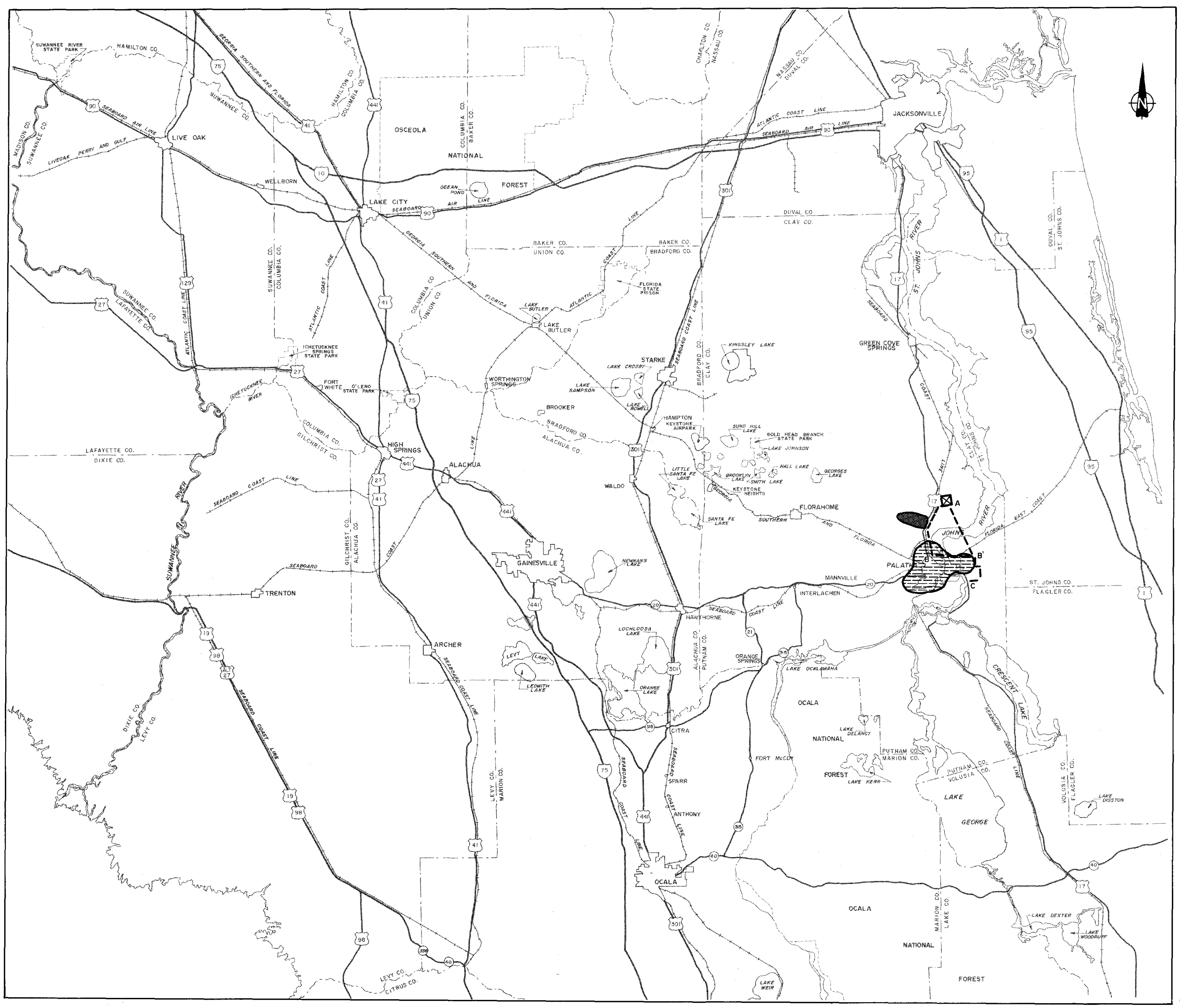


LEGEND:

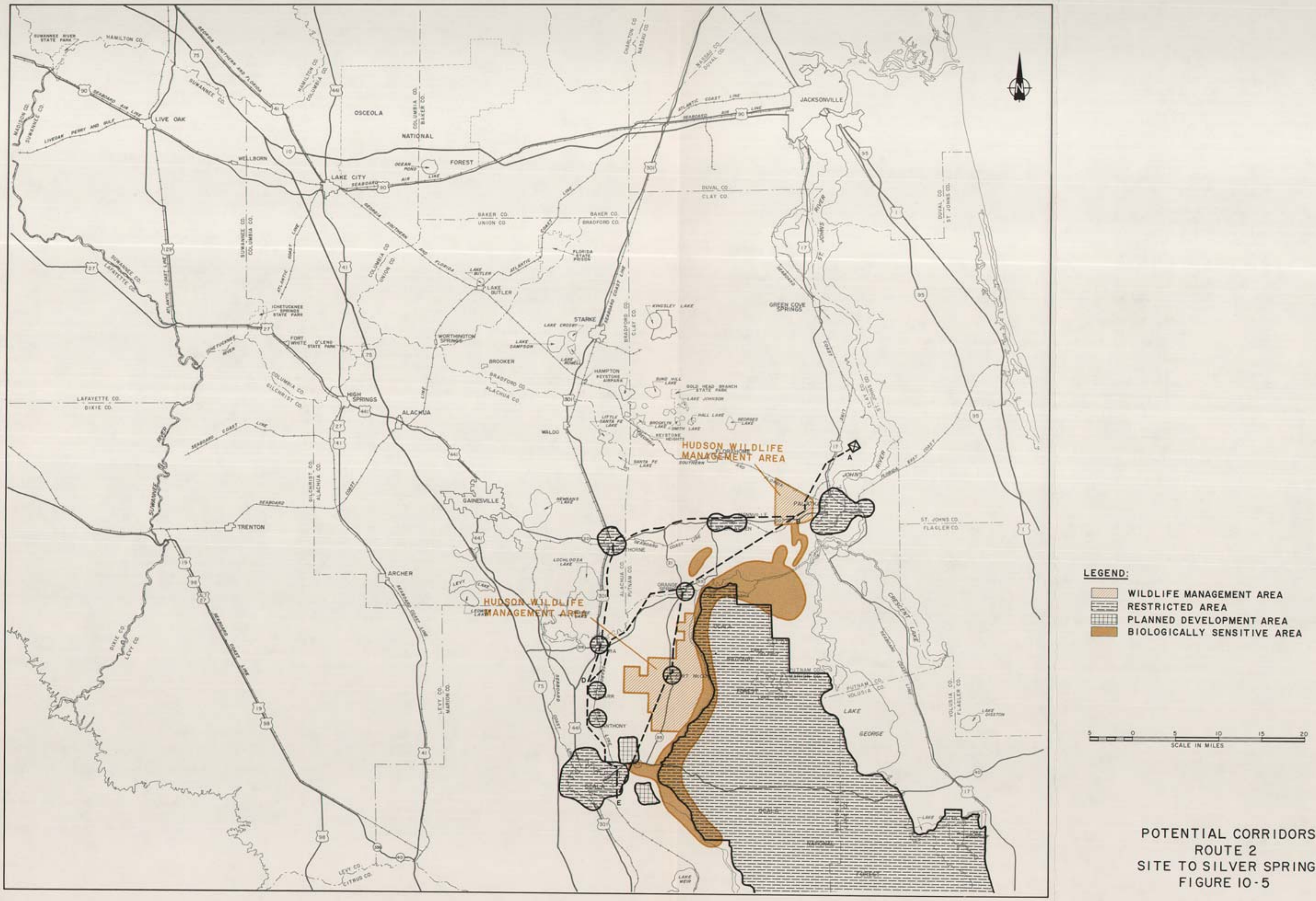
▤ RESTRICTED AREA

▩ BIOLOGICALLY SENSITIVE AREA

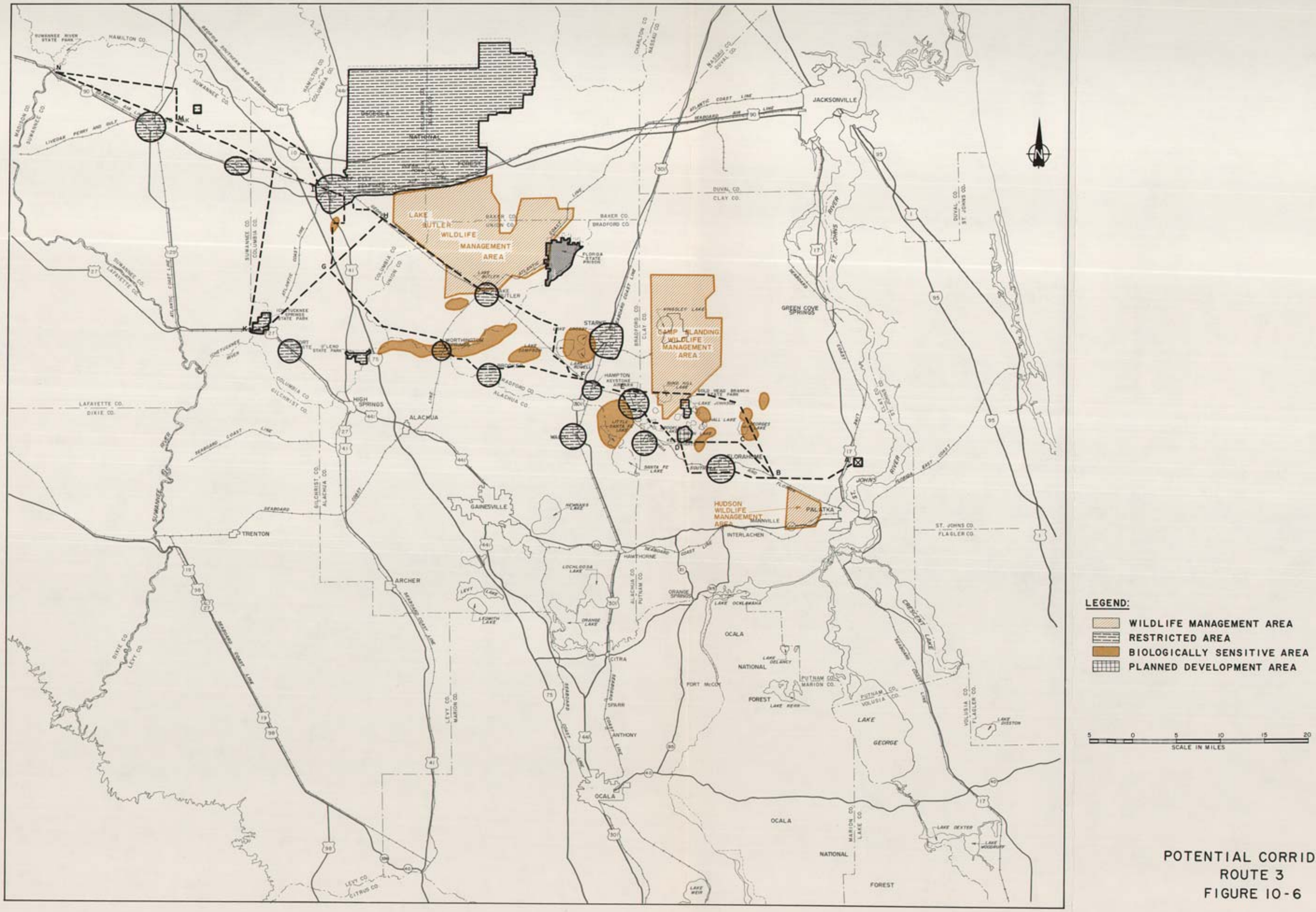
--- POTENTIAL CORRIDOR

5 0 5 10 15 20
SCALE IN MILES

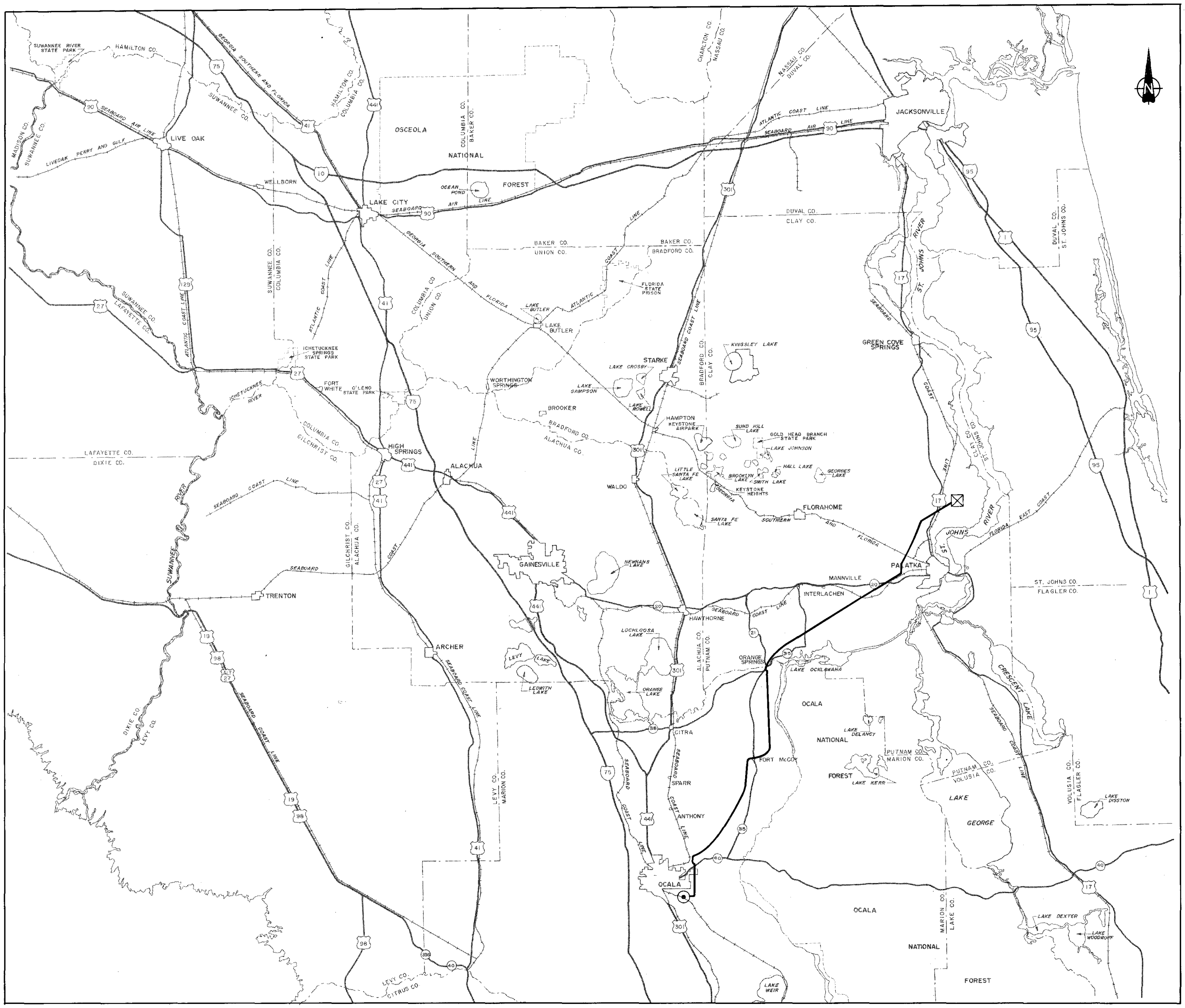
POTENTIAL CORRIDORS
ROUTE I
SITE TO PUTNAM
FIGURE 10-4



POTENTIAL CORRIDORS
ROUTE 2
SITE TO SILVER SPRINGS
FIGURE 10-5



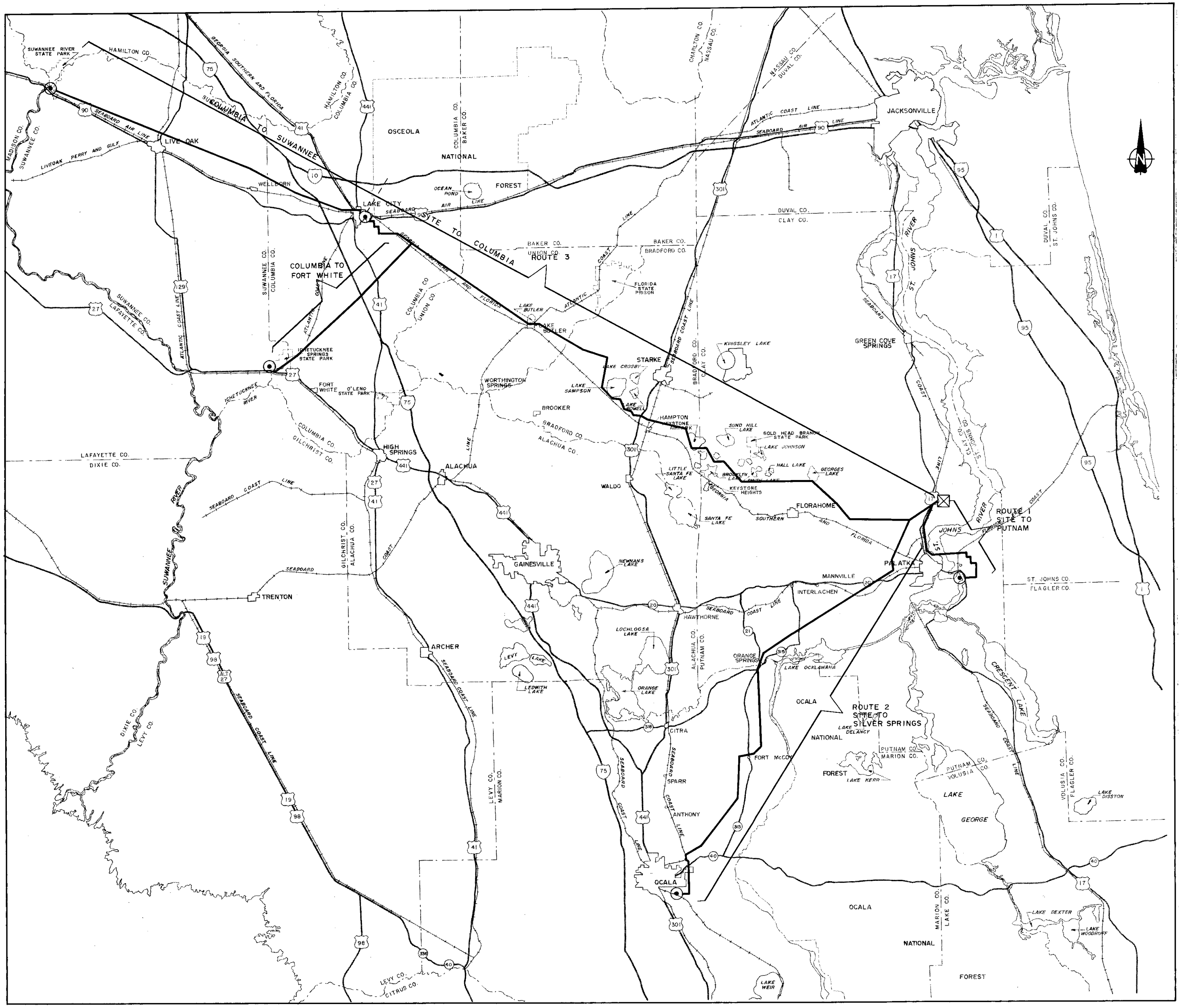
POTENTIAL CORRIDORS
ROUTE 3
FIGURE 10-6



LEGEND:

- ☒ SEMINOLE PLANT
- ⊙ SUBSTATION

PREFERRED CORRIDOR
ROUTE 2
SITE TO SILVER SPRINGS
FIGURE 10-7



LEGEND:

☒ SEMINOLE PLANT

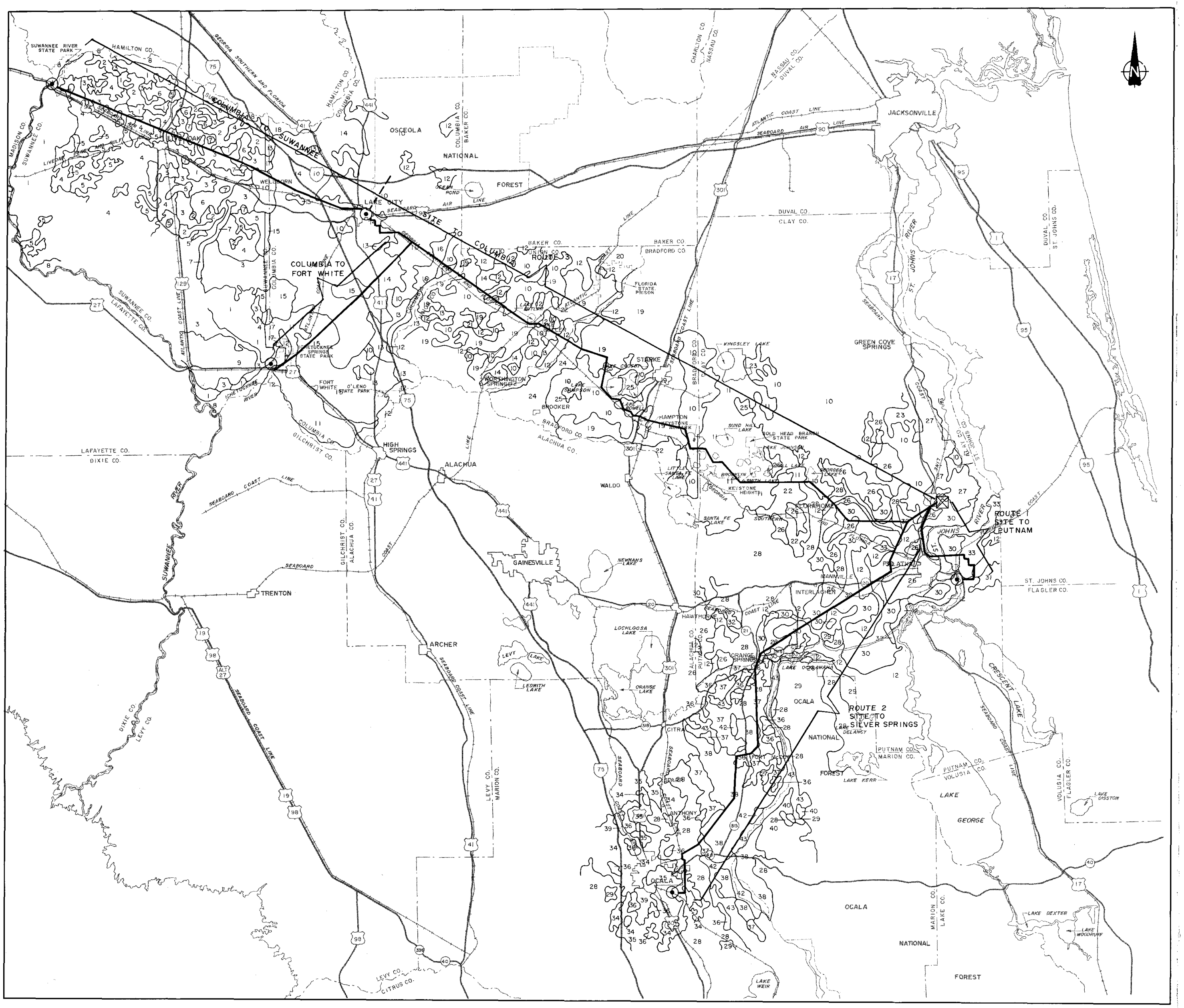
⊙ SUBSTATION

5 0 5 10 15 20

SCALE IN MILES

PREFERRED CORRIDORS

FIGURE 10-8



SOIL ASSOCIATIONS

1	BLANTON (HIGH)-LAKELAND ASSOCIATION
2	ARREDONDO-KANAPAHA ASSOCIATION
3	BLANTON (LOW)-ASSOCIATION
4	BLANTON (LOW) SUSQUEHANNA-BOWIE ASSOCIATION
5	SUSQUEHANNA-BOWIE ASSOCIATION
6	LEON-PLUMMER ASSOCIATION
7	ALLUVIAL LAND-SWAMP ASSOCIATION
8	BLANTON-KALMIA-SWAMP ASSOCIATION
9	BLANTON-CHIEFLAND ASSOCIATION
10	MASCOTTE-LEON-SURRENCY ASSOCIATION
11	ALPIN-BLANTON ASSOCIATION
12	FRESH WATER SWAMP ASSOCIATION
13	ARREDONDO, VAR.-ALAGA-KENNEY ASSOCIATION
14	CHIPLEY-ALBANY-RUTLEGE ASSOCIATION
15	ARCHER-CHIEFLAND ASSOCIATION
16	LEEFIELD-MASCOTTE-ALBANY ASSOCIATION
17	CHIPLEY CHIEFLAND ASSOCIATION
18	SURRENCY-PORTSMOUTH ASSOCIATION
19	STILSON-PELHAM-MASCOTTE ASSOCIATION
20	PELHAM-PLUMMER-RUTLEGE ASSOCIATION
21	PORTSMOUTH-RAINS ASSOCIATION
22	BRIGHTON ASSOCIATION
23	CHIPLEY-LEON-OSIER ASSOCIATION
24	KANAPAHA-CHIPLEY-SCRANTON ASSOCIATION
25	OSIER-RUTLEGE-LEON ASSOCIATION
26	TAVARES-MYAKKA-BASINGER ASSOCIATION
27	OLUSTEE-RUTLEGE-LEON ASSOCIATION
28	CANDLER-APOPKA ASSOCIATION
29	ASTATULA ASSOCIATION
30	MYAKKA-WAUCHULA-PLACID ASSOCIATION
31	OLUSTEE, VAR.-PLACID-MYAKKA ASSOCIATION
32	POMELLO-MYAKKA ASSOCIATION
33	MEGGETT, VAR.-WAUCHULA-CHOBEE ASSOCIATION
34	ARREDONDO-GAINESVILLE ASSOCIATION
35	KENDRICK-HAGUE-ZUBER ASSOCIATION
36	SPARR-LOCHLOOSA-TAVARES ASSOCIATION
37	LYNNE-POMONA-POMPANO ASSOCIATION
38	EUREKA-PAISLEY-EATON ASSOCIATION
39	BLICHTON-FLEMINGTON-KENAPAHA ASSOCIATION
40	MYAKKA-SELLERS ASSOCIATION
41	SELLERS-PAMLICO ASSOCIATION
42	BLUFF-MARTEL ASSOCIATION
43	OKEECHOBEE-TERRA CEIA-TOMOKA ASSOCIATION

☒ SEMINOLE PLANT

⊙ SUBSTATION

NOTE: MAP COMPILED FROM INFORMATION IN THE FLORIDA GENERAL SOILS ATLAS FOR REGIONAL PLANNING DISTRICTS III & IV, AND MARION COUNTY BY FLORIDA DEPARTMENT OF ADMINISTRATION, DIVISION OF STATE PLANNING, BUREAU OF COMPREHENSIVE PLANNING, JULY, 1975.

5 0 5 10 15 20

SCALE IN MILES

SOIL ASSOCIATIONS FOR
PREFERRED CORRIDORS
FIGURE 10-9

11.0

STATUS OF PERMITS AND APPROVALS

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CHAPTER 11.0

PERMITS, APPROVALS, AND OTHER RELATED STATUTORY REQUIREMENTS

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11.0 PERMITS, APPROVALS, AND OTHER RELATED STATUTORY REQUIREMENTS

(Prepared by the Environmental Licensing Group, Inc.)

11.1 Status of Permits and Approvals

The licensing of a coal-fired steam electric power generating station required compliance or conformance with numerous local, state, and federal laws, regulations, and ordinances. These may impose procedural as well as substantive requirements and may mandate performance standards, limitations, consistency reviews, agency approvals, and interagency coordination. Table 11.1-1, State and Federal Laws applicable to the Proposed Power Generating Facility, lists the major state and federal environmental laws that have been considered in the licensing of the proposed power station. Table 11.1-2, Status of Permits and Approvals, identifies specific licensing, permitting, and approval actions and the schedule of such actions necessary for timely licensing of the proposed power station. Figure 11.1-1 presents a Master Permit Schedule which identifies the sequencing of the major permitting actions: site certification application, environmental analysis, National Pollutant Discharge Elimination System permit application, Prevention of Significant Deterioration permit application, and applications for construction in navigable waters and wetlands. Environmental permits are scheduled to be granted prior to final loan approval by the Rural Electrification Administration.

11.2 STATUS OF COMPLIANCE WITH OTHER RELATED STATUTORY REQUIREMENTS

In addition to statutory and regulatory requirements related to the issuance of permits and granting of approvals, there are other statutory requirements having special relevance to NEPA. Some of these are listed in Table 11.1-1. Seminole's status in conforming to other statutory requirements is discussed in this section.

11.2.1 National Energy Act

The so-called National Energy Act of 1978 consists of five separate pieces of legislation:

- National Energy Conservation Policy Act of 1978 (NECPA);
- Powerplant and Industrial Fuel Use Act of 1978 (FUA);
- Public Utility Regulatory Policy Act of 1978;
- Energy Tax Act of 1978; and
- Natural Gas Act of 1978

This discusses the applicability to Seminole Electric Cooperative, Inc., of (1) the National Energy Conservation Policy Act and (2) rules proposed by the U.S. Department of Energy to implement the Powerplant and Industrial Fuel Use Act.

11.2.1.1 National Energy Conservation Policy Act

The National Energy Conservation Policy Act of 1978 contains provisions that are applicable to electric utility companies that meet specific requirements. These provisions are contained in the Act at Part 1 of Title II and at Part 4 of Title VI.

Part I of Title II contains provisions to effect residential energy conservation by requiring, through state residential energy conservation plans, that each "public utility" implement a utility program. A "public utility" is defined as:

> ...any person, State agency or Federal agency which is engaged in the business of selling natural gas or electric energy...to residential customers for use in a residential building.

Because Seminole Electric Cooperative, Inc., does not sell electric energy directly to residential customers, it is not, by DOE's definition, a public utility. Therefore, Seminole is not subject to the requirements of Part 1 of the Act, including the implementation of a utility program.

This distinction between a public utility that sells electric energy direct to residential customers and a utility that generates electric energy for resale is clarified further in section 211(a) of NECPA which states that Part 1 of Title II "shall apply only if...sales of electric energy by such public utility <u>for purposes other</u> than resale exceeded 750 million kilowatt hours" (emphasis added). All of Seminole's power is sold to its member cooperatives for resale.

Part 4 of Title VI, section 661, amends the Energy Policy and Conservation Act to incorporate, with one modification, the provisions of section 125 of the Clean Air Act that require the use of locally or regionally available coal or coal derivatives if such use is determined by the proper authorities to be necessary in order to minimize significant local or regional economic disruption or unemployment that would result from the use of other than locally or regionally available coal, petroleum products or natural gas.

Seminole Electric Cooperative, Inc., has undertaken negotiations to obtain supplies of Eastern Kentucky and/or Illinois coal for use in its Seminole Plant. In addition to coal, relatively small amounts of No. 2 oil will be burned during startup and for low load flame stabilization. Seminole does not anticipate that a change in fuel supplies will be required in order to minimize local or regional economic disruption or unemployment. If, however, the use of other supplies of fuel were determined to be necessary by the proper authorities, Seminole Electric Cooperative, Inc., would act in accordance with the legal requirements of section 125 of the Clean Air Act and section 107 of the Energy Policy and Conservation Act.

11.2.1.2 Powerplant and Industrial Fuel Use Act

The primary purpose of the Powerplant and Industrial Fuel Use Act of 1978 is to minimize the use of petroleum and natural gas in industrial and electric utility boilers. To accomplish this purpose, the FUA prohibits, except for exemptions which may be granted by DOE, the use of petroleum and natural gas by new electric utility powerplants.

The Economic Regulatory Administration (ERA) of DOE has recently proposed rules at 43 Fed. Reg. 53974-54061 (November 16, 1978) to implement the FUA. If promulgated as proposed, these rules would classify Seminole Plant Units No. 1 and 2 as a "new electric powerplant" (see proposed section 500.2(a)(51)), and thus subject to the applicable provisions of final rules promulgated by DOE.

Section 503.2 of the ERA/DOE proposed rules would impose prohibitions on (1) the use of petroleum or natural gas as a primary energy source in any new electric powerplant and (2) the construction of any new electric powerplant without the capability to use an alternate fuel as a primary source.

According to proposed section 500.2(a)(66), "primary energy source" means:

> ...the fuel or fuels used for normal operation by any existing or new electric powerplant...except... [m]inimum amounts of fuel required for unit ignition, startup, testing, flame stabilization and control use.... (Emphasis added.)

"Alternate fuel" is defined in proposed Section 500.2(a)(7) as "electricity of any fuel other than natural gas or petroleum. The term [alternate fuel] includes...coal...."

Seminole Electric Cooperative, Inc., will burn coal, an alternate fuel, as its primary energy source. Only small amounts of No. 2 oil will be burned for initial lightoff and during low load flame stabilization. Consequently, the prohibitions of section 503.2 of the FUA does not apply to Seminole Power Plant Units No. 1 and 2.

11.2.2 National Historic Preservation Act and Executive Order 11593

The National Historic Preservation Act of 1966, Executive Order 11593: Protection and Enhancement of the Cultural Environment, and other related Acts are implemented by 36 CFR 800, "Procedures for the Protection of Historic and Cultural Properties."

To assure the protection of historic and cultural properties, a survey was conducted to locate, identify, and assess the cultural resources that might exist on Seminole' Putnam site. Conducted in accordance with 36 CFR 800, this survey included archaeological field work; a review of previously known site locations recorded in the literature and in the Florida Master File; and a study of historic documents (federal and state land records, published historical studies, Spanish land grants, historical maps and plots, and county property and tax records).

The survey revealed the existence of no properties on the Putnam site that would be considered of National Register importance. Moreover, the nearest National Register properties are located in Palatka, approximately 5 miles south of the site. (October 23, 1978 letter from Mr. L. Ross Morrell, Deputy State Historic Preservation Officer to Mr. Tim Doyle, Dames & Moore, re: Cultural Resource Assessment of Seminole Electric Cooperative, Proposed Generating Facility Putnam County, Florida.)

11.2.3 Coastal Zone Management Act

The Coastal Zone Management Act of 1972 encourages the states to develop and implement coastal zone management programs to achieve wise use of the nation's coastal zone.

Currently, the State of Florida is in the process of developing its own coastal zone management program. Responsibilities for administering and implementing the state program have been delegated to the Florida Department of Environmental Regulation.

In accordance with the Florida Coastal Management Act of 1978, the Florida Coastal Zone Management Program will be based entirely on existing statutes and rules. Because Seminole Electric Cooperative, Inc., has complied with applicable existing statutes and rules, Seminole Plant Units No. 1 and 2 will comply with the provisions of the Florida Coastal Zone Management Program after the program has been adopted. In the event that the state program imposes additional requirements on the Seminole Plant, Seminole Electric Cooperative, Inc., will take appropriate actions to comply with such requirements.

11.2.4 Endangered Species Act

The Endangered Species Act mandates that federal agencies seek to conserve endangered and threatened species. Pursuant to this statutory responsibility, REA has requested that the U.S. Fish and Wildlife Service provide information concerning whether any species listed or proposed to be listed as a federal threatened or endangered species may be present in the area of the proposed Putnam site, as well as two alternate sites. (January 11, 1979 letter from William R. Dalton of REA to the Regional Director, U.S. Fish and Wildlife Service.)

11.2.5 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires that the U.S. Fish and Wildlife Service and state wildlife agency participate in the review of permit applications for activities that would cause any body of water to be modified.

The Field, Area and/or Regional Offices of the U.S. Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission have participated in the licensing process of the proposed Seminold Units No. 1 and 2 since the initial stages of the project in early 1977.

11.2.6 Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act establishes the policy of the United States that certain rivers of the nation, which "...possess outstanding remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit of future generations."

Throughout the process of evaluating alternative sites and in its selection of a preferred site, Seminole has considered the existence of wild and scenic rivers and those potential additions to the wild and scenic rivers system. No rivers of this designation or proposed for this designation occur within the region of the preferred site or would otherwise be impacted by construction or operation of the proposed project.

11.2.7 Executive Order 11990: Protection of Wetlands

Executive Order 11990: Protection of Wetlands directs each federal agency to:

> ...take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for ...(2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resource planning, regulating and licensing activities.

Specifically, the direction is to be carried out in furtherance of Section 101(b) (3) of the National Environmental Policy Act of 1969 and, to the extent possible, follow the procedures of the Council on Environmental Quality and Water Resources Council.

Seminole Electric Cooperative, Inc. has incorporated the guidance of the Council on Environmental Quality and the Water Resources Council in its planning activities and coordinated closely with both state and federal agencies whose responsibilities are to manage wetland resources.

11.2.8 Executive Order 11988: Floodplain Management

Executive Order 11988: Floodplain Management, directs that each federal agency

> ...shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for...(2) providing Federally undertaken, financed or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating and licensing activities.

To implement this directive, the agency must, before taking action, determine whether the proposed action will occur in a floodplain. If, for major federal actions significantly affecting the quality of the human environment, the agency determines to, or proposes to, conduct, support, or allow an action to be located in a floodplain, the agency shall evaluate the action, considering alternatives to avoid adverse effects and incompatible development in the floodplains. The Water Resources Council has developed guidelines for implementing Executive Order 11988, published in the Federal Register Vol. 43, No. 29: February 10, 1978.

Seminole Electric Cooperative, Inc., has planned the location of its proposed facilities with respect to the 100-year and 500-year floodplains. While the 100-year floodplain is shown to infringe upon the site property, no structures, embankments, or fill are planned to be placed in the 100-year floodplain. None of the principal plant equipment is located within the 500-year floodplain.

11.2.9 Secretary's Memorandum No. 1827: Policy on Prime Farmland, Range and Forest Land

The Secretary's Memorandum No. 1827: Policy on Prime Farmland, Range and Forest Land expresses concern for the continued loss of lands well suited to the production of food, forage, fiber, and timber, and the degradation of the environment resulting from those losses. Consequently, major consideration must be given to prime lands and the long-range need to retain the productive capability and environmental values of American agriculture and forestry.

The Secretary's Memorandum sets policy requiring, where federal funds are involved, that Department of Agriculture personnel carefully explore land use alternatives which would mnimize impacts on prime lands, and, where possible, avoid land use decisions which irrevocably commit prime lands to nonfarmland, non-range land uses, thereby foreclosing the options of future generations.

Seminole Electric Cooperative, Inc., has considered the potential presence of prime lands in evaluations of land use on the proposed site. No prime farmlands, range and forest lands exist on the site or will be adversely impacted by the construction or operation of the proposed project.

TABLE 11.1-1

State and Federal Environmental Laws Applicable to the Proposed Power Generating Facility

State

Florida Electric Power Plant Siting Act

Florida State Comprehensive Planning Act

Regulation of Public Utilities

Environmental Control

Florida Water Resources Act

Local Government Comprehensive Planning Act

Land Acquisition Trust Fund

Use of Sovereignty and Other State Owned Lands

Environmental Land and Water Management Act

Florida Archives and History Act

Florida Administrative Procedure Act

Federal

Clean Water Act

National Environmental Policy Act
(Executive Orders 11514 and 11991)

The Clean Air Act

The National Historic Preservation Act
(Executive Order 11593)

Coastal Zone Management Act

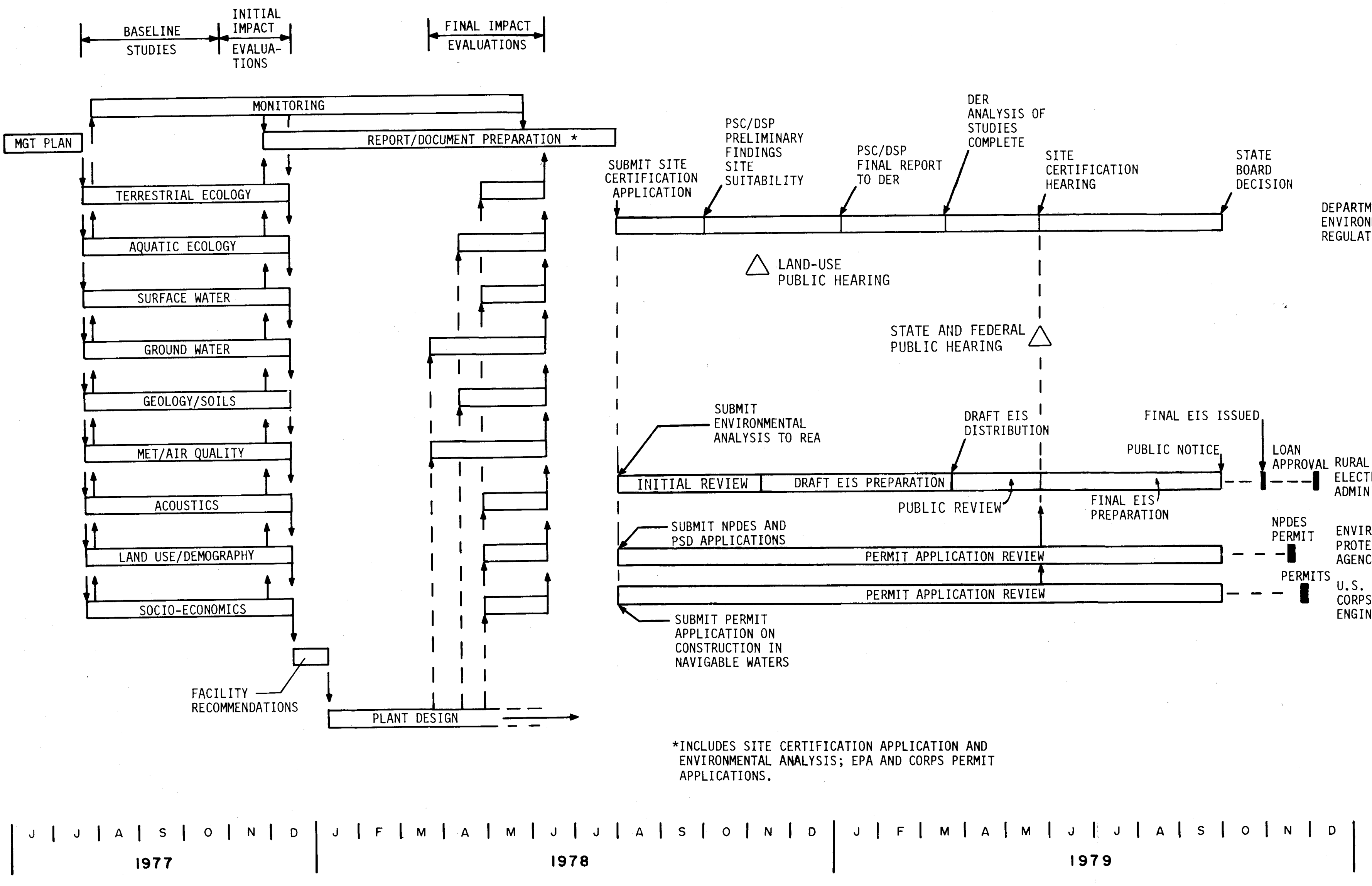
Fish and Wildlife Coordination Act

Endangered Species Act

Wild and Scenic Rivers Act

Rivers and Harbors Act

National Energy Act



*INCLUDES SITE CERTIFICATION APPLICATION AND ENVIRONMENTAL ANALYSIS; EPA AND CORPS PERMIT APPLICATIONS.

Figure 11.1-1. Master Permit Schedule.

Table 11.1-2

STATUS OF PERMITS AND APPROVALS*

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency**	Date of Application (Proposed)	Approval Date (Expected)	Comments
FEDERAL					
Application for loan approval	Rural Electrification Act	REA	(3/79)	(12/79)	
Environmental Analysis	National Environmental Policy Act; Exec. Order 11514: Protection and Enhancement of Environmental Quality; Exec. Order 11991: Relating to Protection and Enhancement of Environmental Quality	REA	8/78	(11/79)	
NPDES	Clean Water Act (§402)	EPA	10/78	(11/79)	Preliminary draft NPDES permit to be issued by 2/79.
Preconstruction New Source Air Quality Review	Clean Air Act (§110)	EPA	8/78	(11/79)	This review will be conducted by the State through its Site Certification process.
PSD	Clean Air Act (§160-169)	EPA	5/78	(Prior to 5/79)	Preliminary determination made by 2/79.
Activities in Navigable Waters	Rivers and Harbors Act (§10)				
1. Intake/discharge structures		COE	9/78	(11/79)	
2. Transmission Lines		COE	5/79	(11/79)	

Table 11.1-2 (Continued)

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency**	Date of Application (Proposed)	Approval Date (Expected)	Comments
Activities in Wetlands	Clean Water Act (§404)	COE	NA	NA	No permit required (June 22, 1978 letter from COE)
Construction of Plant Stack	Federal Aviation Act	FAA	2/78	5/78	FAA approval contingent on DOT stack construction approval
STATE					
Site Certification Application	Florida Electrical Power Plant Siting Act	DER	8/78	(9/79)	
Transmission Line Road Crossings	Ch. 338 F.S. (Ch. 14-46 FAC Utilities Installation or Adjustment)	DOT	(3/79)	(5/79)	
Modifications of State Road 17		DOT	(3/79)	(5/79)	
Construction of Plant Stack	Ch. 75-16 F.S.	DOT	6/78	6/78	
Water Well Drilling	Ch. 381.031(1)(g)(3) F.S.	DHRS and DER	4/78	4/78	
Well Regulation	Florida Water Resources Act	SJRWMD	4/78	4/78	
Easement through State Owned Lands	Ch. 253 F.S. and Ch. 76-24F F.S.	DNR	10/78	12/78	

REVISED 3/15/79

Table 11.1-2 (Continued)

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency**	Date of Application (Proposed)	Approval Date (Expected)	Comments
LOCAL					
Land Use or Zoning Approval	Putnam County Zoning Ordinance 75-6 Chapter 163 F.S. Chapter 125 F.S.	Putnam County Commission	4/78	5/78	
Pipeline Road (209) Crossings	Putnam County Ordinance	Putnam County Commission	(3/79)	(5/79)	
	Ch. 338 F.S.	DOT			

---

* Status as of February 19, 1979

** Abbreviations:

REA	U. S. Rural Electrification Administration
EPA	U. S. Environmental Protection Agency
COE	U. S. Corps of Engineers
FAA	Federal Aviation Administration
DER	Florida Department of Environmental Regulation
DOT	Florida Department of Transportation
DHRS	Florida Department of Health and Rehabilitative Services
SJRWMD	St. Johns River Water Management District
DNR	Florida Department of Natural Resources
NA	Not applicable

12.0

COORDINATION WITH OTHERS

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CHAPTER 12.0

COORDINATION WITH OTHERS

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12.0 COORDINATION WITH OTHERS

(Prepared by the Environmental Licensing Group, Inc.)

From the initiation of the proposed project licensing, it has been the policy of the Seminole Electric Cooperative, Inc. to stimulate open, objective evaluation of its efforts with governmental agencies and the public alike. According to its Statement of Environmental Policy:

> Seminole Electric Cooperative, Inc. recognizes the essentiality of balancing the need for reliability and economy of electric service to its members, with the need to adequately protect the environment for optimum use and enjoyment. Seminole Electric Cooperative, Inc. will:
>
> 1. Strive to design and build an efficient, reliable electric system with capacity to meet present day requirements and flexibility for continued expansion to economically meet the needs of the future in a manner consistent with the environmental objectives of our society.
> 2. Endeavor to avoid actions which might be detrimental to or diminish public enjoyment of existing or planned recreation resources, or resources of historic and scenic value.
> 3. Endeavor to avoid or minimize the effect of actions which might contribute to pollution of the air, water or land.
> 4. Maintain a working relationship with all Federal, State and local regulatory agencies concered with health, safety and the environment.

Consistent with this policy, the Company is conducting its licensing activities in a manner to effect meaningful compliance with the full intent of the National Environmental Policy Act and the Florida Electric Power Plant Siting Act. The Company has emphasized the importance of the decision making process in allocating and using natural resources for power generation and transmission, by encouraging open, responsible interchange of information in the interests of the public. This approach is consistent with the policy and procedure of the proposed Council on Environmental Quality regulations for implementing NEPA.

Coordination among Seminole, governmental agencies and the public is reflected in the summary of pertinent communications, meetings and interactions included in this chapter. Through the licensing process, Seminole has developed and applied six innovative techniques for accomplishing the objectives now proposed by the Council on Environmental Quality. These include:

1. An aggressive, open public information program.
2. The early preparation and distribution of the PLAN OF STUDY, a methodological approach directed to: (1) identify, generally describe and organize the diverse activities required to develop environmental information needed to comply with applicable regulations and to design a power generating station to optimally utilize available natural resources; and (2) encourage responsible, open, extra-agency input to the decision making process through the anticipation of critical points and paths of decision making and information flow by use of a time-scaled network diagram.
3. The coordination and consolidation of state and federal requirements in the preparation of a single Environmental Analysis/Site Certification Application document.
4. Continuing, frequent interaction and interchange in the preparation and review of environmental analyses.
5. Preparation and distribution of an INTERIM REPORT midway through the environmental analyses: (1) to provide an overview and update of project activities; (2) to provide an early opportunity for participant reviewers to focus on site-specific issues and alternatives; (3) to illuminate the on-going decision making process; and (4) to assist in guiding the company and consultants by stimulating critique and recommendations from project reviewers.
6. Early, simultaneous filing of the Environmental Analysis/Site Certification Application with state and federal agencies to allow ample opportunity for public and agency reviews.

Three tables have been prepared for Chapter 12: Coordination with Governmental Agencies, Coordination with the Public and Articles and Notices of Proposed Project.

While records of coordination activities in this chapter have been documented only through January 1979, due to requirements for publication, actual coordination will continue through the federal NEPA process and state Site Certification process which is expected to be concluded by December 1979.

Table 12-1

Coordination with Governmental Agencies

DATE	AGENCY*	NATURE OF COORDINATION
10/27/76	DER, DSP, PSC	Introductory meeting among agencies, applicant and consultant to discuss the regulations and requirements for power plant site selection.
2/10/77	DNR, DSP, DOT, DER	Meeting to review progress of site alternative studies.
3/28/77	DER, DSP	Meeting to discuss alternative site studies and results.
4/12/77	DSP, DER, PSC, GFWFC, DNR-Coastal Zone Planning	Meeting of the Florida Clearinghouse Committee to discuss early siting efforts.
5/25/77	DSP	Transmittal of Minutes for 4/12/77 meeting.
6/2/77	DER	Transmittal of REA bulletin 20-21:320-21 to DER.
6/7/77	REA	Meeting to discuss proposed SECI project and REA requirements and responsibilities under the National Environmental Policy Act.
6/8/77	REA	Transmittal of SECI's Site Selection Study -- Executive Summary.
6/13/77	EPA, USFWS	Meeting to initiate discussion and preparation for the review of proposed electric facilities for SECI.
6/24/77	EPA, USFWS, NMFS, REA, PSC, DSP, SJRWMD, DER, COE	Invitation from SECI for "Interagency Coordination Review Meeting" to be held 7-8 July 1977. Purposes of meeting included: (1) determination of each agency's responsibilities in power plant licensing; (2) the procedures to be used to carry out these responsibilities; and (3) opportunities for consolidating the state and federal regulatory process.
6/26/77	DER	Transmittal of "Draft" outline for review and approval of a consolidated format for Environmental Analysis/Site Certification Application to unify federal and state requirements.
6/30/77	NEFRPC	Telephone conversation with Executive Director to introduce the SECI proposed 1200 MW power generating station project and solicit help in timely review of activities within planning council jurisdiction.
6/30/77	PSC	Letter to solicit comments regarding "Draft" DER application for Certification of a Proposed Fossil Fuel Power Generating Plant Site.
7/7-8/77	DER, SJRWMD, USFWS, EPA, PSC, COE, REA	Interagency coordination meeting held in Keystone Heights, Florida (see 6/24/77 for purpose of meeting).
7/14/77	NMFS	Letter outlining NMFS principal responsibilities in siting review and permitting-licensing process.
7/25/77	DSP	Comments from USFWS to DSP on Ten Year Site Plan for SECI.
7/28/77	NMFS	Transmittal of draft, consolidated federal-state contents for Environmental Assessment Statement/Site Certification Application.
8/1/77	NMFS	Acknowledgement of receipt of "Table of Contents" for the "Environmental Assessment Statement/Site Certification Application" and determination of NMFS interests in power plant siting.
8/2/77	NEFRPC	Meeting with Executive Director to introduce the SECI power plant project, to solicit council's participation, and to determine the council's role in waste treatment management, coastal zone planning, and local comprehensive planning.
8/5/77	EPA	Determination that proposed generating facility will be "new source" and will be subject to NEPA of 1969.
8/17/77	REA, DER, EPA, USFWS, DST, SJRWMD, JAPB	Transmittal of draft PLAN OF STUDY for proposed project.
8/23/77	DER	Comments on Dames & Moore PLAN OF STUDY.
8/25/77	REA	Comments from USFWS to REA on request for technical assistance on proposal to construct power plant.
8/26/77	USFWS	Comments from USFWS on Dames & Moore Environmental Analysis Plant Study.
9/7/77	NMFS	Response to request for comments on PLAN OF STUDY.
9/9/77	SJRWMD	Response to request for comments on PLAN OF STUDY.
9/13/77	REA	Meeting with REA in Washington to review comments of draft Site Certification Application/Environmental Analysis, PLAN OF STUDY and establish direction of continuing efforts of SECI, REA, and Dames & Moore to satisfy requirements of REA.

Table 12-1 (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
9/20/77	REA, NEFRPC, NMFS, SJRWMD, DSP, USFWS, EPA, DER, JAPB	Extension of period for comments on Dames & Moore Site Certification Application/Environmental Analysis PLAN OF STUDY.
9/21/77	REA	Telephone conversation to clarify applicable public notice requirements.
9/23/77	DAH&R	Letter to State Historic Preservation Officer to determine if archaeological study is necessary on preferred site.
9/26/77	USFWS	Response to request for comments on the Site Specific Sampling Plan, Aquatic Ecology.
9/26/77	REA	Letter to REA requesting determination of responsibilities of REA as lead agency under NEPA and clarification of role of applicant in preparation of environmental analysis.
10/13/77	DSP	Meeting of (1) Review SECI's Site Certification activities, (2) Review DSP process for evaluation of Ten Year Site Plan, (3) Review energy element of State Comprehensive Plan.
10/20/77	DAH&R	Request for DAH&R comments on archaeological survey to be conducted on preferred site.
10/20/77	REA, NEFRPC, NMFS, SJRWMD, USFWS, DSP, EPA, DER, COE, GFWFC, JAPB.	Transmittal of revised "Site Certification Application and Environmental Analysis PLAN OF STUDY," 10/14/77.
11/14/77	REA, EPA, DER	Invitation to agencies to discuss compliance with 1977 amendments to Clean Air Act.
11/18/77	EPA, DER	Meeting in Atlanta to determine procedures for compliance with the 1977 amendments to the Clean Air Act in the licensing of the preferred site.
12/7/77	USFWS	Request for comments on location evaluation for intake/discharge structure at preferred site.
12/15/77	USFWS	Response to comments on intake/discharge structure.
12/30/77	DER	Request for DER clarification on PSD permit application requirements.
1/16/78	USFWS	Response to correspondence of 12/7 and 12/15 with USFWS. Restatement of SECI's philosophy of cooperation and open communications.
1/19/78	REA	Invitation to REA to participate in 2/9-10 meeting to visit alternative power plant sites, discuss status of project, and discuss federal agency coordination process.
1/24/78	COE	Transmittal of copy "Site Certification Application and Environmental Analysis Seminole Plant Putnam County PLAN OF STUDY."
1/24/78	GFWFC	Letter concerning tentative selection of pipeline corridor.
1/27/78	GFWFC	Confirmation of meeting with SECI's respresentatives to discuss plans for proposed plant.
2/1/78	FAA	Application for construction of tall structure filed.
2/22/78	EPA	Meeting in Atlanta to identify information to support PSD permit application and review licensing and equipment procurement schedule.
3/1/78	REA	Letter to confirm documentation of site study.
3/2/78	REA, USFWS	Meeting with USFWS in Atlanta to discuss (1) recent correspondence between Dames & Moore, USFWS, and SECI, (2) USFWS procedures for coordination of correspondence with SECI, (3) REA position on site alternatives selection process, and (4) status of proposed SECI power plant project and effects of proposed CEQ regulations on licensing.
3/7/78	GFWFC	Meeting to discuss status of SECI's licensing activities and the relationship between USFWS and GFWFC.
3/8/78	GFWFC	Transmittal of a copy of PLAN OF STUDY.
3/14/78	DER (St. Johns River Subdistrict)	Meeting to discuss suitability of existing ambient air quality data.
3/14/78	DER, Duval County Pollution Control Dept.	Meeting in Jacksonville to discuss application for prevention of significant deterioration.
3/15/78	DER	Transmittal of comments on preferred site study plan.
3/24/78	DER (St. Johns River Subdistrict)	Request of DER for endorsement of comments and available ambient air quality data.
3/24/78	Putnam County Comm.	Application for rezoning of preferred site filed.

Table 12-1 (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
3/31/78	DSP	Transmittal of "Ten-Year Site Plan" discussing electrical need forecasts and forecast for new facilities.
4/3/78	Putnam County Comm.	Private water well construction permit application filed.
4/4-5/78	REA, SJRWMD, DSP, SWFWMD, GFWFC, USFWS, EPA, DER	Interagency Coordination meeting to (1) allow participants to visit "preferred" and alternate sites, and (2) review and discuss engineering and licensing activities, interagency coordination, and results of site investigations.
4/10/78	Putnam County Comm.	Private water well construction permit issued.
4/19/78	REA, NEFRPC, NMFS, SJRWMD, DSP, EPA, DER, COE, GFWFC, JAPB, USFWS	Transmittal of "Interim Report" to (1) coordinate environmental licensing activities and engineering design, (2) ensure regulatory compliance requirements are incorporated early in engineering design process, and (3) assure adequate and orderly opportunity for participation of state and federal agencies in decision making.
4/20/78	DER	Letter responding to 3/15/78 DER comments on aquatic sampling program.
4/20/78	SJRWMD	Water well construction permit issued.
5/2/78	FAA	Permit to construct tall structure issued.
5/2/78	EPA	Conversation regarding Seminole's and Jacksonville Electric Authority's plans for proposed plants and the proper sequence for PSD and FPSD permits.
5/8/78	Putnam County Planning Commission.	Public information workshop on proposed power plant project.
5/10/78	SCWAB	Meeting to discuss Sumter site as an alternative location for a coal-fired power plant. Discussion of sludge disposal, ash disposal, disposal of cooling water, and treated waste water into surrounding area.
5/10/78	Putnam County Planning Commision	Public hearing before Planning Commission.
5/10/78	NMFS	Comments from NMFS on INTERIM REPORT: Environmental Input to Power Plant Enginering Design process.
5/18/78	EPA, (copies to REA, DER)	Transmittal of Prevention of Significant Deterioration (PSD) Permit Application for Seminole Plant Units No. 1 and No. 2.
5/22/78	DER	Comments from DER on INTERIM REPORT: Environmental Input to Power Plant Engineering Design Process.
5/23/78	Putnam County Comm.	Approval of land use zoning change.
5/24/78	COE, EPA	Meeting in Jacksonville to discuss requirements for COE permit applications.
6/2/78	COE	Letter to COE requesting review of alternative sites and a determination of jurisdiction over use of wetlands on the sites and activities in navigable waters adjacent to the sites.
6/5/78	EPA, GFWFC, USFWS	Invitation to meet to discuss alternative cooling water intake/discharge facilities and locations for use at the proposed site.
6/7/77	COE	Visit preferred site to review condition of wetlands.
6/8/78	DOT	Tall structure permit issued.
6/8/78	GFWFC	Receipt from GFWFC of comments on INTERIM REPORT and "Appendix E of PLAN OF STUDY."
6/9/78	DER	Comments on and findings of acceptability of Prevention of Significant Deterioration Application.
6/14/78	EPA	Meeting in Atlanta to discuss 316(b) compliance criteria applicable to the design and operation of a cooling water intake structure to achieve "best available technology."
6/14/78	USFWS	Meeting in Atlanta to discuss proposed "best available technology" design for cooling water intake structure.
6/16/78	GFWFC	Meeting to discuss the proposed cooling water intake structure design as "best available technology" to minimize adverse environmental impact.
6/16/78	NMFS	Transmittal of the results of the 6/14/78 meetings with EPA and USFWS on §316(b) compliance and request for review and comments.
6/16/78	DER	Transmittal of the results of the 6/14/78 meetings with EPA and USFWS on §316(b) compliance and request for review and comments.

Table 12-1 (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
6/22/78	COE	Letter reporting on field trip of COE to the preferred Putnam County Site and determination that COE jurisdiction does not extend to wetlands on this site.

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*ABBREVIATIONS:

Federal

COE	Corps of Engineers
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
NMFS	National Marine Fisheries Services
REA	Rural Electrification Administration
USFWS	U. S. Fish and Wildlife Service

State

DAH&R	Division of Archives, History and Records Management
DER	Department of Environmental Regulation
DNR	Department of Natural Resources
DOT	Department of Transportation
DSP	Division of State Planning
GFWFC	Florida Game and Fresh Water Fish Commission
PSC	Public Service Commission
SJRWMD	St. Johns River Water Management District

Local

JAPB	Jacksonville Area Planning Board
NEFRPC	Northeast Florida Regional Planning Council

Table 12-1a

COORDINATION WITH GOVERNMENTAL AGENCIES
(Additions from August, 1978 to January, 1979)

DATE	AGENCY*	NATURE OF COORDINATION
8/7/78	COE,EPA,DOA,DOCA, DAH&R DNR, DHRS, DOT,GFWFC,DOC, DA&CS,PSC,SIERRA,WiRPC, NEFRPC	Transmittal by DER to agencies of copies of SECI Site Certification Application and Environmental Analysis.
8/4/78	DER,REA	SECI files Site Certification Application and Environmental Analysis with DER and REA.
8/14/78	DER	Determination that Site Certification is "complete".
8/24/78	Sumter County Water Authority	Comments on report on groundwater conditions at Sumter site alternate.
8/31/78	EPA,DOI,COE	Letter from REA to other federal agencies proposing REA be designated as federal "lead agency" on Seminole project.
9/1/78	WiRPC, NEFRPC, NCFRPC	Letter from SECI to planning councils requesting certification that proposed transmission corridors are consistent with applicable land use plans and zoning ordinances.
9/7/78	NEFRPC	Confirmation from NEFRPC that proposed site is consistent with regional land use plan and Putnam County Comprehensive Plan.
9/7/78	EPA	SECI transmittal of draft NPDES application to EPA.
9/7/78	COE	SECI transmittal of application for activities in navigable waters to COE.

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Table 12-1a (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
9/8/78	EPA	Letter from EPA to REA concurring with REA as lead federal agency and agreeing to work to coordinate activities and provide a draft NPDES permit for inclusion in Draft EIS.
9/13/78	DER,COE,EPA,REA	Meeting of agencies with SECI to eliminate duplication among procedures as directed by proposed Council on Environmental Quality regulations.
9/15/78	EPA	Meeting with SECI to discuss draft NPDES application.
9/20/78	WiRPC	SECI request for certification that transission corridors are consistent with regional and local land use plans.
9/20/78	NCFRPC	NCFRPC transmittal of land use plan to SECI.
9/22/78	NCFRPC	Letter to SECI acknowledging consistency of transmission corridor with regional land use plan.
9/27/78	Putnam County Board of County Commission	Transmittal to SECI of Board resolution providing for rezoning of land to allow use as a proposed power plant site.
9/29/78	COE	Letter from COE to REA agreeing with REA as lead agency.
9/29/78	NEFRPC	Transmittal regional land use plan to SECI.
10/4/78	Marion County Zoning and Building Department	Confirmation that transmission corridors would not violate zoning regulations.
10/5/78	DNR	Comments to DER on <u>Site Certification</u> Application.
10/5/78	SJRWMD	Comments to DER on preliminary review of <u>Site Certification Application</u>.

Table 12-1a (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
10/6/78	DNR	SECI submittal to DNR of application for easement across state owned bottomlands.
10/9/78	Columbia County Board of County Commissioners	Transmittal to SECI of Columbia County Comprehensive Plan.
10/9/78	Bradford County Zoning Commission	Transmittal to SECI of Bradford County zoning codes and land use plan.
10/10/78	EPA	Letter from EPA to SECI requesting that the PSD Application be amended and confirming May 19, 1978 as the official date of application.
10/12/78	DOI	Letter concurring with role of REA as lead agency.
10/13/78	DER,COE,EPA,REA	SECI transmittal of minutes of state/federal review coordination meeting held 9/13/78.
10/16/78	DER	Transmittal to SECI of DER questions on the Site Certification Application.
10/23/78	DAH&R	Letter from State Historic Preservation Officer stating compliance with 36 CFR 800.
10/23/78	NCFRPC	NCFRPC comments on consistency of proposed transmission corridor with local and regional plans.
10/30/78	NCFRPC	Comments on transmission line corridor through Lake Butler.
10/31/78	EPA	SECI transmittal of NPDES Application and request for 316(b) determination.
11/1/78	DER	Request by REA for DER to cooperate and coordinate with REA during the NEPA process.

Table 12-1a (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
11/1/78	NMFS	Letter to REA accepting REA as "lead agency" and identifying NMFS responsibilities.
11/6/78	DNR	Letter from DNR to SECI determining requirement for easement across state owned lands.
11/8/78	NCFRPC	Request for NCFRPC to be party to Seminole Site Certification proceedings.
11/9/78	EPA	Meeting of SECI with EPA to discuss PSD Application.
11/13/78	Marion County	Meeting with SECI regarding transmission line routing through county.
11/14/78	Marion County	Transmittal of comments on transmission line routing.
11/28/78	Marion County	Stipulation stating that no zoning ordinance exist which apply to transmission corridor.
12/6/78	NMFS	Letter to REA identifying NMFS interests in environmental impact statement process and permit process.
12/7/78	COE	Meeting of SECI with COE to discuss COE permit application for activities in navigable waters at proposed Putnam County Site.
12/7/78	DER	Meeting with SECI with DER to discuss estuarine modeling of water effluents.
12/12/78	USFWS, EPA, DER, GFWFC	Transmittal by SECI of "Plan of Study Aquatic Biological Program to Monitor <u>In Situ</u> Intake Screen Testing for <u>Seminole</u> Units No. 1 and 2" and request for comments.
12/12/78	COE	Letter from COE determining applicability of COE requirements for alternate power plant sites.

Table 12-1a (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
12/14/78	USFWS	Meeting of SECI with FWS to discuss proposed aquatic biological testing in compliance with Section 316(b) of the Clean Water Act.
12/15/78	EPA	Meeting of SECI with EPA to submit and discuss PSD Application Amendments.
12/19/78	DNR	DNR notification to SECI of Board of Trustees of the Internal Improvement Trust Fund approval of utility easement across state owned bottomlands.
12/21/79	USFWS	Transmittal of USFWS comments on biofouling and aquatic biological testing program for 316(b) compliance.
1/3/79	DER	Letter from DER to SECI acknowledging review of *In situ* screen testing plan and offering comments.
1/3/79	PSC	Meeting of SECI and PSC to discuss SECI expansion plans.
1/4/79	USFWS (Area Office)	Meeting with SECI to discuss proposed project status.
1/4/79	SJRWMD	SECI transmittal to SJRWMD of responses to questions raised by SJRWMD on *Site Certification Application*.
1/8/79	USFWS	REA request of USFWS for USFWS comments for inclusion in Draft EIS.
1/8/79	USFWS	Letter to REA transmitting USFWS comments on intake screen testing program.
1/8/79	NMFS	Transittal by SECI to NMFS of copy of *Site Certification Application*.
1/8/79	NMFS	REA request of NMFS for NMFS comments to be included in Draft EIS.
1/8/79	PSD	Transmittal by PSC to DER of PSC final report of Seminole's *Site Certification Application*.

Table 12-1a (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
1/11/79	USFWS	Letter from REA requesting Section 7 Consultation with USFWS and determination of effects of proposed project on manatee.
1/12/79	DER	Transmittal of SECI responses to DER questions dated 10/16/78.
1/16/79	USFWS (Field Office)	Meeting of SECI with USFWS to discuss NEPA responsibilities and progress of proposed project.
1/17/79	REA	Transmittal by SECI of amended copy of PSD application to REA.
1/18/79	GFWFC	GFWFC recommendations to SECI on intake screen study design.
1/25/79	SJRWMD	Meeting with SECI to discuss Site Certification Application.
1/25/79	DER, SJRWMD	Transmittal by SJRWMD to DER of District comments on Site Certification Application.
1/26/79	GFWFC	SECI response to GFWFC comments on "Aquatic Biological Program to Monitor *In Situ* Intake Screen Testing".
1/26/79	DER	Transmittal to DER of Seminole Plant Units No. 1 and 2 Mixing Zone Assessment Report.
1/31/79	EPA	Letter from EPA (Athens) acknowledging review and acceptance of plan of study for *In Situ* intake screen testing program.
1/31/79	REA, PSC	Transmittal of PSC's final evaluation of SECI Site Certification Application to REA.

Table 12-1b

COORDINATION WITH GOVERNMENTAL AGENCIES
(Additions to Table 12-1)

DATE	AGENCY*	NATURE OF COORDINATION
6/1/77	Department of Navy	Letter cancelling use of Naval restricted bombing site area near Bostwick, Florida, effective 7/1/77.
7/29/77	Putnam County Port Authority	Letter to SECI describing citizen's concerns over property adjacent to proposed plant.
8/15/77	USFWS	Letter to REA concerning potential for threatened or endangered species on proposed site near Bostwick.
8/17/77	NEFRPC	Transmittal by SECI to NEFRPC of Plan of Study and request for comments on Plan.
8/31/77	USFWS	Transmittal to SECI by USFWS of USFWS comments on Plan of Study.
9/28/77	SJRWMD	Transmittal to SECI SJRWMD comments on Plan of Study.
11/18/77	EPA	Meeting of SECI with EPA to discuss air quality issues and requirements for compliance with new source performance standards and prevention of significant deterioration regulations.
3/3/78	DNR	SECI request for determination of existence of state owned bottomlands.
4/11/78	DSP	Trasmittal of "Power Requirements Study, Florida 41, Seminole, for Seminole Electric Cooperative, Inc." from SECI to DSP.
5/9/78	Sumter County Water Authority Board	Meeting with SECI to discuss alternative site Sumter.

Table 12-1b (Continued)

DATE	AGENCY*	NATURE OF COORDINATION
6/6/78	SJRWMD	SECI transmittal to SJRWMD of report: "Floridan Aquifer Study, Boiler Feedwater, Putnam Site."
6/16/78	EPA	Meeting with SECI to discuss procedures for compliance with 316(b) requirements.
6/16/78	USFWS	Meeting with SECI to discuss procedures for compliance with 316(b) requirements.
6/21/78	DOT	Issuance of tall structure permit.
6/22/78	COE	Letter to SECI establishing need for COE permit for intake/discharge facilities and determining that the COE does not have jurisdiction over "wetlands" on the proposed Putnam County site.

*LIST OF ABBREVIATIONS FOR TABLES 12-1a and 12-1b
(Coordination with Governmental Agencies)

Federal

COE	Corps of Engineers
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
NMFS	National Marine Fisheries Service
REA	Rural Electrification Administration
USFWS	U.S. Fish and Wildlife Service
DOI	Department of the Interior

State

DA&CS	Department of Agriculture and Consumer Services
DAH&R	Division of Archives, History and Records Management
DER	Department of Environmental Regulation
DNR	Department of Natural Resources
DOC	Department of Commerce
DOCA	Department of Community Assistance
DOT	Department of Transportation
DSP	Division of State Planning
GFWFC	Florida Game and Fresh Water Fish Commission
PSD	Public Service Commission
SJRWMD	St. Johns River Water Management District

Local

JAPB	Jacksonville Area Planning Board
NCFRPC	North Central Florida Regional Planning Council
NEFRPC	Northeast Florida Regional Planning Council
WRPC	Withlacoochee Regional Planning Council

Table 12-2

Coordination with the Public

Date	Organization/Individual	No. of Participants	Nature of Coordination
5/3/77	Mr. R. E. Hudson, Putnam County Chamber of Commerce		Letter of support from the Industrial Development Team of local businessmen.
7/20/77	Putnam County Chamber of Commerce	125	General presentation of project.
7/26/77	Mr. Prime F. Osborn, The Family Lines System Railroad		Offer of assistance and letter of support for Palatka plant site.
7/27/77	Mr. A. H. "Gus" Craig, The Florida House of Representatives		Offer of personal support and assistance for Putnam County plant.
8/9/77	Palatka Rotary	75	General presentation of project.
8/16/77	Kiwanis (Azalea City)	85	General presentation of project.
8/17/77	Mr. Sherrill "Pete" Skinner, The Florida Senate		Letter of support for Putnam County plant and expression of concern for expeditious handling of permitting process.
9/1/77	Kiwanis (Downtown, Palatka)	80	General presentation of project.
9/17/77	Putnam County Democratic Women	25	General presentation of project.
9/17/77	Tri-County Electric Cooperative Annual Meeting	800	General presentation of project.
9/21/77	Crescent City Rotary	50	General presentation of project.
10/3/77	Palatka Lions Club	70	General presentation of project.
10/12/77	St. Mark's Parish	25	General presentation of project.
11/7/77	Men's Fellowship Group, (Christ Independent Methodist Church, Palatka)	30	General presentation of project.
1/26/78	Friends of the St. Johns	10	General discussion of proposed project.
1/26/78	National Rural Electric Association		Award recognition to Seminole as winner in 1977 member services contest for public information program on the proposed new power station.
3/11/78	Consulting Engineers' Council of Georgia, Inc.		1977 Engineering Award of Merit for Plant Location Study.
5/23/78	Public Meeting	80	REA sponsored public coordination meeting in Sumterville.
5/24/78	Public Meeting	40	REA sponsored public coordination meeting in Palatka.

Table 12-2a

COORDINATION WITH PUBLIC
(Additions)

DATE	ORGANIZATION/INDIVIDUAL	NATURE OF COORDINATION
________	Putnam County Commission	Resolution declaring support for proposed plant.
2/13/78	Friends of the St. Johns River	Meeting with SECI to inform of proposed power plant site.
9/18/78	Putnam County Chamber of Commerce	Resolution declaring support for proposed plant.
10/12/78	City of Palatka Commission	Resolution declaring support for proposed plant.
10/19/78	Board of Directors, Atlanta National Bank of Palatka	Resolution declaring support for proposed plant.
10/25/78	Bill Chappell, Congressman	Letter of support for project.
10/26/78	Putnam County School Board	Resolution declaring support for proposed plant.
11/16/78	Sierra Club	Meeting of Sierra Club to discuss comments on Environmental Analysis.
11/21/78	Sierra Club	Transmittal of copy of NPDES Permit Application by SECI to Sierra Club.
11/27/78	Sierra Club	Transmittal of Sierra Club comments to DSP on DSP Preliminary Report to DER.
12/15/78	Sierra Club	Sierra Club review of the Preliminary Report on the Seminole Site Application by the Sierra Club.
1/17/79	Sierra Club	Transmittal of copy of PSD Application by SECI to Sierra Club.
2/1/79	Sierra Club	Transmittal of SECI responses to questions raised by Sierra Club in review of Environmental Analysis.

Table 12-3

Articles and Notices of Proposed Project

Date	Publication	Nature of Article/Notice
7/20/77	Florida Times Union	Announcement of proposed plant site selection.
7/20/77	Palatka Daily News	Announcement of proposed plant site selection.
7/21/77	Tampa Tribune	Announcement of proposal to construct plant.
7/21/77	Palatka Daily News	Announcement of proposed plant site selection.
7/21/77	Florida Times Union	Announcement of proposed plant site selection.
7/25/77	Palatka Daily News	Adoption of Resolution by Putnam County Commission Board supporting Seminole Electric Cooperative, Inc. plans.
7/26/77	Palatka Daily News	Editorial supporting proposed plant site.
8/15/77	Palatka Daily News	Report of presentation by H. Wright of SECI on results of preliminary site studies.
8/23/77	Tampa Tribune	"Roy Bertke on Business" reports on progress of environmental studies and Seminole's plans for new plant.
8/23/77	Palatka Daily News	Seminole announcement of request for bids from architectural/engineering firms on proposed plant.
9/77	Development News (Florida Div. of Economics)	Announcement of plans to construct electric generating plant in Putnam County.
9/6/77	Federal Register	Notice of anticipation of preparation of Environmental Impact Statement for Seminole Electric Cooperative, Inc.
9/16/77	Palatka Daily News	Notice of speech by Mr. Verne Eveland, president, Seminole Electric Cooperative, on proposed project before the Democratic Women's Club.
10/4/77	Palatka Daily News	Report of speech by Mr. R. Claussen to Lions Club of Palatka.
5/8/78	Ocala Star-Banner	Announcement of potential generating station to be constructed near Sumter and of hearing scheduled for May 24, 7 p.m.
5/17/78	Herald Express	Public Forum Editorial raising questions about proposed plant in Sumter County.
5/19/78	Florida Administrative Weekly (Vol. 4, No. 20)	Department of Environmental Regulation announcement of public information meeting regarding potential power plant site, May 23, 7:30.
5/19/78	Sumter County Times	Public notice of public information meetings and opportunity to provide input to REA by mail.
5/22/78	Palatka Daily News	Announcement of two meetings regarding SECI proposed plant: Putnam County Commissioners and public information meeting, May 23.
5/23/78	Palatka Daily News	Drawing of planned Seminole Electric Plant and announcement of public information hearing May 23, 1978.
5/19,22, 23/78	Palatka Daily News	Public Notice of public information meeting May 23, 1978.
5/24/78	Florida Times Union	Report of public information meeting and public concern over low water table.
5/24/78	Palatka Daily News	Report of public information meeting and public concern over water problems in the area and the proposed plant burning coal.
5/20,22 23,24/78	Leesburg Commercial	Notice of public information meeting.
5/26/78	Sumter County Times	Report of public forum convened by Rural Electrification Administration and support of local people for power plant.
5/29/78	Ocala Star-Banner	Report of public forum conducted by Rural Electrification Administration to find out public opinion in Sumter County on Seminole Electric Cooperative's plans to construct a power generating plant.
5/29/78	Ocala Star-Banner	U. S. Rep. Richard Kelly expressed support for Seminole Electric Cooperative's plans to construct a power generating plant in Sumter County.

Table 12-3a

ARTICLES AND NOTICES OF PROPOSED PROJECT
(Additions)

DATE	PUBLICATION	NATURE OF ARTICLE/NOTICE
3/24/78	Palatka Daily News	Notice of public hearing to consider changes in zoning ordinances in Putnam County.

REVISED 3/15/79

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 520, Palatka, Florida 32077

February 26, 1979

Mr. Marvin Smith, Staff Geographer
Dames & Moore, Consultants
Suite 200, 455 East Paces Ferry Road
Atlanta, Georgia, 30305

Dear Sir:

We have made an intensive soil survey of the property acquired by Seminole Electric Cooperative, Inc. in Putnam County, Florida.

There is no prime agricultural land within the boundaries delineated.

Respectfully yours,

Joseph M. Davenport
District Conservationist

STATE OF FLORIDA

Department of State

THE CAPITOL
TALLAHASSEE 32304

[redacted]
SECRETARY OF STATE
JESSE J. McCRARY, JR.

L. ROSS MORRELL, ACTING DIRECTOR
DIVISION OF ARCHIVES, HISTORY, AND
RECORDS MANAGEMENT
(904) 488-1480

RECEIVED
OCT 30 1978
DAMES & MOORE
1036/PM-022 (2.5.1)

October 23, 1978

IN REPLY REFER TO:

Mr. Louis Tesar
Historic Sites Specialist
(904) 487-2333

Mr. Tim Doyle
Dames and Moore
455 East Paces Ferry Road
Suite 200
Atlanta, Georgia 30305

Re: Cultural Resource Assessment of
Seminole Electric Cooperative
Proposed Generating Facility
Putnam County, Florida

Dear Sir:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Procedures for the Protection of Historic and Cultural Properties"), we have reviewed the above referenced project for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. The authorities for these procedures are the National Historic Preservation Act of 1966 (Public Law 89-665) as amended by P.L. 91-243, P.L. 93-54, P.L. 94-422, and P.L. 94-458, and Presidential Executive Order 11593 ("Protection and Enhancement of the Cultural Environment").

We have reviewed the Florida Master Site File and the results of the recent archaeological and historical survey of the project area by Cultural Resource Management, Inc. Two previously unrecorded prehistoric shell midden sites were found on the St. Johns River in the general area of outfall corridor B, Fryman, Griffin and Miller (1978) report:

> These sites contain intact stratigraphy and, being likely to yield information important in prehistory, must be considered eligible for inclusion in the National Register of Historic Places. Avoidance of impact is recommended by rejection of alternate corridor B.

No other archaeological or historical sites are recorded for the proposed project area. Therefore, it is our opinion that if alternate corridor B is not utilized, then no archaeological or historical sites listed, or eligible for listing, on the National Register of Historic Places, or otherwise of national, state or local significance, and the project may proceed without further involvement with this agency. If alternate corridor B is utilized, it is our recommendation that two identified sites be mitigated through archaeological salvage excavation by a professionally competent agency.

If you have any questions about our comments, or about federal historic preservation regulations, please feel free to contact us.

Your interest and cooperation in preserving Florida's historic resources are appreciated.

Sincerely,

L. Ross Morrell,
Deputy State Historic
Preservation Officer

LRM:Teh

cc: James J. Miller

REC'D JUN 26 1978

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32201

SAJOD-RP

22 June 1978

FILE IDENTIFIER	SUBJECT
A	173 - E.1

Mr. David L. Lester
Environmental Engineer
Seminole Electric Cooperative Inc.
Suite 108
2410 East Busch Blvd.
Tampa, Florida 33612

Dear Mr. Lester:

This letter is in followup to our trip to the site contemplated by Seminole Electric Cooperative Inc., for an electric generating station south of Bostwick, Florida, near the St. Johns River just north of the intersection of the St. Johns River and Rice Creek.

The purpose of this letter is to let you know of our determination of the need for a Department of the Army permit for the work you contemplate.

The wetland areas found on the north end of the property are an isolated wetlands not connected to navigable waters by a surface tributary system and we have determined that the degradation of that area would not adversely impact on interstate commerce. Therefore, they are not subject to the Corps of Engineers jurisdiction pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972 since they are not wetlands which fall under the category of waters of the United States. Therefore, a Department of the Army permit would not be required for placing fill in that wetland area.

The connection of the intake and discharge structures to the St. Johns River will require a Department of the Army permit since we have made an administrative determination that the St. Johns River is a navigable water of the United States, in that reach. Thus, any work in that area would be subject to a permit pursuant to Section 10 of the River and Harbor Act of 1899, and, in addition, the placement of any fill in the river would also be subject to a permit pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500).

