Lagoons	5	
Limestone Storage	5	
Substation	20	
Construction Space	40	
Ash & Sludge Storage (30 Years - 30' deep)		
1.25% Sulfur Coal	400	
3.00% Sulfur Coal	650	
100 Ft. Peripheral Buffer Zone	40	
Total	875	- use 1,000 acres for planning

Table 1

Selecting Parameters - Many factors influence the selection of a site for the Seminole units; however four factors are deemed most important. Early in this study Stanley Consultants identified the following as the most important elements in power plant location. These factors are: 1) cooling water availability; 2) transportation facilities; 3) environmental concerns; and 4) access to the electrical transmission grid. Information gathering efforts were concentrated in satisfying the requirements of these four elements.

Physical and cultural parameters were developed which helped narrow the information gathering effort. These parameters were based on the plant criteria discussed in the preceding paragraphs and are shown below.

Water

Availability of flows of 1,000-2,000 gallons per minute from ground water sources.

Streams with a dry weather flow of at least 500 cubic feet per second.

Surface water and/or salt water within ten miles.

Transportation

Rail line within five miles or a waterway with a depth of at least eight feet.

Transmission

A 240 or 500 kV transmission line within 25 miles.

Environmental

A power plant should not be located in an area where air quality is below standard.

A power plant should not take prime agricultural land out of production.

Sensitive areas such as parks, natural preserves, and critical areas should be avoided.

A power plant should be located on the fringes of growth corridors.

Development of these criteria channeled the information gathering activity. A brief description of the information gathering effort follows.

Information Gathering - A wealth of material on Florida is available. While all such data would contribute to the study in some way, only that data which would lead to identifying the best location was pertinent. Stanley Consultants refined the information available to that pertaining to four factors: cooling water, transportation, transmission, and environmental concerns.

Persons and agencies which could provide information in these four areas were contacted. A partial list of contacts follows:

Water

Florida Department of Natural Resources, Bureau of Geology

Florida Department of Environmental Regulation

Florida Department of Natural Resources, Bureau of Coastal Zone Planning

Transportation

Florida Department of Transportation

U. S. Army Corps of Engineers

Transmission

Florida Coordinating Group

Florida Public Service Commission

Environmental

Florida Department of Natural Resources, Bureau of Coastal Zone Planning

Florida Division of State Planning

Florida Department of Natural Resources, Division of Archives, History and Records Management

Florida Department of Environmental Regulation

U. S. Geological Survey

Florida Department of Natural Resources, Division of Recreation and Parks

Florida Department of Commerce

The parameters established and the precise information gathering efforts resulted in the accumulation of data which could be readily organized into a system for power plant location selection.

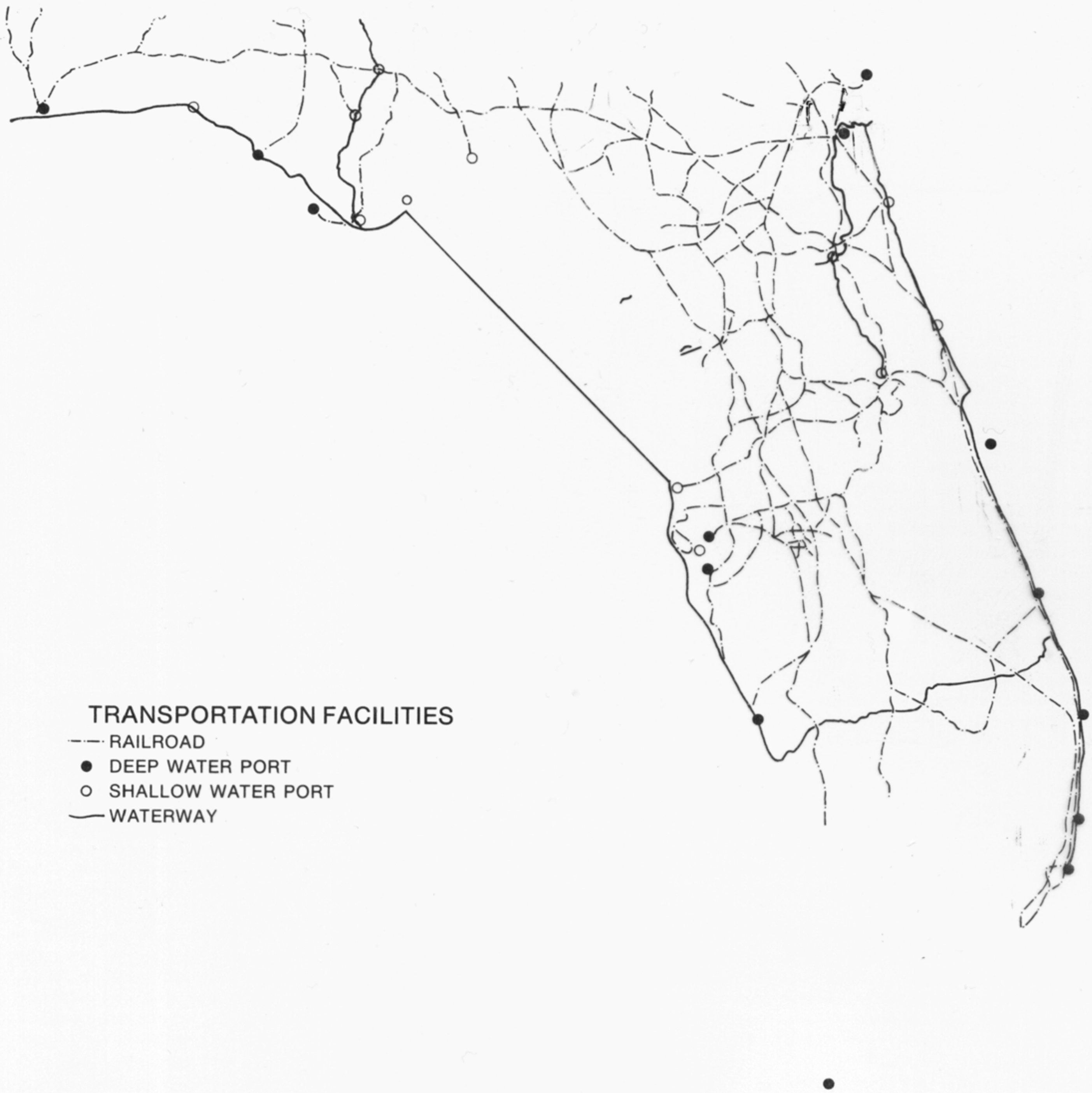
Overlay System - Information pertinent to plant location selection was recorded on a series of acetate overlays. A 3 1/2-foot by 5-foot map of Florida served as the base map for the overlay system. The overlay system allows the recording of information by category or type, then provides the opportunity to analyze the information by putting two or more overlays together. By placing the overlays over one another, it was possible to identify portions of the state which would be likely places to build the Seminole units.

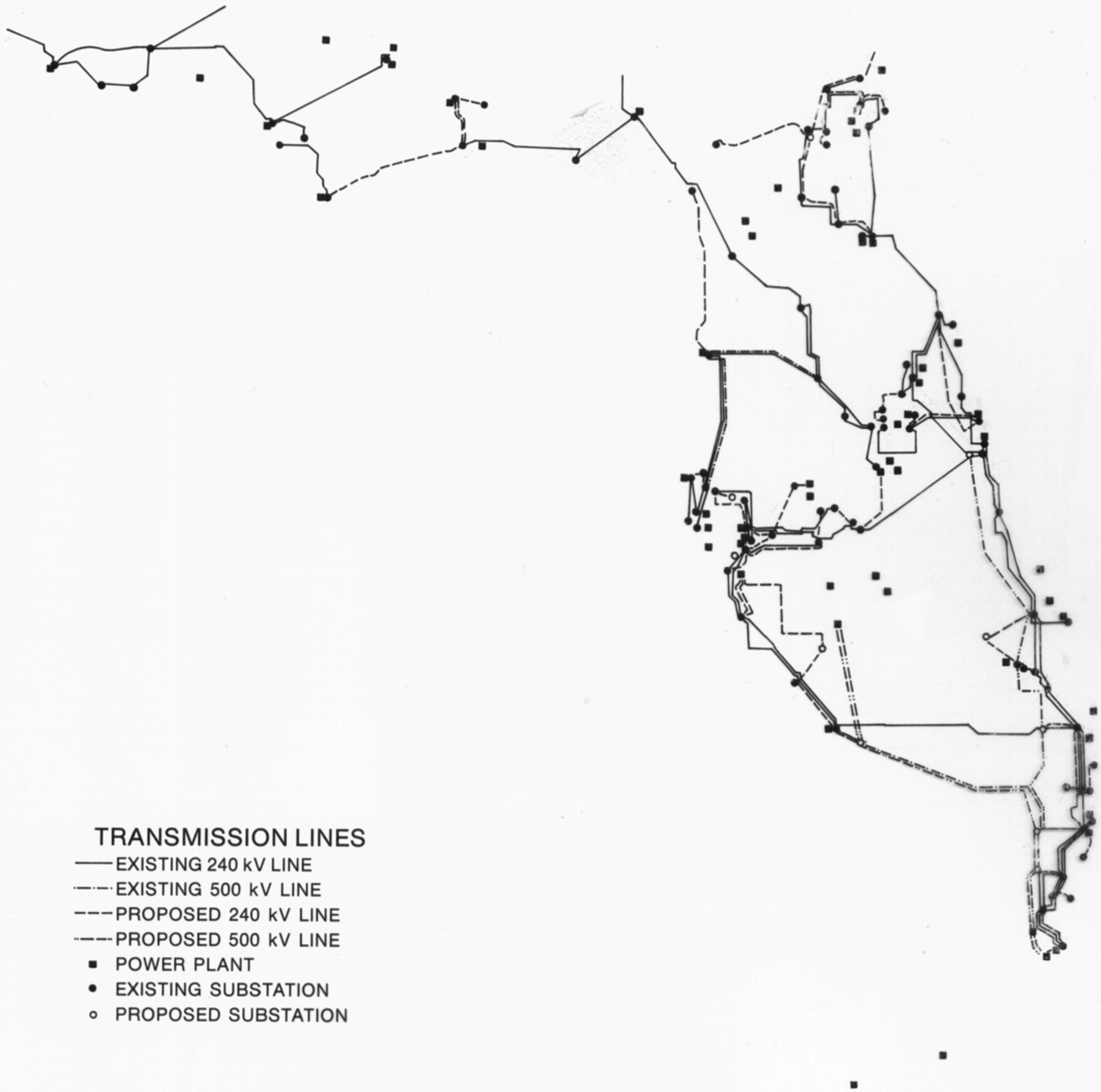
Three positive factors influencing the power plant were recorded on the overlays. These factors were cooling water availability, transportation facilities, and the electrical transmission grid. Portions of the state having combinations of these factors were considered candidate zones for the plant.

Figure 4 and its accompanying overlays are a small scale version of the large overlays actually used in showing positive factors influencing power plant location. The orange overlay for Figure 4 shows the candidate zones for the power plant. These broad geographic zones have adequate supplies of water, are located within five miles of a rail line and/or navigable waterway, and are within 25 miles of Florida's 240/500 kV transmission grid.

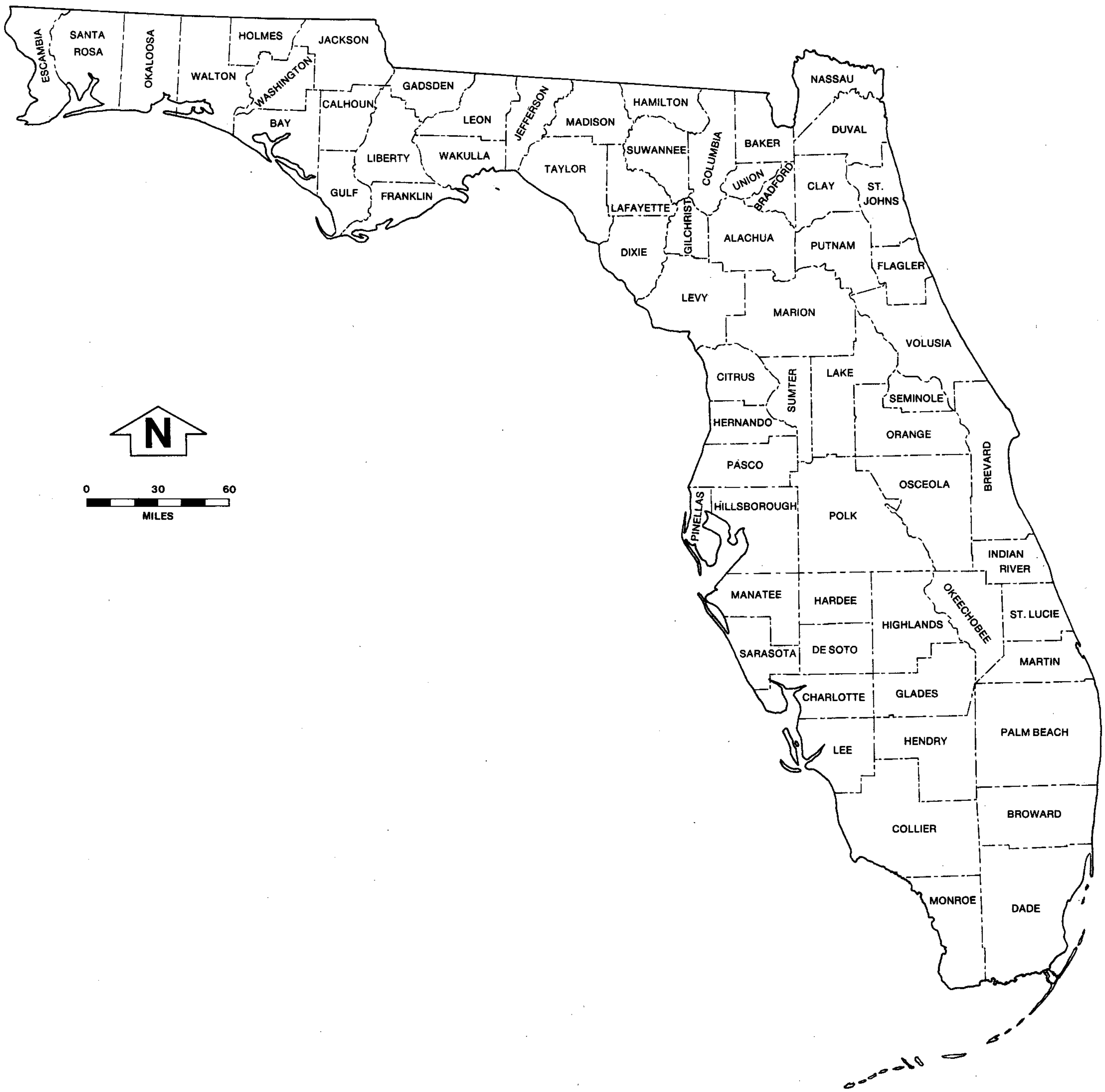
Several factors were used to modify the size of the candidate zones. Four primary modifiers were selected. The first modifier was the counties where existing air quality is below standard. A power plant has a slim chance of gaining acceptance in any of these counties. Sensitive areas such as natural preserves, state and national forests, park and recreation areas, and critical fish and wildlife habitat became the second modification. A power plant cannot be located in these areas, as they have been committed to other uses. The third was a state policy to preserve prime agricultural lands. If at all possible, the approximately 1,000 acres required for the power plant should not


WATER RESOURCES
ADEQUATE GROUND WATER SUPPLY
ADEQUATE SURFACE WATER SUPPLY


TRANSPORTATION FACILITIES
RAILROAD
DEEP WATER PORT
SHALLOW WATER PORT
WATERWAY


TRANSMISSION LINES
EXISTING 240 kV LINE
EXISTING 500 kV LINE
PROPOSED 240 kV LINE
PROPOSED 500 kV LINE
POWER PLANT
EXISTING SUBSTATION
PROPOSED SUBSTATION

■ CANDIDATE ZONES



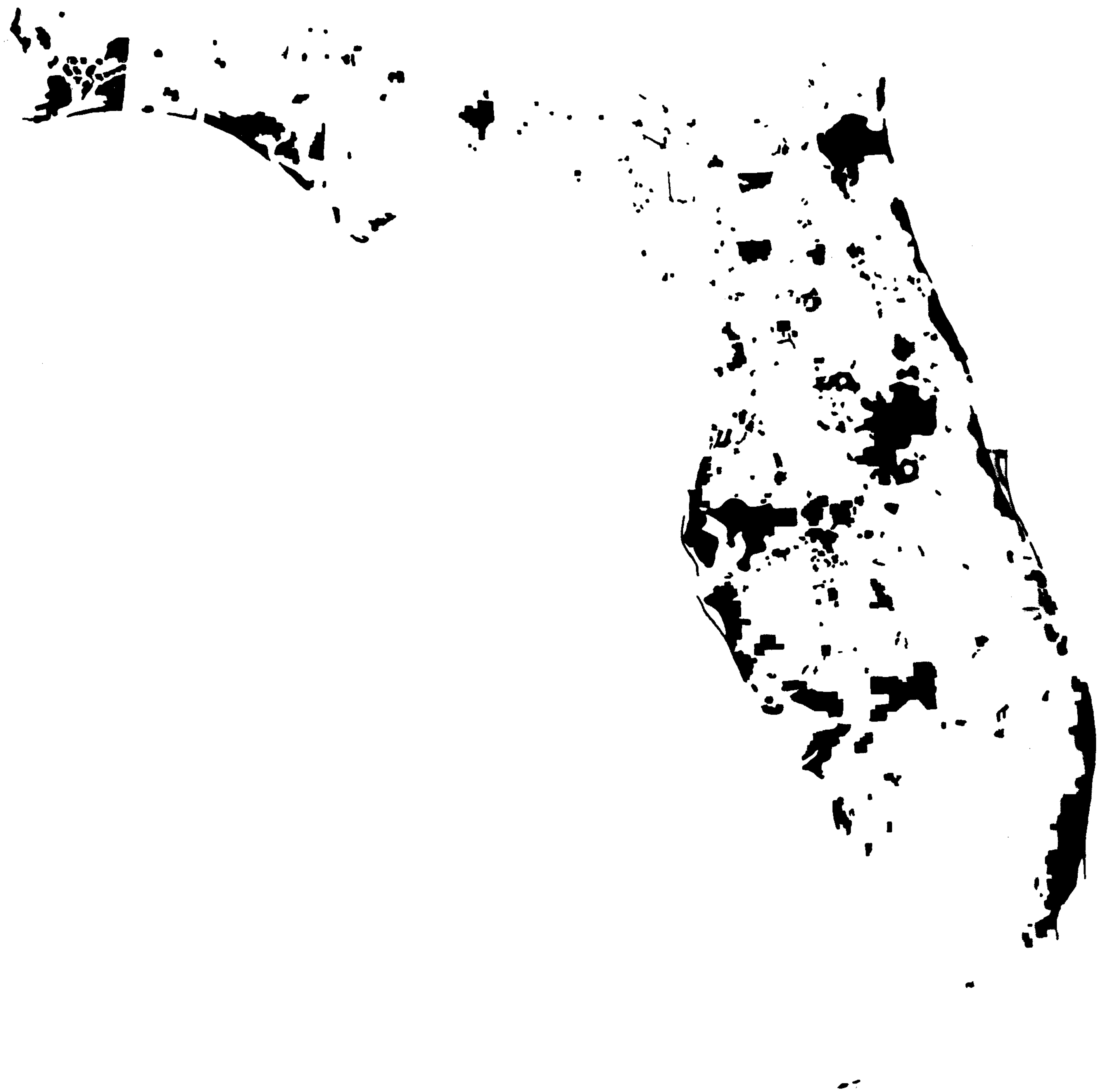
POSITIVE FACTORS

FIGURE 4

be located on prime agricultural land. Finally, a power plant should be located at the edges of anticipated future development. Information pertaining to the four modifiers was plotted on overlays to the large Florida base map.

Figure 5 and its related overlays are a small scale version of the larger overlay process used to show the four factors which reduced the broad candidate zones to a more manageable size. The effect of the modifying factors was to reduce the study area from tens of thousands to thousands of acres. The green overlay for Figure 5 represents smaller geographic units or search areas.

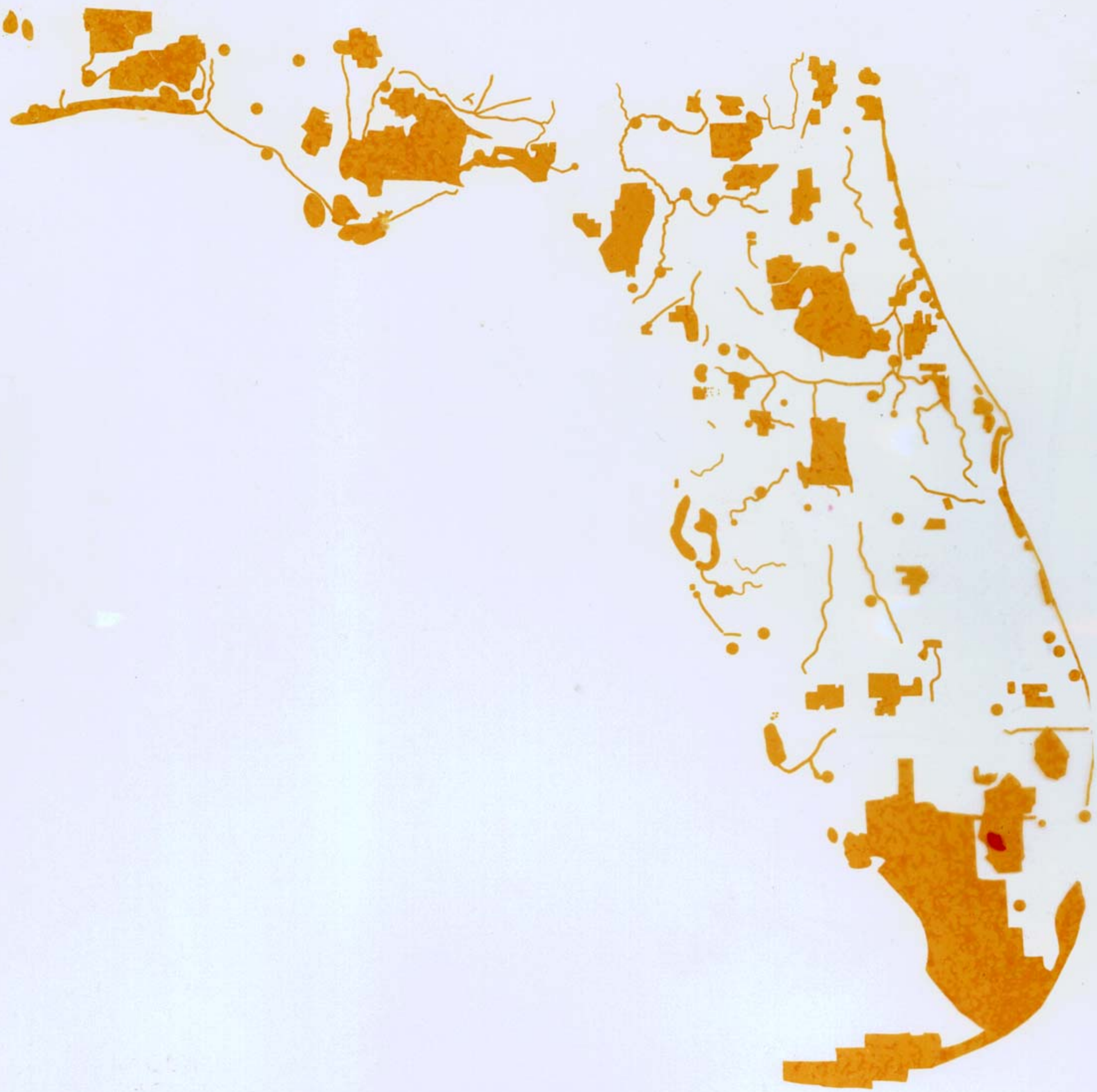
After identification of search areas, an informal review was held with representatives of the state of Florida. Study findings were discussed. Comments resulting from that meeting and more detailed investigation were used to further refine the search areas to even smaller geographic units.



