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EISENHUT,D.G. Division of Licensing

SUBJECT: Forwards "Comparability of St Lucie Site & Liquid Pathway Generic Study From Standpoint of Liquid Pathway," in response to 810505 request. St Lucie site not unique in liquid pathway contribution to risk.

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FLORIDA POWER & LIGHT COMPANY

July, 27, 1981
L-81-319

Office of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

RECEIVED JUL 30 1981 U.S. NUCLEAR REGULATORY COMMISSION

Dear Mr. Eisenhut:

Re: St. Lucie Unit 2
Docket No. 50-389
Liquid Pathway Study

The attached report, "Comparability Of St. Lucie Site And Liquid Pathway Generic Study From The Standpoint Of Liquid Pathway", is provided in response to the May 5, 1981 Hydrologic Engineering Section/Hydrologic and Geotechnical Engineering Branch request for additional information (Question 240.3). The report concludes that the aquatic radiological impact of a core melt accident at the St. Lucie site is estimated to be less than the impact derived in the Liquid Pathway Generic Study, NUREG-0440, for a "typical" coastal land based site. Thus, the St. Lucie site is not unique in its liquid pathway contribution to risk.

Very truly yours,

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/TCG/ah

Attachment

cc: Harold F. Reis, Esquire
J. P. O'Reilly, Director, Region II

A001 S/1

COMPARABILITY OF ST. LUCIE SITE AND LIQUID PATHWAY GENERIC STUDY FROM THE STANDPOINT OF LIQUID PATHWAY

1. Introduction

This report represents an evaluation of the offsite radiological impacts which are unique to a hypothetical accident that results in temperatures inside the reactor core which are sufficiently high to cause core melting and subsequent penetration of the basemat underlying the reactor. Such an accident creates the potential for releases of radioactive material into the hydrosphere through contact with groundwater, which in turn may lead to external exposure to radiation and internal exposures if contaminated food or water is ingested. A discussion is also presented of engineered systems which could be effective in mitigating the impacts of such an accident by isolating the contaminated groundwater aquifer from the hydrosphere.

The penetration of the basemat of the Reactor Building can release molten core debris to the strata beneath the plant. Soluble radionuclides in this debris can be leached and transported with groundwater downgradient to surface water bodies used for aquatic food and recreation. In pressurized water reactors, such as the St. Lucie Unit 2 plant, there is an additional opportunity for groundwater contamination due to the release of contaminated sump water to the ground through a breach in the containment.

An analysis of the potential consquences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS).(1) The LPGS compared the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming and shoreline usage) for four conventional, generic land-based nuclear plants and a floating nuclear plant, for which the nuclear

reactors would be mounted on a barge and moored in a water body. Parameters for the land-based sites were chosen to represent averages for a wide range of real sites and are thus "typical," but represented no real site in particular.

This report presents an analysis to determine whether or not the St Lucie site liquid pathway consequences would be unique when compared to land-based sites considered in the LPGS. The method consists of comparing key parameters which characterize the St Lucie site and the "typical" land based ocean site evaluated in the LPGS. The parameters which are compared include groundwater travel time, sorption on geologic media, surface water transport, aquatic food consumption and shoreline usage.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, commercial and sports fishing, as well as many other water-related activities would be restricted. The consequences would therefore be largely economic or social, rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

2. Comparison of St Lucie Site to LPGS

Figures 1 and 2 (taken from the St Lucie 2 FSAR) present scaled diagrams of the relevant features of the site. The plant is located on Hutchinson Island, a barrier island bounded along the east by the Atlantic Ocean and on the west by the Indian River which, in fact, is not a river but a tidal lagoon. The distance from the Reactor Building to the ocean is about 2500 feet. The distance to the closest water body (i.e. Big Mud Creek) is about 700 feet.

The plant grade around the structure is at elevation plus 18.5 feet mean low water (MLW). The facility is underlain by Class I, high grade, compacted fill to a depth of -60 feet MLW. The base mat beneath the Reactor Building is at elevation -25.5 MWL(2).

The groundwater study region beneath the Class I fill includes a shallow, non artesian aquifer and a deep artesian aquifer. The top of the deep aquifer is typically 600 to 800 feet beneath the surface and therefore is not considered further in this study(3).