File Copy

SITE CERTIFICATION APPLICATION
AND
ENVIRONMENTAL ANALYSIS

SEMINOLE PLANT UNITS NO. 1 & NO. 2

SEMINOLE ELECTRIC COOPERATIVE, INC.

VOLUME III
APPENDICES

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TERRESTRIAL ECOLOGY

APPENDIX A

TERRESTRIAL ECOLOGY

A.1 SURVEY METHODS

The techniques and procedures to identify and characterize terrestrial ecosystems are well established. Methodologies presented here are organized in terms of the major life forms: vegetation, amphibians, reptiles, avifauna, and mammals.

Vegetation

Vegetation of the site was surveyed three times during the study period: summer, winter, and spring. The first survey was conducted in the summer of 1977 and provided the basis for delineating the vegetative communities. The vegetational surveys were accomplished by reconnoitering the project area and identifying representative plant communities. Communities were subsequently described in terms of predominant and characteristic species.

Four higher physiognomic types (growth forms) of vegetation are recognized on the site: herbaceous, woody shrubs and vines, trees, and epiphytes. Herbaceous vegetation includes grasses, sedges, and forbs (broad-leaved herbs). Shrubs are defined for purposes of this study as woody plants less than three meters in height or having a diameter at breast height (1.5 meters) of less than 5 centimeters. Trees are defined as those woody species taller than 3 meters or with a diameter at breast height greater than 5 centimeters. Epiphytes are plants that derive moisture and nutrients from the air and rain and usually grow on other plants. Each physiognomic type requires a different sampling technique.

Herbaceous vegetation was sampled by estimating a percent cover of each species and their frequency of occurrence in a one-meter-square quadrant. Percent cover was estimated by the system devised by Braun-Blanquet (1932). This system was based on a scale from (+) to (5) as follows:

Class	Coverage in Percent
+	less than 1
1	1-5
2	6-25
3	26-50
4	51-75
5	76-100

Frequency, an estimate of plant dispersion in time and space, was primarily used to describe herbaceous ground cover and understory. Frequency expresses the percentage of sample plots in which a given species occurs. Relative frequency is the frequency of a species divided by the sum of frequency values for all species sampled. Frequency data are valuable because they identify many of the species present, and provide an estimated measure of their distribution.

Tree components were evaluated using the point-centered quarter (PCQ) technique (Cottam and Curtis, 1956). The PCQ technique allows rapid data collection at several locations in the stand thereby making the sample data more representative of existing conditions.

For this technique, a series of transects were located through representative portions of the community sampled. A point was established at 20-meter intervals along these transects. The area around each point was divided into four equal parts, or quarters. The individual plant nearest the point of each quarter was then located; and the species, diameter at breast height, and the point-to-plant distance were determined and recorded for each plant. Basal area was determined from diameter measurements. Point-to-plant distances were measured to the center of the crown or to the center of the rooted base rather than to the edge of the crown. An importance value was obtained from the sum of the relative frequency, relative density, and relative dominance values for species at each sampling station. These values provide a comparison of the most important species.

Voucher specimens were collected during each sampling period to establish a species list. As appropriate, botanical authorities at local universities were consulted to verify identifications of voucher specimens. One such authority was James Poppelton at the University of South Florida, Orlando. Nomenclature followed that of standard botanical references such as Kurz and Godfrey (1962) and Radford, et al. (1968). The endangered and threatened plant list published in the July 14, 1977 Federal Register was used to determine the presence of endangered or threatened plant species.

Amphibians and Reptiles

Amphibians and reptiles (herpetiles) were surveyed during the spring, summer, and winter seasons. No herpetiles were found during the winter season.

The principal means of surveying the herpetile populations on the site was to search in all suitable habitats for specimens. Rocks, logs and debris were overturned and replaced throughout the site. Observations were made along roadways of the site both during the day and at night. All sightings of species were noted, and attempts were made to capture the individual for positive identification. Whenever possible, photographs were taken of species observed.

A drift fence was also used on site to capture herpetiles. The drift fence is a barrier placed in suitable habitats, that when encountered by a ground dwelling herpetile, directs that animal into a pitfall (5 gallon bucket) located at either end of and in the middle of the fence. The fence was approximately 25 meters long and 0.5 meters high. It was located in the bottomland hardwood habitat which was quite moist and offered the best opportunity to capture herpetiles.

Birds

Avian transects were used as the primary survey method for birds. Survey transects were placed through all major habitats during the spring, summer, and winter seasons (Figure 2.7-1). This technique involves by walking along predetermined transect lines and counting all birds seen or heard for a finite distance on either side of the transect. This enables the observer to sample the same portion of the habitat during several seasons and thereby better understand the relative abundance and seasonal occurrence of the avifauna.

Additional incidental observations were made of any species seen onsite while engaged in other aspects of this survey. Special assessment lines were established in notably productive areas during breeding season to help document onsite nesting of species. The site and a portion of the St. Johns River from Palatka to Federal Point were flown in a light plane each sampling period in order to search for large raptor nests.

Mammals

The majority of the mammals expected on the Putnam Site are either nocturnal or secretive in their habits. This makes actual observation difficult. Therefore, observations were made of signs of species presence such as tracks, droppings, and food scraps. All habitats were searched for these signs during the spring, summer, and winter seasons.

Tomahawk live traps were placed in all habitats to capture and subsequently release medium-sized mammals (squirrel to bobcat in size). Snap traps were set in all habitats to capture small mammals (shrews to squirrels in size). Individual traplines consisted of twenty traps and were used for from 28 to 60 trapnights (number of trapnights = number of traps x number of nights). Site roads were driven at night and habitats on either side of the road were spot lighted to observe movement of nocturnal species. Photographs were taken of captured mammals to record their occurrence.

A.2 VEGETATIONAL SPECIES LIST FOR THE PUTNAM SITE

TREES

ACERACEAE

Acer saccharum var. floridanum = A. barbata - Maple
A. rubrum - Red maple

AQUIFOLIACEAE

Ilex cassine var. cassine - Dahoon holly

BETULACEAE

Alnus serrulata - Tag alder

EBENACEAE

Diospyros virginiana - Persimmon

FAGACEAE

Quercus laevis - Turkey oak
Q. virginiana - Live oak
Q. michauxii - Chestnut oak
Q. laurifolia - Laurel oak
Q. phellos - Willow oak
Q. nigra - Water oak
Q. falcata - Southern red oak
Q. margaretta - Sand post oak

HAMAMELIDACEAE

Liquidambar styraciflua - Sweetgum

JUGLANDACEAE

Carya glabra - Pignut hickory

LAURACEAE

Persea borbonia - Red bay
P. palustris - Swamp red bay

MAGNOLIACEAE

Magnolia virginiana - Sweet bay magnolia
M. grandiflora - Southern magnolia

MORACEAE

Morus rubra - Red mulberry

NYSSACEAE

Nyssa sylvatica var. *biflora* - Blackgum tupelo

N. aquatica - Water tupelo

OLEACEAE

Fraxinus caroliniana - Carolina ash

PINACEAE

Pinus palustris - Slash pine

P. elliottii - Slash pine

P. serotina - Pond pine

P. clausa - Sand pine

ROSACEAE

Prunus americana - Wild plum

TAXODIACEAE

Taxodium distichum - Bald cypress

T. ascendens - Pond cypress

THEACEAE

Gordonia lasianthus - Loblolly bay

TILIACEAE

Tilia caroliniana - Basswood

ULMACEAE

Ulmus alata - Winged elm

U. americana - American elm

Celtis laevigata - Sugarberry

SHRUBS

ANNONACEAE

Asimina obovatum - Pawpaw
A. parviflora - Custard apple

AQUIFOLIACEAE

Ilex coriacea - Ilex
I. decidua - Possum haw
I. glabra - Gallberry
I. cassine - Dahoon holly

ARECACEAE

Serenoa repens - Saw palmetto
Sabal minor - Palmetto
S. palmetto - Cabbage palmetto

CAPRIFOLIACEAE

Viburnum obovatum - Black haw
Sambucus canadensis - Elderberry

CELASTRACEAE

Euonymus americanus - Strawberry bush

ERICACEAE

Gaylussacia frondosa - Dangleberry
Kalmia hirsuta - Kalmia
Lyonia ligustrina - Lyonia
Vaccinium myrsinites - Shiny blueberry
V. fuscatum - Blueberry
V. stamineum var. *caesium*
Rhododendron alabamense - Azalea

FAGACEAE

Quercus chapmanii - Chapman's oak
Q. geminata - Sand live oak
Q. minima - Dwarf live oak
Q. myrtifolia - Myrtle oak
Q. cinerea - Bluejack oak
Castanea alnifolia - Chinquapin

MYRICACEAE

Myrica cerifera - Wax myrtle

ROSACEAE

Pyrus arbutifolia - Red Choke-cherry

RUBIACEAE

Cephalanthus occidentalis - Button bush

SAMIACEAE

Palafoxia integrifolia - Palafoxia

SAPOTACEAE

Bumelia reclinata - Milk buckthorn

VERBENACEAE

Callicarpa americana - Beauty bush

HERBS OR DWARF SHRUBS

ACANTHACEAE
Ruellia caroliniensis - Ruellia

AMARYLLIDACEAE
Hypoxis juncea - Star grass

ANACARDIACEAE
Rhus radicans - Poison ivy

APIACEAE
Hydrocotyle sp. - Pennywort
Erynigium aromaticum - Button snakeroot
Centella asiatica - Centella

ASCLEPIADACEAE
Asclepias pedicellata - Milkweed

ASTERACEAE
Ambrosia artennisiifolia - Ragweed
Aster reticulatus - White-top aster
Baldwinia angustifolia - Yellow buttons
Berlandiera subacaulis - Little green-eyes
Cacalia floridana - Cacalia
Carduus sp. - Thistle
Carphephorus corymbosus - Carphephorus
C. odoritissimus - Vanilla plant
C. paniculatus - Carphephorus
Conyza canadensis - Dwarf horseweed
Coreopsis leavenworthii - Tickweed
Eclipta alba - Eclipta
Elaphantopus elatus - Elephant's foot
Erigeron philadelphicus - Daisy fleabane
Eupatorium compositifolium - Dog fennel
E. recurvans - Eupatorium
Heterotheca graminifolia - Golden aster
Liatris secunda - Blazing star
L. tenuifolia - Blazing star

Melanthera hastata - Melanthera

Pterocaulon pycnostachyum - Rabbit Tabacco

Redbeckia hirta - Black-eyed susan

Sericocarpus bifoliatus - White-topped aster

Silphium asteriscus - Rosin-weed

Solidago odora - Goldenrod

Solidago sp. - Goldenrod

Vernonia angustifolia - Ironweed

V. gigantea - Ironweed

BRASSICACEAE

Cardamine hirsuta - Bittercress

BROMELIACEAE

Tillandsia usneoides - Spanish moss

T. fasciculata - Wild pine

CAMPANULACEAE

Lobelia paludosa - White lobelia

CISTACEAE

Lechea sessiliflora - Pineweed

COMMELINACEAE

Commelina sp. - Dayflower

Tradescantia graminea - Spiderwort

CYPERACEAE

Bulbostylis ciliatifolia - Bulbostylis

B. warei - Bulbostylis

Cyperus nashii - Cyperus

Rhynchospora megalocarpa - Beak rush

R. corniculata - Beak rush

Scleria triglomerata - Scleria

Carex stricta - Carex

Carex sp. - Carex

EUPHORBIACEAE

Cnidoscolus stimulosus - Tread softly

Croton glandulosus - Croton

Crotonopsis linearis - Crotonopsis
Stillingia sylvatica - Queen's delight
Tragia urens - Tragia

FABACEAE

Cassia nictitans - Wild sensitive plant
Desmodium floridanum - Tick clover
Indigofera caroliniana - Indigo plant
Petalostemon pinnatum - Prairie clover
Psoralea canescens - Buckroot
Schrankia nuttallii - Sensitive brier
Zornia bracteata - Zornia
Vicia acutifolia - Vetch

GENTIANACEAE

Sabatia difformis - Marsh pink

HAEMODORCEAE

Lachnanthes caroliniana - Bloodroot

HYPERCICACEAE

Hypericum cistifolium
H. gentianoides - Pineweed
H. hyperiodoides - St. Andrew's cross
H. reductum - Hypericum
H. tetrapetalum - Hypericum
H. virginicum - Hypericum

IRIDACEAE

Sisyrinchium angustifolium - Blue-eyed grass

JUNCACEAE

Juncus repens - Rush
J. scirpioides - Rush

LAMIACEAE

Trichostema setaceum - Bluecurls
Monarda punctata - Horsemint
Salvia lyrata - Sage

LILIACEAE

Yucca filamentosa - Bear grass

LYTHRACEAE

Cuphea carthagenensis - Cuphea

MELASTOMATACEAE

Rhexia mariana - Meadow beauty

ONAGRACEAE

Ludwigia maritima - Ludwigia

OXALIDACEAE

Oxalis stricta - Wood sorrel

POACEAE

Agrostis perennans - Bent grass
Andropogon ternarius - Broom sedge
Aristida purpurascens - Three-awn grass
A. speciformes - Three-awn grass
Axonopus furcatus - Axonopus
Cenchrus gracillimus - Sandspur
Chloris petraea - Fingergrass
Echinochloa crusgalli - Barnyard grass
Eragrostis elliottii - Love grass
Panicum agrostoides - Panic grass
P. equilaterale - Panic grass
P. joorii - Panic grass
P. rhizomatum - Panic grass
Paspalum setaceum - Paspalum
P. urvillei - Vasey grass
Setaria corrugata - Sand spur
Sporobolus junceus - Dropseed

POLYGALACEAE

Polygala lutea - Polygala

POLYGONACEAE

Eriogonum tomentosum - Wild buckwheat

Polygonella gracilis - Tall jointweed
Polygonum sp. - Smartweed

PONTEDERIACEAE
Pontederia cordata - Pickerelweed

ROSACEAE
Licania michauxii - Gopher apple
Rubus cuneifolius - Brier-berry

RUBIACEAE
Diodia teres - Buttonweed
D. virginiana - Buttonweed
Galium tinctorium - Bedstraw
Houstonia procumbens - Bluet

SARRACENIACEAE
Sarracenia minor - Pitcher plant

SAURURACEAE
Saururus cernuus - Lizard's tail

SCROPHULARIACEAE
Aureolaria pectinata - Aureolaria
Gratiola subulata - Hedge hyssop
G. neglecta - Hedge hyssop
Linaria canadensis - Blue toad flax

VIOLACEAE
Viola triloba - Three-lobed violet
V. pedata - Birdfoot violet
Viola sp. - Violet

XYRIDACEAE
Xyris jupicai - Yellow-eyed grass

VINES

CONVOLVULACEAE

Bonamia patens var. *angustifolia* - Bonamia

FABACEAE

Centrosema virginiana - Butterfly pea
Galactia elliottii - Milk pea
G. regularis - Milk pea
G. volubilis - Milk pea
Tephrosia floridana - Hoary pea

LILIACEAE

Smilax auriculata - Greenbrier
S. laurifolia - Greenbrier

LOGANIACEAE

Gelsemium sempervirens - Yellow jessamine

VITACEAE

Vitis rotundifolia - Muscadine grape
Parthenocissus quinquefolia - Virginia creeper

FERNS, FERN ALLIES, AND LOWER PLANTS

LICHENS

LYCOPODIACEAE

Lycopodium adpressum - Southern clubmoss

OSMUNDACEAE

Osmunda regalis - Royal fern

O. cinnamomea - Cinnamon fern

POLYPODIACEAE

Polypodium sp.

PTERIDACEAE

Pteridium aquilinum - Bracken fern

SCHIZAEACEAE

Lygodium palmatum - American climbing fern

SPHAGNACEAE

Sphagnum sp. - Peat moss

A.3 REFERENCES

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APPENDIX B

AQUATIC ECOLOGY

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AQUATIC ECOLOGY

REVISED 3/15/79

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APPENDIX B

AQUATIC ECOLOGY

B.1 AQUATIC FLORA

B.1.1 Phytoplankton

Methods and Materials

Duplicate, one-liter whole water phytoplankton samples were collected at two stations at each transect (Figure 9.3-2) by using the pump-and-hose technique. A composite volume of approximately 20 liters of subsurface water was pumped into a container and from this two, one-liter samples were taken.

Each liter plankton sample was centrifuged at 18,000 rpm for 30 minutes (EPA, 1973). The centrifuged sample was washed into storage vials using the centrifuged preservative and resuspended to give a final volume of one milliliter or ten milliliters of plankton concentrate. Five to ten replicate mounts were made and species were identified to lowest practicable taxon and enumerated using an oil immersion lense with total magnification of 1000X.

Phytoplankton counts were made using a Levy Corpuscle Counting Chamber (Hemocytometer) (EPA, 1973). A total of 20 secondary squares was counted for each sample. Counts from the two replicate samples were then averaged for the final calculations of cell number per liter of original sample using the following equations:

1. $$\text{Cells/ml of concentrate} = \frac{n \times 10^6}{80}$$

Where n = cell count in 20 secondary squares.

2. Based on the concentration factor,

$$\text{cells/liter of original sample} = \text{cells/ml of concentrate.}$$

Species diversity was calculated for each station using the modified Shannon-Weaver equation described by Patten (1971) for marine algae studies:

$$\bar{H} = -k \sum_{i=1}^{m} p_i \log p_i$$

Where p_i = the proportion of the ith species counted with the Hemocytometer. Species diversity (H) can vary between 0, if all the p_i's except one are 0, and high numbers for samples in which large total counts are evenly distributed among the species present.

B.1.2 Aquatic Macrophytes

Methods and Materials

Aquatic macrophytes were sampled concurrently with fish in the St. Johns River. At each of the four transects (A, B, C, D) vegetation was inspected using a plant grab, by examining seine and trawl hauls for plants, or by visual inspection of waters.

Results

No aquatic macrophytes were present at Transects A or B. Those found at both C and D were water celery (Vallisneria americana), common water nymph (Najas guadalupensis), and stonewort (Chara sp.). At Transect D, spatterdock (Nuphar luteum) and filamentous algae were also present. No vegetation was found at depths greater than one meter. Vegetation was generally scarce throughout the transects.

Note: The macrophyte sampling reported above was accomplished in September 1977 and January 1978. Since that time, a precise 200-foot pipeline corridor was optioned by SECI that is located about 1000 feet east of Transect B. In February 1979, a macrophyte bed extending about 180 feet from the shoreline at the optioned corridor was observed. The extent and significance of this macarophyte bed is currently under study.

B.2 AQUATIC FAUNA

B.2.1 Zooplankton

Methods and Materials

Duplicate zooplankton samples were collected by pumping 100 liters of water into a modified Wisconsin plankton net & bucket equipped with No. 20 (76 micrometer) mesh nylon cloth. The battery operated pump was calibrated by measuring the length of time to pump 100 liters of water into a large bucket several times so that an average elapsed time could be calculated. Zooplankton samples were collected 30.5 cm below the water surface. Organisms retained by the plankton net were concentrated into the net bucket then transferred to 130 ml sample storage bottles and preserved with 4 percent formalin. Storage bottles were labled with client's name, date, transect, station number and replicate. Laboratory analyses of net zooplankton were initiated by establishing constant volumes for representative samples. After thorough mixing, subsamples from the concentrated solution were transferred to a Sedgwick-Rafter (S-R) cell using a large orifice, 1 ml pipette. The S-R cell was pre-checked for its specific volume, determined to be 1± 0.054 ml. The strip counting method was employed after a 10 minute settling period had elapsed (EPA, 1973). Identification and enumeration was at 150X and 300X magnification and 4 to 11 strips were counted to equal a total volume of 139 mm^3. The counting area was delineated with a Whipple Disc which had an area of 0.483025 mm^2. The number of strips counted varied inversely with zooplankton density; the greater the density the fewer strips that were counted. During the counting process only organisms within the outer perimeter and touching the leading edges were counted. Occasionally, glycerine jelly microscope slide mounts of zooplankters were made to aid identification. Glycerine jelly mounts and zooplankton storage samples were retained for a voucher collection.

Zooplankton densities were calculated as organisms/liter and were represented by the following formula (EPA, 1973):

$$\frac{\text{Organisms}}{\text{liter}} = \frac{(C)\ (SRV)}{(\underline{S})\ (WDV)} \times \frac{CV}{SV}$$

Where:

C = Number of organisms counted per ml
SRV = Sedgwick-Rafter cell volume (mm^3)
WDV = Whipple Disc strip volume (mm^3)
$\underline{S}$ = Number of strips counted
CV = Concentrate volume (ml)
SV = Sample volume (100 liters)

Discussion

A broad pattern of distribution of the zooplankton during the September and January sampling periods was found among the sampled transects. Some organisms were abundant at most or all transects in January, such as the rotifers, *Asplanchna* and *Brachionus dimidiatus*, but were found in few samples or were absent in September. Most zooplankters illustrated the opposite distribution pattern, such as the rotifers, *Brachionus caudatus*, *B. havanaensis*, and *Trichocerca*, and the cladocera and ostracods.

The density or number of organisms represented among the various transects also followed seasonal patterns. Rotifers were dominant at all sites studied during both sampling periods, their greatest abundance occurring at offshore sites (Station 1 in each transect), the only exception being Transect C in January. Cladocera were observed in both seasons only on shore at Transect D and at very low densities. Copepod populations, second in abundance to rotifers at every station sampled, were more variable in abundance with more found nearshore in January (with the exception of Transect B) and the majority found offshore in September. Copepods ranged in density from 76 at Transect B in January to a high of 539 at Transect D in September. The seasonal nature of fluctuations in zooplankton density along the Palatka/Rice Creek area of the St. Johns River can be seen in Table B-17. Rotifers appear to dominate during winter (January) and later summer/early fall (August/September), copepods and their nauplii dominate in later winter (February) and late fall (November), and cladocera dominate in late spring/early summer (May/June).

The diversity of organisms, expressed as number of taxa represented, did not follow a clear pattern of seasonal changes as did the distribution and density of zooplankton, noted above. For example, during January, Station 2, Transect B had the lowest number of taxa (8) and Station 2, Transect D had the highest number (15), while Station 2, Transect C had the lowest number (8) in September and Station 2, Transect A had the highest number of taxa (14) during this same sampling period. The rotifers were most represented of those species collected with 23 species (77 percent) found (Tables B-16, B-18, B-19). Copepods were next most frequent in occurrence with 4 species represented (13 percent) and only 20 species of cladocera (7 percent) and 1 species of ostracod (3 percent).

These patterns of zooplankton fluctuations among the transects and, to a greater degree, through the seasons, probably are reflections of a full range of environmental influences. Additionally, these effects may be indirectly mediated by timing of reproduction of planktivores; increase in algal productivity, with both positive and negative influences; and effects of various abiotic changes, such as rainfall and temperature, and the chemical components of the river.

B.2.2 Benthic Macroinvertebrates

Methods and Materials - Field

Three replicate benthos samples were collected with an Ekman dredge (15.2 cm^2) at both nearshore and offshore stations for each of the four transects (Figure 9.3-2). The contents of each sample concentrated by passing through a U. S. Standard No. 30 mesh (0.516 mm aperture) bucket seive with an approximate capacity of 12 liters (EPA, 1973). The concentrated debris was placed into sample bottles labeled with date, transect, station number, and sample sequence number. Each sample was preserved with buffered formalin, pH 7.4, containing rose bengal stain. The final concentration of the preservative in the sample vial was approximately 5 percent by volume.

Methods and Materials - Laboratory

Field samples were washed to remove excessive rose bengal stain and to dilute the formaldehyde preservative. The samples were then sorted individually in white enamel plans with the aid of a 10x magnifying lens. All organisms were placed into vials or whirl-paks and retained for further processing.

Each vial or whirl-pak was emptied into a large sorting dish and all organisms counted and placed according to taxonomic groups. Larger benthic macroinvertebrates were identified using a Wild (Model M5) Stereomicroscope. Smaller organisms, such as Chironomidae, were mounted on glass slides in CMCP-10 media and identified to lowest possible taxa. Densities were determined using a conversion factor of 14.35 to transform number of organisms collected in 3 dredge samples to organisms per M^2.

As an aid in evaluating the quality of the environment and determining the degree of stress on the macroinvertebrate community, two measures of species richness and distribution for the sites samples were used: The Shannon-Weaver index ($\bar{d}$) and the Lloyd-Ghelardi equitability index (e).

The values for mean diversity ($\bar{d}$) obtained by the Shannon-Weaver index provide a means of comparing survey data as well as indicating possible stress in the community. Environmental changes usually modify or eliminate the niche of some species which can result in the displacement of these species. Typically, one or more species find the new conditions tolerable and fill the available niche space, unless conditions are too extreme. Thus, occurrence of stress in an ecosystem may initially be reflected in a lowered diversity and, increases in species capable of tolerating the stress.

Species diversity was calculated using the machine formula of Lloyd, Zar and Karr (1968) by:

$$\bar{d} = \frac{C}{N} (N \log_{10} - \; n_i \log_{10} n_i)$$

where:

$\bar{d}$ = mean diversity (in bits)
C = 3.321928 (converts base 10 log to base 2 [bits])
N = total number of individuals
n_i = total number of individuals in the i^{th} species

The diversity index is affected by the number of species (richness) and the number of individuals representing each species (distribution) and may range from 0 to 3.321928 log N, where low numbers suggest presence of environmental stress.

MacArthur (1957) proposed a model suggesting that natural ecosystems follow a distribution of species where a few relatively abundant species are associated with an increasing number of species represented by fewer individuals (broken stick model). Lloyd and Gelhardi (1964) developed a table of values with which the number of species in a sample could be compared to determine how closely a community conforms to the MacArthur broken stick model, this relationship described as equitability. The proposed measure of equitability (e) is given by:

$$e = \frac{S'}{S}$$

where:

S' = the tabulated value
S - number of taxa in the sample

The range of values for equitability is usually from 0 to 1, except where samples contain few organisms representing several taxa, when values may run above 1.

Discussion

Among the 43 macroinvertebrate taxa identified for both sampling periods, 21 species were representatives of the Insecta, including 19 diptera, 1 ephemeroptern and 1 trichopteran species. The remaining 22 taxa consisted of 9 oligochaetes, 8 crustacea, 3 molluscs, and 1 nematode, 1 bryozoan, and 1 fish. The number of taxa obtained in January (34) ws greater than the number identified in September (28). This difference, in part, may be a reflection of the higher densities collected in January (10,824 organisms) than in September (8,377 organisms). Characteristic of many riverine systems, the major macroinvertebrate fauna collected were dipterans,crustacea, and oligochaetes.

Aquatic dipterans were the predominant taxa collected during the 1977 and 1978 surveys on the St. Johns River and the highest overall densities during the 1978 study. However, during the 1977 aquatic survey, oligochaetes made up the highest, overall, densities. The change from lower densities and fewer species of diptera during September 1977, to higher densities and more species during January 1978 indicates that typical cyclic emergence patterns exist.

The number of taxa at individual stations ranged from 24 (Transect A, Station 2, January 1978) to 3 (Transect A, Station 1, September 1977). The average number of taxa for nearshore stations was 14.7 as opposed to 7.6 for offshore stations. Differences between the number of taxa at inshore and offshore locations was more pronounced during the September 1977 study and was attributed to a direct reduction in the number of insect taxa, particularly dipterans, and non-insect taxa, particularly crustacea. Overall, the range in number of taxa at different transects was from 12 to 30, which occurred at Transects D and A, respectively, during the January 1978 survey. Other than a reduction in numbers of taxa, seasonally, there were no large differences or variations in the taxonomic makeup in the study area by transect or station location. Comparison of present data collected for 1977 and 1978 (Dames & Moore), and previous data (Florida Power & Light [FP&L], 1974) indicate similar taxa exist upstream from the proposed site. This is especially true for common taxa such as fresh water tubificids, midges, and crustaceans.

The numerically dominant macroinvertebrates at the study area were dipterans, primarily chironomids; oligochaetes, primarily tubificids; and crustaceans, primarily amphipods and isopods. Dominant chironomids, which attained densities from 200/m^2 to 1091/m^2, were Chironomus sp., Dicrotendipes nervosus, Procladius sp., and Coelotanypus tricolor. Many Chironomus spp. and several species of Procladius are described as tolerant of organic wastes (EPA, 1973). Many tubificids are considered tolerant or organic pollutants, including several species of Limnodrilus, particularly L. hoffmeisteri, as well as the Lumbriculidae (EPA, 1973; Roback, 1974). The predominant crustacean densities varied from 158/m^2 to 445/m^2, and these included, Gammarus sp., Corophium sp. and Cyathura polita. The highest density recorded for the bythiniid snail was 359/m^2.

The mean annual density for inshore stations was 1576/m^2 as compared to 822/m^2 for offshore stations. This pattern was more pronounced during the fall (September 1977). Average densities in the study area were somewhat lower than for upstream (FP&L, 1975).

Summary

The benthic macroinvertebrate community in the St. Johns River study area was typical of other river sections. There was a variety of macroinvertebrate organisms having ecological functions which complement specific requirements in the overall trophic structure of the aquatic community.

The study area showed generally uniform species structure and distribution for both seasons sampled, although differences in densities were observed that suggest seasonal variations. Greater total numbers of organisms occurred in January, evenly divided between offshore and onshore stations. In September, however, the lower total density was unevenly distributed with onshore stations being almost 5 times greater than offshore collections.

B.2.3 Fish and Ichthyoplankton

Methods and Materials

Fish sampling was conducted at four transects on the St. Johns river (Figure 9.3-2), one upstream from its confluence with Rice Creek and three others in the vicinity of potential intake and discharge structure locations corresponding to corridors A, B and C. Fish were collected at each transect using seines, gillnets, otter trawls, and an electroshocker. Electroshocking was accomplished with a 227 volt AC boom shocker, used along the shoreline for a distance of about 500 yards (about 1 hour) in the vicinity of each transect. One 150-foot monofilament experimental gill net (6 panels, 6 feet deep, 1" to 3-1/2" mesh) was fished at each transect for 24 hours (nets were checked every 12 hours). Three minnow seines of different sizes were used and included a 35-foot seine (6 feet deep, 1/4" mesh), a 25-foot seine (6 feet deep, 1/4" mesh, and 6' x 6' x 6' bag), and a 20-foot seine (4 feet deep, 1/4" mesh). Otter trawls were made using a 10-foot trawl of one inch stretch mesh (3/16" mesh cod end) for five minutes. During the September 1977 survey, one trawl was made at each transect and two trawls were made at each transect during the January 1978 survey. All fish were identified and enumerated and most were also weighed, measured, and, in some cases, sex was recorded.

Larval tow collections were made at two stations on each transect during both day and night, except in February when no night collections were made. Tows were made to collect eggs, larvae, and juvenile fish. Duplicate samples of 100 m^3 or more were collected at each station (Table B-37), approximately 0.5m below the surface. Samples were collected with a 0.762 m (30 inch) diameter metered larval fish net (0.5 mm mesh). All fish were identified to species and enumerated in the laboratory. To complement the March larval fishnet data, two seine hauls (day only) were made at each transect using a 40 foot (1/8" mesh) minnow bag seine.

B.3 PLAN OF STUDY FOR AQUATIC BIOLOGY PROGRAM TO MONITOR IN SITU SCREEN TESTING.

B.3.1 Introduction

Under Section 316(b) of the Clean Water Act, Seminole Electric Cooperative, Inc. (SECI) is required to make a demonstration of "Best Technology Available (BAT) for minimizing adverse environment impact." In this regard the Site Certification Application and Environmental Analysis (SCA&EA) prepared for SECI addressed the criteria important to that demonstration. These included: plant capacity, intake location, intake velocity, and intake design.

As part of the evaluation of intake designs, a fixed "wedge-wire" screen device (manufactured by the Johnson Division of U.O.P.) was chosen for further evaluation to test both the feasibility of the use of the fine slot screens at the site and to evaluate their potential for mitigation of environmental impacts for the BAT assessment.

Since further evaluation and testing were needed, Section 5.2.2.2 of the SCA&EA included a preliminary study outline for screen fouling tests. This Plan of Study updates that outline and expands the scope to provide the information necessary to complete the demonstration of BAT. This Plan of Study has been developed after consultation with the U.S. Fish and Wildlife Service (National Power Plant Team), U.S. EPA, Florida Department of Environmental Regulation, Florida Game and Freshwater Fish Commission, Johnson Division of U.O.P., Dames & Moore, and SECI.

B.3.2 Objectives

The primary objectives which are to be addressed in the test program to be conducted during 1979 are indicated below. This proposed study will focus on the first objective.

1. Assess the potential for adverse impact by the operation of the proposed intake.

2. Assess the degree of mitigation of aquatic impacts caused by the intake utilizing the screen sizes to be tested for demonstration of BAT.
3. Determine the slot sizes of screens which are feasible for use in the St. Johns River based on debris and biofouling tests.

B.3.3 Approach

To attain objectives number one and two, a testing program has been devised to:

1. Take place when eggs, larvae, and adults of important entrainable species may be potentially present near the site,
2. Examine the ability of various slot sizes to by-pass rather than entrain these species, and
3. Enable statistical testing for differences among the slot sizes in their ability to by-pass organisms.

The testing program set up to perform these tasks will be an experiment using acceptable statistical procedures and will take place to compare *in situ* exclusion of fish eggs, larvae, and major macroinvertebrates by the various intake screens. The experiment will be based on a balanced block analysis of covarience design and will consist of replicate exclusion experiments performed over an eight-day period; sampling will be done at night, the time of maximum larval activity and potential entrainment.

These tests will consist of two phases. The first phase will be two one-day samplings that started during January 1979. These samplings will be used to determine if spawning of bay anchovies is occurring. The bay anchovy is the species present in greatest numbers at the site, has small entrainable larvae, and is an important part of the river forage base. Demonstration of the exclusion of bay anchovy from entrainment will mean almost all other fish and macroinvertebrate species will be excluded as well.

When spawning has been demonstrated, an eight-day intensive study will be mobilized to include monitoring of larvae in the river. During this study, 1- and 2-mm slot opening wedge-wire screening will be tested. A comparison with collections made through 3/8" (9.5 mm) wedge-wire screening on the same days will also be made. At the conclusion of this study, the data will be analyzed and reported as part of the BAT demonstration. In addition, results of biological studies conducted during the biofouling tests will be assessed for the degree of mitigation of entrainment impacts. These assessments will also be included in the overall report on BAT impact evaluation which will be submitted at the conclusion of the study.

B.3.4 Methodology

The apparatus for the main part of these experiments will consist of a "platform" (dock) to be located near the site of the Seminole plant proposed intake. It will contain two recessed, impeller water pumps and a bulkhead (similar to that proposed for the plant as presented in the SCA&EA) and a net arrangement for the monitoring of cylindrical wedge-wire screens. The screens will be scaled so that for both slot sizes tested, intake velocity and volume will be the same. This scaling will allow the positions of the screens to be changed so as to control statistical bias. The outflow of each pump will be directed through a pipe to a barrel-net arrangement (Figure 1). A 363 μm mesh plankton net will be suspended in a barrel of water with an overflow so that all water leaving the pump through the pipe is filtered through the net. Keeping the net immersed will minimize damage to organisms entering the net, will prevent clogging, and will ease the process of measurement and identification. The pumps and all related apparatus will be operated from the test platform. A flow meter will be mounted on the pump outflows to monitor flow.

Starting in January 1979 and continuing thereafter, individual egg and larval fish collections will be carried out on the St. Johns River at the site of the test facility to determine if spawning of the bay anchovy is occurring. In addition, adult bay anchovies will be examined to determine gonadal ripeness. Two aquatic ecologists will visit the site equipped with the necessary nets and apparatus to collect the bay anchovy specimens. They will utilize a small, outboard-powered boat and make a series of larval tows using a 75-cm diameter, 363 μm mesh larval net. Collections representing sample volumes of at least 100 m^3 will be preserved in formalin for examination by qualified laboratory personnel. These sampling trips will continue until the spawning period has begun. During these samplings an attempt will be made to ascertain temporal variability in the abundance of bay anchovies at night.

The field team, consisting of one qualified field technician and the principal investigator, will proceed to the SECI site. This team will initiate the intensive field program for larval exclusion by the wedge-wire screens. They will conduct the exclusion study on eight consecutive evenings to minimize the amount of natural variation in the abundance and distribution of fish eggs and larvae over time. This is not a critical timing sequence since bay anchovies have an extended spawning season. The studies will be conducted at night since sampling during 1978 illustrated that the highest catches of fish eggs, larvae, juveniles, and adults were made with tows taken at night. Fish impingement and entrainment at other power plants has generally been found to be highest at night as well. Doing all sampling during a single type of light regime also reduces the variation in captures that may be due to diurnal variations in fish behavior and availability.

Each night of sampling will be divided into four experimental periods of 1-1/2 hours each. This will enable the testing program to have each screen tested in each position every night, thereby controlling for any bias due to the position of the screens on the test platform. The actual positions of the screens for each experimental period will be determined by use of a random number table within the frame work of the balanced block design.

The pumps will run continuously during each period of experimentation. Plankton nets will be placed in the outflow of the pumps prior to the beginning of each period and removed immediately afterwards.

Each experimental period will be immediately preceded and followed by a set-up period for the collection and preservation of samples, exchange of screens, collection of ichthyoplankton tows, and pump versus net calibration tests.

In order to test the comparative efficienty of pump samples as opposed to nets and to provide information on large screen openings, one pump will be operated with a 3/8" (9.5 mm) opening screen (which should not affect the passage of entrainable organisms) during the time in which net tows are being conducted, and both the net and pump results will be compared numerically and statistically. This will allow assessment of impact and of the mitigative effect of the wedge-wire screening.

The tows in the river will also be used as a covariate for the results of the entrainment sampling and will serve as controls for differences in larval abundance during the various experimental periods and days. As in the sampling effort prior to the intensive studies, replicate larval tows will be taken utilizing 75-cm, metered ichthyoplankton nets. Also, during each of the set-up periods, dissolved oxygen, temperature, conductivity, salinity, turbidity, and water velocity near the platform will be measured and recorded. At the end of the experimental period, a 363 μm mesh net on a pole will be fitted over each screen prior to removal or pump shut down to prevent the loss of any macroinvertebrates, fish, fish eggs, or larvae impinged on the screens. These samples will be washed into separate sample jars and preserved with formalin prior to laboratory analyses.

To prevent damage or loss of samples during transshipment, a plankton splitter will be used to divide the samples in half. Each half will be shipped separately so that the loss of one shipment will not cause loss of all the samples and data. This will be done as a precautionary measure to prevent lost time and resources.

Based on initial sampling, weather conditions, and review of the appropriate literature, it is expected that the 1979 bay anchovy spawning will begin some time in March and continue for 6 to 16 weeks thereafter. The intensive study may then be made during a period when other species may be spawning. Data gathered on other species will also be examined and included in the analyses. The type of analyses conducted for these other species may differ somewhat from that proposed for the bay anchovy depending upon the nature and frequency of appearance of those species.

During the intake test devoted to biofouling studies during the spring and summer of 1979, a regular program of biweekly larval sampling and entrainment studies will be conducted. These studies will consist of day-and-night entrainment samples as well as larval tows in the St. Johns River taken during a 24-hour period. Two sets of replicate tows will be conducted during both the day and night periods. Entrainment samples will be collected from each screen-pump combination. Field procedures will be essentially the same as those of the intensive study program. All samples will be split, labelled, assigned numbers, and shipped to the laboratory where they will be inventoried, logged in, and analyzed by qualified laboratory personnel. The work will be subject to quality control procedures.

Ichthyoplankton samples will be sorted, fish eggs will be counted, and fish larvae will be identified to lowest practicable taxon. Representative fish eggs will be sized. Fish and larvae will be identified to life stage and measured. This will allow an assessment of the physical ability of the various slot sizes to exclude fish and to ascertain the relative contribution to the mortality of equivalent adults in the fish population.

Major macroinvertebrates collected will also be identified as to species and life stage and will be counted.

B.3.5 Analyses

Analyses of the data collected will primarily address two areas of interest:

1. An assessment of expected impacts during the operation of the proposed intake, and

2. The ability of the various slot sizes to mitigate impact on the fish populations present.

The first part of the analyses will include the assembly and summarization of data collected, including taxon, life stage, numbers collected, and size ranges for each intake and for river samples. Histograms of size versus frequency will also be prepared for taxa collected and for each intake type. Graphical presentations of these data will include the comparison of intake histograms with those of the river samples. This comparison will be made for both the intensive study as well as the biofouling test samples. Each sampling day will be presented separately, however, due to the small span of the intensive sampling program. Data from all eight days will also be grouped and analyzed.

To address the first area of interest, that of impact assessment, collection of fish eggs and larvae from the river will be used to project numbers available, and therefore vulnerable, to intake impacts during periods sampled. This will be compared with information gathered on entrainment by the pump operating with the 3/8" (9.5 mm) opening screen for assessment of gear efficiency and to correct for any inherent gear bias.

Both total numbers of eggs and larvae present and numbers-per- unit-volume will be calculated. Screen impingment and entrainment data for each screen size will be used to determine numbers of fish, larvae, and eggs entrained or impinged per unit volume of water withdrawn. These data will be compared to numbers of organisms available, and impact assessments will be made based on volumes that will be withdrawn by the proposed plant. Comparisons will also be made with numbers of organisms potentially available at various life stages in the river and, where possible, projected losses of equivalent adults will be made where sufficient data are available. In addition, a comparison will be made to assess the mitigation of impact to fish eggs and larvae demonstrated by the wedge-wire screens as compared to an intake that would not screen out small organisms; this will be based upon both the 9.5 mm screen and ichthyoplankton net results; estimates will be made of losses of equivalent adults where sufficient data are available. Intake selectivity for size and taxa will be examined as well as the influence of such variables as dissolved oxygen, temperature, current, and salinity on taxa impinged, entrained, or present in the river. These latter variables are known to influence the vulnerability of organisms to both entrainment and impingement.

To address the second area of interest, that of slot size mitigation, the covarience statistical procedure will be used. This analysis will determine if any significant differences exist in the performance of the tested slot sizes in their ability to exclude fish eggs and larvae. If significant differences exist, the slot sizes will be ranked in their ability to exclude larvae and eggs. Significant statistical differences due to days, experimental period, screen location, replication, or interactions between two or more of these factors, if they occur, will be reported and interpreted. Also, data collected during the biofouling tests concerning exclusion of other species and size ranges will be examined and interpreted. These findings are important since fish larvae become less vulnerable to entrainment and are potentially more likely to survive to adulthood as they increase in age and size, thus making them more "valuable" to that population.

If significant numbers of fish, eggs, and larvae of other species are also collected, these will also be addressed.

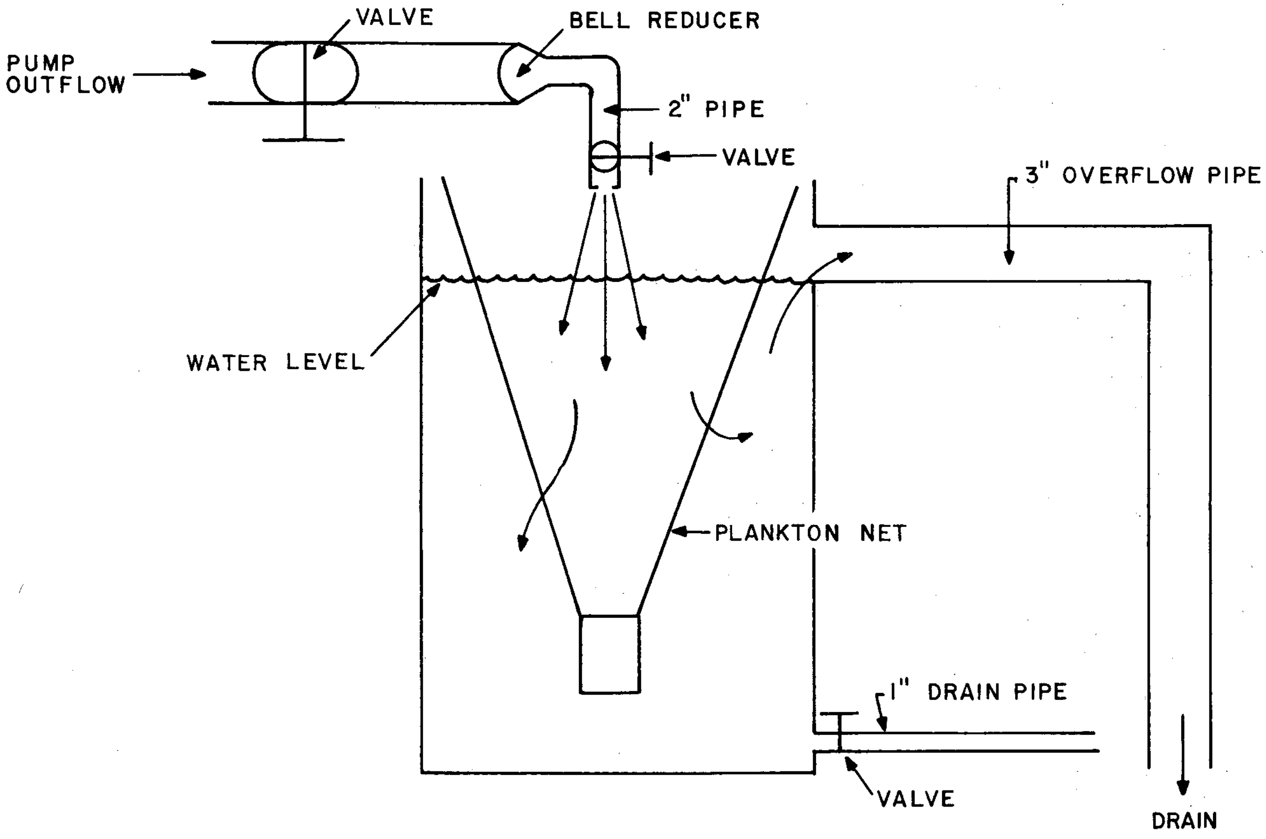

FIGURE 1. PLANKTON NET ARRANGEMENT TO COLLECT ICHTHYOPLANKTON FROM PUMP OUTFLOW.

REVISED 3/15/79

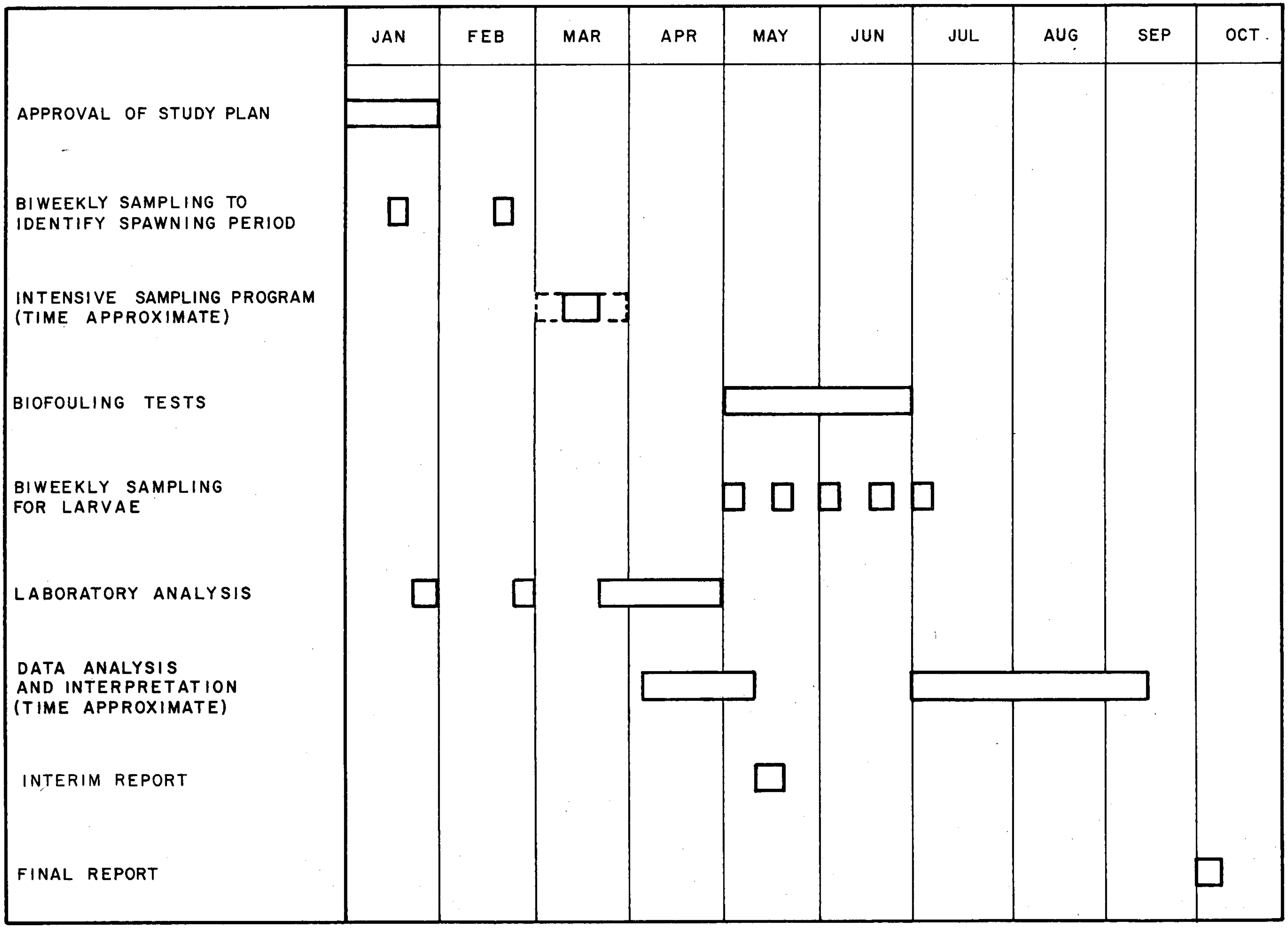

FIGURE 2. PROJECT SCHEDULE FOR BIOLOGICAL MONITORING OF IN SITU SCREEN TESTING PROGRAM.

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Table B-1

Phytoplankton Reported From the St. Johns River Near Palatka, Florida

BACILLARIOPHYTA
(Diatoms)

Amphora ovalis[3]
Amphora sp.[2]
Asterionella formosa[2]
Chaetoceros muelleri[3]
Cocconeis pediculus[3]
Cocconeis placentula[3]
Cocconeis sp.[2]
Coscinodiscus[2,3]
Cyclotella glomerata[3]
Cyclotella meneghiniana[2,3]
Cymatopleura solea[3]
Cymbella lanceolata[2,3]
Cymbella turgiula[3]
Diatoma vulgare[2]
Epithemia argus[3]
Epithemia sp.[3]
Eunotia sp.[3]
Fragilaria construens[2,3]
Fagilaria crotonensis[2,3]
Fragilaria pinnata[2]
Fragilaria sp.[3]
Fragilaria viriscens[3]
Frustulia sp.[4]
Gyrosigma sp.[2,3]
Mastogloia danseii[2]
Melosira ambigua[3]
Melosira granulata[2,3]
Melosira granulata[2,3]
Melosira italica[2,3]
Navicula rhyncocephala[3]
Navicula sp.[2,3]
Nitzschia bilobata[2]
Nitzschia gracilis[2,3]
Nitzschia longissima[2]
Nitzschia palea[2]
Nitzschia reversa[3]
Nitzschia seriata[3]
Nitzschia sp.[2,3]
Opephora martyi[2,3]
Pinnularia lineolata[2]
Pinnularia sp.[3]
Pleurosigma sp.[3]
Rhizoselinia gracilis[2]
Stauroneis sp.[2]
Surirella biseriata[2]
Surirella bohemica[3]
Surirella fastuosa[2]
Surirella minuta[3]
Surirella robusta[3]
Surirella sp.[3]
Surirella tenera[3]
Synedra berolinensis[2]
Synedra sp.[3]
Synedra ulna[2,3]
Tabellaria fenestrata[2]
Tabellaria flocculosa[2]
Trobidoneis sp.[3]

Table B-1 (Continued)

CYANOPHYTA
(Blue-Green Algae)

Agmenellum quadriduplicatum[2,3]
Anabaena circinalis[2,3]
Anabaena flos-aquae[2]
Anabaena sp.[3]
Anabaenopsis elenkinii[2,3]
Anacystis cyanea[2]
Anacystis sp.[4]
Aphanotheca nidulans[3]
Arthrospira comontiana[2]
Calothrix sp.[2]
Chroococcus dispersus[2,3]
Chroococcus limneticus[3]
Chroococcus minimus[3]
Chroococcus minor[2,3]
Chroococcus minutus[3]
Chroococcus refuscens[3]
Cylindrospermum sp.[2]
Dactylococcopsis sp.[4]
Gloeocapsa sp.[2]
Gloeotheca linearis[2,3]
Gloeotrichia sp.[2,3]
Gomphosphaeria aponica[3]
Lyngbya contorta[2,3]
Lyngbya limnetica[3]
Merismopedia tenuissima[2,3]
Microcystis flos-aquae[3]
Microcystis incerta[3]
Nodularis spumigena[2]
Oscillatoria acutissima[3]
Oscillatoria agardhii
Oscillatoria angustissima[2]
Oscillatoria limmetica[2]
Oscillatoria sp.[2]
Phormidium minnesotense[3]
Phormidium tenue[3]
Raphidiopsis currata[2,3]
Spirulina laxa[2,3]
Spirulina laxissma[2,3]
Synechococcus aeruginosus[2]

CHLOROPHYTA, CHRYSOPHYTA AND OTHER GROUPS[1]
(Excluding Bacillariophyta)

Acanthosphaera zachariasi[2]
Actinastrum gracillium[3]
Actinastrum hantzchii[2,3,]
Ankistrodesmus convolutus[3]
Ankistrodesmus falcatus[2,3]
Asterococcus limneticus[3]
Carteria klebsii[3]
Characium limneticum[2,3]
Chlamydomonas globosa[2]
Chlamydomonas sp.[3]
Chlorella vulgaris[3]
Chlorogonium elongatum[3]
Chodatella chodati[2]
Chodatella citriformas[3]
Chodatella droescheri[3]
Chodatella longiseta[2]
Chodatella quadriseta[3]
Chodatella subsala[3]

Table B-1 (Continued)

Chodatella wratislawiensis[3]
Closteriopsis longissima[3]
Closteriopsis sp.[3]
Closterium moniliforme[2]
Coelastrum sphaericum[3]
Coelastrum sp.[2]
Cosmarium bioculatum[2]
Cosmarium polygonum[3]
Cosmarium sp.[3]
Crucigenia irregularis[2]
Crucigenia quadrata[2,3]
Crucigenia tetrapedia[3]
Cryptomonas ovata[2,3]
Desmidium sp.[2]
Dictyospharium ehrenberianum[3]
Dictyospharium pulchellum[3]
Euastrum pulchellum[3]
Euglena acus[2]
Euglena sp.[3]
Glenodinum sp.[3]
Golenkinia paucispina[3]
Golenkinia radiata[2,3]
Gonium sociale[2]
Hormidium scopulinus[2]
Kirchneriella obesa[3]
Mallomonas caudata[2]
Micractinium pusillum[2,3]
Microspora stagnorum[2]
Netrium digitus[2]
Oocystis borgei[3]
Oocystis elliptica[3]
Oocystis parra[3]
Oocystis pusilla[3]
Oocystis sp.[3]
Pediastrum boryanum[3]
Pediastrum duplex[2,3]
Pediastrum simplex[3]
Pediastrum tetras var. *tetraodron*
Peridinium cinctum
Phacus pyram[3]
Phacus sp.[3]
Phacus tortus[2]
Pleodorina illinoisensis[2]
Pleurotaenium ehrenbergii[2]
Quadrigula lacustris[3]
Scenedesmus abundans[3]
Scenedesmus accuminatus[3]
Scenedesmus arcuatus[3]
Scenedesmus armatus[3]
Scenedesmus bijuga[3]
Scenedesmus denticulatus[3]
Scenedesmus dimorphus[2,3]
Scenedesmus longus[3]
Scenedesmus quadricauda[2,3]
Schroederia setigera[2,3]
Selenastrum minutum[3]
Selenastrum westii[2]
Sorastrum americum[2]
Sphaerocystis schroeteri[3]
Staurastrum cuspidatum[3]
Staurastrum leptocladum[3]
Staurastrum longiradiatum[3]

Table B-1 (Continued)

Staurastrum natator[2]
Staurastrum paradoxum[3]
Synura sp.[2]
Tetraedron caudatum[3]
Tetraedron gracile[3]
Tetraedron minimum[3]
Tetraedron muticum[3]
Tetraedron pentaedricum[3]
Sphaerocystis schroeteri[3]
Staurastrum cuspidatum[3]
Staurastrum leptocladum[3]
Staurastrum longiradiatum[3]
Staurastrum natator[2]
Staurastrum paradoxum[3]
Synura sp.[2]
Tetraedron caudatum[3]
Tetraedron gracile[3]
Tetraedron minimum[3]
Tetraedron muticum[3]
Tetraedron pentaedricum[3]

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[1] Other groups include all other phytoplankton taxa except for Bacillariophyta (Diatoms) and Cyanophyta.

[2] Collected during the September 1977, Dames & Moore Field Survey.

[3] Collected during the January 1978, Dames & Moore Field Survey.

[4] Collected near mouth of Rice Creek, March 1977 (Florida Game and Fresh Water Fish Commission, 1977).

Table B-2

Summary of Phytoplankton Taxa Obtained on
St. Johns River Near Rice Creek
September 1977 and January 1978

Transects	A						B						C						D					
Algal Group	Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other	
Stations[a]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
JANUARY																								
Total Taxa Per Station	17	16	19	18	42	42	16	18	19	17	46	47	16	15	22	25	51	46	15	15	23	25	44	41
Mean/Group	16.5		18.5		42		17		18		46.5		15.5		23.5		48.5		15		24		42.5	
Sum of Means Per Transect			77						81.5						87.5						81.5			
SEPTEMBER																								
Total Taxa Per Station	14	16	6	8	14	10	12	14	6	9	15	11	12	12	24	12	13	11	9	9	5	7	8	14
Mean/Group	15		7		12		13		7.5		13		12		18		12		9		6		11	
Sum of Means Per Transect			34						33.5						42						26			

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[a] 1 = offshore sampling site

2 = onshore sampling site

Table B-3

Mean Numbers of Phytoplankton Taxa Obtained at Offshore Versus Onshore Stations Near Rice Creek, September 1977 and January 1978

	January		September	
	Offshore (Station 1)	Onshore (Station 2)	Offshore (Station 1)	Onshore (Station.2)
Blue-Green	16	16	12	13
Diatoms	21	21	10	9
Other	46	44	13	12
TOTALS	83	81	35	34

Table B-4

Summary of Phytoplankton Densities for September 1977 and January 1978[a]

Transects	A						B						C						D					
Algal Group	Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other		Blue-Greens		Diatoms		Other	
Stations[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
JANUARY																								
Totals/ Station	3.9	2.9	1.2	0.8	0.6	0.7	2.2	0.9	0.8	0.5	0.6	0.4	3.1	3.0	1.1	1.3	0.7	0.8	3.0	4.0	1.0	1.6	0.7	0.7
Totals/Group	6.8		2.0		1.3		3.1		1.3		1.0		6.1		2.4		1.5		7.0		2.6		1.4	
Total/Transect ($\bar{x}$ = 9.2)	10.1						5.4						10.0						11.0					
SEPTEMBER																								
Totals/Station	3.1	16.0	1.3	7.1	2.3	2.0	8.7	10.8	3.9	2.0	2.3	1.1	5.4	6.0	1.3	3.4	1.7	2.6	4.6	9.6	1.0	1.8	0.7	1.9
Totals/Group	19.1		8.4		4.3		19.5		5.9		3.4		11.4		4.7		4.3		14.2		2.8		2.6	
Totals/Transect ($\bar{x}$ = 25.2)	31.8						28.8						20.4						19.6					

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[a] Numbers are cells/liter x 10^6

[b] 1 = offshore sampling site
2 = onshore sampling site

Table B-5

Comparison of Offshore and Onshore Phytoplankton Densities Collected in September 1977 and January 1978[a]

	January		September	
	Offshore (Station #1)	Onshore (Station #2)	Offshore (Station #1)	Onshore (Station #2)
Blue-Green	12.2 (3.1)[b]	10.8 (2.7)	21.8 (5.5)	42.4 (10.6)
Diatoms	4.1 (1.0)	4.2 (1.1)	7.5 (1.9)	14.3 (3.6)
Other	2.6 (0.7)	2.6 (0.7)	7.0 (1.8)	7.6 (1.9)
TOTAL	18.9 (4.8)	17.6 (4.5)	36.3 (9.2)	64.2 (16.1)

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[a] Numbers are cells/liter x 10^6.

[b] Numbers in parentheses are mean number of organisms per station per liter x 10^6.

Table B-6

Phytoplankton Exhibiting Dominance at Specified Transects for September 1977 and January 1978.[a] Numbers Represent the Percentage Composition Within Each Major Group

TRANSECTS	JANUARY				SEPTEMBER			
	A	B	C	D	A	B	C	D
Cyanophyta								
Anacystis cyanae							18	
Lyngbya contorta					16	20		18
Merismopedia tenuissima						17		
Oscillatoria acutissima	53	49	57	53				
Oscillatoria limmetica							29	
Oscillatoria sp.					16			52
Spirulina laxissima	19	18	16	18	26	15		
Bacillariophyta								
Cocconeis sp.								18
Cyclotella meneghiniana							26	47
Melosira italica					31	41		20
Navicula sp.	23	27	27	20				
Nitzschia gracilis	23	41	32	34				
Nitzschia sp.	30		15	15	33	26		
Other Algae								
Ankistrodesmus falcatus						17		20
Chlamydomonas globosa							21	
Hormidium scopulinus					28			17
Scenedesmus quadricauda						26		19
Selenestrum minutum	21		19	20				

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[a] Dominance is defined, for this study, as a species comprising 15 percent or more of the total cells of a major group.

Table B-7

Phytoplankton - Cyanophyta Collected (cells/liter)
From the St. Johns River
Near Palatka, Florida - September 1977

Page 1 of 2

	STATION							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Agmenellum quadriduplicatum	437,500	1,500,000	1,250,000	250,000		250,000	625,000	812,500
Anabaena circinalis	187,500	625,000	125,000					
Anabaena flos-aquae				56,250		500,000	125,000	187,500
Anabaenopsis elenkinii	62,500	562,500	375,000	31,500		125,000	125,000	62,500
Anacystis cyanea	62,500	125,000			125,000	1,875,000		
Arthrospira comontiana		25,000	62,500	18,750	25,000			
Calothrix sp.	62,500	187,500	12,500					
Chroococcus dispersus		275,000						
Chroococcus minor	62,500		937,500	168,750	812,500	187,500		
Cylindrospermum sp.	62,500							
Gloeocapsa				812,500		62,500	187,500	
Gloeotheca linearis	312,500	312,500			25,000			
Gloeotrichia sp.				212,500		62,500		
Lyngbya contorta	437,500	2,625,000	2,250,000	1,625,000	62,500	1,250,000	1,312,500	1,187,500
Merismopedia tenuissima	50,000	1,375,000	1,375,000	2,000,000	62,500		437,500	312,500
Nodularis spumigena	62,500				62,500			
Oscillatoria agardhii				1,062,500	6,250			
Oscillatoria angustissima		125,000	62,500		50,000			

Table B-7 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Oscillatoria limmetica	312,500		1,006,250	100,000	3,187,500	62,500		187,500
Oscillatoria sp.		3,125,000		1,375,000		1,125,000	875,000	6,562,000
Raphidiopsis currata	500,000	500,000	875,000	625,000		125,000	18,750	
Spirulina laxa					187,500			12,500
Spirulina laxissma	500,000	4,375,000	381,500	2,500,000	750,000	375,000	937,500	250,000
Synechoccocus aeruginosus		237,500						
TOTAL	3,112,500	15,975,000	8,712,750	10,837,750	5,356,250	6,000,000	4,643,750	9,574,500
TOTAL TAXA	14	16	12	14	12	12	9	9

Table B-8

Phytoplankton - Diatoms Collected (cells/liter)
From the St. Johns River
Near Palatka, Florida - September 1977

Page 1 of 2

SPECIES	Station A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Amphora sp.					62,500			
Asterionella formosa								
Cocconeis sp.	62,500			312,500			187,500	312,500
Coscinodiscus sp.	250,000		62,500		62,500	18,750		
Cyclotella meneghiniana	62,500	1,125,000	125,000	187,000	375,000	875,000	562,500	750,000
Cymbella lanceolata					62,500			
Diatoma vulgare					62,500			
Fragilaria construens						18,750		
Fragilaria crotonensis			125,000	125,000	25,000	250,000		125,000
Fragilaria pinnata		562,500				125,000		
Gyrosigma sp.		312,500			6,250		6,251	6,250
Mastogloia danseii		187,500	62,500					
Melosira granulata				62,500	131,250	62,500		
Meolsira italica	312,500	2,250,000	2,062,500	375,000	12,500	375,000	62,500	500,000
Navicula sp.	62,500			500,000	125,000	375,000		
Nitzchia bilobata					6,250			
Nitschia gracilis		125,000		250,000	18,750			
Nitzhia longissima					18,750			
Nitzschia sp.	500,000	2,250,000	1,437,500	112,500	18,750	625,000	162,600	106,250

Table B-8 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Opephora martyi					6,250			
Pinnularia lineolata				62,500	12,500	187,500		6,250
Rhizoselinia gracilis					6,250			
Stauroneis sp.					62,500			
Surirella biseriata					62,500			
Surirella fastuosa					62,500			
Synedra berolinensis					31,250			
Synedra ulna					12,500			
Tabellaria fenestrata					6,250	500,000		
Tabellaria flocculosa		312,500			12,500	18,750		
TOTAL	1,250,000	7,125,000	3,875,000	1,987,000	1,262,500	3,431,250	981,351	1,806,250
TOTAL TAXA	6	8	6	9	24	12	5	7

Table B-9

Phytoplankton - Chlorophyta, Chrysophyta and other Groups[1] Collected (cells/liter) from the St. Johns River near Palatka, Florida
September 1977

Page 1 of 2

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Acanthosphaera zachariasi								62,500
Actinastrum hantzschii					62,500			
Ankistrodesmus falcatus	125,000	312,500	562,500	62,500		312,500	260,000	250,000
Characium limneticum	62,500	187,500	62,500	6,250				
Chlamydomonas globosa						875,000		312,500
Chodatella chodati						62,500		
Chodatella longiseta			62,500					
Closterium moniliforme					62,500			
Coelastrum sp.					12,500			
Cosmarium bioculatum			62,500	187,500		312,500	18,750	125,000
Crucigenia irregularis					125,000			
Crucigenia quadrata					250,000			
Cryptomonas ovata	62,500				118,750		62,500	
Desmidium				125,000				
Euglena acus						62,500		187,500
Golenkinia radiata	62,500	125,000		6,250	12,500			
Gonium sociale				43,750				
Hormidium scopulinus	1,000,000	168,750	100,000	131,250		312,500	56,250	375,000
Mallomonas caudata	250,000		62,500					

Table B-9 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Micractinium pusillum			187,500					
Microspora stagnorum					6,250			
Netrium digitus	62,500		12,500					
Pediastrum duplex	250,000				62,500			62,500
Peridinium cinctum			62,500					
Phacus tortus	62,500							
Pleurotaenium ehrenbergii	62,500							
Scenedesmus dimorphus		250,000	250,000	62,500	375,000	62,500	62,500	12,500
Scenedesmus quadricauda	62,500	500,000	437,500	500,000	312,500	250,000	250,000	250,000
Schroederia setigera		187,500	125,000					
Selenastrum westii			125,000	12,500		187,500	12,500	12,500
Sorastrum americum	62,500	62,500	6,250					
Staurastrum natator	62,500	62,500	187,500	6,250				
Synura sp.		62,500						6,250
Tetraedron regulare	62,500							6,250
Testrastrum elegans						62,500		
Testrastrum heterocanthum						62,500		125,000
Testrastrum staurogeniaeforme					125,000		6,250	
Treubaria setigerum					125,000			62,500
TOTAL	2,250,000	1,918,750	2,306,250	1,143,750	1,650,000	2,562,500	728,750	1,850,000
TOTAL TAXA	14	10	15	11	13	11	8	14

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[1] Other groups include all other phytoplankton taxa collected except for the Bacillariophyta (Diatoms) and Cyanophyta (Blue-green Algae).

Table B-10

Phytoplankton - Cyanophyta Collected (cells/liter)
from the St. Johns River near Palatka, Florida
January 1978

Page 1 of 2

	STATION							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Agmenellum quadriduplicatum	6,250	6,250	6,250	6,250	18,750	12,500	6,250	12,500
Anabaena circinalis	12,500	6,250	6,250	6,250	12,500	6,250	6,250	6,250
Anabaena sp.	12,500	6,250	18,750	6,250	6,250	6,250	12,500	18,750
Anabaenopsis elenkinii	6,250	25,000	31,250	6,250	62,500	43,750	31,250	62,500
Aphanotheca nidulans	6,250			6,250		6,250		31,250
Chroococcus dispersus	6,250					6,250	6,250	
Chroococcus limneticus		6,250		12,500	6,250		6,250	
Chroococcus minimus	281,250	293,750	212,500	106,250	156,250	112,500	150,000	206,250
Chroococcus minor	6,250							
Chroococcus minutus				18,750	6,250			
Chroococcus refuscens	6,250	25,000	12,500					
Gloeotheca linearis					6,250			
Gloeotrichia sp.	68,750	36,500	25,000	12,500	93,750	56,250	31,250	100,000
Gomphosphaeria aponica		12,500	6,250	6,250				
Lyngbya contorta			6,250					
Lyngbya limnetica	406,250	112,500	187,500	31,250	168,750	118,750	143,750	206,250
Merismopedia tenuissima	37,500	6,250	31,250	6,250	25,000	6,250	25,000	18,750
Microcystis flos-aquae						31,250	87,500	
Microcystis incerta								50,000
Oscillatoria acutissima	2,056,250	1,525,000	1,175,000	350,000	1,750,000	1,700,000	1,556,250	2,168,750

Table B-10 (Continued)

SPECIES	Station A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Phormidium minnesotense	187,500	212,500	68,750	87,500	156,250	193,750	187,500	162,500
Phormidium tenue				18,750				
Raphidiopsis currata	6,250	18,750	12,500	6,250	18,750			12,500
Spirulina laxa	18,750	87,500	25,000	43,750	150,000	162,500	150,000	287,500
Spirulina laxissma	756,250	506,250	375,000	168,750	431,250	525,000	593,750	637,500
TOTAL	3,881,250	2,886,500	2,200,000	900,000	3,068,750	2,987,500	2,993,750	3,981,250
TOTAL TAXA	17	16	16	18	16	15	15	15

Table B-11

Phytoplankton - Diatoms Collected (cells/liter) from the St. Johns River near Palatka, Florida
January 1978

Page 1 of 2

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Amphora ovalis	6,250		6,250			6,250	6,250	
Chaetoceros muelleri					6,250		6,250	
Cocconeis pediculus	6,250	6,250	6,250	6,250	12,500	6,250	12,500	12,500
Cocconeis placentula		6,250			6,250		6,250	6,250
Coscinodiscus sp.	6,250	6,250	6,250	6,250	12,500	25,000	6,250	6,250
Cyclotella glomerata	6,250							
Cyclotella meneghiniana	6,250	6,250	12,500	12,500	25,000	43,750	18,750	100,000
Cymatopleura solea				6,250				
Cymbella lanceolata	6,250	6,250				6,250		6,250
Cymbella turgidla	6,250							
Epithemia argus							6,250	
Epithemia sp.	6,250	6,250		6,250	6,250	6,250		6,250
Eunotia sp.					6,250	6,250	6,250	6,250
Fragilaria construens	37,500	6,250	12,500	6,250	6,250	6,250	6,250	12,500
Fragilaria crotonensis	6,250	6,250	12,500	6,250	12,500	6,250	6,250	18,750
Fragilaria sp.								6,250
Fragilaria viriscens					6,250			
Gyrosigma sp.	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Melosira ambigua	93,750	137,500	56,250	12,500	125,000	125,000	112,500	250,000
Melosira granulata		12,500	12,500	6,250	6,250	6,250	18,750	6,250

Table B-11 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Melosira italica			6,250					6,250
Navicula rhynccephala					6,250			
Navicula sp.	262,500	206,250	243,750	100,000	237,500	425,000	150,000	368,750
Nitzchia gracilis	262,500	212,500	343,750	181,250	368,750	425,000	418,750	456,250
Nitzschia palea	6,250	6,250	6,250	6,250				
Nitzschia reversa			6,250		6,250	6,250	6,250	6,250
Nitzschia seriata						6,250		6,250
Nitzschia sp.	500,000	112,500	25,000	118,750	231,250	143,750	150,000	225,000
Opephora martyi			6,250					
Pinnularia sp.				6,250		6,250	6,250	6,250
Pleurosigma sp.						6,250		
Surirella bohemica	6,250							
Surirella minuta	6,250	6,250	6,250			6,250	6,250	12,500
Surirella robusta						6,250		6,250
Surirella sp.					6,250			
Surirella tenera					6,250	6,250	6,250	6,250
Synedra sp.						31,250	37,500	
Synedra ulna		6,250	6,250	6,250	6,250	6,250	6,250	12,500
Trobidoneis sp.	6,250	6,250	6,250	6,250	6,250	6,250	6,250	12,500
TOTAL	1,243,750	762,500	787,500	500,000	1,112,500	1,331,250	1,012,500	1,568,750
TOTAL TAXA	19	18	19	17	22	25	23	25

Table B-12

Phytoplankton - Chlorophyta, Chrysophyta and Other Groups[1] Collected (cells/liter) from the St. Johns River near Palatka, Florida
January 1978

Page 1 of 4

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Actinastrum gracillium	12,500	6,250	12,500	6,250	12,500	6,250	6,250	12,500
Actinastrum hantzschii	6,250	6,250	12,500	6,250	6,250	6,250	6,250	25,000
Ankistrodesmus convolutus	6,250	37,500	18,750	12,500	31,250	50,000	12,500	56,250
Ankistrodesmus falcatus	25,000	12,500	31,250	6,250	31,250	37,250	18,750	31,250
Asterococcus limneticus							6,250	
Carteria klebsii	6,250		6,250	6,250	6,250	6,250	6,250	12,500
Characium limneticum			6,250	6,250		6,250		
Chlamydomonas sp.		6,250			6,250	6,250	12,500	12,500
Chlorella vulgaris	6,250	6,250	6,250	6,250	6,250	6,250		
Chlorogonium elongatum	6,250	6,250	6,250	6,250	25,000	12,500	18,750	12,500
Chodatella citriformas					6,250			
Chodatella droescheri	12,500	18,750	6,250	12,500	6,250		6,250	18,750
Chodatella quadriseta		6,250			6,250	37,500		
Chodatella subsala		6,250		6,250	12,500	6,250	6,250	
Chodatella wratislawiensis	6,250		6,250	6,250		6,250		6,250
Closteriopsis longissima	6,250	6,250	6,250	6,250	6,250		12,500	6,250
Closteriopsis sp.					6,250			
Coelastrum sphaericum	6,250	12,500	6,250	6,250	12,500	6,250	12,500	6,250
Cosmarium polygonum	6,250	6,250	12,500	6,250	6,250	6,250	12,500	12,500

Table B-12 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Cosmarium sp.	6,250							
Crucigenia quadrata	6,250							
Crucigenia tetrapedia				6,250	6,250	6,250		6,250
Cryptomonas ovata	6,250	12,500	6,250	6,250	6,250	6,250	6,250	6,250
Dictyospharium ehrenberianum		6,250		6,250	6,250	6,250		6,250
Dictyospharium pulchellum					6,250		6,250	6,250
Euastrum pulchellum						12,500	6,250	
Euglena sp.				6,250	6,250	6,250	6,250	6,250
Glenodinium sp.	6.250	6,250	6,250	6,250	6,250		6,250	6,250
Golenkinia paucispina		6,250			6,250			
Golenkinia radiata	12,500	6,250	6,250	6,250	18,750	18,750	25,000	6,250
Kirchneriella obesa	6,250	6,250	12,500	6,250	6,250	12,500	18,750	18,750
Micractinium pusillum		6,250	6,250	6,250	6,250		6,250	
Oocystis borgei	6,250	6,250	6,250		6,250	6,250	12,500	6,250
Oocystis elliptica			6,250					
Oocystis parra		6,250		6,250		6,250	6,250	
Oocystis pusilla					6,250			
Oocystis sp.					6,250			
Pediastrum boryanum	6,250		6,250					
Pediastrum duplex (4 varieties)	6,250	12,500	6,250	6,250	6,250	12,500	6,250	12,500
Pediastrum simplex	6,250	6,250			6,250		6,250	6,250
Pediastrum tetras var. tetraedron	6,250			6,250				
Phacus pyram	6,250	18,750	6,250	6,250	6,250	6,250	6,250	6,250

Table B-12 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Phacus sp.			43,750					
Pleodorina illinoisensis						6,250		
Quadrigula lacustris	6,250	6,250	6,250	6,250	6,250		6,250	
Scenedesmus abundans	6,250	6,250	6,250	6,250	12,500	6,250		6,250
Scenedesmus accuminatus					6,250	6,250		6,250
Scenedesmus arcuatus			6,250	6,250	6,250	6,250	6,250	6,250
Scenedesmus armatus			6,250	6,250		6,250		
Scenedesmus bijuga	6,250	6,250	6,250	6,250			12,500	6,250
Scenedesmus denticulatus			6,250		6,250	6,250	6,250	6,250
Scenedesmus dimorphus	12,500	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Scenedesmus longus	6,250				6,250			
Scenedesmus quadricauda	75,000	37,500	62,500	18,750	62,500	112,500	50,000	81,250
Schroederia setigera	75,000	31,000	12,500	25,000	50,000	31,000	56,250	25,000
Selenastrum minutum	112,500	156,250	100,000	37,500	106,250	168,750	175,000	125,000
Sphaerocystis schroeteri			6,250	6,250			6,250	
Staurastrum cuspidatum	6,250	6,250	6,250	6.,50	6,250	6,250	6,250	6,250
Staurastrum leptocladum		6,250	6,250	6,250	6,250	6,250	6,250	6,250
Staurastrum longiradiatum						6,250		
Staurastrum paradoxum	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Tetraedron caudatum	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Tetraedron gracile	6,250							
Tetraedron minimum	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Tetraedron muticum		6,250		6,250				

Table B-12 (Continued)

	Station							
SPECIES	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Tetraedron pentaedricum						6,250		
Tetraedron regulare		6,250						
Tetraedron trigonum	6,250		6,250	6,250		6,250	6,250	
Testrastrum elegans	12,500		6,250	6,250	12,500	6,250		6,250
Testrastrum staurogeniaeforme	37,500	25,000	25,000	12,500	18,750	31,250	37,500	62,500
Treubaria triappendiculata	6,250		6,250				81,250	68,750
Ulothrix sp.		150,000	68,750	6,250	18,750	43,750	6,250	
Westella botryoides	6,250	6,250	6,250	6,250	6,250			
TOTAL	587,500	712,250	625,000	375,000	656,250	787,000	743,750	743,750
TOTAL TAXA	42	42	46	47	51	46	44	41

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[1] Other groups include all other Phytoplankton taxa collected except Bacillariophyta (Diatoms) and Cyanophyta (Blue-green Algae).

Table B-13

Species Diversity (in bits) of Phytoplankton in the St. Johns River near Palatka, Florida

	Sample Date	
Station	September 1977	January 1978
A1	5.5	5.0
A2	5.8	5.4
B1	5.0	5.6
B2	6.1	6.2
C1	5.9	5.6
C2	5.8	5.6
D1	3.8	5.6
D2	4.5	5.6
Mean for all stations	5.3	5.6

Table B-14

List of Aquatic Plants
Associated with the St. Johns River Basin
(U.S. Army Corps of Engineers, 1973)

<u>Floating</u>

Water hyacinth	<u>Eichhornia crassipes</u>
Water lettuce	<u>Pistia stratiotes</u>
Frogbit	<u>Limnobium spongia</u>
Water pennywort	<u>Hydrocotyle umbellata</u>
Giant duckweed	<u>Spirodela polyrhiza</u>
common duckweed	<u>Lemna minor</u>
Watermeal	<u>Wolffia columbiana</u>
Wolffiella	<u>Wolffiella floridana</u>
Azolla	<u>Azolla caroliniana</u>
Salvinia	<u>Salvinia rotundiafolia</u>
Alligatorweed	<u>Alternanthera philoxeroides</u>
Water paspalum	<u>Paspalum fluitans</u>
Paragrass	<u>Panicum purpurascens</u>
Pithophora	<u>Pithophora</u> spp..

<u>Emersed and Marginal</u>

Maidancane	<u>Panicum hemitomon</u>
Torpedograss	<u>Panicum repens</u>
Sawgrass	<u>Cladium jamaicaensis</u>
Giant cutgrass	<u>Zizaniopsis miliacea</u>
Giant foxtail	<u>Setaria magna</u>
Giant reed	<u>Phragmites communis</u>
Southern watergrass	<u>Hydrochloa carolinensis</u>
Spatterdock	<u>Nuphar leuteum</u> (cadvena)
Fragrant waterlily	<u>Nymphaea odorata</u>
American lotus	<u>Nelumbo lutea</u>

Table B-14 (continued)

Emersed and Marginal (continued)

Watershield	*Brasenia schreberi*
Pickerelweed	*Pontederia lanceolata*
Arrowhead	*Sagitaria graminea*
Cattail	*Typha latifolia*
Softstem bulrush	*Scirpus validus*
Soft rush	*Juncus effusus*
Slender spikerush	*Eleocharis acicularis*
Primrose willow	*Ludwigia penuviana*
Water primrose	*Ludwigia michauxiana*

Submersed

Hydrilla	*Hydrilla verticillata*
Egeria	*Egeria densa*
Widgeongrass	*Ruppia maritima*
Common bladderwort	*Utricularia vulgaris*
Vallisneria (water celery)	*Vallisneria americana*
Cabomba	*Cabomba caroliniana*
Coontail	*Ceratophyllum demersum*
Illinois pondweed	*Potamogeton illinoensis*
Marine naiad	*Najas marina*
Southern naiad (common water nymph)	*Najas guadalupensis*
Parrot feather	*Myriophyllum brasiliense*
Broadleaf waermilfoil	*Myriophyllum heterophyllum*
Eurasian watermilfoil	*Myriophyllum spicatum*
Chara (Stonewort)	*Chara* sp.