1990 LAND USE

EXTENT OF DEVELOPMENT

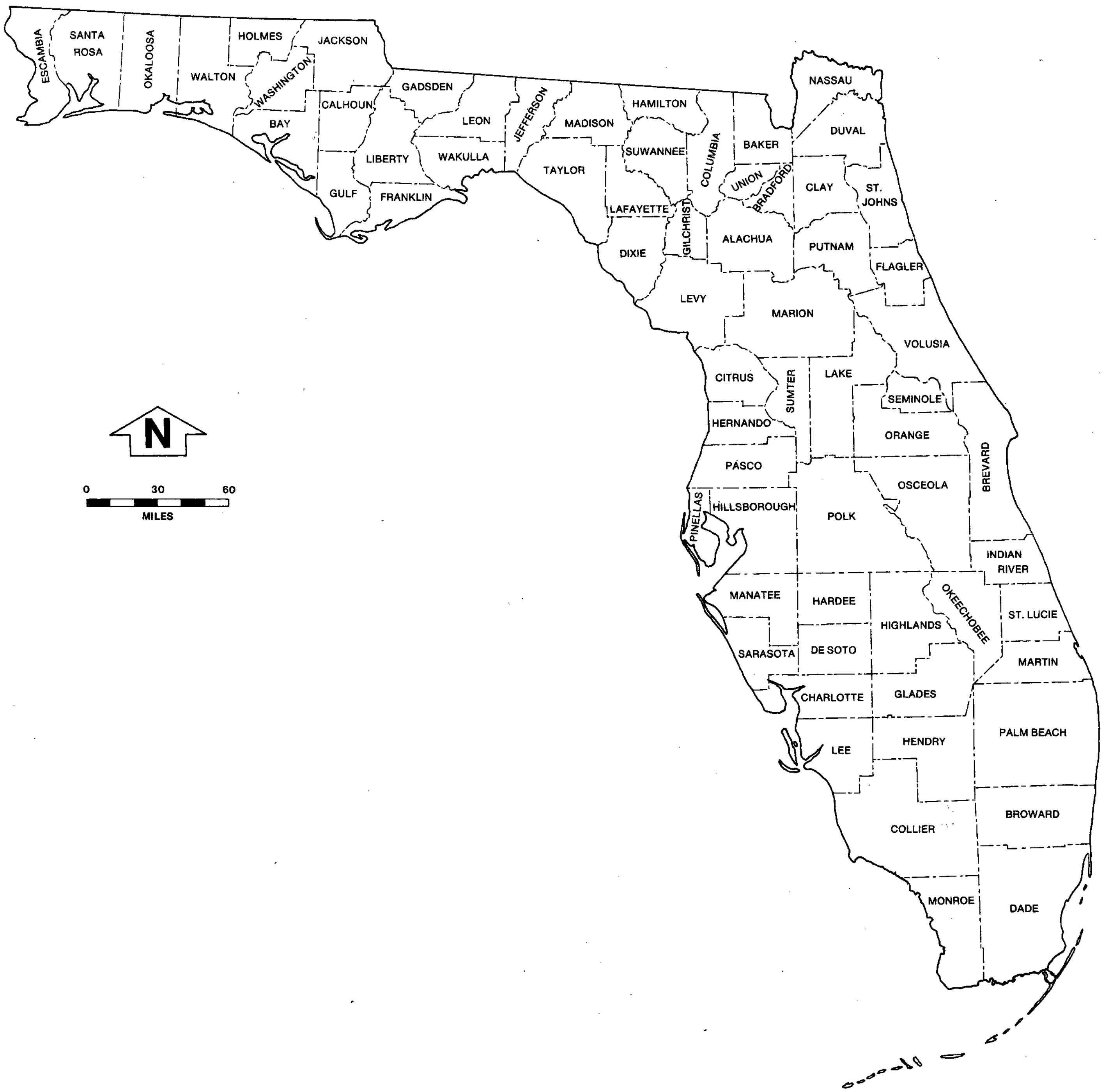
■PRIME AGRICULTURAL LANDS



■ SENSITIVE AREAS

AIR QUALITY
BELOW STANDARD

■ SEARCH AREA



MODIFYING FACTORS

FIGURE 5

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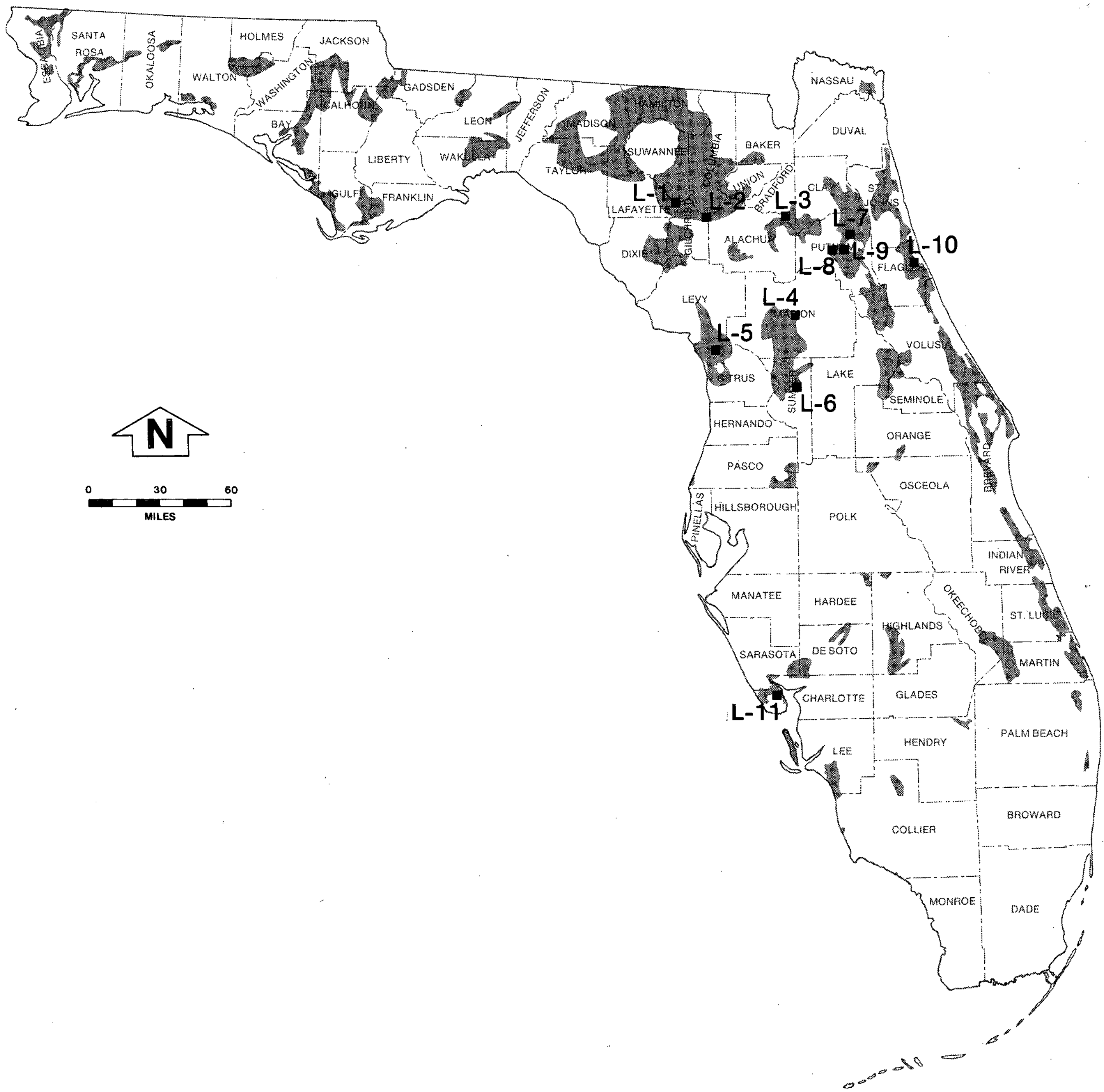
<u>Location Identification</u> - Three senior members of Stanley Consultants' study team independently examined the search areas depicted by the green overlay for Figure 5. Purpose of the examination was to identify 36-square-mile locations which would encompass sites for a power plant. Factors such as consideration of the Seminole service area and more rigid locational crtieria resulted in the identification of 53 locations, all of which could accommodate a power plant.

The 53 locations were then reduced by grouping and selecting the best representative locations. More detailed information, such as county highway maps and ground water data, was used to select the 11 best locations. The following locations were considered the most promising.

- L-1 Branford
- L-2 High Springs
- L-3 - Santa Fe
- L-4 - Silver Springs
- L-5 - Lake Rousseau
- L-6 - Bushnell
- L-7 - Bostwick
- L-8 - Rodman
- L-9 - Satsuma
- L-10 - Flagler
- L-11 - Charlotte Harbor

Figure 6 shows these locations.



■ LOCATION
▩ SEARCH AREA

SEARCH AREAS AND LOCATIONS
FIGURE 6

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Evaluation of Locations - Evaluation followed identification of the eleven 36-square-mile locations. A system was developed which allowed independent evaluation of each location.

The evaluation system consisted of major subheadings for the four established locational criteria of cooling water, transportation, transmission, and environment. These criteria were weighted by a modified Delphi-structured decision-making process (group consensus) performed by members of the project team with experience in power plant design, transportation, transmission, and environmental concerns. Further subheadings were then identified by specialists and weighted in a similar manner. A copy of the detailed evaluation system may be found in Appendix B.

The 11 prime locations were reviewed by the consultant team using the evaluation system. This evaluation required detailed analysis of the gathered information. In some cases, additional information was obtained to ensure timely evaluation.

A field crew visited the locations to gather location specific information. The merits of each location were informally discussed with several state officials. The following location groups are recommended for securing of land options. Option efforts should be first concentrated in Group A. If suitable sites cannot be secured in Group A, real estate representatives should move to Groups B and C.

Group A	Group B	Group C
L-7 - Bostwick	L-2 - High Springs	L-11 - Charlotte Harbor
L-1 - Branford	L-5 - Lake Rousseau	L-10 - Flagler
L-6 - Bushnell	L-3 - Santa Fe	L-8 - Rodman
L-9 - Satsuma	L-4 - Silver Springs	

A detailed map of each location is found in Appendix A. A location analysis accompanies each map.

SUMMARY

There undoubtedly are many acceptable sites within the state of Florida for construction of the two 600 MW generating units that Seminole has resolved to place in commercial operation. The problem is to select the one certifiable site best suited to the requirements of Seminole Electric Cooperative, Incorporated. To solve this problem, Stanley Consultants, Inc., has taken an unbiased, systematic approach to the work performed for this study to ensure credibility in all areas of power plant siting concern.

Some of the steps included in this approach were to:

- Identify and review regulatory requirements and related siting information.
- Establish a base plant description and identify its requirements.
- Present and refine siting data and information through mapping and overlay techniques.
- Conduct informal state reviews and personal contacts.
- Identify and evaluate 11 locations in detail (Appendix A).
- Develop highly objective weighted evaluation criteria (Appendix B).
- Compile detailed supporting material and documentation.

The result of this approach was the identification and evaluation of four highly desirable locations where the land option input should begin immediately as the next step toward commercial operation of the Seminole generating units. These locations are:

L-7 - Bostwick	L-6 - Bushnell
L-1 - Branford	L-9 - Satsuma

Completion within the schedule outlined will require exacting performance by all parties concerned. We look forward to continued cooperation with your staff and the successful completion of the Board's objectives.

Respectfully submitted,

STANLEY CONSULTANTS, INC.

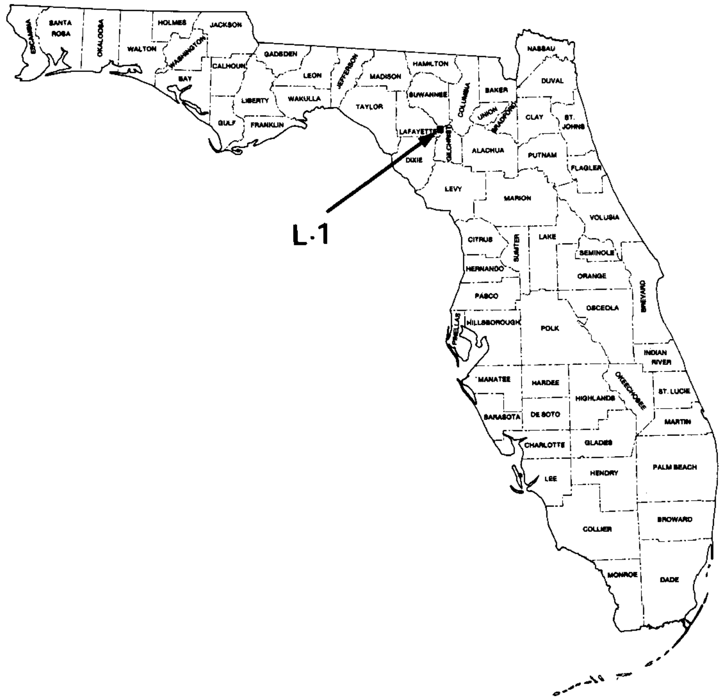
George W. Sampson
Project Manager

John Sayles
Regional Planner

Robert J. Rusch
Electric Systems Engineer

APPENDIX A

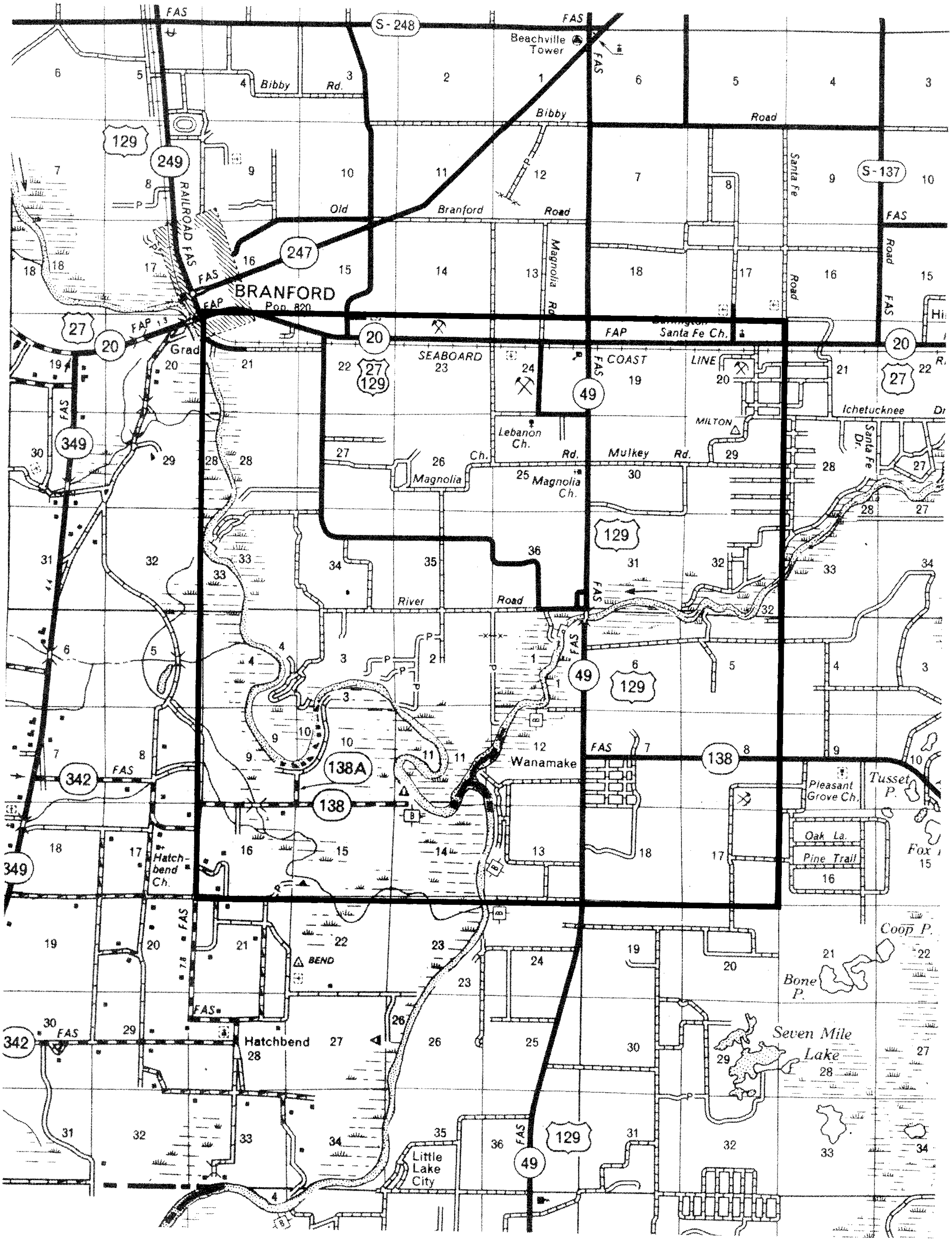
LOCATION ANALYSIS



L-1 BRANFORD

LOCATION ANALYSIS

Cooling water available from the Suwannee and Santa Fe Rivers. Ground water also a possibility. No apparent competition for water. Cooling water discharge to either river. Rail service via the Seaboard Coastline Railroad, track condition is good. 240 kV transmission line within 7 miles of location. Air quality is good. On-site disposal of wastes possible in old quarries. Suitable, well-drained land available.



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MILES

LOCATION L-1

FIGURE A-1

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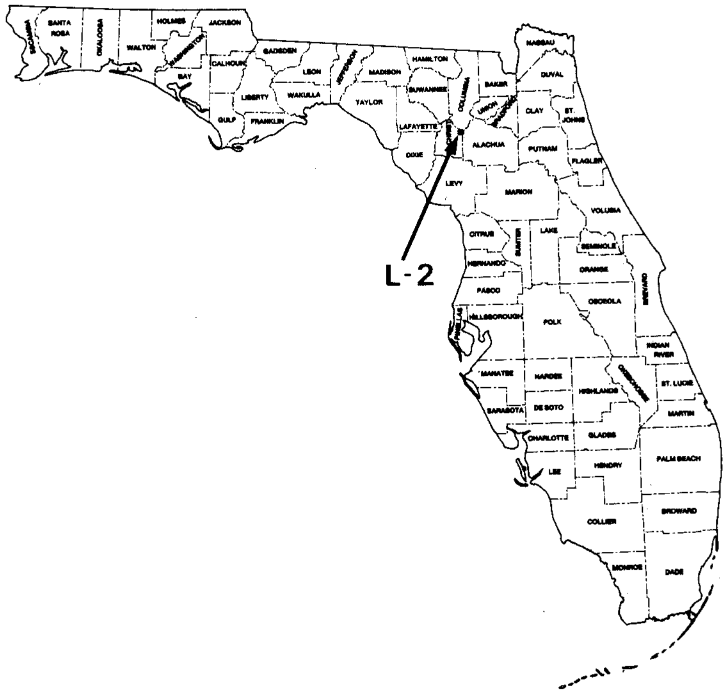
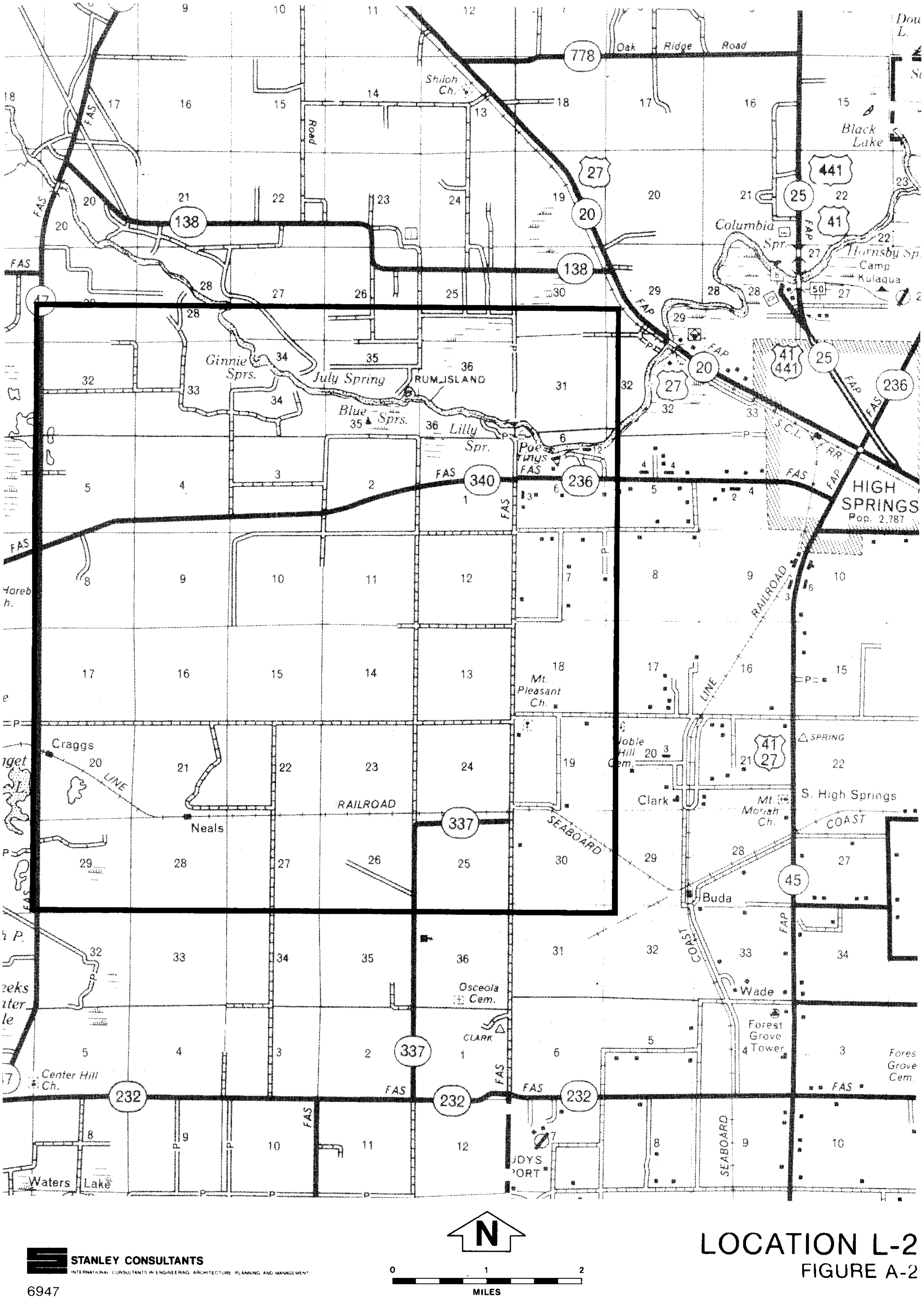


L-2 HIGH SPRINGS

LOCATION ANALYSIS

Cooling water available from the Santa Fe River. Possible use of ground water. Cooling water discharge to the river may meet opposition from state agencies and environmentalists. Other discharge options limited. Rail service via the Seaboard Coastline Railroad (track in fair to poor condition). 240 kV transmission line crosses location. Air quality is good. Flat to rolling, well-drained land available.