The unconfined aquifer beneath the Class I fill is the Anastasia formation. This formation extends to elevation -135 to -155 feet and consists of grey slightly silty fine to medium sand with varying amounts of fragmented shells. It also contains discontinuous pockets of cemented sand with shells and sandy limestone. Occasionally, discontinuous thin plastic clay lenses are found in the upper part of the formation.

The Anastasia formation is the relevent strata in the evaluation. It is divided into three zones. The upper zone which extends to about -60 feet is a loose to medium dense sand with small amounts of silt and clay and containing isolated pockets of shell fragments and limestone nodules. The intermediate zone begins at about -60 feet and extends to about -150 feet. It is denser than the upper zone, contains a greater percentage of fines and very few pockets of shells and limestone fragments. This zone would probably receive the melted core and sump water because it covers the range of depths over which a molten core may penetrate.

The characteristics of the intermediate zone are as follows:

Water Content	25%[4]
Dry Unit Wt	107 lbs per ft^3 [4]
Wet Unit Wt	133 lbs per ft^3 [4]
Specified Gravity	2.73[4]
Relative Density	77%[4]
Void Ratio	0.66[4]
Porosity	40%[4]
Grain Size	Sand (~90%) (.1 to 10 mm)[5] Silt (~5%) (.1 to .001 mm)[5]
Slope	.00016 (toward ocean)
Permeability	5×10^{-3} cm/sec[6]
Dispersivity	2 ft[7]
Distance to Ocean	2444 ft

The groundwater gradient of .00016 towards the ocean is obtained from Figures 3 and 4. Figure 3 shows certain piezometer locations, originally installed in the initial subsurface investigation of the site. Figure 4 shows the range of piezometer levels and average level for the month of April 1968. Also shown on this figure is the slope of the groundwater towards the Atlantic Ocean. The piezometer used for this determination is found at approximately the depth the molten core may penetrate and therefore indicates the groundwater gradient at that elevation.

These parameters establish that the groundwater flows generally toward the ocean and would require about 1164 years to flow from a location immediately beneath the Reactor Building to the ocean.

There exists the possibility of an alternative pathway for contamination of surface water via ground water travel to Big Mud Creek. A phenomenon present on most islands is the presence of a fresh water lens in the water table which floats over the salt water. Extending the procedures presented in "Hydraulics of Groundwater" by Jacob Bear the following equation has been derived and is used to calculate the travel time to Big Mud Creek.

$$t = n\sqrt{\frac{1+\delta}{Nk}}\left\{L\left[\ln\left(\frac{L+\sqrt{L^2-(L-d)^2}}{L-d}\right)\right]-\sqrt{L^2-(L-d)^2}\right\}$$

where t = travel time (years)

n = effective porosity

δ = ratio of unit weights of water = 40

N = infiltration rate of precipitation (ft/year)

k = permeability (ft/year)

L = ½ width of island

d = distance of reactor from shore

Inserting the appropriate values into the equation a travel time of 54 years is obtained.

The effective travel time of radionuclides which may contaminate the aquifer regardless of the flow path following a core melt through would be considerably greater due to adsorption and ion exchange on the sand. The distribution coefficients (Kd) for cesium and strontium, the critical radionuclides, are assumed to be 20 and 2, respectively. These values were taken from Table VII 3-7 of Appendix VII of WASH-1400 and are conservative when compared to values reported in the literature [8]. The calculated retention factors using these values for Kd, a porosity (n) of 0.4 and a bulk dry weight density of 1.7, are 86 for cesium and 9.5 for strontium. Using these retention factors, the travel time for Cs-137 and Sr-90 for transport to the Atlantic Ocean and Big Mud Creek are given in the Table below.

A comparison of the above parameters to those used in the LPGS is presented below:

Parameter	LPGS	St Lucie (towards Atlantic Ocean)	St Lucie (towards Big Mud Creek)
Groundwater velocity to surface water	6.7 feet/day	0.00568 feet/day	N/A
Distance to surface water	1500 feet	2,444	700
Porosity	0.2	0.4	0.4
Sediment retention factor:			
Sr-90	9.2	9.5	9.5
Cs-137	83	86	86
Time to Surface Water (yrs):			
Sr-90	5.7	11,000	510
Cs-137	51	99,000	4600
Number of half lives to reach surface water:			
Sr-90	0.2	380	17
Cs-137	1.7	3,300	150

Based on this comparison, the time for contaminated ground water to reach a surface water location at the St Lucie site is considerably greater than travel time which characterizes the ocean site in the LPGS.