Table B-15

Aquatic Macrophytes Identified from the St. Johns River in the Study Area

SCIENTIFIC NAME	COMMON NAME	TRANSECT
Vallisneria americana	Water Celery	C, D
Najas guadalupensis	Common Water Nymph	C, D
Chara sp.	Stonewort	C, D
Nuphar luteum	Spatterdock	D

Table B-16

Zooplankton Taxa Present (X) in Surface Samples from the St. Johns River
June and September 1977 and January 1978[a]

TAXA	June 1977	September 1977	January 1978
ROTIFERA			
Asplanchna sp.	X		X
Brachionus angularis		X	X
Brachionus calylciflorus	X		
Brachionus capsuliforus		X	X
Brachionus caudatus		X	
Brachionus dimidiatus		X	X
Brachionus havanaensis		X	
Brachionus plicatilis	X		
Conochiloides sp.		X	X
Conochilus sp.		X	X
Esphora sp.			X
Filinia sp.		X	
Hexarthra sp.		X	
Kellicotia longispina			X
Keratella sp.		X	X
Lecane sp.			X
Lepadella sp.		X	
Monostyla sp.			X
Notholca acuminata			X
Notholca striata		X	X
Platyias sp.		X	
Polyarthra sp.		X	X
Trichocerca sp.		X	
Unidentified sp.		X	X
Unidentified Bdelloidae			X
Total Rotifera	3	16	16
CLADOCERA			
Alona sp.	X		X
Bosmina longirostois	X		
Daphnia ambigua	X		
Diaphanosoma brachurum	X		
Unidentified sp.		X	
Total Cladocera	4	1	1

Table B-16 (continued)

TAXA	June 1977	September 1977	January 1978
OSTRACODA			
Unidentified sp.	X	X	
Total Ostracoda	1	1	
COPEPODA			
Unidentified Cyclopoid	X		X
Diaptomous dorsalis	X		
Eucyclops sp.		X	X
Paracyclops sp.		X	X
Nauplii (larval copepods)[b]		X	X
Total Copepoda	2	3	4
Total (All Taxa)	10	21	21

---

[a] The June 1977 data were collected at Station 30, (St. Johns River at entrance of Rice Creek) by personnel from Florida Game and Freshwater Fish commission. The data from September 1977 and January 1978 were collected by Dames & Moore.

[b] The nauplii (larval copepods) were not included as a separate taxon in the subtotals.

Table B-17

Comparison of Zooplankton Densities on the St. Johns River Near Palatka and Rice Creek for Various Sampling Periods of 1975, 1977, and 1978[a]

Sampling Period	Jan (1978)[b]	Feb (1975)[c]	May (1975)[c]	June (1977)[d]	Aug (1975)[c]	Sept (1978)[b]	Nov (1975)[c]
Rotifers	217 (75)	8 (2)	11 (3)	1 (14)	206 (52)	870 (83)	23 (31)
Cladocera	1 (0.3)	35 (9)	216 (63)	5 (71)	2 (0.5)	1 (0.1)	1 (1)
Copepods	8 (3)	44 (11)	18 (5)	1 (14)	22 (6)	26 (2)	5 (7)
Nauplii	63 (22)	314 (78)	97 (28)	0	170 (43)	146 (14)	45 (61)

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[a] Numbers are organisms per liter, rounded to nearest whole number. Numbers in parentheses are percentage composition of that taxon of all zooplankton collected for a specific sampling period.

[b] From data provided from Dames & Moore site collections.

[c] From data provided by Applied Biology, Inc. (1976).

[d] From data provided by FG&FWFC (1977).

Table B-18

Quantitative Comparison (Number of Organisms/Liter, Diversity Indices and Equitability) of Zooplankton Between Transects and Stations, September 1977

Transect	A		B		C		D	
Taxa / Station	1	2	1	2	1	2	1	2
Rotifera								
Brachionus angularis	3.1		20.4	10.2	25.5		20.4	20.4
Brachionus capsuliforus		10.2			17.8	7.7	71.5	10.2
Brachionus caudatus	352.4	81.7	418.8	194.1	137.9	286.0		71.5
Brachionus dimidiatus		20.4						
Brachionus havanaensis	326.4	143.0	275.8	194.1	309.0	68.9	878.6	633.4
Conochiloides sp.	61.0	30.6		30.6				20.4
Conochilus sp.				40.8				
Filinia sp.	6.5	10.2			10.2			
Hexarthra sp.							10.2	
Keratella sp.	199.2	91.9	132.8	102.1	217.0	76.6	234.9	183.9
Lepadella sp.							20.4	30.6
Notholca striata		20.4		1.5	7.6			
Platyias sp.		10.2						
Polyarthra sp.	61.3	20.4		20.4	61.3		40.9	10.2
Trichocerca sp	122.5	81.7	51.0	81.7	45.9	30.6	81.7	30.6
Unidentified sp.	15.3	20.4	10.2	20.4			20.4	10.4
Total Rotifera	1147.7	541.1	909.0	659.9	832.2	469.8	1379.0	1021.4
Cladocera								
Unidentified sp.								2.1
Total Cladocera	0	0	0	0	0	0	0	2.1

Table B-18 (Continued)

Transect	A		B		C		D	
<u>Taxa</u> Station	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>
Copepoda								
nauplius (larval copepod)	76.6	10.2	296.2	81.7	148.1	38.3	347.3	173.7
<u>Eucyclops</u> sp.	30.6				7.6			10.2
<u>Paracyclops</u> sp.	76.6		10.2		11.7	7.7	61.3	
Total Copepoda	183.8	10.2	306.4	81.7	167.4	46.0	408.6	183.9
Others								
Ostracoda		5.5	10.2			7.7		
Total	1331.5	556.8	1225.6	777.6	999.6	523.5	1787.6	1207.4
Total Taxa by station	12	14	9	11	12	8	11	13
Total Taxa by transect	17		13		13		15	
Species diversity ($\bar{d}$)	2.87	3.16	2.31	2.84	2.74	2.05	2.29	2.26
Equitability (e)	0.80	0.83	0.73	0.82	0.76	0.68	0.66	0.61

Table B-19

Quantitative Comparison (Number of Organisms/Liter, Diversity Indices and Equitability) of Zooplankton Between Transects and Stations, January 1978

Transect	A		B		C		D	
Taxa / Station	1	2	1	2	1	2	1	2
Rotifera								
Asplanchna sp.	28.8	45.6	419.0	309.6	118.1	201.9	211.7	133.9
Brachionus angularis	4.8	1.2	1.4			3.7	1.4	
Brachionus capsulforis	2.4			2.9	1.4	3.7	2.9	1.4
Brachionus dimidiatus	9.6	1.2	30.2	11.5	5.8	7.5	10.1	
Conochiloides sp.	1.2	1.2			1.4			1.4
Conochilus sp.	4.8	1.2					1.4	1.4
Esphora sp.			4.3					
Kellicotia longispina	6.0							
Keratella sp.	4.8	2.4	11.5		1.4	7.5	7.2	7.2
Lecane sp.		2.4		1.4	1.4	3.7	2.9	1.4
Monostyla sp.							1.4	1.4
Notholca acuminata		3.6	8.6	7.2	5.8	3.7	10.1	10.1
Notholca striata	1.2					7.5		10.4
Polyarthra sp.	3.6		1.4	1.4	1.4		2.9	2.9
Unidentified Bdelloidae	2.4							
Unidentified sp.						3.7		
Total Rotifera	69.6	58.8	476.4	334.0	136.7	242.9	252.0	171.5
Cladocera								
Alona								2.9
Total Cladocera	0	0	0	0	0	0	0	2.9

Table B-19 (Continued)

Taxa	Transect	A		B		C		D	
	Station	1	2	1	2	1	2	1	2
Copepoda									
Eucyclops sp.				1.4		1.4	3.7	1.4	5.8
Paracyclops sp.				2.9	4.3	2.9	22.4	8.6	5.8
Unidentified cyclopoid									1.4
nauplius (larval copepod)		36.0	44.4	48.9	18.7	49.8	115.9	67.7	122.0
Total Copepoda		36.0	44.4	53.2	23.0	54.1	142.0	77.7	135.0
Total		105.6	103.2	529.6	357.0	190.8	384.9	329.7	309.4
Total Taxa by Station		12	9	10	8	11	12	13	15
Total Taxa by Transect		14		12		14		17	
Species Diversity ($\bar{d}$)		2.76	1.76	1.20	0.87	1.64	1.97	1.76	1.94
Equitability (e)		0.77	0.56	0.36	0.29	0.47	0.55	0.47	0.50

Table B-20

Summary of Zooplankton Densities for September 1977 and January 1978[a]

Transects	A								B							
Major Group	Rotifers		Cladocera		Copepod / Nauplii		Ostracod		Rotifers		Cladocera		Copepod / Nauplii		Ostracod	
Stations[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
JANUARY																
Totals/Station	70	59	0	0	$\frac{36}{0}$	$\frac{44}{0}$	0	0	476	334	0	0	$\frac{53}{4}$	$\frac{23}{4}$	0	0
Totals/Group	129		0		$\frac{80}{0}$		0		810		0		$\frac{76}{8}$		0	
Totals/Transect ($\bar{x}$ = 570)	209								894							
SEPTEMBER																
Totals/Station	1148	541	0	0	$\frac{184}{107}$	$\frac{10}{0}$	0	6	908	660	0	0	$\frac{306}{10}$	$\frac{82}{0}$	10	0
Totals/Group	1689		0		$\frac{194}{107}$		6		1568		0		$\frac{388}{10}$		10	
Totals/Transect ($\bar{x}$ = 2093)	1996								1976							

Table B-20 (Continued)

Transects	C								D							
Major Group	Rotifers		Cladocera		$\frac{\text{Copepod}}{\text{Nauplii}}$		Ostracod		Rotifers		Cladocera		$\frac{\text{Copepod}}{\text{Nauplii}}$		Ostracod	
Stations[b]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
JANUARY																
Totals/Station	137	243	0	0	$\frac{54}{4}$	$\frac{142}{26}$	0	0	252	172	0	3	$\frac{78}{10}$	$\frac{135}{13}$	0	0
Totals/Group	380		0		$\frac{196}{30}$		0		424		3		$\frac{213}{23}$		0	
Totals/Transect ($\bar{x}$ = 570)	606								663							
SEPTEMBER																
Totals/Station	832	470	0	0	$\frac{167}{19}$	$\frac{46}{8}$	0	8	1379	1021	0	2	$\frac{409}{61}$	$\frac{184}{10}$	0	0
Totals/Group	1302		0		$\frac{213}{27}$		8		2400		2		$\frac{593}{71}$		0	
Totals/Transect ($\bar{x}$ = 2093)	1550								3066							

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[a] Numbers are organisms per liter, rounded to nearest whole number.

[b] 1 = offshore sampling station.
2 = nearshore sampling station.

Table B-21

Comparison of Total Offshore and Total Nearshore Zooplankton Collected in September 1977 and January 1978, by Major Group[a]

	JANUARY		SEPTEMBER	
	Offshore	Nearshore	Offshore	Nearshore
Rotifers	935 (234)[b]	808 (202)	4267 (1067)	2692 (673)
Cladocera	0	3 (1)	0	2 (1)
Copepod	221 (55)	344 (86)	1066 (267)	322 (81)
Nauplii	18 (5)	43 (11)	197 (49)	18 (5)
Ostracods	0	0	10 (3)	14 (4)
TOTALS	1174 (294)	1195 (300)	5540 (1386)	3048 (764)

---

[a] Numbers are organisms per liter, rounded to nearest whole number.

[b] Numbers in parentheses are mean number of organisms per liter per station.

Table B-22

Comparison of Total Offshore and Total Inshore Zooplankton Collected in September 1977 and January 1978, by Transect[a]

Seasons	Transects A	B	C	D
January				
Offshore	106	533	195	340
Nearshore	103	361	411	323
Mean	105	447	303	332
September				
Offshore	1439	1234	1018	1849
Nearshore	577	742	532	1217
Mean	1008	988	775	1533

---

[a] Numbers are organisms per liter, rounded to nearest whole number.

Table B-23

Benthic Macroinvertebrates Collected(X) in the St. Johns River[1]

TAXA	April 1974	September 1977	January 1978
Arthropoda			
Insecta			
Ephemeroptera			
Baetidae			
Caenis sp.		X	X
Trichoptera			
Psychomyiidae			
Cyrnellus sp.			X
Diptera		X	
Ceratopogonidae			
Chironomidae			
Ablabesmyia parajanta		X	X
Chironomus anthracinus		X	X
Chironomus sp.		X	X
Cladotanytarsus sp.		X	X
Coelotanypus concinnus		X	X
Coelotanypus tricolor		X	X
Cryptochironomus fulvus		X	
Dicrotendipes nervosus			X
Dicrotendipes lobus			X
Glyptotendipes sp.	X	X	X
Procladius sp.	X	X	X
Polypedilum braseniae		X	
Polypedilum sp.	X		X
Rheotanytarsus sp		X	
Stenochironomus sp			X
Tanytarsus sp. 1		X	
Tanytarsus sp. 2		X	X
Xenochironomus xenolabis			X
Crustacea			
Amphipoda			
Gammaridae			
Gammarus sp.	X	X	X
Talitridae			
Hyalella azteca			X
Corophiidae			
Corophium sp.		X	X

Table B-23 (Continued)

TAXA	April 1974	September 1977	January 1978
Isopoda			
Anthuridae			
Cyanthura polita		X	X
Sphaeromatidae			
Cassidinidea lunifrons		X	X
Sphaeroma destructor			X
Mysidacea			
Mysidae			
Mysidopsis bigelowi		X	X
Decapoda			
Xanthidae			
Unidentified sp.		X	
Annelida			
Oligochaeta			
Lumbriculidae			
Unidentified sp.	X	X	X
Naididae			
Pristina sp.			X
Unidentified sp.			X
Tubificidae			
Immature without hair setae 1		X	X
Immature with hair setae 2		X	X
Limnodrilis hoffmeisteri		X	X
Limnodrilus spp.		X	X
Potamothrix vejdovskyi		X	X
Unidentified sp. (hair setae)		X	X
Mollusca			
Gastropoda			
Pomatiopsis sp.		X	
Bythiniidae			
Unidentified sp.			X
Bivalvia			
Pisidium sp.	X		
Unidentified sp.			X

Table B-23 (Continued)

TAXA	April 1974	September 1977	January 1978
Nematoda			X
Bryozoa			X

---

[1] Collections were made at the confluence of Rice Creek by personnel from Florida Department of Environmental Regulation during April 1974; and by Dames & Moore at all collecting stations on the St. Johns River during September 1977 and January 1978.

Table B-24

Incidental Macroinvertebrates Collected Onsite During Other Sampling Programs (Actual Numbers)

	TRANSECTS			
	A	B	C	D
Total Macroinvertebrates Collected During September 1977 and January 1978 Nekton Sampling (all gears)				
Blue Crab	5	6	4	3
Grass Shrimp	0	0	14	12
Total Macroinvertebrates Colleted During Seining Collections, March 24, 1978				
Blue Crab	0	0	4	2
Unidentified Crab	0	0	0	1
Grass shrimp	0	1	102	177
Totals For All Nekton Collections				
Blue Crab	5	6	8	5
Unidentified Crab	0	0	0	1
Grass Shrimp	0	1	116	189

Table B-25

Quantitative Comparison (Numbers Per Square Meter, Diversity Indices and Equitability) of Benthic Macroinvertebrates, September 1977

		Transect A		Transect B		Transect C		Transect D	
TAXA	Stations	1	2	1	2	1	2	1	2
Arthropoda									
Insecta									
Ephemeropters[a]									
Baetidae									
Caenis sp.			14						
Diptera									
Ceratopogonidae									158
Chironomidae									
Ablabesmyia parajanta			72						
Chironomus sp.			201				1901		
Cladotanytarus sp.					86		186		
Coelotanypus concinnus				14				57	14
Coelotanypus tricolor		72	14			86	100		
Cryptochironomus fulvus					129				
Glypototendipes sp.			29		29		115		
Procladius sp.					143		57		129
Polypedilum braseniae			14						57
Rheotanytarsus sp.					14		14		14
Tanytarsus sp. 1			14	14			29	14	14
Tanytarsus sp. 2									14
Crustacea									
Amphioda									
Gammaridae									
Gammarus sp.			445	14					
Corophiidae									
Corophium sp			57						

Table B-25 (Continued)

TAXA Stations	Transect A 1	Transect A 2	Transect B 1	Transect B 2	Transect C 1	Transect C 2	Transect D 1	Transect D 2
Isopoda								
Anthuridae								
Cyanthura polita		29				72		158
Sphaeromatidae								
Cassidinidea lunfrons								14
Mysidacea								
Mysidae								
Mysidopsis bigelowi	14					14		14
Decapoda								
Xanthidae								
Unidentified sp.								57
Annelida								
Oligochaeta								
Lumbriculidae								
Unidentified sp.			14	14				316
Tubificidae								
1- Immature without hair setae		186	29	129		316		301
2- Immature with hair setae						14		
Limnodrilis hoffmeisteri		57			115	143	43	115
Limnodrilus spp.		244	43	201	100	129	43	186
Potamothrix vejdovskyi		72		14			29	
Unidentified sp. (hair setae)		29						
Mollusca								
Gastropoda								
Bythiniidae								
Unidentified sp.	43		144	14	201	129	359	43

Table B-25 (Continued)

	Transect A		Transect B		Transect C		Transect D	
TAXA Stations	1	2	1	2	1	2	1	2
Total number of organisms/M^2	129	1477	272	773	502	3219	545	1604
Average density for transect	803		522		1861		1075	
Total taxa for station	3	15	7	10	4	14	6	16
Total taxa for transect	17		13		14		17	
Diversity (d)	1.35	3.09	2.13	2.77	1.91	2.77	1.68	3.24
Equitability (e)	0.85	0.79	0.76	0.83	0.96	0.73	0.65	0.79

Table B-26

Quantitative Comparison (Numbers Per Square Meter, Diversity Indices and Equitability) of Benthic Macroinvertebrates, January, 1978

	Transect A		Transect B		Transect C		Transect D	
TAXA Stations	1	2	1	2	1	2	1	2
Arthropoda								
Insecta								
Ephemeroptera								
Baetidae								
Caenis sp.		29		29				
Trichoptera								
Psychomyiidae								
Cyrnellus sp.				14				
Diptera								
Chironomidae								
Ablabesmyia parajanta				86				
Chironomus anthracinius type		14						
Chironomus sp.		14		14				
Cladotanytarsus sp.		158						
Coelotanypus concinnus	43		29		14	14	29	
Coelotanypus tricolor	273	14	890		488	474	158	
Dicrotendipes nervosus		115		201				
Dicrotendipes lobus		14						
Glypotendipes sp.		29						
Procladius sp.	86	158	215	29	72	172	14	14
Polydepilum sp.		14						
Stenochironomus sp.		72						
Tanytarsus sp.	14	43		29	57			
Xenochironomus xenolabis		57						

Table B-26 (Continued)

	Transect A		Transect B		Transect C		Transect D	
TAXA Stations	1	2	1	2	1	2	1	2
Crustacea								
Amphipoda								
Gammaridae								
Gammarus spp.		72	72	14	545	100		14
Talitridae								
Hyalella azteca			14	14	316	14		29
Corphiidae								
Corophium sp.		14		431	14			
Isopoda								
Anthuridae								
Cyanthura polita	29	416		29		14		129
Sphaeromatidae								
Cassidinidea lunifrons		14						
Sphaeroma destructor				43				
Mysidacea								
Mysidopsis bigelowi	14	14						14
Annelidae								
Oligochaeta								
Lumbriculidae								
Unidentified sp.		144						
Niadidae								
Pristina sp.				14				
Unidentified spp.		58		287				
Tubificidae								
1- Immature without hair setae	57		57		14	158	29	398
2- Immature with hair setae		14	86	14	14			

Table B-26 (Continued)

	Transect A		Transect B		Transect C		Transect D	
TAXA Stations	1	2	1	2	1	2	1	2
Limnodrilus hoffmeisteri	115		158		115	287	158	455
Limnodrilus spp.	14				72	129	14	293
Potamothrix vejdovskyi		86						43
Mollusca								
Gastropoda								
Bythiniidae								
Unidentified sp.	14				144	43	330	14
Bivalvia								
Unidentified sp.	14		14		57			
Nematoda		14			273	14		
Bryozoa				14				
Pisces (Goby)	14			14				
Total number or organisms,M^2	687	1577	1535	1276	2195	1419	732	1403
Average density for transect	1132		1405		1807		1067	
Total taxa for station	12	23	9	17	14	11	7	10
Total taxa for transect	30		22		15		12	
Diversity ($\bar{d}$)	2.67	3.75	2.04	2.93	3.02	2.72	2.06	2.37
Equitability (e)	0.77	0.82	0.64	0.72	0.79	0.78	0.73	0.71

Table B-27

Fishes of the St. Johns River System

Information based on McLane (1955) using nomenclature of Bailey et al. (1970) except as noted.

Abundance is a subjective evaluation based primarily on McLane (1955); A = Abundant, C = Common, NC = Not common, and R = Rare.

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Sea lamprey	*Petromyzon marinus*	R
Scalloped hammerhead[1]	*Sphyrna lewini*	R
Southern stingray[1]	*Dasyatis americana*	NC
Atlantic stingray	*Dasyatis sabina*	A
Whip stringray[2]	*Dasyatis hastata*	R
Shortnose sturgeon	*Acipenser brevirostrum*	R
Atlantic sturgeon	*Acipenser oxyrhynchus*	R
Longnose gar	*Lepisosteus osseus*	NC
Shortnose gar[3]	*Lepisosteus platostomus*	R
Florida gar	*Lepisosteus platyrhincus*	C
Bowfin	*Amia calva*	NC
Ladyfish	*Elops saurus*	NC
Tarpon	*Megalops altantica*	NC
American eel	*Anguilla rostrata*	A
Speckled worm eel[4]	*Myrophis punctatus*	R
Blueback herring	*Alosa aestivalis*	C
Hickory shad	*Alosa mediocris*	NC
American shad	*Alosa sapidissima*	A
Yellowfin menhaden	*Brevoortia smithi*	C
Atlantic menhaden[1]	*Brevoortia tyrannus*	R
Gizzard shad	*Dorosoma cepedianum*	A

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[1] Reported by Tagatz (1968).

[2] Nomenclature and classification from McLane (1955).

[3] Reported by Florida Game and Fresh Water Fish Commission (1977).

[4] Reported by Applied Biology, Inc. (1976).

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Threadfin shad	*Dorosoma petenense*	C
Scaled sardine[1]	*Harengula pensacolae*	R
Atlantic thread herring[1]	*Opisthonema oglinum*	R
Striped anchovy	*Anchoa hepsetus*	R
Bay anchovy	*Anchoa mitchilli*	A
Eastern mudminnow[1]	*Umbra pygmaea*	R
Redfin pickerel	*Esox americanus*	R
Chain pickerel	*Esox niger*	R
Inshore lizardfish[1]	*Synodus foetens*	R
Redeye chub	*Hybopsis harperi*	R
Golden shiner	*Notemigonus crysoleucas*	A
Ironcolor shiner	*Notropis chalybaeus*	NC
Dusky shiner	*Notropis cummingsae*	R
Pugnose minnow	*Notropis emiliae*	A
Sailfin shiner	*Notropis hypselopterus*	R
Taillight shiner	*Notropis maculatus*	A
Coastal shiner	*Notropis petersoni*	A
Bluenose shiner[1]	*Notropis welaka*	R
Lake chubsucker	*Erimyzon sucetta*	C
Snail bullhead[1]	*Ictalurus brunneus*	NC
White catfish	*Ictalurus catus*	A
Yellow bullhead	*Ictalurus natalis*	NC
Brown bullhead	*Ictalurus nebulosus*	C
Channel catfish	*Ictalurus punctatus*	A
Tadpole madtom	*Noturus gyrinus*	NC
Speckled madtom	*Noturus leptacanthus*	R
Sea catfish	*Arius felis*	A
Gafftopsail catfish	*Bagre marinus*	R
Pirate perch	*Aphredoderus sayanus*	R
Oyster toadfish	*Opsanus tau*	R

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Skilletfish[1]	Gobiesox strumosus	R
Shortnose batfish[1]	Ogcocephalus nasutus	R
Southern hake[1]	Urophycis floridanus	R
Spotted hake[1]	Urophycis regius	R
Crested cusk-eel[1]	Ophidion welshi	R
Atlantic needlefish	Strongylara marina	A
Lake Eustis minnow	Cyprinodon hubbsi	R
Sheepshead minnow	Cyprinodon variegatus	R
Golden topminnow	Fundulus chrysotus	R
Banded topminnow	Fundulus cingulatus	R
Marsh killifish	Fundulus confluentus	R
Gulf killifish[4]	Fundulus grandis	R
Mummichog	Fundulus heteroclitus	A
Striped killifish	Fundulus majalis	A
Starhead topminnow	Fundulus notti	C
Seminole killifish	Fundulus seminolis	A
Longnose killifish[1]	Fundulus similis	R
Flagfish	Jordanella floridae	R
Pygmy killifish	Leptolucania ommata	R
Bluefin killifish	Lucania goodei	C
Rainwater killifish	Lucania parva	NC
Mosquitofish	Gamfusia affinis	C
Least killifish	Heterandria formosa	NC
Sailfin molly	Poecilia latipinna	C
Brook silverside	Labidesthes sicculus	C
Rough silverside	Membras martinica	R
Tidewater silverside	Menidia beryllina	A
Atlantic silverside	Menidia menidia	R
Opossum pipefish	Oostethus lineatus	R
Northern pipefish[1]	Syngnathus fuscus	R

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Chain pipefish	*Syngnathus louisianae*	R
Gulf pipefish	*Syngnathus scovelli*	C
Snook	*Centropomus undecimalis*	C
Striped bass	*Morone saxatilis*	C
Rock sea bass[1]	*Centropristis philadephica*	R
Black sea bass[1]	*Centropristis striata*	R
Gag[1]	*Mycteroperca microlepis*	R
Mud sunfish	*Acantharchus pomotis*	R
Flier	*Centrarchus macropterus*	R
Everglades pygmy sunfish	*Elassoma evergladei*	R
Okefenokee pygmy sunfish[1]	*Elassoma okefenokee*	R
Banded pygmy sunfish	*Elassoma zonatum*	R
Blackbanded sunfish	*Enneacanthus chaetodon*	R
Bluespotted sunfish	*Enneacanthus gloriosus*	C
Banded sunfish	*Enneacanthus obesus*	NC
Redbreast sunfish	*Lepomis auritus*	A
Warmouth	*Lepomis gulosus*	C
Bluegill	*Leopmis macrochirus*	A
Dollar sunfish	*Lepomis marginatus*	R
Redear sunfish	*Lepomis microlophus*	A
Spotted sunfish	*Lepomis punctatus*	A
Largemouth bass	*Micropterus salmoides*	A
Black crappie	*Pomoxis nigromaculatus*	A
Brown darter	*Etheostoma edwini*	R
Swamp darter	*Ethoestoma fusiforme*	C
Johnny darter	*Etheostoma nigrum*	R
Blackbanded darter	*Percina nigrofasciata*	R
Crevalle jack	*Caranx hippos*	R
Atlantic bumper	*Chloroscombrus chrysurus*	R
Leatherjacket[1]	*Oligoplites saurus*	R

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Lookdown[1]	Selene vomer	R
Permit[1]	Trachinotus falcatus	R
Atlantic moonfish[1]	Vomer setapinnis	R
Mutton snapper[1]	Lutjanus analis	R
Gray snapper	Lutjanus griseus	R
Irish pompano	Diapterus olisthostomus	R
Striped mojarra[1]	Diapterus plumieri	R
Spotfin mojarra	Eucinostomus argenteus	R
Silver jenny[1]	Eucinostomus gula	R
Pigfish	Orthopristis chrysoptera	R
Sheepshead	Archosargus probatocephalus	R
Pinfish	Lagodon rhomboides	NC
Silver perch	Bairdiella chrysura	NC
Spotted seatrout	Cynoscion nebulosus	R
Weakfish[1]	Cynoscion regalis	R
Spot	Leiostomus xanthurus	R
Southern kingfish[1]	Menticirrhus americanus	R
Atlantic croaker	Micropogon undulatus	A
Black drum	Pogonias cromis	R
Red drum	Sciaenops ocellata	R
Star drum[1]	Stellifer lanceolatus	R
Atlantic spadefish[1]	Chaetodipterus faber	R
Nile perch[3]	Tilipia aurea	R
Mountain mullet	Agonostomus monticola	R
Striped mullet	Mugil cephalus	A
White mullet[1]	Mugil curema	NC
Great barracuda[1]	Sphyraena barracuda	R
Southern stargazer[1]	Astroscopus y-graecum	R
Striped blenny[1]	Chasmodes bosquianus	R
Feather blenny[1]	Hypsoblennius hentzi	R

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Freckled blenny[1]	Hypsoblennius ionthas	R
Fat sleeper	Dormitator maculatus	R
Spotted sleeper[1]	Eleotris picta	R
River goby	Awaous tajasica	R
Frillfin goby	Bathygobius soporator	R
Violet goby[1]	Gobioides broussonneti	R
Darter goby	Gobionellus boleosoma	R
Slim goby[1]	Gobionellus gracillimus	R
Sharptail goby[1]	Gobionellus hastatus	R
Freshwater goby	Gobionellus shufeldti	R
Emerald goby[1]	Gobionellus smaragdus	R
Naked goby	Gobiosoma bosci	A
Code goby[1]	Gobiosoma robustum	R
Clown goby	Microgobius gulosus	A
Green goby[1]	Microgobius thalassinus	R
Atlantic cutlassfish[1]	Trichiurus lepturus	R
Spanish mackeral[1]	Scomberomorus maculatus	R
Harvestfish[1]	Peprilus alepidotus	R
Leopard searobin[1]	Prionotus scitulus	R
Bighead searobin[31]	Prionotus tribulus	R
Ocellated flounder[1]	Ancylopsetta quadrocellata	R
Bay whiff	Citharichthys spilopterus	R
Fringed flounder[1]	Etropus crossotus	R
Gulf flounder[1]	Paralichthys albigutta	R
Summer flounder[1]	Paralichthys dentatus	R
Southern flounder	Paralichthys lethostigma	NC
Windowpane[1]	Scophthalmus aquosus	R
Lined sole[1]	Achirus lineatus	R
Hogchoker	Trinectes maculatus	NC

Table B-27 (Continued)

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
Blackcheek touguefish	*Symphurus plagiusa*	R
Planehead filefish[1]	*Monacanthus hispidus*	R
Northern puffer[1]	*Sphoeroides maculatus*	R
Striped burrfish[1]	*Chilomycterus scheopfi*	R

Table B-28

Fish Collected from the St. Johns River near Palatka, Florida during Recent Field Surveys

Common names of fishes follow Bailey et al. (1970).

Data Sources

[1] Data from Applied Biology, Inc. (1976).

[2] Data from Florida Game and Freshwater Fish Commission (1977).

[3] Data from Dames & Moore Field Surveys, September 1977 and January 1978.

[4] Collected during Dames & Moore Larval Fish Survey, February-April, 1978.

	DATA SOURCES			
FISH	1	2	3	4
Atlantic stingray	X	X		
Longnose gar			X	
Florida gar	X		X	
Bowfin			X	
Ladyfish	X		X	X
American eel	X			
Speckeld worm eel	X			
Blueback herring	X		X	X
Hickory shad			X	
American shad	X		X	
Atlantic menhaden			X	
Gizzard shad	X	X	X	X
Threadfin shad	X	X	X	
Bay anchovy	X	X	X	X
Golden shiner	X	X	X	
Taillight shiner	X			
White catfish	X	X	X	
Brown bullhead	X	X	X	
Channel catfish	X	X	X	
Priate perch	X			
Atlantic needlefish	X		X	
Gulf killifish	X			
Mummimchog				X
Seminole killifish	X	X	X	
Bluefin Killifish	X			

Table B-28 (Continued)

	DATA SOURCES			
FISH	1	2	3	4
Rainwater killifish	X	X	X	
Mosquitofish	X		X	
Least killifish	X			
Sailfin molly			X	
Brook silverside			C	
Rough silverside	X			
Tidewater silverside	X	X	X	X
Gulf pipefish	X			X
Snook	X			
Striped bass				X
Flier	X			
Redbreast	X	X	X	
Warmouth	X		X	
Bluegill	X	X	X	X
Redear sunfish	X	X	X	
Spotted sunfish			X	
Largemouth	X	X	X	
Swamp darter		X		
Gray snapper	X			
Striped mojarra	X			
Spotfim mojarra	X			
Spotted seatrout	X			
Spot	X	X	X	X
Atlantic croaker	X	X	X	X
Red drum		X	X	
Striped mullet	X	X	X	X
White mullet		X		
Naked goby	X		X	X
Clown goby	X			X
Bay whiff			X	
Southern flounder			X	
Hogchoker	X	X	X	X

Table B-29

Nekton Collected at Transect A, St. Johns River near Palatka, Florida - September 1977

	Total	Weight (g)				Length (mm)			Sex	
Species[1]	No.	Total	Range	Mean	STD[2]	Range	Mean	STD[2]	No. M	No. F
Gear Type: Electroshock						Date: 14 September 1977				
Florida gar	2	3714	1361-2353	1857	702	535-612	574	54		2
Bluegill	6	835	75-189	139	42	121-165	146	30	6	
Gear Type : Gill Net - night						Date: 12-13 September 1977				
Florida gar	1	650	--	--	0	450	--	0	1	
Gizzard shad	7	2636	276-648	439	127	230-308	259	26	3	4
Channel catfish	3	287	87-108	96	11	156-176	165	10		3
Black crappie	1	160	--	--	0	170	--	0	1	
Spot	14	821	51-91	75	14	122-146	137	8	9	1
Atlantic croaker	1	60	--	--	0	136	--	0		1
Gear Type: Gill Net - day						Date: 13 September 1977				
Gizzard shad	1	575	--	--	0	328	--	0	1	
White catfish	1	102	--	--	0	180	--	0		1
Channel catfish	1	96	--	--	0	176	--	0	1	
Spot	1	65	--	--	0	128	--	0		
Gear Type: Seine A1						Date: 13 September 1977			Area Seined: 2,000 ft^2	
Treadfin shad	1	<1	--	--	0	31	--	0		
Gear Type: Seine A2						Date: 13 September 1977			Area Seined: 1,500 ft^2	
Hickory shad	1	3	--	--	0	59	--	0		
Golden shiner	1	19	--	--	0	106	--	0		
Tidewater silverside	6	4	<1-1	<1	<1	37-46	40	4		
Gear Type: Trawl						Date: 13 September 1977				
Blue crab[3]	2	256	69-187	128	84	115-152	134	26	1	1
White catfish	4	304	62-89	76	12	144-164	152	9	3	1
Brown bullhead	1	253	--	--	0	227	--	0		1
Southern flounder	1	40	--	--	0	127	--	0		

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[1] Common names of fish follow Bailey et al. (1970).

[2] STD - Standard deviation

[3] Blue crab - *Callinectes sapidus*.

Table B-30

Nekton Collected at Transect B, St. Johns River near Palatka, Florida - September 1977

Species[1]	Total No.	Weight (g) Total	Weight (g) Range	Weight (g) Mean	Weight (g) STD[2]	Length (mm) Range	Length (mm) Mean	Length (mm) STD[2]	Sex No. M	Sex No. F
Gear Type: Electroshock					Date: 14 September 1977					
Florida gar	13	1170	405-515	900	254	405-515	459	37	4	9
Golden shiner	1	79	--	--	0	169	--	0		
White catfish	2	1209	75-1134	604	749	153-345	249	136	1	1
Brown bullhead	1	120	--	--	0	153	--	0	1	
Redbreast sunfish	4	223	24-70	56	21	97-131	119	15	3	
Bluegill	20	3368	12-454	168	130	77-202	146	32	5	12
Gear Type: Gill Net - night					Date: 12-13 September 1977					
Longnose gar	1	680	--	--	0	570	--	0		
Ladyfish	1	98	--	--	0	258	--	0		
Gizzard shad	2	576	251-325	288	52	240-250	245	7	2	
White catfish	10	1176	99-293	168	65	128-242	174	35	3	3
Gear Type: Gill Net - day					Date: 13 September 1977					
Longnose gar	1	5670	--	--	0	1010	--	0		1
White catfish	2	220	81-139	110	41	156-186	171	21		
Gear Type: Seine B1					Date: 13 September 1977			Area Seined: 5,000 ft^2		
-- No fish caught after two 2,500 ft^2 sein hauls were taken --										
Gear Type: Seine B2					Date: 13 September 1977			Area Seined: 1,300 ft^2		
Tidewater silverside	5	3	<1-1	<1	<1	35-39	37	2		
Gear Type: Trawl					Date: 13 September 1977					
White catfish	12	513	12-109	43	33	81-174	118	33	3	3
Brown bullhead	1	28	--	--	0	102	--	0		1
Channel catfish	1	12	--	--	0	90	--	0		
Hogchoker	2	14	7	7	<1	55-57	56	1		

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[1] Common Names of fish follow Bailey et al. (1970).

[2] STD - Standard deviation

Table B-31

Nekton Collected at Transect C, St. Johns River near Palatka, Florida - September 1977

	Total	Weight (g)				Length (mm)			Sex		
Species[1]	No.	Total	Range	Mean	STD[2]	Range	Mean	STD[2]	No. M	No. F	
	Gear type:	Electroshock		Date:	12 September 1977						
Blue crab[3]	3	55	2-39	--	--	32-96	64	32	1	1	
Grass shrimp[3]	13	3	--	--	--	--	--	--			
Florida gar	5	4627	680-1134	926	189	419-485	454	30	2	3	
Bowfin	2	6123	2495-3629	3062	802	510-607	559	69		2	
Threadfin shad	7	26	1-6	4	2	39-66	54	9			
Bay anchovy	2	<1	<1	<1	<1	34-36	35	1			
White catfish	4	231	11-102	58	37	83-159	126	32	2	1	
Seminole killifish	10	73	1-15	7	5	35-94	70	19			
Rainwater killifish	9	3	<1-1	<1	<1	17-38	25	6			
Sailfin molly	16	13	<1-4	6	1	15-50	27	10			
Tidewater silverside	1	<1	--	--	0	36	--	0			
Redbreast sunfish	5	203	12-80	41	26	68-133	101	24	2	1	
Bluegill	25	2512	<1-408	101	135	23-202	122	56	7	3	
Redear sunfish	7	235	11-93	34	32	67-137	91	28	2		
Largemouth bass	3	4678	340-3657	1559	1825	279-559		140	3		
Striped mullet	16	2240	27-726	140	214	102-278	152	53	6	4	
Southern flounder	1	27	--	--	0	114	--	0			
	Gear Type:	Gill Net - night		Date:	12-13 September 1977						
Blueback herring	1	41	--	--	0	118	--	0			
Gizzard shad	5	2038	304-566	408	104	248-330	276	32		2	
Spot	2	156	62-94	78	23	130-140	135	7		1	
Red drum	1	717	--	--	0	334	--	0		1	
	Gear Type:	Gill Net - day		Date:	13 September 1977						
Spot	2	57	28	28	0	63	63	0		1	
	Gear Type:	Seine C1		Date:	13 September 1977			Area Seined:	2,500 ft^2		
Grass shrimp[3]	1	<1	--	--	0	--		--	--		
Bay anchovy	1	2	--	--	0	51		--	0		
White catfish	1	<1	--	--	0	28		--	0		
Rainwater killifish	1	<1	--	--	0	25		--	0		
Redbreast sunfish	1	60	--	--	0	121		--	0		
Bluegill	10	13	<1-2	1	<1	27-40		34	5	1	
Spotted sunfish	3	14	1-10	5	4	37-67		49	16		
Largemouth bass	1	24	--	--	0	--		--	0		
	Gear Type:	Seine C2		Date:	13 September 1977			Area Seined:	1,500 ft^2		
Florida gar	1	1021	--	--	0	550		--	0		
Threadfin shad	107	128	<1-2	1	<1	33-47		38	4		
Rainwater killifish	9	2	<1	<1	<1	17-32		23	5		
Mosquitofish	12	5	<1-1	<1	<1	19-34		27	5	1	11
Sailfin molly	1	3	--	--	0	45		--	0		
Tidewater silverside	8	4	<1	<1	<1	33-40		37	3		
Bluegill	2	3	<1-3	2	1	30-42		36	9		
	Gear Type:	Trawl		Date:	13 September 1977						
White catfish	2	37	9-29	19	14	74-112		93	27	1	

---

[1] Common names of fish follow Bailey et al. (1970).

[2] STD - Standard deviation

[3] Bluecrab - <u>Callinectes sapidus</u>; grass shrimp - <u>Palaemontes pugio</u>.

Table B-32

Nekton Collected at Transect D, St. Johns River near Palatka, Florida - September 1977

Species[1]	Total No.	Weight (g) Total	Weight (g) Range	Weight (g) Mean	Weight (g) STD[2]	Length (mm) Range	Length (mm) Mean	Length (mm) STD[2]	Sex No. M	Sex No. F
Gear Type: Electroshock				Date: 14 September 1977						
Grass shrimp[3]	12	6	--	--	--	--	--	--		
Florida gar	3	3459	595-1616	1153	517	400-595	504	98		2
Golden shiner	17	17	<1-2	1	<1	37-48	42	3		
Atlantic needlefish	1	<1	--	--	0	42	--	0		
Seminole killifish	31	162	2-16	5	4	44-96	65	15		
Rainwater killifish	60	8	<1	<1	<1	18-33	24	4		
Sailfin molly	1	1	--	--	0	37	--	0		
Tidewater silverside	14	4	<1	<1	<1	24-42	36	6		
Redbreast sunfish	3	117	27-52	39	13	93-113	105	10	1	2
Bluegill	29	2674	1-482	92	151	38-200	91	57	5	5
Redear sunfish	3	361	54-205	120	77	112-167	137	28		3
Largemouth bass	4	3137	18-1446	784	587	97-388	281	128	3	
Spot	3	194	61-66	65	3	129-136	132	4		
Striped mullet	8	3139	31-1474	392	634	101-395	192	120		3
Bay whiff	1	26	--	--	0	112	--	0		
Southern flounder	2	101	46-55	50	6	133-143	138	7		
Gear Type: Gill Net - night				Date: 12-13 September 1977						
Blueback herring	1	49	--	--	0	130	--	0		1
Gizzard shad	15	5171	35-532	369	156	116-310	243	54	4	8
Atlantic needlefish	1	330	--	--	0	530	--	0		1
Spot	1	--	--	--	--	--	--	--		
Atlantic croaker	1	52	--	--	0	132	--	0		
Gear Type: Gill Net - day				Date: 13 September 1977						
Gizzard shad	1	386	--	--	0	254	--	0	1	
Gear Type: Seine D1				Date: 13 September 1977				Area Seined: 2,500 ft^2		
Gizzard shad	44	164	2-7	4	1	47-69	57	5		
Gear Type: Seine D2				Date: 13 September 1977				Area Seined: 1,500 ft^2		
Atlantic needlefish	2	2	<1-2	1	1	62-110	86	34		
Seminole killifish	117	281	<1-11	2	2	26-87	51	12		
Rainwater killifish	152	40	<1-1	<1	<1	14-35	23	5		
Mosquitofish	48	17	<1-2	<1	<1	17-35	26	5	8	22
Sailfin molly	1	<1	--	--	0	33	--	0		
Brook silverside	201	93	<1	<1	<1	24-43	36	6		
Bluegill	1	3	--	--	0	43	--	0		
Naked goby	1	<1	--	--	0	21	--	0		
Gear Type: Trawl				Date: September 1977						
Blue crab[3]	2	84	12-72	42	43	58-117	88	42	1	1
Southern flounder	1	22	--	--	0	108	--	0		

---

[1] Common names of fish follow Bailey et al. (1970).

[2] STD - Standard deviation

[3] Blue crab - Callinectes sapidus; Grass shrimp - Palaemonetes pugio.

Table B-33

Nekton Collected at Transect A, St. Johns River near Palatka, Florida - January 1978

	Total	Weight (g)				Length (mm)			Sex	
Species[1]	No.	Total	Range	Mean	STD[2]	Range	Mean	STD[2]	No. M	No. F
	Gear Type:	Electroshock			Date:	31 January 1978				
Bay anchovy	3	<1	<1	<1	0	23-28	26	3		
Seminole killifish	2	27	12-15	14	3	83-90	87	5		
Tidewater silverside	3	3	<1-2	<1	<1	41-53	47	6		
Redbreast sunfish	2	207	14-193	103	127	78-212	145	95	1	
Warmouth	1	72	--	--	0	116	--	0	1	
Bluegill	10	1679	5-242	168	71	53-228	189	50	5	3
Redear sunfish	1	3	--	--	0	48	--	0		
Largemouth bass	4	2054	57-1644	514	759	130-454	253	146	1	2
Striped mullet	2	867	130-737	435	429	226-374	300	105	1	1
	Gear Type:	Gill Net - night			Date:	30-31 January 1978				
Blue crab[3]	1	88	--	--	0	115	--	0	1	
Blueback herring	8	2002	231-269	250	13	254-304	286	15	4	4
American shad	1	26	--	--	0	119	--	0		
Atlantic menhaden	28	1715	45-75	61	13	130-163	141	9		
Gizzard shad	9	2402	34-531	267	187	127-370	270	104	3	3
	Gear Type:	Gill Net - day			Date:	31 January 1978				
Atlantic menhaden	2	111	50-60	55	7	134-139	137	4		
	Gear Type:	Trawl A1			Date:	1 February 1978				
Blue crab[3]	1	4	--	--	0	38	--	0		
Redear sunfish	1	52	--	--	0	158	--	0	1	
Atlantic croaker	2	<1	<1	<1	0	32-34	33	1		
	Gear Type:	Trawl A2			Date:	1 February 1978				
Blue crab[3]	1	<1	--	--	0	25	--	0		
Bay anchovy	1	<1	--	--	0	24	--	0		
Southern flounder	1	66	--	--	0	156	--	0		

---

[1] Common Names of fishes follow Bailey et al. (1970).

[2] STD - Standard deviation

[3] Blue crab - *Callinectes sapidus*.

Table B-34

Nekton Collected at Transect B, St. Johns River near Palatka, Florida - January 1978

	Total	Weight (g)				Length (mm)			Sex	
Species[1]	No.	Total	Range	Mean	STD[2]	Range	Mean	STD[2]	No. M	No. F
	Gear Type:	Electroshock			Date:	31 January 1978				
Florida gar	9	8788	425-2693	997	723	452-774	568	96	7	2
Bay anchovy	30	5	<1	<1	<1	22-29	25	2		
Seminole killifish	9	167	9-35	19	8	77-117	96	14		
Tidewater silverside	11	13	<1-2	1	<1	41-57	48	5		
Redbreast sunfish	2	91	33-58	45	17	101-117	109	11		
Bluegill	11	789	10-224	72	61	65-214	117	39	6	
Redear sunfish	1	7	--	--	0	60	--	9		
Largemouth bass	7	3495	31-1371	499	516	116-416	258	126	4	2
Striped mullet	10	8135	55-1871	814	575	143-536	383	111	3	6
	Gear Type:	Gill Net - night			Date:	30-31 January 1978				
Gizzard shad	15	6073	101-1191	405	258	232-450	336	52	7	8
Golden shiner	1	169	--	--	0	246	--	0	1	
	Gear Type:	Gill Net - day			Date:	31 January 1978				
No fish collected										
	Gear Type:	Trawl B1			Date:	1 February 1978				
Blue crab[3]	5	23	<1-10	5	4	23-61	41	15		
Gizzard shad	2	279	65-214	140	106	147-219	183	51		
Bay anchovy	124	77	<1-2	<1	<1	24-56	43	7		
Bluegill	1	289	--	--	0	236	--	0	1	
Black crappie	3	188	58-75	63	11	120-132	125	6	2	1
Atlantic croaker	1	<1	--	--	0	36	--	0		
	Gear type:	Trawl B2			Date:	1 February 1978				
Blue crab[3]	1	5	--	--	0	45	--	0		
Threadfin shad	3	17	2-10	6	4	52-80	65	14		
Bay anchovy	53	28	<1-3	<1	<1	26-61	38	8		
Atlantic croaker	17	8	<1-2	<1	<1	14-44	23	11		

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[1] Common names of fishes follow Bailey et al.)1970).

[2] STD - Standard deviation

[3] Blue crab - Callinectes sapidus.

Table B-35

Nekton Collected at Transect C, St. Johns River near Palatka, Florida - January 1978

	Total	Weight (g)				Length (mm)			Sex	
Species[1]	No.	Total	Range	Mean	STD[2]	Range	Mean	STD[2]	No. M	No. F
	Gear Type:	Electroshock			Date:	31 January 1978				
Atlantic menhaden	1	39	--	--	0	124	--	0		
Gizzard shad	2	488	60-428	244	260	158-347	253	134		1
Bay anchovy	58	11	<1	<1	<1	21-30	26	2		
Golden shiner	1	13	--	--	0	90	--	0		
Sailfin molly	1	2	--	--	0	39	--	0		
Tidewater silverside	10	7	<1-2	<1	0	33-53	41	6		
Bluegill	2	450	144-306	225	115	154-246	200	65	2	
Redear sunfish	10	13	<1-3	1	<1	27-47	35	7		
Largemouth bass	4	1791	161-851	448	292	180-340	277	68	2	2
Black crappie	1	680	--	--	0	332	--	0		1
Striped mullet	4	1271	238-396	318	71	284-348	313	28	3	1
	Gear Type:	Gill Net - night			Date:	30-31 January 1978				
Gizzard shad	8	3753	171-851	469	224	263-404	341	44	2	6
	Gear Type:	Gill Net - day			Date:	31 January 1978				
No fish collected										
	Gear Type:	Trawl C1			Date:	1 February 1978				
Blue crab[3]	1	8	--	--	0	50	--	0		
Atlantic croaker	3	3	<1-2	1	<1	32-41	38	5		
Hogchoker	1	6	--	--	0	52	--	0		
	Gear Type:	Trawl C2			Date:	1 February 1978				
Bay anchovy	1	<1	--	--	0	40	--	0		
Atlantic croaker	4	7	<1-3	2	<1	35-49	41	6		
Naked goby	1	<1	--	--	0	-23	--	0		

---

[1] Common names of fishes follow Bailey et al. (1970).

[2] STD - Standard deviation

[3] Blue crab - <u>Calinectes sapidus</u>.

Table B-36

Nekton Collected at Transect D, St. Johns River near Palatka, Florida - January 1978

Species[1]	Total No.	Weight (g) Total	Weight (g) Range	Weight (g) Mean	Weight (g) STD[2]	Length (mm) Range	Length (mm) Mean	Length (mm) STD[2]	Sex No. M	Sex No. F
	Gear Type:	electroshock			Date:	31 January 1978				
Florida gar	3	3685	737-2070	1229	732	506-720	590	114	2	1
Golden shiner	1	85	--	--	0	--	--	0		
Seminole killifish	4	41	6-14	10	4	72-92	84	9		
Brook silverside	13	4	<1	<1	<1	33-54	38	6		
Redbreast sunfish	3	221	28-135	74	55	94-158	124	32		1
Bluegill	13	3400	128-374	262	63	158-265	222	32	5	8
Redear sunfish	12	33	<1-10	3	3	27-69	44	11		
Striped mullet	9	6992	80-1588	777	511	163-500	380	124	3	4
	Gear Type:	Gill Net - night			Date:	30-31 January 1978				
Gizzard shad	5	1630	262-463	326	82	305-351	320	18	4	1
	Gear Type:	Gill Net - day			Date:	31 January 1978				
No fish collected										
	Gear Type:	Trawl D1			Date:	1 February 1978				
Bay anchovy	2	<1	<1	<1	0	28-30	29	1		
Atlantic croaker	1	3	--	--	0	--	--	0		
	Gear Type:	Trawl D2			Date:	1 February 1978				
Blue crab[3]	1	2	--	--	0	--	--	0		
Gizzard shad	1	67	--	--	0	--	--	0		
Bay anchovy	1	<1	--	--	0	34	--	0		
Atlantic croaker	6	11	<1-4	2	2	28-58	41	12		

---

[1] Common names of fishes follow Bailey et al (1970).

[2] STD - Standard deviation

[3] Blue crab - _Callinectes_ _sapidus_.

Table B-37

Day and Night[3] Densities of Fish Caught During 1978 Larval Tow Sampling
in St. Johns River near Palatka, Florida
(All Densities Reported in #'s/100^3)

Sample Date	March								April							
Station Number	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2
Actual Sample Volume (m^3)	$\frac{240}{254}$	$\frac{264}{300}$	$\frac{220}{220}$	$\frac{234}{212}$	$\frac{220}{222}$	$\frac{388}{240}$	$\frac{226}{238}$	$\frac{230}{212}$	$\frac{266}{258}$	$\frac{302}{0}$	$\frac{236}{218}$	$\frac{226}{230}$	$\frac{216}{272}$	$\frac{224}{236}$	$\frac{248}{258}$	$\frac{250}{246}$
Species[1]																
Bay anchovy	$\frac{0}{133.9}$	$\frac{0}{233.7}$	$\frac{0}{9.5}$	$\frac{0}{15.1}$	$\frac{0}{8.1}$	$\frac{0.3}{10.8}$	$\frac{0}{40.8}$	$\frac{0}{35.8}$	$\frac{1.1}{120.5}$	$\frac{3.0}{-}$[2]	$\frac{0}{33.9}$	$\frac{0}{37.8}$	$\frac{0}{107.2}$	$\frac{0}{89.8}$	$\frac{0}{13.6}$	$\frac{0}{27.6}$
Atlantic croaker	$\frac{0}{.4}$	$\frac{0}{1.3}$	$\frac{0}{0.5}$	$\frac{0}{1.4}$	$\frac{0}{0.9}$	$\frac{0}{5.0}$	$\frac{0}{4.3}$	$\frac{0}{1.9}$	$\frac{0}{.8}$	$\frac{0}{-}$	$\frac{0}{.5}$	$\frac{0}{0}$	$\frac{0}{3.3}$	$\frac{0}{3.0}$	$\frac{0}{0.4}$	$\frac{0}{0.8}$
Mummichog	$\frac{0}{1.6}$	$\frac{0}{1.7}$	$\frac{0}{0.5}$	$\frac{0}{0}$	$\frac{0}{0.5}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.4}$	$\frac{0}{0}$	$\frac{0}{0}$
Blueback herring	$\frac{0}{19.7}$	$\frac{0}{16.0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.5}$	$\frac{0}{2.5}$	$\frac{0}{28.6}$	$\frac{0}{4.2}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
Gizzard shad	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.5}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{1.9}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{7.4}$	$\frac{0}{4.2}$	$\frac{0}{0.8}$	$\frac{0}{0}$
Striped bass	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0.9}{0}$	$\frac{0.4}{0}$	$\frac{1.6}{0}$	$\frac{0}{0}$
Ladyfish	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0.3}{-}$	$\frac{0}{0.5}$	$\frac{0}{0}$	$\frac{0}{4.0}$	$\frac{0}{1.3}$	$\frac{0}{0.4}$	$\frac{0.8}{1.2}$
Spot	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{1.7}$	$\frac{0}{0}$	$\frac{0}{0.4}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.7}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
Tidewater silverside	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.5}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{5.9}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0.5}$	$\frac{0}{0.4}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
American eel	$\frac{0}{0.4}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
Striped mullet	$\frac{0}{0}$	$\frac{0}{0.3}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0.9}$	$\frac{0}{0}$	$\frac{0}{2.5}$	$\frac{0}{0.9}$	$\frac{0}{0}$	$\frac{0}{-}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$	$\frac{0}{0}$
Total density per 100m^3	$\frac{0}{156.0}$	$\frac{0}{253.0}$	$\frac{0}{10.5}$	$\frac{0}{17.5}$	$\frac{0}{10.9}$	$\frac{0.3}{18.3}$	$\frac{0}{83.8}$	$\frac{0}{42.8}$	$\frac{1.1}{123.6}$	$\frac{3.3}{0}$	$\frac{0}{35.4}$	$\frac{0}{38.4}$	$\frac{0.9}{124.6}$	$\frac{0.4}{98.7}$	$\frac{1.6}{15.2}$	$\frac{0.8}{29.6}$

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[1] Common names of fish follow Bailey et al. (1970).

[2] Night samples at Station A-2 were not taken in April.

[3] Values above line are for day samples and those below the line are for night samples.

Table B-38

SUMMARY OF SEINE COLLECTIONS (NUMBER COLLECTED) MADE IN THE ST. JOHNS RIVER NEAR PALATKA, FLORIDA,

29 MARCH, 1978

Species[2]	Transect A	B	C	D
Blue crab[3]			4	2
Crab (unidentified)				1
Shrimp[3]		1	102	177
American eel				
Blueback herring			328	
Gizzard shad		8	20	
Bay anchovy	6	23	24	99
Mummichog		1		
Tidewater silverside			11	9
Shiner[3]		1	110	342
Gulf pipefish			1	
Bluegill			2	3
Atlantic croaker	2		4	
Striped mullet			75	
Naked goby	2		38	
Clown goby	2	8	20	6
Hogchoker			3	
Total invertebrates	0	1	106	180
Total fish	12	41	636	459
Total collection	12	42	742	639

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[1] Survey conducted in conjunction with larval fish survey.

[2] Common names follow Bailey et al. (1970), except as noted.

[3] Blue crab - *Callinectes sapidus*; Shrimp - *Macrobrachium* sp.; Shiner - *Notropis* sp.

SURFACE WATER HYDROLOGY

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SURFACE WATER HYDROLOGY

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APPENDIX C

SURFACE WATER HYDROLOGY

C.1 BASELINE CONDITIONS

C.1.1 St. Johns River

General

As discussed in Section 2.3.1.1 the Seminole steam-electric generating station is located northwest of the St. Johns River, approximately 73 miles from its mouth and five miles downstream from Palatka, Florida. Although USGS (1977) flow records at Palatka and Jacksonville are available, the strong tidal action at both stations makes mean daily flow computations difficult. Due to the uncertainty of the data and the limited period of record, substantiation of the Palatka records was sought through analysis and comparison with other stations in the St. Johns watershed. Average discharges in cubic feet per second (cfs) per square mile are given in Table C-1 for the selected main stem St. Johns' stations. As seen in the table, the average fresh water discharge at Palatka of 1.07 cubic feet per second per square mile (cfsm) is comparable to the discharge from upstream stations that are not tidally influenced.

However, due to the tremendous storage capacity in the estuary from Palatka to Jacksonville, daily flow records from upstream stations cannot be used to extend the daily records at Palatka. In addition, as shown in Table C-2, the Jacksonville station with its 20 years of records shows no flow correlation with flows at Palatka.

The only source of meaningful data on the flow regime of the St. Johns River near the site other than the Palatka station is the USGS station on Rice Creek (Figure C-1). Because Rice Creek is a backwater to the St. Johns River at the station and experiences rapid responses to stage fluctuations in the river, it may be used to extend the stage record available on the St. Johns station. The peak stage records from the two stations are shown in Table C-3.

Low Flows

The simulation of surface water discharge impacts requires selection of a design worst-case flow condition. The general approach is to define or select a number of "reference" or "representative" scenarios which envelop the expected or known behavior of the water body. For a water body under study for potential environmental impacts, these scenarios are typically defined to include the case of known or expected worst environmental impact.

Environmental impacts on the St. Johns River were defined in terms of the areal impact of isotherms or isopleths in excess of Florida DER (1979) standards. Therefore, the worst-case flow condition (ambient current and local turbulence) was defined to be the flow scenario providing the least transport and diffusion of the effluent pollutants. Such hydrodynamic conditions result in the greatest buildup of pollutants in the vicinity of the Point of Discharge (POD) and maximum extent of required mixing zones.

In order to determine a critical historical tidal flow scenario, the USGS Palatka station tidal velocity and stage records were examined for three seven-day flow periods which bracket the historical tidal conditions. The seven-day periods represent a maximum net upstream flow (MUF), a similar downstream flow (MDF), and a minimum net absolute or approximately oscillatory flow (MAF). The average velocities and tidal ranges for each flow condition are shown in Table C-4.

In addition to the above assessment, the daily tidal ranges from one complete year (1971) were examined, and the average tidal variance about the mean depth for any seven-day period was found to average about 0.5 foot. The tidal range as shown in Table C-4 experiences insignificant variation between flow conditions.

In contrast to the relative consistency of the tidal range, the tidal velocity shows marked directional variation. Velocity may be taken as a function of time,

e.g. $u(t) = u_0 + u_a \cos \sigma t$

where: u_0 = baseline velocity,
u_a = tidal velocity.

From Table C-4 the MAF represents tidal flow conditions closely approximating $u_0 = 0$. As the lateral and horizontal pollutant redistribution is dependent on velocity and depth, the condition of minimum baseline velocity (i.e. $u_0 = 0$) prior to superposition of the sinusoidal tidal velocity should produce the minimum dispersion and the maximum areal extent of required mixing zones if the tidal range is relatively consistent for varying tidal scenarios.

This assumption, in addition to support from the literature such as Bork and Maier-Reiner (1978), was tested by a dimensionless simulation of pollutant redistribution under conditions of once through cooling (i.e., discharge = 1900 cfs) during both the MAF and MUF. Isopleths during flood, ebb, and slack tide are presented in Figures C-2 through C-4. Note that the areas influenced by a given excess concentration increase sharply between the MUF and the MAF scenarios.

The MAF was selected as a practical expediency which provided an approximation of potential worst-case flow conditions relative to required mixing zones. In addition, precaution was exercised by applying this flow conditon with conservative input data about other influences (discussed in Section C.4) such as zero net atmospheric heat loss and calm wind conditions.

High Flows

In order to obtain a quantitative estimate of the potential flood elevations in the vicinity of the site, the available data base was examined for peak stage events during each year of record. As described earlier, the eight years of record at Palatka were increased by utilizing stage data from the Rice Creek station. The results of the comparison are shown on Table C-3. As seen in the table, for the five years of overlapping record between the stations, the Rice Creek stages were from 0.05 foot to 0.16 foot higher than the St. Johns stages. An average value of 0.08 foot was used to convert the Rice Creek stages for the period 1959 to 1967 to the St. Johns stages.

C.1.2 Local Tributaries and Site Hydrologic Characteristics

Local Tributaries

The tributaries draining the general site area are shown in Figure C-5. Average discharge data are available from only two stations in the Rice Creek drainage basin. In order to obtain average discharge values for the ungaged tributaries, the discharges in cfsm from the two gaged stations were assessed. As seen in Table C-5, the cfsm of 0.76 at the Rice Creek station was significantly different from the Etonia Creek station discharge of 0.23 cfsm. The 0.76 cfsm was utilized in obtaining the average discharges shown in Table C-6 because it represented drainage from an area most indicative of the small areas drained by the subject tributaries.

From Table C-6, each of the watercourses draining the site area has an average discharge of less than 5 cfs. As defined by 33 CFR 323, an average discharge of 5 cfs is utilized by the U.S. Corps of Engineers (COE) to define those watercourses over which they exercise jurisdiction.

Site Erosion

The quantity of soil eroded per year may be estimated with the Universal Soil Loss Equation (USLE) developed by the Soil Conservation Service (SCS, 1975). The complete USLE is A = RKLSCP, where:

A = computed soil loss (sheet and rill erosion in tons per acre per year);

B = rainfall factor; number of erosion-index units in a normal year's rain;

K = soil-erodibility factor; erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow, on a 9-percent slope 72.6 feet long;

L = slope-length factor; ratio of the soil loss from the field slope length to that from a 72.6 foot length on the same soil type and gradient;

S = slope-gradient factor; ratio of soil loss from the field gradient to that from a 9-percent slope;

C = cropping management factor; ratio of soil loss from area with specific vegetative conditions to that from the fallow condition on which the factor K is evaluated;

P = erosion-control practice factor; ratio of soil loss with contouring, stripcropping, or contour irrigated furrows to that with straightrow farming, up-down slope.

The parameter values are shown in Table C-7. The soil loss should average from 0.18 to 0.36 tons per acre per year, or 300 to 600 tons/year over the 1550-acre area experiencing erosion.

Only a portion of the soil lost will actually leave the upland area. This portion, which is determined by a sediment delivery ratio, is deposited in the lowlands surrounding the upland area. Based on SCS (1965) data, the delivery ratio to the lowlands may be related to the drainage areas contributing sediment. The upland area drains into five distinct lowland areas of which four are partially within site boundaries. The respective drainage areas range from approximately 0.1 to 0.5 square mile. With such areas, the delivery ratio should be between 0.4 and 0.5. Using a conservative value of 0.5, the sediment deposition would be between 150 and 300 tons/year.

C.1.3 Water Quality

A summary of the water quality data available from the EPA (1978a, 1978b) STORET files of the USGS water quality stations at Palatka and Rice Creek is presented in Tables C-8 and C-9. Site specific water quality field and laboratory data gathered by Dames & Moore are presented in Tables C-10 and C-11. Chemical analysis of sediment samples taken in the site vicinity are presented in Table C-12.

The river quality generally is well within DER standards for all constituents. However, five constituents, lead, mercury, zinc, cadmium, and oil and grease have been measured at total concentrations in excess of present (1979) numerical state standards. The data base is limited, but the high concentrations appear to be unusual conditions which are not representative of the concentrations generally experienced in the river. A comparison of water quality with state standards in presented in Table 2.3-1.

C.1.4 Water Discharges

Downstream of the site, there are twelve waste water treatment facilities discharging into the St. Johns River in water quality segment 20.3 FA shown in Figure C-6. These twelve facilities, detailed in Table C-13, have a total design capacity of 5.55 mgd (DER, 1975).

Upstream of the site there are seven facilities which discharge into either Rice Creek or the St. Johns in water quality segments 20.3 GA and 20.3 HA shown in Figure C-6. These facilities are detailed in Table C-14. Hudson Pulp and Paper Company is the major discharger, with 48 mgd of industrial waste discharged into Rice Creek. The next major contributor is a Florida Power & Light electric generating plant whose major contribution is 2.0 mgd of heated cooling water.

C.2 CONSTRUCTION IMPACTS

Approximately 420 acres of the 1550 acre upland area (Section C.1.2) of the site will be cleared during site preparation and construction activity (Figure 3.1-3, Area 1). It is generally the least steep part of the site and was assumed to have slopes after grading of about 0.5 percent. During construction most of the ground and canopy cover will be removed, and the affected USLE factors become (see Table C-7):

SL = 0.24
C = 0.4

Applying these to the USLE, resulted in an estimated annual soil loss of about 6 tons per acre. Assuming a delivery ratio of 0.5, the potential soil loss from the cleared area was estimated to be 1320 tons per year. This compares to an estimated loss of 40 to 90 tons per year from the same area under existing conditions. This "loss" is actually a displacement of soil from replaced cleared areas to onsite lowlands. Since storm runoff will be directed mainly to these lowlands, no offsite impacts are expected.

C.3 OPERATION IMPACTS

C.3.1 Effluent Quality

An assessment of pollutant sources, individual waste streams water quality, and constituent concentrations in the discharge to the St. Johns River is presented in the National Pollutant Discharge Elimination System Application included in Appendix C as Attachment C-1. Data are presented for three phases: 1) Phase 1 - Unit 1 Construction; 2) Phase II - Unit 1 Operation; Unit 2 Construction; 3) Phase III - Unit 1 and Unit 2 Operation.

The data in Attachment C-1 are supplemented with Section C.3.2 conconcerning the methodology for obtaining total sulfate concentrations and Section C.3.3 concerning the methodology for determining the total waste stream water quality shown in Attachment C-1, pages II-6 and II-7.

C.3.2 Sulfate Increase from Addition of Sulfuric Acid (H_2SO_4)

The increase in sulfate concentration is determined by the alkalinity of the makeup water which ranges from 39 to 123 mg/liter. The alkalinity level to be maintained in the cooling tower is from 70 to 100 mg/liter. Minimum alkalinity was adopted in the calculations to maximize sulfate concentrations in the blowdown. Therefore, the alkalinity reduction required is:

Minimum alkalinity reduction = 4 x 39 - 70 = 86 mg/liter
Maximum alkalinity reduction = 4 x 123 - 70 = 442 mg/liter

These reductions, however, will cause a sulfate increase which can be found by multiplying the alkalinity reduction by the ratio of the atomic weights ($SO_4/CaCO_3$):

Atomic weight SO_4 = 96 atomic mass units
Atomic weight $CaCO_3$ = 100 atomic mass units
Ratio = $SO_4/CaCo_3$ = 0.96

Minimum sulfate increase = 86 x 0.96 = 83 mg/liter
Maximum sulfate increase = 422 x 0.96 = 405 mg/liter

To find the total sulfate in the blowdown, the sulfate concentration due to ambient conditions must be added to the sulfate increase due to the acid.

Minimum total sulfate = 148 + 83 = 231 mg/liter
Maximum total sulfate = 456 + 405 = 861 mg/liter

C.3.3 Wastewater Stream Mixing

It is assumed that the three wastewater streams (ash pond, sanitary, and cooling tower blowdown) will be fully mixed into discharge 001 (Att. C-1) before reaching the St. Johns River. The concentration of chemical constituents in the combined wastewater stream was computed by the following equation:

$$C_4 = \frac{Q_1C_1 + Q_2C_2 + Q_3C_3}{Q_1 + Q_2 + Q_3} \qquad (1)$$

where:

C_4 = concentration of constituents in the fully mixed combined waste water stream (Att. C-1, Page II-6 and II-7).

Q_1 = chemical wastewater flow rate (Att. C-1, Table VII, Line No. V).

C_1 = concentration of constituents in the treated chemical wastewater (att. C-1, Table Vb).

Q_2 = sanitary wastewater flow rate (Att. C-1, Table VII, Line No. JJ).

C_2 = concentration of constituents in the sanitary wastewater (Att. C-1, Table Vc).

Q_3 = cooling water blowdown flow rate to the St. Johns (Att. C-1, Table VII, Line No. J)

C_3 = concentration of constituents in cooling tower blowdown (Att. C-1, Table Va).

Blowdown is the major source of chemical constituents with 70 percent of the total wastewater stream. Therefore, the range of blowdown chemical constituent concentrations shown on pages II-6 and II-7 were assessed in determining the range of the combined wastewater stream's quality, while conservatively assuming constituents in the remaining two waste streams would always be present at their maximum concentrations.

Details concerning the flow rates used are given in Att. C-1 page II-9b under "Mixing of Waste Streams into Discharge 001."

C.3.4 Pollutant Redistribution in the St. Johns

General

Modeling dualism separating the near- and far-field regions was utilized in assessing the combined wastewater stream pollutant redistribution in the St. Johns River during the design (MAF) condition (see Section C.1.1). The models, which are discussed in detail in Section C.4 along with model assumptions and verification included a near-field turbulent jet dispersion model and far-field hydrodynamic and water quality models.

Results of the near-field assessment (NEWJET) of thermal and chemical impacts for various ambient velocities are presented in Figures C-7 through C-12. The velocity vectors computed with TIDAL2 for three different periods of the tidal cycle relating to slack tide, flood tide, and ebb tide during the seven-day MAF are shown in Figures C-13 through C-15. Results of the far-field water quality assessment (WQUAL2) in terms of the percent remaining of the initial excess constituent concentration are presented in Figure C-16.

Thermal Discharge Assessment

For the near-field thermal analysis both winter and summer conditions were investigated using the data presented in Att. C-1, Table VI. The temperature differential of +27°F (ΔT - 27°F) with an ambient of 59°F shown on Figures C-7 through C-9 was selected as the design winter scenario for assessment of potential incremental rise in ambient water temperatures. This condition requires the simultaneous occurrence of the minimum measured winter water temperature at the USGS Palatka station and the measured winter meteorological conditions providing the least cooling of the recirculation water. In addition it requires a temperature rise across the condensers of at least 27°F. The differential of 3°F with an ambient of 90°F shown on the above figures, was selected as the design summer scenario for assessment of potential maximum water temperatures. This condition requires the simultaneous occurrence of the maximum measured summer water temperatures and the measured worst-case meteorological conditions.

For the far-field thermal analysis shown in Figure 5.2-3 only one scenario was investigated. A temperature differential of 12°F (ΔT = 12°F) with an ambient of 61°F was utilized as the design worst-case scenario for assessment of potential incremental rise in ambient water temperatures in the far field. This scenario represents the maximum measured differential between average monthly ambient and blowdown temperatures (Att. C-1, Table VI). The duration of the far-field assessment (seven-days) minimizes the possibility of a more critical combination of temperatures (ΔT > 12°F) enduring for a period of time sufficient to significantly alter the model results.

A far-field assessment of maximum temperature impacts that may occur under summertime conditions was not conducted, as the 3°F increment between maximum blowdown and ambient water temperature would be undetectable by the far-field WQUAL2 simulations. Figures C-7 through C-9 indicate the 93.0°F maximum POD effluent temperature should be reduced to 90.1°F within 250 feet of the POD, thus making a far-field assessment unnecessary.

Chemical Discharge Assessment

The near-field assessment of chemical impacts shown on Figures C-10 through C-12 utilized a ΔT of 27°F while the far-field WQWAL2 assessment shown on Figure C-16 utilized a ΔT of 12°F. These differentials represent the maximum values discussed in the preceding thermal discharge assessment section. The use of maximum ΔT values provides conservative results, as the greater the effluent/ambient temperature differential, the greater the surface area affected before constituent concentrations are diluted to within state standards.

C.3.5 Interpolation of Near-Field/Far-Field Model Results

General

The near-field/far-field modeling dualism discussed in Section C.4 was formulated with regard to the then-current regulatory emphasis on mixing zones in relationship to stream width. The modeling program was presented to the Florida DER in a Plan of Study (Dames & Moore, 1978) and approved in a DER memorandum dated February 20, 1978 from George Horvath to Hamilton Oven (DER, 1978a).

Subsequent to the August 4, 1978 issuance of the EA, Chapter 17-3 of the Rules of the Department of Environmental Regulation was revised and the application of mixing zones was altered. The current regulations in Section 17-4.244 (DER, 1979) pertinent to the estuarine system (DER, 1978b) of the St. Johns require that:

(g) In lakes, estuaries, bays, lagoons, bayous and sounds, the area of a mixing zone shall be 125,000 square meters unless a lesser area is necessary to prevent significant impairment of a designated use. In no case shall a mixing zone be larger than that necessary to meet water quality standards.

However, the grid size of the far-field water quality modeling effort was larger than the zone of mixing allowed by 17-4.244. Therefore, determination of mixing zone surface areas for conservative constituents which may buildup due to flow reversals requires interpolation of the existing near-field/far-field data.

The required interpolation was discussed on December 7, 1978 in a meeting involving the Florida DER, Seminole Electric Cooperative and Dames & Moore. The DER agreed to an interpolation of existing model data and requested a detailed description of the assumptions and methodology involved. The following sections summarize a Mixing Zone Assessment Report (Dames & Moore, 1979) presented to DER on January 19, 1979.

Interpolation Model - General Form

From Ward and Espey (1971) the decay of the conservative effluent constituent concentratons should be expected to take the form;

$$C_x = C_o e^{ax} \qquad (2)$$

where:

C_x = effluent constituent concentration at distance x from the Point of discharge (POD)

C_o = initial effluent constituent concentration.

a = logarithmic decay rate coefficient (1/ft).

x = distance from the POD (ft).

In addition, the logarithmic decay rate coefficient "a" should experience a decrease with distance from the POD (Ward and Espey, 1971). Therefore, the form of the equation for "a" was taken to be:

$$a = z_1/(x + z_2) \qquad (3)$$

where:

a = as above
x = as above
z_1 = dimensionless constant
z_2 = constant (ft)

Combining equations 2 and 3, the general form of the interpolation model is:

$$C_x = C_o e^{z_1 x/(x+z_2)} \quad (4)$$

Application of Model

The general equation (4) was solved along four radials from the POD (Lines A, B, C, and D shown on Figure C-16). Line E was assumed to posses essentially the same decay characteristics as Line A. Similarly, the decay of constituent concentrations north of the POD was assumed to be equivalent to decay characteristics south of the POD. Therefore, the resulting mixing zones shown on Figure C-17 are symmetrical about an east/west axis through the POD.

This assumption is conservative as the discharge nozzle is oriented at an angle of approximately 135° from the bank towards the center of the river. Wind induced ambient velocity vectors with an angle of incidence to the shore greater than shown in Figures C-13 through C-15 may occur. However, available meteorological data indicate southerly winds producing such conditions are unlikely to persist long enough to increase the conservative values north of the POD determined as described above.

The applicability of equation (4) was tested as described below and found to provide an acceptable approximation of the data obtained from the near-field/far-field modeling effort.

Solution of General Interpolation Model

Rearranging equation (2) produces the following equation for "a" if C_o is taken to be unity:

$$a = \ln C_x^{1/x} \quad (5)$$

If values for C_x are available at two distances, x_1 and x_2, along each radial shown in Figure C-16 (Lines A, B, C, D), then equation (5) may be solved to obtain two unique values for "a." The resulting "a" values may then be used with equation (3) to obtain values for z_1 and z_2 which provide solutions for equation (4) between points x_1 and x_2 along the radials from the POD.

Each solution must be tested against known C_x values at additional distances (x) from the POD to determine its general applicability as an interpolation model along the radial for which it was derived.

Selection of Input Data

The far- and near-field models provided dimensionless data for C_x in terms of the percent remaining of the initial POD excess concentration as shown on figure C-16 and Table C-15, respectively.

The region of primary concern for the interpolation model lies between the POD and the nearest far-field grid points (Figure C-16, Grids Point E8/N18, E8/N17, E7/N17, E6/N17, E6/N18). Therefore, C_x values for use in solving equation (5) as described above should lie in this region.

The near-field model results shown in Table C-15 represent the maximum rate of decay of excess constituent concentrations that may occur in the vicinity of POD. These values represent minimum remaining effluent constituent concentrations, as the effect of flow reversals are not included. However, as the distance from the POD decreases, the accuracy of the concentrations shown in Table C-15 increases. This can be demonstrated with the following relationship:

$$C_R = y(C_D - C_a) + C_a \qquad (6)$$

where:

C_R = total concentration of constituent; excess concentration plus ambient concentration.

y = ratio of remaining excess to initial excess, C_x.

C_D = concentration of constituent at POD.

C_a = ambient concentration of constituent.

Table C-16 is developed with equation (6) for a hypothetical scenario in which an initial dimensionless ambient concentration of 0.0 is increased to 0.2 by a flow reversal. From the table it is seen that the impact of flow reversals on the near-field assessment decreases as the distance from the POD decreases. However, a distance of five feet from the POD was assumed to be the closest distance at which the near field assessment provided reasonable results due to the five-foot depth and 20° upward angle of the discharge nozzle.

The near-field assessment may be used to verify that the value of C_x at five feet from the POD (C_5) should be no less than 60 percent of the initial excess. However, if the plume experienced no effective dilution due to flow reversals, the value of C_5 could be 100 percent of the initial excess. The range for C_5 may therefore be assumed to be a ratio of from 1.0 to 0.6 of the initial excess. As discussed below, an average between the two C_5 ratio values or 0.8 provided solutions to equation (4) which reasonably approximated the near-field/far-field model data.

Interpolation Model Parameters and Verification

Using $C_5 = 0.8$ for each radial in conjunction with the closest far-field concentration (Figure C-17), equation (3) was solved for z_1 and z_2. The resulting values for each line are shown in Table C-17.

The interpolation model values for C_x for each radial were compared with the near-field/far-field results as shown in Table C-18 to determine their general applicability. Note that the interpolation models provide dimensionless values for C_x which are higher than the near-field model data but which are approximately equivalent to the far-field model data. The results are reasonable, as the near-field model does not reflect excess constituent concentration increase due to the flow reversals. The close fit with the far-field data indicates that the general function (equation [3]) for the logarithmic decay rate coefficient "a" is appropriate.

C.3.6 Determination of Mixing Zones

Required mixing zones were determined for the parameters listed in Att. C-1, pages II-6 and II-7 that may be discharged at concentrations in excess of state standards. The effluent constituent concentrations shown in Table C-19 will be reduced to levels below Florida DER (1979) standards within the maximum allowable mixing zone when ambient values are equal to or less than the values included in the table.

The reduction in initial excess, C_x, required for each parameter is shown in Table C-19. Applying equation (4) with the required C_x values from Table C-19 and the parameters shown in Table C-17, the dimensions of the mixing zones were determined to be as shown in Table C-20 and Figure C-17.

C.3.7 Chemical Buildup at Intake

If an upstream flow with a sustained on-shore wind persists for a period of time sufficient for total recirculating water replacement, the incremental constituent concentration (total concentration-original ambient concentration) may increase over non-buildup conditions. The assessment is described below.

The initial excess concentration of the blowdown, due to the factor of four reconcentration of makeup may be represented by:

$$C_{eo} = 4C_{ao} - C_{ao} = 3\ C_{ao} \qquad (7)$$

where:

C_{eo} = initial excess blowdown concentrations
C_{ao} = initial St. Johns River ambient concentrations

The initial excess blowdown concentrations, C_{eo}, will be diluted before reaching the intake and the ambient concentration of the makeup water will be increased as follows:

$$C_{a1} = C_{ao} + (C_{eo})P \qquad (8)$$

where:

C_{a1} = ambient concentrations of makeup water after wastewater plume reaches intake.

P = maximum percentage of C_{eo} to reach the makeup water

C_{eo} = as defined

C_{ao} = as defined

This increased ambient makeup water concentration, C_{a1}, will be reconcentrated four times if it persists at the intake long enough to completely replace the recirculating water (1 cycle). The blowdown excess concentration after one complete replacement cycle of recirculating water would then become:

$$C_{e1} = 4C_{a1} - C_{a1} = 3C_{a1} \qquad (9)$$

where:

C_{e1} = excess blowdown concentration after one replacement cycle.

C_{a1} = as defined

The incremental blowdown excess is given by:

$$C_{ex} = C_{e1} - C_{eo} \qquad (10)$$

where:

C_{ex} = incremental excess concentration of blowdown (increase in blowdown excess concentration due to the buildup of constituents at intake)

C_{e1} = as defined

C_{eo} = as defined

The incremental excess concentration would be diluted before reaching the intake. The total concentration at the intake would then be given by:

$$C_{a2} = C_{a1} + (C_{ex})P \qquad (11)$$

where:

C_{a2} = ambient concentration of makeup water after diluted incremental blowdown excess reaches intake

C_{a1} = as defined

C_{ex} = as defined

P = as defined

By combining Equation 7 through Equation 11, C_{a2} may be found by:

$$C_{a2} = C_{ao}\ (1 + 3P + 9P^2) \qquad (12)$$

Equation 13 may be rewritten in the following general form:

$$C_{ai} = C_{ao}\ (1 + 3P + 3^2p^2 + \ldots + 3^iP^i) \qquad (13)$$

where:

i = the number of cycles of complete replacement of recirculating water with makeup water at higher chemical concentrations.

C_{ai} = concentration of chemical constituents at intake after "i" cycles of recirculating water replacement.

C_{ao} = as defined

P = as defined

The above formulation requires the assumption that the buildup will occur in distinct steps rather than as a continuous process. It also neglects the alteration of blowdown chemical constituent concentrations due to the other two waste streams combined with the blowdown before discharge to the St. Johns River.

The analysis does indicate, however, that buildup of constituents would not be a problem. Assuming the intake is approximately 500 feet from the POD, the "P" value from Section C.3.5 should be no more than 2.5 percent. With this "P" value, the successive terms in equation 11 become insignificant after only three cycles of recirculating water replacement.