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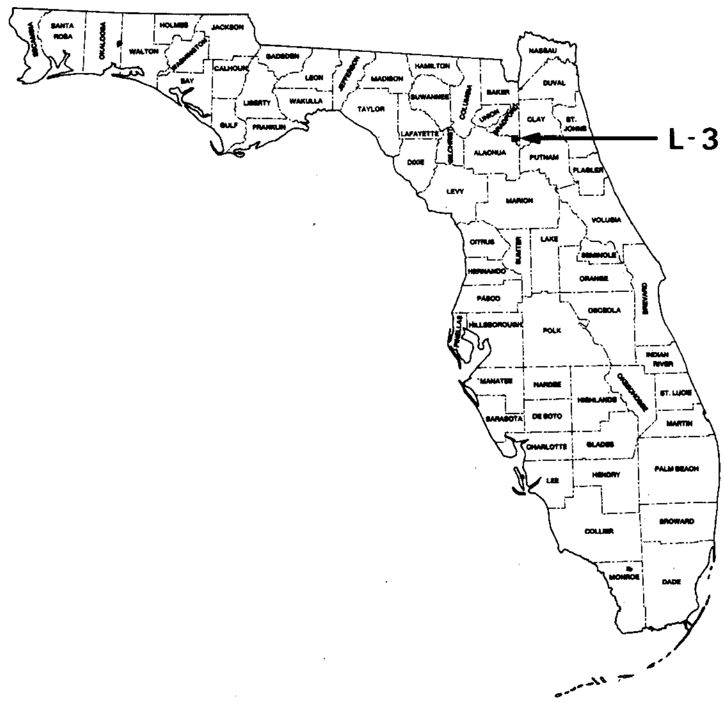
LOCATION L-2

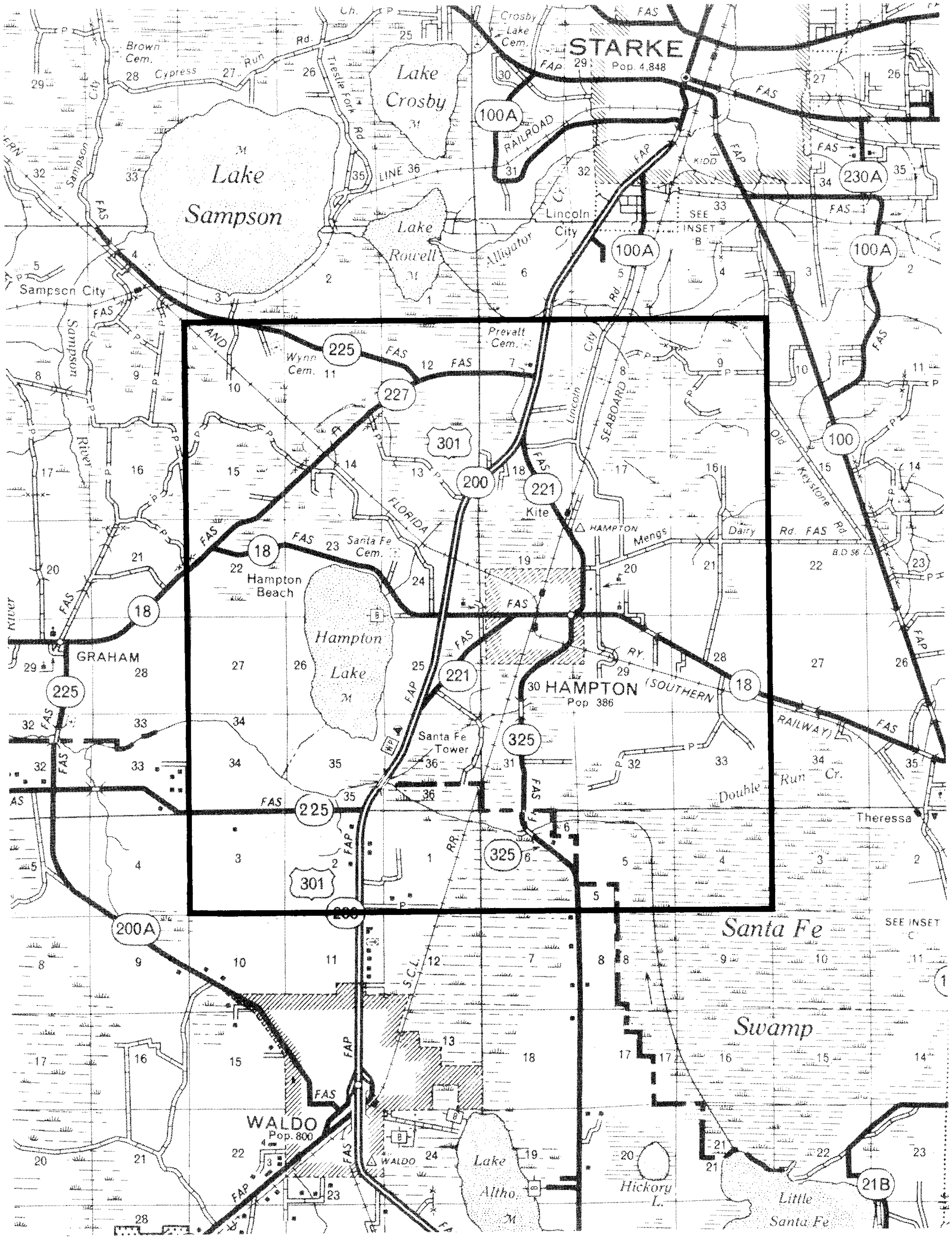
FIGURE A-2



L-3 SANTA FE

LOCATION ANALYSIS

Wells should be able to provide water for cooling. Cooling water discharge options are somewhat limited but headwaters of the Santa Fe River offer some possibilities. Rail service by both the Seaboard Coastline and Georgia Southern and Florida rail lines. Condition of Seaboard Coastline track is good to very good (main line) while the GS & F is fair to poor. 240 kV transmission line located within three miles. Air quality is good. Topography ranges from flat and well-drained to low and wet. Trees, pasture, and crop lands predominate.



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MILES

LOCATION L-3

FIGURE A-3

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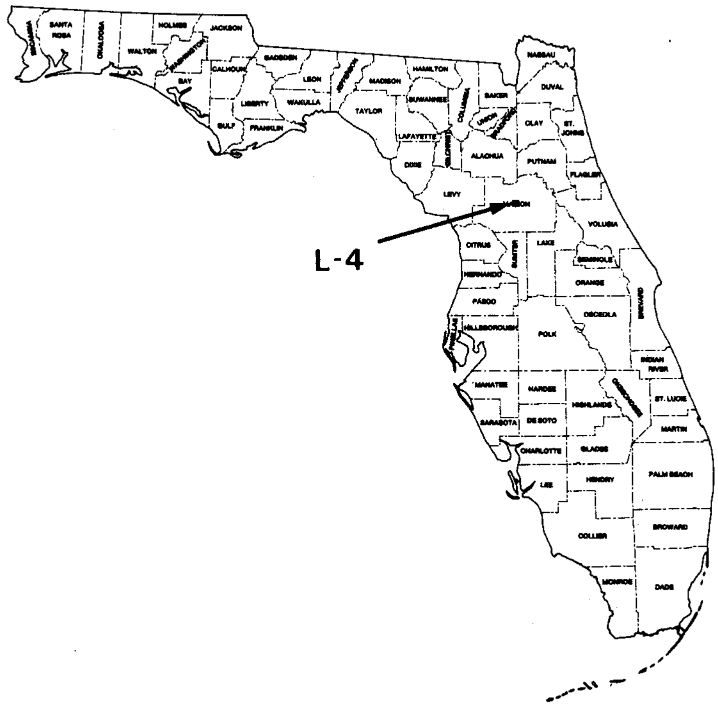
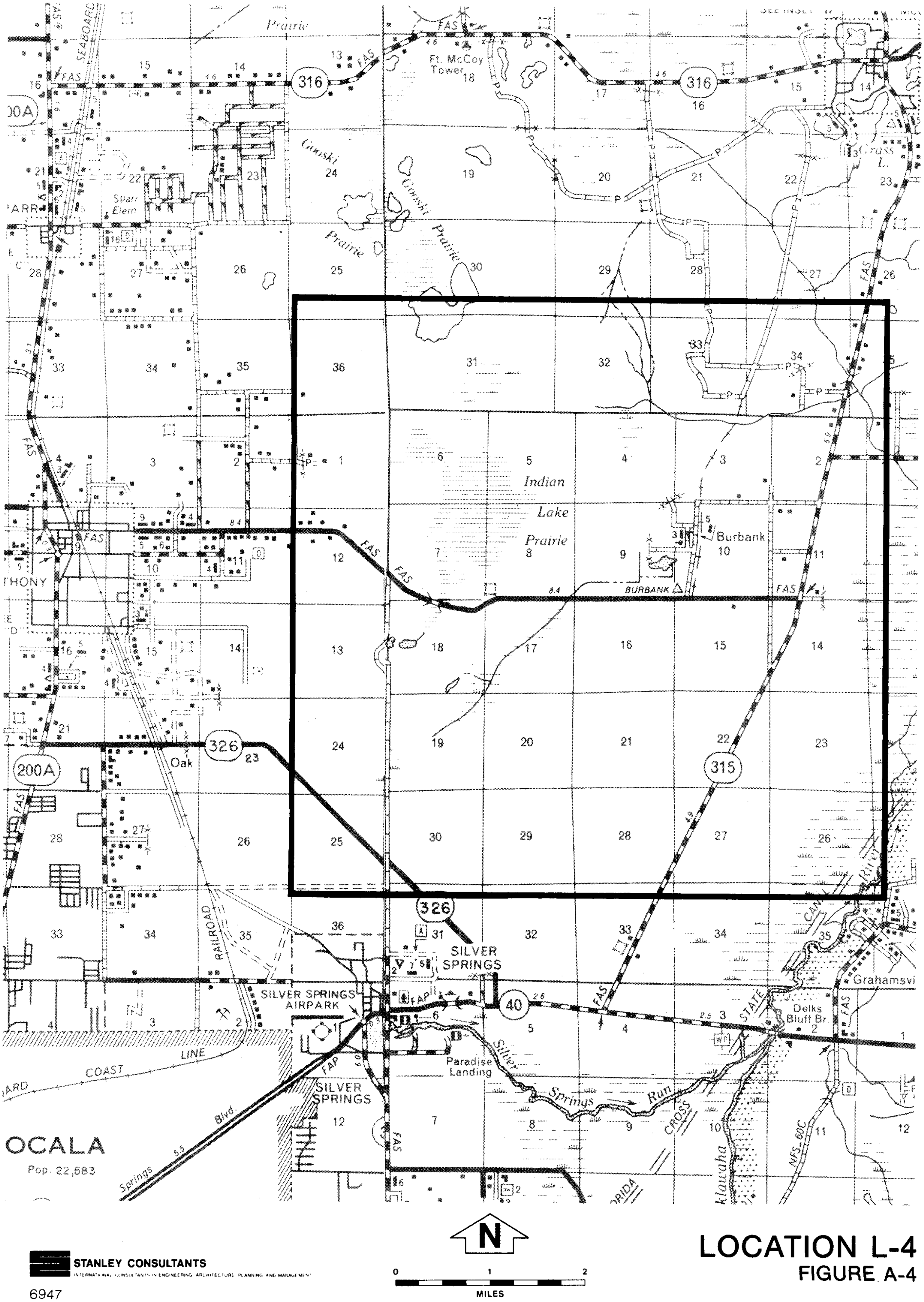


L-4 SILVER SPRINGS

LOCATION ANALYSIS

Cooling water is available from underground sources. Use of the Oklawaha River for cooling water or discharge is an environmental concern. Construction of a cooling lake or injecting cooling water into shallow wells for aquifer recharge is possible. Seaboard Coastline Railroad is a mile from the location. Track condition is good. 240 kV line within two miles of location. Air quality good. Flat, well-drained land available. May have strong objection from residents in this tourist area.



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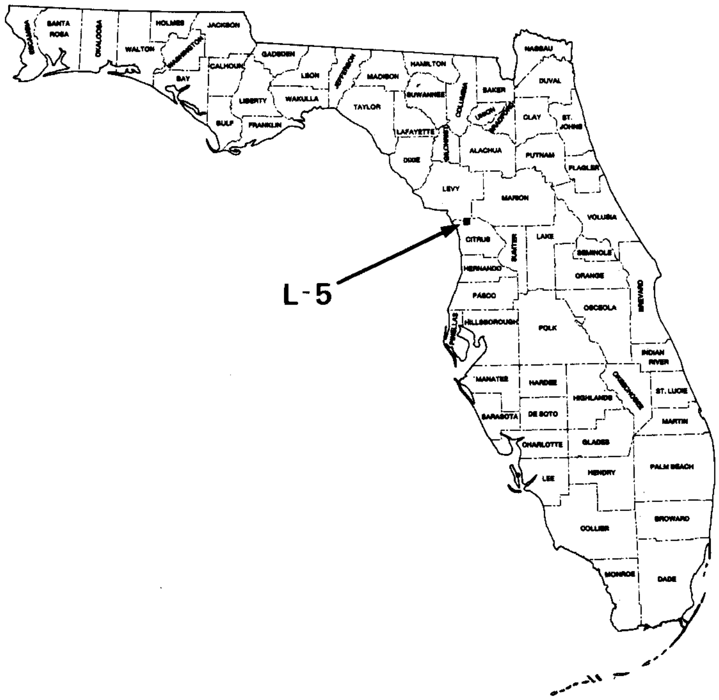
LOCATION L-4

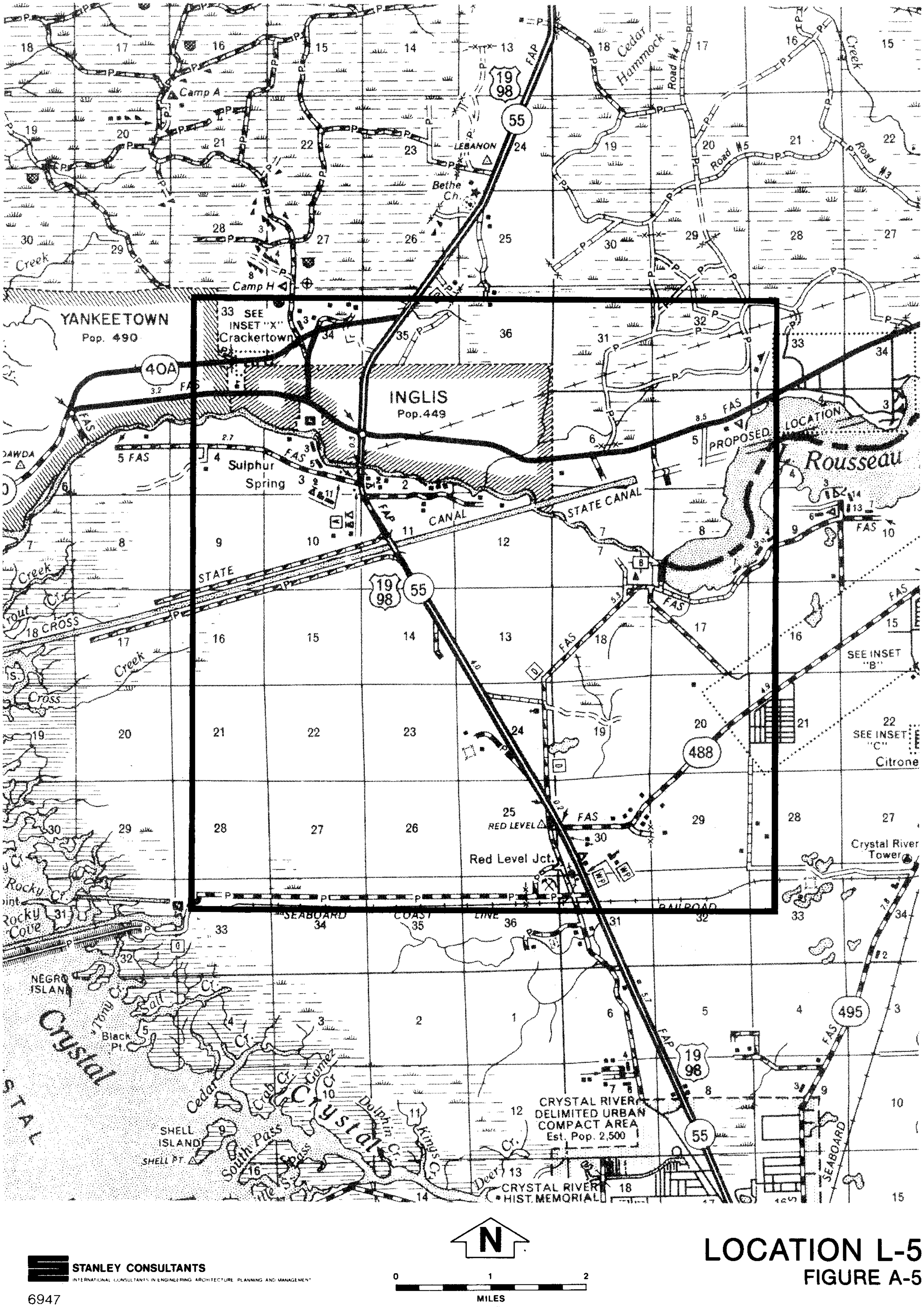
FIGURE A-4



L-5 LAKE ROUSSEAU

LOCATION ANALYSIS

Gulf of Mexico is most reliable source of cooling water. Use of underground supplies, Withlacoochee River, or Lake Rousseau may cause environmental problems. Discharge to the Withlacoochee, Lake Rousseau, or Gulf could cause environmental problems. Discharge to cross Florida Barge Canal a possibility. The Seaboard Coastline tracks provide rail access (track condition good to very good). Use of the Withlacoochee River and Cross Florida Barge Canal by coal-carrying barges is possible. 240 and 500 kV transmission lines cross location. Location may be air quality limited because of existing and proposed power generation units. Land is generally flat with some scrub forest. Demands for land by other utility and residential developers is apparent.