Once the contaminated water reaches the ocean, it is reasonable to assume that dilution for St Lucie site is represented by the LPGS since the standard land based ocean site in the LPGS is located on the east coast of Florida. Accordingly, dilution factors can be considered comparable. For example, the offshore current of 0.4 to 1.6 feet per second at the St Lucie site is comparable to the velocity used in the LPGS. The only comparison which remains is the fishery catch and shoreline usage factors.

The annual commercial and recreational finfish and shellfish catch within 50 miles of the St Lucie site, including brackish inland waterways, is estimated to be the following (Kg/yr)[9]

	0-3 miles	>3 miles
Commercial		
Finfish	8.26×10^6	-
Shellfish	1.58×10^6	
Recreational*	9.55×10^6	6.84×10^6

The recreational use of the beaches within a 50 mile radius of the site has been estimated from the data presented in Table 2.1-26 in the St Lucie Unit 2 Environmental Report (O.L. Stage). Based on an annual per capita participation rate of 6.57 days for residents and 13 days for tourists, assuming 3 hours of beach activities per beach day, the annual beach usage by the year 2000 population is estimated to be approximately 3.3×10^7 user-hours.

The following presents a comparison of the values to those used in the LPGS:

	LPGS	St Lucie
Fishery (kg/ha/yr)		
0-5 Km	120	227
5-19 Km	7.3	30
19-80 Km	1.1	-
Beach Activities	1.1×10^7 user hrs/yr	3.3×10^7 user hrs/yr

These results reveal that the usage factors for the St Lucie site are somewhat higher than those used in the LPGS for a land based ocean site. However, factoring in the transport time, the aquatic radiological impact of a core melt accident at the St Lucie site is estimated to be less than the impact derived in the LPGS for a "typical" coastal land based site. Thus the St Lucie site is not unique in its liquid pathway contribution to risk.

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* The recreational catch is based on the number of fish estimated in Reference 9 and assuming an average of 0.43 Kg/fish.

3. Mitigative Measures

The minimum ground water travel time from the St Lucie site to the Atlantic Ocean and Big Mud Creek was estimated to be roughly 1164 and 54 years respectively, and because of the filtering properties of soil the holdup of much of the radioactivity would be even greater. This would allow ample time for engineering measures, such as slurry walls, to isolate the radioactive contamination near the source.

As a means of isolating contaminated groundwater in the St Lucie site area, the feasibility of constructing an impermeable membrane was investigated. Alternate means, such as pumping or sheet piling were also considered. Pumping a large volume of water would impose unreasonable treatment requirements. Sheet piles will corrode in the salt water. A slurry trench was thought to be the most efficient method of isolation for this site. Two types of slurry trenches are available, cement bentonite and soil bentonite.

Based upon previous experience, a cement bentonite slurry wall was investigated. Cement bentonite is used where slope support is needed for dewatering excavation sites and for groundwater control. The cement bentonite requires 24 hours to cure. The bentonite can either be installed into 2-3 foot wide trenches directly, or pumped by use of adapters to drive piles. Cement bentonite construction is a much slower and expensive process than for soil bentonite but provides added strength.

Soil bentonite is more flexible and less expensive since the trenching soil is used in the backfilling. Soil bentonite is quicker to install but must be installed in a continuous fashion. The native material can be used in the backfilling operation if it is sand, such as exists at St Lucie, preferably a poorly graded mixture. No curing time is required for the soil bentonite and dewatering can begin immediately after construction whereas cement bentonite requires 24 hours for curing prior to any dewatering measures.

Since the St Lucie Site consists of fine sands, excavation in this material would be relatively easy and the excavated material could be mixed with the bentonite to produce a soil bentonite mixture. There is nothing at the St Lucie Site that would preclude the use of this method of groundwater isolation.

(1) NUREG-0440 Liquid Pathway Generic Study. February, 1978.