C.4 MATHEMATICAL MODELS

C.4.1 General

A complement of mathematical models was selected to assess the impact of the combined wastewater stream constitutents on the St. Johns River. Specifically, these models included:

a. A hydrodynamic model, TIDAL2, to simulate the flow and circulation patterns in the river as influenced by the tidal flow;

b. A water quality model, WQUAL2, to simulate the far-field thermal and conservative constituent concentrations in the river under a range of discharge and flow conditions; and

c. A jet dispersion model, NEWJET, to simulate the near-field impact of the thermal and conservative constituent discharge.

The models TIDAL2 and WQUAL2 are proprietory computer software developed by Dames & Moore. These models are depth-averaged, two-dimensional numerical models and are suitable for examining the far-field impact of the proposed thermal and conservative substance discharges. The model NEWJET is an integral-profile type of three-dimensional model for buoyant surface plumes developed by Shirazi and Davis (1974). This model is suitable for analysis of the near-field impact of the proposed near-surface discharges.

Fuller details of these models, reasons of choice, and their limitations are discussed in the following sections.

C.4.2 Description of Far-field Models

General

The far-field models TIDAL2/WQUAL2 utilized to simulate the pollutant redistribution patterns in the St. Johns are derived from the well-known and widely employed models developed by Leendertse and coworkers (1970). The general modifications made by Dames & Moore fall into the following categories:

1. Ease of specification of input data;
2. Development of sophisticated input and output subroutines;
3. Definition of the model variables on a 2-grid system rather than the 3-grid system employed by Leendertse; and
4. Enhancement of the stability properties by optional use of the widely employed "donor" cell approach for convective formulation rather than the centered approach.

For the problem studied, none of these modifications are likely to make any significant differences in the conclusions obtained from Dames & Moore models as compared to those obtained by the use of Leendertse's models. The employment of optional "donor cell" difference is likely to alter the numerical dispersion and diffusion characteristics of the model to a certain extent. However, this practice has a number of advantages for convection dominant flows and is widely employed (Roache, 1972). Leendertse's models have been exposed to technical scrutiny for over a decade and have drawn very favorable comments from the technical community. In support of these statements is Orlob (1972).

The predictions from Leendertse's models and from the Dames & Moore models have been compared with field data and analytical solutions. The various aspects of these models, including calibration and validation, have been published in the open literature. Authors offering some supportive evidence are Runchal (1976), Runchal (1978), Dames & Moore (1977), Leendertse and Liu (1975), and Liu (1974).

The Hydrodynamic Model, TIDAL2

The local circulation patterns and water heights in the St. Johns River, in the vicinity of the site were simulated by the hydrodynamic model TIDAL2, based on the classical shallow-water equations (Stoker, 1957).

The particular form of the equations used here is derived by integration of the three-dimensional, time-dependent set of hydrodynamic equations over the vertical dimension. This results in a two-dimensional, time-dependent set of equations of mass and momentum balance, in which the horizontal components of velocity represent "depth-averaged" values. The physical mechanisms that are accounted for in the equations governing momentum exchange are: local and convective accelerations, pressure variations in the water body, Coriolis force, bottom friction, surface wind drag, and atmospheric pressure variations. Other mechanisms, such as the intrafluid viscous forces which likely play only a minor role, were omitted.

The symbolic form of these equations for TIDAL2 are given below:

Momentum Balance

$$\partial_t U + U\partial_x U + V\partial_y U = C_w W^2 H^{-1} \cos\theta$$

$$-g\partial_x \eta - \rho^{-1}\partial_x Pa + \Omega V - C_1(U^2 + V^2)^{1/2} U H^{-1} \qquad (14)$$

$$\partial_t V + U\partial_x V + V\partial_y V = C_w W^2 H^{-1} \sin\theta$$

$$-g\partial_y \eta - \rho^{-1}\partial_y Pa - \Omega U - C_1(U^2 + V^2)^{1/2} V H^{-1} \qquad (15)$$

and

Mass Balance

$$\partial_t \eta + \partial_x (HU) + \partial_y (HV) = 0 \qquad (16)$$

Two auxiliary relations which accompany the above equations are:

$$\eta = H - h, \qquad (17)$$

$$C_w = C_2 + C_3 \ (\mathrm{MAX}\ (o., (1 - W_o/W)^2) \qquad (18)$$

The notation used in the above equations is as follows:

C_1 is a bottom stress coefficient;

C_w, C_2, C_3 are wind stress coefficients;

g	is the coefficient of gravitational acceleration;
h	is the depth of water below a horizontal datum plane;
H	is the total depth of water;
Pa	is the atmospheric pressure;
t	is the time coordinate;
U,V	are the "depth-averaged" horizontal velocity components in the directions of x and y respectively;
W	is the wind velocity;
W_o	is a reference wind velocity;
$x,y,$	are a set of mutually orthogonal coordinates in the horizontal directions;
η	is the departure of the water surface measured positive upward from the datum plant;
ρ	is the mass density of water;
Ω	is the Coriolis parameter; and
θ	is the direction of wind measured from the positive direction of x towards the positive direction of y.

The above equations, when solved with appropriate boundary and initial conditions, yield the time history of water movement (via U, V, η, as a function of x and y).

The equations (14 to 16) form a set of coupled non-linear hyperbolic equations for which no general solution can be obtained by known analytical means. At present, the best solution techniques seem to be of the numerical kind, and one such was used in the present work.

The numerical method adopted to solve the set of shallow-water equations is an Integrated Finite-Differences (IFD) scheme (Runchal, 1977). Numerically, the scheme may be described as space-staggered, split-time-level and semi-implicit. It has been shown that this scheme is especially efficient in preserving the amplitudes and propagation speeds of waves over long-term integration and is numerically stable (Runchal, 1977).

For numerical solution, the area is covered by an interlaced spatial grid. The grid for η, is considered to be the primary grid; the locations of U-nodes are space-staggered in the x-direction to lie midway between the η-nodes; in a similar manner V-nodes lie midway between the η-nodes in the y-direction.

The IFD equations are derived by integrating the differential equations (14 to 16) for U, V, and η, individually for each of the grid notes over an area.

The Water Quality Model, WQUAL2

The far-field water quality was simulated by Dames & Moore Water Quality program WQUAL2, for both transient and steady states.

Similar to TIDAL2, the numerical solution method of WQUAL2 is also based on IFD schemes. The governing mathematical equations are derived by integration, in vertical direction, of the basic three-dimensional, time-dependent equations of mass balance. A typical governing equation is given by:

$$\partial_t(HQ) + \partial_x(HVQ) + \partial_y(HVQ) = \partial_x(HD\partial_x Q) + \partial_y(HD\partial_y Q) + m'Q+S \quad (19)$$

where:

H is the depth of water;

m' is the local volumetric inflow rate of water per unit surface area of the bay;

S is the local volumetric load rate from sources (such as that resulting from discharge effluents);

t is the time coordinate;

U,V are the horizontal velocity components in the x and y directions, respectively;

x,y is a set of mutually orthogonal horizontal coordinates;

D is the diffusivity coefficient for the property Q, and

Q is the water quality parameter in appropriate units.

The numerical method adopted to solve equation 19 is an IFD scheme derived in a manner similar to that for TIDAL2. For numerical solution, the area of interest is covered by an interlaced spatial grid. The grid for Q is considered to be the primary grid; the locations of U-nodes are space-staggered in the x-direction to lie midway between the Q-nodes in the y-direction.

The IFD equation is derived by integrating the differential equation for each of the grid nodes over a control volume surrounding each of the nodes.

C.4.3 Description of Near-Field Model

The near-field model employed by Dames & Moore is one of the most widely employed and recommended models for surface discharges. the model was developed by Shirazi and Davis (1974) from an earlier model proposed by Prych (1972) and forms the basis of the EPA workbook on thermal plumes. The Dames & Moore version of this model is named NEWJET.

The mathematical basis of this model is essentially in the three-dimensional equations of mass balance, which are simplified by assuming Guassian type profiles for the water quality parameters. In its original form the model was developed and employed for thermal plumes. However, with a minor change by the elimination of the surface heat loss terms, the model is equally well applicable to a conserved constituent, such as chemical constituents, in a buoyant jet. Numerous papers have been written on the model and it has been well calibrated, verified, and employed (Dunn and others, 1975).

At the time of the modeling effort the location of the discharge structure was not finalized. To ensure conservative results, a surface rather than a submerged discharge was utilized. As presently envisioned the discharge nozzle during mean low water levels is one foot off the bottom and five feet below the surface with an upward angle of

20°. The assumption of a surface discharge is conservative relative to dilution and surface mixing zone areas as less of the vertical water column is involved with the discharge in the immediate vicinity of the POD.

The NEWJET Model requires treatment of the estuarine conditions in the river in terms of a number of quasi-steady state scenarios. This is a widely employed engineering practice, and numerous examples of such studies by a number of respected practitioners can be cited (Dunn and others, 1975).

C.4.4 Model Assumption

Stratification and Baroclinic Pressure Gradient

The data base indicates that no significant temperature or salinity stratification exists in the reach of the river under investigation. The available salinity (chlorides) data between Palatka and the river mouth indicates that the salinity in the relevant reach of the river is much less than 1 part per thousand (Reynolds, Smith & Hills, 1974).

Further, in the vicinity of the site, the St. Johns River has a width of approximately 5000 feet, and the depth varies from a few feet to 15 feet (depths in the relatively narrow navigation channel range from 13 to 23 feet). The average depth is on the order of 10 feet. In addition, the proposed site is approximately 73 miles upstream from the mouth of the river. Under these conditions, it is unlikely that density stratification will occur or that significant saline instrusion will take place so far upstream from the mouth of the river.

The influence of tidal excursions on the St. Johns should not be confused with saline intrusion. The estimated time of propagation of a pressure wave from the mouth of the river to the site, with an average depth, for example, of 10 feet, and a speed of 18 fps, is roughly 6 hours. On the other hand, the corresponding time of travel of water mass, even presuming a constant net upstream speed of 0.5 fps, is 214 hours. This latter period represents approximately 17 tidal cycles. Saline intrusion cannot be calculated by such a simple method, as the processes of diffusion and tidal exchanges are significant contributing factors. Nonetheless, the above simplified assessment indicates significant saline intrusion is highly unlikely to persist or progressively propagate over such a long distance in waters as shallow as 10 feet in the face of the net downstream freshwater flow of the St. Johns River.

From Ward and Espey (1971) the terms neglected by the Dames & Moore models (and also Leendertse's models), with the possible exception of the baroclinic pressure gradient, are usually or justifiabily ignored in prevalent mathematical modeling practice. Some of the most widely employed models have chosen to ignore the effect of these terms in varied conditions. For the present study, the magnitude of these terms is likely to be small in comparison to the other terms. An order of magnitude estimate is made in the manner of Ward and Espey (1971) below.

From the data of Reynolds, Smith, and Hills (1974), it is seen that, under the worst conditions reported (extreme low net flow) the chlorides in the 10-mile region immediately downstream of Palatka show a rise from 0.2 parts per thousand to 2 parts per thousand. The net change in density is approximately 0.0015 g/cc. The average baroclinic pressure gradient for a 10-foot depth is estimated as (Ward and Espey, 1971):

$$i = \frac{1}{2} H \frac{\Delta\rho}{x} \tag{20}$$

where: i = the average baroclinic pressure gradient

H = the average water depth in feet,

$\Delta\rho$ = the change in density, and

x = the horizontal distance, in feet, over which the density change takes place.

Substituting the appropriate values in the equation, the average baroclinic pressure gradient becomes:

$$i = \frac{1}{2} \times 10 \times \frac{0.0015}{10 \times 5280} \simeq 1.4 \times 10^{-7}$$

For the reported high net flow condition, the value of the gradient, "i", is nearly zero.

The value of the gradient of the tidal forcing function, for a typical tidal range of 1.0 foot, is calculated to be approximately

$$\frac{\partial \eta}{\partial x} = \frac{\Delta \eta}{t\ C} \tag{21}$$

where: $\Delta\eta$ = the vertical departure of the water surface during a typical tidal cycle measured from a datum plane, taken as 1.0 foot;

t = the time, in seconds, from high tide to low tide; and

C = the estimated tidal wave celerity; taken as 18 feet per second (see Section C.4.6).

Substituting the values in the equation, the approximate magnitude of the tidal forcing function is:

$$\frac{\partial \eta}{\partial x} = \frac{1}{18 \times 12.5 \times 3600 \times 0.5} \simeq 2.5 \times 10^{-6}$$

Thus, the baroclinic pressure term is more than an order of magnitude smaller than the tidal pressure term. It was therefore assumed that this term would have insignificant effect on the reach of the water body under study.

"Diving Plume" Condition

The "diving plume" conditon was not assessed because the maximum surface area impact will occur under buoyant plume conditions. The conclusion is supported by the available literature such as Prych (1970) concerning the effects of density difference on lateral mixing in open channel flows.

DER regulations allow a mixing zone within which the numerical pollutant concentration standards are not applied. If the mixing zone required for a buoyant plume is acceptable, then that for a diving plume will be likewise.

Buoyant plume conditions are in compliance with DER mixing zone standards except during periods when ambient concentrations approximate DER standards. During such periods the high ambient concentrations will result in a contravention of the standards that is independent of pollutant material added to the river from plant operation.

Wind and Bottom Friction Terms

Wind terms were taken to be zero in recognition of area meteorological conditions. This is a conservative assumption as far as surface areal impact is concerned.

The bottom friction coefficient of 0.01 was selected in accordance with accepted engineering practice (Dronkers, 1964). Further support for this value came from our calibration of the model with the observed tidal range and phase at Palatka (Section C.4.6).

C.4.5 Far-Field Dispersion Coefficients

General

The physics of turbulent mixing which lead to dispersion of a pollutant in a water body are not clearly understood at this time though a considerble amount of research is being conducted. For practical problems turbulent mixing is often taken account of by introducing an eddy diffusivity coefficient much in the manner of the molecular diffusivity coefficient. However, unlike the latter, the eddy diffusivity coefficient is not a physical property of the fluid but is governed by the conditions of flow (Tennekes and Lumley, 1972).

In mathematical modeling studies the governing flow equations are often solved by numerical discrete-space methods such as the finite-difference techniques. Typically, the governing equations are solved over discrete time and space intervals; this process may be conceptually likened to time and space integration (or averaging) of the governing equations much in the manner of the Reynold's averaging of the turbulent flow processes (Deardorff, 1971; Nihoul, 1975; Spraggs and

Street, 1975). This process is then equivalent to the introduction of a numerical eddy diffusivity often called SGS (for sub grid scale) eddy coefficient.

The magnitude of the turbulence and the SGS eddy diffusivity coefficients are discussed below.

Turbulent Eddy Diffusivity

A number of alternative hypotheses have been proposed to estimate the magnitude of the turbulent eddy diffusivity coefficient. Several were employed as shown below to obtain a range of values for the Seminole mathematical model study.

Elder's Hypothesis

According to Elder's hypothesis, an estimate of the eddy diffusivity coefficient, K, may be obtained from (Ward and Espey, 1971):

$$K = 5.93\ Hu^* \qquad (22)$$

where u* is the friction velocity and H is the depth of water.

Further, from Manning's formula:

$$u^* = \frac{n}{1.486}\, g^{1/2} H^{-1/6} u \qquad (23)$$

where g is the gravitational coefficient, n is the Manning factor, and u is a representative velocity scale.

For the reach of the St. Johns River under study, we may assume that n = 0.035 (typical for a rough-bed channel), H = 10 ft (typical value at the site) and u = 0.5 fps.

Thus:

$$u^* = 0.045 \text{ fps} \qquad (24)$$

and $K = 2.68\ ft^2/s$ (25)

Modified Taylor's Hypothesis

The Taylor's hypothesis as modified by Holley and Harleman (Ward and Espey, 1971) for longitudinal dispersion in oscillating tidal flow is given by:

$$K = 100\ n\ \ u\ H^{5/6} \qquad (26)$$

With the same values for n, u and H as before, this yields

$$K = 11.8\ ft^2/s \qquad (27)$$

Kolmogorov's Similiarity Hypothesis

According to Kolmogorov's similarity hypothesis, the dispersion in the inertial subrange can be expressed as (Orlob, 1959; Brandsma and others, 1976):

$$K = A\ L^{4/3} \qquad (28)$$

where A is an empirical coefficient and L is a representative length scale. In empirical practice, equation (28) has been employed over a wide range of conditions including those representative of estuarine and oceanic conditions.

The value of the coefficient A is somewhat uncertain and a range of values from $1.5x10^{-4}$ to $9x10^{-3}$ ($ft^{2/3}/s$) have been reported with the higher numbers being atypical.

For the St. Johns River, a length scale of 5000 feet, on the order of width of the river, may be taken as representative of the far-field dimensions of the thermal plume. Thus, the range of eddy diffusivity coefficients according to equation (28) is calculated as:

$$K = 12.8\ ft^2/s \text{ to } 769.5\ ft^2/s \qquad (29)$$

A representative value with $A = 5x10^{-4}$ is:

$$K = 42.7\ ft^2/s \qquad (30)$$

SGS Eddy Diffusivity

The SGS eddy diffusivity coefficient is typically taken to be a function of the grid size employed for the modeling study and some kinematic properties of the flow. An approximate value may be obtained from (Deardorff, 1971):

$$K_s = 0.71\ C^2\ \Delta^2\ \ D \qquad (31)$$

where C is an empirical constant, Δ may be taken as the typical grid size and D is the magnitude of the local velocity deformation calculated on the finite difference grid. An approximate estimate of D for St. Johns River is obtained from:

$$D \simeq C_1\ \delta\ u/\Delta \qquad (32)$$

where C_1 is a constant and δu is a typical velocity difference.

Thus from (31) and (32):

$$K_s \simeq 0.71\ C_1\ C^2\ \ \Delta\delta u \qquad (33)$$

For the Seminole study, a representative value of Δ may be taken as 1000 ft and that δu as 0.5 fps. Thus:

$$K_s \simeq 350\ C_1\ C^2\ \ ft^2/s \qquad (34)$$

The value of C_1 may be taken to be 2 and that of C has been quoted in the range of 0.1 and 0.4. Thus:

$$K_s = 7 \text{ to } 112\ ft^2/s \qquad (35)$$

With a representative value of C as 0.2, the SGS coefficient is given as:

$$K_s \simeq 28\ \ ft^2/s \qquad (36)$$

Conclusion

From the above discussion the estimates of the magnitude of the turbulent eddy diffusivity for the Seminole study ranges from 2.7 to 770 ft^2/s and that for the SGS coefficient from 7 to 112 ft^2/s. The values for the turbulent eddy diffusivity determined in equations 27 and 30 were assumed to be the most representative based on the available literature quoted in the preceeding sections. The SGS coefficient shown in equation (36) was utilized based on information provided by Deardorff (1971).

The cumulative composite value for the diffusivity coefficient should therefore be in the approximate range of from 40.0 to 71 ft/sec. Considering the uncertainties of the process, a value of 50 ft^2/s was employed for the study. As the pollutant transport processes are strongly affected by the convective flow processes, reasonable changes in the value of the eddy diffusivity coefficient are unlikely to have any substantial impact on the model predictions.

C.4.6 Model Verification

For the hydrodynamic simulation, the basic long-term input data consisted of measured values of current and tidal height at the Palatka gaging station and the tidal data at the Rice Creek station. The current record at Palatka was employed to provide the upstream boundary conditions, while the tidal data were employed both for downstream boundary conditions and for calibration.

The model input requires water heights and velocities at each open boundary grid point during the entire tidal cycle. This input was estimated from the tidal and velicity records obtained from the USGS station at Palatka. The gaging station provides continuous data at one measurement point on the river cross section. The program TIDAL2 (and WQUAL2) requires the input at each grid point at the upstream and downstream open boundaries. It was assumed that the flow conditions across the upstream boundary (Palatka) and the water height across the downstream open boundary were uniform. The upstream boundary conditions consisted of the measured velocity taken to be uniform across the opening. The downstream open boundary conditons were obtained by estimating the phase shift and variation of amplitude between the boundary and tidal (stage) data at Palatka.

For an average depth of approximately 10 feet, the wave celerity in the vicinity of the site should vary from approximately 16 to 18 ft/sec. The 4 miles between the Palatka and Rice Creek stations should produce a time lag of 20 to 22 minutes based on the above wave celerity. This value compares very well with the measured time lag between the two stations as obtained from USGS records (Figure C-18) thus confirming the wave celerity estimate of 16 to 18 ft/sec. Based on this estimate, the phase difference between the extreme boundaries of the study reach is 40 to 45 minutes.

In addition to the phase shift, the amplitude was also estimated. An amplitude was selected that enabled the model to reproduce, with a negligible margin of difference, the measured conditions at the Palatka station. After some experimentation, the Palatka stage records with an amplitude amplification factor of 1.05 and a phase lead of 45 minutes were employed at the downstream boundary.

The predicted tidal heights at the Palatka station in comparison with the measured values for the period of minimum absolute flow conditions are shown in Figure C-19. As shown, the maximum difference between the computed and measured values is on the order of 0.1 ft, and in general the two curves are seen to be in satisfactory agreement.

C.4.7 Applicability and Limitations of the Models

The TIDAL2 and WQUAL2 Models

Both the TIDAL2 and WQUAL2 are depth-averaged models and this represents their single most prominent theoretical limitation. In essence, the models therefore are most suitable for water bodies with near-uniform condition with depth at any location--in other words, for water bodies with little or no stratification. Such conditions are expected to prevail in the St. Johns as discussed in Section C.4.4.

Although stratification may develop in the immediate vicinity of the discharge, the ambient mixing and loss of heat to the atmoshpere will cause the stratification to weaken or disappear away from the point of discharge. With discharge into shallow, well-mixed receiving water such as the St. Johns, the plume will quickly grow in depth to cover the entire column of water. The TIDAL2 and WQUAL2 are, therefore, suitable as tools for analysis of dilution and dispersion of wastewater in the St. Johns.

There are also some pratical considerations which, though not being limitations of the model, may yet limit the validity of the predictions. The TIDAL2 and WQUAL2 are very general and comprehensive models. Ideally, they need a very detailed and sophisticated level of input. This relates to the initial and boundary conditions, time histories of the flow rates and pollutant loads, the tidal and current history at open boundaries, and surface winds, diffusivity, and bottom-friction coefficients throughout the field of computation. Almost always, for any practical application, these inputs to the required detail and reliability, are not available. Thus, simplifying assumptions need to be made and these, in turn, limit the quality of the model predictions. This fact is of considerable importance both in comparing the predictions with the field data and in relating the predictions to the likely behavior of the water body.

For adequate resolution of the river reach of interest, compatible with the detail and reliability of input data, a discrete grid size of typically 1000 feet was employed for St. Johns River. Because only one value of water column depth is specified per grid cell, the model simplifies the irregular bathymetry in terms of rectangular prisms. The simulated grid node values will thus be representative of a water column typically 1000 by 1000 feet in horizontal extent and should not be interpreted as local point values.

NEWJET Model

The principal theoretical limitations of the NEWJET model are that it can only be utilized for buoyant plumes and it ceases to be valid once the wastewater discharge jet loses its initial momentum.

The applicability of the model to only that region in which the wastewater maintains a velocity should not be critical in the assessment of wastewater impacts. Under the low ambient velocities existing in the St. Johns River, the jet velocity should usually not be dissipated within 300 feet of the POD. As the far-field model is adequate for defining wastewater impacts within 500 feet of the POD, the region of ill-defined impacts is insignificant compared to the size of the St. Johns River.

Other less critical limitations of the model include: discharges are limited to rectangular or circular cross sections; the receiving water body is assumed to be quiescent or moving with a constant, uniform flow; the receiving water body is limited to homogeneous, unstratified conditions; wind effects are ignored; discharge is limited to a constant and uniform velocity and temperature; and the model ignores boundary effects such as shorelines and obstructions.

Consequently, the model does not provide a precise description of a real plume. It does, however describe a plume realistically as the real factors that have been ignored or idealized in the model generally do not become dominant. The utility of the idealized model for the St. Johns River is described below:

1. The effect of wind in the St. Johns estuary is minimized due to the lack of a prevailing wind direction.

2. The ambient conditions of the St. Johns may be assumed nearly constant when compared with the plume response.

3. The model provides meaningful results if the initial plume depth is small compared with the ambient water depth, as in the present study, regardless of bottom slopes.

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TABLE C-1

STREAMFLOW GAGING STATIONS ON ST. JOHNS RIVER, FLORIDA

Stations	Drainage Area (sq. mi.)	Discharge (cfs)	Discharge Per Sq. Mi. (cfsm)	Period of Record (m/y)
Melbourne	968	703	0.73	10/39-current year
Cocoa	1,331	1,060	0.79	10/53- "
Christmas	1,539	1,339	0.87	10/33- "
Deland	3,066	3,177	1.04	10/33- "
Palatka	7,117	7,613	1.07	01/68-02/76
Jacksonville	8,754	5,515	0.63	02/54-current year

Note: Station locations shown in Figure C-1.

Source: USGS, 1976.

TABLE C-2

COMPARISON OF SAMPLE STREAMFLOW RECORD AT PALATKA AND JACKSONVILLE

(Water Year Oct., 73 - Sept., 74)

	Jaunary		April		October	
Day	Palatka	J'ville.	Palatka	J'ville.	Palatka	J'ville.
1	14,000	4,090	14,900	21	22,400	11,900
2	11,000	-6,770	12,300	15,300	15,500	25,300
3	5,000	-49,100	9,930	-14,900	12,000	-1,700
4	12,000	1,850	10,700	-9,540	10,500	6,120
5	6,000	-42,800	4,150	-14,900	7,700	771
6	10,000	-2,920	756	-9,060	3,860	-19,700
7	13,000	7,660	6,150	-3,570	1,760	-30,400
8	10,000	-548	9,270	7,490	8,840	6,740
9	7,000	-11,600	699	-440	13,000	30,900
10	14,000	26,400	298	-24,000	10,600	850
11	8,000	-10,100	5,200	9,150	9,780	1,830
12	7,000	-16,200	6,670	-5,660	9,750	18,800
13	6,000	-16,300	8,130	4,910	9,730	6,540
14	10,000	-2,370	11,400	-8,030	9,210	43,100
15	12,000	1,400	9,690	11,900	16,100	17,400
16	16,400	31,800	4,590	5,910	17,400	26,000
17	16,700	-6,310	4,360	-11,100	9,780	13,700
18	11,200	-38,200	-2,660	-4,740	-753	-4,400
19	3,510	-43,100	1,630	-5,040	3,600	-21,700
20	9,310	-6,460	3,760	2,640	3,310	-20,500
21	11,200	-35,800	3,230	5,670	6,810	4,510
22	8,530	10,000	5,990	5,590	4,150	9,910
23	8,040	31,700	6,450	2,770	4,610	10,500
24	9,940	-11,000	3,840	-10,900	3,570	-1,780
25	10,200	24,600	-6,810	-13,400	6,700	8,610
26	11,800	17,900	-4,890	-9,220	11,300	10,400
27	11,100	17,900	49	2,580	16,900	23,300
28	12,700	-458	6,830	-15,000	18,000	19,300
29	12,800	498	6,160	9,880	22,300	48,300
30	10,000	1,480	10,300	20,900	24,700	56,300
31	5,000	-1,970			28,200	54,200

Note: Flow specified in cfs.
(+) downstream flow
(-) upstream flow.

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TABLE C-3

ST. JOHNS RIVER AND RICE CREEK ANNUAL FLOOD STAGES

Year	Measured State Records (ft.-MSL)	
	Rice Creek	St. Johns
1959	2.56	2.48*
1960	3.64	3.56*
1962	2.50	2.42*
1963	3.76	3.68*
1964	5.62	5.54*
1965	2.90	2.82*
1966	2.71	2.63*
1967	2.78	2.70*
1968	3.81	3.76
1969	3.87	3.71
1970	2.44	2.37
1971	2.71	2.60
1972	2.73	2.64
1973	**	2.98
1974	**	3.32
1975	**	2.78

---

*Approximated as discussed in Section C.1.1. High Flows.

**Data not available

Table C-4

REPRESENTATIVE TIDAL VELOCITIES AND RANGE

	MAF[a]		MUF[b]		MDF[c]	
	Ebb Tide	Flood Tide	Ebb Tide	Flood Tide	Ebb Tide	Flood Tide
Average Velocity (ft/sec)	+0.12	-0.12	-0.08	-0.13	+0.22	+0.12
Average Daily Tidal Range (ft)	1.25		1.1		0.6	
Maximum Stage of Period (ft MSL)	1.6		2.0		3.1	
Minimum Stage of Period (ft MSL)	-0.1		0.4		2.3	

---

a. Minimum absolute flow. Historical seven-day flow most closely approximating oscillatory conditions.

b. Maximum upstream flow. Historical seven-day flow with the maximum net upstream discharge.

c. Maximum downstream flow. Historical seven-day flow with the maximum net downstream discharge.

TABLE C-5

TRIBUTARY WATER DISCHARGE IN GENERAL SITE AREA IN CUBIC FEET PER SECOND PER SQUARE MILE (CFSM)

Stream Basin	Area (mi^2)	Discharge Water Year	Discharge cfsm	Average Discharge Mi^2 (cfsm)
Rice Creek near Springside	43.2	1974	1.10	.76
		1975	.52	
		1976	.66	
Etonia Creek at Bardin	219	1974	.28	.23
		1975	.22	
		1976	.20	

TABLE C-6

TRIBUTARY CHARACTERISTICS

	Area[a] (mi^2)	Average Discharge (cfs)	Unit Discharge[b] (cfsm)
Area "1"	2.7	2.05	.76
Mason Branch Area	6.5	4.94	.76
Fish Creek Area	4.7	3.57	.76
Area "2"	.5	.38	.76
Area "3"	6.25	4.75	.76
Mocassin Creek Area	1.9	1.44	.76
Cedar Creek Area	18.0	13.7	.76

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[a] Areas shown on Figure C-5.

[b] Determined from Table C-5.

TABLE C-7

USLE[a] COEFFICIENTS FOR SITE EROSION PROPERTIES

Property	Property Characteristics	Symbol	USLE Coefficient
Rainfall	-	R	350
Soil Erodibility	Tavares-Immokalee-Cassia series assoc.	K	.17
Slope Length Factor	1.5% slopes, 2000-3000 foot lengths	SL	.3
Cropping Management Factor	Forest with 40 to 70% tree canopy	C	.01 - .02
Erosion Control Factor	None practiced	P	1.0

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[a] Universal Soil Loss Equation (SCS, 1975). For application of equation see Section C.1.2.

TABLE C-8

WATER QUALITY DATA - ST. JOHNS RIVER[(a)]

Parameter Measured	Units	Measurements	Data Average	Maximum Value	Minimum Value	Beginning Date	Ending Date
Water Temp.	°C	68	23.9	30.5	8.5	62-08-16	77-05-20
Turb. JKSN	JTU	56	4.875	21	1	68-09-24	77-05-20
Specific Conductivity at 25°C	µmhos/cm	66	974	1400	510	62-06-08	77-05-20
DO	mg/l	64	6.6	11.6	2.7	68-04-26	77-05-20
DO saturated	%	57	76	107	35	68-04-26	77-05-20
BOD (5-day)	mg/l	35	2.1	8.2	.6	68-09-24	77-05-20
pH	units	51	6.1	9.4	5.4	62-06-08	77-05-20
Bicarbonate HCO_3	mg/l	48	102	150	48	62-08-16	77-02-25
Carbonate CO_3	mg/l	1	3	3	3	66-11-22	76-07-18
Phosphate PO_4 Tot	mg/l	5	.15	.24	.05	68-04-26	70-09-21
Ortho PO_4 Diss.	mg/l	7	.09	.16	.01	66-11-22	71-00-14
TOT Hard $CaCO_3$	mg/l	58	196.1	310	94	62-06-08	77-05-20
Ammonia Nitrogen Tot	mg/l	54	.05	.28	.01	68-09-24	77-05-20
Calcium Ca, Diss.	mg/l	52	47.7	78	30	62-06-08	77-05-20
Magnesium Mg, Diss.	mg/l	52	17.8	28	10	62-06-08	77-05-20
Sodium Na, Diss.	mg/l	48	121.6	180	70	62-06-08	77-02-25
Potassium K, Diss.	mg/l	48	4.5	8.8	1.2	62-06-08	77-02-25
Chloride Cl, Diss.	mg/l	57	220	400	120	62-06-08	77-05-20
Sulfate SO_4, Diss.	mg/l	48	64.7	114	37	62-06-08	77-02-25

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TABLE C-8 (Continued)

Parameter Measured	Units	Measurements	Data Average	Maximum Value	Minimum Value	Beginning Date	Ending Date
Arsenic As, Tot	µg/l	13	5.4	20	1	72-05-22	77-02-25
Cadmium Cd, Tot	µg/l	22	.64	6(b)	0	72-05-22	78-08-28
Chromium Cr, Tot	µg/l	11	<12.7	20	<9	70-05-18	77-02-25
Copper Cu, Tot	µg/l	12	3.25	10	1	72-05-22	77-02-25
Iron Fe, Tot	µg/l	16	218	560	40	72-05-22	77-02-25
Lead Pb, Tot	µg/l	23	13.9	74	0	72-05-22	78-08-28
Mercury Hg, Tot	µg/l	25	.175	.5	0	71-05-12	78-08-28
Manganese Mn, Tot	µg/l	14	15.7	30	6	72-05-22	76-05-18
Zinc Zn, Tot	µg/l	20	19.6	70	0	72-05-22	78-08-28
CO_2	mg/l	36	4.5	14	.1	62-08-16	77-02-25
Fec.Col.	/100ml	31	74.2	1200	5	74-01-16	76-11-10
Fecstrep	/100ml	2	27.5	50	5	76-12-21	77-05-20
Aldrin Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
DDD Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
DDT Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
DDE Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
Endrin Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
HCHLR Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
Lindane Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
Alkalinity ($CaCo_3$)	mg/l	48	73	123	39	62-06-08	77-02-25
Total Carbon (C)	mg/l	30	32.8	72	24	71-05-12	77-05-20

TABLE C-8 (Continued)

Parameter Measured	Units	Measure-ments	Data Average	Maximum Value	Minimum Value	Beginning Date	Ending Date
Silica SiO_2, Diss.	mg/l	48	4.4	14	.1	62-06-08	77-02-25
Flouride f, Diss.	mg/l	48	.3	.8	.1	62-06-08	77-02-25
Cobalt Co, Tot	µg/l	5	2	5	1	72-05-22	77-02-05
Nickel Ni, Tot	µg/l	3	2	3	1	73-05-25	76-05-18
Strontium Sr, Diss	µg/l	42	1086	8600	80	66-11-22	77-02-25
Aluminum Al, Tot	µg/l	3	83	150	40	70-05-18	76-05-18
Selenium Se, Tot	µg/l	5	5	10	1	74-01-16	77-02-25
Silvex	µg/l	0	0	0	0	75-07-22	75-07-22
Eldrin Whl Smpl	µg/l	0	0	0	0	68-09-24	68-09-24
Total 24-D	µg/l	6	.09	.28	.0	75-07-22	76-01-27
Total 245-T	µg/l	1	.04	.04	.04	75-07-22	76-01-27
TSS	mg/l	2	8	8	8	73-05-25	73-09-21
TDS Residue @180°	mg/l	48	578	935	378	62-06-08	77-02-25
Phenols	µg/l	1	1	1	1	68-09-24	70-05-18
Nitrite Tot	mg/l	41	.013	.10	.01	68-09-24	77-05-20
Nitrate Tot	mg/l	39	.098	.54	.01	62-06-08	77-05-20
KJELDAHL Nitrogen Tot	mg/l	50	1.0	2.5	.10	73-05-25	77-05-20

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a. EPA (1978a) STORET data file. Due to internal inconsistancies in the data and the limited data base, the above statistical summarization can only be used as a general indication of water quality.

b. A value of 100 µg/l was recorded in the EPA STORET data for 78/05/31. The value is two orders of magnitude higher than most other measured cadmium concentrations at St. Johns water quality stations. Based on an extensive examination of water quality stations in the St. Johns Basin, the 100 µg/l measurement was determined to be a data error.

TABLE C-9

WATER QUALITY DATA - RICE CREEK[(a)]

Parameter Measured	Units	Measure-Ments	Data Average	Maximum Value	Minimum Value	Beginning Date	Ending Date
Water Temp.	°C	17	28.9	30.0	25.0	67-05-12	73-09-26
Turb. JTU	JTU	7	15.3	20	2	70-09-28	73-09-26
Specific Conductivity at 25°C	mhos	14	564	1120	220	67-05-12	73-09-26
DO	mg/l	15	1.82	6.0	.1	67-05-12	73-09-26
DO saturated	%	10	17.8	77	1	67-05-12	72-09-27
BOD 5-day	mg/l	8	4.91	11	.5	70-04-29	73-09-26
pH	units	16	6.11	7.9	6.3	67-05-12	73-09-26
Bicarbonate HCO_3	mg/l	10	121.1	192	52	67-05-12	73-06-27
Carbonate CO_3	mg/l	0	0	0	0	67-05-12	73-06-27
Phosphate PO_4 T	mg/l	2	.99	1.1	.88	70-04-29	70-09-28
Ortho PO_4 Diss.	mg/l	2	.56	.85	.27	67-05-12	68-04-26
TOT Hard $CaCO_3$	mg/l	12	99.7	183	47	67-05-12	73-09-26
Ammonia Nitrogen Tot	mg/l	5	.05	.09	.03	71-09-14	73-06-27
Calcium Ca, Diss.	mg/l	12	28.2	50	13	67-05-12	73-09-26
Magnesium Mg, Diss.	mg/l	12	6.9	14	3.4	67-05-12	73-09-26
Sodium Na, Diss.	mg/l	11	91.8	172	32	67-05-12	73-09-26
CO_2	mg/l	1	6.6	6.6	6.6	73-06-27	73-06-27
Alkalinity (CaCO3)	mg/l	10	99.3	157	43	67-05-12	73-06-27
Carbon (C)	mg/l	5	48	57	42	72-05-10	73-06-26
Potassium K, Diss.	mg/l	11	2.6	3.8	1.3	67-05-12	73-06-26
Chloride Cl, Diss.	mg/l	11	102	242	10	67-05-12	73-06-26

(a) Source: EPA (1978b), STORET data file

TABLE C-9 (Continued)

Parameter Measured	Units	Measure-ments	Data Average	Maximum Value	Minimum Value	Beginning Date	Ending Date
Sulfate SO_4, Diss.	mg/l	11	43.4	78	16	67-05-12	73-09-26
Silica Sio_2, Diss	mg/l	11	6.8	9.0	5.8	67-05-12	73-09-26
Flouride F, Diss.	mg/l	11	.4	.6	.3	67-05-12	73-09-26
Arsenic As, Tot	ug/l	5	14	20	5	72-02-10	73-09-26
Cadmium Cd, Tot	ug/l	4	1	1	1	72-05-10	73-09-26
Cobalt Co, Diss.	ug/l	2	1	1	1	70-09-28	72-09-27
Copper Cu, Tot	ug/l	6	15.3	30	3	70-09-28	72-09-27
Iron Fe, Tot	ug/l	5	637	750	460	72-05-10	73-09-26
Lead Pb, Tot	ug/l	4	4.2	7	2	72-05-10	73-09-26
Manganese Mn, Tot	ug/l	5	45	70	20	72-05-10	73-09-26
Nickel Ni, Tot	ug/l	1	17	17	17	73-06-27	73-09-26
Strontium Sr, Diss.	ug/l	9	280	460	120	67-05-12	73-09-26
Zinc Zn, Tot	ug/l	6	141	400	30	70-04-29	72-09-27
Alumimum Al, Tot	ug/l	3	790	840	740	70-04-29	73-09-26
TSS	mg/l	2	8	8	8	73-06-27	73-09-26
TDS Residue @180°	mg/l	11	407	685	192	67-05-12	73-09-26
TDS sum of const.	mg/l	10	352	664	135	67-05-12	73-09-26
Nitrite Tot	mg/l	5	.01	.02	.01	72-05-10	73-09-26
Nitrate Tot	mg/l	3	.01	.02	.01	72-05-10	73-09-26
Mercury Hg, Tot	ug/l	5	1.19	3.5	.3	70-09-28	73-09-26

TABLE C-10

WATER QUALITY FIELD ANALYSIS - ST. JOHNS RIVER

Transect[a]	Date	Time	Water Depth (m)	Sample Depth (m)	Water Temp. (c)	Air Temp. (c)	D.O. (mg/l)	Conductivity (mhos)	pH	Secchi (m) Down[b]	Secchi (m) Up[c]
A	9-13-77	0925	1.22	0.10	29.8	--	4.9	1200	7.2	.60	.60
			--	1.00	29.5	--	3.9	1210	7.2	--	--
A-1	1-30-78	0940	2.00	0.10	8.5	--	12.0	780	8.3	.62	.62
			--	1.00	8.5	--	11.4	780	--	--	--
			--	2.00	8.5	--	11.4	780	--	--	--
	3-28-78	0800	2.00	--	18.5	11.0	7.8	850	7.2	.55	--
A-2	1-30-78	0840	1.00	.10	6.0	--	12.1	620	8.2	.59	.60
			--	1.00	6.0	--	12.0	620	--	--	--
	3-28-78	0730	1.52	--	18.5	--	7.5	850	7.2	.55	--
		2400	1.52	--	20.00	13.0	9.1	920	7.2	--	--
	4-13-78	1100	1.5	--	24.5	25.0	8.1	975	7.4	.55	--
B	9-13-77	0910	1.22	0.10	29.3	--	4.2	1175	7.3	.85	.59
			--	1.00	29.0	--	3.9	1180	7.3	--	--
B-1	1-30-78	1125	3.00	0.10	9.0	--	8.1	550	8.4	.46	.45
			--	1.00	9.0	--	8.3	575	--	--	--
			--	2.00	9.0	--	8.9	625	--	--	--
			--	3.00	9.0	--	8.8	625	--	--	--
	3-28-78	0850	3.00	--	19.5	17.8	6.2	815	7.2	.45	--

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TABLE C-10 (Continued)

Transect[a]	Date	Time	Water Depth (m)	Sample Depth (m)	Water Temp. (c)	Air Temp. (c)	D.O. (mg/l)	Conductivity (mhos)	pH	Secchi (m)	
										Down[b]	Up[c]
B-2	1-30-78	1040	1.00	.10	9.0	--	6.4	550	8.4	.48	.47
			---	1.00	9.0	--	6.2	550	--	--	--
	3-28-78	0920	1.00	--	19.0	--	5.4	800	7.0	.55	--
		1945	1.00	--	21.5	15.0	9.7	960	7.1	--	--
	4-13-78	1230	1.5	--	26.0	25.0	6.8	1000	7.3	.50	--
C	9-13-77	0850	.90	.10	29.0	--	5.9	1120	7.3	.51	.51
			--	.73	29.0	--	5.4	1120	7.3	--	--
C-1	1-30-78	1310	3.00	.10	10.0	--	11.0	750	8.1	.67	.66
			--	1.00	10.0	--	10.9	750	--	--	--
			--	2.00	10.0	--	10.8	750	--	--	--
			--	3.00	10.0	--	10.7	750	--	--	--
	3-28-78	1100	3.00	--	20.0	18.0	7.6	860	7.2	.60	--
C-2	1-30-78	1220	1.00	.10	9.5	--	11.4	700	8.5	.55	.54
			---	1.00	9.5	--	10.3	700	--	--	--
	3-28-78	1030	1.00	--	20.0	--	7.7	850	7.2	.60	--
		2125	1.00	--	19.5	14.0	9.0	930	7.1	--	--
	4-13-78	1330	1.5	--	26.5	25.0	7.6	1010	7.5	.35	--
D	9-13-77	0810	.90	.10	28.8	--	5.5	1120	7.5	.60	.59
			--	.73	28.5	-	4.7	1120	7.5	--	--

TABLE C-10 (Continued)

Transect[a]	Date	Time	Water Depth (m)	Sample Depth (m)	Water Temp. (c)	Air Temp. (c)	D.O. (mg/l)	Conductivity (mhos)	pH	Secchi (m)	
										Down[b]	Up[c]
D-1	1-30-78	1450	3.00	.10	10.0	--	11.6	700	8.6	.55	.55
			--	1.00	10.0	--	11.5	700	--	--	--
			--	2.00	10.0	--	11.5	700	--	--	--
			--	3.00	10.0	--	11.5	700	--	--	--
	3-28-78	1215	3.00		21.0	19.0	8.9	850	7.4	.60	--
D-2	1-30-78	1405	1.00	.10	10.0	--	11.8	700	8.7	--	--
			--	1.00	10.0	--	11.8	700	--	.47	.47
	3-28-78	1230	1.00	--	20.5	--	8.1	900	7.4	.60	--
		2230	1.00	--	19.5	14.0	9.6	890	7.1	--	--
	4-13-78	1430	.8	--	26.5	24.5	7.6	975	7.4	.60	--

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[a] For transect locations see Figure C-5.

[b] Reading taken as secchi disk is being lowered.

[c] Reading taken as secchi disk is being raised.

TABLE C-11

ST. JOHNS RIVER - WATER QUALITY LABORATORY ANALYSIS
(Samples Collected by Dames & Moore)

	February 1, 1978				March 29, 1978			
	TRANSECTS[a]				TRANSECTS[a]			
Parameter[b]	A	B	C	D	A	B	C	D
Total Alkalinity $CaCO_3$	76	68	64	68	55	70	55	60
Total Hardness $CaCO_3$	224	184	196	200	195	190	190	190
Total Dissolved Solids	815	680	715	730	608	596	606	606
Total Suspended Solids	<1	1	1	1	28	4	6	46
Ortho-Phosphate, P	0.01	0.01	0.07	0.03	0.02	<0.01	<0.01	<0.01
Total Phosphate, P	0.06	0.07	0.14	0.05	0.10	0.10	0.10	0.25
Nitrate Nitrogen, N	1.00	1.60	1.10	2.60	0.01	0.02	0.02	0.01
Nitrite Nitrogen, N	0.010	0.002	0.002	0.004	0.001	0.002	0.004	0.006
Ammonia Nitrogen, N	0.05	0.12	0.09	0.10	0.38	0.14	0.12	0.16
Kjeldahl Nitrogen, N	0.06	0.14	0.11	0.11	1.58	1.36	1.11	2.09
Sulfate, SO_4	80	80	68	65	67	1.79	73	65
Silica, SiO_2	2.6	3.8	4.0	4.0	1.1	11	1.0	1.0
BOD (5-day)	0.2	1.2	0.6	0.4	3.0	1.0	2.0	3.0
Detergents, MBAS[c]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fecal Coliform/100 ml (MFT)[d]	2	8	4	2	300	40	12	12
Magnesium Hardness, $CaCO_3$	80	60	72	68	65	70	70	70
Calcium Hardness, $CaCO_3$	144	124	124	132	130	120	120	120
Chemical Oxygen Demand, COD	46	56	60	58	88	64	64	106

TABLE C-11 (Continued)

	February 1, 1978				March 29, 1978			
	TRANSECTS[a]				TRANSECTS[a]			
Parameter[b]	A	B	C	D	A	B	C	D
Oil & Grease, Infrared	10	4.0	20	22	13	10	10	12
Phenols (µg/l)	<1	<1	<1	<1	<1	<1	<1	<1
Turbidity, JTU	<25	<25	<25	<25	<25	<25	<25	<25
Turbidity, NTU	2.5	3.5	<3.2	2.9	6.2	4.5	4.4	9.5
Color (units)	80	120	80	75	100	140	110	80
Chloride, Cl	290	230	225	245	210	230	240	204
Flouride, F	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Carbonate, CO_3	0	0	0	0	0	0	0	0
Bicarbonate, HCO_3	93	83	78	83	67	85	67	73
Chromium, Total (µg/l)	<10	<10	<10	<10	<10	<10	<10	<10
Mercury, Hg (µg/l)	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic, As (µg/l)	2.9	1.9	1.9	1.9	20	5	2	4
Lead, Pb (µg/l)	1.89	<0.01	1.86	<0.01	13	12	9	10
Copper, Cu (µg/l)	<100	<100	<100	<100	<100	<100	<100	<100
Iron, Fe (µg/l)	80	120	80	60	100	90	50	20
Zinc, Zn (µg/l)	140	160	180	120	14	22	20	56
Cadmium (µg/l)	--	--	--	--	1	2	<1	<1

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[a] For transect locations see Figure C-5.

[b] Values in mg/liter unless otherwise noted.

[c] Methyl blue active substance.

[d] Membrane filter technique.

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TABLE C-12

SEDIMENT SAMPLES - ST. JOHNS RIVER
(in mg/kg dry weight)

Parameter	Analysis A	Analysis B	Analysis C	Analysis D
Chromium, Cr	2.98	5.29	42.58	0.998
Mercury, Hg	5.3	1.4	6.0	<0.1
Arsenic, As	1.99	3.17	1.77	0.998
Lead, Pb	2.49	2.11	17.74	0.998
Copper, Cu	2.53	4.23	10.64	0.998
Iron, Fe	1,491	1,480	14,192	289
Zinc, Zn	30.8	54.9	97.6	469
Cadmium, Cd	0.10	0.21	0.43	0.37
Phenols	27.0	<0.2	19.7	<0.02
BHC	<0.001	<0.001	<0.001	<0.001
Lindane	0.023	0.011	0.004	0.002
Heptachlor	<0.001	<0.001	<0.001	<0.001
Aldrin	0.280	0.024	0.009	0.006
Heptachlor Epoxide	0.026	0.029	0.004	0.002
Dieldrin	<0.001	0.022	<0.001	<0.001
Endrin	<0.001	<0.001	<0.001	<0.001
Captan	<0.001	<0.001	<0.001	<0.001
DDE	<0.001	<0.001	<0.001	<0.001
DDD	<0.001	<0.001	<0.001	<0.001
DDT	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.001	<0.001	<0.001	<0.001
Endosulfan	<0.001	<0.001	<0.001	<0.001
Dichloran	<0.001	<0.001	<0.001	0.001
Mirex	<0.001	<0.001	<0.001	<0.001
Pentachloronitrohenzene	<0.001	<0.001	<0.001	<0.001
Trifluralin	<0.001	<0.001	<0.001	<0.001
Strobane	<0.001	<0.001	<0.001	<0.001
Toxaphene	<0.001	<0.001	<0.001	0.001
Chlordane	<0.001	<0.001	<0.001	<0.001
Polychlorinated Biphenyls	<0.001	<0.001	<0.001	<0.001

Notes: 1) Date of collection: April 13, 1978.

2) Collecting device: K-B Cora Sampler; sample contained a plastic tube liner.

3) Samples placed in containers supplied by Orlando Laboratories Inc. (no preservative added).

4) Analysis for: Heavy metals (similar to the water column) PCB's; Pesticides.

5) For sampling locations see Figure C-5.

TABLE C-13

WASTEWATER DISCHARGES DOWNSTREAM OF SITE
(SEG. 20.3 FA)

No.	Plant Name and Location	Discharge Point	Plant Flow (mgd)		Waste Water Effluent Charact. (lbs/day)				Estimated UOD
			Design	Aver.	BOD 5	TSS	Nitro.	Tot P04	
	DOMESTIC								
1	Town of Green Cove Spgs.	St. Johns River	0.500	.400	55	96	108	64	528.0
2	Town of Hastings	Swamp to Cracker Cr. to St. Johns River	0.100	.075	10.4	18	20.4	12	99.0
3	Magnolia Sprgs. Apts.	Swamp to St. Johns R.	0.070	.070	12	9.0	21	12	92.4
4	Reynolds Indust. Pk.	St. Johns River	0.068	.068	2.8	6.8	18.5	10.9	89.8
5	Holiday Inn	Ditch to Six Mile Swamp to St. Johns R.	0.050	.0006	0.8	1.4	1.6	1.0	7.9
6	Econo Travel Motor Hotel	Ditch to swamp to St. Johns River	0.020	.015	2.1	3.6	4.1	2.4	19.8
7	Candyland, Inc.	Ditch to swamp to St. Johns River	0.015	.015	2.1	3.6	4.1	2.4	19.8
8	Wesley Retirement Village	St. Johns River	0.010	.010	1.4	2.4	27	1.6	13.3
9	Vines Union 76	Red House Br. to Six Mile Cr. to St. Johns R.	0.008	.008	1.1	1.9	2.2	1.3	10.6
10	Johns Manville	St. Johns River	0.005	.005	.7	1.2	1.4	8	6.6
	COMMERCIAL OR INDUSTRIAL								
11	Titanium Enterprises	Ditch to Clark Cr. to St. Johns River	4.4	2.3	-	-	-	-	-
12	Johns Manville	St. Johns River	.300	.300	-	-	130	77	-
	Total		5.546	3.2666					

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TABLE C-14

WASTEWATER DISCHARGES UPSTREAM OF SITE
(SEG. 20.3 GA and 20.3 HA)

No.	Plant Name and Location	Discharge Point	Plant Flow (mgd)		Waste Water Effluent Charact. (lbs/day)				Estimated UOD
			Design	Aver.	BOD 5	TSS	Nitro.	Tot PO4	
	DOMESTIC								
13	City of Palatka, Putnam County	Canal to St. Johns River	1.750	1.700	128	142	462	272	2,244
14	Captain Joe's Restaurant	St. Johns River	.0075	UK	0.8	0.7	-	-	-
15	Paradise Park MHP Rt. #1, Palatka	Rice Creek,	.010	.006	0.8	1.4	1.6	1.0	7.9
	COMMERCIAL OR INDUSTRIAL								
16	Florida Power & Light	St. Johns River	2.0	2.0	NA	UK	-	-	-
17	East Side Launderomat	Ditch to St. Johns River	.010	.003	1.4	2.4	2.7	1.6	13.2
18	Florida Packing & Provisions, Inc.	Pipeline to St. Johns River	.009	.005	0.6	1.2	1.4	0.8	6.6
19	Hudson Pulp & Paper Co.	Rice Creek	50.0	48.0	-	-	-	-	-
	Total		53.7865	51.714					

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TABLE C-15

RATIO OF REMAINING EXCESS TO INITIAL EXCESS CONCENTRATION NEAR-FIELD ASSESSMENT[a]

Distance From POD (ft)	Ambient Current[b] Velocity (fps) +1.0	+0.2	0.0	-0.2	-0.1
5	.60	.58	.57	.57	.57
10	.39	.38	.37	.37	.37
20	.25	.24	.23	.23	.22
50	.12	.11	.10	.10	c
100	.07	.06	.06	.06	c

---

[a] As discussed in Section C.4, the near-field model (Shirazi and Davis, 1974) assumes steady state conditions.

[b] + downstream flow
- upstream flow

[c] Discharge momentum is reduced to zero by the ambient current within 50 feet of the POD. The near-field model is not applicable once discharge momentum is reduced to zero.

TABLE C-16

EFFECT OF FLOW REVERSALS ON NEAR-FIELD MODEL ACCURACY (DIMENSIONLESS ANALYSIS)

Distance From POD (ft)	CR Values[a] (Dimensionless) CR_1[b] Ca = 0	CR_2[c] Ca = 0.2	CR_2/CR_1[d] %
5	.6	.68	113
10	.39	.51	131
20	.25	.40	160

---

[a] Cr = y (Cd-Ca) + Ca (Section C.3.5)
where:

Cr = Total dimensionless concentrations of constituent prior to flow reversal.
Ca = Ambient concentration
Cd = 1.0 = Concentration of constituent at POD.
y = Ratio of remaining excess to initial excess concentration

[b] Total concentration if steady state ambient flow equals 0.0.

[c] Total concentration if ambient equals 0.2 due to a hypothetical flow reversal.

[d] Percent increase of Cr between steady state ambient flow conditions and hypothetical flow reversal.

TABLE C-17

VALUES FOR z_1 and z_1

$$C_x = Z_o e^{C_1 X/(x + z_2)} \qquad \text{Eq. (4)}$$

	LINE A	LINE B	LINE C	LINE D
z_1	-4.1	-4.74	-4.63	-4.4
z_1	86.88	101.23	98.81	93.5

TABLE C-18

VERIFICATION OF INTERPOLATION MODELS

Cx Values (dimensionless)

Distance From POD (ft)	Line A		Line B		Line C		Line D	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Near-Field Region								
5	.60	.80	.60	.80	.60	.80	.60	.80
10	.39	.65	.39	.65	.39	.65	.39	.65
20	.25	.46	.25	.46	.25	.46	.25	.46
50	.12	.22	.12	.21	.12	.21	.12	.21
100	.07	.11	.07	.09	.07	.10	.07	.10
Grid Points(c)								
Far-Field Region								
1	.024	.024	.012	.012	.014	.014	.016	.016
2	.02	.02	.008	.010	.010	.012	.012	.014
3	.018	.019	.008	.009	.008	.011	.010	.013

(a) Ratio of remaining excess constituent concentration to initial excess as determined from the near-field/far-field models (see Table C-15 for ambient velocity of +1.0 fps).

(b) Ratio of remaining excess constituent concentration to initial excess as determined from interpolation models (see Table C-17).

(c) See Figure C-16. Grid Point values refer to successive grid intersections from the POD.

TABLE C-19

REQUIRED REDUCTION OF INITIAL EXCESS CONCENTRATIONS

Parameter	Units	1 DER Standard[a]	2 POD Concentration[d]	3 Ambient Concentration[e]	4 EX_I[f]	5 EX_A[g]	6 C_x[h]
Iron	mg/l	1.0	3.95	.56	3.39	.44	.129
Chlorine							
1 unit	mg/l	.01	0.4	0	0.4	.01	.025
2 units	mg/l	.01	0.2	0	0.2	.01	.05
Specific Conductance	µmhos/cm	765.[b]	--	510.[b]	--	--	--
TDS	mg/l	440.[c]	3764.	280.[c]	3484.	160.	.046
Ammonia (un-ionized)	µg/l	20.	282.[i]	11.4[i]	271.	8.6	.032
Aluminum	mg/l	1.5	51.1	.15	51.	1.35	.026
Copper	µg/l	30.	222.	10.	212.	20.	.094
Selenium	µg/l	25.	39.	10.	29.	15.	.517
Cadmium	µg/l	1.2	15.	0.87	14.13	.33	.023
Lead	µg/l	30.	111.	28.	83.	4.	.023
Mercury	µg/l	.2	1.06	.18	.879	.02	.023
Zinc	µg/l	30.	248.	25.	223.	5.	.023
Oil & Grease	mg/l	5.	19.	4.67	14.33	.33	.023
Phenolic Compounds	µg/l	1.0	1.12	.28	.84	.72	.86

TABLE C-19 (Continued)

[a] Florida DER (1979).

[b] Specific conductance standard = 5000 μmhos/cm or 150 percent of ambient. Therefore a minimum standard will occur during minimum ambient values. Minimum ambient = 510 μmhos/cm^2. See note c for methodology.

[c] In the absence of discharge data on specific conductance a relationship was developed between conductivity and total dissolved soilids (TDS) by examining the water quality data at Palatka. Discharge conductivity was then determined in terms of the TDS. TDS values shown should approximately produce the associated conductivity values.

[d] See Attachment C-1, Pages II-6 and II-7.

[e] See Table C-8. The concentrations shown in Column 2 will be reduced to levels below Florida DER standards within the mixing zones shown in Table C-20 when ambient values are less than or equal to the values shown in Column 3.

[f] EX_I = excess constituent concentration at the POD (POD concentration - ambient concentration).

[g] EX_A = allowable excess concentration. (DER standard - ambient).

[h] $C_X = EX_A/EX_I$. Percent reaming of initial excess concentration. Mixing zone areas required to obtain indicated constituent concentration reductions are given in Table C-20.

[i] The percentage of the total ammonia as NH_3 was determined from the EPA Quality Criteria for Water, (1976). As the concentration of NH_3 increases with increasing temperature and decreasing ionic strength, a discharge water temperature of 93°F and pH of 7.5 were used as design parameters for determining the percentage of un-ionized ammonia in both discharge and ambient waters.

TABLE C-20

MIXING ZONE DIMENSIONS

PARAMETER	C_X[a]	DISTANCE FROM POD (ft)[b] A	B	C	D	AREA[c]
Iron	.129	87	77	78	81	0.5
Copper	.09	124	105	107	113	1.0
Specific Conductance	.046	262	188	196	217	4.0
Chlorine						
1 unit	.025	780	355	387	485	23.0
2 units	.05	236	174	181	200	3.0
Ammonia (un-ionized)	.032	455	270	285	335	10.5
Aluminum	.026	704	339	368	455	19.2
Cadmium	.023	950	440	440	550	31.0
Lead	.023	950	440	440	550	31.0
Mercury	.023	950	440	440	550	31.0
Zinc	.023	950	440	440	550	31.0
Oil & Grease	.023	950	440	440	550	31.0
Phenolic Compounds	.86	4	4	4	4	50 sq. ft.
Selenium	.517	17	16	16	16	900 sq. ft.

---

[a] See Table C-19

[b] Calculated with equation (4). See Table C-17.

[c] Area in acres except where noted.

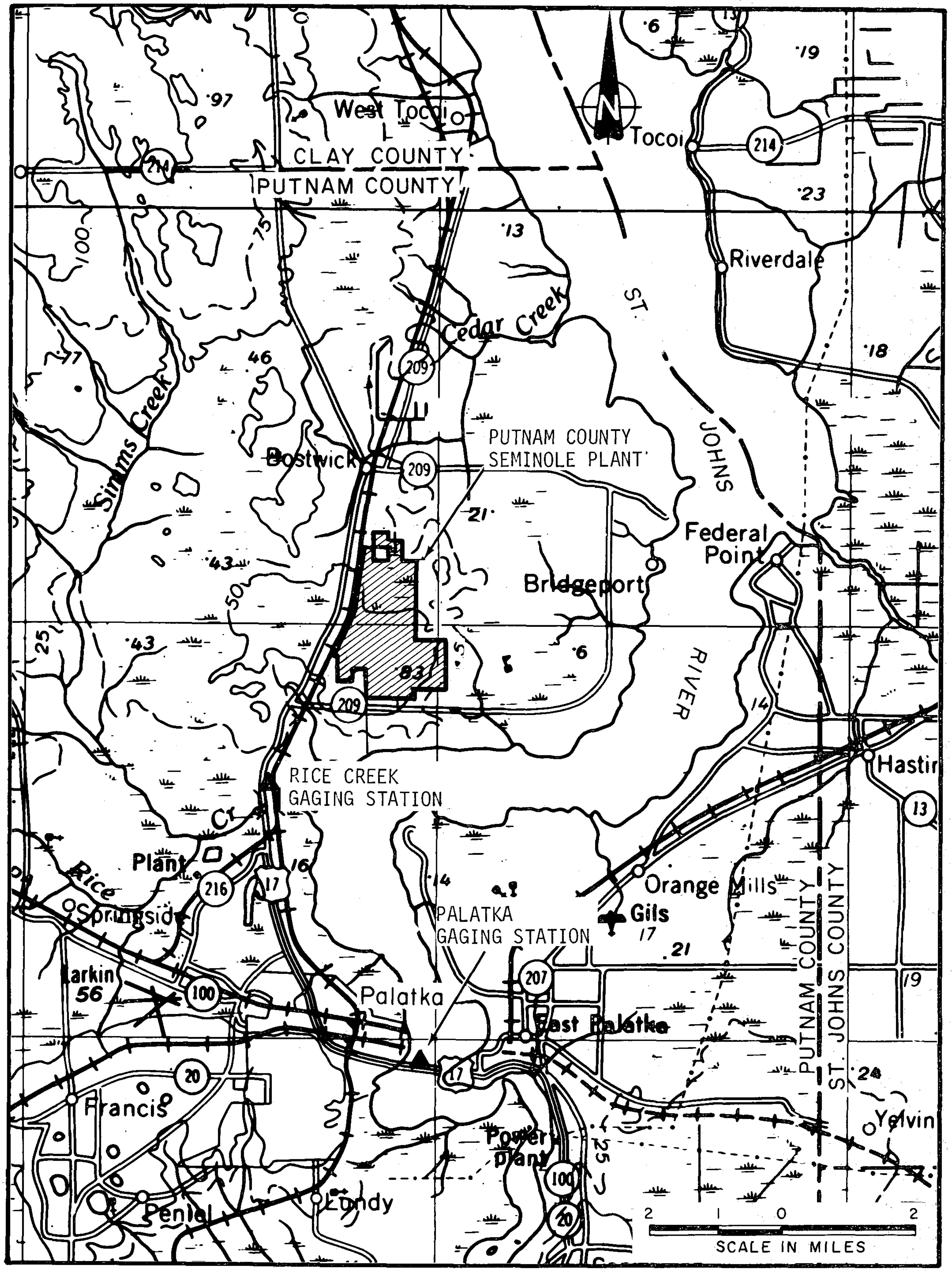

Figure C -1. Location Map.

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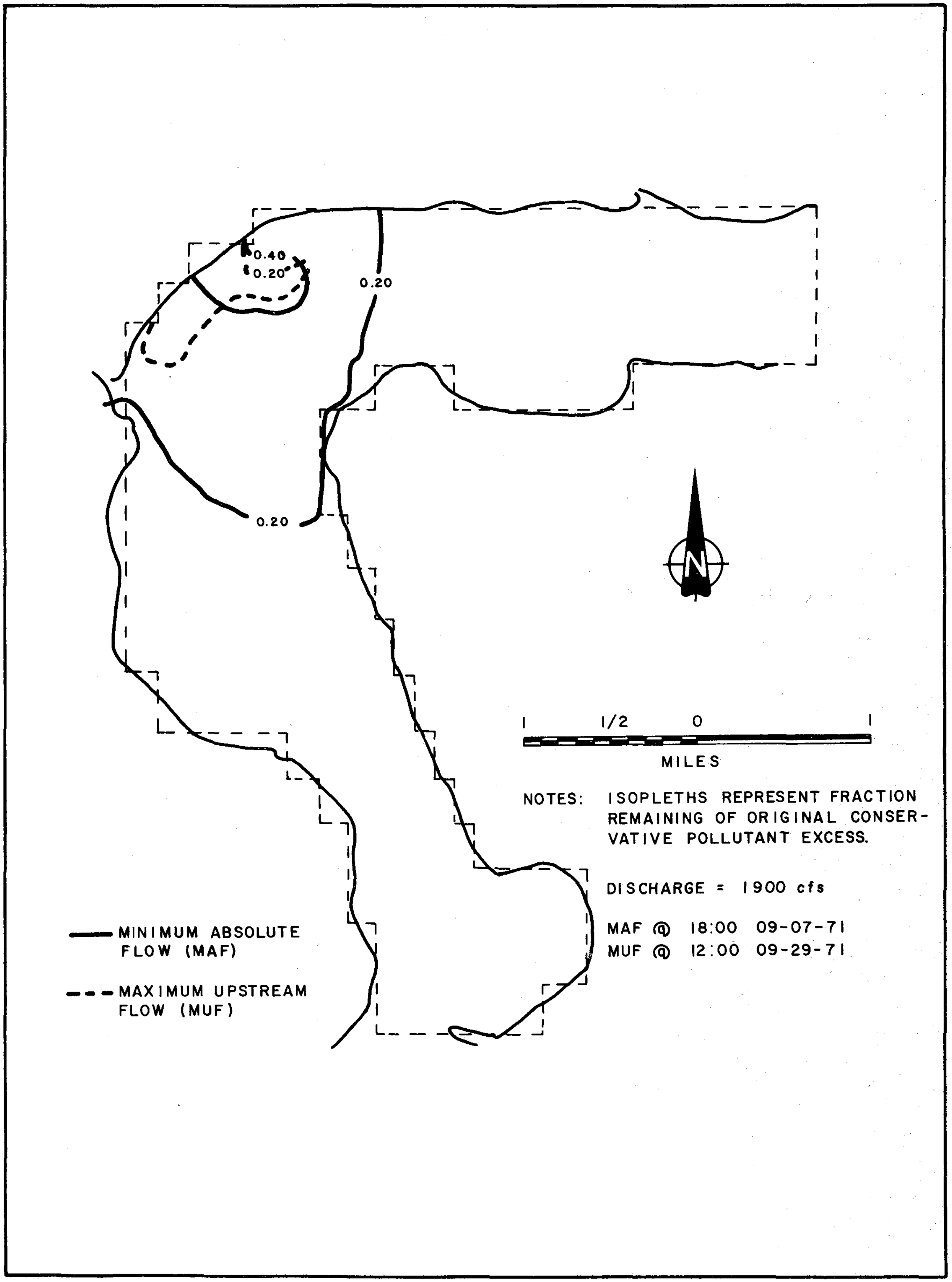
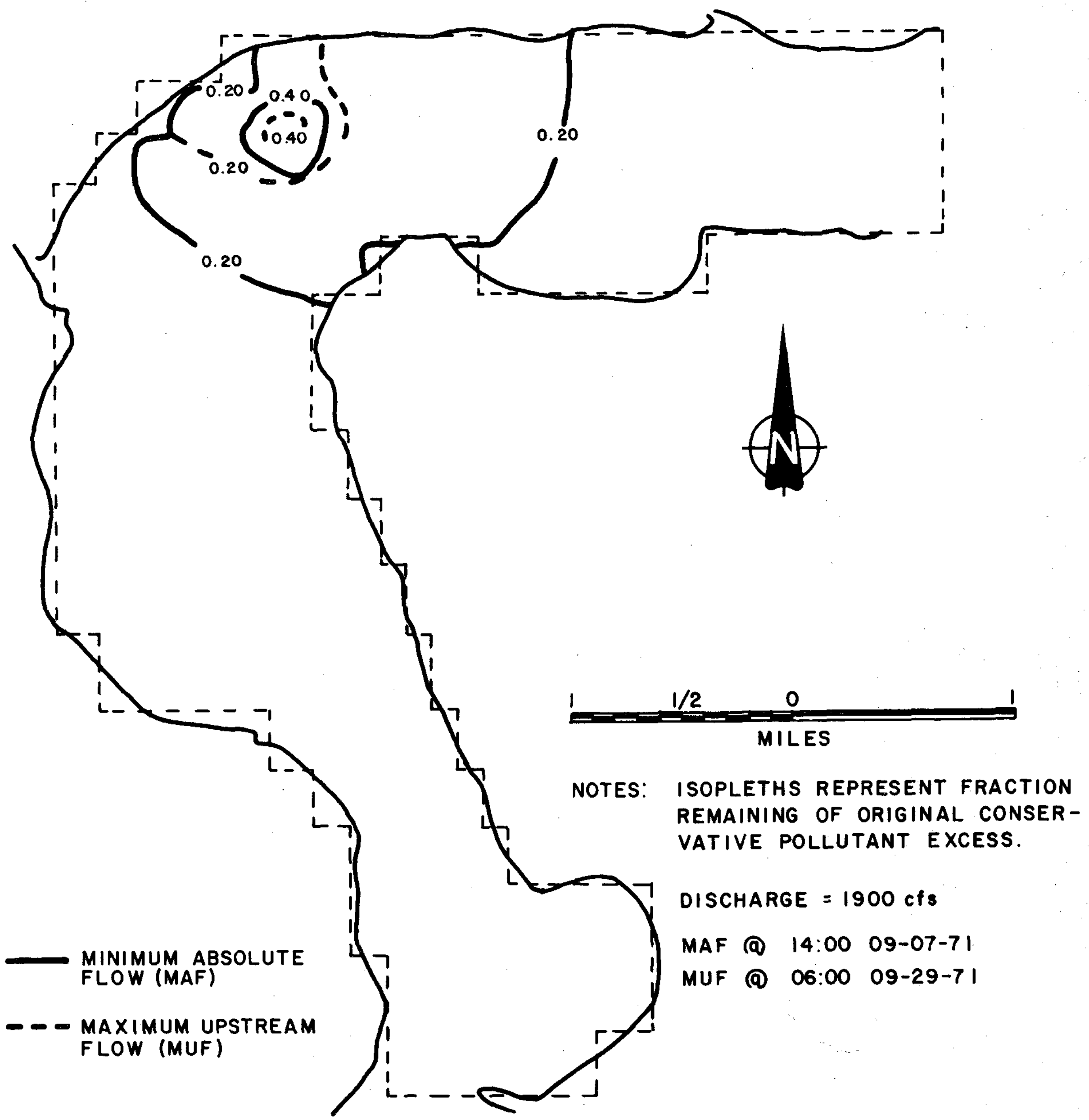


NOTES: ISOPLETHS REPRESENT FRACTION REMAINING OF ORIGINAL CONSERVATIVE POLLUTANT EXCESS.

DISCHARGE = 1900 cfs

MAF @ 18:00 09-07-71
MUF @ 12:00 09-29-71

Figure C-2. Predicted Dimensionless Isopleths: MAF and MUF Analysis at Flood Tide.



NOTES: ISOPLETHS REPRESENT FRACTION REMAINING OF ORIGINAL CONSERVATIVE POLLUTANT EXCESS.

DISCHARGE = 1900 cfs

MAF @ 14:00 09-07-71
MUF @ 06:00 09-29-71

Figure C-3. Predicted Dimensionless Isopleths: MAF and MUF at Slack Tide.

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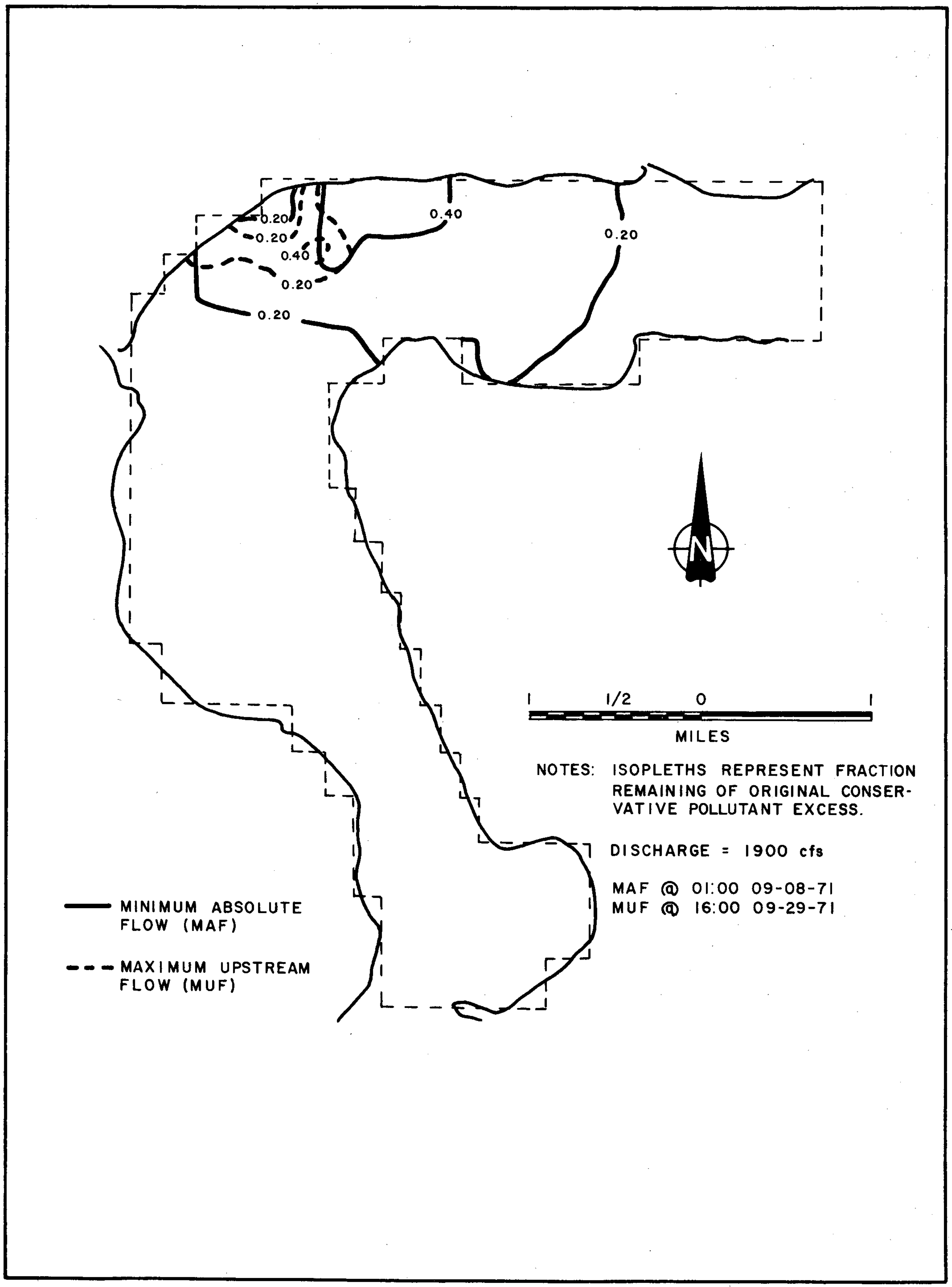

NOTES: ISOPLETHS REPRESENT FRACTION REMAINING OF ORIGINAL CONSERVATIVE POLLUTANT EXCESS.

DISCHARGE = 1900 cfs

MAF @ 01:00 09-08-71
MUF @ 16:00 09-29-71

Figure C-4. Predicted Dimensionless Isopleths: MAF and MUF at Ebb Tide.

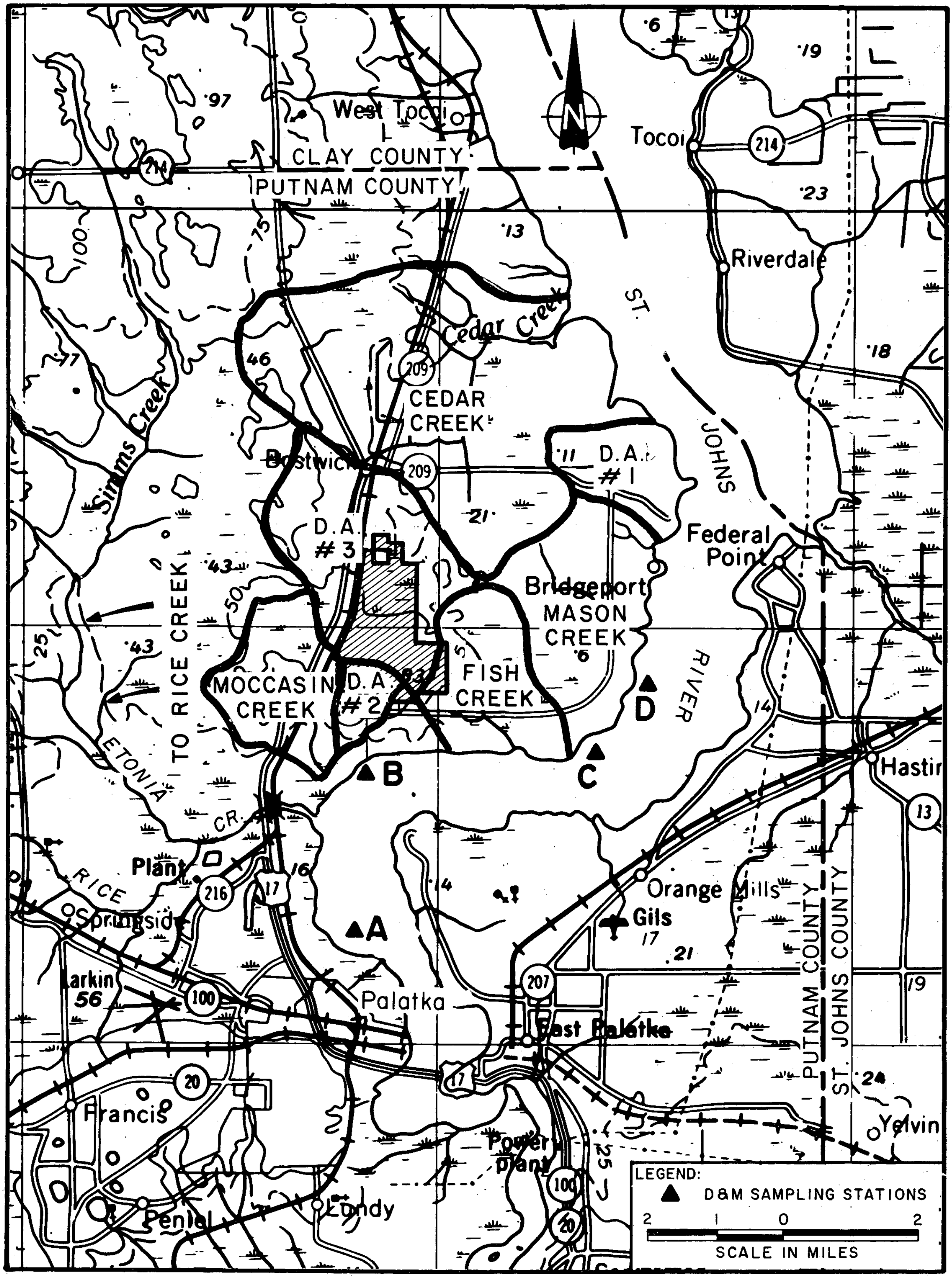

Figure C-5. Local Tributaries.