LOCATION L-5

FIGURE A-5

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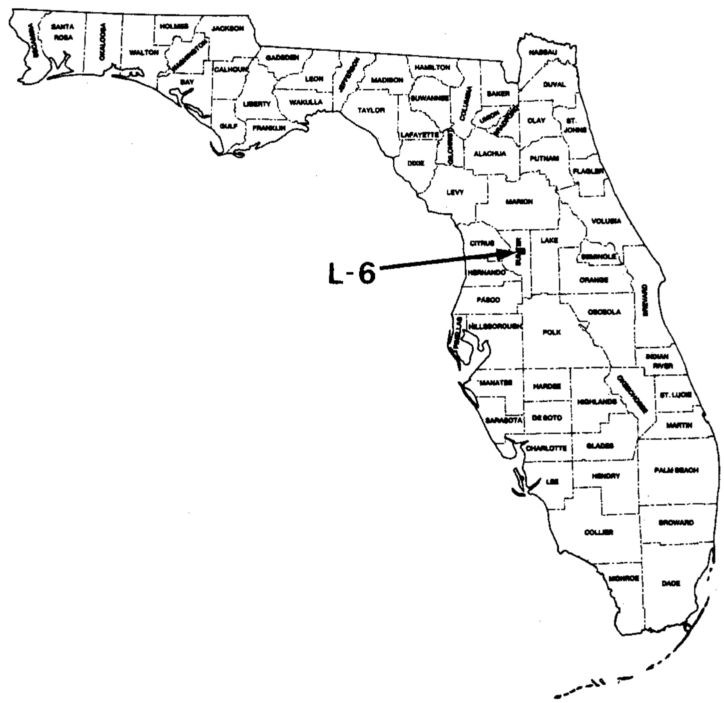
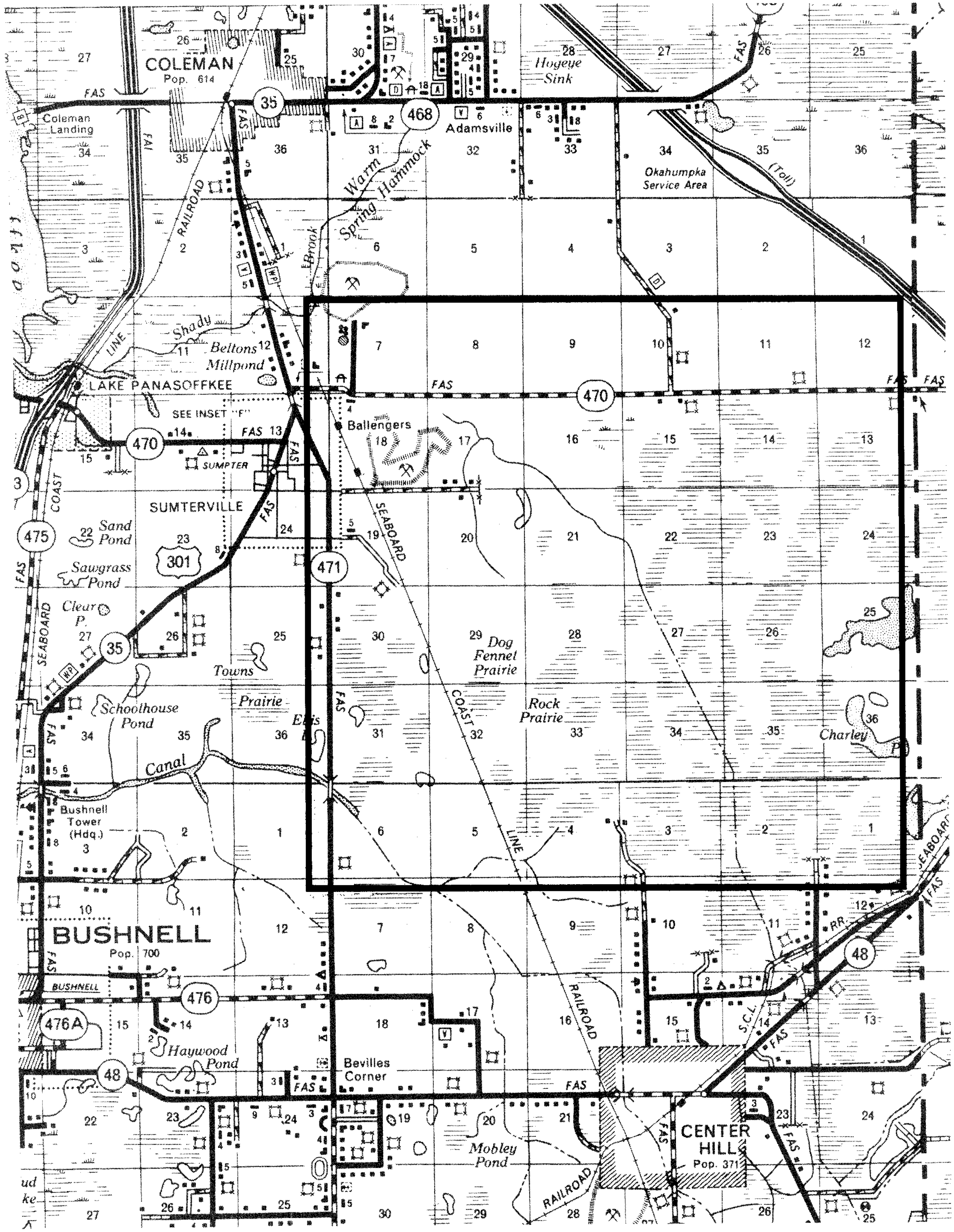
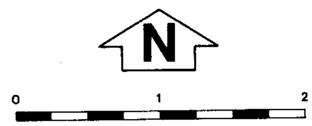


L-6 BUSHNELL

LOCATION ANALYSIS

Cooling water available from underground sources. Discharge possibilities limited but Shady Brook (Juniper Creek) appears most feasible. Location served by the Seaboard Coastline Railroad. Tracks in good condition. 240 and 500 kV transmission lines one mile east. Air quality good. Land is fairly open with some tree cover. Good drainage except to south. Disposal of waste possible in old quarries.





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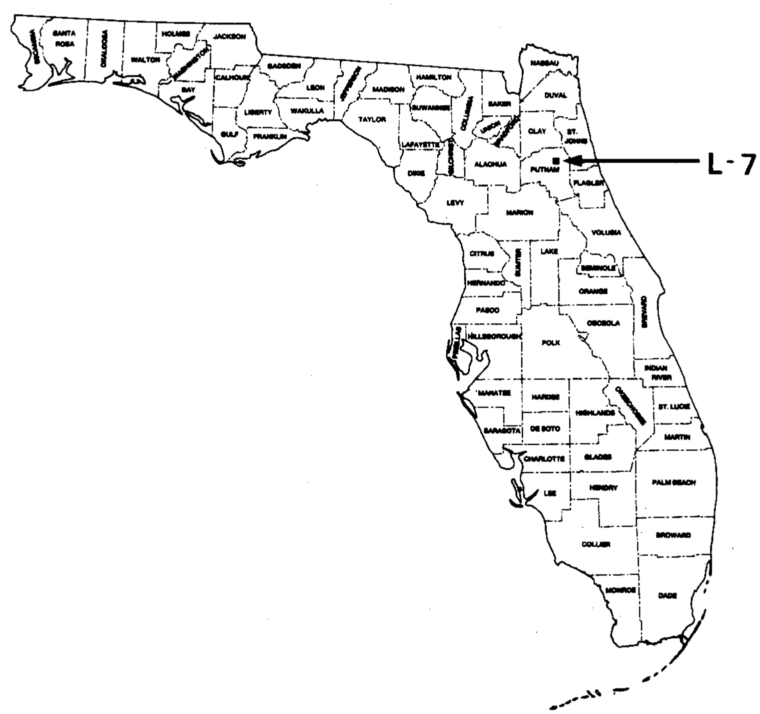
LOCATION L-6

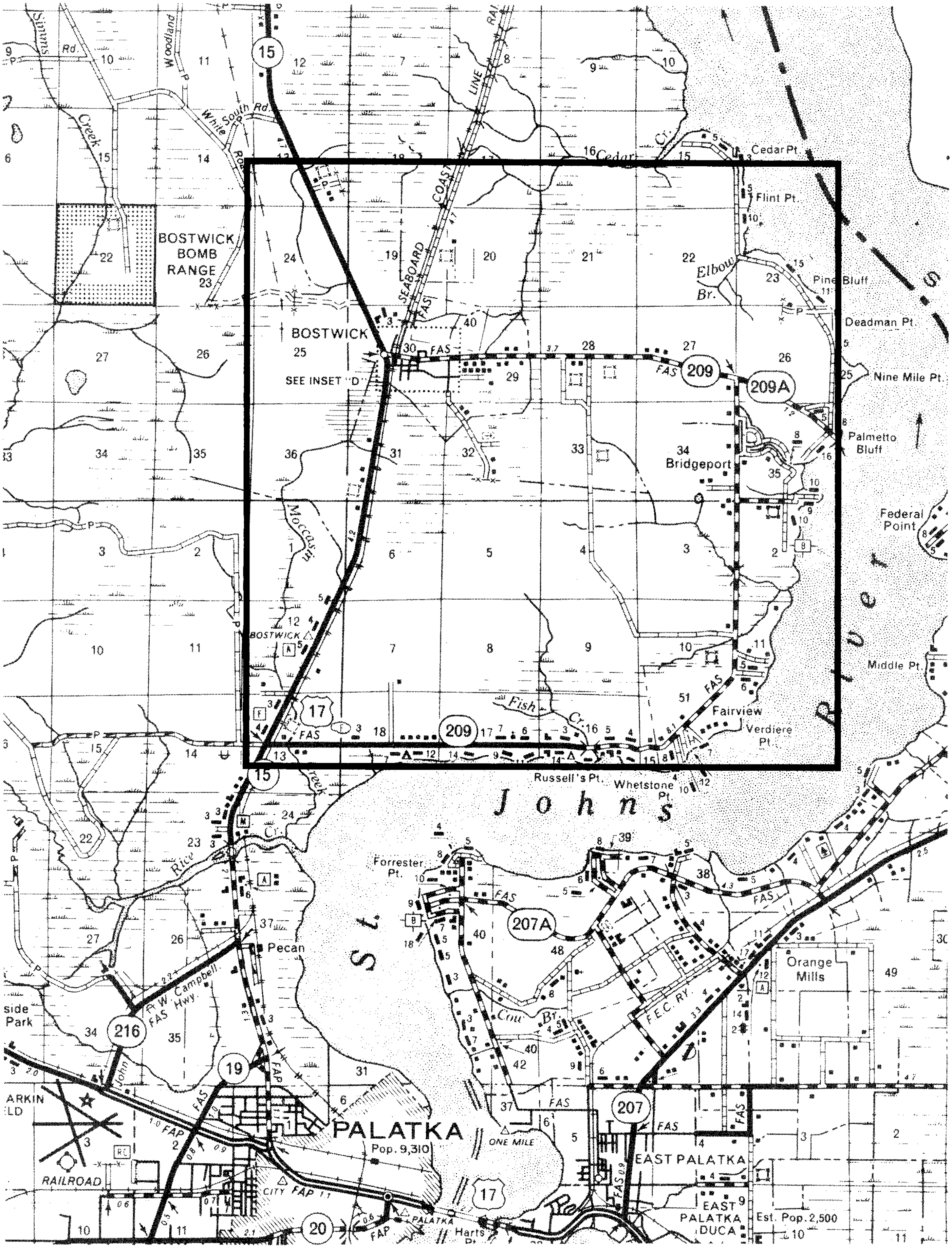
FIGURE A-6



L-7 BOSTWICK

LOCATION ANALYSIS

St. John's River is source of cooling water. Cooling water discharge to the St. John's. Seaboard Coastline tracks on location (good condition). Location can be served by barge. 240 kV line located three miles south. Air quality may be a problem due to existing industrial uses in the Palatka area. Land is flat, well-drained with moderate tree cover. Most of the river frontage is occupied by homes. Vacant land less than one-half mile from river.



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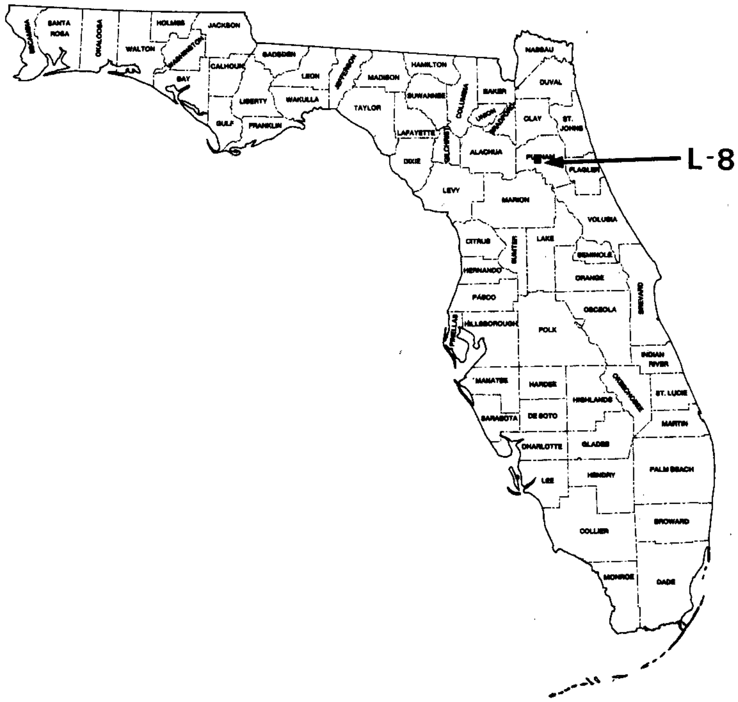
LOCATION L-7

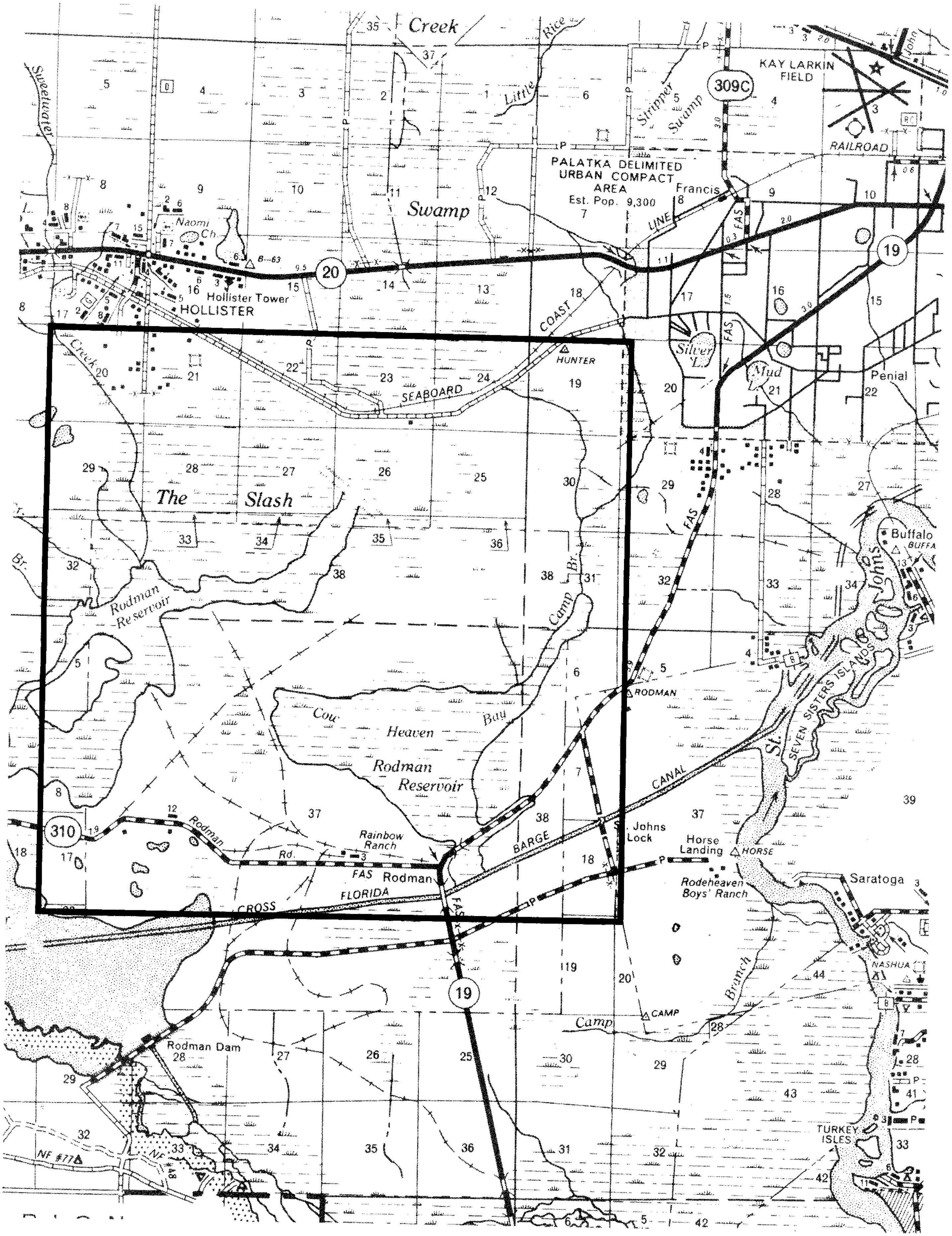
FIGURE A-7



L-8 RODMAN

LOCATION ANALYSIS

Ground water and the St. John's River provide potential for cooling water. Piping water three miles from the St. John's may be a problem. Use of ground water may meet objections of the water management district. Cooling water discharge to St. John's or several creeks possible. Seaboard Coastline provides rail access (tracks in poor condition). Use of the Cross Florida Barge Canal and Rodman Reservoir for coal barges hinges on federal/state decisions concerning both facilities. 240 kV transmission line located seven miles northeast. Air quality may be a problem due to existing industrial uses in the Palatka area. Land is generally low and tree covered.



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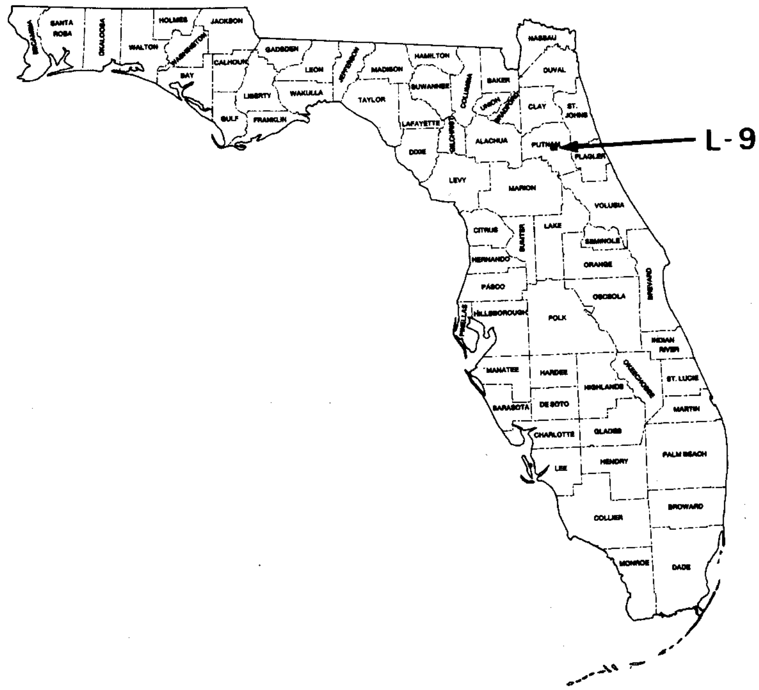
MILES

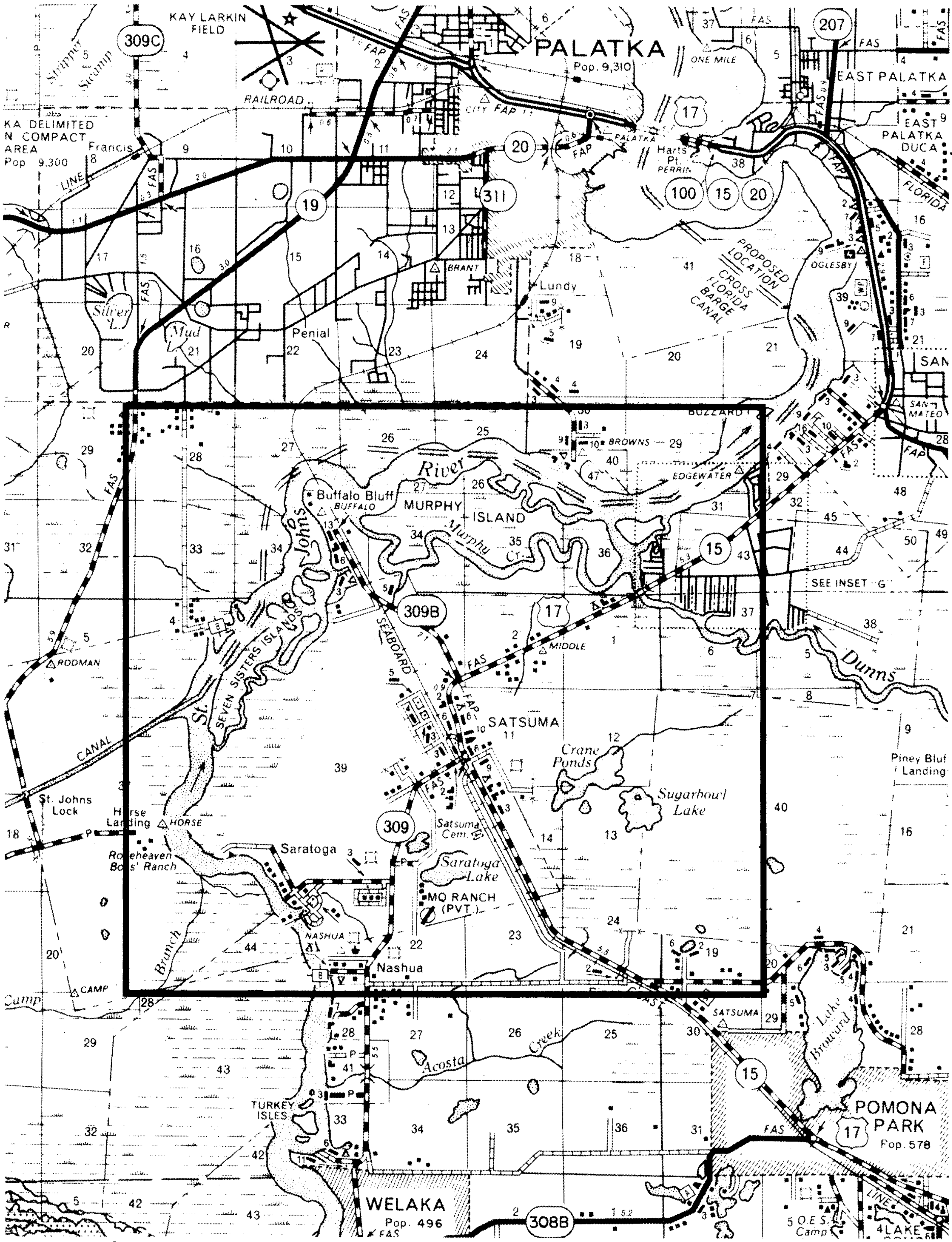
LOCATION L-8
FIGURE A-8



L-9 SATSUMA

LOCATION ANALYSIS

Water source is the St. John's River. Ground water may also be supplemental source. Discharge to the St. John's or creeks. Seaboard Coastline Railroad tracks in good to very good condition. St. John's and possibly Dunn's Creek provide the location with barge access. 240 kV transmission lines located five miles to the north. Air quality may be a problem due to existing industrial uses in the Palatka area. Land is rolling to flat; predominantly tree covered, but with large amounts of cleared land. Some subdivision activity in the location.