(2) See Figures 2.4-1 of FSAR

(3) See FSAR Section 2.4.13.1 (pg 2.4-40)

(4) See Table 2.5-5 of the FSAR (pg 2.5-93)

(5) See Appendix 2.5.A of the FSAR

(6) See Section 2.5.4.2.2 of the FSAR

(7) See Section 2.4.13.3 (pg 2.4-45) of the FSAR

(8) NUREG/CR-0912 Volume 1. Geoscience Data Base Handbook for Modeling a Nuclear Waste Repository. January 1981.

(9) Response to NRC questions 291.8 and 291.10.

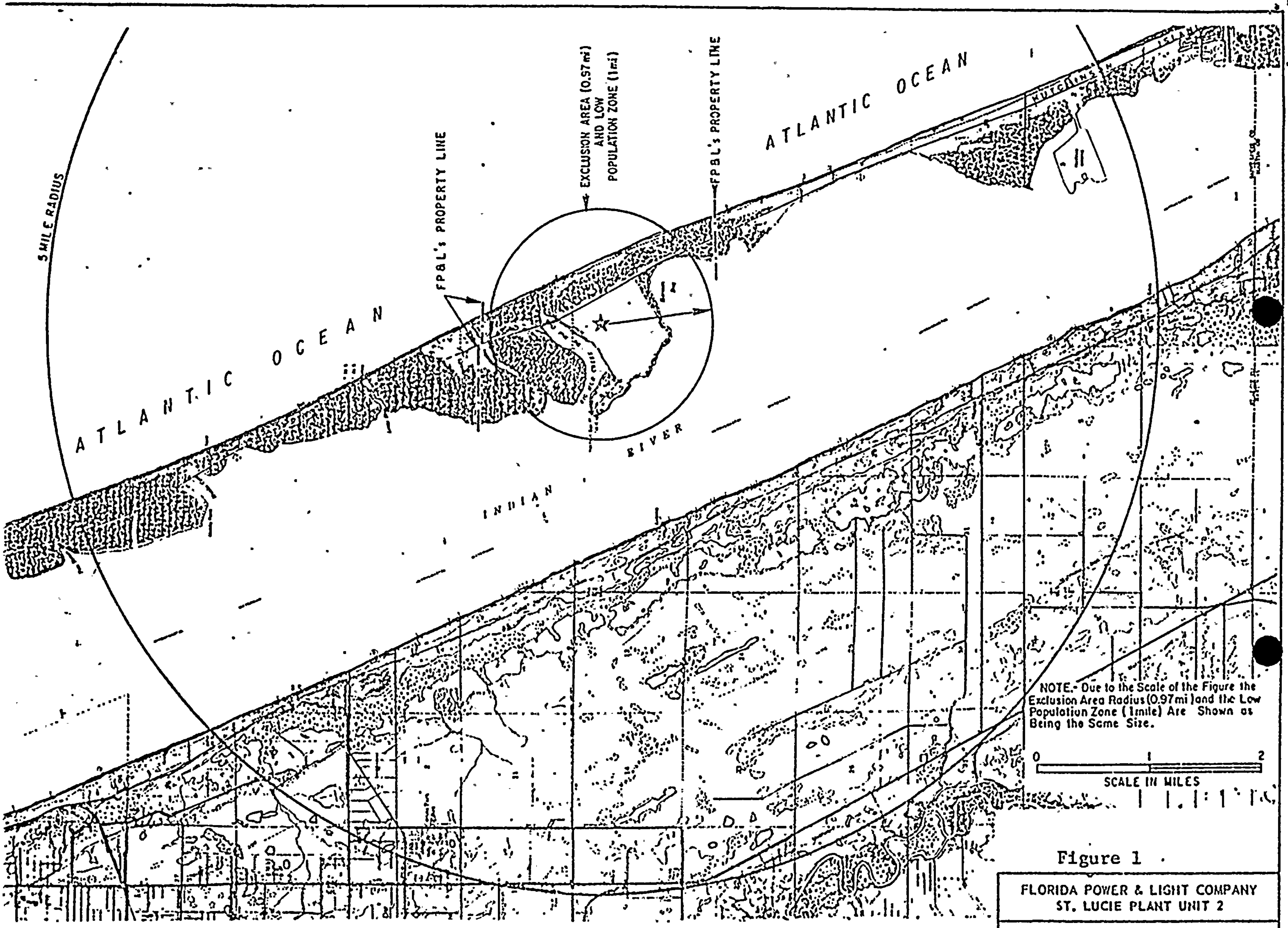

Figure 1

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ST. LUCIE PLANT UNIT 2