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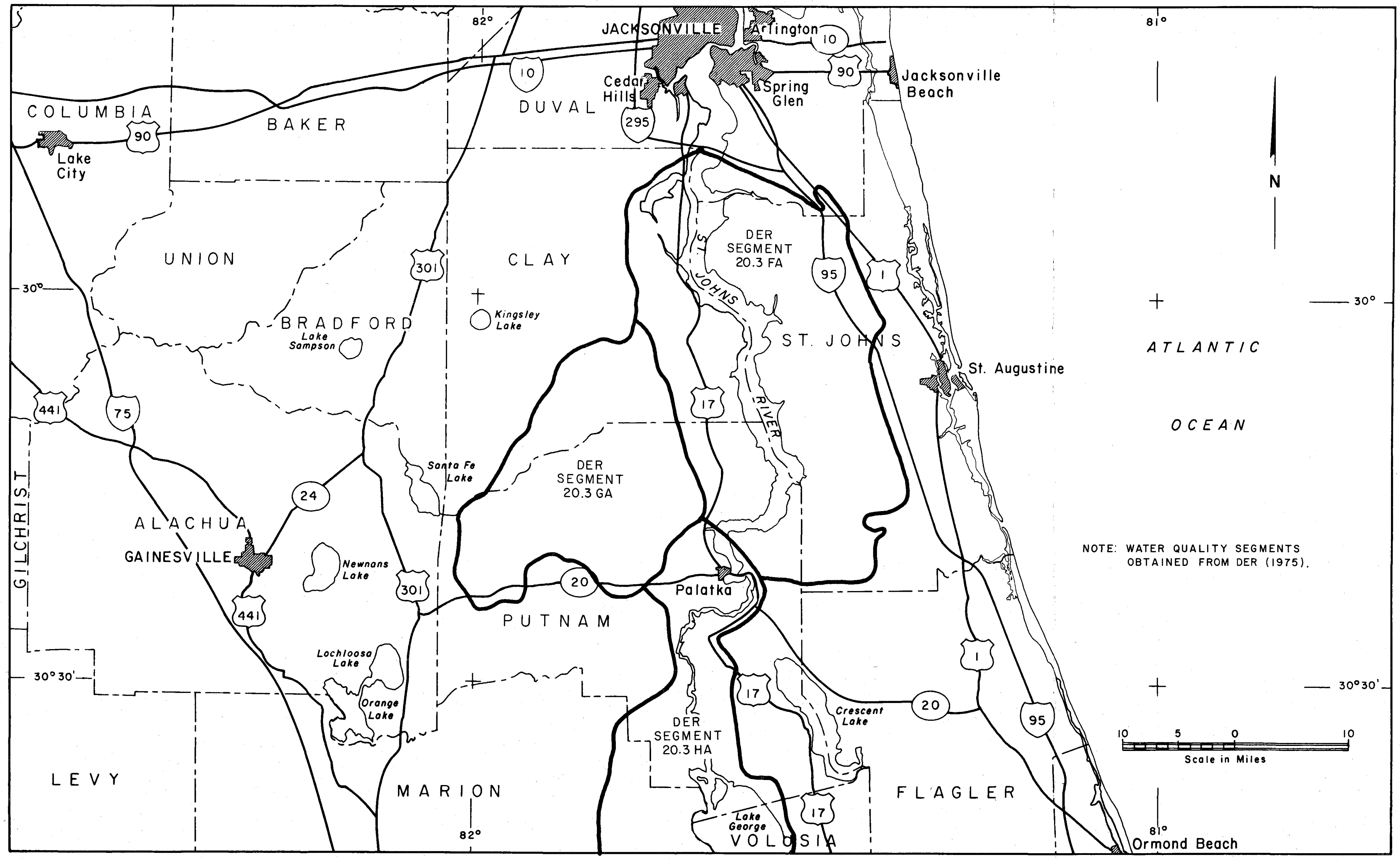

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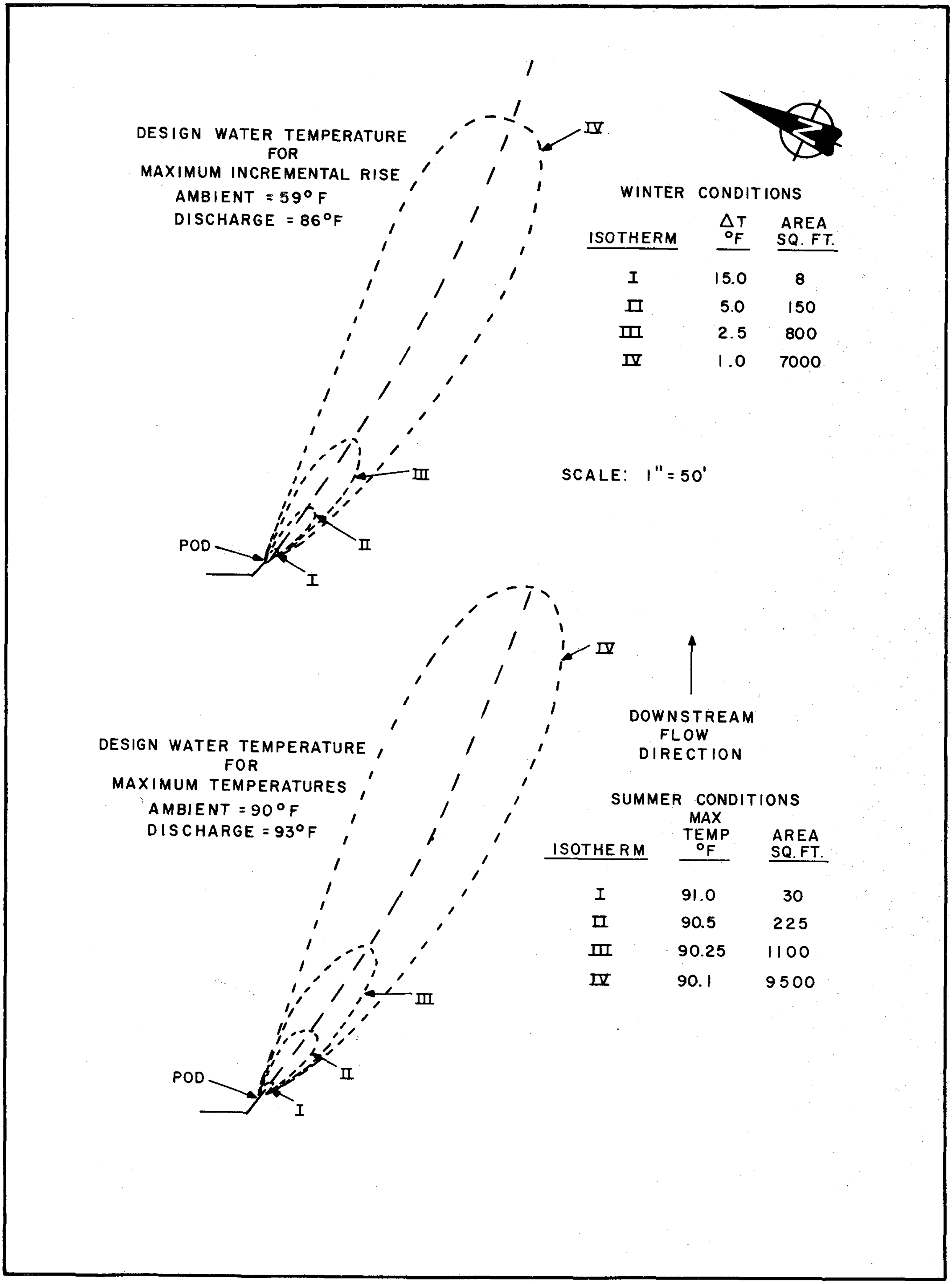
Figure C-6. St. Johns River Water Quality Management Segments.



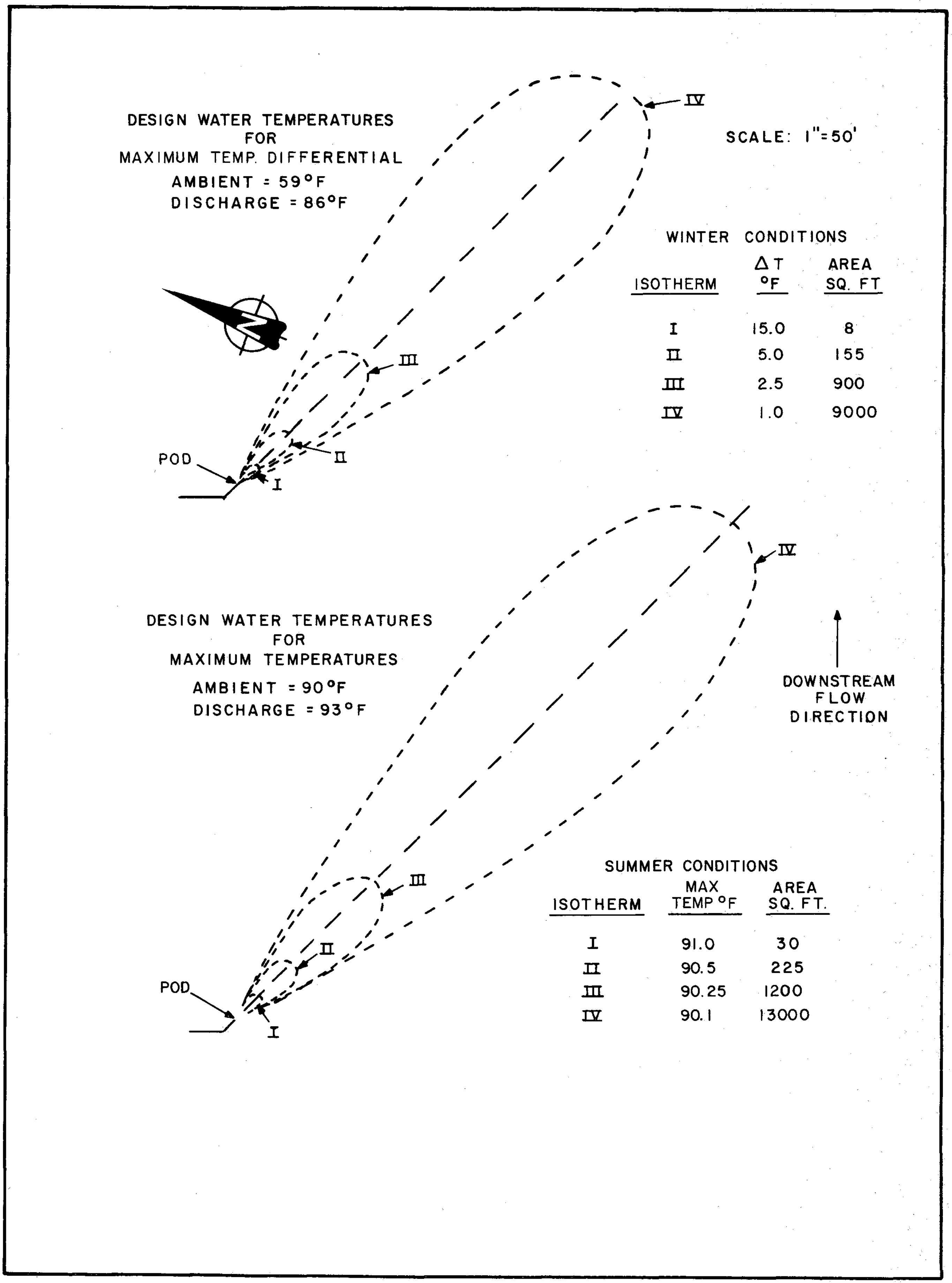
WINTER CONDITIONS

ISOTHERM	ΔT °F	AREA SQ. FT.
I	15.0	8
II	5.0	150
III	2.5	800
IV	1.0	7000

SUMMER CONDITIONS

ISOTHERM	MAX TEMP °F	AREA SQ. FT.
I	91.0	30
II	90.5	225
III	90.25	1100
IV	90.1	9500

Figure C-7. Near-Field Isotherms, Ambient Velocity = 0.2fps.



DESIGN WATER TEMPERATURES
FOR
MAXIMUM TEMP. DIFFERENTIAL
AMBIENT = 59°F
DISCHARGE = 86°F

WINTER CONDITIONS

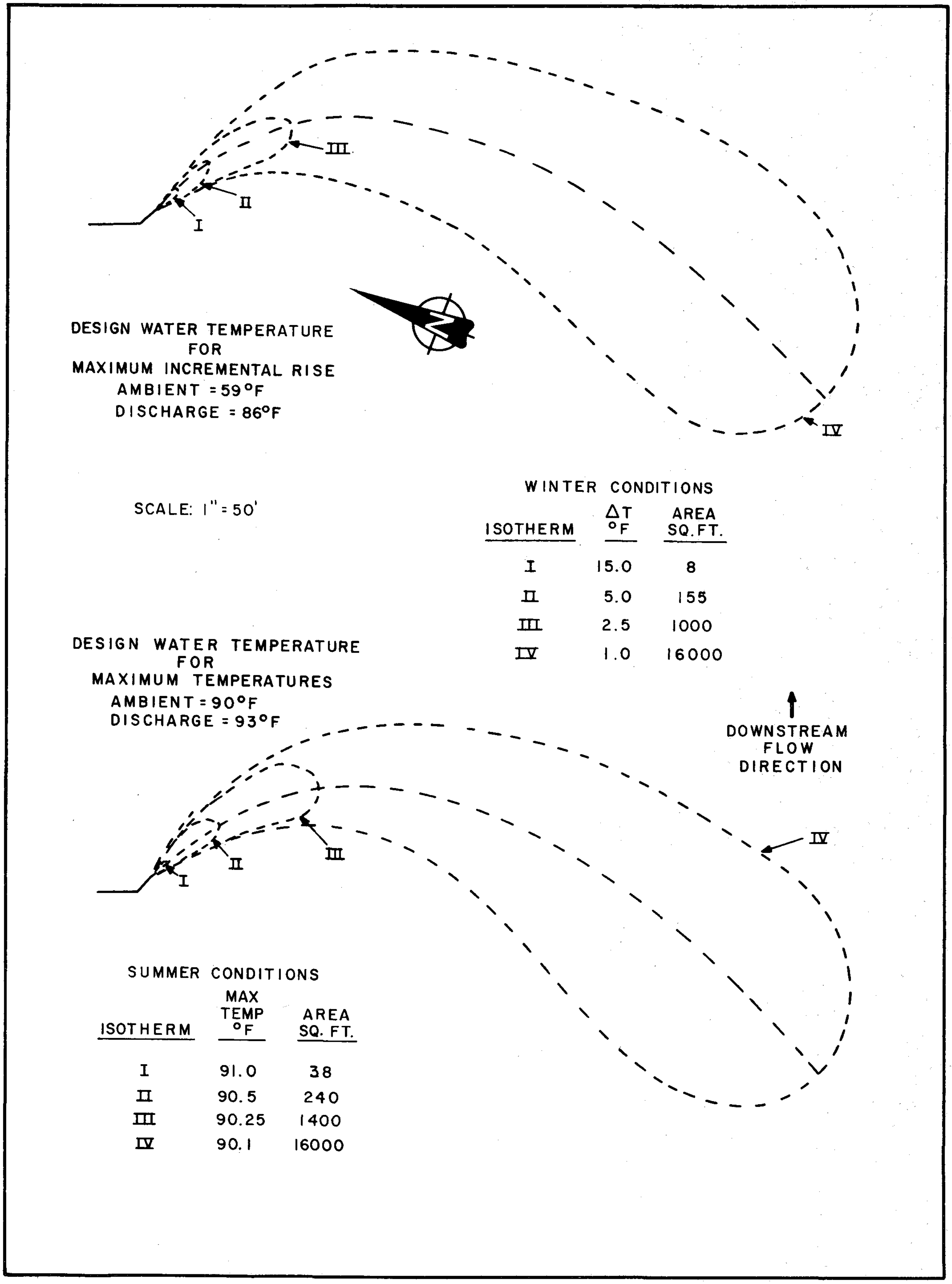
ISOTHERM	ΔT °F	AREA SQ. FT
I	15.0	8
II	5.0	155
III	2.5	900
IV	1.0	9000

DESIGN WATER TEMPERATURES
FOR
MAXIMUM TEMPERATURES
AMBIENT = 90°F
DISCHARGE = 93°F

SUMMER CONDITIONS

ISOTHERM	MAX TEMP °F	AREA SQ. FT.
I	91.0	30
II	90.5	225
III	90.25	1200
IV	90.1	13000

Figure C-8. Near-Field Isotherms, Ambient Velocity = 0.0fps.



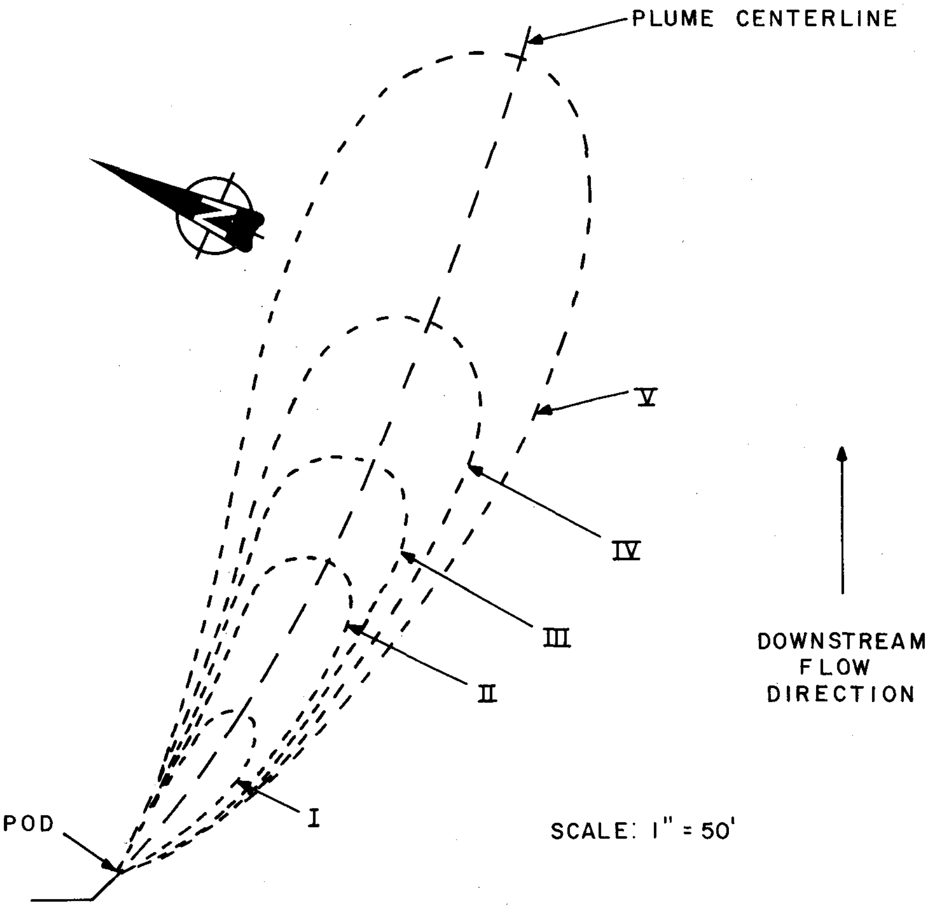
WINTER CONDITIONS

ISOTHERM	ΔT °F	AREA SQ.FT.
I	15.0	8
II	5.0	155
III	2.5	1000
IV	1.0	16000

SUMMER CONDITIONS

ISOTHERM	MAX TEMP °F	AREA SQ. FT.
I	91.0	38
II	90.5	240
III	90.25	1400
IV	90.1	16000

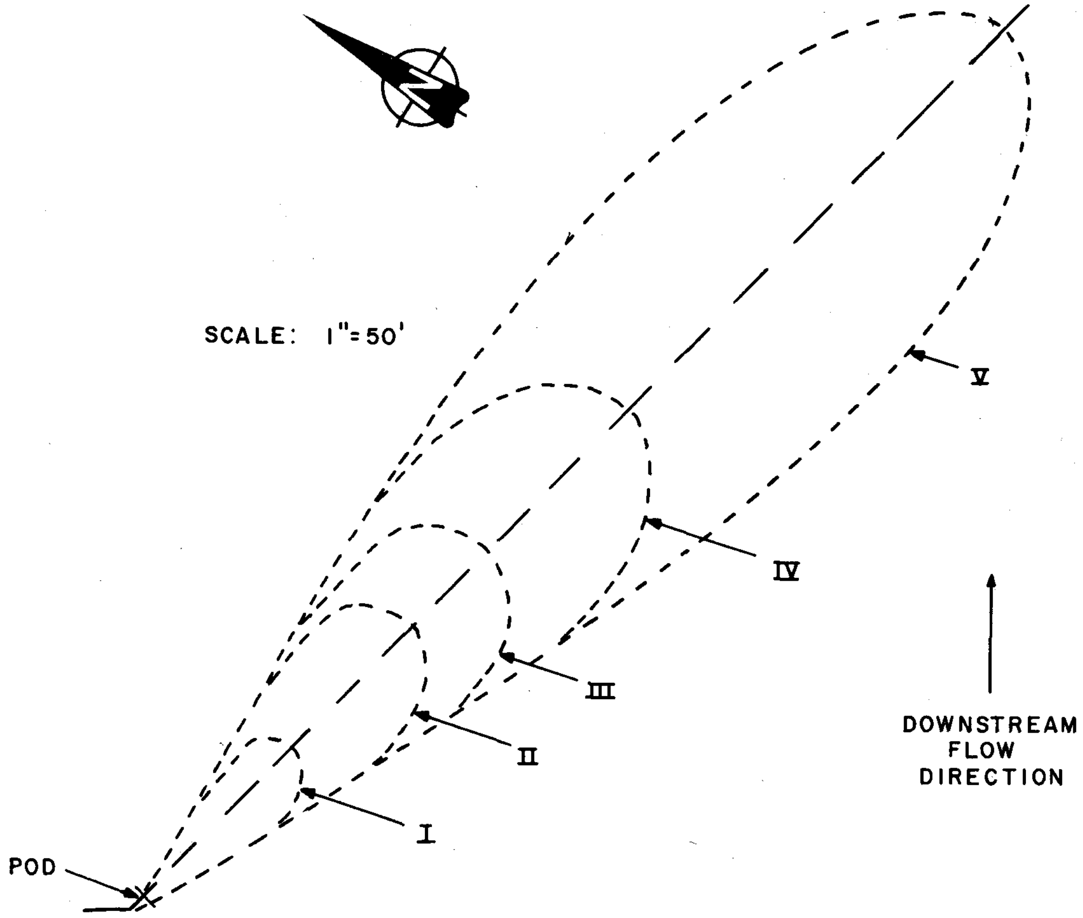
Figure C-9. Near-Field Isotherms, Ambient Velocity =-0.2fps.



ISOPLETH	% OF ORIGINAL EXCESS REMAINING @ ISOPLETH	AREA (FT^2)
I	10.0	650.
II	6.0	2100.
III	5.0	3250.
IV	4.0	5800.
V	3.0	12000.

NOTE: ISOPLETHS REPRESENT LINES OF EQUAL EXCESS CONCENTRATION FOR EACH CHEMICAL CONSTITUENT.

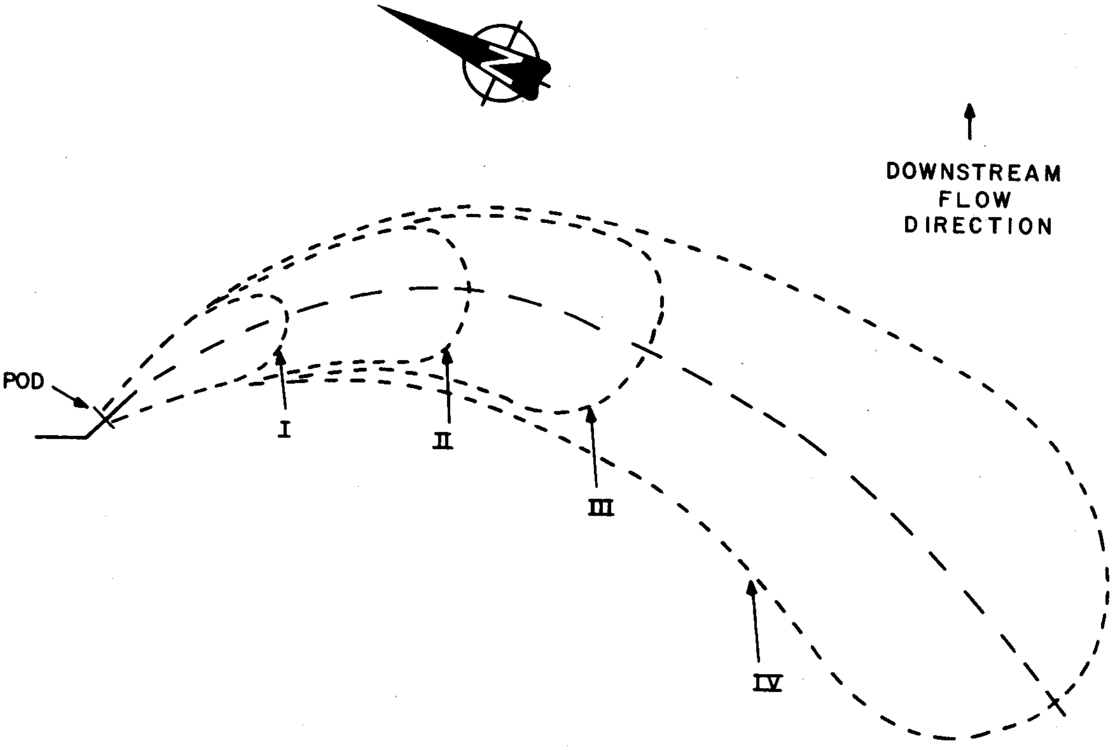
Figure C-10. Near-Field Isopleth, Velocity = 0.2fps.



ISOPLETH	% OF ORIGINAL EXCESS REMAINING @ ISOPLETH	AREA (FT)^2
I	10	650
II	6	2550
III	5	3900
IV	4	7000
V	3	15000

NOTE: ISOPLETHS REPRESENT LINES OF EQUAL EXCESS CONCENTRATION FOR EACH CHEMICAL CONSTITUENT.

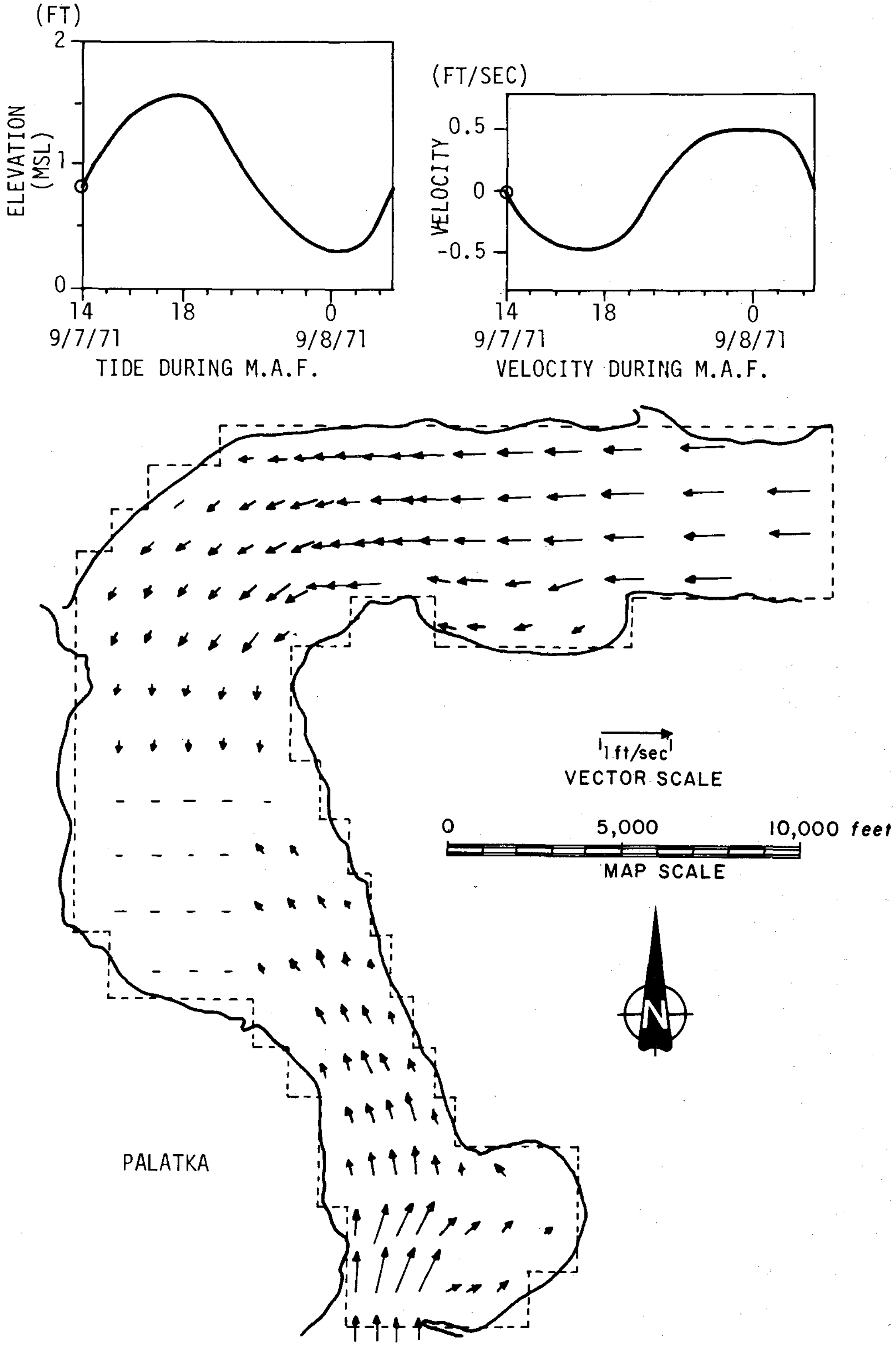
Figure C-11. Near-Field Isopleths, Velocity = 0.0fps.



ISOPLETH	% OF ORIGINAL EXCESS REMAINING @ ISOPLETH	AREA $(FT)^2$
I	10	700
II	6	3200
III	5	6100
IV	4	15000

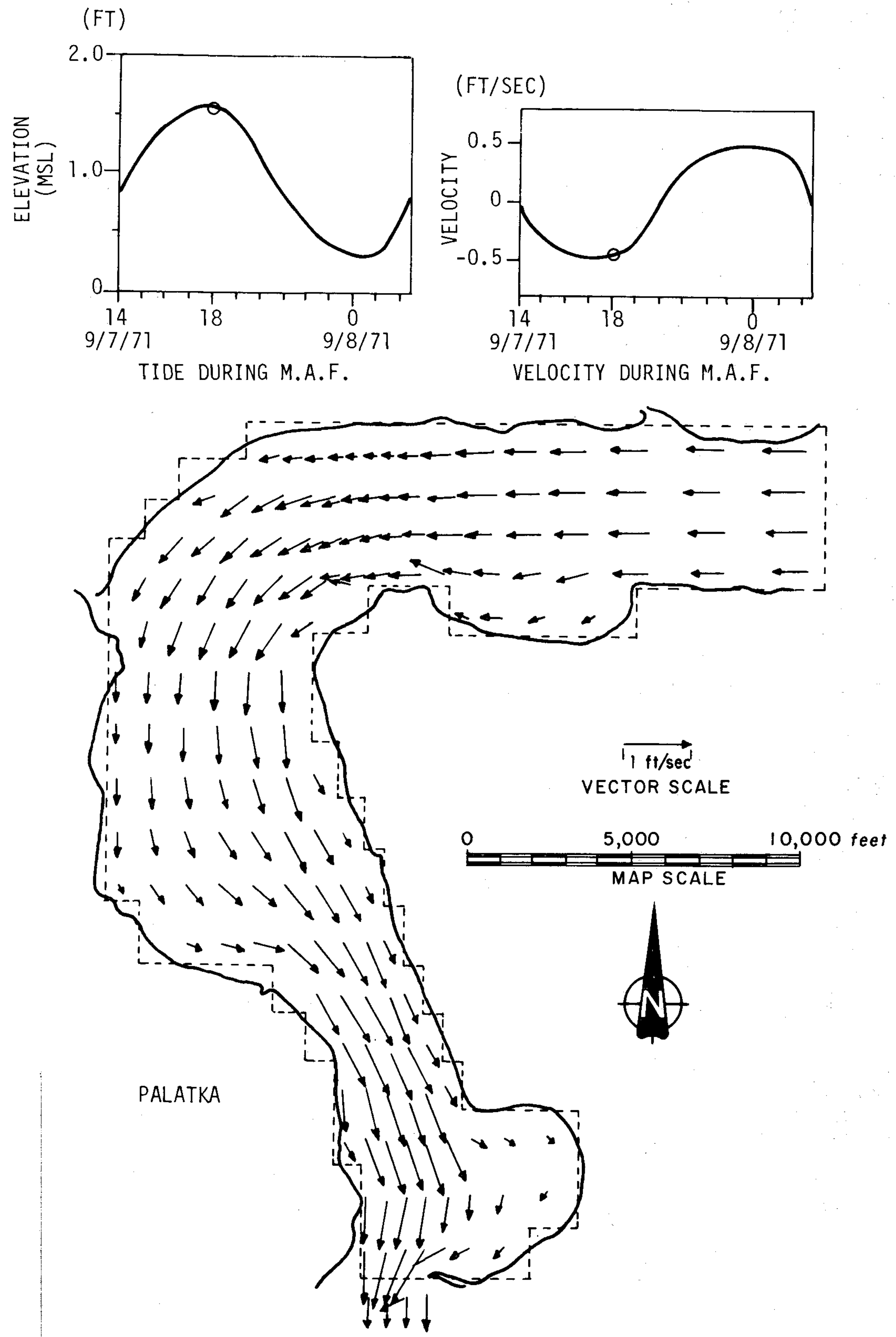
NOTE: ISOPLETHS REPRESENT LINES OF EQUAL EXCESS CONCENTRATION FOR EACH CHEMICAL CONSTITUENT.

Figure C-12. Near-Field Isopleth, Velocity = -0.2fps.



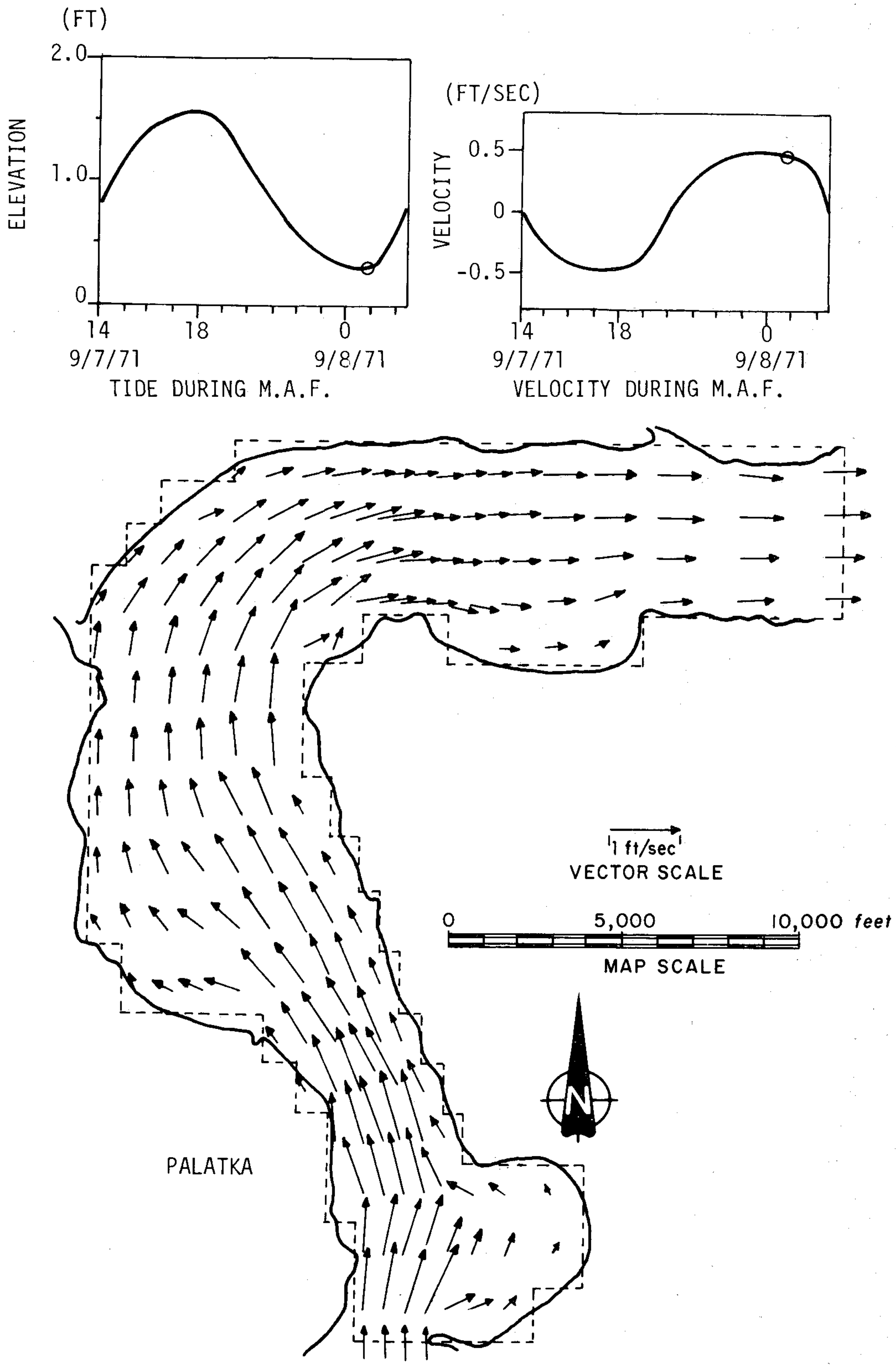
NOTE: Velocity vectors predicted with Dames & Moore hydrodynamic model (Tidal 2) from USGS records at U.S. Route 17 St. Johns River gaging station.

Figure C-13.Predicted Velocity Vectors At Slack Tide (14:00 09-07-71) During Minimum Absolute Flow



NOTE: Velocity vectors predicted with Dames & Moore hydrodynamic model (Tidal 2) from USGS records at U.S. Route 17 St. Johns River gaging Station.

Figure C-14. Predicted Velocity Vectors At Flood Tide (18:00 09-07-71) During Minimum Absolute Flow



NOTE: Velocity vectors predicted with Dames & Moore hydrodynamic model (Tidal 2) from USGS records at U.S. Route 17 St. Johns River gaging station.

Figure C-15. Predicted Velocity Vectors at Ebb Tide (01:00 09-08-71) During Minimum Absolute Flow

OVERSIZE DOCUMENT WAS REMOVED AND INSERTED INTO OCULUS SEPARATELY.

Notes:

1. Mixing Zone

Reference No.	Constituent	Area (Acres)
1	Selenium	.02
2	Iron	0.5
3	Copper	1.0
4	Ammonia (Un-ionized)	10.5
5	Conductance	4.0
6	Aluminum	19.2
7	Chlorine 1 Unit	23.0
8	Lead	31.0
	Mercury	31.0
	Cadmium	31.0
	Zinc	31.0
	Oil & Grease	31.0

2. The decay rate of the effluent constituent concentrations along Line E was assumed to be essentially equivalent to the decay rate along Line A. Similarly, the decay of constituent concentrations north of the POD was assumed to be equivalent to decay characteristics south of the POD.

3. Isopleths envelope the maximum area that may experience constituent concentrations in excess of applicable standards.

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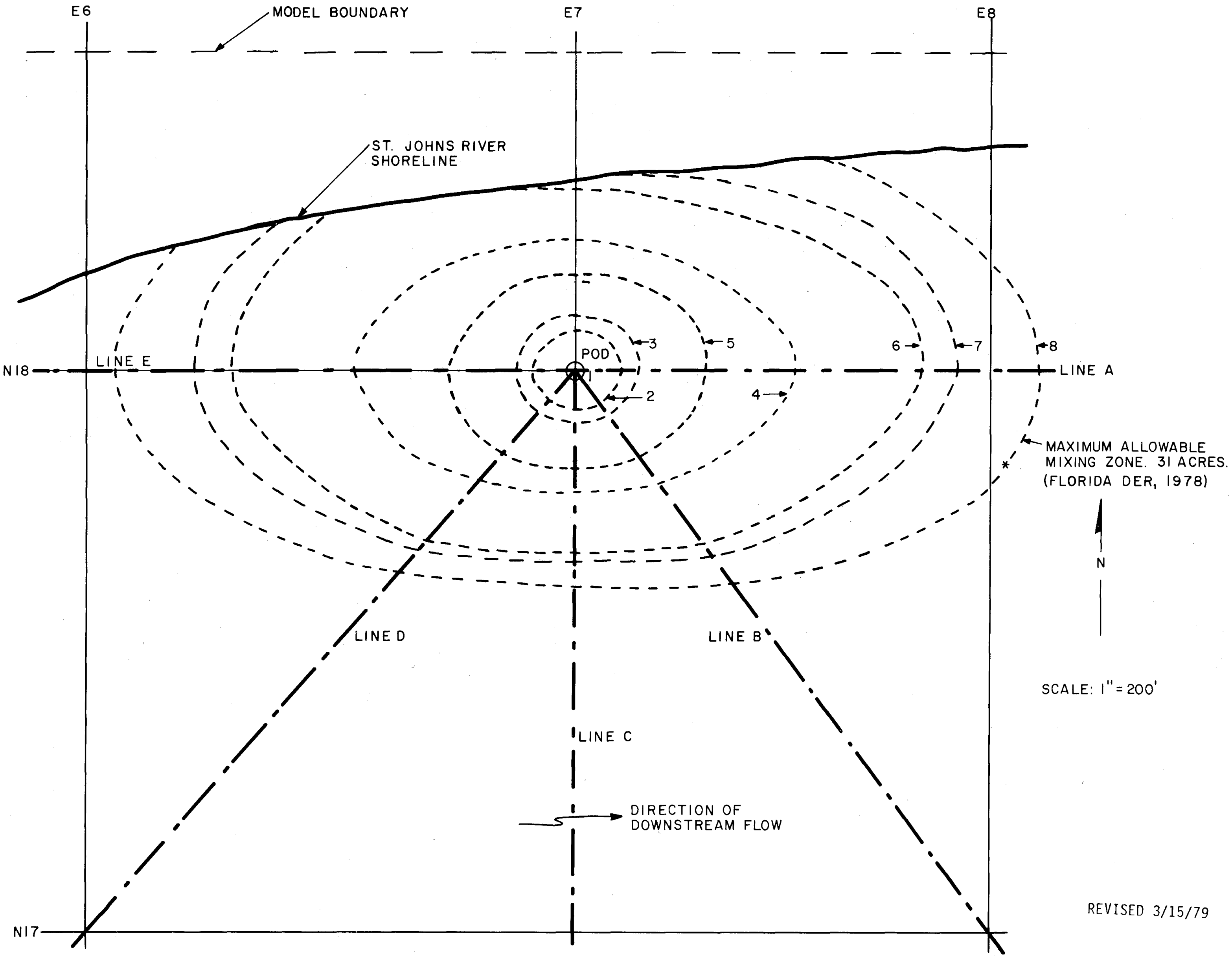

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Figure C-17. Near-field/Far-field interpolation - St. Johns River, Seminole Electric Discharge.

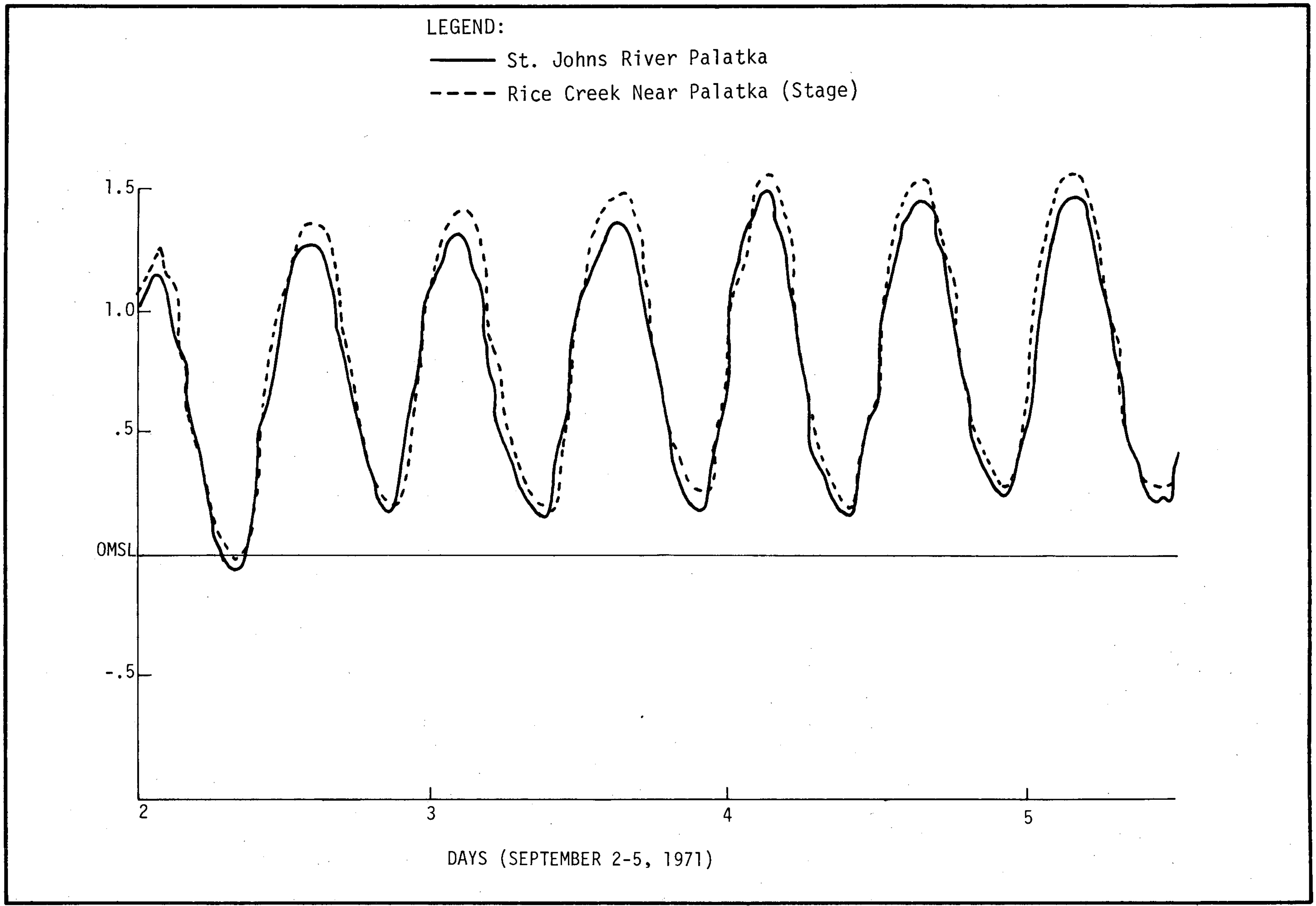

Figure C-18. Stage Records Rice Creek/St. Johns Palatka Stations.

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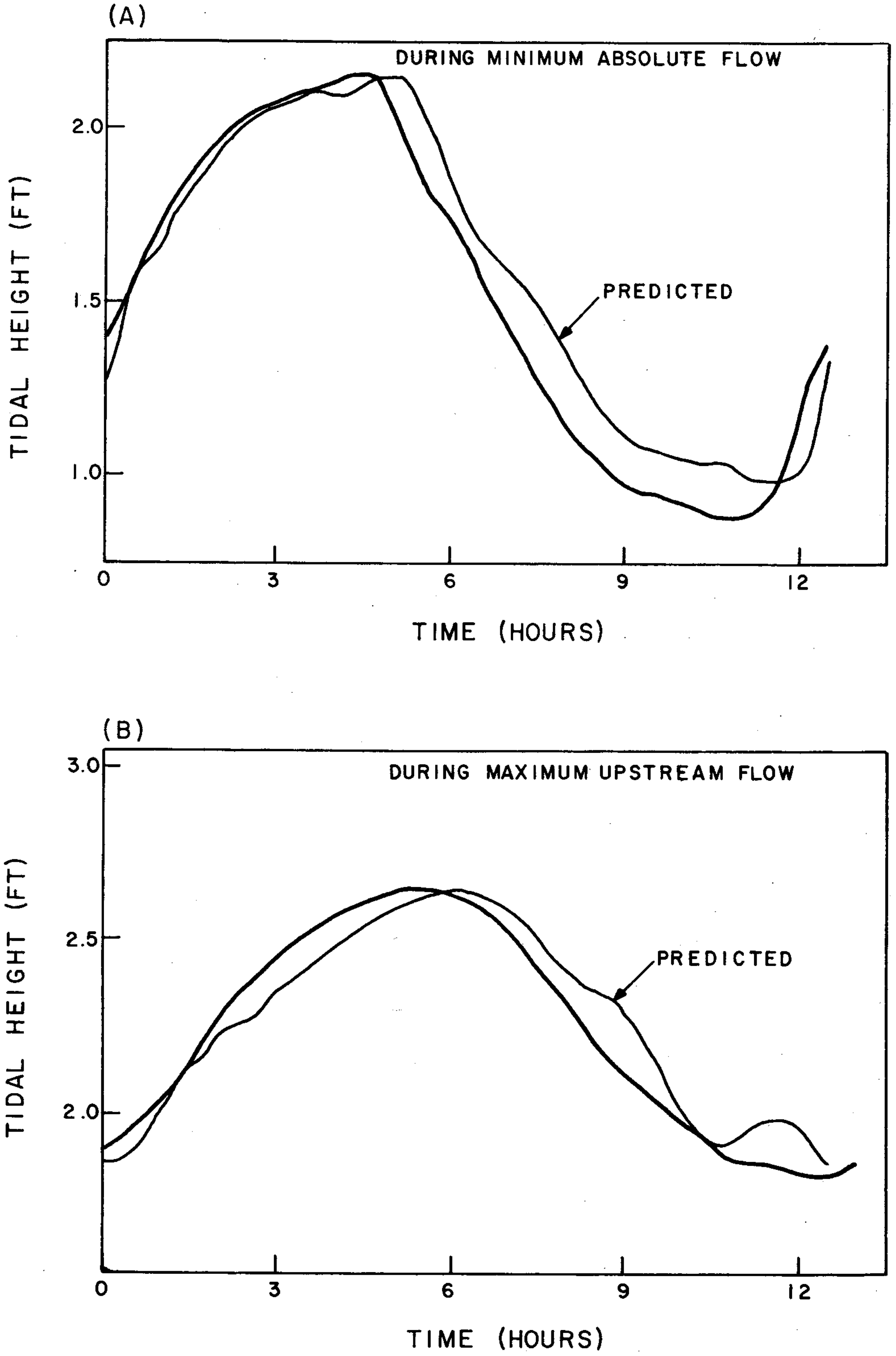

Figure C-19. Comparison of Predicted and Observed Tide at Palatka.

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ATTACHMENT C-1

NPDES PERMIT

FORM APPROVED
OMB No. 158–R0100

FOR AGENCY USE

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER

STANDARD FORM C – MANUFACTURING AND COMMERCIAL

SECTION I. APPLICANT AND FACILITY DESCRIPTION

Unless otherwise specified on this form all items are to be completed. If an item is not applicable indicate 'NA.'

ADDITIONAL INSTRUCTIONS FOR SELECTED ITEMS APPEAR IN SEPARATE INSTRUCTION BOOKLET AS INDICATED. REFER TO BOOKLET BEFORE FILLING OUT THESE ITEMS.

Please Print or Type

1. **Legal Name of Applicant** (see instructions) — 101 — Seminole Electric Cooperative, Inc. (SECI)

2. **Mailing Address of Applicant** (see instructions)
   - Number & Street — 102a — 2410 East Busch Boulevard
   - City — 102b — Tampa
   - State — 102c — Florida
   - Zip Code — 102d — 33612

3. **Applicant's Authorized Agent** (see instructions)
   - Name and Title — 103a — Tom Crumlish
Project Director
   - Number & Street Address — 103b — 2410 East Busch Boulevard
   - City — 103c — Tampa
   - State — 103d — Florida
   - Zip Code — 103e — 33612
   - Telephone — 103f — 813 (Area Code) 933-7406 (Number)

4. **Previous Application** If a previous application for a National or Federal discharge permit has been made, give the date of application. Use numeric designation for date. — 104 — ____ YR ____ MO ____ DAY

I certify that I am familiar with the information contained in this application and that to the best of my knowledge and belief such information is true, complete, and accurate.

Harry W. Wright
Printed Name of Person Signing

102e — Executive Vice Pres. and General Manager
Title

Harry W Wright
Signature of Applicant or Authorized Agent

78 10 31
YR MO DAY
102f — October 31st, 1978
Date Application Signed

18 U.S.C. Section 1001 provides that:

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and wilfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statement or representation, or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

FOR AGENCY USE

Received ____ ____ ____
YR MO DAY

OFFICE: ____ EPA Region Number
____ State

This section contains 3 pages.

FOR AGENCY USE

5. **Facility/Activity** (see instructions) Give the name, ownership, and physical location of the plant or other operating facility where discharge(s) does or will occur.		
Name	105a	Seminole Electric Putnam County Steam-electric Generating Station Units 1 and 2
Ownership (Public, Private or Both Public and Private)	105b	☐ PUB ☒ PRV ☐ BPP
Check block if Federal Facility and give GSA Inventory Control Number	105c	☐ FED
	105d	NA
Location Street & Number	105e	29° 44' north latitude/81° 38' west longitude (Site Center
City	105f	Palatka
County	105g	Putnam
State	105h	Florida
6. **Nature of Business** State the nature of the business conducted at the plant or operating facility.	106a	Electric Power Generation
	106b	AGENCY USE
7. **Facility Intake Water** (see instructions) Indicate water intake volume per day by sources. Estimate average volume per day in thousand gallons per day.		
Municipal or private water system	107a	* thousand gallons per day
Surface water	107b	* thousand gallons per day
Groundwater	107c	* thousand gallons per day * See Table I
Other*	107d	* thousand gallons per day
Total Item 7	107e	* thousand gallons per day
*If there is intake water from 'other,' specify the source.	107f	Runoff from coal pile and limestone storage areas is directed into the bottom ash sump.
8. **Facility Water Use** Estimate average volume per day in thousand gallons per day for the following types of water usage at the facility. (see instructions)		
Noncontact cooling water	108a	* thousand gallons per day
Boiler feed water	108b	* thousand gallons per day
Process water (including contact cooling water)	108c	* thousand gallons per day
Sanitary water	108d	* thousand gallons per day * See Table II
Other*	108e	* thousand gallons per day
Total Item 8	108f	* thousand gallons per day
*If there are discharges to 'other,' specify.	108g	*
If there is 'Sanitary' water use, give the number of people served.	108h	* people served

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9. **All Facility Discharges and other Losses; Number and Discharge** (see instructions) **Volume** Specify the number of discharge points and the volume of water discharged or lost from the facility according to the categories below. Estimate average volume per day in **thousand** gallons per day.

		Number of Discharge Points		Total Volume Used or Discharged, Thousand Gal/Day
Surface Water	109a1	*	109a2	*
Sanitary wastewater transport system	109b1	*	109b2	*
Storm water transport system	109c1	*	109c2	*
Combined sanitary and storm water transport system	109d1	*	109d2	*
Surface impoundment with no effluent	109e1	*	109e2	*
Underground percolation	109f1	*	109f2	*
Well Injection	109g1	*	109g2	*
Waste acceptance firm	109h1	*	109h2	*
Evaporation	109i1	*	109i2	*
Consumption	109j1	*	109j2	*
Other*	109k1	*	109k2	*
Facility discharges and volume Total Item 9.	109l1	*	109l2	*

*See Table III

*If there are discharges to 'other,' specify. 109m1 *

10. **Permits, Licenses and Applications** (See Table IV)
List all existing, pending or denied permits, licenses and applications related to discharges from this facility (see instructions).

	Issuing Agency	For Agency Use	Type of Permit or License	ID Number	Date Filed YR/MO/DA	Date Issued YR/MO/DA	Date Denied YR/MO/DA	Expiration Date YR/MO/DA
110	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1.								
2.								
3.								

11. **Maps and Drawings**
Attach all required maps and drawings to the back of this application. (see instructions)

12. **Additional Information**

112 Item Number	Information
105	Figure 4
107	Table I, Figures 1 to 3 and Table VII
108	Table II, Figures 1 to 3 and Table VII
109	Table III, Figures 1 to 3 and Table VII
110	Table IV

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STANDARD FORM C – MANUFACTURING AND COMMERCIAL

SECTION II. BASIC DISCHARGE DESCRIPTION

Complete this section for **each** discharge indicated in Section I, Item 9, that is to surface waters. This includes discharges to municipal sewerage systems in which the wastewater does not go through a treatment works prior to being discharged to surface waters. Discharges to wells must be described where there are also discharges to surface waters from this facility. **SEPARATE DESCRIPTIONS OF EACH DISCHARGE ARE REQUIRED EVEN IF SEVERAL DISCHARGES ORIGINATE IN THE SAME FACILITY.** All values for an existing discharge should be representative of the twelve previous months of operation. If this is a proposed discharge, values should reflect best engineering estimates.

ADDITIONAL INSTRUCTIONS FOR SELECTED ITEMS APPEAR IN SEPARATE INSTRUCTION BOOKLET AS INDICATED. REFER TO BOOKLET BEFORE FILLING OUT THESE ITEMS.

1. **Discharge Serial No. and Name**

   a. **Discharge Serial No.** (see instructions) — **201a** 001

   b. **Discharge Name** Give name of discharge, if any. (see instructions) — **201b** Seminole (Putnam) Plant Discharge

   c. **Previous Discharge Serial No.** If previous permit application was made for this discharge (see Item 4, Section I), provide previous discharge serial number. — **201c** NA

2. **Discharge Operating Dates**

   a. **Discharge Began Date** If the discharge described below is in operation, give the date (within best estimate) the discharge began. — **202a** NA (YR MO)

THE THREE PERIODS

	PHASE I*	PHASE II*	PHASE III*
b. **Discharge to Begin Date** If the discharge has never occurred but is planned for some future date, give the date (within best estimate) the discharge will begin. — **202b**	79 11 YR MO	83 6 YR MO	85 6 YR MO
c. **Discharge to End Date** If discharge is scheduled to be discontinued within the next 5 years, give the date (within best estimate) the discharge will end. — **202c**	83 6 YR MO	85 6 YR MO	2020 6 YR MO

* See Item 26 for Description of Phases.

3. **Engineering Report Available** Check if an engineering report is available to reviewing agency upon request. (see instructions) — **203** ☒ See Item 26

4. **Discharge Location** Name the political boundaries within which the point of discharge is located.

			Agency Use
State	**204a** Florida	**204d**	
County	**204b** Putnam	**204e**	
(if applicable) City or Town	**204c** (near) Palatka	**204f**	

5. **Discharge Point Description** Discharge is into (check one): (see instructions)

Stream (includes ditches, arroyos, and other intermittent watercourses)	**205a**	☒STR
Lake		☐LKE
Ocean		☐OCE
Municipal Sanitary Wastewater Transport System		☐MTS
Municipal Combined Sanitary and Storm Transport System		☐MCS

This section contains 9 pages.

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Municipal Storm Water Transport System ☐ STS

Well (Injection) ☐ WEL

Other ☐ OTH

If 'other' is checked, specify **205b** ______

6. **Discharge Point — Lat/Long** Give the precise location of the point of discharge to the nearest second.

Latitude	**206a**	29 DEG	42 MIN	41 SEC	See Figure IV
Longitude	**206b**	81 DEG	38 MIN	14 SEC	

7. **Discharge Receiving Water Name** Name the waterway at the point of discharge.(see instructions) **207a** St. Johns River

If the discharge is through an outfall that extends beyond the shoreline or is below the mean low water line, complete Item 8.

207b

For Agency Use			**207c**	For Agency Use
Major	Minor	Sub		303e

8. **Offshore Discharge**
   a. **Discharge Distance from Shore** **208a** 500 feet
   b. **Discharge Depth Below Water Surface** **208b** 5 feet (to MLW)

9. **Discharge Type and Occurrence**
   a. **Type of Discharge** Check whether the discharge is continuous or intermittent. (see instructions) **209a** ☒ (con) Continuous ☐ (int) Intermittent
   b. **Discharge Occurrence Days per Week** Enter the average number of days per week (during periods of discharge) this discharge occurs. **209b** 7 days per week
   c. **Discharge Occurrence** —Months If this discharge normally operates (either intermittently, or continuously) on less than a year-around basis (excluding shutdowns for routine maintenance), check the months during the year when the discharge is operating. (see instructions) **209c**

☐ JAN ☐ FEB ☐ MAR ☐ APR
☐ MAY ☐ JUN ☐ JUL ☐ AUG NA
☐ SEP ☐ OCT ☐ NOV ☐ DEC

:omplete Items 10 and 11 if "inter-
ıittent" is checked in Item 9.a.
)therwise, proceed to Item 12.

0. **Intermittent Discharge Quantity** State the average volume per discharge occurrence in thousands of gallons. **210** NA thousand gallons per discharge occurrence.

11. **Intermittent Discharge Duration and Frequency**
   a. **Intermittent Discharge Duration Per Day** State the average number of hours per day the discharge is operating. **211a** NA hours per day
   b. **Intermittent Discharge Frequency** State the average number of discharge occurrences per day during days when discharging. **211b** NA discharge occurrences per day

12. **Maximum Flow Period** Give the time period in which the maximum flow of this discharge occurs. **212** From Jan (month) to Dec (month)

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13. Activity Description Give a narrative description of activity producing this discharge.(see instructions)

213a Generation of electrical power and the use of wet natural draft cooling towers to dissipate heat from condenser cooling water.

14. Activity Causing Discharge For each SIC Code which describes the activity causing **this** discharge, supply the type and maximum amount of **either** the raw material consumed (Item 14a) **or** the product produced (Item 14b) in the units specified in Table I of the Instruction Booklet. For SIC Codes not listed in Table I, use raw material or production units normally used for measuring production.(see instructions)

a. **Raw Materials**

214a	SIC Code (1)	Name (2)	Maximum Amount/Day (3)	Unit (See Table I) (4)	Shared Discharges (Serial Number) (5)
	NA	NA	NA	NA	NA

b. **Products**

214b	SIC Code (1)	Name (2)	Maximum Amount/Day (3)	Unit (See Table I) (4)	Shared Discharges (Serial Number) (5)
	Z-1	Electric Power	32.64	1000 MW/Day (Gross)	
		Services			
	Average net plant generation based on 68% capacity factor = 19.58 (1000 MW/Day)				
	Lifetime plant capacity factor = 68%				

Lifetime plant operating load factor = 80%

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______

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15. Waste Abatement

a. Waste Abatement Practices
Describe the waste abatement practices used on this discharge with a brief narrative. (see instructions)

215a

Narrative: A central wastewater treatment system is provided to collect, equalize, treat and monitor process and blowdown waters before release. Strong wastes are batch treated at the source and oil is trapped locally before wastes are pumped to the bottom ash sump adjacent to the treatment facility.

Stabilized and fixed sludge containing fly ash and bottom ash, mixed in a cementitious form containing approximately 15% water by (continued below)

b. Waste Abatement Codes
Using the codes listed in Table II of the Instruction Booklet, describe the waste abatement processes for this discharge in the order in which they occur if possible.

215b

(1) ESEGRE, (2) ESURFA, (3) EMERGE*,
(4) RECOVE, (5) RECYCLE, (6) REHEATR,
(7) LOCALS, (8) OMONIT, (9) OOTHER**,
(10) PEQUAL, (11) PSCREE, (12) PAERAT,
(13) PSECIM, (14) PFLOAT, (15) PSKIMC,
(16) PSEPAR***, (17) PSANDF, (18) CNEUTR,
(19) CPHADJ, (20) CFLOCC, (21) CCLDIS,
(22) BACTIV, (23) STHICK, (24) SVACUM,
(25) SLANDD.

* Defined as main surface condenser.

** Oil and grease will be controlled at the source where possible.

*** Not an API separator.

(continued from above)
weight will be disposed in a surface impoundment. There will be no direct discharge to any surface water source. Runoff from this process will be contained and directed to the scrubber for makeup.

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16. Wastewater Characteristics

Check the box beside each constituent which is present in the effluent (discharge water). This determination is to be based on actual analysis or best estimate.(see instructions)

Parameter 216	Present	Parameter 216	Present
Color 00080		Copper 01042	X
Ammonia 00610	X	Iron 01045	X
Organic nitrogen 00605		Lead 01051	X
Nitrate 00620	X	Magnesium 00927	X
Nitrite 00615		Manganese 01055	X
Phosphorus 00665	X	Mercury 71900	X
Sulfate 00945	X	Molybdenum 01062	X
Sulfide 00745		Nickel 01067	X
Sulfite 00740	X	Selenium 01147	X
Bromide 71870	X	Silver 01077	X
Chloride 00940	X	Potassium 00937	X
Cyanide 00720	X	Sodium 00929	X
Fluoride 00951	X	Thallium 01059	
Aluminum 01105	X	Titanium 01152	
Antimony 01097	X	Tin 01102	
Arsenic 01002	X	Zinc 01092	X
Beryllium 01012		Algicides* 74051	
Barium 01007	X	Chlorinated organic compounds* 74052	
Boron 01022		Pesticides* 74053	
Cadmium 01027	X	Oil and grease 00550	X
Calcium 00916	X	Phenols 32730	
Cobalt 01037		Surfactants 38260	
Chromium 01034	X	Chlorine 50060	X
Fecal coliform bacteria 74055	X	Radioactivity* 74050	

*Specify substances, compounds and/or elements in Item 26.

Pesticides (insecticides, fungicides, and rodenticides) must be reported in terms of the acceptable common names specified in *Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels,* 2nd Edition, Environmental Protection Agency, Washington, D.C. 20250, June 1972, as required by Subsection 162.7(b) of the Regulations for the Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act.

NOTE: For Items 17, 19, 22, 25 - NA = Not Available

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17. **Description of Intake and Discharge** for Phases II & III (See Item 26)

For each of the parameters listed below, enter in the appropriate box the value or code letter answer called for.(see instructions)

In addition, enter the parameter name and code and all required values for any of the following parameters if they were checked in Item 16; ammonia, cyanide, aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, phenols, oil and grease, and chlorine (residual).

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) Runoff (1)	In-Plant Treated Intake Water (Daily Average) Surface Water Ground Water (2)	Daily Average (3)	Minimum Value (4)	Maximum Value* (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)
Flow* MGD (50050) Phase II	0.39	8.2	1.22	0.0	3.73			
Phase III	0.78	16.4	2.45	0.0	7.46			
pH Units 00400	NA	6.1		6.0	8.5			
Temperature (winter) ° F 74028	SEE TABLE VI →							
Temperature (summer) ° F 74027	SEE TABLE VI →							
Biochemical Oxygen Demand ** (BOD 5-day) mg/l 00310	NA	1.9	6.8	2.0	12.4			
Chemical Oxygen Demand (COD)** mg/l 00340	NA	64.	250.	200.	370.			
Total Suspended (nonfilterable)** Solids mg/l 00530	NA	8.	52.	32.	159.			
Specific Conductance micromhos/cm at 25° C 00095	NA	NA		NA	NA			
Settleable Matter (residue) ml/l 00545	NA	NA	NA	NA	NA			
Ammonia mg/l	NA	0.1	8.6	8.5	9.4			
Aluminum mg/l	NA	0.083	51.1	51.1	51.1			
Arsenic mg/l	NA	0.0054	0.033	0.020	0.073			
Cyanide mg/l	NA	0.0	0.001	0.001	0.001			
Cadmium mg/l	NA	0.0021	0.014	0.012	0.031			
Chromium mg/l	NA	0.013	0.078	0.066	0.097			

* Estimates based on best available data. Maximum values shown represent the worst case combination of ambient and operating conditions.

** See Page II-7 for note.

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17. (Cont'd.)

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) (1)	In-Plant Treated Intake Water (Daily Average) (2)	Daily Average (3)	Minimum Value Observed or Expected During Discharge Activity (4)	Maximum Value Observed or Expected During Discharge Activity (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)
Copper mg/l	NA	0.003	0.202	0.197	0.222			
Lead mg/l	NA	0.015	0.061	0.016	0.255			
Mercury mg/l	NA	0.0002	0.001	0.0004	0.002			
Nickel mg/l	NA	0.002	0.032	0.029	0.035			
Selenium mg/l	NA	0.005	0.025	0.014	0.039			
Oil and Grease mg/l**	NA	10.	34.	17.	68.			
Chlorine (Phase II)	NA	--	--	--	0.4			
(Phase III) mg/l	NA	--	--	--	0.2			
Zinc mg/l	NA	0.026	0.228	0.16	0.752			

** Values for these parameters are dependent on ambient river concentrations increased by a factor of four due to four cycles of concentration from cooling towers (Table Va). Internal waste streams (Table Vb - Ve) are controlled within 40 CFR 423 limitations.

18. Plant Controls Check if the following plant controls are available for this discharge. 218

Alternate power source for major pumping facility. ☐ APS NA

Alarm or emergency procedure for power or equipment failure ☐ ALM NA

Complete item 19 if discharge is from cooling and/or steam water generation and water treatment additives are used.

19. Water Treatment Additives If the discharge is treated with any conditioner, inhibitor, or algicide, answer the following:

a. Name of Material(s) 219a Sulfuric acid (hypochlorite)

b. Name and address of manufacturer 219b NA

c. Quantity (pounds added per million gallons of water treated). 219c Sulfuric Acid - 1175#
Chlorine - 50#

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d. Chemical composition of these additives (see instructions). 219d H_2SO_4, Cl_2

Complete items 20-25 if there is a thermal discharge (e.g., associated with a steam and/or power generation plant, steel mill, petroleum refinery, or any other manufacturing process) **and** the total discharge flow is 10 million gallons per day or more. (see instructions)

20. Thermal Discharge Source Check the appropriate item(s) indicating the source of the discharge. (see instructions) 220

Boiler Blowdown ☐ BLBD
Boiler Chemical Cleaning ☐ BCCL
Ash Pond Overflow ☒ APOF
Boiler Water Treatment — Evaporator Blowdown ☐ EPBD
Oil or Coal Fired Plants — Effluent from Air Pollution Control Devices ☐ OCFP
Condense Cooling Water ☐ COND
Cooling Tower Blowdown ☒ CTBD
Manufacturing Process ☐ MFPR
Other ☐ OTHR

21. Discharge/Receiving Water Temperature Difference

Give the maximum temperature difference between the discharge and receiving waters for summer and winter operating conditions. (see instructions)

Summer 221a 21* °F.
Winter 221b 15* °F.

* See Table VI for supporting data. The worst case temperature differentials at discharge 001 are highly conservative. The differentials represent maximum recorded wet bulb/dry bulb temperatures occurring in conjunction with minimum recorded river temperatures.

22. Discharge Temperature, Rate of Change Per Hour 222 NA °F./hour

Give the maximum possible rate of temperature change per hour of discharge under operating conditions. (see instructions)

23. Water Temperature, Percentile Report (Frequency of Occurrence) In the table below, enter the temperature which is exceeded 10% of the year, 5% of the year, 1% of the year and not at all (maximum yearly temperature). (see instructions)

Frequency of occurrence	10%	5%	1%	Maximum
a. Intake Water Temperature (Subject to natural changes) 223a	86 °F	87.5 °F	88.5 °F	90.5 °F
b. Discharge Water Temperature 223b	88 °F	89 °F	91 °F	93 °F

24. Water Intake Velocity (see instructions) 224 Less than 0.5 feet/sec.

25. Retention Time Give the length of time, in minutes, from start of water temperature rise to discharge of cooling water. (see instructions) 225 NA minutes

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001

FOR AGENCY USE

26. Additional Information

226

Item	Information
2	Description of Phases Phase I - Unit 1 Construction Phase II - Unit 1 Operation, Unit 2 Construction Phase III - Unit 1 and 2 Operation
3	Site Certification Application and Environmental Analysis for Seminole Plant Units No. 1 and No. 2, Seminole Electric Cooperative, Inc., prepared by Dames & Moore and submitted to the U.S. EPA by the Florida Department of Environmental Regulation on August 7, 1978.
9	The discharge structure will be designed to discharge nominally at 10 to 15 fps. A surge basin will be provided in the discharge system to maintain the design exit velocities within the above range.
16	The constituents listed are those expected to be present in the effluent due to proposed facility operations such as water treatment, maintenance cleaning, chemical cleaning, ash handling and coal pile drainage.
17	Individual Waste Streams Constituent Concentrations* The following Tables are provided to support the Discharge 001 constituent concentrations given in Item 17. (Discharge lines shown on Figures 2 and 3)

TABLE NO.	TITLE
Va	Cooling Tower Blowdown, (line J) Constituent Concentrations (includes ambient river water quality)
Vb	Chemical Wastewater Treatment Facility

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FOR AGENCY USE

26. Additional Information

226 Item	Information
17 (cont'd)	Vb (cont.) (line T) Constituent Concentrations (includes Contaminated Runoff, line W)
	Vc Sanitary Wastewater Treatment Facility (line JJ) Constituent Concentrations
	Vd Low Volume Wastewater (lines X + Y + Z + AA) Constituent Concentrations
	Ve Bottom Ash Transport Water (lines Q + YY) Constituent Concentrations
	* The following wastewater streams are not discharged to surface waters (see figures 2 and 3)
	Metal Cleaning Wastes (Chemical Cleaning Waste, XX)
	Boiler Blowdown (WW)
17 (cont'd)	<u>Mixing of Waste Streams into Discharge 001</u>.
	Except for chlorine, the constituent concentrations in the combined wastewater stream (Discharge 001) are based on <u>average</u> flow rates from the three streams combined into 001. (i.e., chemical waste treatment facility effluent, sanitary treatment facility effluent, and cooling tower blowdown). The concentrations shown should be essentially the same for Phase II and Phase III as the average flow rates of all waste streams are doubled between Phase II and III.
	To maximize the estimate of chlorine concentrations, the maximum

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001

FOR AGENCY USE

26. Additional Information

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Item	Information
	cooling tower blowdown flow rate was combined with the average flow rates from the other waste streams for both Phase II and Phase III.
	It was conservatively assumed that the constituent concentrations in the effluent from the chemical waste treatment facility (Line T, figures 2 and 3) and the sanitary treatment facility (Line ZZ, figures 2 and 3) would always be present at the maximum values and only the blowdown constituents vary in concentrations as shown in Table Va.
17 (cont'd)	Water Temperature
	The influent/effluent water temperatures on a monthly basis are shown in Table VI.
	Note: Sensible cooling effect for cooling tower evaporation rates is relatively insignificant (less than 10%) and the capacity factor on a monthly basis is uniform over the life of the project. Therefore monthly flow data have not been shown. The value shown is slightly higher than the evaporation and blowdown that will actually occur due to the additional sensible cooling which was ignored.
17 (cont'd)	In-Plant Usage of Wastewater
	Cooling tower Blowdown and chemical wastewater will be utilized for scrubber make-up if found to be practical, but it should be noted that the use of such water for SO_2 scrubber usage has not proven to be successful in other applications.

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FOR AGENCY USE

26. Additional Information

Item	Information
17 (cont'd)	Chlorine Mixing Zone Phase II: Mixing zone ≤ 25.0 acres Phase III: Mixing zone ≤ 5.0 acres Basis: The proposed wastewater discharge into the St. Johns River will be near the surface and, except during periods of rapid air temperature cooling, will be elevated in temperature above the ambient river temperature. Spreading of the wastewater will be most pronounced during periods of high blowdown temperature and low river temperature as the plume will be buoyant. Such conditions should produce the maximum surface area mixing zone as less of the vertical water column mixes with the wastewater. Spreading of the buoyant plume was analyzed with a well tested plume transport model developed by Shirazi and Davis (1974, Workbook of Thermal Plume Prediction, Vol. 2, EPA-R2-72-005b).

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Section III is not applicable to this proposed facility.

STANDARD FORM C – MANUFACTURING AND COMMERCIAL

SECTION III. WASTE ABATEMENT REQUIREMENTS & IMPLEMENTATION (CONSTRUCTION) SCHEDULE

This section requires information on any uncompleted implementation schedule which may have been imposed for construction of waste abatement facilities. Such requirements and implementation schedules may have been established by local, State, or Federal agencies or by court action. In addition to completing the following items, a copy of an official implementation schedule should be attached to this application. IF YOU ARE SUBJECT TO SEVERAL DIFFERENT IMPLEMENTATION SCHEDULES, EITHER BECAUSE OF DIFFERENT LEVELS OF AUTHORITY IMPOSING DIFFERENT SCHEDULES (Item 1a.) AND/OR STAGED CONSTRUCTION OF SEPARATE OPERATION UNITS (Item 1c), SUBMIT A SEPARATE SECTION III FOR EACH ONE.

FOR AGENCY USE
SCHED. NO. ____

1. Improvements 300

a. **Discharge Serial Number Affected** List the discharge serial numbers, assigned in Section II, that are covered by this implementation schedule. 301a 001, ____, ____, ____, ____, ____.

b. **Authority Imposing Requirements** Check the appropriate item indicating the authority for implementation schedule. If the identical implementation schedule has been ordered by more than one authority, check the appropriate items. (see instructions)

Locally developed plan	301b	☐LOC
Areawide Plan		☐ARE
Basic Plan		☐BAS
State approved implementation schedule		☐SQS
Federal approved water quality standards implementation plan.		☐WQS
Federal enforcement procedure or action		☐ENF
State court order		☐CRT
Federal court order		☐FED

c. **Facility Requirement.** Specify the 3-character code of those listed below that best describes in general terms the requirement of the implementation schedule and the applicable six-character abatement code(s) from Table II of the Instruction booklet. If more than one schedule applies to the facility because of a staged construction schedule, state the stage of construction being described here with the appropriate general action code. Submit a separate Section III for each stage of construction planned.

3-character (general)
301c ____

301d 6-character (specific) (see Table II)
____
____
____

New Facility	NEW
Modification (no increase in capacity or treatment)	MOD
Increase in Capacity	INC
Increase in Treatment Level	INT
Both increase in Treatment Level and Capacity	ICT
Process Change	PRO
Elimination of Discharge	ELI

This section contains 2 pages.

FOR AGENCY USE

2. **Implementation Schedule** and 3. **Actual Completion Dates**

Provide dates imposed by schedule and any actual dates of completion for implementation steps listed below. Indicate dates as accurately as possible. (see instructions)

Implementation Steps		2. Schedule (Yr./Mo./Day)		3. Actual Completion (Yr./Mo./Day)
a. Preliminary plan complete	302a	____/____/____	303a	____/____/____
b. Final plan submission	302b	____/____/____	303b	____/____/____
c. Final plan complete	302c	____/____/____	303c	____/____/____
d. Financing complete & contract awarded	302d	____/____/____	303d	____/____/____
e. Site acquired	302e	____/____/____	303e	____/____/____
f. Begin action (e.g., construction)	302f	____/____/____	303f	____/____/____
g. End action (e.g., construction)	302g	____/____/____	303g	____/____/____
h. Discharge Began	302h	____/____/____	303h	____/____/____
i. Operational level attained	302i	____/____/____	303i	____/____/____

Table I - Item 7

Facility Intake Water
Average Flow
(Thousand Gallons Per Day)

		Phase I	Phase II	Phase III	Line Reference*	Comments
107a	Municipal or Private Water Supply	N/A	N/A	N/A	N/A	None
107b	Surface Water	N/A	7,905	15,810	A	None
107c	Groundwater	34	324	590	AAA	None
107d	Other **	0	392	783	M,W	None
107e	Total	34	8,621	17,184	A+AAA+M+W	None
107f	Specify Source**	**	**	**	--	--

---

*See Table VII and Phase I - Figure 1, Phase II - Figure 2, Phase III - Figure 3.

**Runoff from coal pile and limestone storage areas will be directed to the bottom ash sump. Sludge pond runoff is returned to the FGD system as make-up.

Table II - Item 8

Facility Water Use
Average Flow
(Thousand Gallons Per Day)

		Phase I	Phase II	Phase III	Line Reference*	Comments
108a	Non Contact Cooling Water	0	6821	13641	F+G+J	None
108b	Boiler Feed Water	0	216	432	(EE minus CC)	None
108c	Process Water	8	1553	3088	B+C+D+VV+I+K+M+W+CC+BB+HH+GG+DDD	Item DDD included in Phase I & II only
108d	Sanitary Water	12	17	9	CCC+EEE	Phase I - CCC only Phase III - EEE only
108e	Other**	14	14	14	MM	Fire Water System make-up
108f	Total	34	8621	17184	----	None
108g	Specify Source**	**	**	**	----	----
108h	No. of People Served	600	770	140	----	----

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* See Table VII and for Phase I - Figure 1, Phase II - Figure 2, Phase III - Figure 3.

**Fire protection water make-up.

Table III - Item 9

All Facility Discharges and Other Losses; Number and Discharge Average Flow (Thousand Gallons Per Day)

Page 1 of 2

		Phase I		Phase II		Phase III		Line Reference*	Comments
		1**	2***	1**	2***	1**	2***		
109a 1&2	Surface Water	NA	NA	NA	1238	1	2448	ZZ	See Item 109f
109b 1&2	Sanitary Wastewater Transport System	NA	NA	NA	NA	NA	NA	---	None
109c 1&2	Storm Water Transport System	NA	NA	NA	NA	NA	NA	---	None
109d 1&2	Combined Sanitary & Storm Water Transport System	NA	NA	NA	NA	NA	NA	---	None
109e 1&2	Surface Impoundment With No Effluent	NA	NA	1	10	1	20	N	None
109f 1&2	Underground Percolation	2	26	2	45	2	75	RR+CCC	CCC will be percolated in first phase only. Fire Water assumed to percolate.
109g 1&2	Well Injection	NA	NA	NA	NA	NA	NA	---	
109h 1&2	Waste Acceptance Firm	1	0.1	1	0.1	1	0.3	XX	Phase I, II, III - boiler cleaning.
109i 1&2	Evaporation or Emissions to Gas	NA	NA	4	7321	4	1464	G+F+O+L+DD	None
109j 1&2	Consumption	1	8	1	8	NA	NA	DDD	None

Table III - Item 9 (continued)

		Phase I		Phase II		Phase III		Line Reference *	Comments
		1**	2***	1**	2***	1**	2***		
109k 1&2	Other	NA	NA	NA	NA	NA	NA	---	None
109l 1&2	Total	4	34	10	8,621	9	17,184	---	None

---

* See Table VII and for Phase I - Figure 1, Phase II - Figure 2, Phase III - Figure 3.

** Number of discharge points.

*** Total volume used or discharged.

Note: NA = Not applicable.

TABLE IV

(Section I, Item 10)
SEMINOLE ELECTRIC PUTNAM STATION
STEAM ELECTRIC GENERATING FACILITY

STATUS OF PERMITS AND APPROVALS

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency	Date of Application (Proposed)	Approval Date (Expected)	Comments
FEDERAL					
Application for loan approval	Rural Electrification Act	REA	(3/79)	(12/79)	
Environmental Analysis	National Environmental Policy Act; Exec. Order 11514: Protection and Enhancement of Environmental Quality; Exec. Order 11991: Relating to Protection and Enhancement of Environmental Quality	REA	(8/78)	(11/79)	
NPDES	Federal Water Pollution Control Act (§402)	EPA	(11/78)	(11/79)	
Preconstruction New Source Air Quality Review	Clean Air Act (§110)	EPA	(8/78)	(11/79)	This review will be conducted by the State through its Site Certification process.
PSD	Clean Air Act (§160-169)	EPA	5/78	(Prior to 5/79)	
Activities in Navigable Waters	Rivers and Harbors Act (§10)				
1. Intake/discharge structures		COE	(8/78)	(11/79)	
2. Transmission Lines		COE	NA	NA	Applications to be filed prior to line construction.