LOCATION L-9

FIGURE A-9

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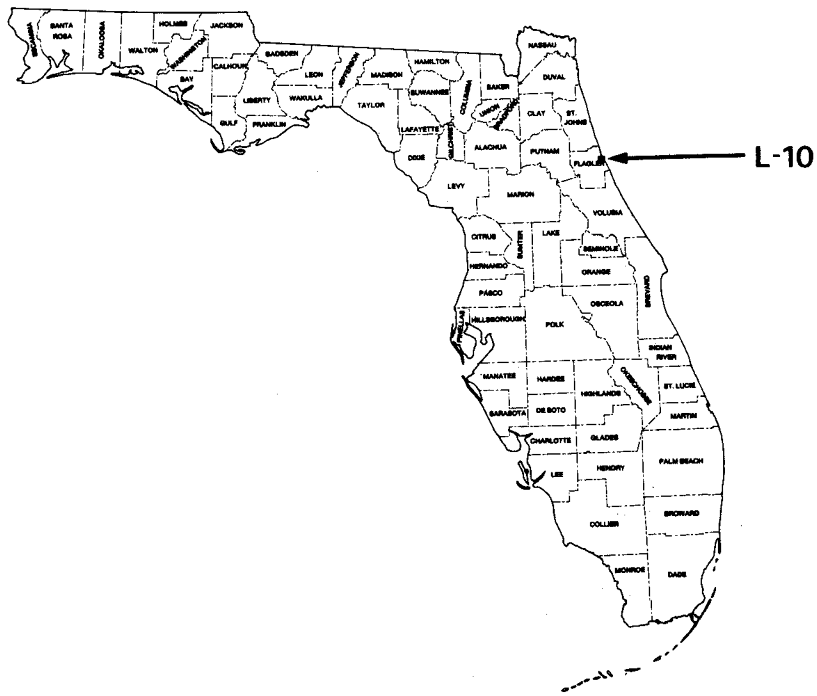
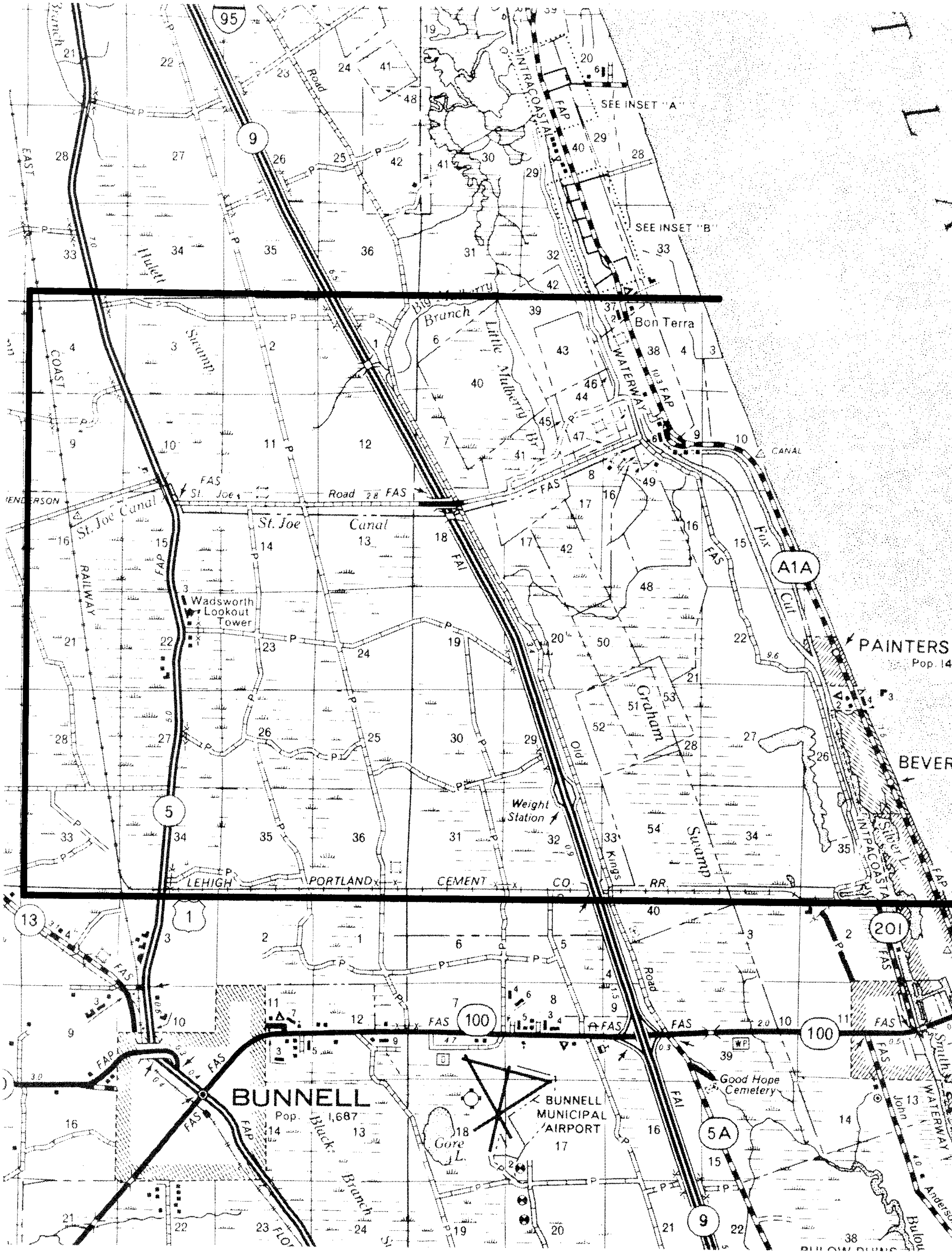
0 1 2 MILES



L-10 FLAGLER

LOCATION ANALYSIS

The Intracoastal Waterway could supply cooling water to the location. Cooling water discharge would be to the waterway. Florida East Coast Railway and Lehigh Portland Cement Company Railroad serve the location. Rails in good to fair condition. Possibility of coal barges via the Intracoastal Waterway. 240 kV transmission line just to the south of the location. Land is flat with tree cover predominating. Most of the location is committed to residential development. The east side of the location offers the only possibility of a power plant site. Old quarries available as waste disposal sites (reclamation a factor).



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MILES

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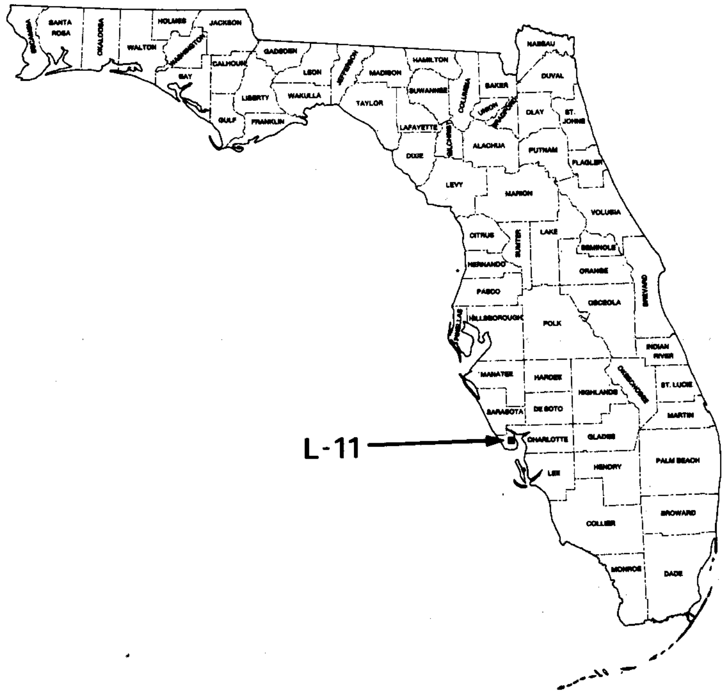
LOCATION L-10

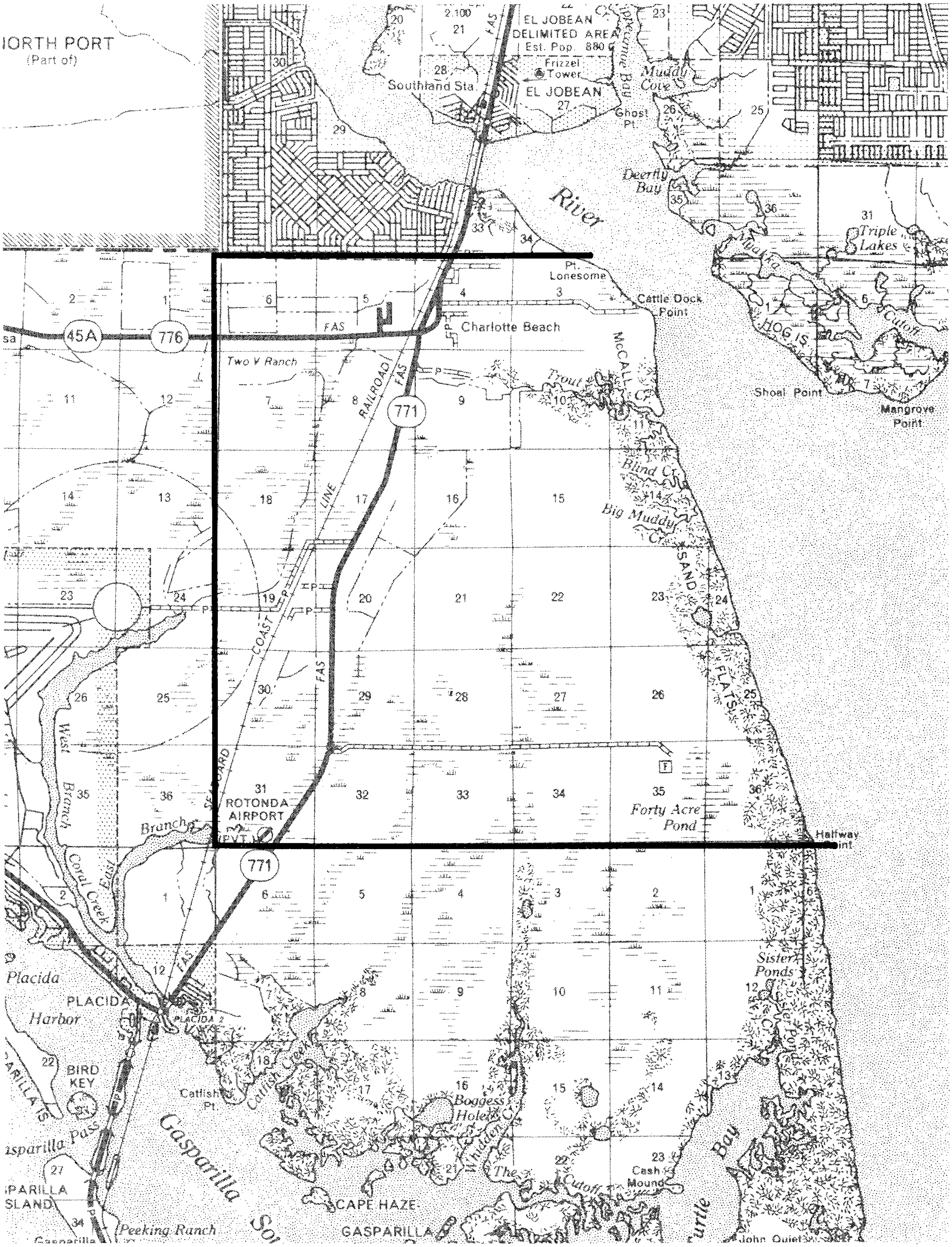
FIGURE A-10



L-11 CHARLOTTE HARBOR

LOCATION ANALYSIS

Secure cooling water from Charlotte Harbor and discharge to same body of water. Charlotte Harbor is an environmentally sensitive area and opposition to intake and discharge may be vigorous. Seaboard Coastline Railroad provides rail access (rail condition unknown). Charlotte Harbor too shallow to accommodate ships or barges without dredging. 240 kV transmission located twelve miles northeast. Land is flat with mangrove swamp lining the harbor. Approximately half of the location has been committed to residential use.



LOCATION L-11

FIGURE A-11

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APPENDIX B

EVALUATION CRITERIA

INTRODUCTION

It is the purpose of this appendix to provide additional information regarding the evaluation criteria applied in the body of this report. Seven separate disciplines were involved in the evaluation of individual locations. The reader must bear in mind that the level of detail is an approximately 36-square-mile location. This does not allow detail on the ground type data but requires gross mapping information.

Certain definitions are in order. The major Roman numeral headings in the evaluation criteria are issues of major concern. An issue of major concern is an issue which is required for plant operation, such as water, transportation, and transmission or an issue which would restrict plant location or operation (environmental).

Major alphabetic subheadings under the issues of major concern are termed categories. These categories further define and break down an issue of major concern into its component problems. Subheadings are modifiers or additional terms which break down each individual category.

APPENDIX B

EVALUATION CRITERIA

I. <u>WATER (250 points)</u>

A. <u>Quantity and Reliability (140)</u> - The following items are to be considered when evaluating locations under this subject:

- Source of water
- Ability to procure water withdrawal permits
- Minimum water required for plant use (20,000 gpm or 45 cfs)
- Continual flow of water guaranteed

<u>Add categories for total.</u>

1. Location Near Salt Water Source (20)
2. Location Near Surface Water Source (20)
3. Location Near Ground Water Source (20)
4. The Water Source Should Continuously have Greater than or Equal the Required Plant Water Supply (i.e., nearby wells causing drawdown will not reduce the plant ground water supply below required minimums and existing surface water uses will not encumber plant supply).

<u>Choose one category only.</u>

a. Wells:

1) With 2,000 gpm flow (80)

2) With 1,000 gpm flow (40)

b. Surface water - add for total

1) If 10 times that required for plant use exists (40)

2) If no problem exists with surface water control structures (40)

B. <u>Quality (30)</u> - Any of the water used on this location can be treated to allow use for all of the individual processes. The ranking is, therefore, based upon cost of treatment. <u>Choose only one for total.</u>

1. Treat Salt Water Source (10)
2. Treat Surface Water Source (25)
3. Treat Ground Water (30)

C. Accessibility (80) - The ranking in this category is determined by the distance of water resource from location and the method used to extract water from the area. Choose only one major category.

1. Distance of surface or salt water resource (80)

a. Water on location (80)

b. Water not on location (0)

2. Wells for ground water (80) - distance of drilling for existing wells

a. Less than 100 feet (80)

b. 100 feet (70)

c. 200 feet (60)

d. 300 feet (50)

e. 400 feet (40)

f. 500 feet (30)

II. TRANSPORTATION (250 points)

A. Mode (60) - Ratings are assigned on potential bulk transport capacities available for shipping coal from source to plant location. Since water transport has normally reduced the cost per ton, shipping by water is rated higher. Add for total.

1. Navigable waterway located at plant location (35)

2. Rail facilities located at plant location within five (5) miles (25)

B. Accessibility (100) - Ratings are based on existing and/or potential facilities with consideration given to general cost trends as they relate to shipping, handling facilities, and combination of different modes. Add major categories for total.

1. Port Facilities (60) - Evaluate location on basis of having or potential of having port located. Choose only one.

a. Plant location has adequate existing deep draft port facility to handle coal (60)

b. Plant location has adequate existing shallow draft port facility to handle coal (50)

c. Plant location has deep draft port facility with potential for coal handling (40)

d. Plant location has waterway with potential for shallow draft port facility to handle coal (30)

2. Rail Facilities (40) - Evaluate location on basis of having or potential of having rail service. Choose only one.

a. Plant location has adequate existing rail facilities to handle coal less than one (1) mile (40)

b. 1 to 2 miles (30)

c. 2 to 3 miles (20)

d. 3 to 4 miles (10)

e. 4 or more (5)

C. Capacity (90) - In addition to mode and accessibility, the transport facilities need capacity to handle bulk coal shipments. Ratings are assigned according to general cost trends, operational advantages, and physical capabilities. Add major categories for total.

1. Waterways and Ports (55) - Choose only one.

a. Waterway or port has no depth limitations (55)

b. Waterway or port only suitable for shallow draft barges (35)

2. Rail (35) - Add for category total.

a. Existing track with adequate structural strength and scheduling potential (35) by unit train.

b. Subtract (10) points for scheduling problems due to different rail lines.

c. Subtract (10) points for difficulty regarding crews, engines, etc.

d. Subtract (5) points for limitations on track length (side tracks) to permit long unit trains.

III. TRANSMISSION (150 points)

A. Interconnection (30) - Add for total.

1. Number of 240 kV on 500 kV interconnection points available and distance to interconnection (20) - Add for total.

a. Number of interconnection points (5) - Choose one.

1) More than three (5)

2) Two or three (3)

3) One (1)

b. Distance to interconnection point measured by circuit miles (15) - Choose one.

1) Zero to 25 miles (15)

2) 26 to 50 miles (12)

3) 51 to 75 miles (9)

4) 76 to 100 miles (6)

5) More than 100 miles (3)

2. Probability of adequate interconnection agreement (inter-company relationships) (10)

B. System Capacity (40) - Add for total.

1. Existing System Capacity (20) - Add for total.

a. System voltage level at time unit is operational (10) - Choose one.

1) 500 kV (10)

2) 240 kV (8)

3) 138 kV (4)

b. System capacity and future plans for area capacity expansion (10) (Judgment).

2. Capacity Required (20) - Add for total.

a. Number of new substations at voltages other than those present in the area that are required (10) - Choose one.

1) One or less (10)

2) Two (5)

3) Three or more (1)

b. Total number of circuit miles required (includes any transmission which is required outside of that needed to get to interconnection point (10) - Choose one.

1) Zero to 25 miles (10)

2) 26 to 40 miles (5)

3) More than 40 miles (0)

C. Routing and Siting - Add major categories for total (80)

1. Soil Conditions - Choose one (20)

a. Depth to rock (4)

1) 10 Feet or More (4)

2) 5 to 10 feet (3)

3) 2 to 5 feet (2)

b. Ground water table (6)

1) 10 feet (6)

2) 5 feet (5)

3) 1 foot (2)

4) 0 feet (0)

c. Soil type (10)

1) Type 1 - firm clay, gravel (10)

2) Type 2 - loam, sandy clay (7)

3) Type 3 - wet fine sand, silt (5)

4) Swamp (0)

2. Terrain - Choose one.

a. Access (2)

1) Good (2)

2) Fair (1)

3) Poor (0)

b. Ground slopes (2)

1) 0 - 5 percent (2)

2) 5 - 10 percent (2)

3) 10 percent plus (1)

c. Surface stability (6)

1) Good (6)

2) Fair (4)

3) Poor (1)

d. ROW clearing (10)

1) 0 to 1 percent (10)

2) 1 to 5 percent (8)

3) 5 to 10 percent (3)

4) 10 to 20 percent (1)

5) 20 percent plus (0)

3. Right-of-Way Requirements - Choose one (30)

a. Circuit separation (5)

1) 5 plus miles (5)

2) 3 miles (4)

3) 1 mile (3)

4) .5 or less mile (1)

b. Number of line angles (5)

1) Less than 2 per mile (5)

2) 3 or more per mile (2)

c. Land uses crossed by transmission line (20)

1) Industrial open land (pasture) (20)

2) Forest (6)

3) Agricultural (12)

4) Other (4)

4. Crossings - Choose one (10)

a. T-lines (5)

1) One or less per 25 miles (5)

2) Two per 25 miles (4)

3) Three or more per 25 miles (2)

b. Railroads, highways (5)

1) Three or less per 25 miles (5)

2) Five or less per 25 miles (4)

3) Eight or more per 25 miles (2)

IV. ENVIRONMENTAL (350 points)

A. Emissions (70) - Points are awarded on the location's ability to meet state, local, and federal regulations as they pertain to air, noise, water, and solid waste disposal.

1. Air (25) - Ability of the location to meet all air regulations (i.e., SO_2, particulates, etc.). Add major categories for total.

a. Sulfur dioxide arithmetic mean (15) - Choose only one.

1) 0 - 14 ug/m^3 (15)

2) 15 - 29 ug/m^3 (8)

3) 30 - 44 ug/m^3 (4)

4) 45 ug/m^3 (2)

b. Particulates geometric mean (10) - Choose only one.

1) 0 - 14 ug/m^3 (10)

2) 15 - 29 ug/m^3 (8)

3) 30 - 44 ug/m^3 (4)

4) 45 ug/m^3 (2)

2. Water (25) - Ability of the location to meet all discharge regulations. Add major categories for total.

   a. Thermal discharges - Need approximately 16,000 cfs for once-through cooling. Also required an approved 316 A demonstration (15) - Choose only one.

      1) Once-through cooling (15)

      2) Mechanical cooling system (5)

   b. Effluent discharge (10) - Choose only one

      1) Receiving water Class III, IV, or V (10)

      2) Receiving water Class I or II (5)

3. Solid Waste (15) - Ability of the location to meet solid waste disposal regulations. Add major categories for total.

   a. Scrubber SO_2 sludge disposal (10) - Choose only one.

      1) On location (10)

      2) Not on location (0)

   b. Precipitator fly ash disposal (5) - Choose only one.

      1) On location (5)

      2) Not on location (0)

4. Noise (5) - Choose only one.

   a. Location boundary ambient noise level not increase (5)

   b. Location boundary ambient noise level increased (0)

B. Physical (100) - Physical characteristics and forces acting on the locations are both internal and external. External factors are generally of a regional nature while internal factors are generally location specific. Points are awarded for absence of constraints.

   1. External Factors (25) - Add for total.

      a. Atmospheric Conditions (5) - Absence of occurrence of extreme winds and vortex phenomena, hurricanes, water spouts, and wind pressures.

b. Seismicity (5) - Absence of seismic occurrences.

c. Flooding (15) - Elevation of above 100-year flood whether from ocean, gulf, stream, or lake.

2. Internal Factors (75) - Add major categories for total.

a. Geology and Physiography (20) - Nature and condition of bedrock and/or soil bearing capacity to ensure stable foundations.

b. Local Topography (25) - Favorable to adequately locate sufficient land area for project: Add for category total.