THE AREA WITHIN
5 MILES OF ST LUCIE UNIT 2

FIGURE 2.1-2

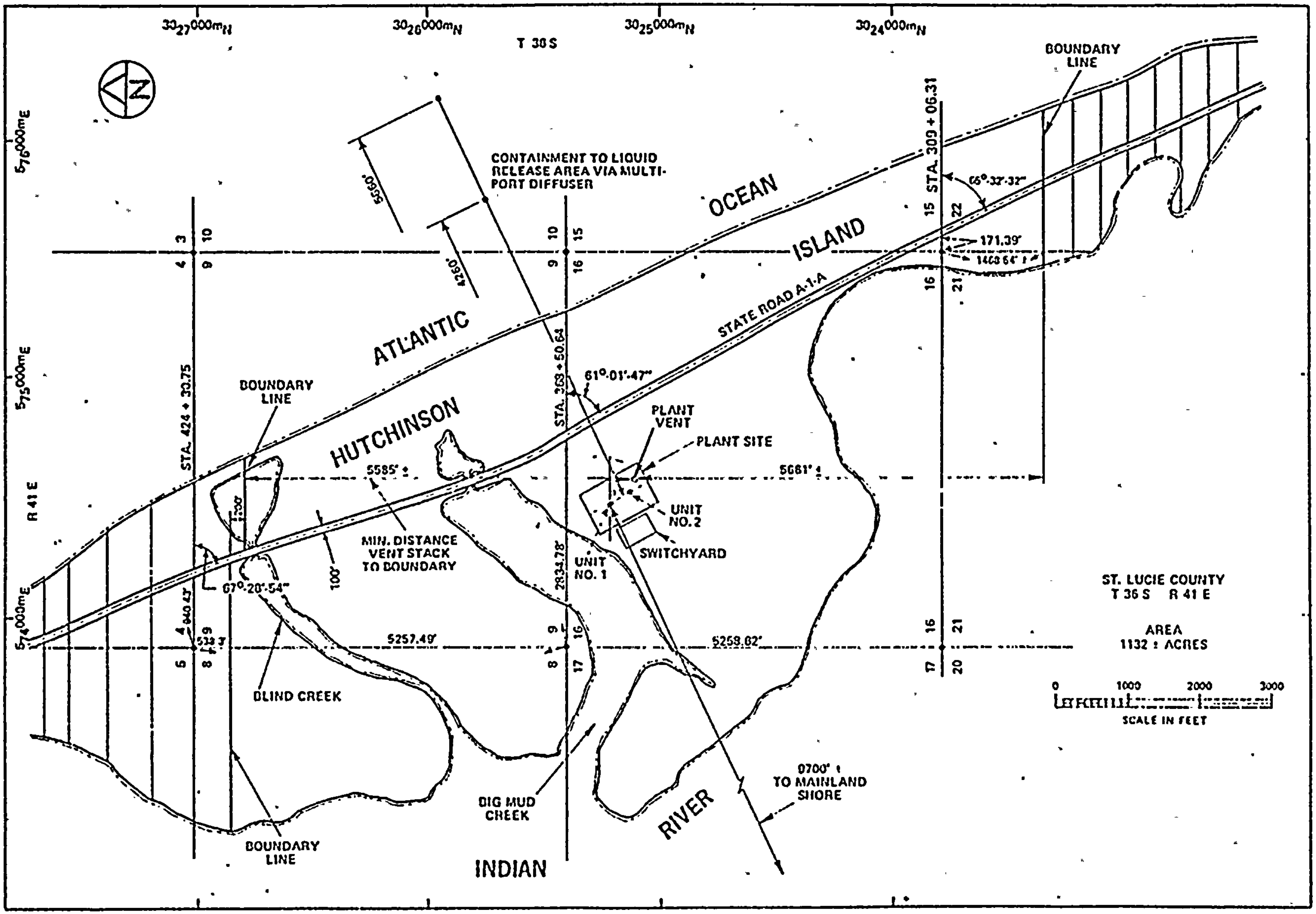

Figure 2

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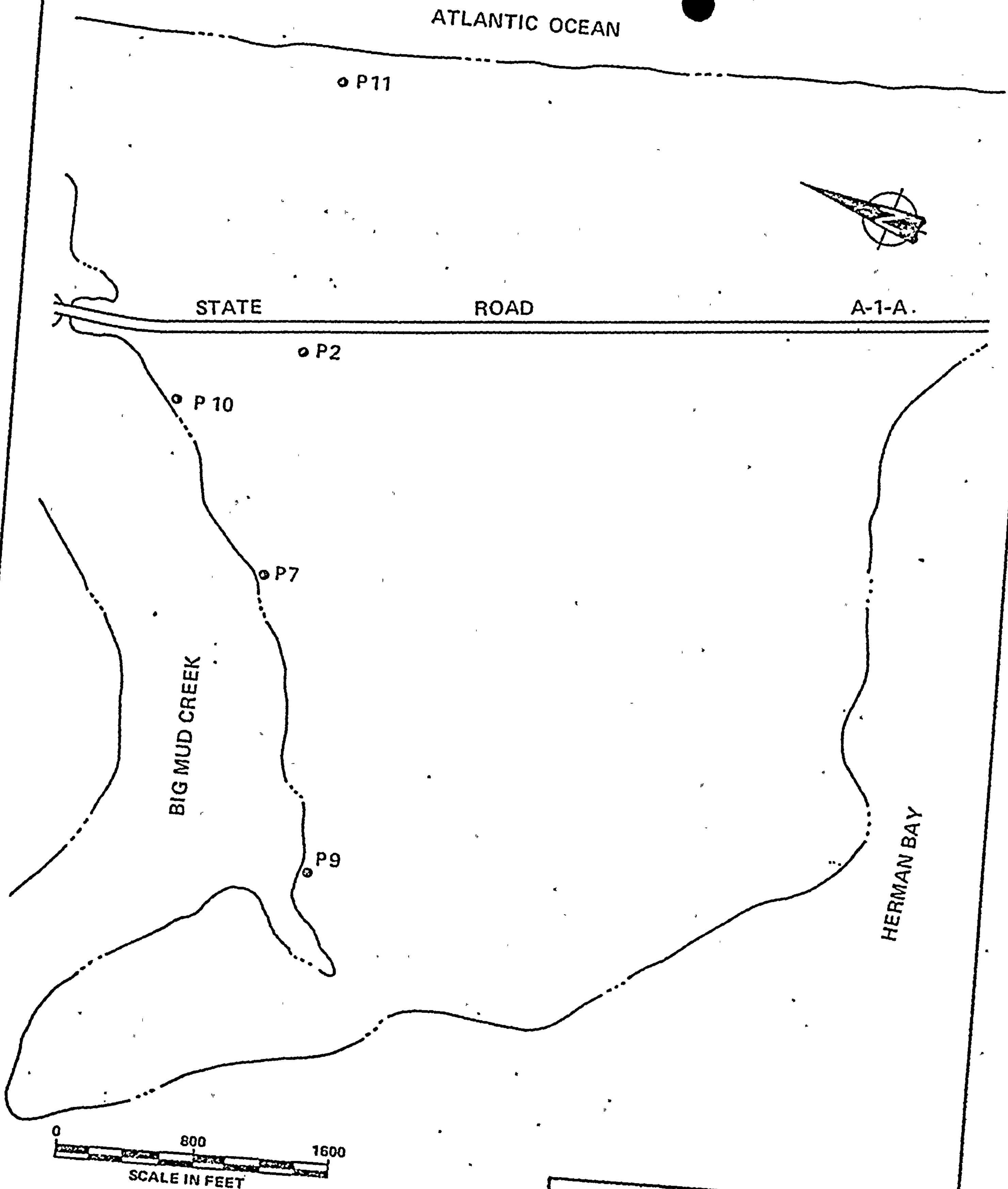
PROPERTY PLAN