Table IV (continued)

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency	Date of Application (Proposed)	Approval Date (Expected)	Comments
Activities in Wetlands	Federal Water Pollution Control Act (§404)	COE	(8/78)	(11/79)	
Construction of Tall Stack	Federal Aviation Act	FAA	2/78	5/78	Approval contingent on State DOT stack construction approval
STATE					
Site Certification Application	Florida Electrical Power Plant Siting Act	DER	(8/78)	(10/79)	
Transmission Line Road Crossings	Ch. 338 F.S. (Ch. 14-46 FAC Utilities Installation or Adjustment)	DOT	NA	NA	Application to be filed prior to construction.
Modifications of State Road 17		DOT	(8/79)	(11/79)	
Construction of Tall Stack	Ch. 75-16 F.S.	DOT	6/78	6/78	
Water Well Drilling	Ch. 381.03(1)(9)3 F.S.	DHRS	4/78	4/78	
Well Regulation	Florida Water Resources Act	SJRWMD	4/78	4/78	
Easement through State Owned Lands	Ch. 253 F.S. and Ch. 76-24F F.S.	DNR	(10/78)	(Prior to 10/79)	

Table IV (continued)

Subject of Permit Application or Approval	Statutory Mandate	Administering Agency	Date of Application (Proposed)	Approval Date (Expected)	Comments
LOCAL					
Land Use or Zoning Approval	Putnam County Zoning Ordinance 75-6 Chapter 163 F.S. Chapter 125 F.S.	Putnam County Commission	4/78	5/78	
Pipeline Road (209) Crossings	Putnam County Ordinance	Putnam County Commission			Application processed within two weeks of submission.
	Ch. 338 F.S.	DOT	NA	NA	

Abbreviations:

REA	U. S. Rural Electrification Administration
EPA	U. S. Environmental Protection Agency
COE	U. S. Corps of Engineers
FAA	Federal Aviation Administration
DER	Florida Department of Environmental Regulation
DOT	Florida Department of Transportation
DHRS	Florida Department of Health and Rehabilitative Services
SJRWMD	St. Johns River Water Management District
DNR	Florida Department of Natural Resources
NA	Not available

Table Va

Cooling Tower Blowdown
(Line J, Figures 2 and 3)
Estimated Constituent Concentrations
(mg/l)
Average Flow (Phase III) = 1722 TGD

Page 1 of 2

Parameter	Maximum Ambient*	Maximum Blowdown**	Average Ambient*	Average Blowdown**	Minimum Ambient*	Minimum Blowdown**
TSS***	46.0	184.	8.0	32.0	<1.	4.
TDS	935.	3740.	578.	2312.	378.	1512.
Sodium	180.	720.	122.	488.	70.	280.
Magnesium	28.	112.	18.	72.	10.	40.
Copper	0.010	0.040	0.003	0.012	0.001	0.004
Nickel	0.003	0.012	0.002	0.008	0.001	0.004
Zinc***	0.18	0.72	0.020	0.08	0.000	0.00
Chromium	0.020	0.080	0.013	0.052	0.009	0.036
Mercury	0.0005	0.002	0.00018	0.00072	0.0	0.0
Aluminum	0.150	0.6	0.083	0.332	0.04	0.16
Iron***	0.560	2.240	0.219	0.876	0.020	0.08
Manganese	0.030	0.120	0.016	0.064	0.006	0.024
Chloride	400.	1600.	220.	880.	120.	480.
Sulfate****	--	861.	--	--	--	231.
Phosphorus	0.40	1.6	0.2	0.8	0.06	0.24
Oil & Grease	22.	88.	10.	40.	4.	16.
Residual Chlorine						
Phase II	--	0.4	--	0.4	--	0.4
Phase III	--	0.2	--	0.2	--	0.2
Ammonia***	0.38	1.52	0.1	0.4	0.05	0.2

Table Va (continued)

Parameter	Maximum Ambient*	Maximum Blowdown**	Average Ambient*	Average Blowdown**	Minimum Ambient*	Minimum Blowdown**
COD***	106.	424.	64.	256.	46.	184.
BOD_5***	3.9	15.6	1.9	7.6	0.2	0.8
Arsenic	0.02	0.08	0.0054	0.022	0.001	0.004
Antimony	NA	NA	NA	NA	NA	NA
Berylium	NA	NA	NA	NA	NA	NA
Boron	NA	NA	NA	NA	NA	NA
Cadmium	0.006	0.024	0.00064	0.00256	0.0	0.0
Cyanide	NA	NA	NA	NA	NA	NA
Flouride	NA	NA	NA	NA	NA	NA
Lead	0.074	0.296	0.0139	0.0556	0.001	0.004
Selenium	0.01	0.04	0.005	0.02	0.001	0.004
Silver	NA	NA	NA	NA	NA	NA
Thorium	NA	NA	NA	NA	NA	NA
Uranium	NA	NA	NA	NA	NA	NA
pH	--	7.5	--	--	--	7.0
Nitrate	2.6	10.4	0.01	0.04	0.098	0.392

---

*Data for river water constituent concentrations obtained from STORET file, St. John's River Palatka station (except where noted).

**Constituent concentrations considered to be the same for both Phase II and Phase III, (except for Free Residual Chlorine).

***Values revised based on water quality data obtained by Dames & Moore in 1978.

****Total Sulfate after addition of H_2SO_4.

Table Vb

Chemical Wastewater Treatment Facility*
(Line T, Figures 2 and 3)
Estimated Maximum Constituent Concentrations
(mg/l)

Page 1 of 2

Constituent	Coal Pile, Limestone Drainage Line W**	Low Volume Waste Table Vd	Bottom Ash Transport Water Table Ve	Treatment Facility Influent Line R**	Treatment Facility Effluent Line T**
Flow (TGD)***	150.	135.	432.	717.	717.
TSS	610.	184.	184.	273.	100.
TDS	5800.	2126.	3740.	3867.	***
Sodium	1260.	586.	720.	808.	***
Magnesium	174.	33.	112.	110.	***
Copper	1.8	0.88	0.19	0.66	***
Nickel	0.2	0.0	0.075	0.09	***
Zinc	1.6	0.04	0.81	0.83	***
Chromium	0.3	0.001	0.12	0.14	***
Mercury	0.002	0.0001	0.003	0.002	***
Aluminum	825.	0.0	2.067	174.	***
Iron	0.9	4.38	11.49	7.94	1.
Manganese	180.	0.021	0.12	37.7	***
Chloride	23.	144.	1600.	996.	***
Sulfate	5231.	1787.	861.	1950.	***
Phosphorus	1.2	0.104	1.6	1.23	***
Oil & Grease	100.	10.4	88.	76.	20.
Free Chlorine	0.0	0.02	0.13	0.082	***
Ammonia	1.35	150.	0.0	28.5	***

Table Vb (continued)

Constituent	Coal Pile, Limestone Drainage Line W**	Low Volume Waste Table Vd	Bottom Ash Transport Water Table Ve	Treatment Facility Influent Line R**	Treatment Facility Effluent Line T**
COD	1080.	21.	424.	485.	243.
BOD_5	3.	NA	15.6	10.	5.
Arsenic	0.05	0.0	0.08	0.059	***
Antimony	0.1	"	0.033	0.041	***
Berylium	0.01	"	0.003	0.004	***
Boron	5.	"	1.67	2.05	***
Cadmium	0.1	"	0.049	0.05	***
Cyanide	0.01	"	0.003	0.004	***
Flouride	0.0	"	0.0	0.0	***
Lead	0.1	"	0.23	0.16	***
Selenium	0.01	"	0.03	0.039	***
Silver	0.01	"	0.003	0.004	***
Thorium	0.005	"	0.002	0.002	***
Uranium	0.01	"	0.003	0.004	***

---

*Basis for constituent concentrations:
Coal Pile/Limestone Drainage - Except for trace metals, values taken from Development Document for the Steam Electric Generating Point Source Category. Trace metals estimated based on coal analysis.
Low Volume Waste - See Table Vd
Bottom Ash Transport Water - See Table Ve
Treatment Facility Influent - Composite result of treatment in central waste facility of collected and equalized waste streams.

**See Figures 2 and 3.

***Thousand gallons/day (Phase III).

****As the effect of treatment on these constituents cannot be predicted, it was conservatively assumed there would be no reduction in constituent concentration.

Table Vc

Sanitary Waste
(Line J, Figures 2 and 3)
Estimated Maximum Constituent Concentration
(mg/l)

Parameter	Treated Water Quality
TSS	<5.0*
TDS	242.0
Sodium	11.0
Magnesium	10.0
Manganese	0.050
Copper	0.150
Zinc	0.340
Chromium	0.010
Mercury	0.001
Iron	12.4
Chloride	12.2
Sulfate	25.3
Phosphorus	<1.00*
BOD_5	<5.00*
Free Chlorine Residual	1.00 to 2.00*
Nitrate	<3.00*

---

*Constituents assumed to be directly treated in the sanitary treatment facility (other values are based on maximum recorded groundwater constituent concentrations).

Table Vd

Low Volume Waste*
Estimated Maximum Constituent Concentrations
(mg/l)

Page 1 of 2

Constituent	Lab and Floor Drains Line X**	Aux. Boiler Line Y**	Neut. Tank Line Z**	Pre-Treatment System, Line AA**	Combined Low Volume Wastes
Average Yearly Flow (TGD)***	14.	0.	78.	43.	135.
TSS	100.	5.	25.	500.	184.
TDS	240.	5.	3560.	140.	2126.
Sodium	20.	1.	1000.	20.	586.
Magnesium	10.	0.0	50.	10.	33.
Copper	0.15	0.5	1.5	0.0	.88
Nickel	0.0	0.0	0.0	"	0.0
Zinc	0.34	"	"	"	.04
Chromium	0.01	"	"	"	.001
Mercury	0.001	"	"	"	.0001
Aluminum	0.0	"	"	"	0.0
Iron	0.1	1.0	7.5	0.1	4.38
Manganese	0.05	0.0	0.0	0.05	0.021
Chloride	40.	"	220.	40.	144.
Sulfate	45.	"	3060.	45.	1787.
Phosphorus	1.	"	0.0	0.0	0.104
Oil & Grease	100.	"	"	"	10.4
Free Chlorine	0.2	"	"	"	0.02
Ammonia	0.0	1.	260.	"	150.

Table Vd (continued)

Constituent	Lab and Floor Drains Line X**	Aux. Boiler Line Y**	Neut. Tank Line Z**	Pre-Treatment System Line AA**	Combined Low Volume Wastes
COD	200.	NA	NA	NA	21.
BOD_5	NA****	"	"	"	NA
Arsenic	"	"	"	"	"
Antimony	"	"	"	"	"
Berylium	"	"	"	"	"
Boron	"	"	"	"	"
Cadmium	"	"	"	"	"
Cyanide	"	"	"	"	"
Flouride	"	"	"	"	"
Lead	"	"	"	"	"
Selenium	"	"	"	"	"
Silver	"	"	"	"	"
Thorium	"	"	"	"	"
Uranium	"	"	"	"	"

---

*Basis for constituent concentrations:
Lab and Floor Drains - water supply for this source is groundwater. Volumes of oil & grease and TSS generated at this source were estimated. Concentrations of other constituents represent maximum measured naturally occurring groundwater concentrations.
Aux. Boiler - concentrations represent the maximum operating control limits for the boiler water.
Neut. Tank - concentrations determined from average composition of the neutralized waste from the makeup demineralizer and condensate polisher operating under design conditions.
Pre-Treatment System - concentrations determined from composite of pretreatment clarifer blowdown and filter backwash water.

**See Figures 2 and 3.

***Thousand gallons/day (Phase III).

****NA - not available. Assumed to be zero.

Table Ve

Bottom Ash Transport Water*
Estimated Maximum Constituent Concentration
(mg/l)

Constituent	Dewatering Bin Line Q**	Seal Trough Overflow Line YY**	Combined
Average Yearly Flow (TGD)***	144.	288.	432.
TSS	184.	184.	184.
TDS	3740.	3740.	3740.
Sodium	720.	720.	720.
Magnesium	112.	112.	112.
Copper	0.5	0.04	0.19
Nickel	0.2	0.012	0.075
Zinc	1.	0.72	0.81
Chromium	0.2	0.08	0.12
Mercury	0.005	0.002	0.003
Aluminum	5.	0.6	2.067
Iron	30.	2.24	11.49
Manganese	0.12	0.12	0.12
Chloride	1600.	1600.	1600.
Sulfate	861.	861.	861.
Phosphorus	1.6	1.6	1.6
Oil & Grease	88.	88.	88.
Free Chlorine	0.0	0.2	0.13
Ammonia	0.0	0.0	0.0
COD	424.	424.	424.
BOD_5	15.6	15.6	15.6
Arsenic	0.08	0.08	0.08
Antimony	0.1	0.0	0.033
Berylium	0.01	"	0.003
Boron	5.	"	1.67
Cadmium	0.1	0.024	0.049
Cyanide	0.01	0.0	0.003
Flouride	0.0	"	0.0

Constituent	Dewatering Bin Line Q**	Seal Trough Overflow Line YY**	Combined
Lead	0.1	0.29	0.23
Selenium	0.01	0.04	0.03
Silver	0.01	0.0	0.003
Thorium	0.005	"	0.002
Uranium	0.01	"	0.003

---

*Basis for constituent concentrations:
Dewatering Bin - constituent concentrations based on cooling tower blowdown water quality (Table Va) and coal analysis.
Seal Trough Overflow - Constituent concentrations based on cooling tower blowdown water quality (Table Va).

**See Figures 2 and 3.

***Thousand gallons/day (Phase III).

Table VI - Item 21

(Estimated) Discharge/Receiving Water Temperature (°F)

		001 Discharge Water Temperature*			Ambient Water Temperature**		
	Month	Max.	Min.	Avg	Max.	Min.	Avg.
Winter	Jan	82	32	72	68	63***	65
	Feb	83	32	74	69	68	69
Summer	Mar	84	32	76	74	69	71
	April	84	40	79	82	72	75
	May	88	52	84	88	73	75
	June	91	65	88	88	73	86
	July	92	69	89	88	83	84
	Aug	93	69	90	90	82	84
	Sept	92	60	88	90	83	83
	Oct	89	42	82	79	72	74
Winter	Nov	86	32	76	77	65	71
	Dec	86	32	73	66	59	61

---

*Cooling tower recirculating water temperature. Conservatively assumed that the chemical wastewater (Line T, Figures 2 and 3) and sanitary wastewater (Line JJ, Figures 2 and 3) are discharged at the same temperature as the recirculating water (blowdown).

**Except where noted, river temperature data were developed from USGS daily instantaneous water temperature measurements at the St. Johns River Palatka station.

***A temperature of 43°F was obtained from Dames & Moore field data. Measurements were made within 500 feet of the Point of Discharge on 1-30-78 at 0840 hours at a maximum depth of 1 foot. The corresponding dry bulb ambient air temperature was approximately 24°F during the test. Freezing temperatures were obtained during the two(2) days preceeding the test with maximum temperatures less than 50°F. As the average minimum air temperature at Jacksonville in 34 years of record is 45°F, and the extreme low is 19°F, the extended cold spell is viewed as an anomolous situation. In addition, the upper one foot of the water body was likely stratified, with much warmer temperatures at five feet of depth. As a result of the anomolous air temperatures and probable stratification in the water body, the USGS data has been shown in the Table is considered more representative of minimum January temperatures.

Note: The maximum potential temperature differential (82°F - 43°F) was utilized in the mixing zone analysis.

Table VII

Facility Water Use

Average Flow
(Thousand Gallons Per Day)
(See Figures 1, 2, & 3)

Line No.		Phase I	Phase II	Phase III	
		Average Usage	Average Usage	Average Usage	Maximum Usage
A	Total river water make-up	0	7,905	15,810	28,437
B	Screen wash return	0	0	0	1,440
C	Boiler blowdown quench water	0	0	0	288
D	FGD system fresh water make-up	0	0	0	3,486
E	Cooling tower make-up	0	7,904	15,807	23,223
F	Cooling tower drift	0	19	39	39
G	Cooling tower evaporative	0	5,940	11,880	17,467
H	Cooling tower blowdown	0	1,944	3,888	5,717
I	Cooling tower blowdown make-up to FGD system	0	867	1,734	3,486
J	Cooling tower blowdown to river (001 discharge)	0	861	1,722	5,717
K	Cooling tower blowdown make-up to bottom ash system	0	216	432	432

Notes:

1) Phase I - Unit 1 construction. 11/79 to 6/83
2) Phase II- Unit 1 operation, Unit 2 construction. 6/83 to 6/85
3) Phase III- Unit 1 and 2 operation. 6/85 to 6/2020
4) Maximum usages are not additive and are maximum based upon worst conditions.

Table VII (cont'd)

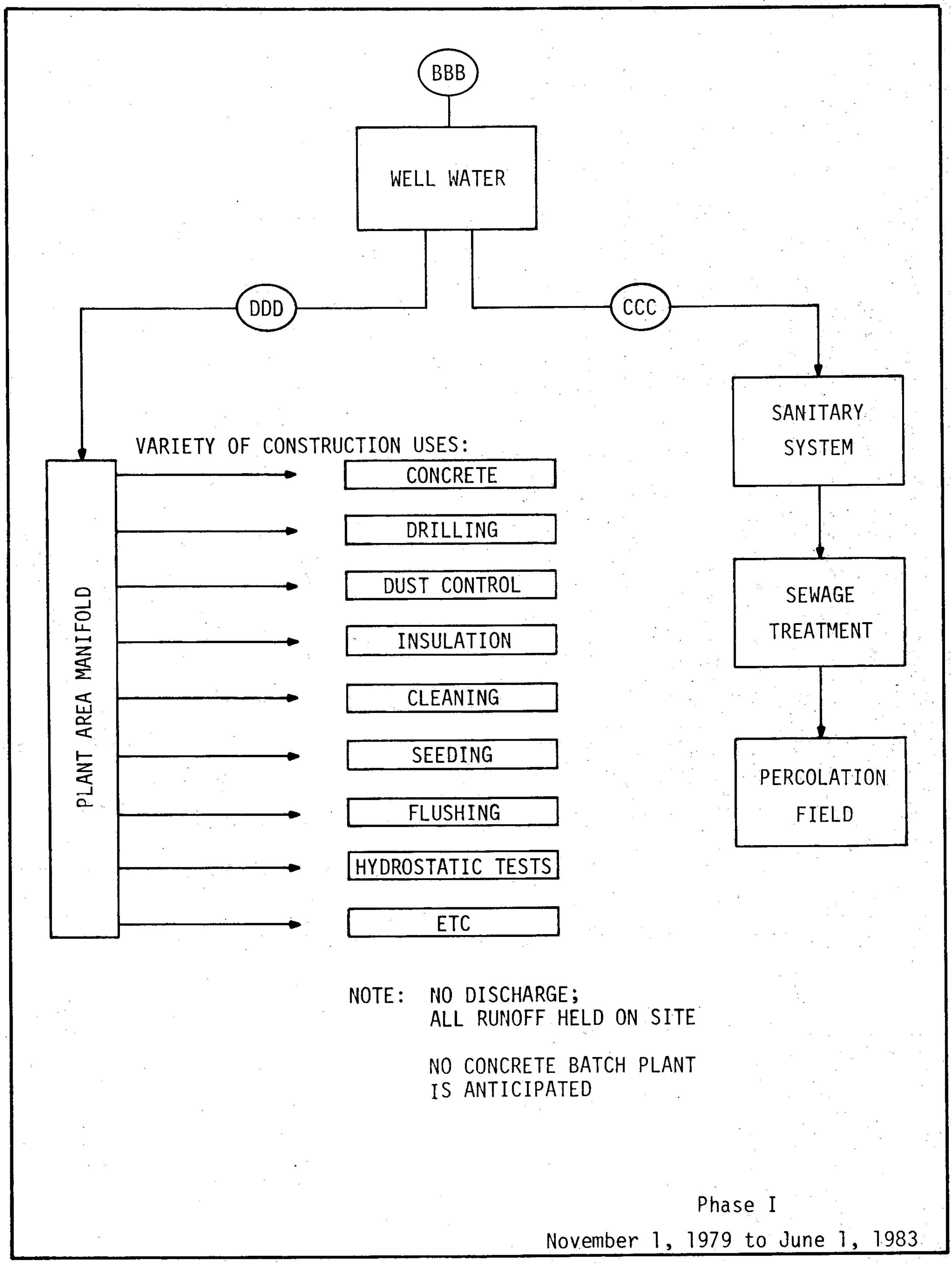
Line No.		Phase I	Phase II	Phase III	
		Average Usage	Average Usage	Average Usage	Maximum Usage
L	FGD system evaporation	0	1,174	2,347	3,456
M	Sludge pond runoff	0	317	634	1,426
N	FGD system effluent	0	10	20	30
O	Bottom ash system evaporation	0	0	0	0
P	Bottom ash system sluice water	0	1,440	2,880	2,880
Q	Dewatering bin blowdown	0	72	144	144
R	Total bottom ash sump to waste treatment facilities	0	359	717	1,728
S	Waste treatment facility recirculation	0	0	0	1,728
T	Waste treatment effluent to monitor	0	359	717	1,728
U	Waste treatment effluent to meter facility	0	359	717	1,728
V	Waste treatment effluent to river (001 discharge)	0	359	717	1,728
W	Coal and limestone storage runoff	0	75	150	337
X	Lab and floor drains	0	7	14	439
Y	Auxiliary boiler blowdown	0	0	0	3
Z	Neutralization tank effluent	0	39	78	576
AA	Pretreatment system blowdown and backwash	--	22	43	1,224

Table VII (cont'd)

Line No.		Phase I Average Usage	Phase II Average Usage	Phase III Average Usage	Phase III Maximum Usage
BB	Auxiliary boiler make-up	--	--	0	3
CC	Cond. polisher make-up (condensate system)	--	17	35	360
DD	Soot blowing and vent losses	--	187	374	374
EE	Demineralizer effluent	--	233	467	1,152
FF	Condensate polisher backwash and regeneration	--	17	35	360
GG	Demineralizer	--	22	43	576
HH	Mis. station uses	--	7	14	439
II	Demineralizer water supply	--	255	510	1,440
JJ	Sanitary treatment system effluent to river (001 discharge)	--	18	9	14
KK	Pretreatment system effluent	--		533	1,440
LL	Pretreatment system supply	--	288	576	1,728
MM	Fire water system supply	14	14	14	2,160
NN	Boiler blowdown to percolation fields	--	29	58	288
OO	Boiler fireside wash to percolation fields	--	0.3	0.6	288

Table VII (cont'd)

Line No.		Phase I	Phase II	Phase III	
		Average Usage	Average Usage	Average Usage	Maximum Usage
PP	Air preheater wash to percolation fields	--	0.9	1.6	3,600
QQ	Stack wash to percolation field	--	0.3	0.6	288
RR	Effluent from percolation field (not including Item CCC)	--	30	60	4,464
SS	Stack wash water	--	0.3	0.6	288
TT	Air preheater wash water	--	0.9	1.6	3,600
UU	Boiler fires wash water	--	0.3	0.6	288
VV	Service water supply	--	1.4	2.7	4,176
WW	Boiler blowdown	--	29	58	288
XX	Chemical cleaning wastes	0.1	0.1	0.3	720
YY	Seal trough overflow	--	144	288	576
ZZ	Total discharge to river (including construction sanitary wastes)	--	1,238	2,448	7,459
AAA	Well water make-up	34	324	590	3,888
BBB	Construction water usage (including sanitary wastes generated by construction personnel)	20	22	0	0
CCC	Construction sanitary wastes	12	14	0	0
DDD	Plant area manifold	8	8	0	0
EEE	Plant operation sanitary wastes	--	4	9	14

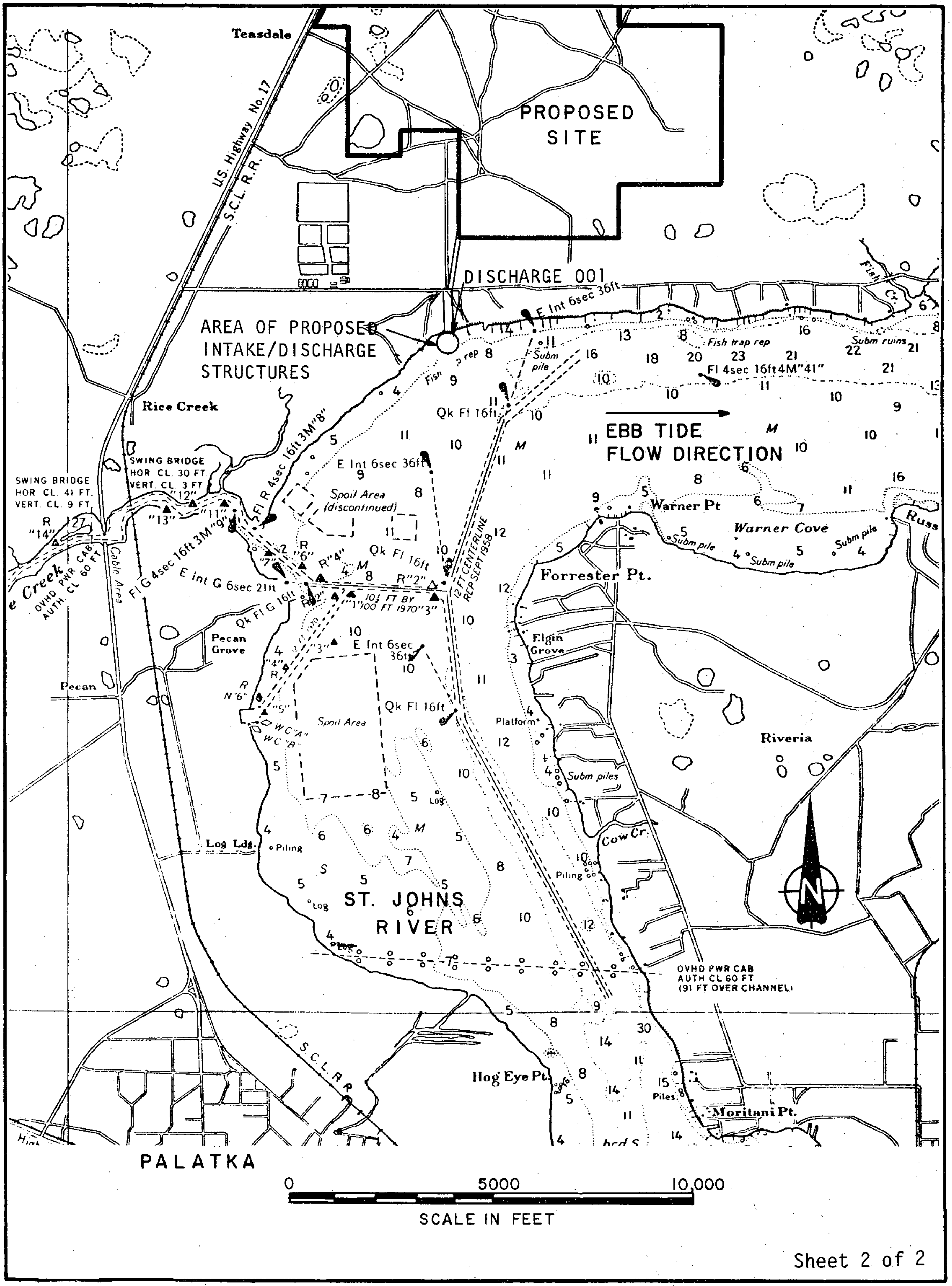


NOTE: NO DISCHARGE;
ALL RUNOFF HELD ON SITE

NO CONCRETE BATCH PLANT
IS ANTICIPATED

Phase I
November 1, 1979 to June 1, 1983

Figure 1. Schematic of Water Flow: Unit 1 Construction, Seminole Electric, Putnam Station Steam Electric Generating. Nov. 1, 1978



Sheet 2 of 2

Figure 4. "Location Map" From: National Ocean Survey Chart No. 11492, 1975. Seminole Electric, Putnam County Steam Electric Generating Facility, November 1, 1978.

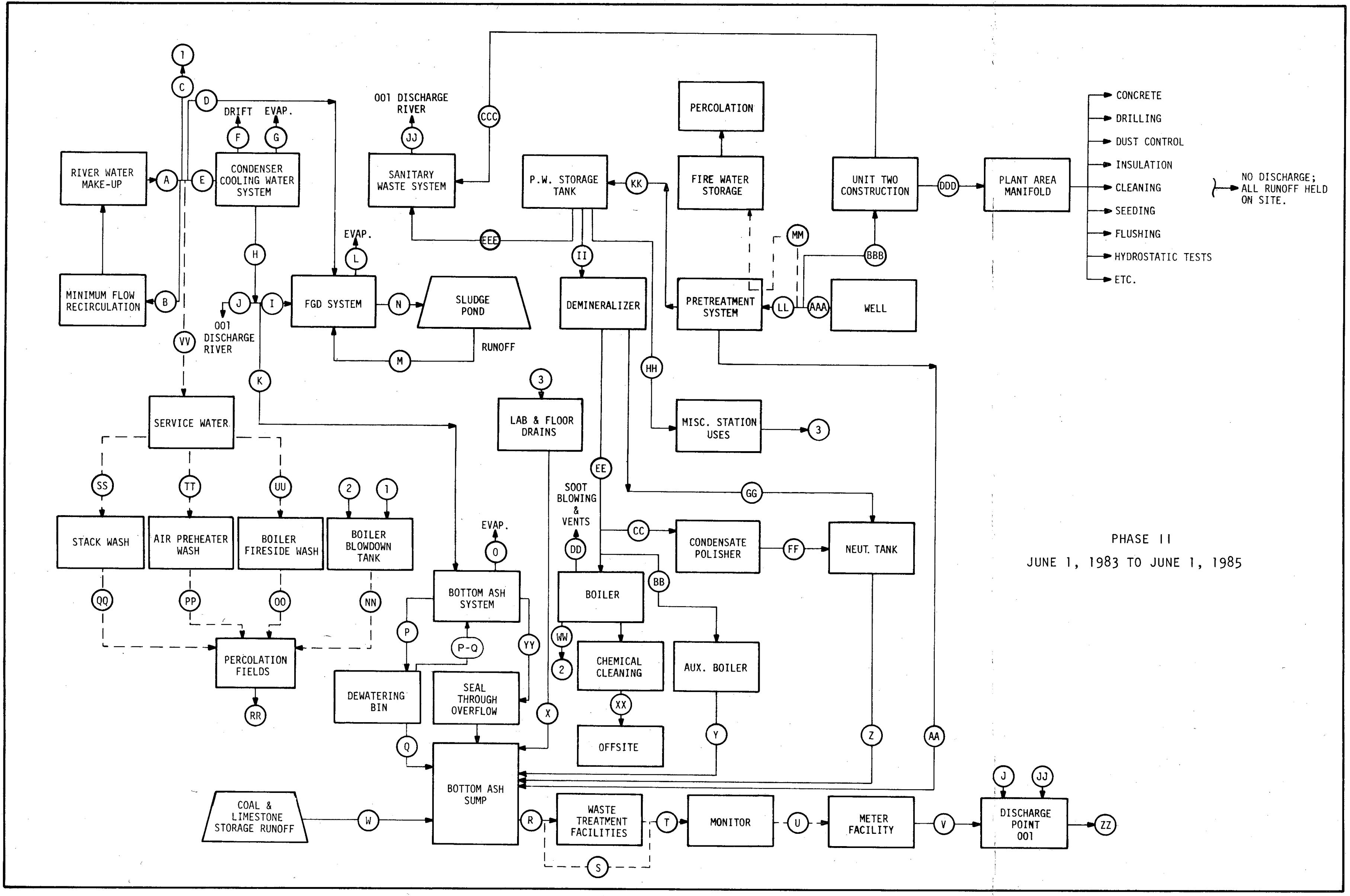


Figure 2. Schematic of Water Flow: Unit 1 Operation,
Unit 2 Construction
Seminole Electric, Putnam Station
Steam Electric Generating. Nov. 1, 1978

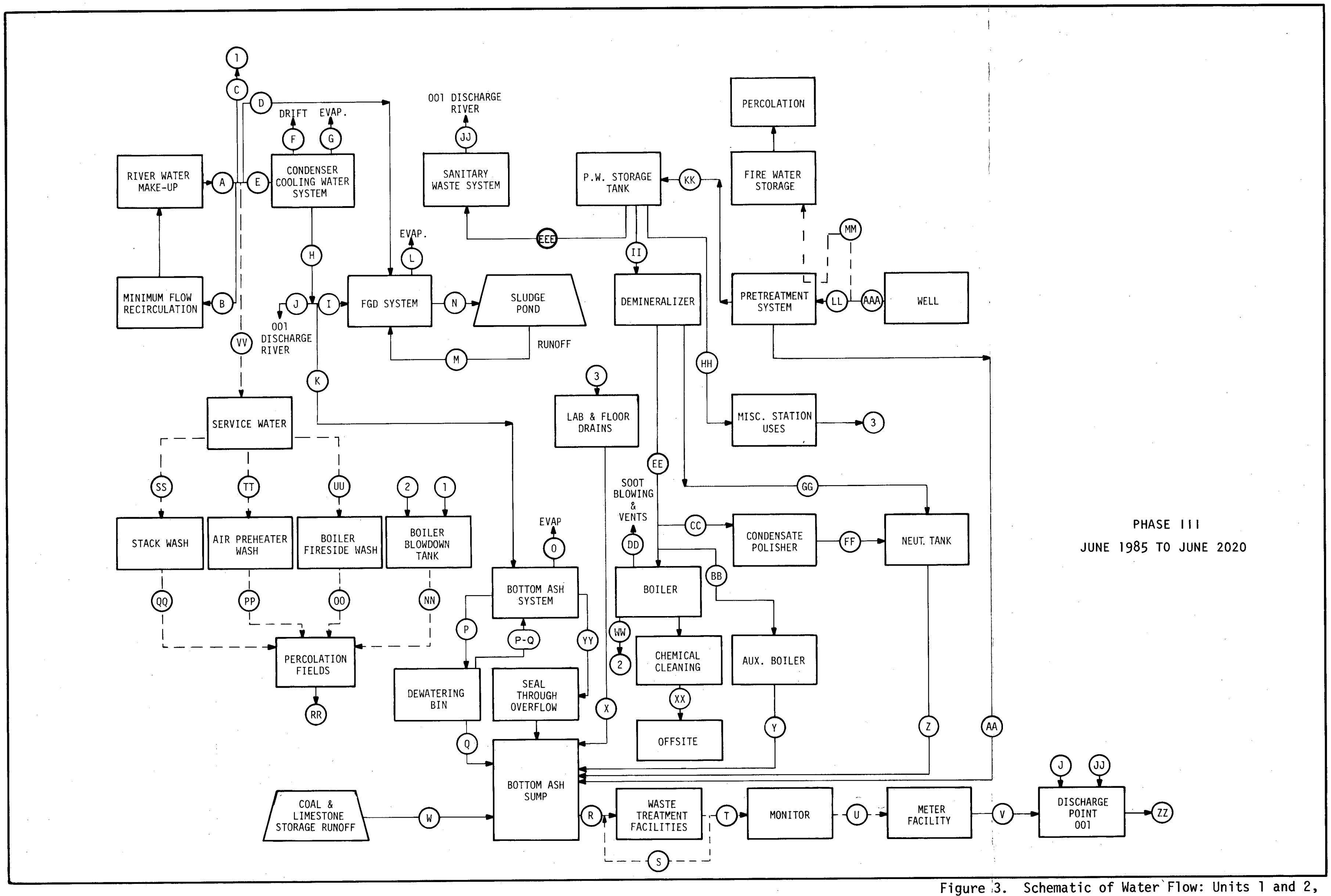


Figure 3. Schematic of Water Flow: Units 1 and 2, Seminole Electric, Putnam Station Steam Electric Generating. Nov. 1, 1978

GROUND WATER HYDROLOGY

APPENDIX D

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APPENDIX D

GROUND WATER HYDROLOGY

D.1 MONITOR WELLS

Borings 1 and 3 from the drilling program of June 1977 were used as monitor wells for the water table aquifer. Figure D-1 shows their locations; Figures D-2 and D-3 show their geologic characteristics and details of construction.

A private domestic well outside the site boundary near Bostwick was chosen for additional sampling of water from the water table aquifer. Mr. S. R. Harrison, Sr. is the owner and has given permission to sample. He reports the well to be completed at 80 feet total depth in the water table aquifer. It is cased with 1-1/2 inch diameter steel casing.

Water from the Floridan Aquifer was sampled in two wells (F-1 and F-2) drilled for that purpose. The wells are adjacent to Borings 2-1 and 2-2 drilled for soil samples and reported under Section 2.2, Geology and Soils. Details of construction and geologic characteristics of Wells F-1 and F-2, and shallow water supply wells drilled during drilling, are given in Figures D-4, D-5, and D-6.

D.2 HYDRAULIC CHARACTERISTICS OF THE WATER TABLE AQUIFER

A hydraulic test of the water table aquifer was made in November 1977. A test well 100 feet deep with casing slotted from 10 to 95 feet (Figure D-6) was pumped for 24 hours at 48 gpm. Drawdown observed in Boring No. 1, 74 feet west of the test well, was 5.5 feet at the end of the test period.

The specific capacity was computed to be about 9 gallons per minute per foot of drawdown. The transmissivity of the aquifer was computed to be about 16,500 gallons per day per foot (gpd/ft) of aquifer and the storage coefficient was computed to be about 0.30.

Storage coefficients, as calculated, were highly variable. Most were inapplicable because values pertaining to artesian conditions were obtained because of incomplete aquifer drainage. However, the average of the values obtained by using the Boulton curves that are applicable to unconfined conditions is comparable to reported results from similar well-sorted, fine-grained sands. Table D-1 gives details of the aquifer test.

The upper 40 to 50 feet of the water table aquifer is of primary concern with reference to water movements (this unit is referred to as Layer 1 in Section 2.2). In calculating horizontal permeabilities, the total transmissivity of the unconfined aquifer (16,500 gpd/ft) is considered to be 80 percent attributable to Layer 1. The saturated thickness of Layer 1 was 34 feet at the time of the aquifer test. Results appear in Table D-2.

D.3 HYDRAULIC CHARACTERISTICS OF THE FLORIDAN AQUIFER

Studies by the U. S. Geological Survey (USGS) and the Florida Geological Survey (FGS) provide information on the hydraulic and other characteristics of the Floridan Aquifer. A transmissivity of about 275,000 gpd/ft of aquifer is representative of the Floridan Aquifer in the Putnam County vicinity. This figure is based on results of pumping tests performed by the USGS (Bermes and others, 1963) and by a more recent pumping test near Bostwick in which a transmissivity of about 127,000 gpd/ft was calculated (Bentley, 1977) based on a well that does not completely penetrate the aquifer. The full transmissivity is considered to be possibly about 500,000 gpd/ft (Craig Bentley, personal communication, October 1977). For the entire Putnam, St. Johns, and Flagler County area, Bentley (1977) considers about 450,000 gpd/ft as representative.

The storage coefficient of the Floridan Aquifer ranges from less than 1.0×10^{-4} to more than 9.0×10^{-4} with the high end of the range measured near Palatka at the Hudson Pulp and Paper Company (Bermes and others, 1963). The small values of the coefficients are indicative of artesian conditions. The well tested was pumped at 5,000 gpm for two days. Bentley (1977) considers 8×10^{-4} to be the best estimate for the three-county area.

However, the transmissivities and storage coefficients of the Floridan Aquifer may vary throughout the State of Florida and locally by <u>several</u> orders of magnitude. This variance is especially common in limestone karst topographic regions as solutioning of the aquifer in many localized areas magnifies this variance.

As detailed in Appendix L, analysis of the Floridan Aquifer pumping test on the Putnam Site ~~indicates~~ a transmissivity of 46,000 gpd/ft and a storage coefficient of 1×10^4

1×10^{-4}

D.4 WATER LEVEL FLUCTUATIONS

Water level measurements of both the water table and Floridan Aquifer taken during the monitoring program are shown in Table D-3 and D-4. Because of the short monitoring period, the data may not necessarily be indicative of long-term fluctuations.

The longest-term available record of water level fluctuations in the water table aquifer consists of measurements in three borings drilled during June 1977. In order to compare the three wells, Table D-3 shows water levels in the three wells over a six-month period from June to November 1977. (Sometime after the November readings, Boring No. 2 was disturbed and, therefore, was eliminated from the monitoring program.) Table D-3 also contains the maximum measured fluctuations in the three wells. The largest recorded fluctuation was seven feet amplitude and occurred between June 1977 and February 1978.

Water level data for the two wells in the Floridan Aquifer are based on a six month period of record from November 1977 to April 1978 (Table D-4). The largest recorded fluctuation was 4 feet in amplitude between March and April 1978. This figure agrees with short term reported fluctuations (Bermes and others, 1963).

D.5 GROUND WATER QUALITY MONITORING DATA

Results of the six-month monitoring program (November 1977 through April 1978) are presented in Table D-5, Ground Water Quality Parameters. Well locations are shown in Figure D-1.

D.6 WATER WELL INVENTORY

Introduction

Wells within a five-mile radius of the site were inventoried for physical characteristics and use. The wells are numbered according to quadrants, based on townships (see Figures D-7 and D-9), and designated with prefixes of A through D.

The inventory was performed from October 17 to 28, 1977, with a special inventory near Bostwick on November 16, 1977 (Figure D-8). Well information, such as casing depth and total depths, were based on interviews with the well owners. Efforts were made to obtain drillers logs for the wells to verify well construction. However, very limited well data were available. Table D-6 presents the inventory data. Figure D-7 locates the wells in the October inventory, and Figure D-8 shows the well locations in the special inventory.

Published data from an earlier inventory by the U. S. Geological Survey (USGS) provided information on additional wells within the five-mile radial area. Results are in Table D-7. Only a few of the wells inventoried by the USGS were located and restudied during the field inventories.

An average of one well per square mile was inventoried as a representative number. In areas of low well density, all wells were inventoried. In areas in which similar wells were clustered, one or more were selected. All wells known to have higher than average yields were given particular attention. Wells producing from the Floridan Aquifer and those tapping the water table aquifer were identified. Near Bostwick, the special inventory identified water table wells at a greater density than the other inventory. The results of the inventories are summarized in the following sections.

Quadrant A

Quadrant A covers the area north and northeast of the site and includes the Community of Bostwick (approximately 150 families). Bostwick is in an area of moderate artesian flow. The well and water use inventory located a total of 16 water table aquifer wells ranging from 56 to 120 feet in depth with 14 wells in the range of 80-100 feet (Figure D-8). The remainder of the wells serving Bostwick produce from the Floridan Aquifer with depths ranging from 180 to 300 feet. Those were not inventoried, but one Floridan well (S-17) downstream from the site was inventoried. Most wells serve one family only; a trailer park is served by a single well tapping the water table aquifer. One well located during the special inventory (S-1) was monitored monthly to assist in establishing baseline water quality.

The area directly to the east of Bostwick along State Route 209 is lightly populated, with approximately one family per quarter mile. The wells serving this area are flowing Floridan Aquifer wells ranging from 150 to 500 feet in depth. These wells serve one family each, with the exceptions of Well A-16 which is a 6-inch Floridan well that serves the St. Johns Harbor Trailer Park (approximately 75 families), and Well A-23, a 6-inch Floridan well serving the Community of Bridgeport (approximately 12 families). The wells in the Flint Point, Pine Bluff, Deadman Point, Nine Mile Point, and Palmetto Bluff areas are flowing Floridan wells serving one family each.

Quadrant B

Quadrant B located to the northwest of the site is a sparsely populated area, in which the Floridan Aquifer is tapped by single-family wells ranging in depth from 180 to 500 feet. Only one water table aquifer well could be found in this area.

Quadrant C

Quadrant C covers the area to the west and southwest of the site and includes the Community of Bardin (approximately 50 families), Hudson Pulp and Paper Company, and the St. Johns River Barge Port.

No flowing wells were found in the area directly west of the site between State Route S209 and Bostwick along U. S. Route 17. However, well depths suggest that at least some wells reach the Floridan Aquifer. The wells range in depth from 135 to 200 feet and serve individual families.

The inventory in the Bardin area showed Floridan Aquifer wells ranging in depths from 114 to 300 feet and serving one family each. Also two wells owned by Hudson Pulp and Paper Company, Well C-6 (12 inches; 600 feet) and Well C-7 (20 inches; 1203 feet), were uncapped and flowing into Etonia Creek. These wells were also included in the 1963 USGS inventory.

Quadrant D

This quadrant includes the area directly south and east of the site. The wells in this area are flowing Floridan Aquifer wells ranging in depth from 150 to 310 feet. Each serves one family. These wells were, for the most part, located between State Route S209 and the St. Johns River.

Also included in this quadrant is an area on the east bank of the St. Johns River just north of East Palatka. This is mainly an agricultural area (potatoes, cabbage); however, the wells inventoried were mostly residential and each served a single family. These wells were found to be flowing Floridan wells ranging in depth from 150 to 350 feet. Each owner reported that his well was affected by irrigation pumping in the fields directly to the east in the Patersonville-Orange Mills area. Data on agricultural wells were unavailable at the time of inventory.

General Findings

In all areas covered, the Floridan Aquifer wells observed were equipped with aeration and filtration systems to eliminate hydrogen sulfide odor in the water. About 40 percent of the owners of water table aquifer wells surveyed reported a high iron content in their water.

Well yields from the Floridan Aquifer are usually dependent on the size of pipe chosen for water delivery, hence not likely to be representative of the capacity of the well. Well yields from the water table aquifer were unavailable, but presumed to be modest, inasmuch as most are two inches in diameter. No springs were found during the inventory.

D.7 ASSESSMENT OF POTENTIAL IMPACTS UPON GROUND WATER

D.7.1 General

As previously discussed two aquifers underlie the site: a surficial water table aquifer consisting of moderately to highly permeable sands extending to a depth of 40 to 50 feet, and the Floridan Aquifer occurring at a depth of approximately 200 feet. The Floridan Aquifer is the principal ground water aquifer in the site region and is protected from potential water quality impacts from surface activities by a confining layer known as the Hawthorn Formation and the positive ground water gradient from the Floridan Aquifer. Therefore, there should be no potential impacts to the Floridan Aquifer from waste leachate at the Putnam Site. Since the water table aquifer is not protected from surface effects, and in fact receives its principal recharge from infiltration of rainfall, the focus of the present study is on potential impacts to this ground water body. Hereinafter, whenever the terms "aquifer" or "ground water" occur, they refer to the water table aquifer.

D.7.2 Sources of Potential Impacts

There are four potential sources of impacts to ground water at the site. These are: (1) Disposal via landfilling of coal combustion and flue gas desulfurization wastes (fly and bottom ash, and scrubber sludge); (2) disposal via percolation field of stack wash, air preheater wash, boiler fireside wash and the boiler blowdown; (3) seepage from the coal storage area; and (4) seepage from the dredge disposal area. The approximate locations of these areas are shown on Figure D-10 in relation to the surface drainage basins in which they are located and the general direction of ground water flow.

D.7.3 Methodology

Power augering, soil sampling, and measurement of verticle permeabilities were made in the field. Samples were studied for clay mineral type and proportion of total sample, total organic carbon, and grain size distribution by Dr. James Eads of the University of Florida, Gainesville. Orlando Laboratories, Incorporated, Orlando, Florida, determined the cation exchange capacities. The coal source has been identified and the chemical composition of the coal and coal ash has been determined. These data were evaluated using two techniques, one empirical, and one analytical.

The evaluation of potential ground water impacts addressed in this section considers site specific parameters such as ground water velocity and flow rates, chemical properties of the soil (cation exchange, etc.) and dilution potential. Given these site parameters, the potential quality of leachate was empirically derived and served as input to an analytical evaluation of the potential impacts upon the ground water system and the ability of the site to assimilate the proposed method of plant operation. To this end, the principle criteria used in evaluating the site with respect to ground water was to determine the impact upon ground water quality at the property boundary in the direction of ground water flow.

D.7.4 Site Description

The water table aquifer underlying the site extends to a depth of approximately 100 feet. The upper 40 to 50 feet consists of loose, uncemented, fine grained sand with moderate to high permeability. This interval is referred to as Layer 1 in Appendix E. Layer 1 is present over most of the site and has a relatively uniform thickness as shown on Figure 2.2-15 (Vol. 1). Underlying this upper layer are less permeable, sands, silts, alternating silts and clays which extend to a depth of approximately 100 feet. This interval is referred to as Layer 2. Recharge to the water table aquifer is from direct infiltration of precipitation.

A special field investigation was conducted in the low lying area in the north central part of the site to determine various physical and chemical parameters of the soils. The field investigation included an auger boring, falling-head permeability tests, and bulk soil sample collection. These bulk samples were analyzed in the laboratory for grain size distribution, clay identification, and determination of total organic carbon and cation exchange capacity.

A power auger boring (A-7) was drilled to determine subsurface conditions (Figure D-11). Cross-sections A-A' and B-B' show the geologic materials underlying the site (Figures D-12, D-13, and D-14). The proposed waste storage area is underlain by a fine sand approximately 34-feet thick (Layer 1 described in Appendix E). Overlying the sand in the northeast area of the site was an organic silt layer ranging from 0 to 4 feet in thickness.

A water table aquifer pumping test was conducted by Dames & Moore in a test well near Boring No. 1 in November 1977. The pumping test data show that the sand layers are a shallow aquifer with a transmissivity of approximately 16,500 gallons per day per foot (gpd/ft). The topographic high located directly south of the waste storage area is the primary recharge area of the shallow aquifer. The water table contour map depicts the present hydrologic setting (Figure 2.3-6). The water table map was extrapolated from the topography and water level measurements made in October and November 1977. Low water table conditions are depicted on Figure D-15.

Underlying the sands of the shallow aquifer was a second layer of sands with alternating silts and clays (Layer 2 described in Appendix E). The lithology of the material indicates relatively low permeabilities. For purposes of this analysis, Layer 2 was assumed to be the base of the shallow aquifer.

The results of the field investigation and laboratory analyses used in the analytical study are in Tables D-8 and D-9. The gradation curves showing the grain size distributions are shown in Figures D-16, D-17, and D-18. Vertical permeabilities were determined using falling-head permeability tests. The vertical permeabilities allowed the calculation of seepage rates from the waste areas. The horizontal permeability of the sand layer was computed from the transmissivity data developed from the pumping test. It was assumed that 80 percent of the transmissivity was developed from the sand Layer 1 while 20 percent orginated from the sand of Layer 2. The adjusted transmissivity of Layer 1 was divided by the saturated thickness to obtain the permeability in a horizontal direction.

D.7.5 Analytical Approach

Although the hydrogeologic characteristics of the 4 areas considered in this analysis may be slightly different, the basic equations used to evaluate the potential impacts are appropriate in most respects. Therefore, the analytical equations used in this investigation are presented here.

The basic equations used are as follows:

- Ground Water Velocity (Dupuit-Forchheimer Assumption to the Darcy equation).

$$V = \frac{KI}{n} \qquad \text{(Walton, 1962)} \qquad (1)$$

where: V = velocity (L/T)
K = permeability (L/T)
I = hydraulic gradient (L/T)
n = effective porosity (decimal)

- Ground water flow rate (Darcy equation).

$$Q = KIA \text{ (or } Q = TIL) \text{ (Walton, 1965)} \qquad (2)$$

where: Q = flow rate (L^3/T)
K = as before
I = as before
A = area through which flow occurs (L^2)
T = transmissivity (L^2/T)
L = length over which flow occurs (L)

- Continuity Equation (used to estimate dilution).

$$Q_3 C_3 = Q_1 C_1 + Q_2 C_2 \text{ (Hem, 1970)} \qquad (3)$$

where: Q_1 = ground water flow beneath site (L^3/T)
C_1 = concentration of constituent in ground water (M/L^3)
Q_2 = seepage from site (L^3/T)
C_2 = concentration of constituent in leachate (M/L^3)
Q_3 = total flow away from site (L^3/T)
C_3 = concentration of constituent after dilution (M/L^3)

- Equivalent Permeability For Beds in Series (McWhorter and others, 1977).

$$K_e = \frac{L_{a+b+c}}{\frac{L_a}{K_a} + \frac{L_b}{K_b} + \frac{L_c}{K_c}} \qquad (4)$$

where: K_e = equivalent permeability of beds in series (L/T)
L_{a+b+c} = thickness of beds considered (L)
L_a, L_b, L_c = thickness of individual beds (L)
K_a, K_b, K_c = permeability of individual beds (L/T)

- Material Transport Equation (used to evaluate leachate concentrations down-gradient of site).

$$C = \frac{QC_o \exp\left(\frac{xV}{2D_x}\right)}{4\pi n \left(D_x D_y\right)^{1/2}} \; W\left[\frac{R_d r^2}{4 D_x t}, \frac{rV}{2 D_x}\right]$$

(Wilson and Miller, 1978) (5)

where: C = leachate concentration down-gradient of site at any point of interest (m/L^3)
Q = volumetric injection rate (L^3/T)
C_o = concentration of injected waste (m/L^3)
V = as before
D_x, D_y = longitudinal and transverse dispersion coefficients, respectively (L^2/T)
n = effective porosity (decimal)

$$r = \left[x^2 + \frac{D_x}{D_y} y^2 \right]^{1/2}$$

where: r = radial distance down-gradient to point of interest (L)

x,y = distance along x and y axis, respectively (L)

$W(f)$ = "well function" developed by Hantush, (1956)

T = time (T)

$$R_d = 1 + \frac{\rho}{n} K_d$$

where R_d = retardation factor (dimensionless)

ρ = bulk density (M/L^3)

n = effective porosity (decimal)

K_d = distribution coefficient (L^3/M)

Equation 5 includes two mass transport components and one mass transfer component. The transport components describe convection and hydrodynamic dispersion. Hydrodynamic dispersion includes both mechanical dispersion and molecular diffusion. Solute attenuation is achieved through the combined effects of dispersion and mass transfer. The mass transfer term includes the results of all the chemical processes and reactions, such as precipitation and solution, coprecipitation, oxidation and reduction, adsorption and desorption, ion exchange, complexation, nuclear decay, ion filtration, and gas generation. The reactive term affects the solute concentration and it has long been recognized that solute concentration is a function of mineral solubility, flowpath and residence time.

In the analysis of contaminant transport through saturated granular deposits, the reaction term is commonly expressed in terms of the retardation factor and distribution coefficient, as shown in Equation 5.

The dispersion coefficients, distribution coefficients and retardation factors used in this investigation are discussed below.

Dispersion Coefficients

Dispersion is a measure of the molecular and convective diffusion between two fluids of different concentrations. Dispersion coefficients can be expressed as a function of dispersivity and ground water velocity as follows:

$$D_x = \alpha_x V \qquad (6)$$

where: D_x = as before

α_x = longitudinal dispersivity (L)

V = as before

Most values of dispersion and dispersivity quoted in the literature were determined in the laboratory using column devices. Field experiments have shown that the laboratory values are generally too low by 3 to 6 orders of magnitude (Pickens and Lennox, 1976). Values of dispersivity determined in the field have ranged from approximately 30 to 300 feet, depending upon the hydrogeologic characteristics of the site being considered. For this analysis, longitudinal dispersivity was estimated to be 50 feet. Transverse dispersion has been found to be 5 to 20 times less than longitudinal dispersivity (Pickens and Lennox, 1976). Therefore, transverse dispersivity was taken to be 10 feet.

Distribution Coefficients

The distribution coefficient (K_d) is the reaction between a contaminant and the chemical properties of the carrying fluid, and the soil or rock medium. It is dependent on many variables such as the pH of the fluid, the ionic strength of the dissolved constituents in the fluid, kinetics of the adsorpton reaction, chemical properties of the contaminant ion, chemical composition of the medium, and the area of contact per-unit-bulk-volume between the porous medium and moving fluid. No such data were available on soils in the study area. Therefore, K_d was largely extrapolated from data on soils in other areas, and was estimated using the following equations:

$$K_d = \frac{\text{quantity of adsorbed material/mass of solid}}{\text{quantity of dissolved material/volume of fluid}} \quad (7)$$

(Duquid and Reeves, 1976)

The above equation can be modified to a simplified form based upon the cation exchange capacity of the soil. The above equation becomes:

$$K_d = K_s \frac{Q}{C_e} \qquad \text{(Pickens and Lennox, 1976)} \quad (8)$$

where: K_s = selectivity coefficient
Q = cation exchange capacity of the soil (meq/gram)
C_e = total concentration of an exchangeable species in solution (meq/cm^3)

The selectivity coefficient varies with respect to individual cations. A conservatively representative value of 0.2 was assumed for this analysis.

Distribution coefficients, estimated by Schnider and Platt (1974), were found to vary widely for typical desert soils, from zero for chlorine to 15,000 cm^3/g for thorium. The more common cations, such as calcium, potassium, and sodium, have low distribution coefficients (10 to 35 cm^3/g). The metals tend to have relatively high K_d numbers (2,000 to 4,000 cm^3/g), which indicates a strong tendency for adsorption.

Distribution coefficients were estimated for this analysis using Equation 8 with the estimated leachate concentrations for the waste storage area, and are given on Table D-10 along with the calculated retardation factors. The trace elements have high distribution coefficients while the major cations have low coefficients.

Holland and others (1975) determined distribution coefficients for various trace metals in sludge and ash leachate with respect to the soils at a Southern California power plant. The soils at the Putnam site are similar to the soils used in the California experiment; a comparison of these two soils is shown on Table D-11. The cation exchange capacity of the soil at the Putnam site is generally greater; therefore indicating a probable greater adsoprtion capacity. The distribution coefficients and retardation factors determined in the California study are given on Table D-12.

Retardation Factors

The retardation factor (R_d) can be calculated from the following equation:

$$R_d = 1 + \frac{\rho K_d}{n} \qquad (9)$$

where: ρ = bulk density (M/L^3)
K_d = distribution coefficient (L^3/M)
n = effective porosity (decimal)

Retardation factors were calculated for the trace metals and the major cations and are given on Table D-10. The retardation factors are very high for the trace metals, as would be expected. However, for conservatism, the retardation factors were lowered considerably and a representative group value was taken to be 50. The retardation factors for the major cations were taken to be 5 while the anions were arbitrarily taken to be 1.5. These values indicate high attenuation for the trace metals, moderate attenuation for the major cations and minor attenuation for the anions.

Contaminant migration analyses for each ion group were conducted in order to evaluate the potential of contamination from each of the areas of potential ground water impact.

D.7.6 Waste Storage Area

D.7.6.1 Hydrologic Characteristics

The approximate configuration of the waste storage area is shown on Figure D-10. When filling is complete, the area will encompass 275 acres and will have an average thickness of approximately 58 feet. Approximately 16,000 acre-feet of waste material will be disposed of which approximately 30 percent will consist of fly and bottom ash and 70 percent will consist of SO_2 scrubber sludge. The bottom ash and the scrubber sludge will be dewatered prior to disposal and the water will be returned to the plant water system. The sludge and bottom ash will be dewatered further by mixing with dry fly ash until a solids content ranging from 55-80 percent is attained. This material is normally referred to as being "physically stabilized" and will be referred to as such hereinafter. Part of this material will be mixed with lime or cement to form a cementatious product (typically referred to as chemically stabilized) which will be used to form the base and the dikes of the waste storage area. The thickness of the base will be approximately 8 feet. The permeability of this cementatious product has been found to be approximately 1 x 10^{-7} cm/sec (2.8 x 10^{-4} ft/day) after one year, based upon laboratory testing of core samples (Sananta, 1977). However, due to a low tendency to saturate, the effective permeability has been found to be considerably below the laboratory values (Mullan and others, 1976). For this analysis, 1 x 10^{-7} cm/sec will be used. The remainder of the waste material will be placed over the base and will be compacted. The permeability of this material should range from 1 x 10^{-4} to 1 x 10^{-5} cm/sec (2.8 x 10^{-1} to 2.8 x 10^{-2} ft/day) (Duvel and others, 1978). For this analysis, 5 x 10^{-5} cm/sec will be used. After filling, the surface of the waste storage area could be sealed with the low permeability cementatious product used for the base to reduce infiltration and the potential for ground water contamination.

The degree of impact of the waste storage area upon ground water will depend, in part, upon the ability of precipitation to infiltrate the disposed waste and permeate to the underlying water table aquifer (Layer 1). The amount of infiltration is dependent upon the permeability of the surface layer of the disposed waste, degree of compaction, slope angle maintained during filling and the amount of ponding of rainfall in the disposal area. Of these, the permeability of the disposed material and ponding are the most important. During disposal operations, surface runoff will be collected and recycled to the plant water system. Therefore, ponding in the disposal area will be kept to a minimum, and a minimal head is assumed.

Dames & Moore (1978) estimated through the use of computer modeling the ability of materials of differing permeabilities to infiltrate rainfall. These studies indicated that an unvegetated soil with a minimum surface slope and a permeability of 1 x 10^{-6} cm/sec (2.8 x 10^{-3} ft/day) would infiltrate approximately 5 inches of rainfall per year. Extrapolating from these results, it is estimated that approximately 6 inches of rainfall per year will infiltrate the disposal area with a minimal head. The ability of this infiltration to eventually reach the water table depends upon the effective permeability of the disposed waste, including both the compacted material and the cementatious base. The potential flow rate through the waste storage area can be evaluated with the Darcy equation (Eq. 2).

In this application, a unit gradient (assuming minimum ponding) is applied through a vertical strip with an area of 1 square foot. The equivalent permeability was determined using Equation 4 for beds in series.

These equations were used with the permeability values of the waste material and the vertical permeability of Layer 1 and thicknesses of 50 feet for the compacted waste material, 8 feet for the cementatious base, and 5 feet for the unsaturated zone in the underlying aquifer. The calculated flow through the waste disposal area is 1.9 x 10^{-3} ft^3/day or 8.3 inches/year. Therefore, at completion the permeability of the waste material will be sufficient to infiltrate the 6 inches per year. It is noted that the equivalent permeability decreases as the thickness of the physically stabilized material decreases, and approaches the permeability of the cementatious base. If the thickness of the physically stabilized material is taken to be 1 foot, the resulting flow rate is 4.9 x 10^{-4} ft^3/day (2"/year). Therefore, in the early stages of disposal, the permeability of the cementatious base will control seepage to the water table and during the latter stages of filling, the infiltration capacity of the physically stabilized material will control.

The principles discussed in the preceeding paragraph assume that the waste material at a given thickness is continuously saturated. However, the waste materials will be placed in a partially saturated condition. Seepage will not occur until sufficient moisture is added to bring the physically stabilized waste and the base to field capacity, which is defined as the moisture content required to initiate passage of water. If it is assumed that the ultimate thickness of the waste is 58 feet, that solids content of the waste material when placed is 70 percent and the moisture content is 15 percent, then an additional 15 percent moisture, or 9 feet of water will be required to bring the waste material to field capacity. At the 6 in/year infiltration rate, it would take an estimated 18 years for the waste material to reach field capacity, and for any significant production of leachate. Therefore, given the influence of waste material thickness on the equivalent permeability, actual seepage rates will depend upon the thickness of the waste material at the time field capacity is attained.

In summary, assuming that field capacity is attained, seepage potential from the waste storage area during the early stages of filling, when the cementatious base is being deposited, should be approximately 2 in/yr; as the thickness of the physically stabilized waste increases, the seepage potential should increase eventually to a maximum of 6 in/yr.

D.7.6.2 Contamination Potential

Waste Characteristics

The chemical compositon of wastes from coal-fired power plants varies widely and depends on a number of factors including:

1. Coal composition, which varies by grade of coal, source, blending, preparation, and on a local scale even by individual seam;
2. Type of boiler (stoker, cyclone, pulverizer, etc.); boilers produce different ratios of fly ash to bottom ash, different particle sizes, and different fractionation of volatile metals depending on combustion temperature;

3. Type of collection system (wet vs. dry);

4. Scrubber type, operation and reagent (lime, limestone);

5. Quality of water supply, etc.

The physical properties of the waste also vary widely depending on particle size, specific gravity, solids content, and particle morphology. These properties, in turn, influence the permeability, porosity, and leaching characteristics of the waste.

Chemical analysis of the coal that SECI has contracted to use is presented on Table D-13. These analyses are for raw washed coal from the Illinois Basin (western Kentucky and southern Illinois). A typical chemical analysis of the coal ash is presented on Table D-14. A comparison of the SECI coal with typical Illinois Basin coal is presented on Table D-15, and shows that many constituents in the SECI coal have lower concentrations than typical coal.

The largest fraction of coal waste is silicon dioxide (sand). The second largest fraction of coal waste is aluminum oxide (Al_2O_3) or iron oxide (Fe_2O_3). Other forms of oxides are also produced. It is believed that some trace elements may be in their elemental form, although only in certain cases. Nevertheless, metals both in the elemental form and as oxides are very stable, with only a few exceptions.

The solubility of the elemental metals and metal oxides is very low by their very nature. Should these chemical forms be subjected to acids, they become more soluble, but still many times less so than other forms of the metals (e.g., sulfates, chlorides, and nitrates). For several reasons, utility liquid wastes are generally neutral to basic (alkaline). The acidic or alkaline characteristics depend on the content of sulfur trioxide and alkaline metal oxides in the waste materials. Chu, Ruane and Krenkel (1978), in a study of effluents from Tennessee Valley Authority (TVA) power plants, found that for plants using pulverized coal, the pH of ash pond effluents was generally alkaline for plants that receive coal from western Kentucky and southern Illinois. In addition, lime or limestone is usually employed for scrubbing the sulfur oxide.

The lime, or limestone, is alkaline, and along with the oxides derived from the coal, react with water to form bases, and thereby maintain a relatively high pH, thus reducing their solubility.

Chemical analyses of some typical scrubber liquors and coal ash leachate are presented for reference on Tables D-16 and D-17. The calcium and magnesium arise principally from the limestone. Both the sulfite and sulfate forms are found in the reaction products from the scrubber. The sodium comes principally from the make-up water. The chloride comes principally from the flyash (original source is the coal). Most of the trace elements originate in the flyash (coal), but some are contributed by the make-up water and the limestone.

Water retained in FGD sludge after dewatering contains essentially the same dissolved solids found in the scrubber liquor and, as such, acts as a blowdown of the scrubber system. Because these constituents are water-soluble, they will also be found in displaced water or in leachate from disposal areas. Laboratory leachate studies have shown that approximately 3 pore volumes are required to displace substantially all the interstitial liquor (Aerospace Corp, 1976), but that the majority of the displacement occurs during the first pore volume, as shown on Figure D-19. From that point, the total dissolved solids in the leachate decrease sharply and result from solution of the solid components. After approximately 5 pore volumes the concentration remains relatively constant.

The leaching capability of the cementatious base is also important to this investigation. It has been found that chemical fixation processes decrease rather sharply the leaching potential of coal plant waste. In general, the total dissolved solids content of leachate from chemically fixed waste can be expected to be at least 50 percent less than that from physically stabilized waste (Aerospace Corp, 1976). However, for this analysis, the leachate quality will be based upon the physically stabilized waste to be deposited over the chemically stabilized, cementatious base.

As mentioned previously, the concentration of chemical constituents in coal greatly influence the amount of dissolved constituents contained in effluents from coal-powered plants. A relationship between the observed concentration range of trace metals in coal and in sludge solids is shown in Figure D-20. Similarily, Figure D-21 illustrates a relationship between the concentrations in sludge liquors and the coal, with the bandwidth being nearly two orders of magnitude. The trace metal concentration in the liquor is approximately two orders of magnitude less than that for the solids. The scatter in the data is believed to be associated with lack of precision at lower concentrations and differences in pH (Aerospace Corp, 1976). Additionally, some of the scatter may be due to individual trace metals leaching into the effluent differing percentages of their concentrations in the coal.

A plot similar to Figures D-20 and D-21 was prepared using data from Southern California power plants and is shown on Figure D-22. The source of the data was Holland and others (1975). Their data, however, include chemical data for fly and bottom ash, FGD sludge liquor and disposal pond liquor. The data indicate a general decrease in trace metal concentrations from the scrubber liquor to the disposal pond effluent. A similar decrease was found by Aerospace Corp (1976) at other power plants, and was attributed to coprecipitation or scavenging in the scrubber bleed system.

Chu, Ruane, and Krenkel (1978) conducted leaching tests on fly ash from a TVA power plant to characterize the nature of wastes from ash pond leachates. The test was conducted on alkaline fly ash from a plant utilizing pulverized coal from western Kentucky. The operational features of the plant are given on Table D-18. The chemical nature of the fly ash used in the test is compared to SECI coal on Table D-19. As shown, the nature of the wastes are very similar. The results of the leaching test is shown on Figure D-23. The total dissolved solids content leveled off and stablized somewhat at approximately 4500 mg/liter. The test results indicated that certain chemical constituents were leachable while others were not. The individual constituents relative to their leaching potential are identified on Table D-20.

The results of the test indicated that low pH water does favor the leaching of trace metals. The ranking of trace metal concentrations resulting from leaching of the alkaline fly ash after numerous cycles was B>Ba>Al>Cr>Zn>Ni>Cu>Se>As. The ranking of the percent of total trace metal content by element released was Se>B>Cr>Ni>Cu>Ba>As>Zn>Al. The test data (Figure D-23) was used to compile Table D-21 which gives the approximate percent of each trace metal leached during the test. It is noted that the order of the percentages leached agree with that given by Chu, Ruane, and Krenkel, except that copper and barium are reversed. This could be due to error in interpreting Figure D-23. These results indicate that varying precentages of trace metals are leached from coal and coal ash, but are generally low. This probably accounts to a large degree, for the scatter in the data shown on Figures D-21 and D-22.

The percentages developed above were applied to SECI coal. Using a sluice ratio of 15 percent solids, the concentration of various trace metals were estimated for SECI scrubber liquor. These results are shown on Figure D-24 along the range in scrubber liquor observed for the Southern California data. As shown, the results are comparable.

Leachate Migration Analysis

The potential migration of leachate from the waste storage area was evaluated using the site hydrogeologic parameters, and the analytical techniques presented earlier in this Appendix. The results of the leachate migration analysis are given on Table D-22. The assumed concentrations of the chemical constituents are given, along with the estimated concentrations of the constituents at the boundary of the site. To evaluate the potential impact of the waste storage area upon ground water, the concentrations at the property boundary were compared to the State of Florida water quality criteria for ground water (Class I-B).

The quality of leachate used was derived from data presented in the preceeding section. Trace metal concentrations were conservatively taken at the upper limit of the bandwidth shown on Figure D-24. The concentrations of the major cations and anions (sulfate, calcium, magnesium) were established at general solubility limits for a neutral pH in warm water. The minor cations and anions were established by performing a cation/ anion balance to bring the solution to equilibrium. For this analysis, it was conservatively assumed that all constituents would leach, even though the study by Chu, Ruane and Krenkel indicated that certain constituents should not.

The velocity of ground water flow and flow rates beneath the waste storage area were determined using Equation 1 and 2, and were calculated to be 1.7 feet per day (ft/day) and 594,000 gallons per day (gpd), respectively. The dilution potential for any leachate flowing from the water disposal area was evaluated using Equation 3. Seepage to Layer 1 from the waste storage area was taken to be 6 in/yr, based upon analyses presented in a previous section. The leachate was assumed only to mix by dispersive action within the top half of the aquifer. The resulting diluted concentration of leachate at the down-gradient boundary of the waste storage area was 0.30 of the assumed original concentration. Using the diluted concentrations as input to Equation 5, the concentrations at the property boundary were estimated.

As discussed in the proceeding section, the majority of the interstitial liquor deposited with the physically stabilized waste is flushed out during the first pore volume of displacement. Thereafter, the concentration of the leachate decreases rather rapidly and generally stabilizes. Therefore, the potential impact to ground water would be at a maximum during the displacement of the first pore volume. If it is assumed that the waste storage area is at design capacity, and that field capacity has been attained, the time required for 1 pore volume to be displaced can be estimated using Equation 1 with the equivalent permeability, and porosity developed in a previous section. Assuming a unit gradient, the time required for this displacement to occur would be 22 years. For conservatism, the leachate concentrations at the property boundary were determined after 25 years. It is noted that the concentrations of the anions (R_d = 1.5) were at steady state after this period of time. Therefore, assuming no increase in input concentrations, no further increase with time would be expected.

In summary, the concentrations of all the chemical constituents evaluated were estimated to be within State of Florida ground water quality criteria and significant impacts to off-site ground water quality are not anticipated with respect to the waste storage area.

D.7.7 Coal Pile Storage

D.7.7.1 Hydrologic Characteristics

The location of the coal pile storage area is shown on Figure D-10. The area encompasses approximately 50 acres. The majority of the coal will be stored in the inactive (dead storage) pile. The coal will be maintained at a height of approximately 45 feet.

A large percentage of the precipitation falling on the pile will tend to infiltrate the pile due to its porous nature. The infiltrating water should move rapidly through the pile and upon reaching the original ground surface will either infiltrate to the ground water table or drain along the base of the pile to collection ditches located around the perimeter of the area. The potential for impact to ground water will be a function of the quantity of water which is able to infiltrate the original ground surface and permeate to the water table. During the early life of the coal pile, the amount of infiltration will largely be a function of the infiltration capacity of the original ground surface. It has been shown, however, that with time coal fines are washed through the pile and accumulate at the base. It has been found that this accumulation of fines tends to lower the permeability at the base of the pile, forming a less pervious base. The permeability at the base of a coal pile was investigated by Woodward-Clyde Associates (date unknown) and was found to be approximately 2 x 10^{-5} cm/sec (5.7 x 10^{-2} ft/day). This compares to a vertical permeability of 3.8 ft/day (saturated) for Layer 1 at the Putnam Site. Ultimately, the amount of infiltration to ground water should be controlled by the permeability of this zone of fine material and the amount of ponding that occurs at the base of the pile.

As discussed in a previous section, the ability of a material with a permeability of 1 x 10^{-5} cm/sec should infiltrate approximately 6 in/yr of rainfall, assuming minimal ponding. Surface water discharge measurements given in the surface water section (Appendix C) indicate that approximately 11 inches of the total annual rainfall of 50 inches recharge the water table aquifer. Therefore, assuming minimal ponding at the base of the coal pile during the wet season and virtually no ponding during the dry season, it is estimated that approximately 9 in/yr will eventually reach the water table.

D.7.7.2 Contamination Potential

Using an infiltration rate of 9 in/yr over the area of the coal pile and ground water flow from up-gradient, the potential dilution can be evaluated with Equation 3. Ground water flow up-gradient was determined with Equation 2 and was calculated to be about 29,700 gpd, assuming that only the upper half of Layer 1 contributes to dilution. The infiltration through the coal pile was calculated to be about 33,600 gpd at 9 in/yr of recharge. Based upon these volumes, the leachate from the coal pile will be reduced in concentration approximately 47 percent. This diluted concentration was used as input to Equation 5 to determine the concentrations down-gradient from the coal pile. The retardation factors used are given on Table D-10.

The results of the analysis is given on Table D-23. As shown, all of the constituent concentrations at the property boundary are within Florida ground water quality criteria (Class I-B). Sulfate concentrations are computed to increase more than the others and will reach approximately 730 mg/liter after 35 years at the property boundary.

In order to evaluate the potential impact upon users of ground water in the direction of ground water flow, the concentration of sulfate was estimated at a distance of 2500 feet from the coal pile. This is the approximate distance to the nearest shallow well in the area of potential impact. This well is designated on Figure D-7 and Table D-6 as Well C-27. The depth of the well is 68 feet. The screened interval or zone of withdrawal is not known nor is there sufficient hydrogeologic information available in the vicinity of the well to accurately ascertain the potential impact. However, assuming the hydrogeologic conditions are similar to the site, the concentration of sulfate in the vicinity of the well may approach 500 mg/liter after 35 years.

D.7.8 Percolation Field

The general location of the percolation field is shown on Figure D-10. At this time, the design has not been finalized, therefore the size and shape of the field, as shown on Figure D-10, is approximate.

The waste water to be disposed of in the percolation field will originate in the plant as boiler blowdown, boiler fireside wash, air preheater, wash and stack wash. The quantities to be disposed of are a continuous 40 gpm for the boiler blowdown and a batch volume of 270,000 gallons four times a year for the remaining three items.

The quality of the waste water is variable. The boiler blowdown is projected to have a total dissolved solids content of less than 5 mg/liter, with approximately 1 mg/liter of iron, and small amounts of ammonia (Burns and Roe Inc., 1979, personal communication). The quality of the remaining three items (the batch volume) should be similar to bottom ash sluice water. Therefore, the maximum potential impact to ground water will be the batch volumes disposed of four times per year.

If it is assumed that the batch volumes are released over several days at an average rate of approximately 40 gpm, the discharge to Layer 1 will be 80 gpm. If it is furthered assumed that this 80 gpm is discharged through a strip 3000 feet in length, and perpendicular to the direction of ground water flow, the dilution potential can be evaluated with Equation 3. As before, it was assumed that only the top half of Layer 1 contributed to dilution. The aquifer discharge was calculated to be approximately 396,000 gpd. The discharge from the percolation field at a rate of 80 gpm would be approximately 115,000 gpd. The resulting dilution factor equals 0.23. It is recalled that the boiler blowdown water contains less than 5 mg/liter of total dissolved solids, which will also provide a source of dilution for the batch volumes. Allowing for complete mixing, the total dissolved solids content of the batch volumes will be diluted by 50 percent prior to discharge to Layer 1. Therefore, the total dilution factor for the batch volumes should approximate 0.12, which means that the concentration of the waste water flowing downgradient from the percolation field would be 12 percent of the original concentrations in the batch volume waste water. These diluted concentrations were used as input to Equation 5 to estimate the wastewater concentrations at the property boundary.

The results of this analysis are summarized on Table D-24. As shown, the estimated concentrations at the property boundary are within the State of Florida ground water quality criteria. Therefore, potential impacts to ground water beyond the site boundary are expected to be insignificant.

D.7.9 Dredge Disposal Area

The dredge disposal area is shown on Figure D-10. Approximately 2,000 cubic yards of spoil at approximately 15 percent solids will be sluiced to the disposal area for containment. In addition, approximately 1,000 cubic yards of essentially dry spoil will be disposed of in this area. The potential impact upon ground water is associated with the slurry water used to transport the spoil to the disposal area. This water will be the interstitial water naturally contained in the sediments prior to dredging.

To evaluate the potential impacts of this percolation to the water table aquifer, the water quality data for the St. Johns River (Table C-8) and the sediment analyses (Table C-12) were used. The total dissolved solids content of the St. Johns generally exceed 500 mg/liter by small amounts, and generally range from about 300 mg/liter to 900 mg/liter with an average of approximately 600 mg/liter. Sulfate was never found to exceed 250 mg/liter. Chloride concentrations exceeded 250 mg/liter on occasion but the data average was below this level.

The trace metals considered were cadmium, mercury, lead, and zinc because these metals exceeded the Florida surface water quality criteria in isolated cases. However, in general the concentrations are below the surface water quality criteria. For the impact analysis, the maximum concentrations observed were used as input.

Compounds such as pesticides and phenols were found in low concentrations in the sediments at Transect B (Section 2.3.1.4) but in most cases were at undetectable levels. For the impact analysis, the concentrations of these constituents were estimated by conservatively assuming that 100 percent of the maximum concentrations found in the sediments would leach into the sluice water.

The amount of sluice water to be placed in the disposal area was calculated to be approximately 8 million gallons, based upon the sluice ratio of 15 percent solids and the disposal volume of 2,000 cubic yards of spoil. The potential impact upon the water table aquifer is dependent upon the rate at which the sluice water percolates from the disposal area. Assuming that the rate of percolation is sufficient to cause saturated flow conditions (mounding of ground water) beneath the disposal area, the increase in the hydraulic gradient due to mounding can be used to estimate the quantity of flow from the disposal area. The seepage from the disposal area was calculated to be about 134,000 gpd, assuming a ground water mound 10 feet in height. At this daily seepage rate, approximately 60 days will be required to dissipate the volume of sluice water. Due to the formation of this ground water mound, dilution of the sluice water by ground water flowing from up-gradient should be negligible and was discounted in the impact analysis.

The results of the impact analysis are summarized on Table D-25. As shown, the concentrations at the property boundary were calculated to be within the State of Florida ground water quality criteria, and impacts to off-site ground water are expected to be insignificant.

D.8 REFERENCES

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TABLE D-8

RESULTS OF FIELD INVESTIGATION AND LABORATORY ANALYSES

	PERMEABILITY (ft/sec)				
MATERIAL	VERTICAL	HORIZONTAL	CATION EXCHANGE CAPACITY	TOTAL ORGANIC CARBON	CLAYS
Organic silt	$2.9\text{x}10^{-6}$	NA	20.37 $\frac{\text{meq}}{\text{100g soil}}$	4.06%	+99% kaolinite with trace illite
Sand	$4.4\text{x}10^{-5}$	$7.75\text{x}10^{-4}$	7.75 $\frac{\text{meq}}{\text{100g soil}}$	3.23%	51% kaolinite 11% illite 38% montmorillonite

TABLE D-9

SOIL CHARACTERISTICS OF THE ORGANIC LAYER AND LAYER 2 OF THE PUTNAM SITE

	Organic Layer	Layer 2
Basic texture	Sand	Sand
Sorting	Well-sorted (77% fine-grained sand)	Well-sorted (85% fine-grained sand)
Clay-size particles (%)	0.8	9.0
Clay minerals in clay-size fraction	Kaolinite (99%) Illite (trace)	Montmorillonite (99%) Kaolinite (trace)
Cation exchange capacity (meq/100 g soil)	20.37	9.00
Total organic carbon (%)	4.06	3.54

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TABLE D-10

RETARDATION FACTORS USED IN THIS STUDY

Constituent	Calculated Distribution Coefficient (cm^3/g)	Calculated Retardation Factor	Retardation Factor Assumed for This Study
Calcium	0.44	3.6	5
Sodium	0.92	6.5	5
Potassium	2.0	13	5
Magnesium	2.0	13	5
Bicarbonate	-	-	1.5
Sulfate	-	-	1.5
Chloride	-	-	1.5
Fluoride	-	-	1.5
Nitrate	-	-	1.5
Arsenic	557	3343	50
Barium	78	469	50
Cadmium	7,800	46,800	50
Chromium	54	324	50
Copper	222	1,333	50
Iron	142	852	50
Lead	780	4,680	50
Manganese	223	1,338	50
Mercury	156,000	936,000	50
Selenium	520	3,120	50
Silver	52,000	312,000	50
Zinc	195	1,170	50

TABLE D-11

COMPARISON OF SOILS USED IN THE CALIFORNIA ASH AND SLUDGE LEACHATE EXPERIMENT WITH THE LAYER 1 SOIL AT THE PUTNAM SITE

	Station 1 Soil (Calif.)	Layer 1 Soil (Putnam Site)
Basic texture	Sand	Sand
Sorting	Poorly sorted (10% fine-grained sand)	Well sorted (89% fine-grained sand)
Clay-size particles (%)	3	2
Clay minerals in clay-size fraction	Illite (70%) Montmorillonite (20%) Kaolinite (10%)	Kaolinite (51%) Montmorillonite (38%) Illite (11%)
Cation exchange capacity (meq/100g Soil)	3.8	7.8
Total organic carbon(%)	0.25	3.23

Source: Holland and others, 1975.