1) Good local relief (5)

2) Adequate drainage (5)

3) Surface materials of minimum value for economic mineral extraction (5)

4) Land available to dispose of solid waste from power plant (10)

c. Stability (25) - Location free from following: Add for category total.

1) Fullers earth or sensitive shales and clays with inherently high shrink-swell problem (8)

2) Ground water withdrawal - subsidence (5)

3) Subsidence hazards related to Karst terrain sinks or solution cavities (10)

4) Hydrocompaction - when water is added to certain granular material formations (2)

d. Forest Vegetation (5) - Location is in a forest setting.

C. Ecology (100) - Points are awarded on the basis of the location's ability to accomodate the power plant. Add major categories for total.

1. Botanical Elements (50) - Add for category total.

a. Terrestrial Systems (8) - This item should include botanical communities, species diversity, and community importance to the ecosystem. (This item includes uplands, bottomlands, and wetlands.)

b. Fresh-Water (Aquatic) System (10) - This item should include botanical communities, species diversity, and community importance to the ecosystem. (This item includes lakes, ponds, marshes, and rivers.)

c. Marine (Aquatic) System (10) - This item should include botanical communities, species diversity, and community importance to the ecosystem. (This item includes estuaries, tidal marshes, and ocean waters.)

d. Threatened or Endangered Species (22) - This item includes the absence of threatened, endangered, and unique botanical species.

2. Zoological Elements (50) - Add for category total.

a. Terrestrial Systems (8) - This item should include primary zoological species, species diversity, and species importance to the ecosystem.

b. Fresh-Water (Aquatic) System (10) - This item should include primary zoological species, species diversity, and species importance to the ecosystem.

c. Marine (Aquatic) System (10) - This item should include primary zoological species, species diversity, and species importance to the ecosystem.

d. Threatened or Endangered Species (22) - This item includes the absence of threatened, endangered, and unique zoological species.

D. Socio-Economic (30) - Add major categories for total.

1. Taxation Policies (9) - Choose only one.

a. Total county levy less than 13.700 mills (9)

b. Total county levy more than 13.701 mills (0)

2. Land Values (7) - Choose only one.

a. Agricultural land valued at less than $2,600 per acre (7)

b. Agricultural land valued at more than $2,600 per acre (0)

3. Housing Availability (5) - Add for category total.

   a. Rental availability - vacancy rate of 10.6% or greater (2)

   b. Purchase availability - vacancy rate of 1.2% or greater (3)

4. Income (2) - Choose only one.

   a. Per capita income of less than $4,000 annually (2)

   b. Per capita income of more than $4,000 annually (0)

5. Employment (3) - Add for category total.

   a. Unemployment - rate greater than 9.5% (2)

   b. Work force available - more than 700 (1)

6. Population (4) - Add for category total.

   a. Less than 30 persons/square mile in county (2)

   b. Less than 85 percent increase in 1970 population by 1990 (2)

E. Land Use (50) - Add major categories for total.

1. Existing Land Use (16) - Based upon combined percentage of cropland, pasture and forest - Choose only one.

   a. 80 percent to 100 percent of area (16)

   b. 60 percent to 79 percent of area (10)

   c. 40 percent to 59 percent of area (6)

   d. Less than 40 percent (0)

2. Predominate Future Land Use (8) - Choose only one.

   a. Industrial (8)

   b. Commercial (3)

   c. Residential (0)

   d. Agricultural/forest (6)

1) 80 percent or more in forest (6)

2) 60 percent agricultural and 40 percent forest (5)

3) 50 percent agricultural and 50 percent forest (5)

4) 40 percent agricultural and 60 percent forest (5)

5) 80 percent or more agricultural (4)

e. Swamp (3)

f. Recreational or institutional (0)

3. <u>No Prime Agricultural Land in Location (6) - Choose only one.</u>

4. <u>No Known Historical Sites in Location (6) - Choose only one.</u>

5. <u>No Harm to Known Archaeologic Sites (6) - Choose only one.</u>

6. <u>Minimal Harm to Park and Recreation Areas (6) - Choose only one.</u>

7. <u>No Known Competition for Land in Location (2) - Choose only one.</u>

8. <u>If Airport Located within Following Distances Subtract: Choose only one.</u>

a. 0 - 1 mile (3)

b. 1.1 - 3 miles (2)

c. 3.1 - 5 miles (1)

PUMP TEST

APPENDIX L

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FLORIDAN AQUIFER TEST

L.1 EXECUTIVE SUMMARY

A hydrogeologic study of the Floridan Aquifer was performed for Seminole Electric Cooperative, Inc. The study area is designated as the Putnam Site and is the proposed location of a steam-electric generating station in Putnam County, Florida. This investigation was performed to determine the aquifer coefficients and the associated water quality at the site. This information will be utilized to evaluate the potential for developing the Floridan Aquifer as a source of boiler feed-water for the proposed station.

A 14-inch diameter Production Test Well (PTW) and an 8-inch diameter Observation Well (OW) were drilled. The wells were 440 feet deep and penetrated a depth of 220 feet into the Floridan Aquifer. The two wells were used to perform an aquifer pumping test. The maximum drawdown of the static water level at the pumping test rate of 954 gpm was 47.7 feet. The elevation of the static water level in the PTW was +26.7 feet MSL at the start of the pumping test, yielding a water level elevation at the maximum drawdown of -21.0 feet MSL.

The aquifer characteristics selected as representative of the Floridan Aquifer at the test site includes a transmissivity of 46,000 gpd/ft, a storage coefficient of 1×10^{-4}, and a leakance of 1×10^{-3} gpd/cu ft. The quality of the ground water in the Floridan Aquifer at the test site is characterized by a chloride content of less than 36 mg/l and a total dissolved solids content on the order of 260 mg/l.

L.2 INTRODUCTION

The purpose of this investigation was to develop specific hydrogeologic information for the Floridan Aquifer at the Putnam Site. This information is required to evaluate the Floridan Aquifer as a potential source of boiler feed-water for the proposed Seminole Electric Cooperative, Inc., steam-electric generating station. The Putnam Site is located in Putnam County, Florida, several miles north of the City of Palatka and is bordered on the west by U.S. Route 17 and the south by State Route S209, as shown on Figures L-1 and L-2.

Information provided in this report includes local geological stratigraphy, physical and hydrogeological characteristics of the Floridan Aquifer and the confining bed, and Floridan Aquifer ground water quality.

This investigation was conducted in three phases: (1) Phase 1 included an initial compilation and evaluation of existing hydrogeological information to assess the Floridan Aquifer as a potential water source and to plan Phase 2 (Dames & Moore, 1978); (2) Phase 2 consisted of performing a well drilling and aquifer testing program to obtain site specific aquifer information; and (3) Phase 3 involved the evaluation of aquifer testing results to determine local aquifer and confining bed coefficients and to evaluate available water quality.

L.3 DRILLING PROGRAM

The hydrogeologic information obtained from the Phase 1 study provided the guidelines for planning and implementation of the site data collection program. That study found the local hydrogeologic setting to include a shallow non-artesian aquifer and the deeper artesian Floridan Aquifer. The shallow aquifer is a fine sand and is capable of producing moderate amounts of water. The Floridan Aquifer consists of permeable limestone formations and is the primary source of large quantities of ground water in Putnam County.

The study indicated the upper portion of the Floridan Aquifer would likely provide an estimated need requirement of 1,000 gallons per minute (gpm) of water with a total dissolved solids (TDS) quality better than 600 milligrams per liter (mg/l). The depth of the major water-producing zones was anticipated to be between 200 to about 400 feet and to have a transmissibility in excess of 100,000 gallons per day per foot width of aquifer (gpd/ft) (Bermes, 1963) which would produce 1,000 gpm with minimal aquifer drawdown. Water quality was anticipated to be better in the northwest portion of the site and would not likely exceed 600 mg/l TDS within the depth interval being considered. Water quality was anticipated to decline with depth.

As a result of the Phase 1 information, this current investigation included the drilling and construction of a 14-inch diameter, cased Production Test Well (PTW) and an 8-inch diameter, cased Observation Well (OW) to test and monitor the Floridan Aquifer. These wells are located as shown on Figure L-2.

In addition to its use as an observation well during aquifer testing, the drilling of the OW was planned to provide geological data for regional correlation and also to determine depths and thicknesses of water bearing zones, confining beds, and water quality versus depth for use in determining the final design depth of the PTW. The drilling of the OW was started several days before the PTW in order to obtain this information.

A 2-inch diameter sand-point well was placed into the shallow aquifer as a Shallow Observation Well (SOW) to evaluate whether this aquifer and the

Floridan Aquifer are hydraulically connected. The SOW is located 34 feet northeast of the OW and 74 feet southeast of the PTW.

The SOW was installed prior to starting the drilling of the OW. The sand-point was set into a 7 7/8-inch diameter hole drilled with a Gardner-Denver 1500 drill rig. The hole was drilled to a depth of 56 feet and penetrated through the upper fine sand aquifer and 3.5 feet into a silty clay. Drilling mud was necessary to maintain the stability of the hole sidewalls. The sand-point was placed at a depth of 40 feet following caving of the lower portion of the hole during installation. The sand-point was gravel packed with a medium course sand and gravel from 25 feet to 40 feet. The SOW was developed by suction pumping until clear water was discharging. The SOW was completed with a capped 2" pipe extending 1.6 inches above a 2- to 3-foot diameter concrete pad at the ground surface.

The OW was drilled with a Gardner-Denver 1500 drill rig to a total depth of 440 feet. The drill bit cuttings were examined and a continuous descriptive log maintained during drilling to record lithological characteristics. Air lift pumping tests were performed at selected depths during drilling to provide information regarding the specific capacity of the Floridan Aquifer with depth. The specific capacity was evaluated by measuring the drawdown in the OW for the rate of air lift pumping discharge which was measured by recording the time interval to fill a container of known volume. The pumping discharge water quality was also monitored at intervals during the drilling using field testing equipment to evaluate water quality versus depth. The information obtained during drilling is presented in Table L-1. The various types of information obtained during drilling were used in conjunction with geophysical log information of the OW provided by the St. Johns River Water Management District (SJRWMD) to determine the final drilling depth and construction details of the PTW.

The OW was completed at the depth of 440 feet on the basis of:

a. Examinations of cuttings indicated the lower rock formation was crystalline and characterized by low visible porosity;
b. The specific capacity information did not indicate a measureable increase in water production from the lowest depth interval penetrated.

c. Geophysical logging information indicated the lower formation was the Avon Park Limestone and the reported water producing zone at the upper contact appeared to have been penetrated; and,

d. Available information indicated the major water producing layers in the Avon Park Limestone were at much greater depths and it was likely the water quality would be unacceptable for intended uses within these deeper zones.

The PTW casing and hole diameter were selected to provide a water source of 1,000 gpm efficiently and to accommodate a vertical turbine pump capable of pumping 2,000 gpm. The final depth of the PTW was selected at 440 feet on the basis of information obtained during the drilling of the OW. The PTW was drilled using a Failing 2000 drill rig. The lithology encountered at the PTW location during drilling correlated with the OW information and, therefore, the PTW was completed at the total depth of 440 feet.

The general field construction procedure included drilling through the non-indurated sand and clay formations with large diameter tricone bits using drilling mud for fluid, grouting-in of casing, and completion of drilling to total depths with tricone bits and reverse-air circulation of ground water as fluid. This technique provides essentially continuous aquifer development during the drilling process and eliminates potential plugging of the water producing formations with drilling mud.

The drilling depths and construction details for the PTW and the OW are summarized on Figures L-3 and L-4, respectively. These figures also summarize the stratigraphy penetrated at each location, the geologic age of the formations, delineation of aquifer and confining layers, and the geophysical logging information provided by SJRWMD.

L.4 GEOPHYSICAL LOGGING

Geophysical logging of the PTW and OW was completed by the St. Johns River Water Management District (SJRWMD). The logging information is incorporated in this report and is presented on Figure L-3 for the PTW and Figure L-4 for the OW.

Geophysical well logging is a technique which includes the lowering of various sensing devices into a well to make a record that can be interpreted in terms of rock characteristics, nature of contained fluids, and well construction. A combination of several types of geophysical logs is usually required to evaluate subsurface geologic and hydrologic conditions. Parameters applicable to each log are considered in conjunction with standard interpretation techniques to arrive at qualitative and/or quantitative assessments.

The types of geophysical logging information provided by SJRWMD included electric resistivity, gamma ray, caliper, and temperature without pumping and during pumping. It was initially planned to obtain a flow meter log of the OW to provide additional information for determining the stratigraphic origin of the water flow. However, SJRWMD personnel declined to run this log because of the low pumping rate and their feeling that an unrepresentative flow meter record would be obtained.

Data obtained from the geophysical logs were used in conjunction with the lithological logs to assist in correlation of geologic formations between wells, to provide data for evaluation of well completion methods, and to obtain qualitative hydrogeological information about the subsurface formations.

L.4.1 Electric Resistivity Log

The resistivity of a substance, in this case limestone rock formations, is its ability to impede the flow of electric current. In conventional resistivity logs, currents are passed through the formation via certain electrodes, and voltages are measured with certain others. These measured voltages provide the resistivity determinations. The logging probe must be run in holes containing electrically conductive fluids of drilling mud or water to provide a current path between electrodes and the formation.

Electrical conductivity of a substance is the reciprocal of resistivity; that is, if resistivity is high, conductivity is low. In general, the higher the concentration of salts in the water, the higher the conductivity and the lower the resistivity.

The resistivity logs for the PTW and OW indicated that the depth interval with the highest and most varied resistivity occurs between 240 and 378 feet. This would tend to suggest that the lithology is somewhat varied and the formational waters are relatively fresh. The resistivity decreased below 378 feet to a depth of 429 feet and increased again from 429 feet to 440 feet. Down-hole water quality data suggests these changes are primarily related to rock resistance and not increased water salinity.

L.4.2 Gamma Ray Log

The gamma ray log provides a record in cased and uncased hole intervals and is very useful for correlation purposes. The log records the natural radioactivity of the sediments penetrated. In general, radioactive elements tend to be concentrated in shales and clays. Sedimentary rocks such as coarse grained or purely crystalline limestones usually have a very low level of radioactivity. Gamma ray logs were used in conjunction with recorded lithologic descriptions for the purpose of determining the site geologic stratigraphy and the geology between the PTW and the OW.

In the PTW and OW, the gamma ray logs indicated the lithology changes from a sand at the surface to a clayey sand below 50 to 60 feet. Below 96 feet to a depth of 220, the lithology changes often and consists principally of layers of sandy clays and clay. A dense, indurated, argillaceous limestone occurs at a depth of 220 to 235 feet and is characterized by a relatively high level of natural radioactivity. Below 235 feet the gamma ray logs consistently measured relatively low levels of natural radioactivity with depth. This suggests that the lithology, in this case primarily granular and crystalline limestone, remains relatively constant to the total depth of 440 feet. A small increase in the natural radioactivity at a depth of about 380 feet correlates with a thin layer of clay indentified from the cuttings at this depth. In general, the gamma ray log correlated with the lithologic log of the PTW and OW.

L.4.3 Caliper Log

The caliper log is a highly sensitive device which measures the diameter of the drilled hole. This log is normally the initial tool used in the hole because it provides data useful in casing installation and in determining required cement volumes. The caliper log is also used in conjunction with flowmeter data when available to determine quantitative flow measurements.

In general, the hole diameter in the OW was within 1-inch of the drill bit diameter. The only large increase in hole diameter occurred within the 10-foot interval below the casing, where the diameter increased up to 6 inches for a 6-foot interval. Hole diameter increased were greater in the PTW. The increase was typically about 3 inches or less; however, below the casing the increase was 6 to 8 inches over an interval of about 60 feet.

Larger increases in hole diameters suggest that the limestone between the bottom of the casing down to about 295 feet may be more porous and possibly less indurated than underlying material. Hole sizes remaining relatively constant with bit sizes suggest a relatively well indurated rock material. This trend correlates with the lithologic descriptions of cuttings from the PTW and OW.

L.4.4 Temperature Log

The temperature log provides a continuous recording of water temperature versus depth. A temperature log conducted while a well is being pumped may indicate zones of flow on the basis of temperature differences. A log conducted while the well is not being pumped indicates equilibrium water and formation temperature with depth. Temperature recorded within the casing may reflect curing temperatures of recently placed ground.

A temperature log was not run in the PTW; however, a temperature log was made in the OW for both pumping and non-pumping conditions. The equilibrium temperatures increase approximately 1.5°C with depth below the casing. The temperature log obtained during pumping recorded an increased temperature zone between a depth of 376 to 394 feet. This zone correlates well with the upper contact of the Avon Park Limestone. The temperature scale indicated on the log from SJRWMD appears to be roughly 3°C higher than actual temperatures, based on field thermometer measurements of pump discharge water (Table L-1).

L.5 GEOLOGY

A general discussion of the subsurface geologic formations encountered during drilling of the PTW and OW is presented to provide background information for the understanding of the subsurface hydrogeology. Discussions of regional geology have been previously presented (Dames & Moore, 1977, 1977b, 1978b). The site specific geologic formations penetrated during drilling were identified on the basis of local formation descriptions (Bermes, 1963; Bentley, 1977) compared with lithic characteristics of drill cuttings and gamma ray geophysical logs taken in each well by SJRWMD.

The uppermost formations penetrated in drilling range in age from Late Miocene to Recent. These formations consist of a sand at the surface which is underlain by undifferentiated marine deposits. The Hawthorn Formation of Miocene Age underlies the upper formations and in turn is underlain by the Ocala Group of Eocene Age. The Ocala Group consists of the Crystal River, the Williston, and the Inglis Formations. The Avon Park Limestone formation underlies the Ocala Group and is also of Eocene Age. The PTW and OW were terminated within the Avon Park Limestone.

The lithologic log for the PTW and the OW is presented in Table L-2. Figures L-3 and L-4 summarize the stratigraphy, geologic age, and gamma ray log information for the PTW and OW, respectively.

L.5.1 Avon Park Limestone

The Avon Park Limestone is the deepest formation penetrated during drilling. The upper contact was encountered at a depth of 376 to 379 feet. The thickness of the formation is reported to be 150 to 250 feet and overlies the Lake City Limestone (Bermes, 1963). This formation is of Eocene Age and is described as white to light brown, indurated, dense limestone and dolomite. There may be restricted zones of very poory indurated, porous, and chalky limestone. Drill cuttings indicate this formation locally is fine grained, crystalline, moderately indurated, and has moderate secondary porosity visible under a microscope. Some chalky to coarse grained, poory indurated bioclastics are also present locally.

L.5.2 Inglis Formation

The Inglis Formation overlies the Avon Park Limestone and is also of

Eocene Age. This formation is described as a light brown, coarse to fine grained marine limestone which may include thin beds of dolomite and foraminiferal coquina. This formation was roughly 40 feet thick in the PTW and the OW and was encountered between the depths of about 337 feet to between 376 to 379 feet. The upper contact was not clearly apparent due to lithological similarities with the overlying Williston Formation. Drill cuttings indicate locally this formation is fine grained, granular, sparsely fossiliferous, and poorly to moderately indurated. Porosity is readily visible when viewed under a microscope.

L.5.3 Williston Formation

The Williston Formation is of Eocene Age and overlies the Inglis Formation. This formation is described as a light brown, granular marine limestone. The formation was roughly 50 feet thick and was present at a depth of 287 feet to 337 feet. The lower contact was not clearly apparent due to lithological similarities with the underlying Inglis Formation. Drill cuttings indicate locally the Williston Formation is a white, fine to medium grained, granular limestone, which grades to light brownish-white below 305 feet in depth. The formation is poorly indurated and contains abundant microfossils. Porosity is readily visible under a microscope. Thin layers of gray dolomite were encountered at a depth of 300 to 310 feet.

L.5.4 Crystal River Formation

The Crystal River Formation is of Eocene Age and overlies the Williston Formation. This formation is described as a white marine limestone which is chalky and abundantly fossiliferous. The upper contact of this formation was penetrated at a depth of about 233 feet. The formation was roughly 54 feet thick, with the lower contact at a depth of 287 feet. Drill cuttings indicate locally this formation is visibly porous, medium grained, granular to chalky, and poorly indurated. The formation is abundantly fossiliferous and characterized by easily indentifiable Lepidocyclina. Layers of quartzitic sandstone were encountered between 244 and 264 feet.

The depth of the upper contact of the Crystal River Formation was anticipated on the basis of onsite borings to occur at about 200 feet uniformly across the site (Dames & Moore, 1978). However, the contact was actually penetrated in the PTW and OW at a depth of about 235 feet. This places the contact roughly 35 feet lower than anticipated.

L.5.5 Hawthorn Formation

The Hawthorn Formation is of Miocene Age and overlies the Crystal River Formation. This formation is described as consisting of gray to green, sandy and plastic clay with thin beds of sand and sandy limestone. The upper contact of the Hawthorn Formation is placed at a depth of 96 feet on the basis of gamma ray log information. This formation is roughly 137 feet thick with the lower contact at a depth of about 233 feet. Drill cuttings indicate the upper portion of the Hawthorn Formation consists primarily of clayey sands and sands with phosphate pebbles. The lower portion of the formation, below a depth of about 130 and to a depth of 220 feet, consists primarily of clays and sandy clays with thin layers of moderately indurated limestone and calcareous clay. The bottom of the Hawthorn Formation from 220 feet to 233 feet consists of an indurated, dense argillaceous limestone.

L.5.6 Undifferentiated Marine Deposits

The undifferentiated marine deposits are of Pliocene or Late Miocene Age. The deposits are described as interbedded lenses of fine to medium sand, shell, and silty clay. Drill cuttings indicate that locally these deposits appear to be primarily a gray clayey sand with some layers of silty clay. Shell fragments and phosphate pebbles are present in the lower portion of these deposits. The upper surface of these deposits was penetrated at a depth of about 56 feet. The bottom was taken as the top of the Hawthorn Formation at about 96 feet, indicating a local thickness of 40 feet.

L.5.7 Pleistocene and Recent Deposits

The Pleistocene and Recent deposits are described as discontinuous fine to medium quartz sand, clay, and shell beds. Drill cuttings indicate locally these deposits consist primarily of a fine, dark brown quartz sand with a trace of organic silt. These deposits occur at the surface of the site and extend to a depth of about 56 to 59 feet.