FIGURE 2.1-4



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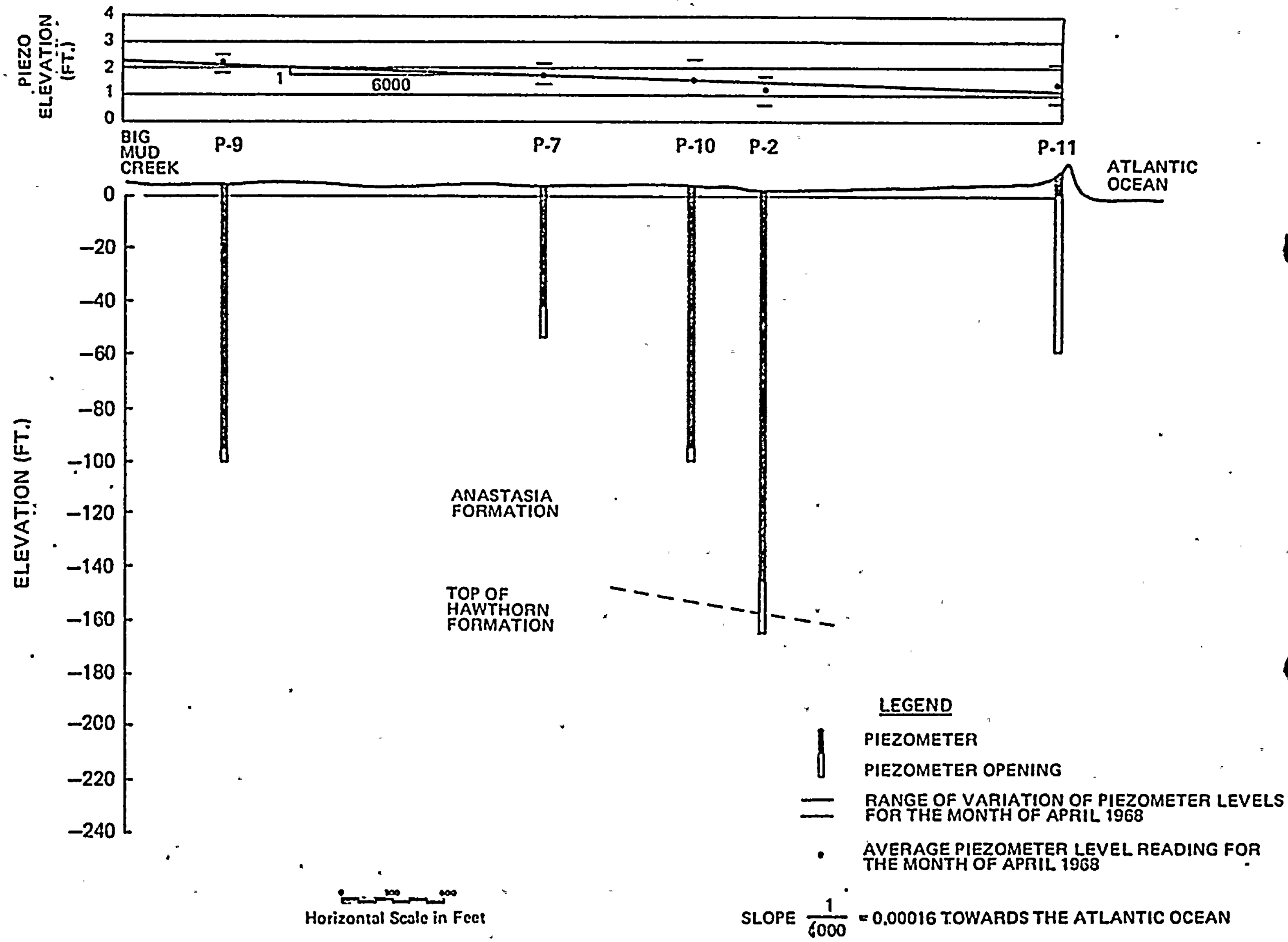
PIEZOMETER LOCATIONS

FIGURE 3



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ST. LUCIE PLANT UNIT 2

PIEZOMETRIC CROSS SECTIONS

FIGURE 4