TABLE D-12

DISTRIBUTION COEFFICIENTS AND RETARDATION FACTORS FOR TRACE ELEMENTS IN STATION 1 LEACHATES WITH RESPECT TO STATION 1 SOILS

	Sludge Leachate		Ash Leachate	
Constituent	Distribution Coefficient (cm^3/g)	Retardation Factor	Distribution Coefficient (cm^3/g)	Retardation Factor
Arsenic	-	-	50	>300
Chromium	1.8	10	1.7-3.4	10-20
Copper	300	1800	50	>300
Fluorine	1.8	10	0	1
Mercury	6.7	40	-	-
Selenium	-	-	4.3	25
Zinc	167	1000	-	-

Source: Holland and others, 1975

TABLE D-13

COAL ANALYSES

	Webster Co., Ky. Dotiki Mine - Crushed Run Of Mine		White Co., Ill. Hole #'s N-18, N-35 #6 Seam		White Co., Ill. Hole #'s N-9, N-17 #6 Seam		White Co., Ill. Hole #'s N-19, N-27 #6 Seam		White Co., Ill. Hole #'s N-10, N-11, N-16 #6 Seam		White Co., Ill. Hole #'s N-26, N-28, N-36 #6 Seam		White Co., Ill. Hole #'s N-12 N-13, N-33 #6 Seam	
	As Rec'd	Dry Basis	As Rec'd	Dry Basis	As Rec'd	Dry Basis	As Rec'd	Dry Basis	As Rec'd	Dry Basis	As Rec'd	Dry Basis	As Rec'd	Dry Basis
Proximate Analysis														
% Moisture	3.51	xxxxx	5.16	xxxxx	4.93	xxxxx	5.47	xxxxx	5.55	xxxxx	5.35	xxxxx	5.26	xxxxx
% Ash	8.42	8.73	6.75	7.12	7.11	7.48	6.64	7.02	6.73	7.13	6.50	6.87	6.97	7.36
% Volatile	38.15	39.54	37.92	39.98	36.85	38.76	36.09	38.18	37.50	39.70	35.96	37.99	36.96	39.01
% Fixed Carbon	49.92	51.73	50.17	52.90	51.11	53.76	51.80	54.80	50.22	53.17	52.19	55.14	50.81	53.63
Btu	13157	13636	12505	13185	12441	13086	12534	13259	12407	13136	12498	13204	12439	13130
% Alk as Na_2O	0.17	0.18	xxxxx	0.16	xxxxx	0.22	xxxxx	0.17	xxxxx	0.17	xxxxx	0.19	xxxxx	0.19
Sulfur Forms														
% Pyritic Sulfur	0.92	0.95	1.21	1.28	1.26	1.33	0.86	0.91	0.90	0.95	0.71	0.75	1.08	1.14
% Sulfate Sulfur	0.03	0.03	0.18	0.19	0.20	0.21	0.14	0.15	0.16	0.17	0.08	0.08	0.22	0.23
% Organic Sulfur	1.82	1.89	1.93	2.03	1.91	2.01	1.70	1.80	1.68	1.78	1.64	1.73	1.85	1.95
Water Soluble Alkalies														
% Na_2O	0.014	0.014	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
% K_2O	0.003	0.003	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Ultimate Analysis (%)														
Moisture	3.51	xxxxx	5.16	xxxxx	4.93	xxxxx	5.47	xxxxx	5.55	xxxxx	5.35	xxxxx	5.26	xxxxx
Carbon	72.62	75.26	69.54	73.32	69.52	73.13	70.12	74.18	68.97	73.02	70.06	74.02	69.04	72.87
Hydrogen	5.02	5.20	4.69	4.95	4.70	4.94	4.77	5.05	4.70	4.98	4.77	5.04	4.71	4.97
Nitrogen	1.45	1.50	1.38	1.45	0.81	0.85	1.37	1.45	1.48	1.57	1.46	1.54	1.37	1.45
Chlorine	0.29	0.30	0.23	0.24	0.28	0.29	0.25	0.26	0.25	0.26	0.25	0.26	0.24	0.25
Sulfur	2.77	2.87	3.32	3.50	3.37	3.55	2.70	2.86	2.74	2.90	2.42	2.56	3.15	3.32
Ash	8.08	8.38	6.75	7.12	7.11	7.48	6.64	7.02	6.73	7.13	6.50	6.87	6.97	7.36
Oxygen (diff.)	6.26	6.49	8.93	9.42	9.28	9.76	8.68	9.18	9.58	10.14	9.19	9.71	9.26	9.78

TABLE D-13 (Continued)

	Webster Co., Ky. Dotiki Mine - Crushed Run Of Mine	White Co., Ill. Hole #'s N-18, N-35 #6 Seam	White Co., Ill. Hole #'s N-9, N-17 #6 Seam	White Co., Ill. Hole #'s N-19, N-27 #6 Seam	White Co., Ill. Hole #'s N-10, N-11, N-16 #6 Seam	White Co., Ill. Hole #'s N-26, N-28, N-36 #6 Seam	White Co., Ill. Hole #'s N-12 N-13, N-33 #6 Seam
	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis
Mineral Analysis (%)							
Phos. Pentoxide, P_2O_5	0.41	0.08	0.15	0.10	0.11	0.10	0.17
Silica, SiO_2	48.92	42.86	38.30	45.87	45.17	48.12	41.83
Ferric Oxide, Fe_2O_3	19.74	27.48	26.95	2.125	21.14	17.18	25.19
Alumina, Al_2O_3	19.00	20.00	19.24	20.72	20.35	23.23	20.92
Titania, TiO_2	1.04	0.90	0.88	1.03	1.03	1.10	0.98
Lime, CaO	3.28	2.57	6.19	4.50	4.75	2.88	3.77
Magnesia, MgO	0.94	0.72	0.71	0.83	0.77	0.87	0.82
Sulfur Trioxide, SO_3	3.83	2.19	4.66	2.33	3.22	2.26	2.77
Potassium Oxide, K_2O	2.34	1.83	1.75	2.00	1.90	2.17	2.04
Sodium Oxide, Na_2O	0.50	1.04	1.07	1.09	1.13	1.29	1.18
Undetermined	0.00	0.33	0.10	0.28	0.48	0.80	0.33
Base; Acid Ratio	0.39	0.53	0.63	0.44	0.45	0.34	0.52
Silica Value	67.12	58.21	53.08	63.31	62.86	69.69	58.41
Element (ppm)							
Uranium	14	22	7	18	21	13	6
Thorium	10	6	3	9	7	9	5
Bismuth	0.3						
Lead	33	26	6	15	34	17	8
Thallium	≤0.2	≤0.6		≤0.9	≤0.2	≤0.2	<0.5
Mercury	NRR	0.32	.20	.30	≤0.01	.03	.14
Gold							
Platinum							
Iridium							
Osmium							
Rhenium							
Tungsten	2		≤0.4	≤1	≤0.7	0.8	0.8
Tantalum							

	Webster Co., Ky. Dotiki Mine - Crushed Run Of Mine	White Co., Ill. Hole #'s N-18, N-35 #6 Seam	White Co., Ill. Hole #'s N-9, N-17 #6 Seam	White Co., Ill. Hole #'s N-19, N-27 #6 Seam	White Co., Ill. Hole #'s N-10, N-11, N-16 #6 Seam	White Co., Ill. Hole #'s N-26, N-28, N-36 #6 Seam	White Co., Ill. Hole #'s N-12 N-13, N-33 #6 Seam
	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis
Element (con't)							
Hafnium	0.5				0.8	0.9	0.7
Lutetium	≤0.1			0.2	0.1		0.1
Ytterbium	0.4			0.9	0.6		0.5
Thulium	<0.1	0.1	<0.1	0.1	0.1		<0.1
Erbium	0.4	0.6	0.3	0.8	0.3	0.2	0.4
Holmium	0.5	0.8	0.4	1	0.4	0.5	0.5
Dysprosium	0.8	1	0.7	2	0.6	1	0.9
Terbium	0.4	0.3	0.2	0.4	0.3	0.4	0.2
Gadolinium	2	0.7	0.4	1	0.9	1	0.5
Europium	1	0.4	0.2	5	0.4	0.5	0.3
Samarium	5	3	2	4	3	2	2
Neodymium	8	3	2	2	4	4	3
Praseodymium	5	2	2	2	3	5	1
Cerium	52	20	9	16	20	21	21
Lanthanum	23	15	8	9	20	9	12
Barium	960	150	86	290	80	130	96
Cesium	6	2	1	2	2	3	1
Iodine	2	0.7	0.3	0.8	<0.1	0.4	0.5
Tellurium	≤0.3	≤0.3	≤0.2	≤0.3	0.6		≤0.1
Antimony	5	0.3	1	0.6	0.5	0.5	0.7
Tin	2	3	2	2	2	0.8	2
Cadmium	2	2	0.6	1	0.6	0.3	0.3
Silver		0.5	0.1	≤0.2	0.1	<0.1	<0.1
Palladium							
Rhodium							
Ruthenium							
Molybdenum	45	39	9	23	37	45	5

TABLE D-13 (Continued)

	Webster Co., Ky. Dotiki Mine - Crushed Run Of Mine	White Co., Ill. Hole #'s N-18, N-35 #6 Seam	White Co., Ill. Hole #'s N-9, N-17 #6 Seam	White Co., Ill. Hole #'s N-19, N-27 #6 Seam	White Co., Ill. Hole #'s N-10, N-11, N-16 #6 Seam	White Co., Ill. Hole #'s N-26, N-28, N-36 #6 Seam	White Co., Ill. Hole #'s N-12 N-13, N-33 #6 Seam
Element (con't)	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis
Niobium	18	7	4	10	9	12	2
Zirconium	120	73	13	58	110	47	29
Yttrium	13	20	7	17	25	12	15
Strontium	140	50	32	65	24	29	29
Rubidium	31	10	17	35	29	10	16
Bromine	19	30	17	44	52	35	10
Selenium	10	14	8	11	20	5	2
Arsenic	12	7	4	6	13	2	4
Germanium	5	3	1	3	8	2	1
Gallium	12	12	5	7	10	4	7
Zinc	59	37	12	13	50	15	30
Copper	30	19	27	22	40	12	15
Nickel	7	15	3	17	25	9	8
Cobalt	3	4	3	6	13	6	8
Iron	MC	MC	MC	MC	MC	MC	MC
Manganese	20	16	18	14	17	10	23
Chromium	23	36	20	92	70	25	51
Vanadium	90	42	40	60	380	55	75
Titanium	MC	MC	420	MC	MC	710	MC
Scandium	2	2	1	3	4	4	3
Calcium	MC	MC	MC	MC	MC	MC	MC
Potassium	MC	MC	MC	MC	MC	MC	MC
Chlorine	110	20	45	50	14	20	5
Sulfur	MC	MC	MC	MC	MC	MC	MC
Phosphorus	68	60	46	35	58	7	51
Silicon	MC	MC	MC	MC	MC	MC	MC
Aluminum	MC	MC	MC	MC	MC	MC	MC
Magnesium	MC	MC	MC	MC	MC	MC	MC

TABLE D-13 (Continued)

Element (con't)	Webster Co., Ky. Dotiki Mine - Crushed Run Of Mine	White Co., Ill. Hole #'s N-18, N-35 #6 Seam	White Co., Ill. Hole #'s N-9, N-17 #6 Seam	White Co., Ill. Hole #'s N-19, N-27 #6 Seam	White Co., Ill. Hole #'s N-10, N-11, N-16 #6 Seam	White Co., Ill. Hole #'s N-26, N-28, N-36 #6 Seam	White Co., Ill. Hole #'s N-12 N-13, N-33 #6 Seam
	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis	Ignited Basis
Sodium	MC	MC	MC	MC	MC	MC	MC
Fluorine	70	22	13	18	66	25	16
Oxygen	NR	NR	NR	NR	NR	NR	NR
Nitrogen	NR	NR	NR	NR	NR	NR	NR
Carbon	NR	NR	NR	NR	NR	NR	NR
Boron	84	60	150	130	47	38	42
Beryllium	0.4	0.8	0.5	3	0.5	0.4	0.7
Lithium	4	5	15	7	3	3	3
Hydrogen	NR	NR	NR	NR	NR	NR	NR

MC = Major Component

NR = Not Reported; all values "not reported" <0.1 ppm weight.

xxxxx = no data.

TABLE D-14

TYPICAL ASH ANALYSIS OF SECI RAW COAL

CONSTITUENT	DESIGN PERFORMANCE
SiO_2	44.51
Al_2O_3	19.06
TiO_2	0.93
Fe_2O_3	26.96
CaO	3.17
MgO	0.01
Na_2O	0.68
K_2O	1.29
P_2O_5	0.03
Base-to-Acid Ratio	0.49
SO_3	0.68
Undetermined	0.57

TABLE [illegible]-15

COMPARISON OF TRACE ELEMENTS IN TYPICAL ILLINOIS BASIN COAL WITH SECI COAL

	Illinois Basin		SECI	
	Arithmetic Mean (ppm)	Geometric[a] Mean (ppm)	Arithmetic Mean (ppm)	Geometric[a] Mean (ppm)
Arsenic	14	7.4	7	5.8
Barium	100	75	256	166
Boron	110	98	79	68.9
Cadmium	2.2	0.59	1	0.74
Chromium	18	16	45	38.9
Copper	14	13	24	21.9
Fluorine	67	63	33	26.6
Lead	32	15	20	16.7
Mercury	0.2	0.16	0.10	0.13
Selenium	2.2	2.0	10	8.2
Silver	0.03	0.03	0.2	0.19
Zinc	250	87	31	25.8

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[a] The geometric mean "more closely approximates the value that would be expected in an unknown sample" because it de-emphasizes the extremely high individual values resulting from epigenetic mineralization within the coal (Gluskoter and others, 1977).

TABLE D-16

SUMMARY OF CHEMICAL DATA FROM SEVERAL STUDIES OF FGD SLUDGE LIQUOR AND COAL ASH LEACHATE

Constituent^{a}	Range in Scrubber Liquor^{b}	Scrubber Liquor From Eastern Coal^{c}		Range in Scrubber Liquor^{e}	Range in Scrubber Liquor^{f}	Range in Coa Ash Leachate^{g}	Range in Ash Pond Effluent^{h}		Major Species in Coal Plant Leachates^{i}		Equilibrium Concentrations in Leachate^{i}	
		Range	Median				Range	Median	Ash Leachate	Sludge Leachate	Coal Ash Leachate	FGD Sludge Leachate
TDS	3,200-15,000	2,500-70,000^{d}	7000	-	2600-7000	2200	142-524	279	2270	5600	-	-
pH	3.04-10.7	7.1-12.8	-	3.4-9.7	-	13	4.4-11.3	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-	-	790	-	-
Calcium	520-3000	470-2600	700	-	-	-	-	-	900	600	-	-
Carbonate	<0.01-<10	-	-	-	-	-	-	-	70	-	-	-
Chloride	420-4800	470-5000	2300	-	-	-	-	-	10	450	-	-
Fluoride	0.07-10	1.4-70	3.2	7.6-31.5	-	1.4-17.3	-	-	-	-	1.4-17.3	-
Hydroxide	-	-	-	-	-	-	-	-	800	-	-	-
Magnesium	3.0-2750	-	-	-	-	-	0.4-14	3.9	1	100	-	-
Nitrate	-	-	-	-	-	-	-	-	2	30	-	-
Nitrogen (Total)	<0.001-0.002	-	-	-	-	-	-	-	-	-	-	-
Phosphate	0.03-0.41	-	-	-	-	-	0.002-0.016	0.011	-	-	-	-
Potassium	5.9-32	-	-	-	-	-	-	-	4	30	-	-
Sodium	14.0-2400	36-20,000^{d}	118	-	-	-	-	-	72	1000	-	-
Sulfite	0.8-3500	-	-	-	-	-	-	-	-	-	-	-
Sulfate	720-10,000	720-30,000^{d}	2100	-	-	-	49-358	133	10	3000	-	-
Aluminum	0.03-0.3	-	-	-	-	-	1.6-7.2	2.0	-	-	-	-
Antimony	0.09-2.3	0.46-1.6	1.2	-	-	-	-	-	-	-	-	-
Arsenic	<0.004-0.3	<0,004-1.8	0.02	<0.002-0.03	0.006-0.019	<0.002-0.084	0.005-0.1	0.013	-	-	<0.002-0.084	<0.002-0.03
Barium	-	-	-	<0.3-2	-	<0.3-40	0.1-0.3	0.2	-	-	<0.3-40	<0.3-2
Beryllium	<0.002-0.14	<0.0005-0.05	0.014	0.001-0.002	0.0005-0.01	0.0006-0.003	<0.01-0.01	-	-	-	0.00026-0.003	0.001-0.002
Boron	8.0-46	41	41	0.96-6.3	-	0.03-17	-	-	-	-	0.3-16.9	0.22-6.3
Cadmium	0.004-0.11	0.004-0.1	0.023	0.0005-0.002	0.014-0.032	<0.001-0.0025	<0.001-0.037	<0.001	-	-	<0.001-<0.01	0.0005-0.002
Chromium	0.01-0.5	0.001-0.5	0.02	<0.001-0.011	0.002-0.08	<0.001-0.21	0.005-0.067	0.012	-	-	<0.001-1.0	<0.001-0.011
Cobalt	0.10-0.7	<0.002-0.1	0.35	-	-	-	-	-	-	-	-	-
Copper	<0.002-0.2	0.002-0.4	0.015	<0.005-0.045	0.004-0.3	<0.005-0.092	0.02-0.31	0.05	-	-	<0.005-0.092	<0.005-0.045
Iron	0.02-8.1	0.02-0.1	0.026	-	-	-	0.23-5.98	0.95	1	1	-	-
Lead	0.01-0.4	0.002-0.55	0.12	0.003-0.006	0.0029-0.06	0.0027-0.024	0.01-0.06	0.014	-	-	0.0027-0.024	0.0027-0.0056
Manganese	0.09-2.5	<0.01-9.0	0.17	<0.002	0.01-9.0	<0.002	<0.01-0.58	0.05	-	-	<0.002-0.002	<0.002-0.002
Mercury	0.0004-0.07	0.0009-0.07	0.001	0.0005-0.001	0.01-0.03	0.0003-0.015	0.0002-0.038	0.0007	-	-	0.0003-0.015	0.0005-0.008
Molybdenum	0.91-6.3	5.3	5.3	0.006-0.007	-	0.01-0.7	-	-	-	-	0.01-0.69	<0.011-0.075
Nickel	0.05-1.5	0.03-0.91	0.13	<0.05	0.007-0.03	0.015-0.05	<0.05-1.1	0.05	-	-	<0.05-0.046	<0.05-0.05
Selenium	<0.001-2.2	<0.005-2.7	0.11	0.01-0.045	0.005-0.13	0.0005-0.47	0.002-0.016	0.011	-	-	<0.0005-0.47	0.0005-0.016
Silicon	0.2-3.3	-	-	-	-	-	4.8-12.6	7.4	-	-	-	-
Silver	0.005-0.6	-	-	-	-	-	<0.01-0.01	-	-	-	-	-
Tin	3.1-3.5	-	-	-	-	-	-	-	-	-	-	-
Vanadium	<0.001-0.67	-	-	<0.1	-	<0.1	-	-	-	-	<0.1-<0.2	<0.1-0.1
Zinc	0.01-0.35	0.01-27	0.046	0.005-0.045	0.024-0.88	<0.005-0.038	0.03-1.51	0.06	-	-	<0.005-0.19	<0.005-0.11

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[a] Concentrations given in mg/liter.
[b] Source: Bornstein and others, 1976.
[c] Source: Rossoff and Rossi, 1974
[d] Levels of soluble sodium salts in dual alkali sludge (filter cake) depend strongly on the degree of cake wash. The highest levels shown reflect single measurements on an unwashed dual alkali filter cake.
[e] Source: U.S. Environmental Protection Agency, 1976.
[f] Source: McKee and Wolf, 1971.
[g] Source: Seaver, Schmidt, and Woodyard, 1977.
[h] Source: Chu, Ruane, and Krenkel, 1978, data based upon 12 ash ponds.
[i] Source: Holland and others, 1975.

TABLE D-17

MAJOR SPECIES PRESENT IN LEACHATES FROM STATION 1 OF THE SO. CALIFORNIA EXPERIMENT

ASH LEACHATE

Cation	ppm	Anion	ppm
Ca	900	OH	800
Na	72	CO_3	70
K	4	CL	10
Mg	1	SO_4	10
Fe	1	NO_3	2

Total Dissolved Solids = 2270 ppm. pH = 13.0

SLUDGE LEACHATE

Cation	ppm	Anion	ppm
Na	1000	SO_4	3000
Ca	600	HCO_3*	790
Mg	100	Cl	450
K	30	NO_3	30
Fe	1		

Total Dissolved Solids = 5600 ppm. pH = 7.6

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*Calculated

Source: Holland and others, 1975.

TABLE D-18

RELATIONSHIP BETWEEN PLANT OPERATIONS AND PH VALUES OF ASH POND EFFLUENTS AT TVA PLANT E

Parameter	Plant E
Coal source	W. Kentucky
Method of Firing	Circular-Tangential
Ash Content in Coal (%)	15.3
Fly Ash (%)	67
Bottom Ash (%)	33
Ash to Sluice Ratio[1] (g/l)	15
pH of Raw Water (make-up water)	7.0
pH of Ash Pond Effluent[a]	11.1

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[a] Based on average values during 1974. Combined bottom and fly ash pond.

Source: Chu, Ruane, and Krenkel, 1978.

TABLE D-19

COMPARISON OF MAJOR CHEMICAL CONSTITUENTS OF FLY ASH USED IN TVA STUDY WITH SECI COAL ASH

Constituent	Plant E[a] (TVA)	SECI[b]
Aluminum (Al_2O_3),%	18.52	19.06
Calcium Oxide (CaO), %	5.74	3.17
Iron Oxide (Fe_2O_3), %	20.79	26.96
Magnesium Oxide (MgO), %	1.23	0.01
Potassium Oxide (K_2O), %	3.37	1.29
Silica (SiO_2), %	46.28	44.51
Sodium Oxide (Na_2O), %	0.66	0.68
Sulfur Trioxide (SO_3), %	1.55	0.68
Titanium Oxide (TiO_2), %	1.07	0.93
Base/Acid Ratio	0.48	0.49

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[a] Source: Chu, Ruane, and Krenkel, 1978.

[b] Geometric Mean.

TABLE D-20

LEACHING POTENTIAL OF CHEMICAL CONSTITUENTS FROM ALKALINE COAL ASH (PLANT E, TVA)[a]

Leachable	Non-Leachable
Calcium	Cadmium
Sodium	Iron
Potassium	Lead
Chloride	Magnesium
Sulfate	Manganese
Aluminum	Mercury
Arsenic	Silica
Barium	Titanium
Boron	
Chromium	
Copper	
Nickel	
Selenium	
Zinc	

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[a] Coal Source: Western Kentucky.

Source: Chu, Ruane, and Krenkel, 1978

TABLE D-21

LEACHABILITY OF ALKALINE FLY ASH[a]
(PLANT E, TVA)

Constituent	Concentration in 30-gram Fly Ash Sample (g)	Amount Leached During Test (g)	Percent Leached During Test
Aluminum	2.94	6.0×10^{-4}	0.02
Arsenic	1.65×10^{-3}	1.0×10^{-5}	0.6
Barium	6.00×10^{-2}	1.4×10^{-3}	2.3
Boron	5.40×10^{-2}	5.0×10^{-3}	9.3
Chromium	2.70×10^{-3}	1.3×10^{-4}	4.8
Copper	2.34×10^{-3}	4.0×10^{-5}	1.7
Nickel	3.00×10^{-3}	1.0×10^{-4}	3.3
Selenium	1.80×10^{-4}	3.0×10^{-5}	16.7
Zinc	1.62×10^{-2}	8.0×10^{-5}	0.5

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[a] Coal Source - Western Kentucky.

TABLE D-22

COMPARISON OF WATER QUALITY CRITERIA WITH ESTIMATED GROUND WATER QUALITY AT PROPERTY BOUNDARY

(Waste Storage Area)

Constituent[a]	Florida[b] Criteria	Assumed[c] Leachate Concentration in Landfill	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Calcium	NS	700	80	40	120
Sodium	NS	400	14	25	39
Potassium	NS	300	2.22	20	22
Magnesium	NS	100	6.6	5	12
Bicarbonate	NS	800	293	50	343
Sulfate	NS	2000	2.9	125	128
Chloride	NS	600	13	38	51
Fluoride	1.5[g]	3.2	0.3	0.2	0.5
Nitrate	10	31	3.4	2	5
Arsenic	0.05	0.7	0.01	ND	0.01
Barium	1	14	<0.5	ND	<0.5
Cadmium	0.01	0.13	0.005	ND	0.005
Chromium	0.05	4.0	0.01	ND	0.01
Copper	NS	2.3	<0.16	ND	<0.16
Iron	NS	3.0	0.75	ND	0.75
Lead	0.05	1.8	<0.01	ND	<0.01
Manganese	NS	1.9	<0.05	ND	<0.05

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TABLE D-22 (Continued)

Constituent[a]	Florida[b] Criteria	Assumed[c] Leachate Concentration in Landfill	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Mercury	0.002	0.024	<0.001	ND	<0.001
Selenium	0.01	1.0	<0.01	ND	<0.01
Silver	0.05	0.034	0.019	ND	0.019
Zinc	NS	2.7	0.33	ND	0.33
TDS	NS[h]	∿5,000	310	∿305	∿615

---

[a] Concentrations given in mg/liter.

[b] Criteria applicable to ground water in Florida (Class I-B).

[c] Concentrations do not include background concentrations.

[d] Based upon average at monitoring well S-1.

[e] Property boundary assumed to be 2300 feet from edge of landfill.

[f] Background quality plus estimated increase in concentrations.

[g] If background levels exceed 1.5 mg/liter, the criteria must not be exceeded.

[h] Class I-B waters are classified as having less than 10,000 mg/l total dissolved solids.

NS = no standard applicable.

ND = constituent did not reach property boundary.

TABLE D-23

COMPARISON OF WATER QUALITY CRITERIA WITH ESTIMATED GROUND WATER QUALITY AT PROPERTY BOUNDARY

(Coal Storage Area)

Constituent[a]	Florida[b] Criteria	Assumed[c] Leachate Concentration in Landfill	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Sodium	NS	1260	4.5	50	55
Magnesium	NS	174	2.7	7	10
Sulfate	NS	5230	12.2	730	742
Chloride	NS	23	5.35	3	8
Fluoride	1.5[g]	0.0	<0.1	0.0	<0.1
Arsenic	0.05	0.05	<0.013	ND	<0.013
Cadmium	0.01	0.1	<0.005	ND	<0.005
Chromium	0.05	0.3	<0.01	ND	<0.01
Copper	NS	1.8	<0.1	ND	<0.1
Iron	NS	0.9	10.9	ND	10.9
Lead	0.05	0.1	<0.011	ND	<0.011
Manganese	NS	180	<0.05	ND	<0.05

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TABLE D-23 (Continued)

Constituent[a]	Florida[b] Criteria	Assumed[c] Leachate Concentration in Landfill	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Mercury	0.002	0.002	<0.001	ND	<0.001
Selenium	0.01	0.01	0.009	ND	0.009
Silver	0.05	0.01	<0.015	ND	<0.015
Zinc	NS	1.6	0.06	ND	0.06

---

[a] Concentrations given in mg/liter.

[b] Criteria applicable to ground water in Florida (Class I-B).

[c] Concentrations do not include background concentrations.

[d] Based upon average at monitoring well No. 1.

[e] Property boundary assumed to be 1500 feet from edge of landfill.

[f] Background quality plus estimated increase in concentrations.

[g] If background levels exceed 1.5 mg/liter, the criteria must not be exceeded.

NS = no standard applicable.

ND = constituent did not reach property boundary.

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TABLE D-24

PERCOLATION FIELD
WASTE WATER QUALITY

Constituent[a]	Florida[b] Criteria	Assumed[c] Concentration in Leachate	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Chloride	NS	900	8.4	23	31
Fluoride	1.5[g]	0	<0.1	0	<0.1
Magnesium	NS	75	2.45	1.89	4.34
Sodium	NS	490	10.6	12.6	23.2
Sulfate	NS	550	8.6	13.9	22.5
Aluminum	NS	4.7	NA	ND	--
Antimony	NS	0.10	NA	ND	--
Arsenic	0.05	0.07	<0.011	ND	<0.011
Beryllium	NS	0.01	NA	ND	--
Cadmium	0.01	0.10	0.007	ND	0.007
Chromium	0.05	0.17	<0.01	ND	<0.01
Copper	NS	0.47	<0.1	ND	<0.1
Iron	NS	28.6	0.75	ND	0.75
Lead	0.05	0.10	0.014	ND	0.014
Manganese	NS	0.06	<0.05	ND	<0.05
Mercury	0.002	0.005	<0.001	ND	<0.001
Selenium	0.01	0.03	<0.01	ND	<0.01

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TABLE D-24 (Continued)

Constituent[a]	Florida[b] Criteria	Assumed[c] Concentration in Leachate	Background[d] Concentrations in Ground Water	Estimated Increase[e] in Concentrations at Property Boundary	Estimated Ground[f] Water Quality at Property Boundary
Silver	0.05	0.034	<0.01	ND	<0.01
Zinc	NS	0.80	0.08	ND	0.08
Oil & Grease	NS	40	NA	ND	--
Total Dissolved Solids	NS[h]	2300	164	52	216

---

[a] Concentrations given in mg/liter.

[b] Criteria applicable to ground water in Florida (Class I-B).

[c] Concentrations do not include background concentrations.

[d] Based upon average at monitoring well No. 3.

[e] Property boundary assumed to be approximately 2200 feet from percolation field.

[f] Background quality plus estimated increase in concentrations.

[g] If background levels exceed 1.5 mg/liter, the criteria must not be exceeded.

[h] Class I-B waters are classified as having less than 10,000 mg/liter total dissolved solids.

NA = not analyzed.

NS = no standard.

ND = constituent did not reach property boundary.

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TABLE D-25

COMPARISON OF WATER QUALITY CRITERIA WITH ESTIMATED GROUND WATER QUALITY AT PROPERTY BOUNDARY
(Dredge Disposal Area)

Constituent[a]	Florida[b] Criteria	Concentration St. Johns River	Concentration in St. Johns Bottom Sediments (mg/kg)	Assumed[c] Leachate Concentration	Concentrations[d] in Ground Water	Estimated[e] Increase in Concentrations at Property Boundary	Estimated[f] Concentrations at Property Boundary
Chloride	NS	120-400		400	8.4	16	24
Sulfate	NS	1.79-114		114	8.6	4.8	13.4
Cadmium	0.01	0-0.006		0.006	0.007	ND	0.007
Mercury	0.002	0.0005		0.0005	<0.001	ND	<0.001
Lead	0.05	0-0.074		0.074	0.014	ND	0.014
Zinc	NS	0-0.07		0.07	0.08	ND	0.08
Phenols	NS	<0.001	<0.02 - 27.0	3.8	<0.001	0.0009	<0.0019
Lindane	0.004	0	0.002 - 0.023	0.0033	NA	0.0000005	∿0.0000005
Heptachlor Epoxide	NS	NA	0.002 - 0.029	0.0041	NA	0.0000009	∿0.0000009
Dieldrin	NS	NA	<0.001 - 0.022	0.0031	NA	0.0000007	∿0.0000007
Aldrin	NS	0	0.006 - 0.280	0.04	NA	0.000009	∿0.000009

---

[a] Concentrations in mg/liter unless otherwise noted.

[b] Criteria applicable to ground water in Florida (Class I-B).

[c] Concentrations do not include background concentrations.

[d] Based on data from monitoring well No. 3.

[e] Property boundary assumed to be 500 feet from disposal area.

[f] Background concentrations plus estimated increase in concentrations.

NS - no standard applicable.

NA - not analyzed.

ND - constituent did not reach property boundary.

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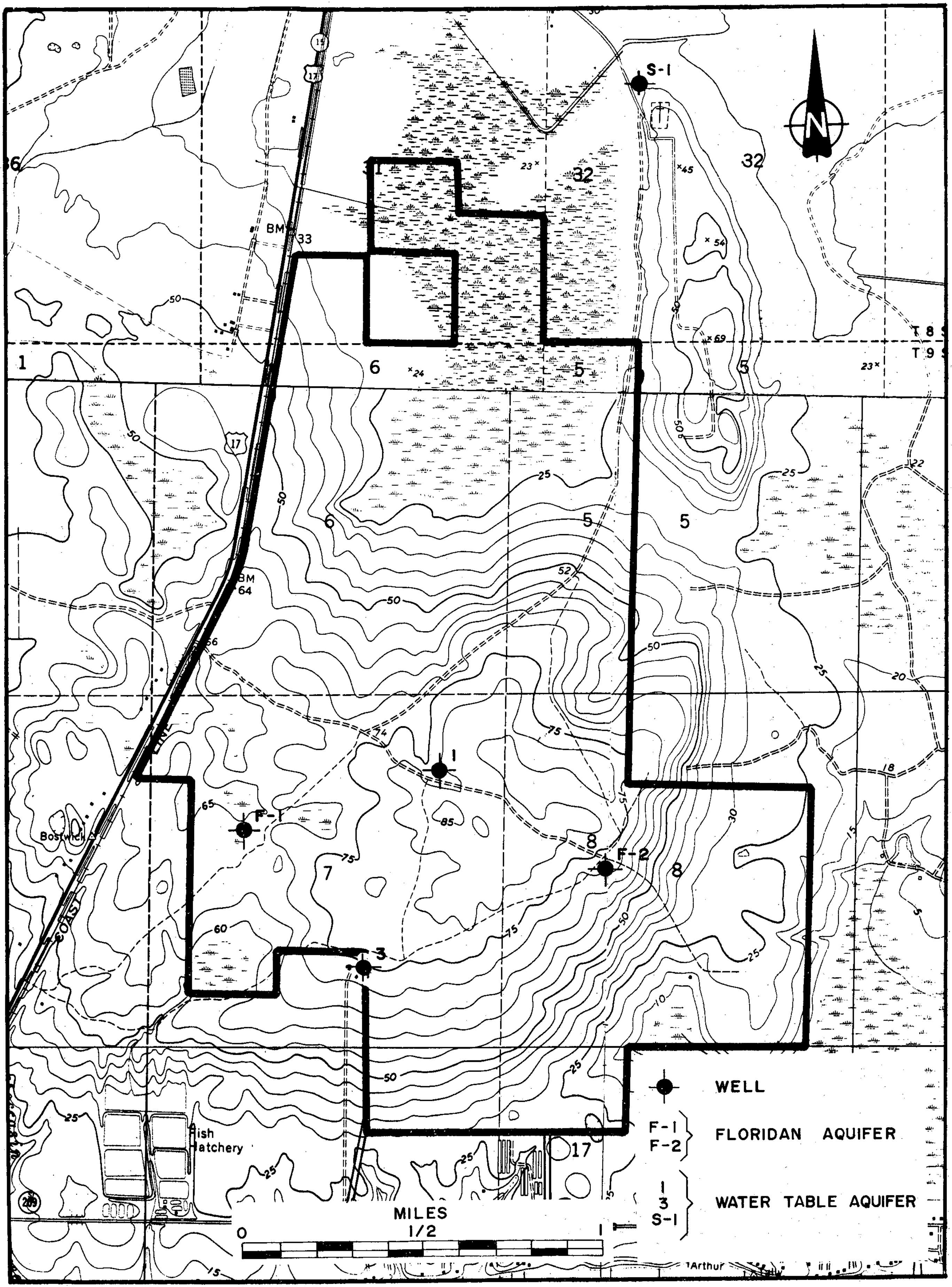

Figure D-1. Monitor Well Location Map.

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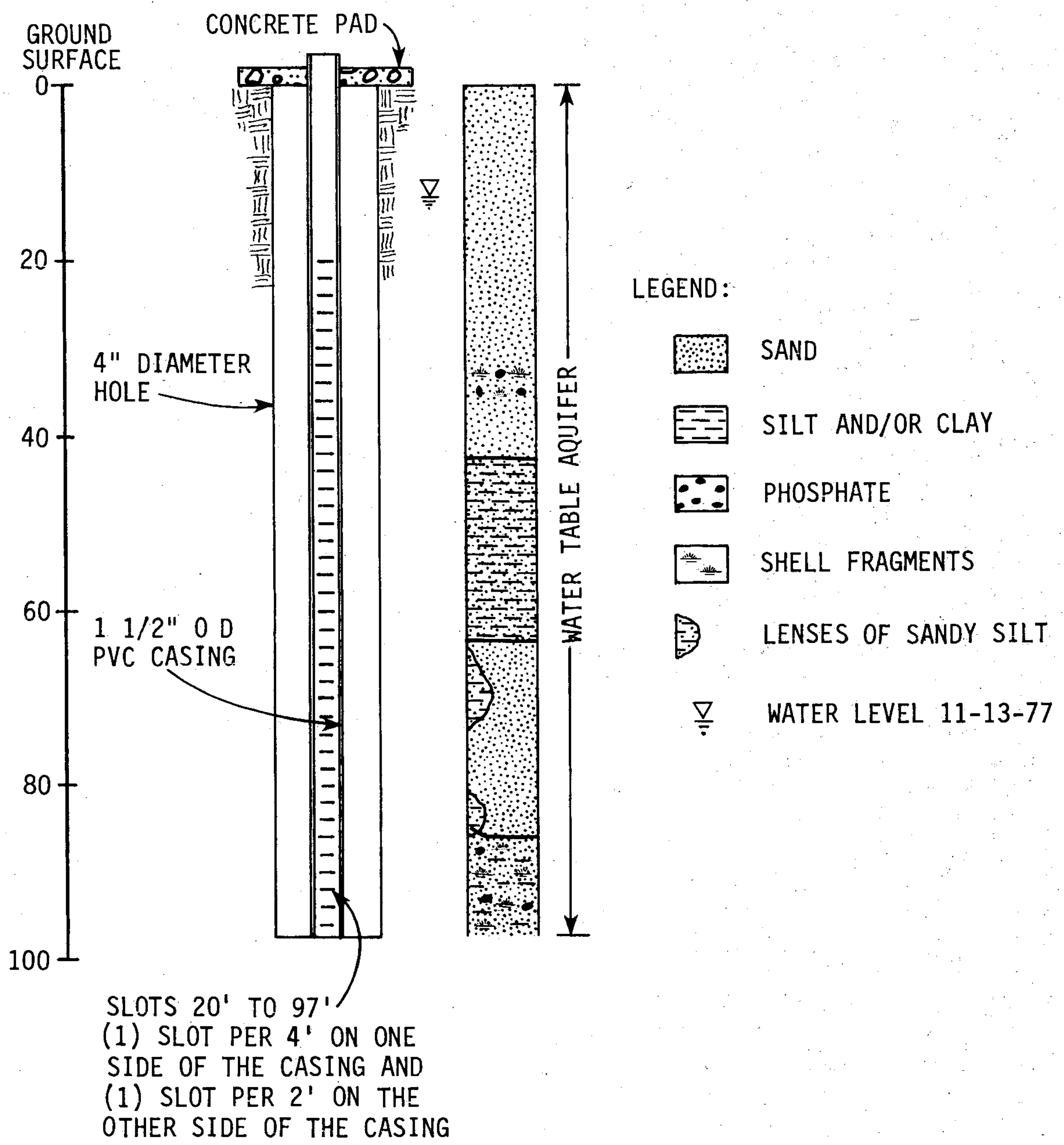


Figure D-2. Monitor Well No. 1 Surface Elevation (Approx.) +79' MSL.

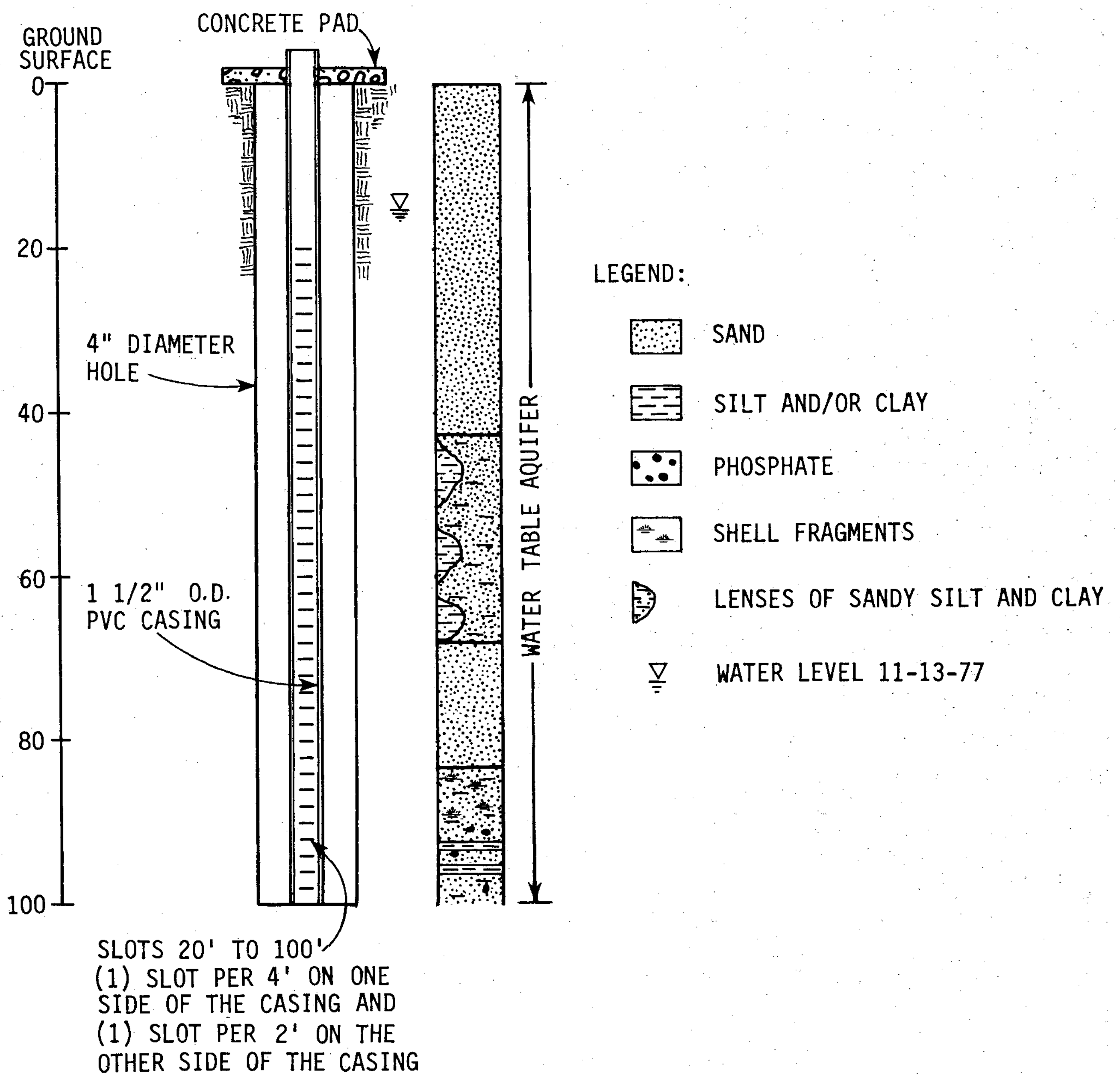


Figure D-3. Monitor Well No. 3 Surface Elevation (Approx.) +75' MSL.

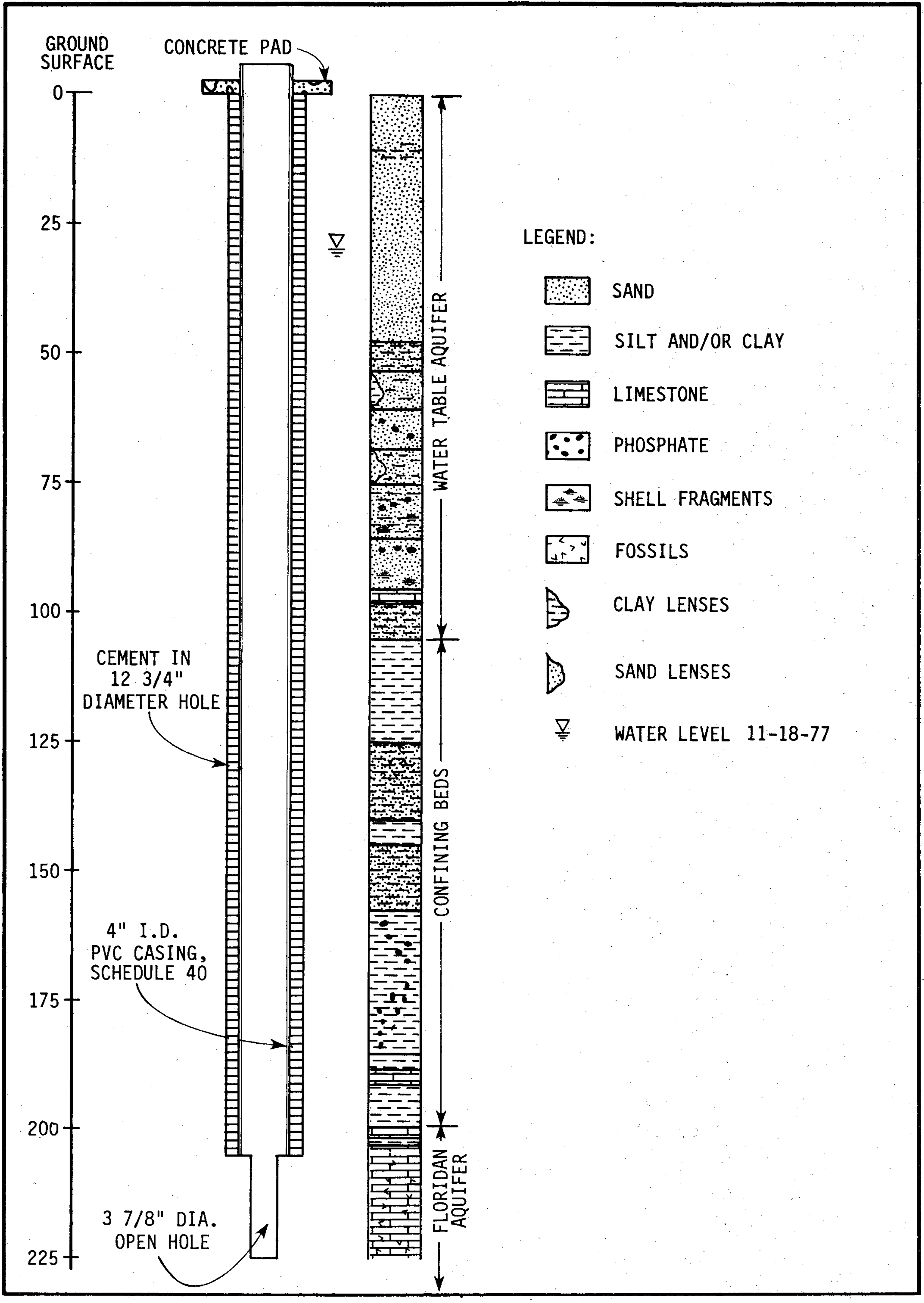


Figure D-4. Monitor Well F-1 Surface Elevation (Approx.) +67' MSL.

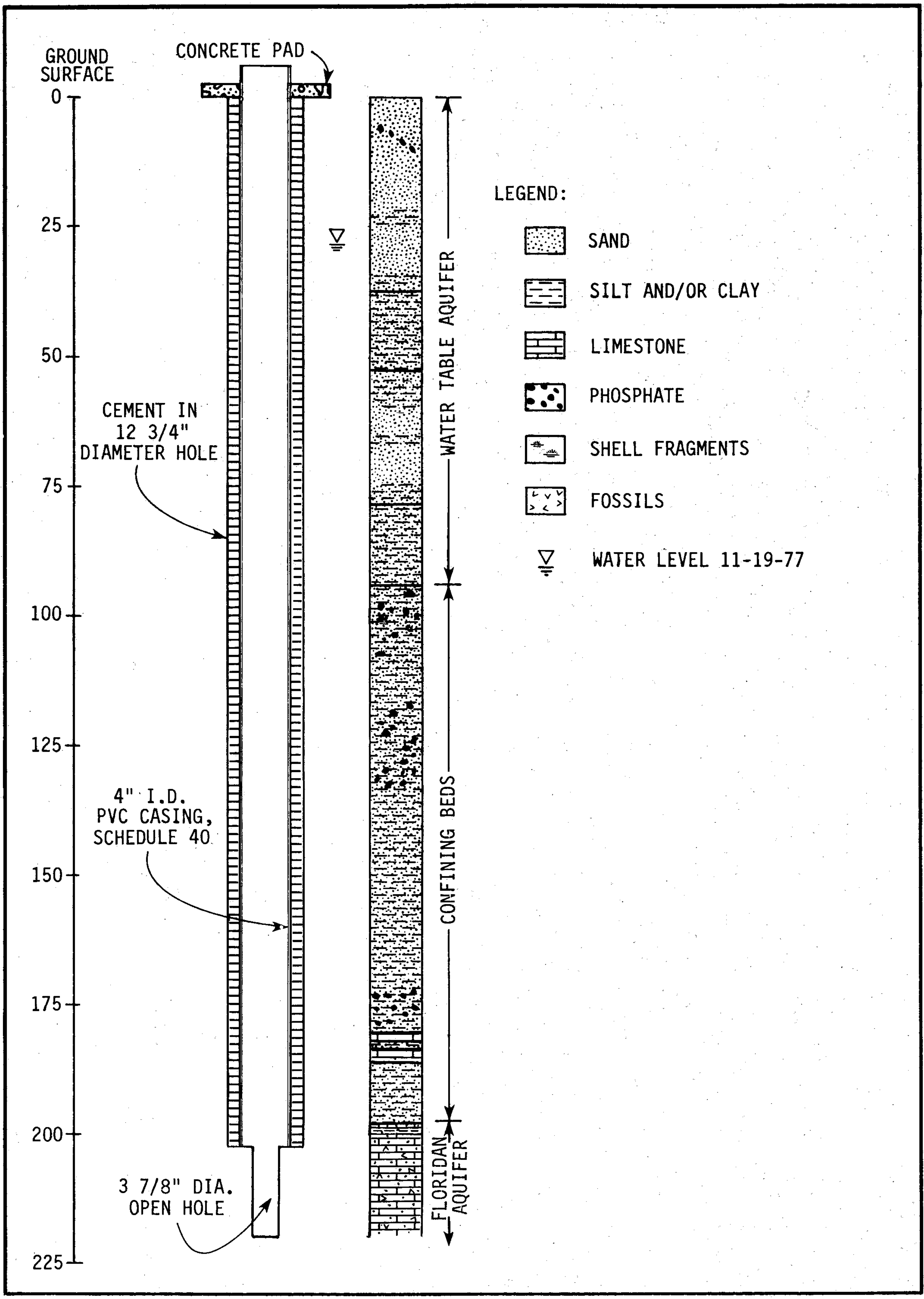


Figure D-5. Monitor Well F-2 Surface Elevation (Approx.) +72' MSL.

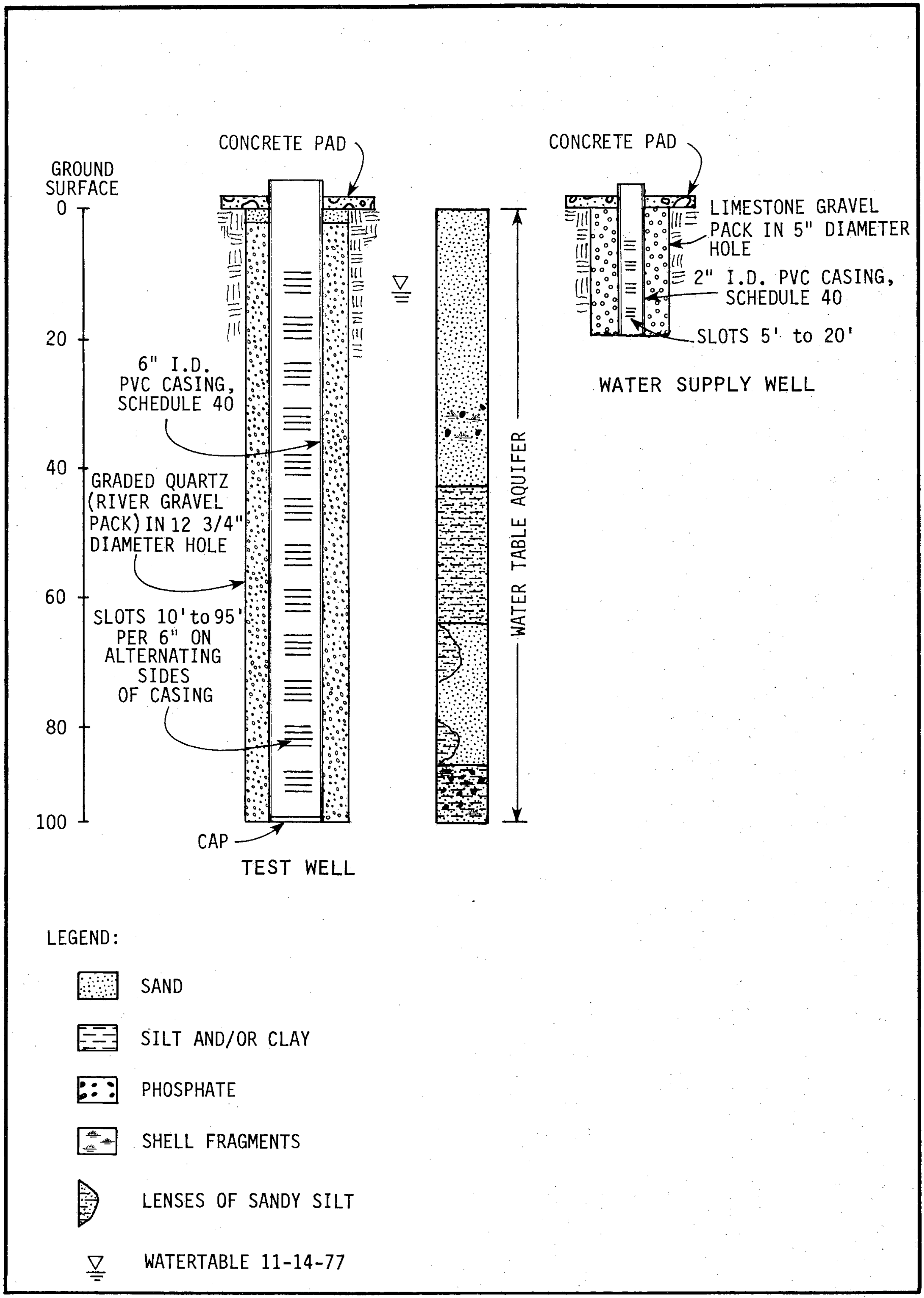
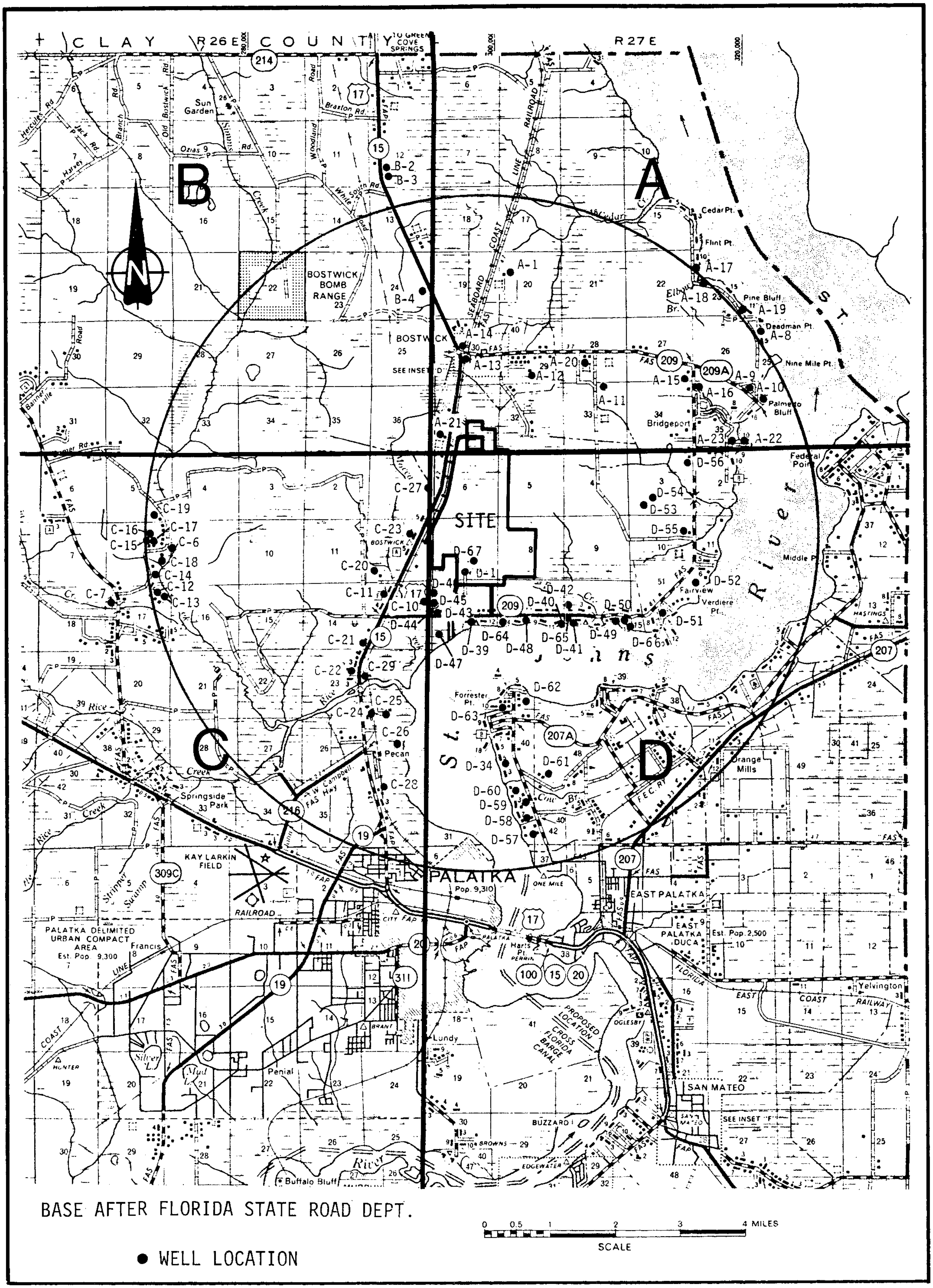


Figure D-6. Test Well (TW) and Water Supply Well (WS-TW) Surface Elevation (Approx.) +80' MSL.



BASE AFTER FLORIDA STATE ROAD DEPT.

● WELL LOCATION

Figure D-7. Location Map Dames & Moore Field Inventory.

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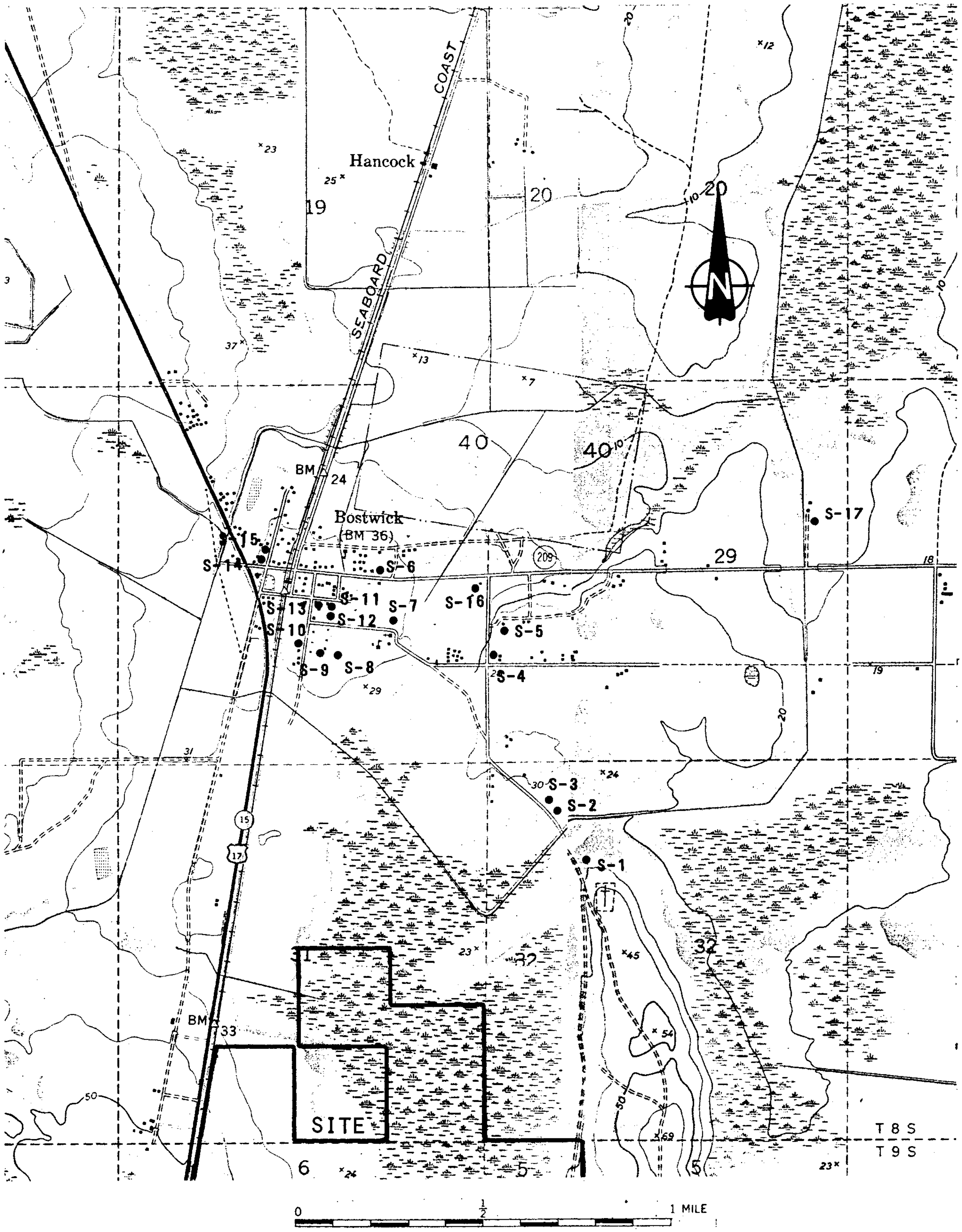

Figure D-8. Location of Water Table Aquifer Wells at Bostwick.

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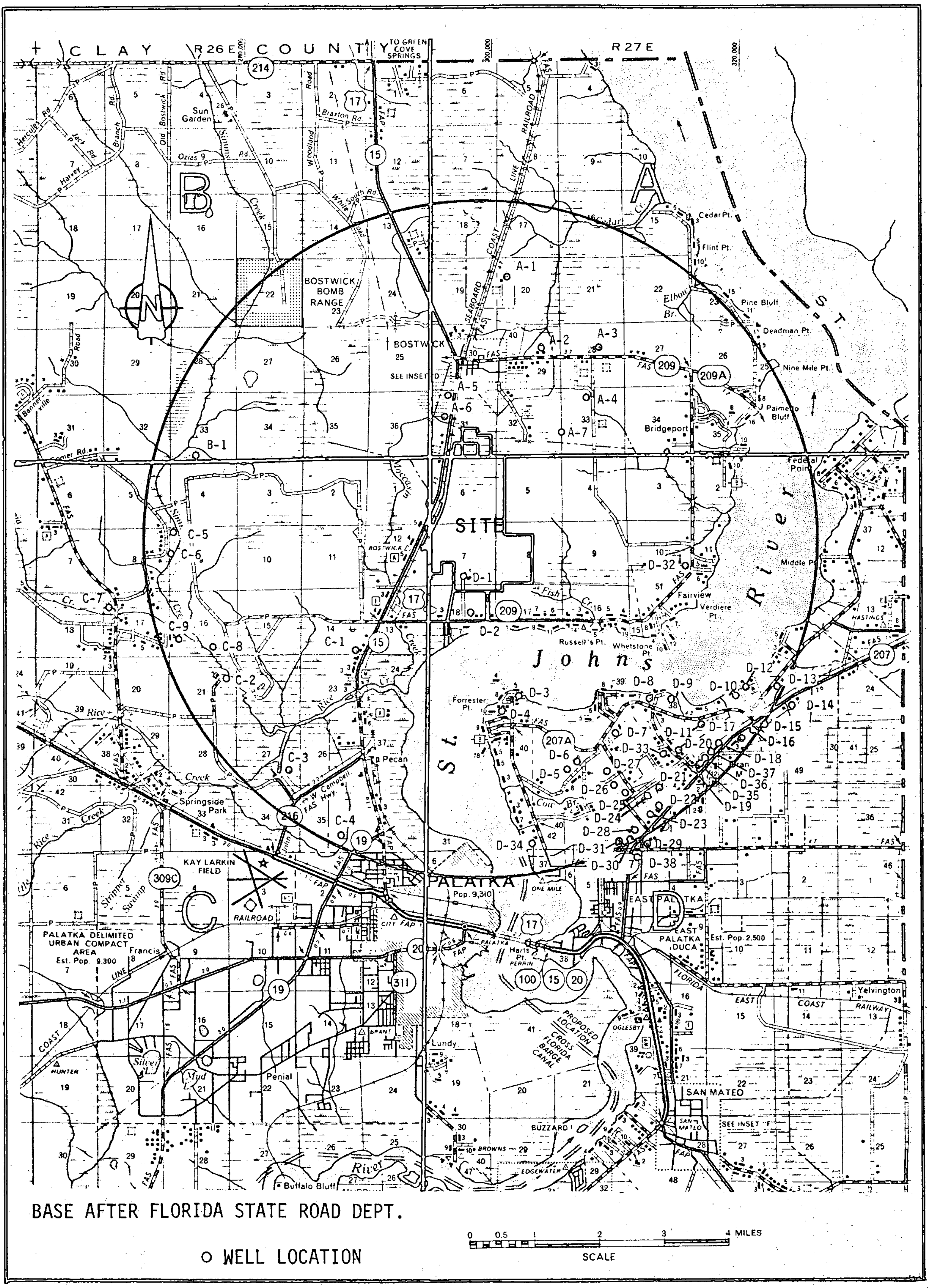

Figure D-9. Location Map USGS Inventory.

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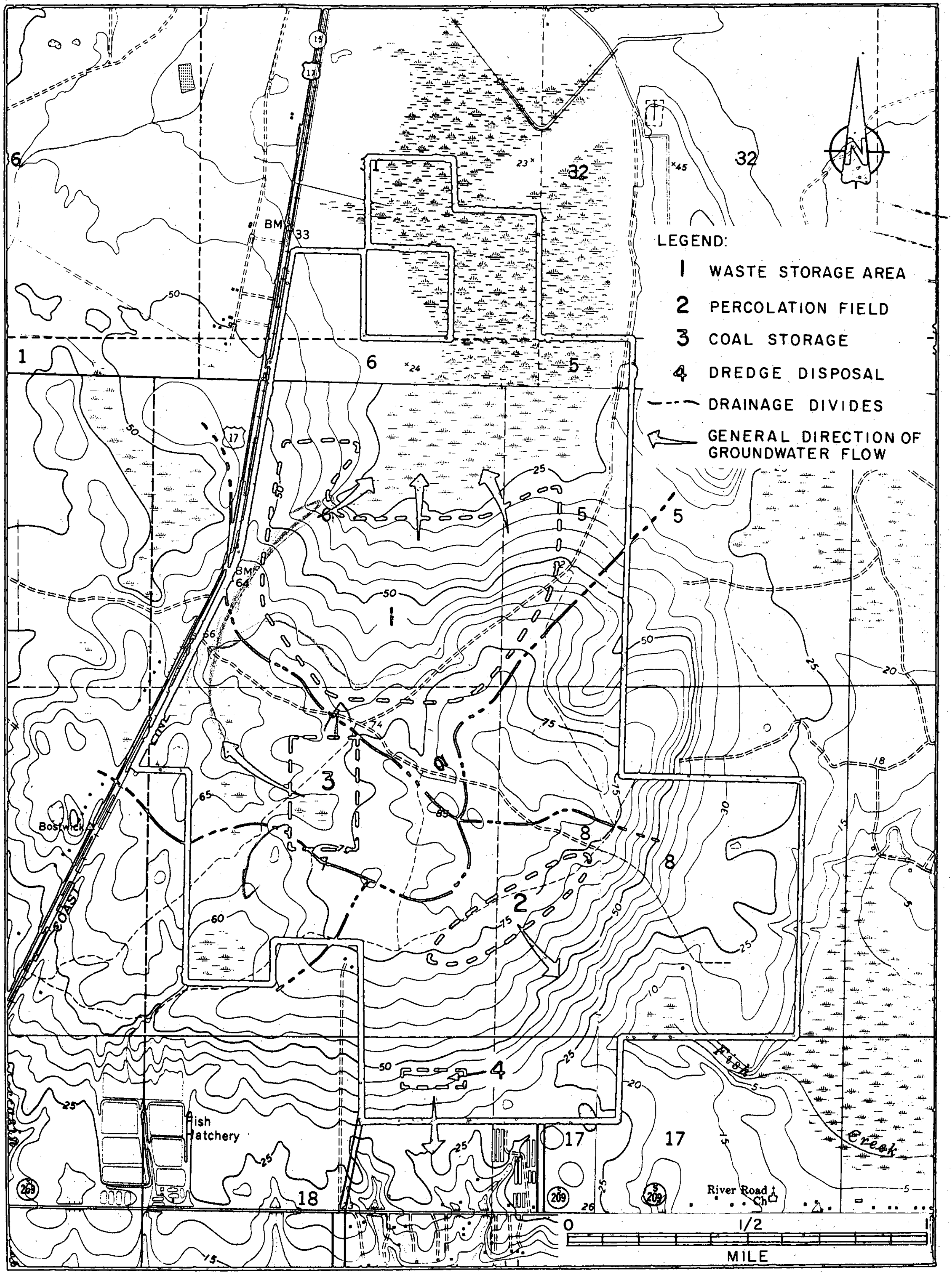

Figure D-10. Generalized Directions of Groundwater Flow with Respect to Disposal and Storage Areas.

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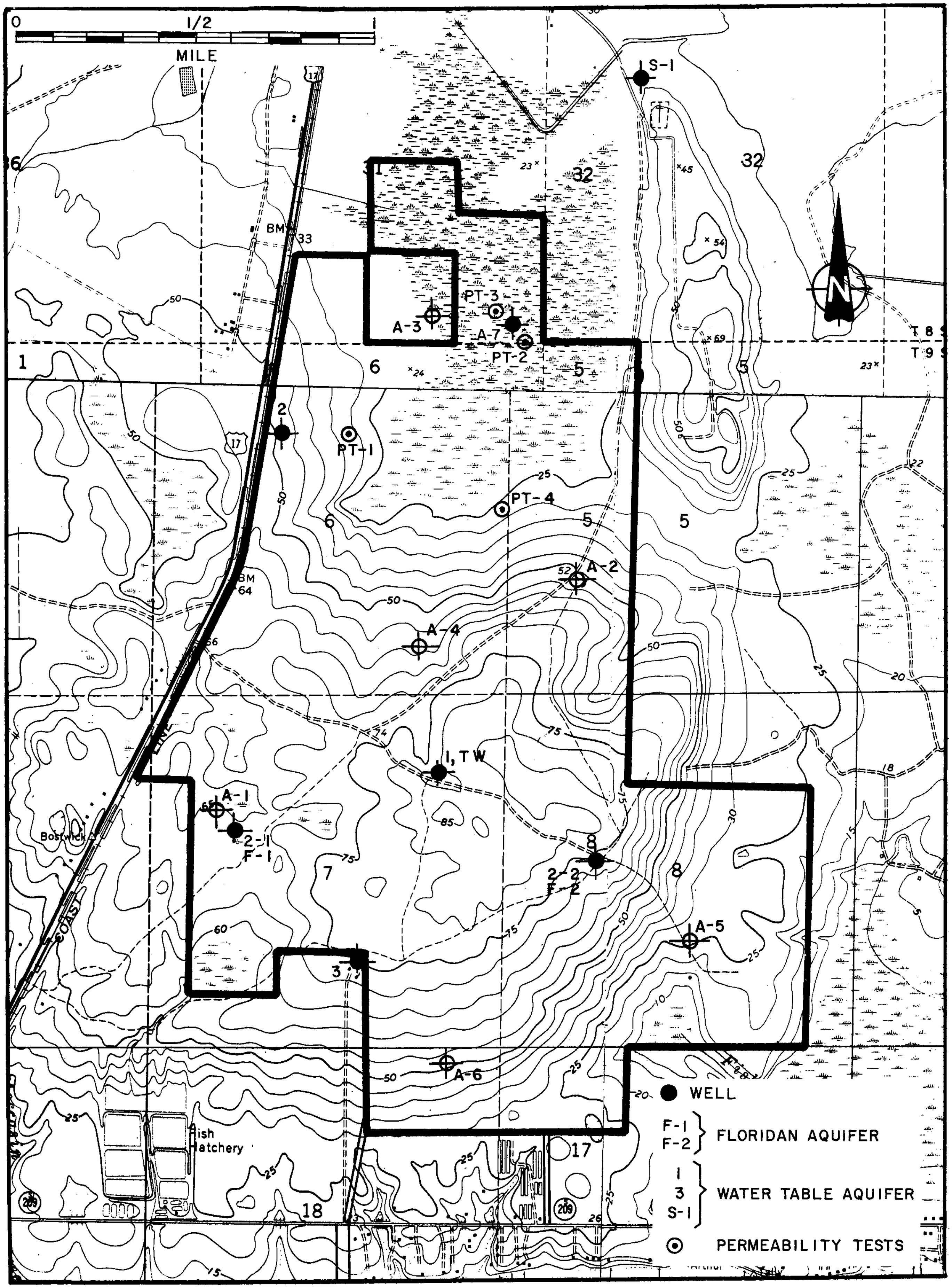

Figure D-11. Boring Location Map.

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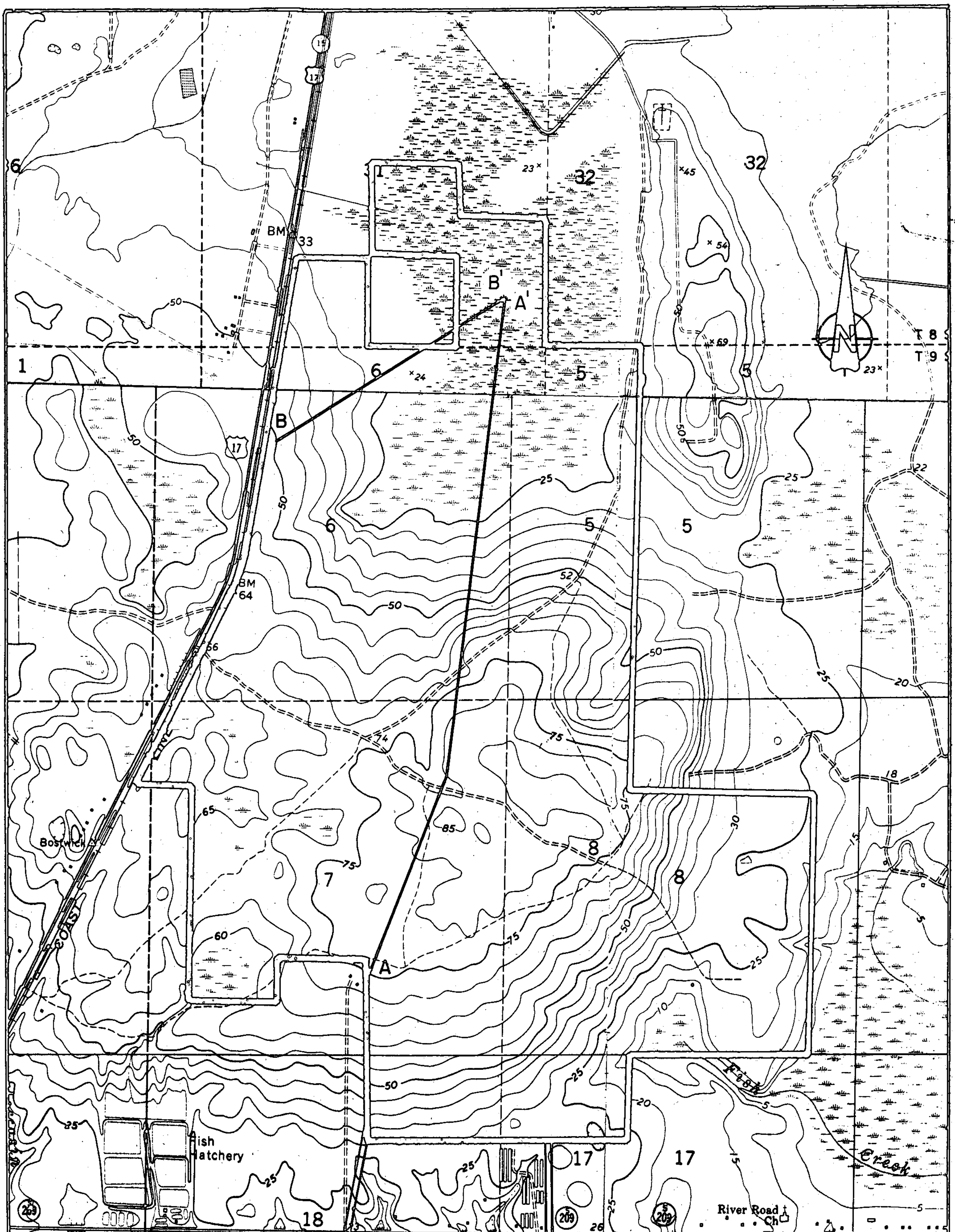

Figure D-12. Cross Section Locations.

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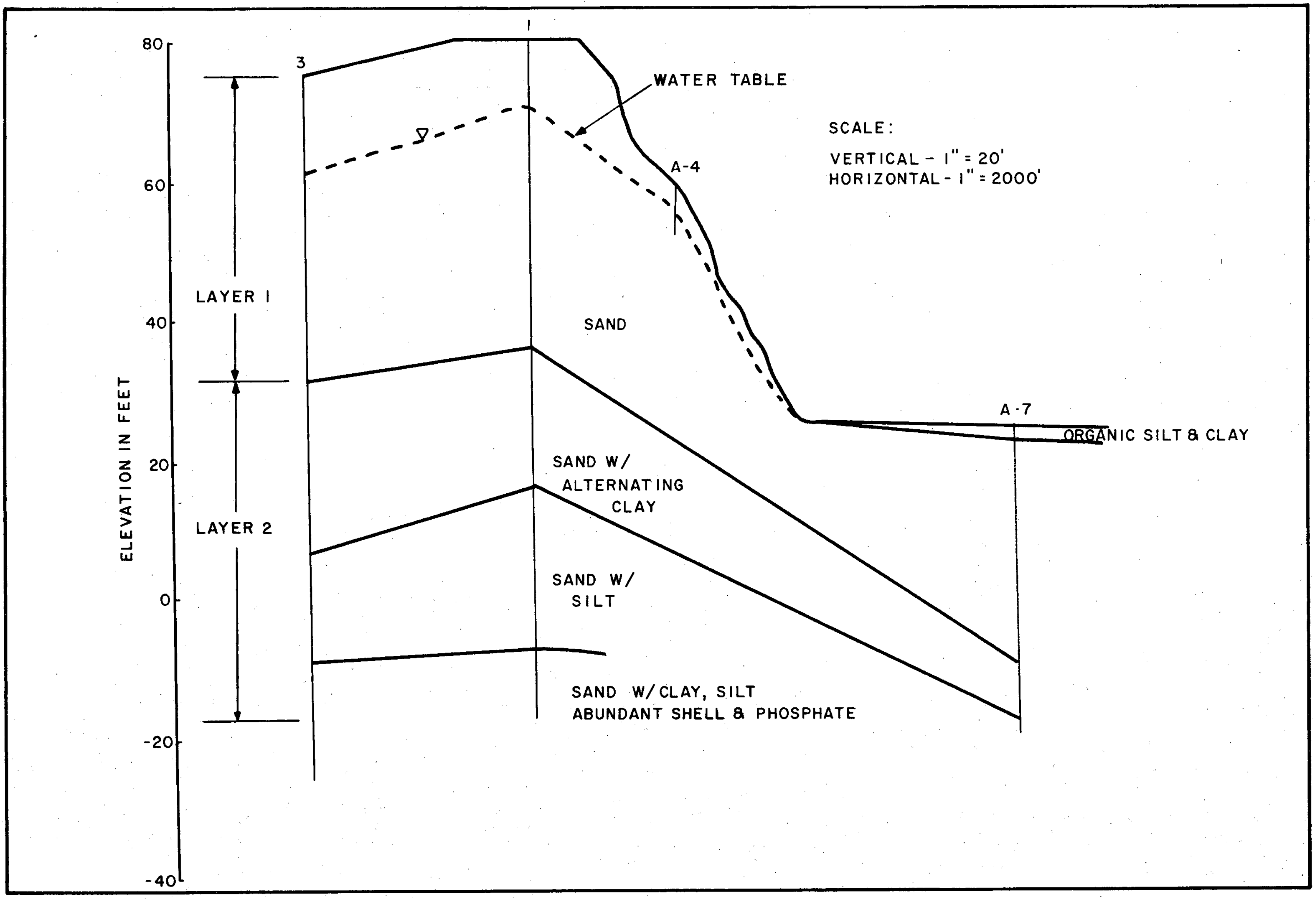


Figure D-13. Cross Section A-A'.

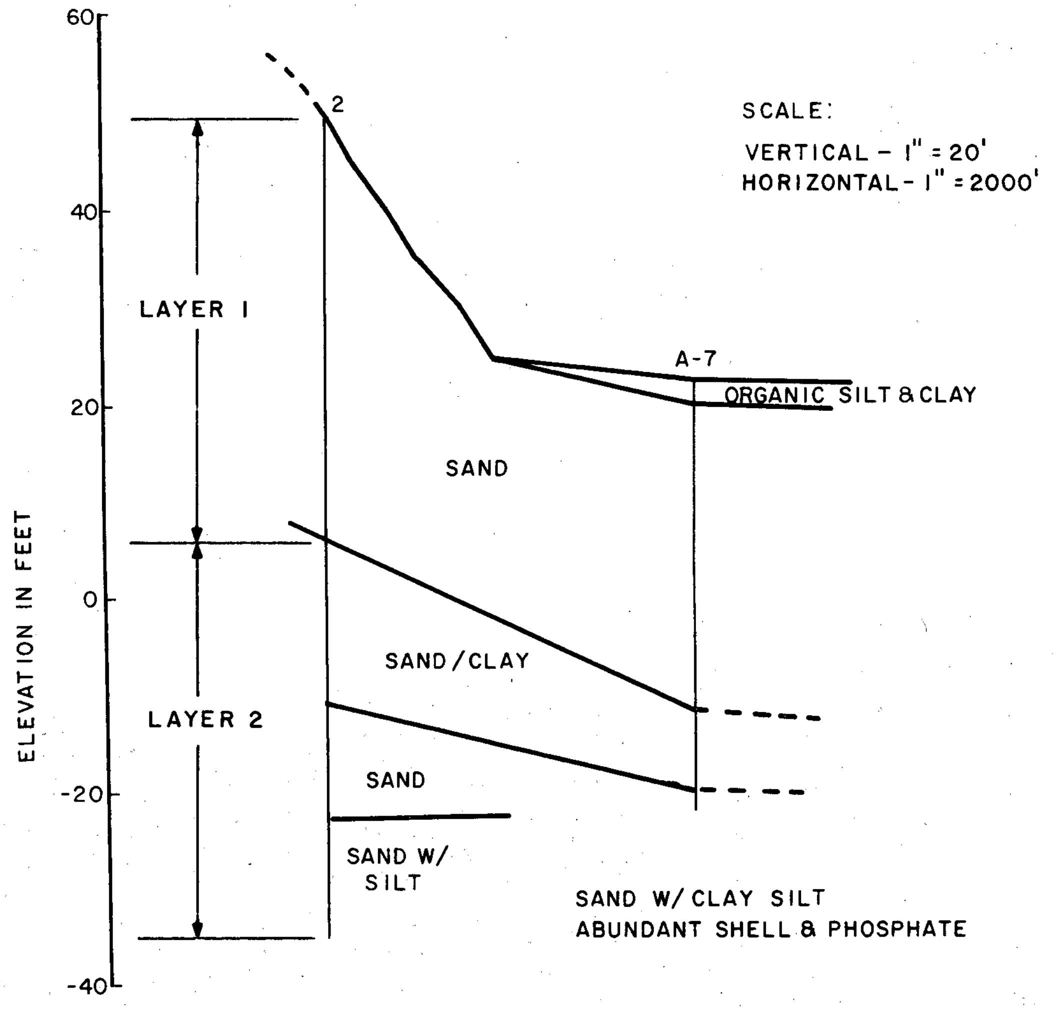


Figure D-14. Cross Section B-B'.