L.6 HYDROGEOLOGY

L.6.1 Aquifers

Two primary aquifers were identifiable at the Putnam Site. A shallow aquifer which is non-artesian and provides moderate amounts of water and the Floridan Aquifer at depth. The Floridan Aquifer is artesian and provides the major source of large quantities of ground water in Putnam County. The two aquifers are separated by confining beds consisting principally of the clays and limestone of the Hawthorn Formation.

The Floridan Aquifer locally includes the Lake City and Avon Park Limestones, the Ocala Group, and the basal Hawthorn Formation. Regionally the thickness of the Floridan Aquifer exceeds 750 feet of limestone and dolomite (Bermes, 1963). Locally the Ocala Group provides the major source of high quality ground water. The upper portion of the basal Hawthorn limestone layer penetrated at the site appears to be part of the overall Hawthorn Formation confining layer; however, the lower portion may produce some amount of water. The lower portion of the Avon Park Limestone and the underlying Lake City Limestone contain water producing zones; however, the water quality is usually lower than produced in the Ocala Group and the upper Avon Park Limestone.

The upper sand layer of the shallow aquifer extended to a depth of about 56 feet at the testing site. This sand layer was penetrated to a depth of 40 feet with the Shallow Observation Well (SOW).

The major water producing zone of the Floridan Aquifer correlated with the top of the Ocala Group at a depth of about 233 feet. Both the PTW and the OW penetrated about 147 feet of the Ocala Group and about 60 feet further into the Avon Park Limestone, terminating at a depth of 440 feet. On the basis of visible porosity in cuttings and the specific capacity testing of the OW during drilling, it appears the water producing characteristics of the Ocala Group were fairly uniform with the Crystal River producing somewhat more water than the underlying Williston and Inglis Formations. Based on the temperature log in the OW and the specific capacity information, a relatively large flow of water occurs over a zone at the top of the Avon Park Limestone. The water producing capability of the Avon Park Limestone below the contact appeared to be similar to the Ocala Group for the interval to the lower dolomite contact. The dolomite zone did not produce any measureable increase in specific capacity.

Delineation of the aquifer and confining bed layers and associated stratigraphy is presented on Figure L-3 for the PTW and Figure L-4 for the OW.

L.6.2 Aquifer Test

The aquifer pumping test to evaluate the local characteristics of the Floridan Aquifer was a constant rate pumping test conducted for 28 hours at an average rate of 954 gpm. The pumping test was performed using a vertical turbine pump placed in the PTW which was capable of pumping water in excess of 2000 gpm. Rates of pumping were determined using totalizing flow meter measurements of water volume versus pumping time. A rapid two step drawdown test with average pumping rates of 585 gpm and 1155 gpm was conducted initially to evaluate the well efficiency of the PTW.

Hydrologic data collected during the pumping test program included: (1) static water level in the shallow aquifer and the Floridan Aquifer; (2) water level drawdown and recovery for the Floridan Aquifer in the PTW and the OW: (3) water level measurements of the shallow aquifer in the SOW during testing of the Floridan Aquifer; and, (4) water quality information from pump discharge and down-hole samples.

Water levels in the PTW for static and also drawdown and recovery were measured using a steel tape with a Soil Test electric probe tied at the zero point. The static water levels in the OW were measured using a steel tape with a chalked length on the bottom. The OW drawdown and recovery water levels were monitored continuously with a Stevens Type F water level recorder with periodic confirmation with a chalked steel tape.

L.6.3 Aquifer Test Data and Analysis

Aquifer characteristics for the Floridan Aquifer were evaluated by analysing the data collected for the constant rate of pumping test. The various methods of data analysis included using the Theis non-equilibrium type-curve graphical method for a leaky artesian aquifer (Walton, 1962) and the Jacob modified non-equilibrium straight line method (Johnson, 1966). Data analysis included log-log and semilog plots of time since pumping started (t) versus drawdown, recovery versus time since pumping stopped (t'), recovery versus the ratio of time since pumping started to the time since pumping stopped (t/t'), and distance (r) versus drawdown. The data collected for the Floridan Aquifer during the step drawdown pumping test was analyzed for well efficiency using a method presented by Jacob (Walton, 1962). The vertical permeability of the confining layer was determined from the type-curve method of analysis and was used to determine the leakance value (Davis, 1966).

The shallow aquifer static water level was measured in the SOW at a depth of 2.7 feet below the ground surface at the start of the Floridan Aquifer pumping test. Discharge water from the pumping test was directed away from the SOW in a lined ditch to minimize surface recharge during the test. The drawdown water level measurements taken in the SOW indicate no measureable drawdown took place in the shallow aquifer during the Floridan Aquifer pumping test. Table L-3 presents the results of the SOW water level measurements.

The static water level of the Floridan Aquifer at the start of the pumping test was measured in the PTW and the OW at a depth of about 33 feet below the ground surface, approximately +26.7 feet MSL. The maximum total drawdown below the static level in the pumped well was 47.7 feet. This level of drawdown was to an elevation of about -21 feet MSL. The maximum drawdown in the OW was about 19 feet. The changes in slope of the drawdown data indicate an apparent recharge source after about 100 minutes of pumping, which reduced the rate of drawdown. The drawdown appears to reach equilibrium after 800 to 1000 minutes in both the PTW and OW. The recovery data also suggest a recharge source as the time interval for the wells to recover was shorter than the pumping interval. Both wells recovered to static water levels above those at the start of the test, suggesting influences from changes in barometric pressure. The drawdown and recovery data is plotted on Figures L-5 and L-6 for the PTW and OW, respectively.

The well loss constant for the PTW was calculated to be 0.16 sec^2/ft^5; based on this constant the head loss in the PTW during the 954 gpm pumping test was about 0.7 feet.

A transmissivity value of 46,000 gpd/ft, a storage coefficient of 1×10^{-4}, and a leakance value of 1×10^{-3} gpd/ft^3 are representative of the Floridan Aquifer at the Putnam Site. These values were selected on the basis of a review of all the results obtained from the various methods of analysis.

L.6.4 Aquifer Water Quality

The Floridan Aquifer was selected for evaluation as the potential source of boiler feed-water on the basis that water quality would likely be higher and more stable during the life of the proposed facility than would water taken from the St. Johns River. Decisions regarding the location of the test wells and also the final design depth were made on the basis of maximizing potential water quality as well as water quantity. Water quality within the Floridan Aquifer was anticipated to decrease in southerly and easterly directions and also with depth of penetration. Specific knowledge of the ground water quality is necessary to allow proper use and development as a water source.

Water quality samples were obtained at various times during this hydrogeologic data collection program. These included the following: (1) sampling and field testing of the OW drill rig pump discharge during the drilling to assist in determining the final design depth of the PTW to maximize water quality as well as water quantity; (2) sampling and field testing of the turbine pump discharges water during testing of the PTW to observe potential water quality changes during pumping and to determine the quality of water available from the PTW for use as a source of boiler feed-water; and, (3) down-hole sampling in the PTW and OW to determine changes in water quality versus depth in the Floridan Aquifer.

Field and/or laboratory analysis of water samples were conducted. The field tests were conducted to provide general water quality information as needed to assist field design decisions (Table L-1). The tests included measurements of chloride content, temperature, and conductivity using a Hach Chemical Company water analysis kit and also a YSI Model 33/SCT meter. The laboratory test were conducted by an outside professional laboratory. Samples were collected by Dames & Moore personnel and placed in storage and shipping containers provided by the laboratory. Several samples were split and provided individual sample numbers as a test control.

The quality of the ground water is better than anticipated. In general, the PTW discharge water quality is characterized by a chloride content of 36 milligrams/liter (mg/l) and total dissolved solids (TDS) on the order of 260 mg/l. The water quality of the section of the Floridan Aquifer penetrated appears to remain quite constant with depth. The laboratory analyses indicate the chloride content ranges from 29 to 31 mg/l and the TDS content ranges from 200 to 270 mg/l. Water sample number 7 and 11 taken at depths of 250 and 400 feet in the PTW were apparently contaminated with H_2SO_4 and are not representative of the actual water quality.

The results of field tests of water quality during pumping are provided in Table L-1. Laboratory water quality analyses of pump discharge samples during the pumping test are summarized in Table L-4. Laboratory water quality analyses of down-hole water samples are summarized in Table L-5. The chloride and TDS water quality data for the down-hole samples taken in the PTW are plotted versus depth on Figure L-3.

L.7 REFERENCES CITED

Bentley, C. B., 1977, Aquifer Test Analyses for the Floridan Aquifer in Flagler, Putnam, and St. Johns Counties, Florida, U.S. Geological Survey, Water Resources Investigations 77-36.

Bermes, B. J., et. al., 1963, Geology and Ground Water Resources of Flagler, Putnam, and St. Johns Counties, Florida, Florida Geological Survey Report of Investigations No. 32.

Brownell-Moger & Associates, Inc., 1978, Boundary Survey, Seminole Plant Unit No. 1, Seminole Electric Cooperative, Inc., Dated April 14, 1978, Scale of 1" = 600'.

Dames & Moore, 1977, Preliminary Environmental Assessment and Fatal Flaw Analysis, Bostwick Site, for Seminole Electric Cooperative, Inc. Project Report, 10359-002-09.

Dames & Moore, 1977b, Bostwick Site, Environmental/Design Recommendations, Based on Soils and Geotechnical Conditions, for Seminole Electric Cooperative, Inc., Project Report, 10359-004-09.

Dames & Moore, 1978, Floridan Aquifer, Preliminary Water Quality Analysis and Proposed Scope of Work for Additional Floridan Aquifer Studies for Boiler Feed-Water, Putnam County Site, for Seminole Electric Cooperative, Inc., Project Report, 10359-004-09.

Dames & Moore, 1978b, Interim Report, Environmental Input to Power Plant Engineering Design Process, Proposed Electric Generating Plant, Putnam County, Florida, for Seminole Electric Cooperative, Inc., Project Report, 10359-004-09.

Davis, S. N., and De Wiest, R. J. M., 1966, Hydrogeology, John Wiley and Sons, Inc., New York, 463 Pages.

Johnson, Edward E., Inc., 1966, Ground Water and Wells, Edward E. Johnson, Inc., Saint Paul, Minnesota, 440 Pages.

Walton, W. C., 1962, Selected Analytical Methods for Well and Aquifer Evaluation, Illinois Water Survey Bulletin 49.

TABLE L-1

OBSERVATION WELL

SPECIFIC CAPACITY AND WATER QUALITY DURING DRILLING

OBSERVATION WELL		PUMP DISCHARGE WATER QUALITY		
Depth (ft)	Specific Capacity (gpm/ft)	Temperature (^{o}C)	Specific Conductance (umhos/cm)	Chloride (mg/l)
268	12.6	22	310	40
299	16.6	--	--	--
320	--	22	320	35
331	18.6	--	--	--
362.5	21.3	21	340	35
394	26.9	22	290	36
426	30.8	23	310	37
440	27.3	22.5	345	35

TABLE L-2

LITHOLOGIC LOG
PRODUCTION TEST WELL (PTW)
AND
OBSERVATION WELL (OW)

Owner: Seminole Electric Cooperative, Inc.

County: Putnam

General Location: Section 6, T.9S, R. 27E

Drilling Company: Alsay-Pippin Corporation

	PTW	OW
Coordinates:	N 1966775.12 E 296464.93	N 1966723.15 E 296517.82
Ground Elevation	+59.7 MSL	+59.5 MSL
Drill Rig:	Failing 2000	Gardner-Denver 1500
Started:	4/23/78	4/20/78
Completed:	4/30/78	4/27/78
Total Depth:	440 Feet	440 Feet
Casing:	0-59.5 - 20" O.D. 0-240 - 14" O.D.	0-61.5 - 14" O.D. 0-240 - 8" I.D.

DEPTH PTW	DEPTH OW	
		Pleistocene to Recent
		Surficial Deposits:
0 - 56	0 - 59	sand, light gray, fine; grades to dark brown at 7 feet, with trace organic silt.
		Miocene
		Undifferentiated Marine Deposits:
56 - 90	59 - 89	sand, gray, fine to medium, with silt and clay; trace silty clay layers; grades with phosphate nodules below 77 feet; grades with shell fragments below 85 feet; silty clay layer in OW from 59 to 62 feet.

PTW	OW	
90 - 96	89 - 95	sand, gray, fine with shell fragments, pebble phosphate, trace of silt and clay; trace silty clay layers.
		Hawthorn Formation:
96 -118	95 -145	sand, gray, fine with shell fragments, pebble phosphate, trace of silt, and clay; trace silty clay layers; grades with increased silt below 102 feet in PTW and 132 feet in OW.
118-132	---	clay, greenish gray and brown, sandy and silty, with phosphate pebbles and trace of limestone pebbles; grades greenish gray below 124 feet.
132-148	145-165	sand, gray, fine with clay, shell fragments and pebble phosphate.
148-220	165-220	clay, greenish gray, with silt, fine to medium sand, pebble phosphate, and shell fragments; grades with decreased silt, sand, and shell fragments below 164 feet in PTW; grades with layers of fine to coarse phosphate sands and moderately indurated limestone and calcareous clay below 178 feet in PTW and 186 feet in OW.
220-234	220-233	limestone, gray, argillaceous; dense, indurated; low visible porosity; sparsely fossiliferous
		Eocene
		Ocala Group:
		Crystal River Formation
234-287	233-287	limestone, white, medium grained, granular to chalky; poorly indurated; high visible porosity; abundantly fossiliferous with Lepidocyclina; layers of quartzitic sandstone between 244 to 264 feet.
		Williston Formation
287-337	287-337	limestone, white, fine to medium grained, granular; poorly indurated; high visible porosity under microscope; abundant microfossils; layers of gray dolomite 300 to 310 feet; grades light brownish white below 305 feet.

PTW	OW	
		Inglis Formation
337-379	337-376	limestone, light brownish white, fine grained, granular, sparry carbonate grains; poorly to moderately indurated; high visible porosity under microscope; moderately to sparsely fossiliferous.
		Avon Park Limestone:
379-430	376-427	limestone, white to light grayish and brownish white, fine grained crystalline with some chalky to coarse grained bioclastics; moderately indurated with bioclastics to poorly indurated; low primary porosity with moderate secondary porosity visible under microscope; sparsely fossiliferous.
430-440 T.D.	427-440 T.D.	dolomite, light brown (tan), fine grained crystalline; indurated to moderately indurated; low primary porosity with moderate secondary porosity visible under microscope.

1. Log based on visual identification of drill cuttings and correlation with gamma ray geophysical logs.

2. All casing is black steel with 0.375-inch wall thickness, except for the 8-inch I.D. casing which is schedule 40, 0.322-inch wall.

TABLE L-3

SHALLOW AQUIFER

SHALLOW OBSERVATION WELL (SOW)

PUMPING TEST DRAWDOWN DATA

Date Time	Pumping Time (hours)	Depth Below Static Water Level (ft)
5/2/78 0900 hrs	0	.00[1]
	0.5	-.21[2]
	1	-.19
	2	-.10
	3	-.08
	4	-.07
	6	-.03
	8	.00
	10	-.02
	13	-.02
5/3/78 0100 hrs	16	-.05
	20	-.06
	24	-.11
5/3/78 1300 hrs Pump Off	28	-.07

1. Static water level measured at 2.7 feet below ground surface; ground surface elevation of 59.5 feet MSL indicates static water level of about 56 feet MSL.

2. Negative indicates water level above static measurement at 0900 hrs.

TABLE L-4

GROUND WATER QUALITY
PRODUCTION TEST WELL
PUMPING TEST DISCHARGE SAMPLES
(Uncased Hole Interval Extends From 240 to 440 Feet)

Date Sampled Time Sampled Sample No.	5/2/78 1120 hrs 1	5/2/78 2400 hrs 2	5/3/78 1200 hrs 3	5/3/78 1200 hrs 5	5/3/78 1200 hrs 4
Calcium, Ca	37	37	38	35	--
Magnesium, Mg	16	16	15	17	--
Sodium, Na	15	15	15	15	--
Potassium, K	1.24	1.18	1.18	1.09	--
Bicarbonates, HCO_3	146	142	151	151	--
Carbonates, CO_3	0	0	0	0	--
Hydroxide, OH	0	0	0	0	--
Sulfate, SO_4	16	32	15	12	--
Chloride, Cl	36	36	36	36	--
Nitrate, NO_3	<0.1	<0.1	<0.1	<0.1	--
Phosphate, PO_4	<0.03	<0.03	<0.03	<0.03	--
Flouride, F	0.3	0.3	0.3	0.3	--
Total Hardness, $CaCO_3$	156	156	154	156	--
Total Alkalinity, $CaCO_3$	120	116	124	124	--
pH	7.5	7.1	7.7	7.6	--
Iron, Total, Fe	<0.01	<0.01	<0.01	<0.01	--
Manganese, Mn	<0.05	<0.05	<0.05	<0.05	--
Silicon, Si	6.3	6.3	6.5	6.5	--
Chemical Oxygen Demand, COD	4.1	6.1	8.1	4.1	--
Color	0	0	0	0	--
Turbidity, NTU	1.9	1.9	1.1	1.1	--
Specific Conductance umhos/cm @ 25°C	350	370	360	360	--
Total Dissolved Solids	259	272	264	264	--
Aluminum, Al_2O_3	0.05	0.05	0.08	0.04	--
Total Coliform/100 ml (MFT)	--	--	--	--	<1

Note: All parameters given in mg/liter except as noted.

REVISED 3/15/79

TABLE L-5

GROUND WATER QUALITY

DOWN-HOLE SAMPLES - MAY 5, 1978

(Uncased Hole Intervals Extend From 240 to 440 Feet)

Well	OW	PTW	PTW	PTW	PTW	PTW	PTW	PTW
Sample Depth (ft)	250[1]	250	300	300	350	400	434	434
Sample No.	6	7[2]	8[3]	9[3]	10	11[2]	12[3]	13[3]
Calcium, Ca	54	38	38	38	41	52	28	36
Magnesium, Mg	5.1	15	15	16	15	17	17	12
Sodium, Na	6.6	15	15	16	15	13	12	12
Potassium, K	1.9	2.2	1.9	2.1	1.9	2.1	1.7	1.7
Bicarbonates, HCO_3	198	3.7	150	102	110	0	93	110
Carbonates, CO_3	0	0	0	0	0	0	7.3	0
Hydroxide, OH	0	0	0	0	0	0	0	0
Sulfate, SO_4	11	140	35	55	47	170	25	49
Chloride, Cl	7.7	28	30	31	31	31	29	29
Nitrate, NO_3	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
Phosphate, PO_4	1.4	0.19	0.19	0.19	0.28	0.47	0.62	0.31
Fluouride, F	0.2	0.3	0.3	0.3	0.3	0.4	0.3	0.3
Total Harndess, $CaCO_3$	156	156	156	162	162	198	140	140
Total Alkalinity, $CaCO_3$	162	3.0	123	84	90	0	88	90
pH	7.1	5.5	7.2	6.5	7.3	2.8	8.6	8.3
Iron, Total, Fe	1.14	0.26	0.61	1.3	0.75	0.44	0.01	0.05
Manganese, Mn	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silicon, Si	6.0	7.0	7.5	6.5	9.0	13	15	17
Silica, SiO_2	13	15	16	14	19	28	32	36
Chemical Oxygen Demand, COD	1.5	5.1	14	14	8.1	4.1	14	10
Color	0	0	0	0	0	0	0	0
Turbidity, NTU	28	0.38	3.3	4.2	8.5	5.7	1.6	1.7
Specific Conductance umhos/cm @ 25°C	295	435	360	380	380	1,200	300	310
Total Dissolved Solids	240	270	260	250	250	440	200	230
Aluminum, Al_2O_3	0.06	0.06	0.04	0.06	0.08	0.15	0.04	0.02

Note: All parameters given in mg/liter except as noted.

1. Partially bridged hole at 305 feet prevented deeper undisturbed samples.
2. Samples seemingly contaminated with H_2SO_4.
3. Split samples.

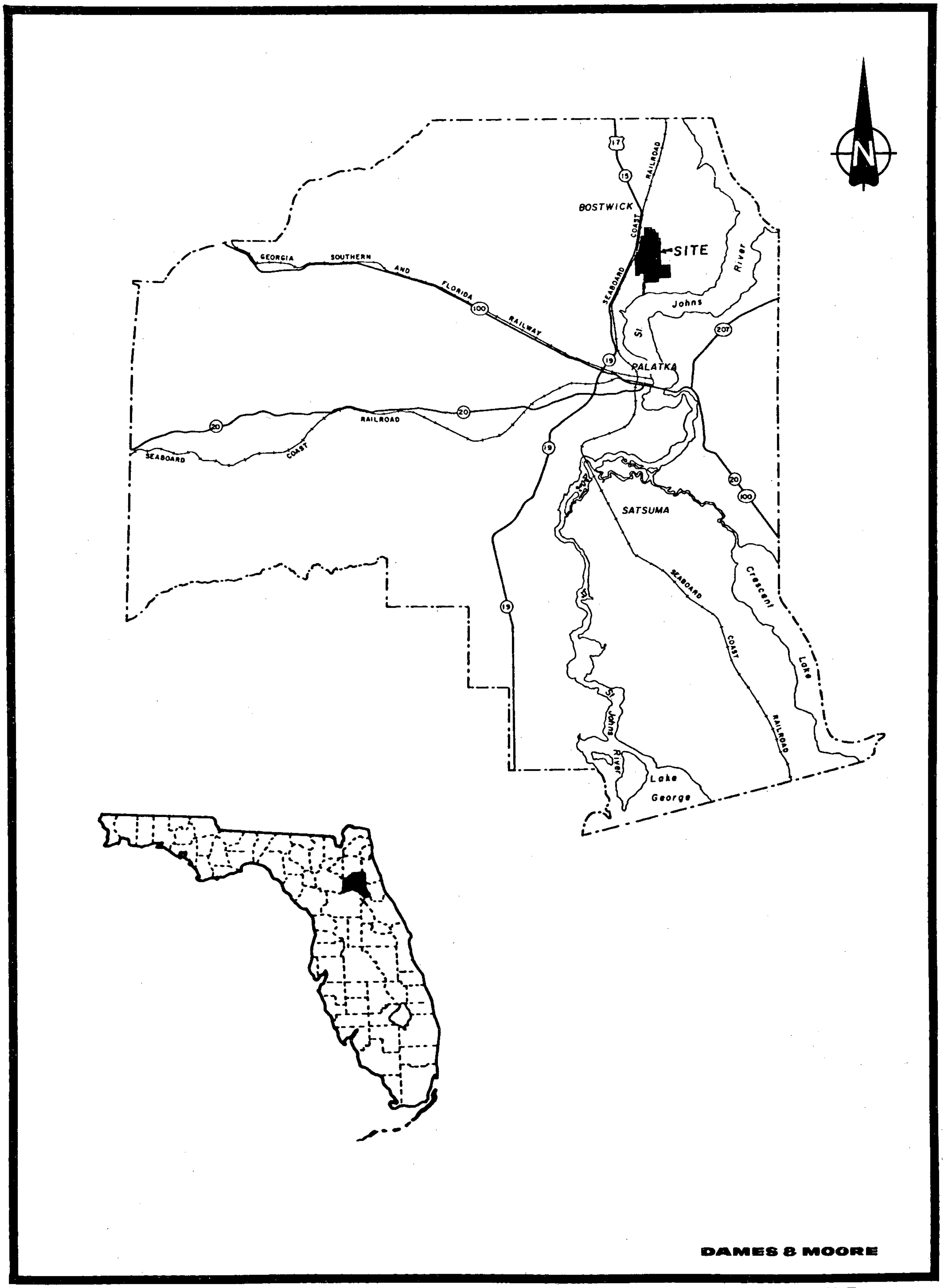


FIGURE L-1

SITE LOCATION MAP
PUTNAM COUNTY, FLORIDA

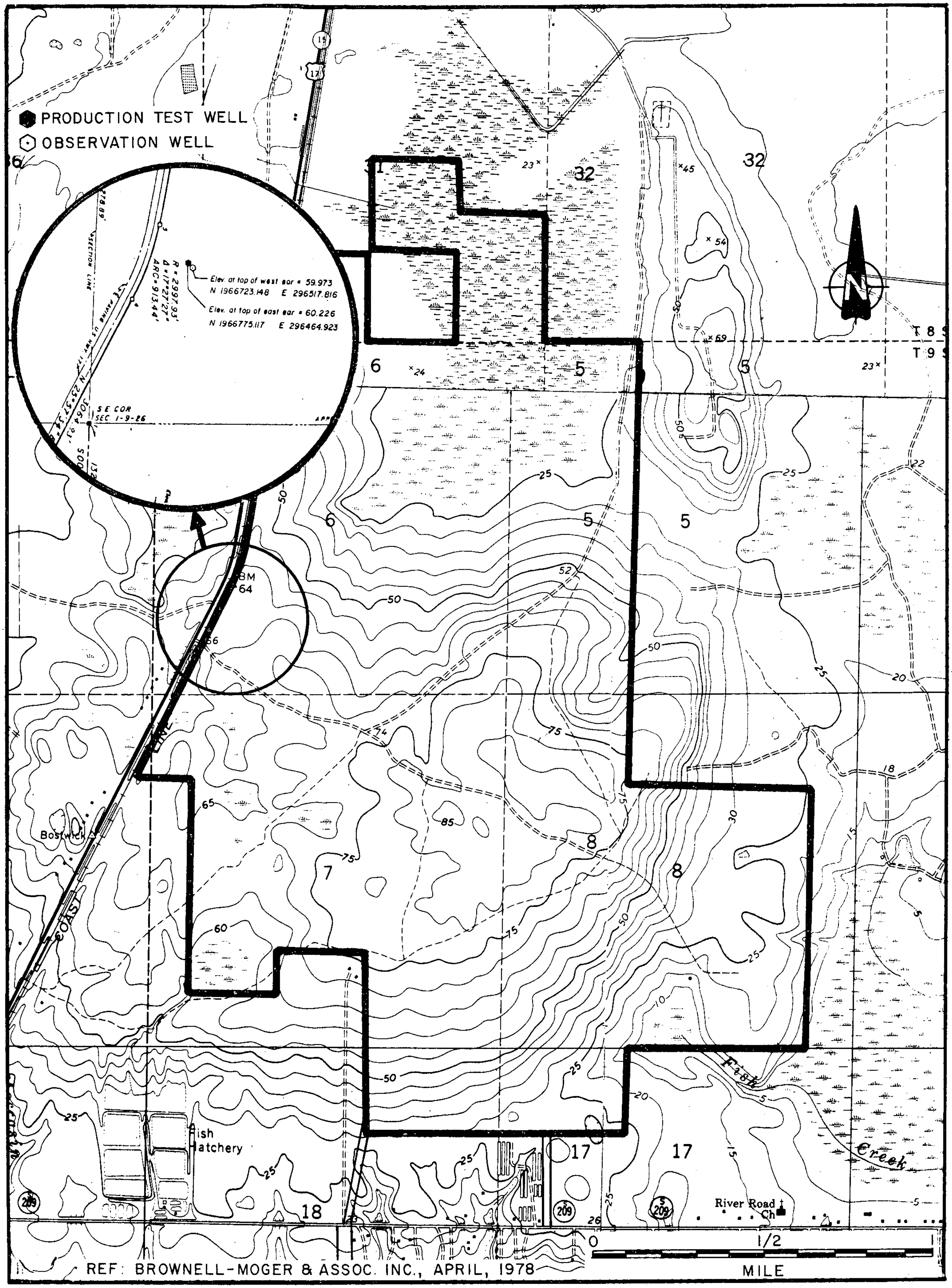
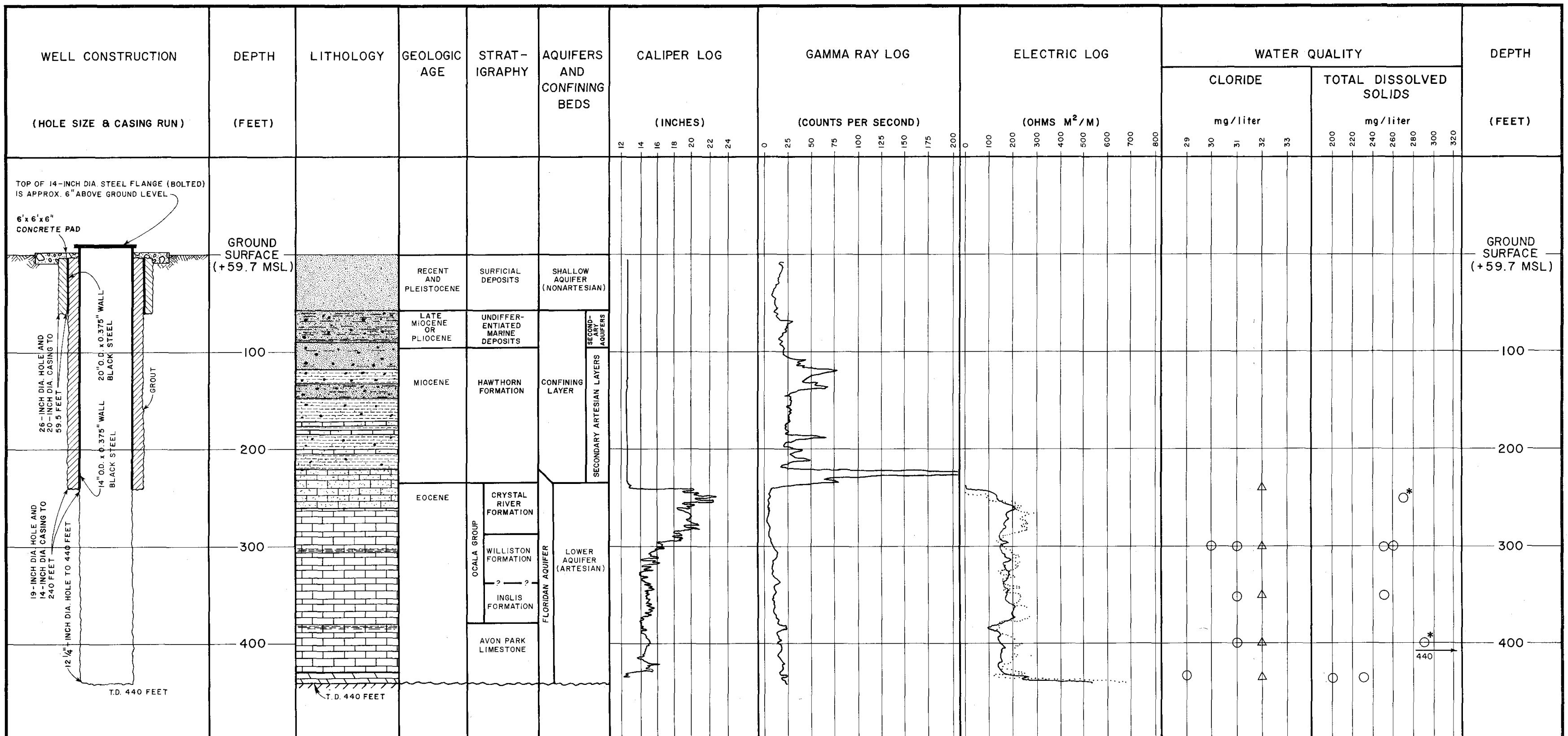


Figure L-2. Well Location Map, Floridan Aquifer Test.



LEGEND:

SAND
CLAY
PHOSPHATE
LIMESTONE
DOLOMITE

○ SAMPLED BY DAMES & MOORE 5-5-78

△ SAMPLED BY ST. JOHNS RIVER WATER MANAGEMENT DISTRICT 5-8-78

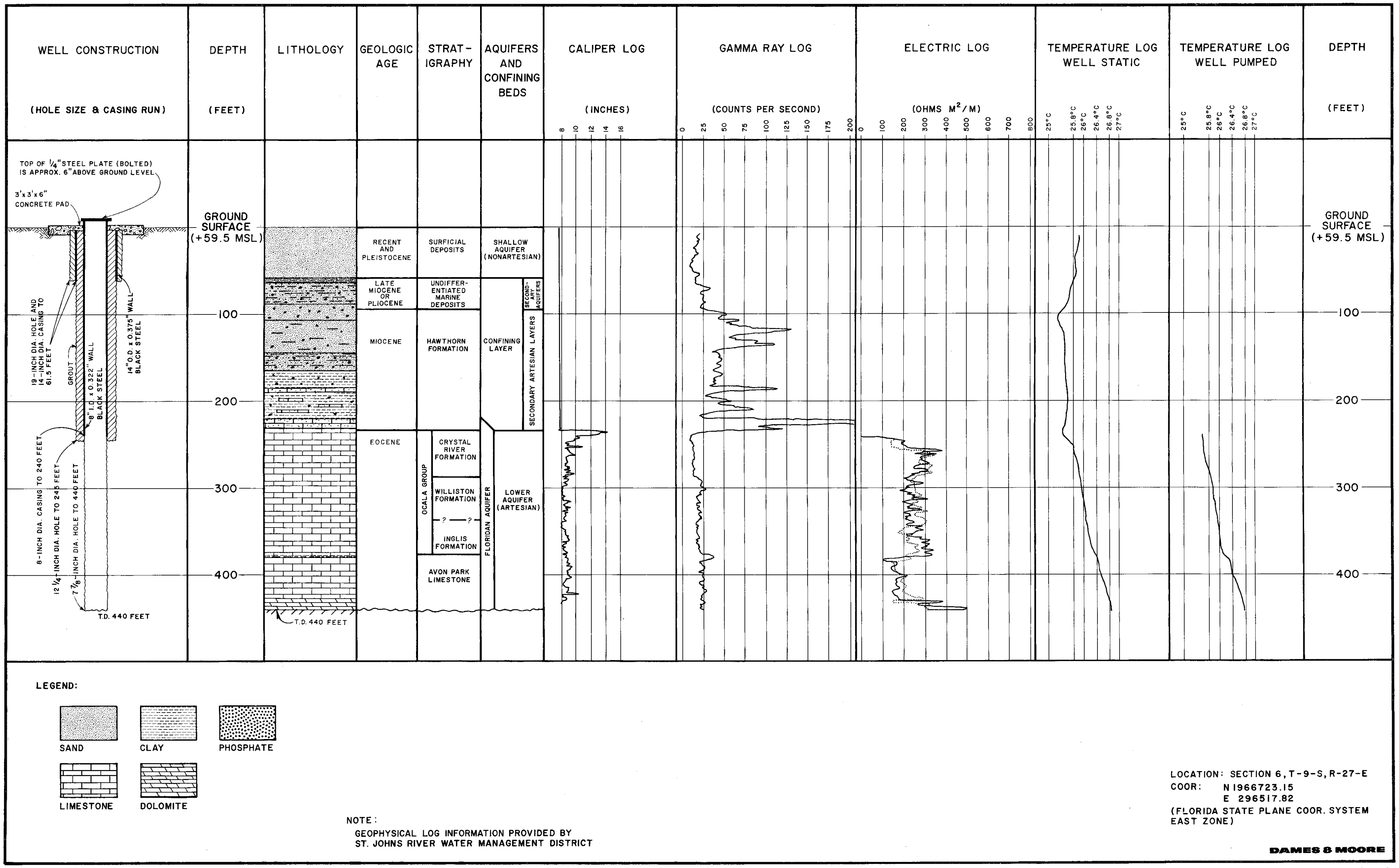
* QUESTIONABLE RESULTS-SAMPLES SEEMINGLY CONTAMINATED WITH H_2SO_4

NOTE:
GEOPHYSICAL LOG INFORMATION PROVIDED BY ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

LOCATION: SECTION 6, T-9-S, R-27-E
COOR: N 1966775.12
E 296464.93
(FLORIDA STATE PLANE COOR. SYSTEM EAST ZONE)

DAMES & MOORE

FIGURE L-3
PRODUCTION TEST WELL
WELL CONSTRUCTION AND HYDROGEOLOGY
FLORIDAN AQUIFER TEST

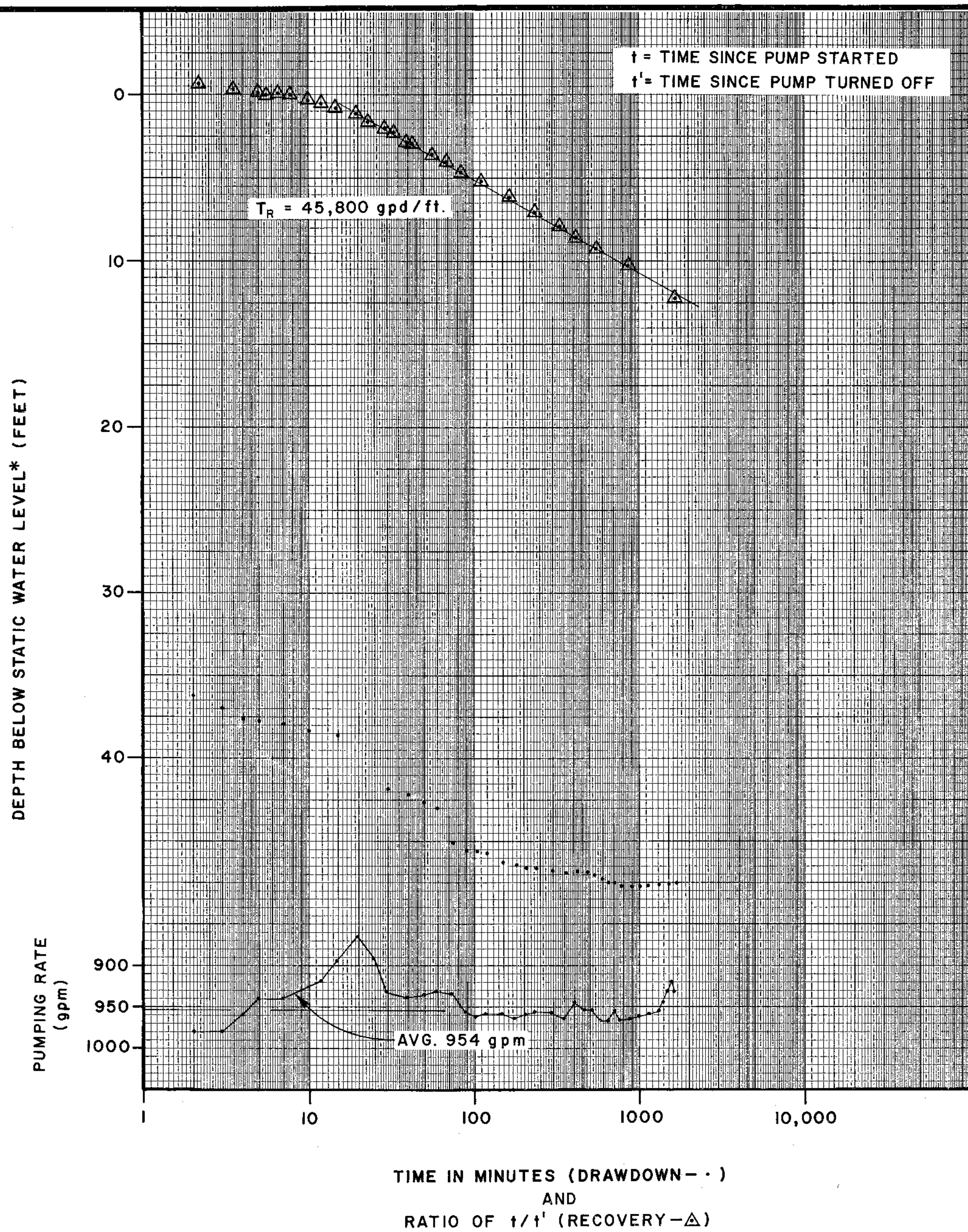


NOTE:
GEOPHYSICAL LOG INFORMATION PROVIDED BY
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

LOCATION: SECTION 6, T-9-S, R-27-E
COOR: N 1966723.15
E 296517.82
(FLORIDA STATE PLANE COOR. SYSTEM EAST ZONE)

DAMES & MOORE

FIGURE L-4
OBSERVATION WELL
WELL CONSTRUCTION AND HYDROGEOLOGY
FLORIDAN AQUIFER TEST

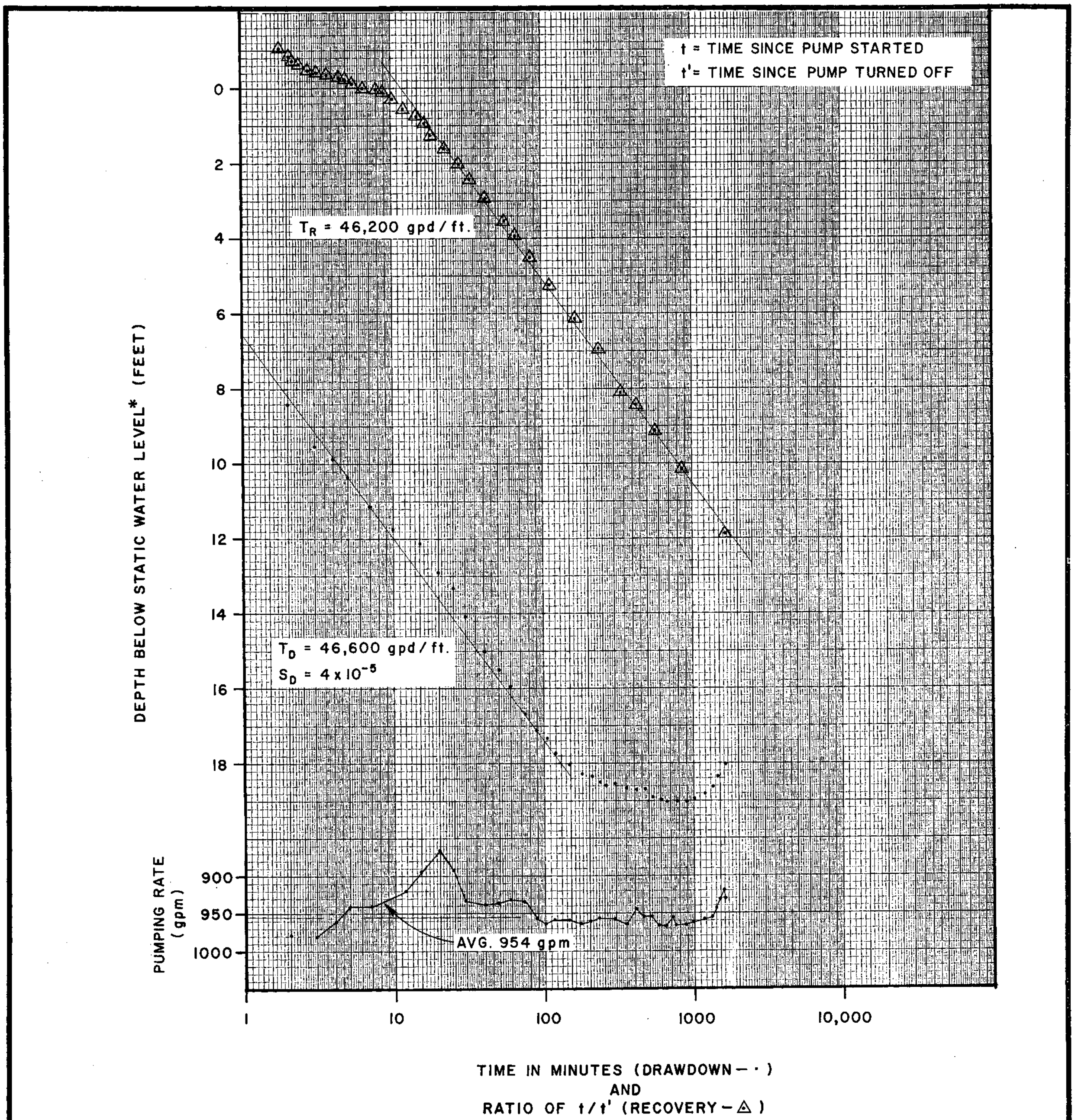


*STATIC WATER LEVEL ~ +26.7 FEET MSL (0900 Hr.; 5-2-78)

DAMES & MOORE

FIGURE L-5

PRODUCTION TEST WELL – DRAWDOWN AND RECOVERY
FLORIDAN AQUIFER TEST



*STATIC WATER LEVEL ~ +26.7 FEET MSL (0900 Hr.; 5-2-78)

DAMES & MOORE

FIGURE L-6

OBSERVATION WELL – DRAWDOWN AND RECOVERY
FLORIDAN AQUIFER TEST