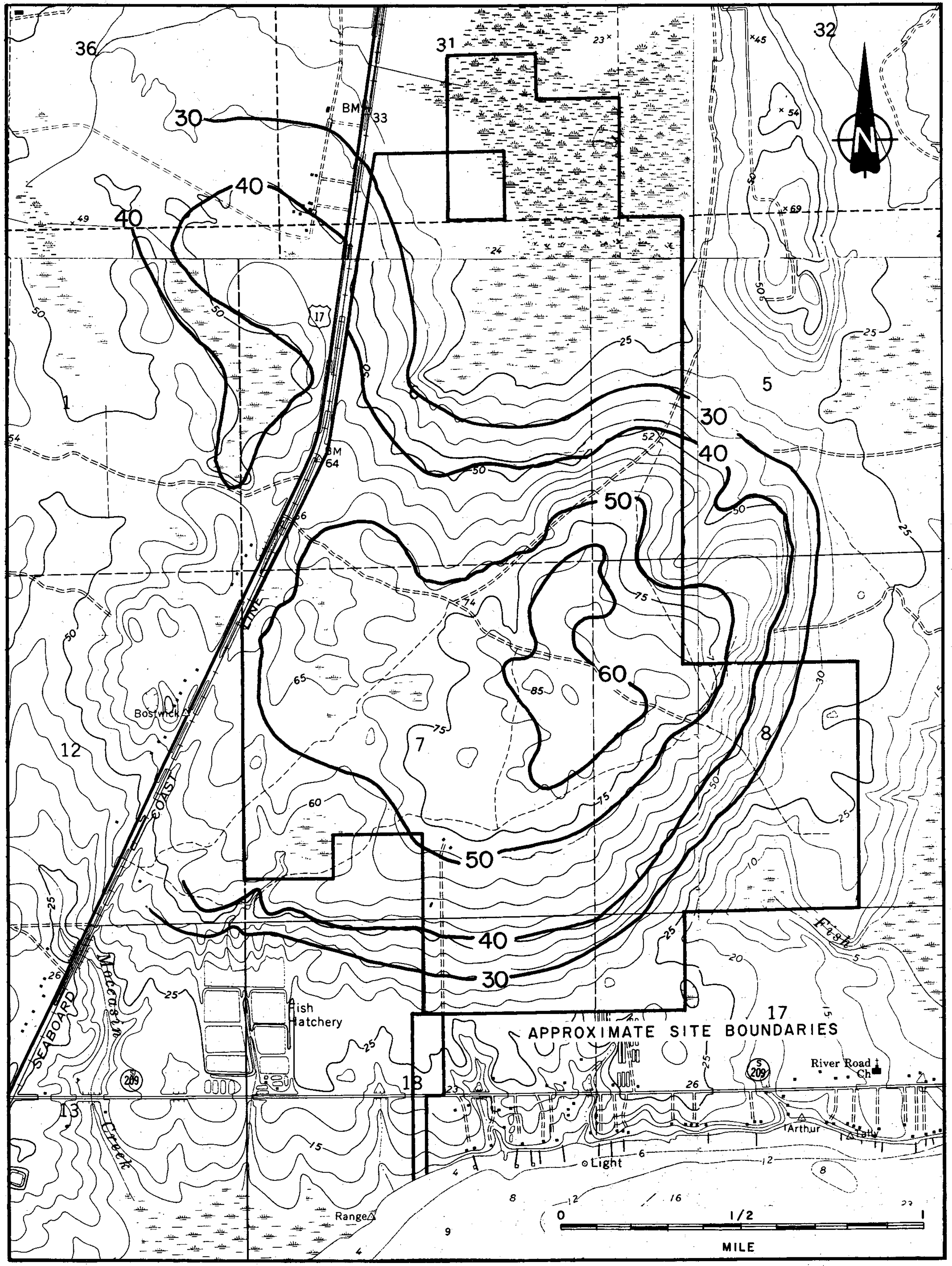
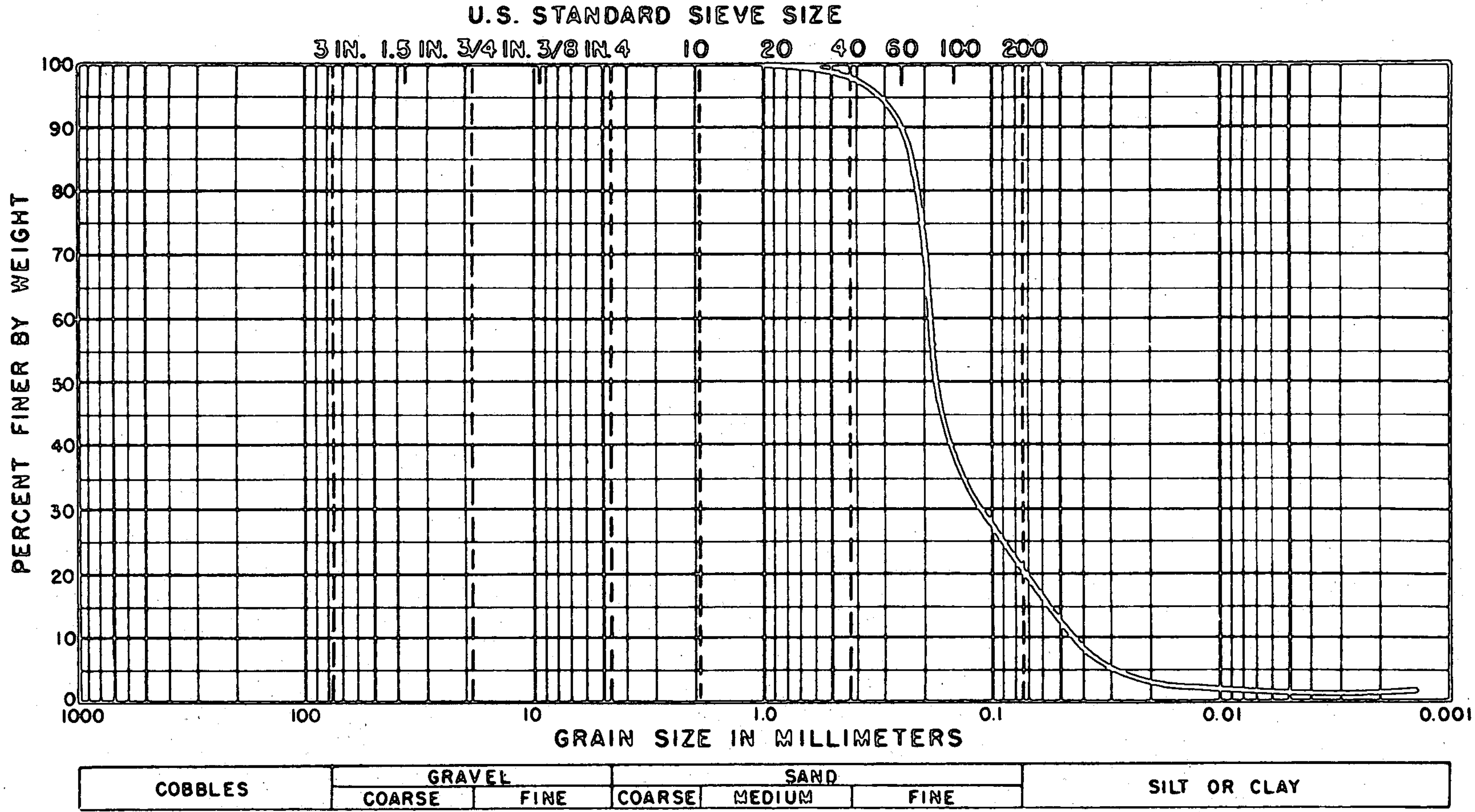


Figure D-15. Site Water Level Contour Map-Low Water Table Conditions.



	DEPTH	CLASSIFICATION	NAT. WC	LL	PL	PI	

Figure D-16. Gradation Curve, Organic Layer.

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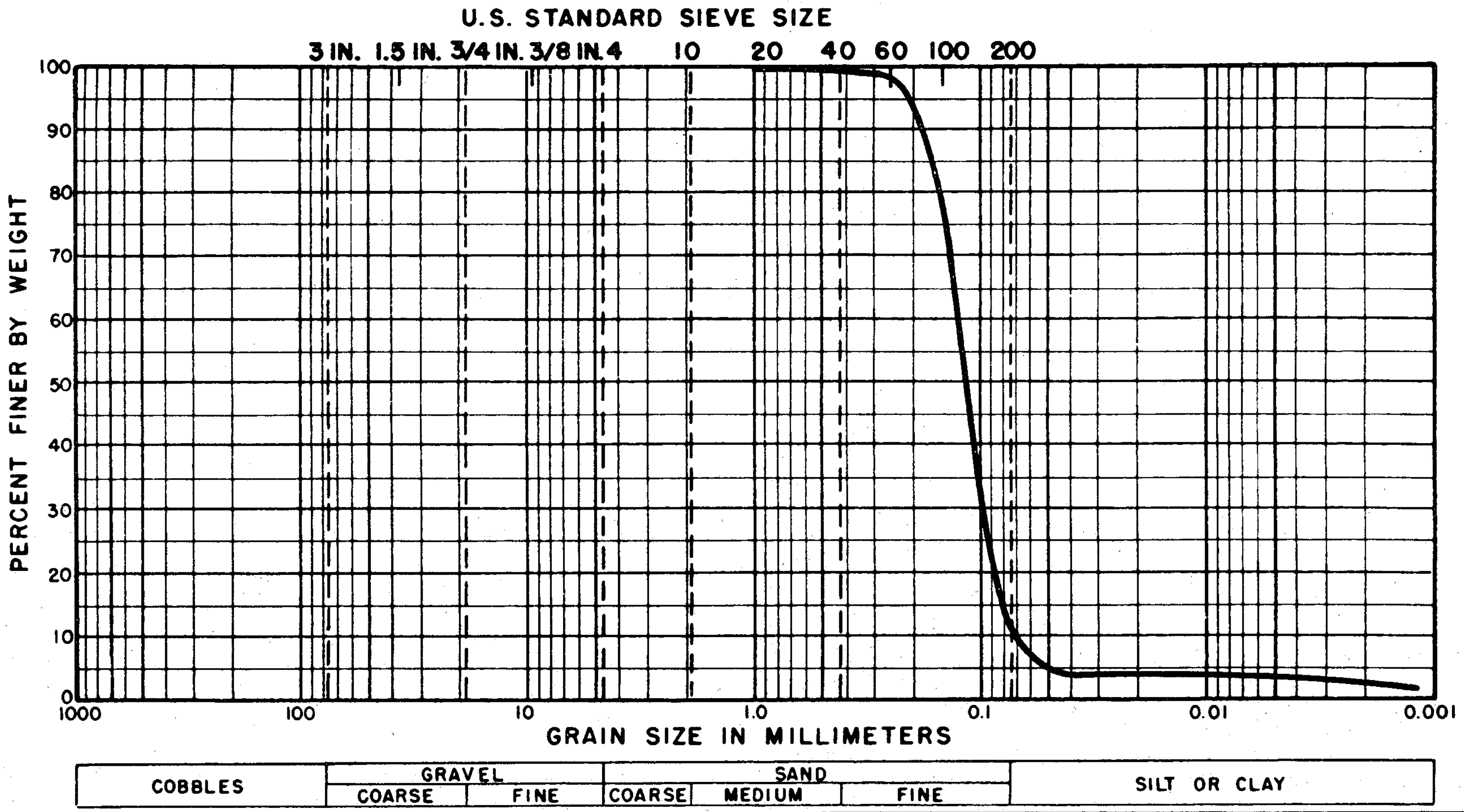

	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	

Figure D-17. Gradation Curve, Layer 1.

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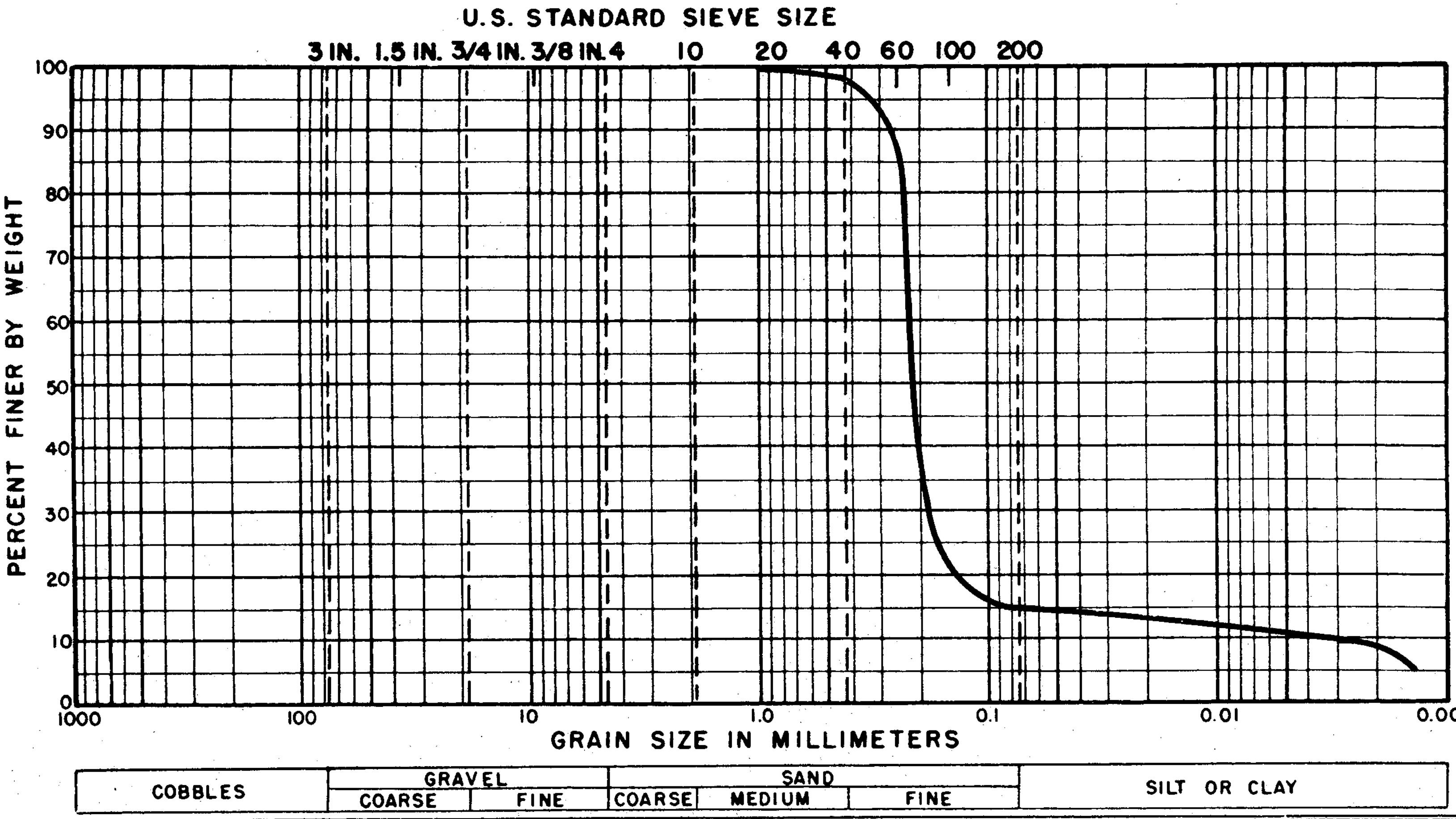

	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	

Figure D-18. Gradation Curve, Layer 2.

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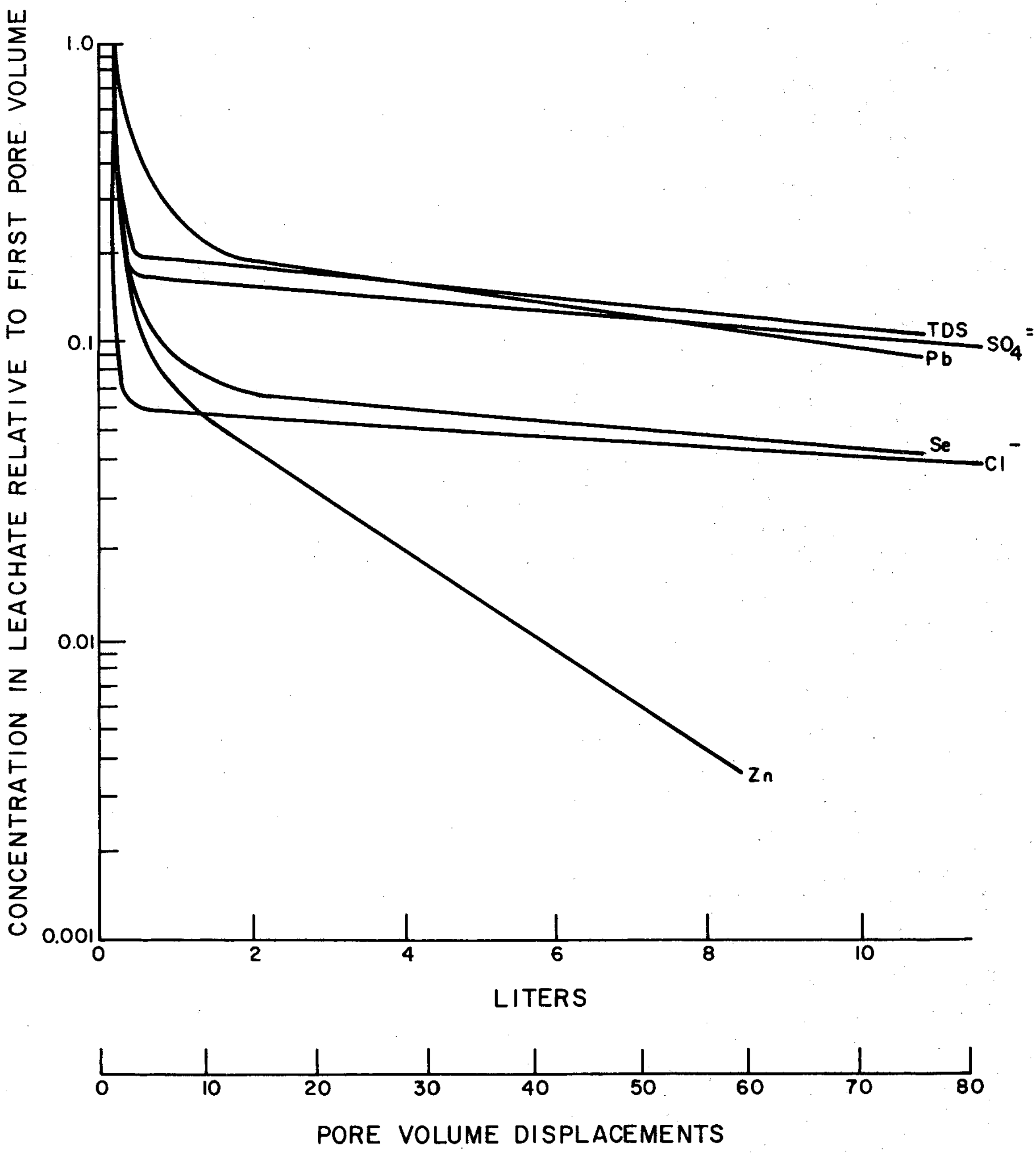
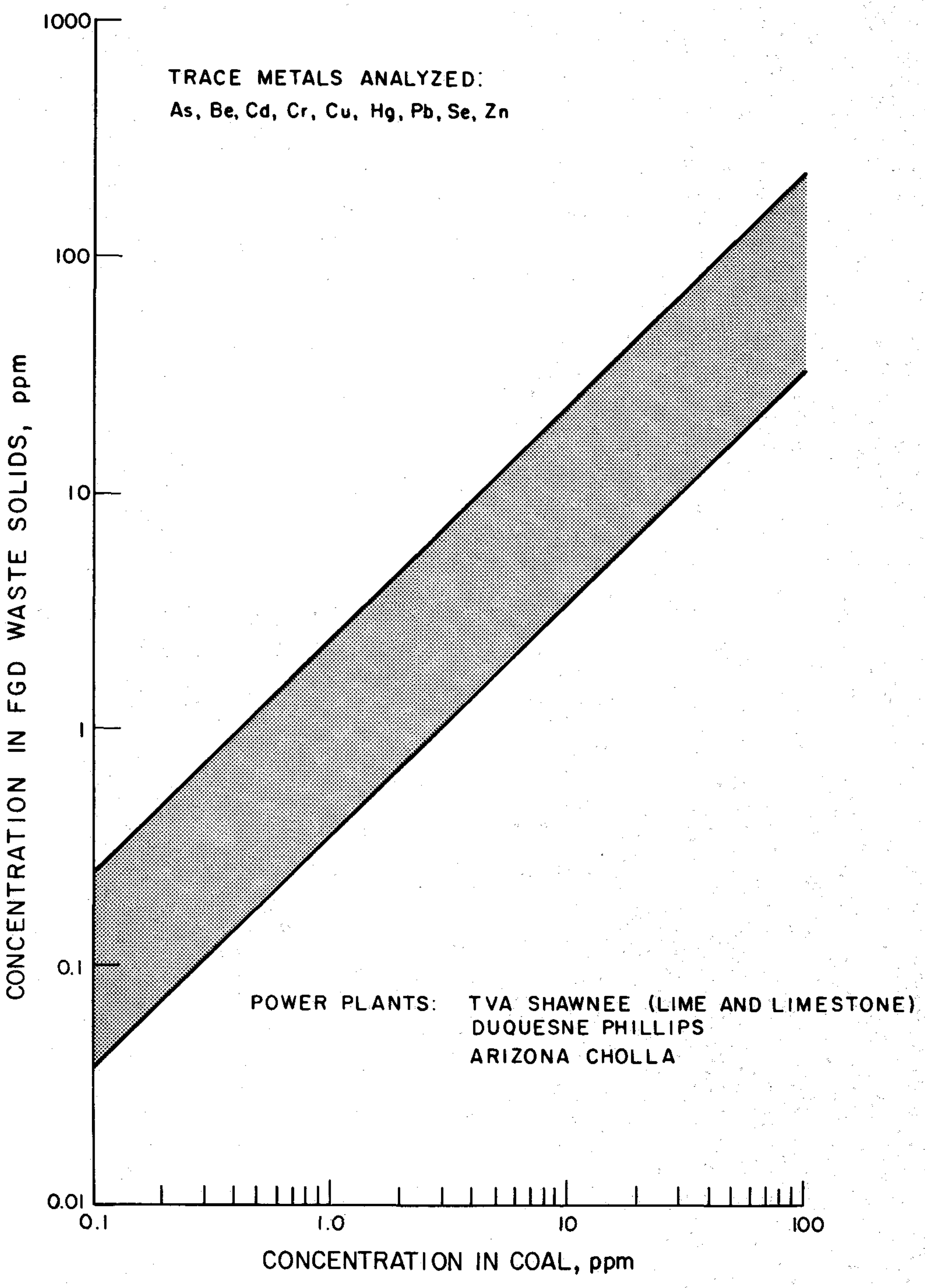


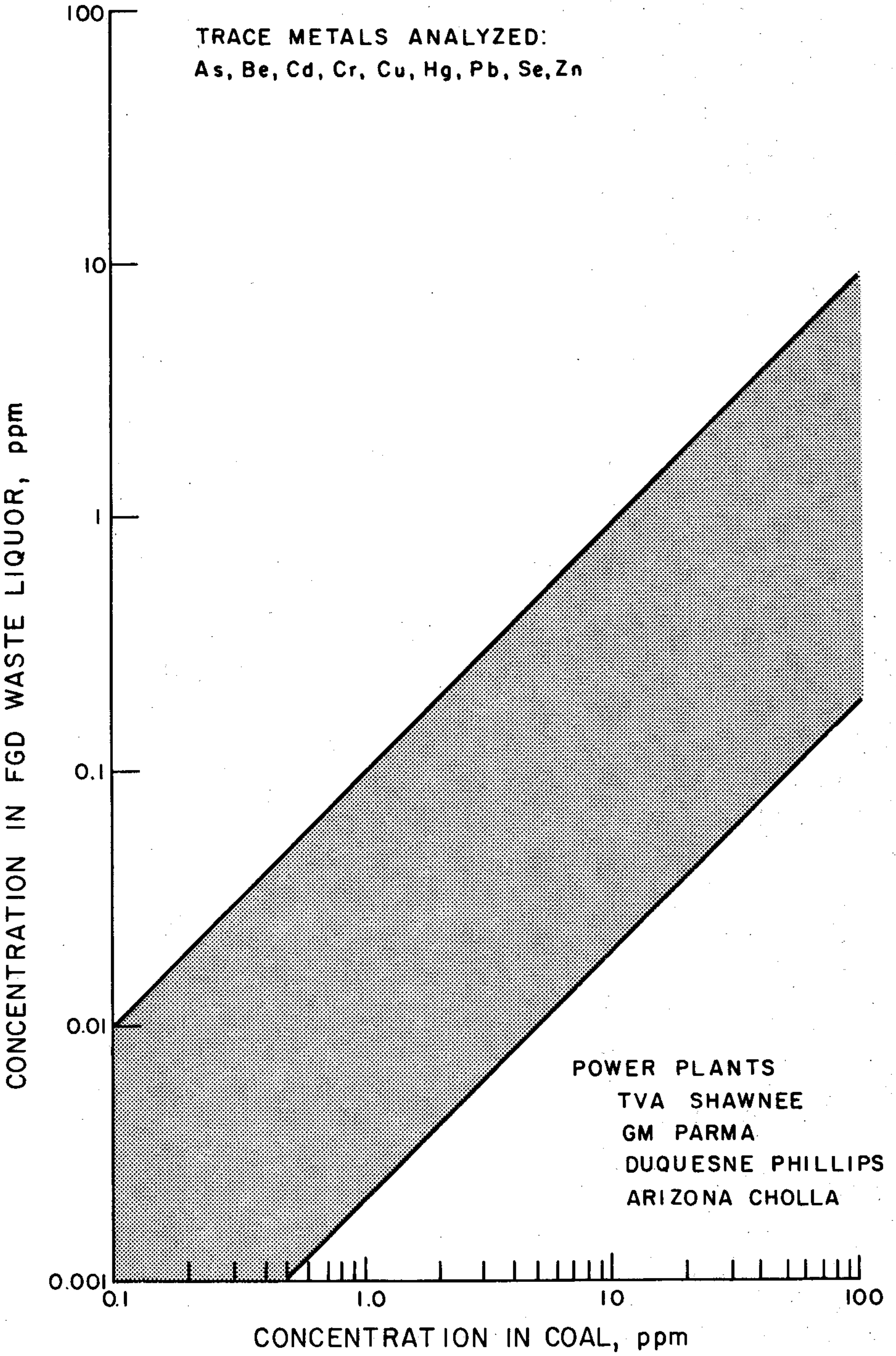
Source: Aerospace Corp., 1976

Figure D-19. Leachate Analyses from TVA Shawnee Untreated Limestone Waste: Anaerobic Conditions.



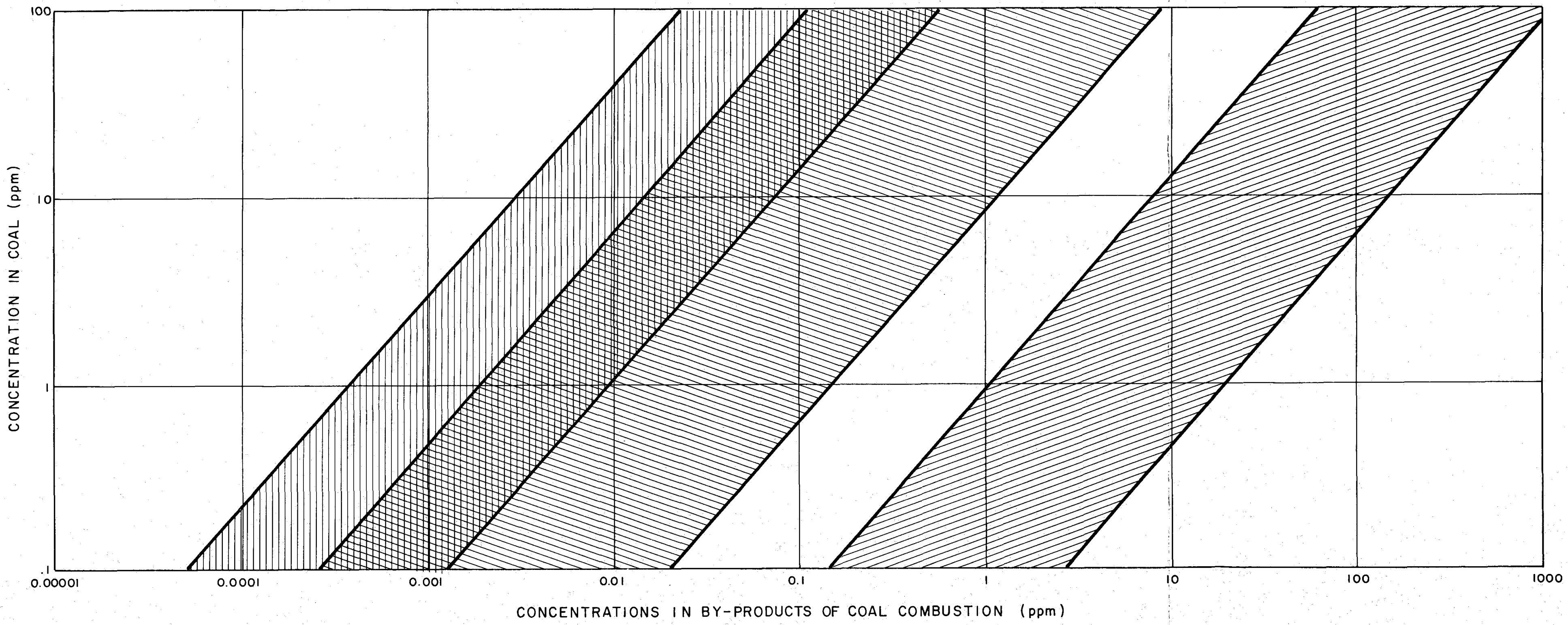
Reference: Aerospace Corporation, 1976

Figure D-20. Relationship Between Trace Metal Content in Coal and FGD Waste Solids.



Reference: Aerospace Corporation, 1976

Figure D-21. Relationship Between Trace Metal Content in Coal and FGD Waste Liquors.



SOURCE: HOLLAND & OTHERS, 1975

LEGEND:

- ▨ FLY ASH, BOTTOM ASH, LIME/LIMESTONE SCRUBBER SLUDGE
- ▧ LIME/LIMESTONE SCRUBBER LIQUOR
- ▥ DISPOSAL POND LIQUOR (4 ASH PONDS, 1 MIXED FLY ASH/ SCRUBBER SLUDGE POND)

NOTES:

1. DISPOSAL POND LIQUOR CONCENTRATIONS ADJUSTED FOR RAW WATER QUALITY.
2. DATA BANDWIDTH DRAWN TO INCLUDE ~90% OF DATA POINTS.

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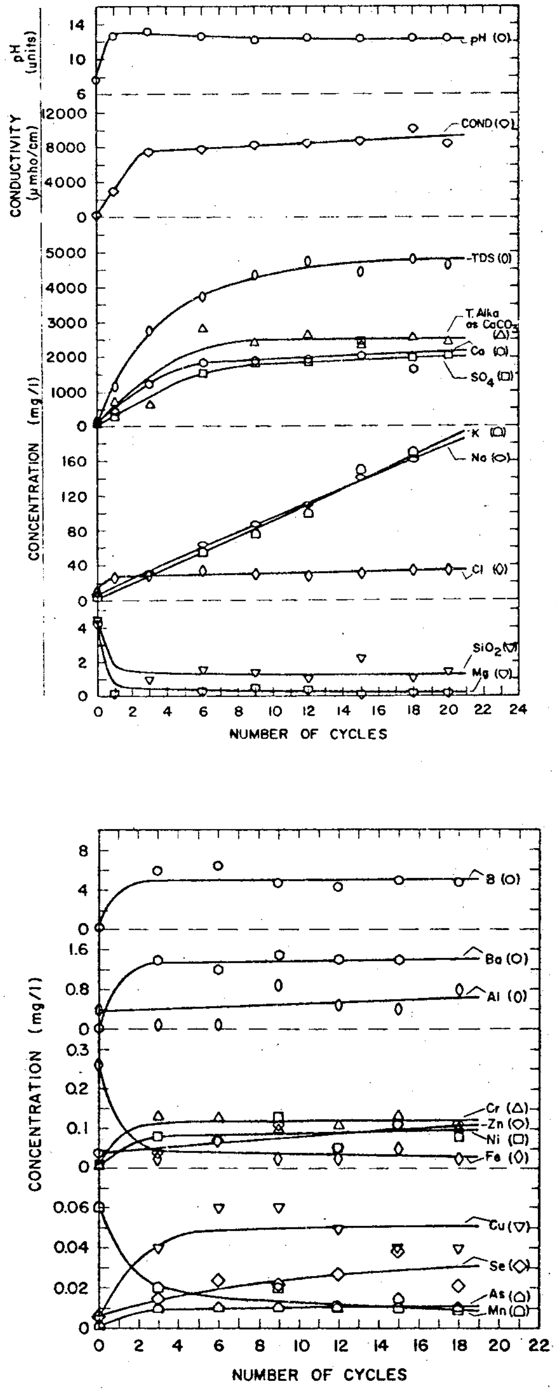
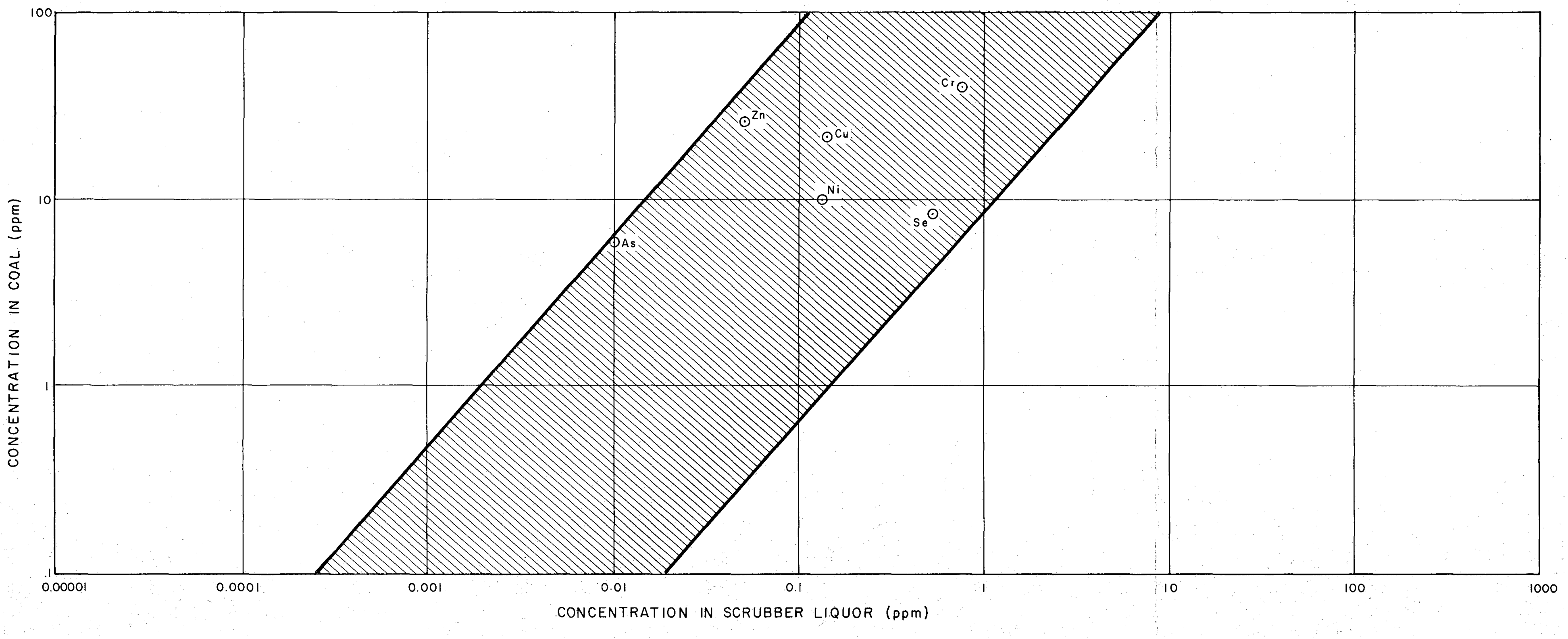
Figure D-22. Relationship Between Trace Metal Concentrations in Coal and Combustion By-Products (Southern California Power Plants).



Source: Chu, Ruane and Krenkel, 1978

Figure D-23. Major Leaching Componenets after Repeated Cycles of Contact with Fresh Alkaline Fly Ash from Plant E (TVA).



LEGEND:

⊙ CONCENTRATION OF TRACE METAL BASED UPON CONCENTRATIONS IN SECI COAL AND CALCULATED PERCENTAGES FROM TVA LEACHATE TEST

▨ LIME/LIMESTONE SCRUBBER LIQUOR (BASED UPON SOUTHERN CALIFORNIA POWER PLANTS; SEE FIGURE D-22).

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Figure D-24. Relationship Between Trace Metal Concentrations in SECI Coal and Calculated Trace Metal Concentrations in FGD Sludge Liquor.

GEOLOGY/SOILS

APPENDIX E

TABLE OF CONTENTS

APPENDIX E

GEOLOGY/SOILS

LIST OF FIGURES

The scope of the second, or more detailed phase of investigation included a detailed literature review, two onsite borings sampled to depths on the order of 200 feet below existing grade (into Eocene limestones), laboratory tests on representative samples, and a detailed analysis of the engineering nature of subsurface materials. The analysis addressed (1) the relative suitability of subsurface conditions for the proposed facilities; (2) potential foundation problems; and (3) identification of mitigating measures to either reduce environmental impacts, or improve, from a geotechnical stanpoint, the design layout of major plant facilities.

The findings of geologic, soils, and geotechnical conditions are described in Sections 2.2.3 and 2.2.7 and in Appendix E.

2.2.3 Physiography

General

White (1970) has divided the state of Florida into three broad physiographic zones (Figure 2.2-1).

- The Northern or Proximal zone, typified by continuous high ground forming a broad upland between the Gulf Coastal lowlands and the Eastern Valley and extending into the Western highlands of Florida.
- The Central or Mid-Peninsular zone, characterized by discontinuous highlands in the form of subparallel ridges separated by broad valleys.
- The Southern or Distal zone, distinguished by a broad, flat, gently sloping and poorly drained plain bounded on the east by the Atlantic Ridge.

The line separating the Northern and Central zones passes roughly through St. Augustine, Palatka, Hawthorne and Gainesville. The site lies within the Northern, or Proximal zone.

Figure 2.2-2, which illustrates the physiographic features of northeastern Florida in greater detail, shows the proposed steam-electric generating station site at the extreme southeastern extension of the Duval upland. The site property includes Teasdale Hill, which rises in elevation to approximately +85 feet Mean Sea Level (MSL).

The physiography of the region immediately surrounding the site is dominated by the St. Johns River and a series of marine terraces, seven of which are documented in the literature. Figure 2.2-3 shows the Penholoway, Wicomico, Sunderland and Coharie terraces forming the uplands of western Putnam County. This high area ranges in altitude from approximately 42 feet to 170 feet MSL, but for the most part lies between 70 and 170 feet MSL. These uplands are characterized by rolling, well drained hills, and sinkholes partially filled with water to form lakes. Sinkhole topography does not persist eastward and is not evident in the vicinity of the site.

The Penholoway Terraces make up most of the high ground of the site property, a substantial portion of which is at an elevation of +50 feet MSL. Teasdale Hill, however, is a remnant of the higher Wicomico Terrace (70 to 100 feet MSL) while the northern extension of the property falls off to the low-lying, less well drained Pamlico Terrace (10 to 25 feet MSL).

East of the river, in St. Johns County, the ground is lower showing a broad section of the Pamlico Terrace. This is incised opposite the site by a lower terrace which, although shown on Figure 2.2-3 as the Silver Bluff Terrace, is probably not a true marine terrace, but rather a river terrace formed when the river was at a higher elevation.

East of the river valley, elevations rise to the Talbot Terrace then fall off again towards the coast.

Genesis and Evolution of Landforms

Although the Florida peninsula has existed as part of the more extensive Florida Plateau since the early Cretaceous, its earlier land surfaces were modified by a series of major events including, in the Tertiary, a number of sea level changes responding to alternate advances and retreats of the ice sheets. The result of this activity is that the present landscape is a relatively recent one.

The series of terraces mentioned above and delineated in Figure 2.2-3 evolved as a result of Quaternary sea level changes (Bermes and others, 1963). Terraces formed when the sea was relatively stationary for long periods and the sea floor was eroded to a fairly flat surface. At the end of the stationary period when the sea level fell, the one-time sea bed emerged as a terrace. In this evolutionary process the landward edge of the terrace became an abandoned shoreline which, as subsequent terraces emerged during a sea level decline, could be recognized by a low scarp.

It is widely believed (Cook, 1945; White, 1958) that in the vicinity of the site each successively lower terrace is younger than the one above it. This would apply to seven terraces shown in Figure 2.2-3 for the tri-county area of Putnam, St. Johns and Flagler. These are seven of a total of eight marine terraces originally recognized by Cook (1945) in the State of Florida.

The St. Johns River merits attention both because it is a major feature and because of its proximity to the site. This river, some 200 miles in length, and the longest in Florida, has its headwaters in St. Johns Marsh some 20 miles west of Vero Beach. From here the river flows approximately north-northeasterly along a lake chain until just south of Deland Ridge (Figure 2.2-2) where it leaves the eastern valley, flows a short distance westward and then parallels the coastline again in what is known as the St. Johns River Offset. It enters the eastern valley again just south of Palatka and from there to its mouth at Mayport exists as a broad, winding estuary.

White (1970) presents strong evidence to support the fact that the multiple lakes along the St. Johns are relicts of a former estuary. These lakes are not likely to be solution related depressions formed in the limestone after the deposition of the flood plain, because they differ from the inland, typically karst, lakes in their shape, grouping, and orientation in relation to drainage.

2.2.4 Stratigraphy

General

This discussion places emphasis on Eocene and younger rocks, since these represent the limit of formations penetrated by water wells in the vicinity of the proposed power plant and are thus the best indicators of environmental sensitivity. A discussion of pre-Eocene rocks is confined to a general description of major time stratigraphic units.

A regional geologic map is presented in Figure 2.2-4, while Figure 2.2-5 shows a generalized stratigraphic cross-section of the upper formations. Table 2.2-1 summarizes the geologic and hydrogeologic characteristics of these same stratigraphic units.

In very broad terms, the cover of Mesozoic and Cenozoic sedimentary formations that overlies the Paleozoic basement of Florida varies from approximately 2,500 feet in north central Florida to some 15,000 feet in southern Florida.

Figure 2.2-6, showing the altitude of the top of the first intersected limestone of Eocene age, indicates that in western Putnam County the limestone (Floridan Aquifer) shows surface outcrop. As may be expected this area is characterized by sinkhole topography which diminishes and disappears as the limestones dip beneath the confining Hawthorn Formation eastwards. At the site the limestone is found at a depth of about 200 feet below surface.

Paleozoic Rocks

The Paleozoic Rocks consist of both crystalline and sedimentary rocks. The Applin Line (Applin, 1951) constitutes the contact between the unmetamorphosed sedimentary rocks to the northwest of the line and the crystalline rocks to the southeast. Figure 2.2-7 shows the line trending northeasterly just east of the site.

The crystalline rocks range from granites to basalt flows and pyroclastics, while the sediments are mainly unmetamorphosed to very weakly metamorphosed noncalcareous shales and sandstones (Applin & Applin, 1944).

Mesozoic Rocks

The rocks characterizing this era consist, in northern Florida, of mixed clastics and silty to sandy limestones with some sandstones. In southern Florida the formations are comprised of clean limestones and dolomites with some evaporites.

It is interesting to note that no sediments representing the long interval (+150 million years) between the middle Paleozoic and the Triassic have been identified in Florida (Rainwater, 1970) thus suggesting erosion of a highland area during this period. During the Jurassic, however, regional subsidence caused a marine transgression with the subsequent deposition of shallow, shelf-type carbonate rocks.

The Peninsular Arch (Figure 2.2-8) and land to the north were uplifted prior to the end of the Jurassic and large quantities of eroded materials were supplied to depositional basins. Uplift of the Arch intensified during the lower Cretaceous and while terrigenous clastics continued to be deposited on the flanks of the peninsular Arch, the coastal plain and offshore parts of the Gulf Basin continued to subside.

The sea level then began to rise and the upper Cretaceous witnessed a marine transgression over the Peninsular Arch and the deposition of chalk, limestone and dolomite (Rainwater, 1970).

Cenozoic Rocks

The Cenozoic Era is the one most relevant to the geologic framework of the proposed site. In general the Cenozoic strata of Florida consist primarily of shallow-water marine carbonates and evaporites, and indurated to uncemented sands, silts and clays.

Paleocene Rocks

The Paleocene is characterized by both bank-type carbonate sediments and evaporites. The latter were in all probability deposited when a reef formed completely around the edge of the Continental Shelf and restricted seawater exchange with the confined area (Puri and Winston, 1974).

Eocene Rocks

Eocene strata range in depth from an average of approximately 500 feet in northern Florida to more than 300 feet in the extreme southern portion of the state. The series consists mainly of limestones and dolomites with minor amounts of evaporites and carbonaceous material. The limited evaporite deposition during this epoch suggests that the Paleocene barrier reef described above was discontinuous in the Eocene, allowing an open connection with the sea.

The lowest Eocene formation intersected by water wells in the vicinity of the site is the Lake City Limestone, which, according to Applin and Applin (1944), underlies all of peninsular Florida. The characteristics of this and younger formations are summarized in Table 2.2-1. The Lake City Limestone consists of alternating beds of brown to buff, soft, porous, fossiliferous limestone; brown to white, hard, dense, massive limestone and bluish-grey to tan, densely indurated crystalline dolomite (Bermes and others, 1963). The soft, porous beds described above are reported by the same authors to supply water to a few deep wells in the tri-county area: Flagler, Putnam, and St. Johns. The competent, more indurated beds are said to be relatively impermeable, in some areas possibly isolating water-producing zones from the rest of the aquifer.

Wells in Flagler, Putnam, and St. Johns Counties suggest that the contact between the Lake City Limestone and the overlying Avon Park Limestone is unconformable. This formation is described by Vernon and Puri (1964) as being "poorly permeable," but Bermes and others, (1963) consider the Avon Park formation to be similar in lithology to the underlying Lake City Limestone: comprised of alternating beds of differing permeability.

The Avon Park Limestone is unconformably overlain by what is now officially referred to by the Florida Geological Survey as the Ocala Group. It consists of the Inglis, Williston, and Crystal River Formations. All of these, as defined by Puri (1953), are recognized in Flagler, Putnam, and St. Johns Counties; and, although the Crystal River Formation pinches out east of the St. Johns River further south, it was found to underlie the site.

The Ocala Group is significant in that it comprises the principal water bearing formations in the project area. As emphasized in Section 2.3.2, the formations of the Ocala Group are similar in lithology and hydrologic properties (Bermes and others, 1963) and are treated as a single hydrologic unit.

The Inglis, Williston, and Crystal River Formations underlie the site and consist of tan to buff granular, fragmental marine limestone.

<u>Oligocene</u>

A major regional unconformity followed the deposition of Eocene sediments (Vernon, 1951) so that strata of Oligocene age are missing over much of northern and eastern Peninsular Florida (Rainwater, 1970).

<u>Miocene</u>

During the Miocene, parts of Florida emerged for the first time since late Cretaceous times (Rainwater, 1971). This uplift was accompanied by the deposition of terrestrial sediments, but these were subsequently eroded from a major portion of northwestern Florida. Marine transgression then followed; and, in the vicinity of the site, it is the

Hawthorn Formation which lies on the eroded surface of the Ocala Group. Puri (1953) and Vernon (1951) date the Hawthorn as Middle Miocene in age.

The unconformity between the Hawthorn Formation and Formations of the Ocala Group is distinguished by a hard, dense, phosphatic, sandy, dolomitic limestone averaging 5 feet in thickness (Bermes and others, 1963). The same authors described the Hawthorn as a gray to green, plastic, phosphatic, sandy clay and marl; interbedded with lenses of phosphorite, pebbles, phosphatic sand; and phosphatic, sandy limestone.

Although in parts of the region the more permeable lenses of sand and limestone in the Hawthorn Formation comprise a secondary artesian aquifer, the major significance of the Hawthorn Formation is its ability to confine the artesian water in the underlying Floridan Aquifer formations.

Upper Miocene or Pliocene

In many parts of Florida the Pliocene was a period of uplift and erosion (Rainwater 1970). Bermes and others (1963), however, describe inundation by late Miocene or Pliocene seas over the study area and refer to the presence of interbedded lenses of marine fine to medium sand, shell, and green, calcareous, silty clay overlying the Hawthorn Formation in most of eastern Putnam County, central and northern Flagler County, and in all of St. Johns County. These, according to Bermes and others, (1963), are described by Vernon (1943, 1951, 1955, 1956) as late Miocene in age, but by Cooke (1945) as Pliocene deposits. The matter remains unresolved, and these materials may for the present be referred to simply as Upper Miocene or Pliocene in age.

As described in the literature, the less permeable beds of these deposits often act as confining layers; and, like the Hawthorn Formation, they contribute to discontinuous secondary aquifers with sand and shell beds yielding, in places, moderate amounts of artesian water to wells (Bermes and others, 1963).

Pleistocene and Recent

The purpose of the following discussion of Pleistocene and Recent deposits is these upper materials was particularly important to (1) complete the present description of stratigraphy in time-stratigraphic terms; (2) set the nature of deposits at the site in regional context; and (3) emphasize the variable nature of these deposits.

These deposits are a product of the alternating advances and retreats of worldwide ice sheets and accompanying eustatic sea level changes. The marine terraces formed at this time were described in Section 2.2.3. Pleistocene deposits are typically discontinuous and variable in lithology and texture both vertically and laterally. The upper sands of these deposits constitute a water-table aquifer (Section 2.3.2.1) and supply moderate amounts of water to screened wells for domestic use.

Borings on the site property showed clean quartz sands to a depth of approximately 40 feet, followed by alternating beds containing increasing percentages of fines (silt and sandy silt) and layers of relatively clean sand (Figure 2.2-15). Wells of the nearby (less than 5 miles) Hudson Pulp and Paper Company, however, show a markedly different sequence which includes a clay layer between approximately 15 and 35 feet below surface. Because of the laterally variable nature of these deposits, it is emphasized that, in an environmental appraisal, these materials (and in fact all post-Hawthorn deposits) may be most meaningfully considered in site-specific terms. This is done in lithostratigraphic and geotechnical terms in Section 2.2.7 and from a ground water standpoint in subsections of Section 2.3.2.

2.2.5 Structure

Regional geologic structure is presented in Figures 2.2-7 and 2.2-8. As is evident from these figures, the Peninsular Arch forming the axis of the Florida Platform is one of the major regional subsurface structures. The Applin Line is another prominent feature shown in Figure 2.2-7 in the vicinity of the site. This line is the contact zone between two deep-seated Paleozoic rock groups. More recent features also present in the general region of the site include the Ocala Uplift and the Kissimmee Faulted Flexure.

The Ocala Uplift, which developed on the western flank of the Peninsular Arch, is dated by Vernon (1951) as post-Oligocene in age. The feature is about 230 miles long and approximately 70 miles wide where exposed in the central portion of Florida. The uplift may be simply described as consisting of two composite shallow folds that converge and separate down-axis. In fact, it is more complex in a structural sense, since the crests of folds tend to show the development of dip-slip faults. In the vicinity of Lake, Orange, and Osceola counties, the two folds mentioned above diverge and the eastern fold merges with a large fault block, referred to by Vernon (1951) as the Kissimmee Faulted Flexure. This structural system shows relatively complex deformation, apparently being tilted and rotated, with beds showing considerable deformation.

None of the faults associated with these features are considered to be active (capable). According to Vernon (1951), faulting in basal Miocene beds along the uplift, and the wedging out of Miocene sediments, provide a probable lower Miocene age ($\pm 20 \times 10^6$ years before present) of the movements. The fact that younger formations that flank the arch show progressively lower dips suggests that there has been little if any renewed tectonic activity of the uplift. The near-horizontal attitude of all Pleistocene formations suggests that the uplift has been stable for at least 500,000 years.

Likewise, the fault zones that bound the Kissimmee Faulted Flexure cut upper Eocene beds but are covered by lower Miocene sediments (Vernon, 1951) and are thus Eocene or Oligocene events, at least 25 million years in age.

Other regional features are shown in Figures 2.2-7 and 2.2-8, but because of their distance from and lack of influence on the site, are not discussed further.

It is pertinent to briefly discuss the question of geologic structural influence on the St. Johns River. The literature indicates that faults have been postulated over a significant portion of the river. Figure 2.2-9 delineates faults reported by Leve (1966), Bermes and others, (1963), Vernon (1951), Wyrick (1960), Barraclough (1962) and Lichtler and others, (1968). Pirkel (1971) emphasizes the fact that faulting and other movements associated with the Ocala uplift have played an important role in determining the course of the St. Johns River. However, with the possible exception of the fault postulated by Bermes and others (1963), the structural features shown along the river are incidental to the present project because of their lack of influence on the proposed site.

The fault reported by Bermes and others (1963) trends from the western portion of Lake George approximately northward. The river follows the alignment of this fault from Lake George to just south of Palatka, where it breaks to the east to re-enter the eastern valley. As shown by a dashed line in Figure 2.2-6, this fault might extend further northward to pass approximately 4 miles west of the site. However, as shown in cross-sectional view in Figure 2.2-5, this fault is certainly earlier than Pliocene (+10 x 10^6 years before present) and is thus considered non-capable.

No other structural features were found in the literature or mapped in the field that could possibly influence the site.

2.2.6 Earthquake History

Seismic considerations and the phenomena generated by seismically induced ground motions, such as liquefaction, are not of major concern to the siting of a fossil-fueled power station. Earthquake history is discussed in the context of foundation suitability.

The Florida peninsula is one of the most seismically stable areas of the United States. Table 2.2-2 lists some thirteen earthquakes of Modified Mercalli (MM) III or greater reported in the literature to have affected Florida. Table 2.2-3 gives a Modified Mercalli damage scale. All earthquakes that have originated within the state of Florida (Figure 2.2-10) may be considered relatively minor (MM VI or less), and damage resulting from these has been slight.

One of the more recent earthquakes was a MM V event, which occurred south of Orlando in 1973. The only damage reported from the maximum intensity area associated with this earthquake involved cracks being formed or extended. Cracks generally occurred along construction joints or on previously patched masonry (Long, 1974). A Modified Mercalli isoseismal map of this event shown in Figure 2.2-11 indicates that the site would have been in area of intensity of less than MM III.

Another recent event was the earthquake near Daytona Beach that occurred on December 4, 1975. This, however, was of only intensity MM III to IV and its "felt" area was localized.

Two less recent shocks in the proximity of the site were the MM V earthquake near Jacksonville in 1900 and the MM VI event located near Gainesville in 1879. This latter earthquake was the first recorded event to have had its epicenter within the state, and is the strongest noted to date in Florida. The "felt" area of this shock included Savannah (Georgia) and Tallahassee in the north and Punta Rosa and Daytona Beach in the south. The only damage, however, was sustained in St. Augustine. It may be significant to note that St. Augustine has some of the oldest buildings in the United States, and that damage was confined to plaster falls in a few houses (Earthquake Information Bulletin, 1967).

The strongest events recorded in Table 2.2-2 were the MM XII series of earthquakes centered near New Madrid, Missouri in 1811-1812, and two closely spaced intensity IX-X events in August, 1886 in the vicinity of Charleston, South Carolina. These earthquakes had a "felt" area of approximately 2 million square miles, caused considerable damage, and resulted in some loss of life in their epicentral areas.

2.2.8 References

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UNIFIED SOIL CLASSIFICATION SYSTEM

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

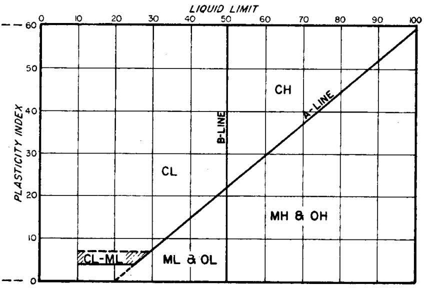
FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

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



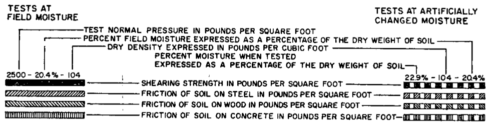
PLASTICITY CHART

NOTES:

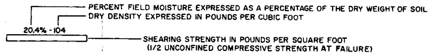
1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
2. WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

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		

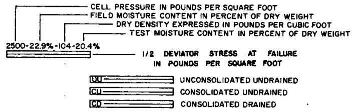
KEY TO TEST DATA



DIRECT SHEAR AND FRICTION TESTS



UNCONFINED COMPRESSION TESTS



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

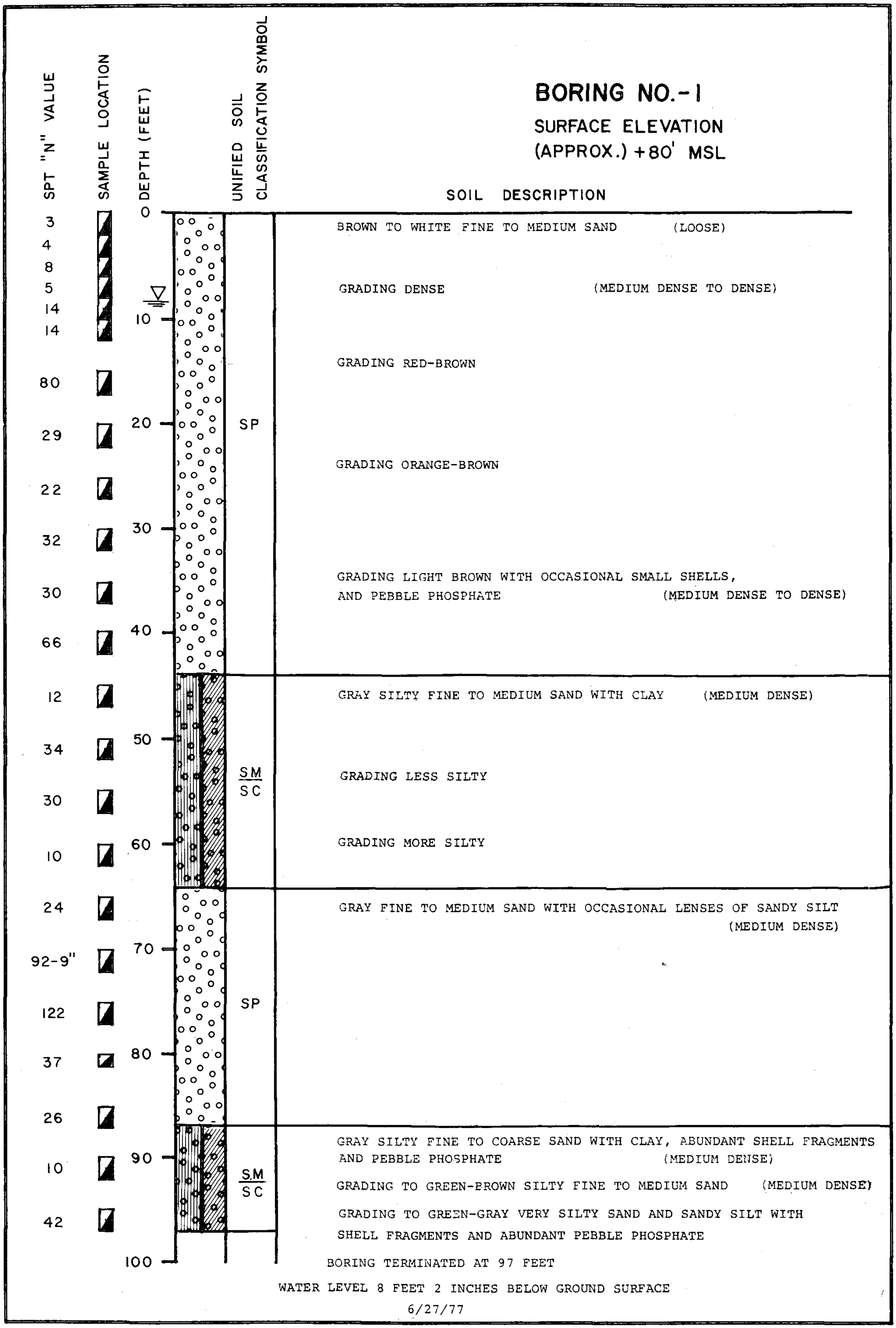
■ INDICATES UNDISTURBED SAMPLE
☒ INDICATES DISTURBED SAMPLE
☐ INDICATES SAMPLING ATTEMPT WITH NO RECOVERY

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

SOIL DESCRIPTION

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)

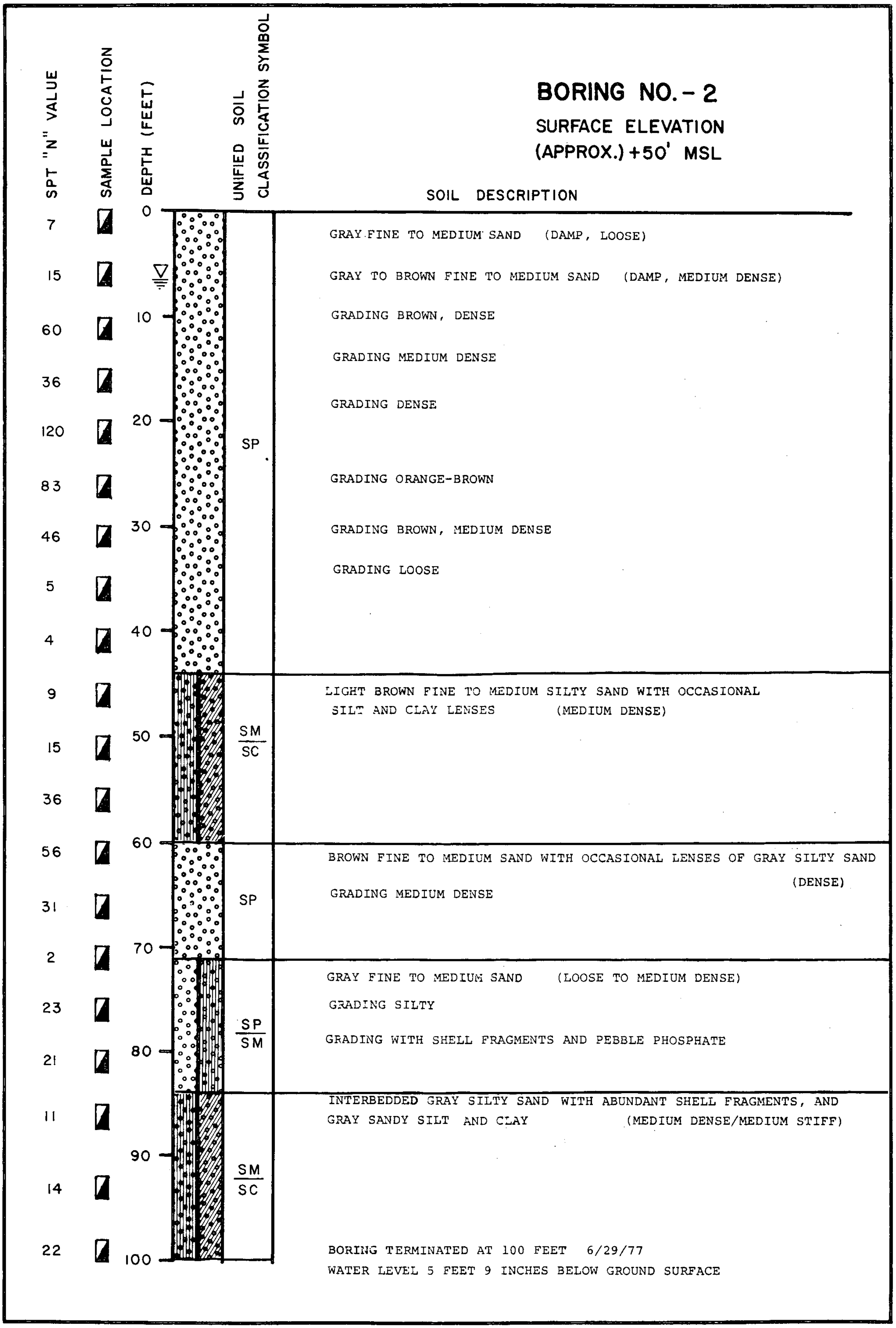
GRADING TO GREEN-GRAY VERY SILTY SAND AND SANDY SILT WITH SHELL FRAGMENTS AND ABUNDANT PEBBLE PHOSPHATE

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

SOIL DESCRIPTION

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

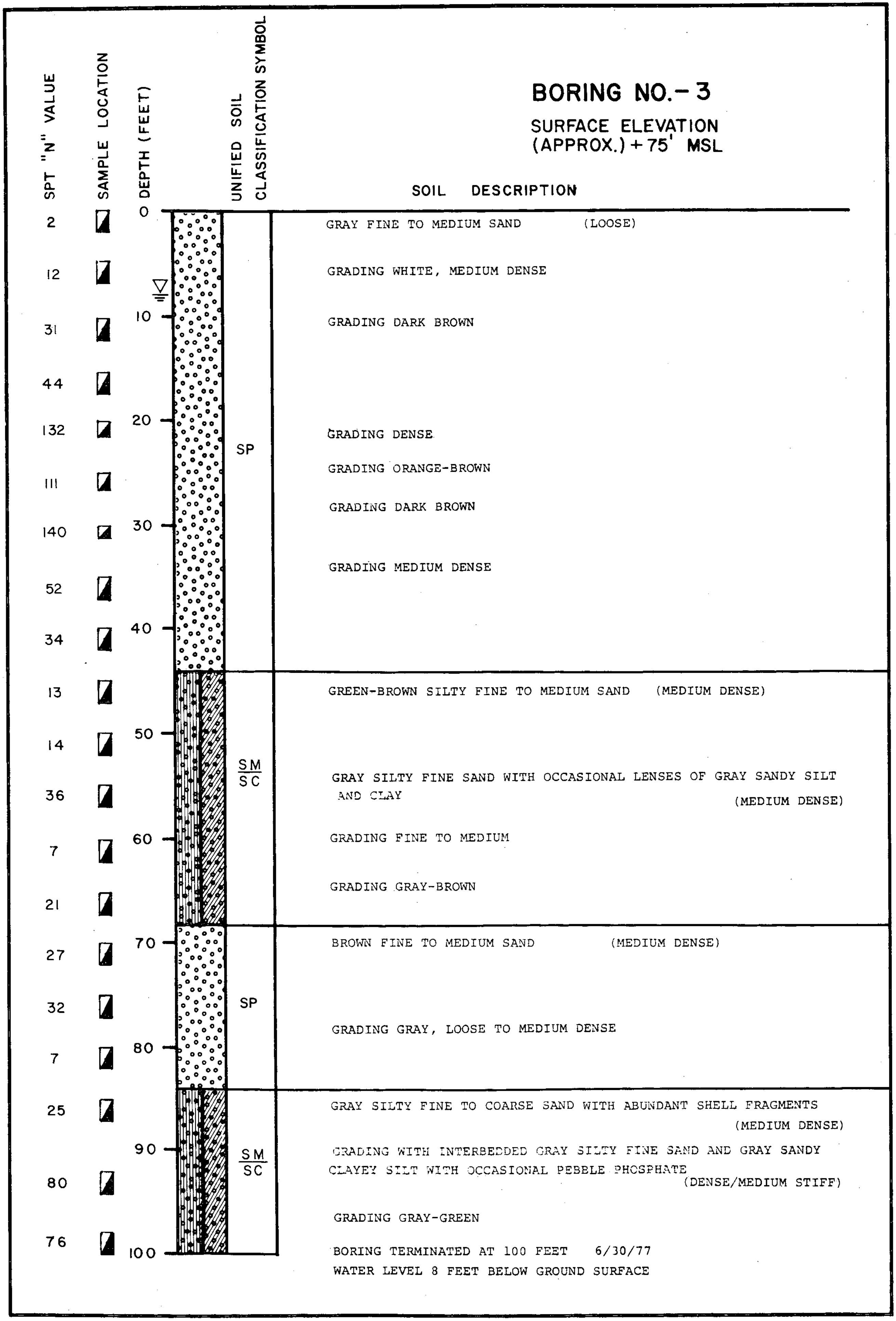
GRADING WITH SHELL FRAGMENTS AND PEBBLE PHOSPHATE

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

SOIL DESCRIPTION

GRAY FINE TO MEDIUM SAND (LOOSE)

GRADING WHITE, MEDIUM DENSE

GRADING DARK BROWN

GRADING DENSE

GRADING ORANGE-BROWN

GRADING DARK BROWN

GRADING MEDIUM DENSE

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

BROWN FINE TO MEDIUM SAND (MEDIUM DENSE)

GRADING GRAY, LOOSE TO MEDIUM DENSE

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		ATTERBERG LIMITS		MOISTURE CONTENT, %	DRY DENSITY, PCF	% PASSING 200 SIEVE	TYPE AND DEPTH OF SAMPLE	SPT 'N' VALUE	D&M (BLOWS/FT)		SOIL DESCRIPTION
		τ	σ_3 OR σ_N	LIQUID LIMIT	PLASTIC LIMIT								
0						18.4	113.3	15	■		11	≚	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	SP	GRADING LIGHT BROWN (DENSE)
									◩	42			
30						25.3	98.6	2	■		75		
									◩	30			GRADING WITH STRINGERS OF CLAY AND ORGANIC SILTY SAND
40						22.0	103.4	5	■		41		
									◩	23			GRADING LESS SILT
												CH	GRAY CLAY, TRACE OF FINE SAND
50				147	35	66	60		■		7		
						39.4		20	■		P	SM/SC	BROWN SILTY SAND WITH CLAY LENSES
				NON-PLASTIC		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									◩	2		SM/SC	BROWN CLAYEY SILTY SAND WITH LENSES OF FINE TO MEDIUM SAND
	TV	1.5				40.6	80		■		P		
	PP	.25		NON-PLASTIC		34.7	86.2		■ TW				
									◩	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"			GRAY SILTY SAND AND CLAYEY SAND WITH FINE TO MEDIUM SAND AND PEBBLE PHOSPHATE
90				NON PLASTIC		24.8		25	■		190/9"	SM/SC	
									◩	35			ABUNDANT SHELL FRAGMENTS AND THIN BEDDED STRUCTURE OF LIMESTONE PRESENT
100													

Figure E-5A.

BORING NO. 2-1 (cont.)

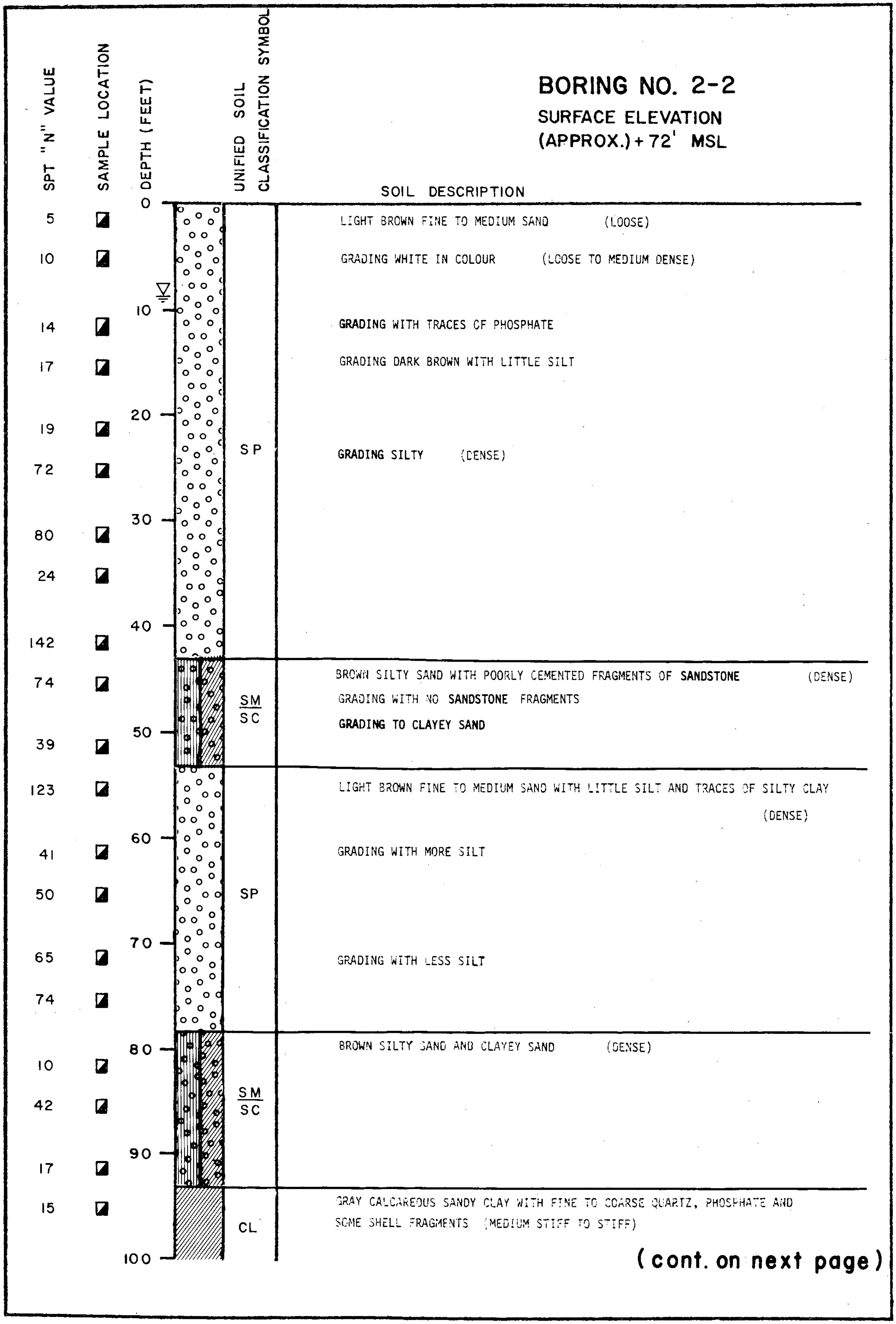
SURFACE ELEVATION
(APPROX.) +67' MSL

DEPTH BELOW GRADE	TYPE OF STRENGTH TEST	SHEAR STRENGTH TEST RESULTS, TSF		ATTERBERG LIMITS		MOISTURE CONTENT, %	DRY DENSITY, PCF	% PASSING 200 SIEVE	TYPE AND DEPTH OF SAMPLE	SPT 'N' VALUE	D&M (BLOWS/FT)		SOIL DESCRIPTION
		τ	σ_3 OR σ_N	LIQUID LIMIT	PLASTIC LIMIT								
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

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)

BROWN SILTY SAND WITH POORLY CEMENTED FRAGMENTS OF SANDSTONE (DENSE)

GRADING WITH NO SANDSTONE FRAGMENTS

GRADING TO CLAYEY SAND

LIGHT BROWN FINE TO MEDIUM SAND WITH LITTLE SILT AND TRACES OF SILTY CLAY (DENSE)

GRADING WITH MORE SILT

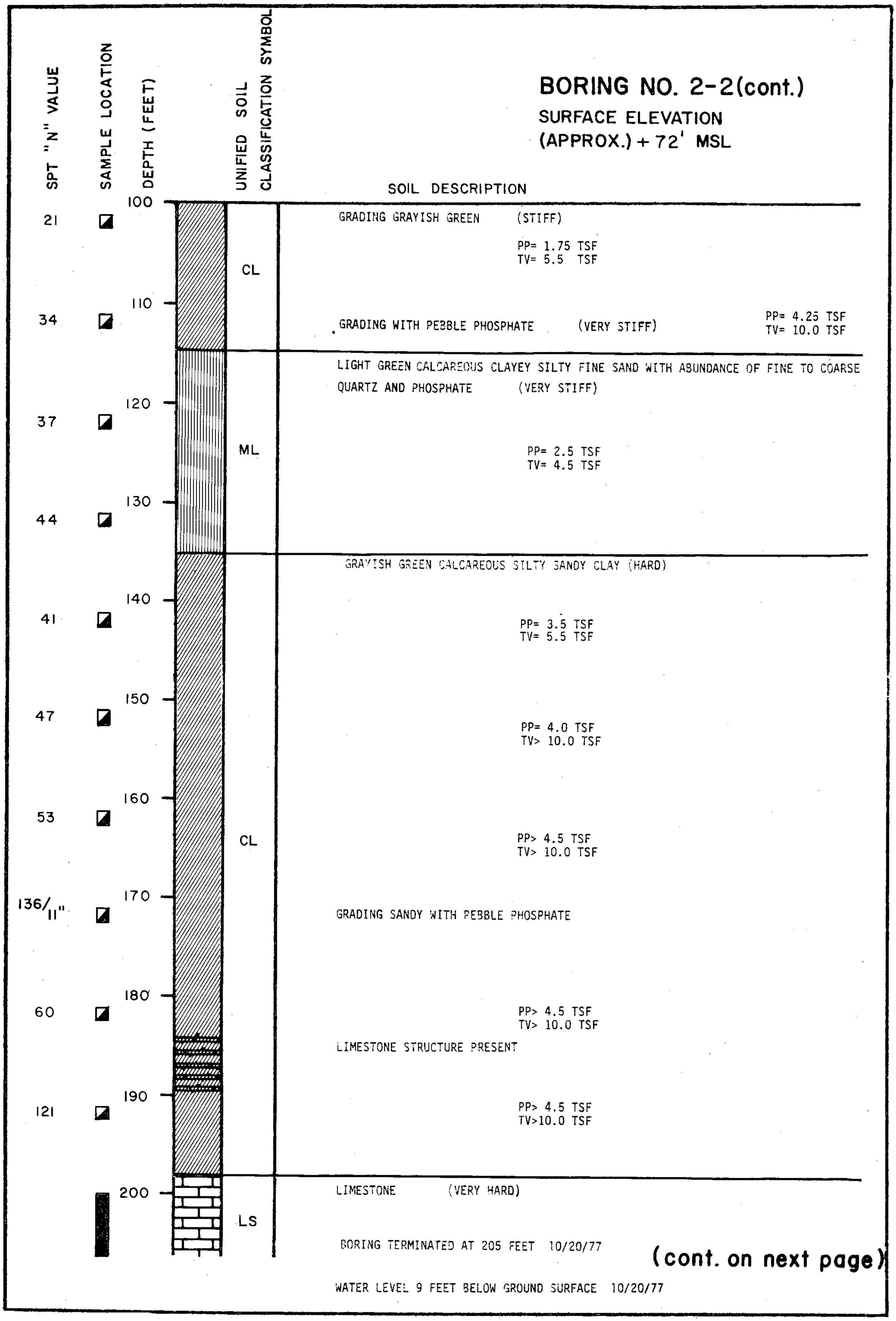
GRADING WITH LESS SILT

BROWN SILTY SAND AND CLAYEY SAND (DENSE)

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

GRADING GRAYISH GREEN (STIFF)

PP= 1.75 TSF
TV= 5.5 TSF

GRADING WITH PEBBLE PHOSPHATE (VERY STIFF)

PP= 4.25 TSF
TV= 10.0 TSF

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

GRAYISH GREEN CALCAREOUS SILTY SANDY CLAY (HARD)

PP= 3.5 TSF
TV= 5.5 TSF

PP= 4.0 TSF
TV> 10.0 TSF

PP> 4.5 TSF
TV> 10.0 TSF

GRADING SANDY WITH PEBBLE PHOSPHATE

PP> 4.5 TSF
TV> 10.0 TSF

LIMESTONE STRUCTURE PRESENT

PP> 4.5 TSF
TV>10.0 TSF

LIMESTONE (VERY HARD)

BORING TERMINATED AT 205 FEET 10/20/77

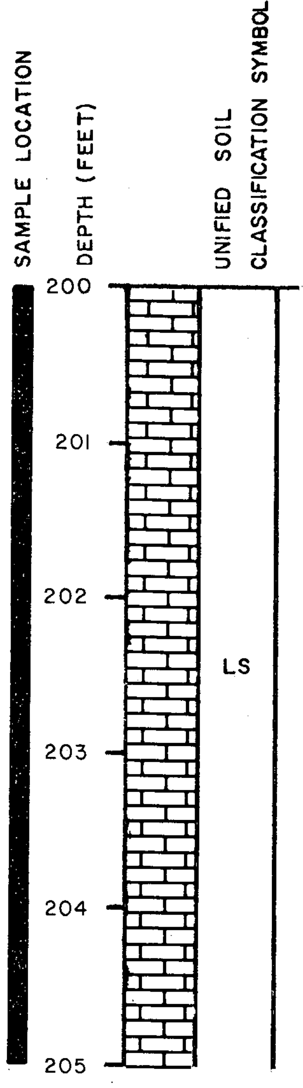
(cont. on next page)

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

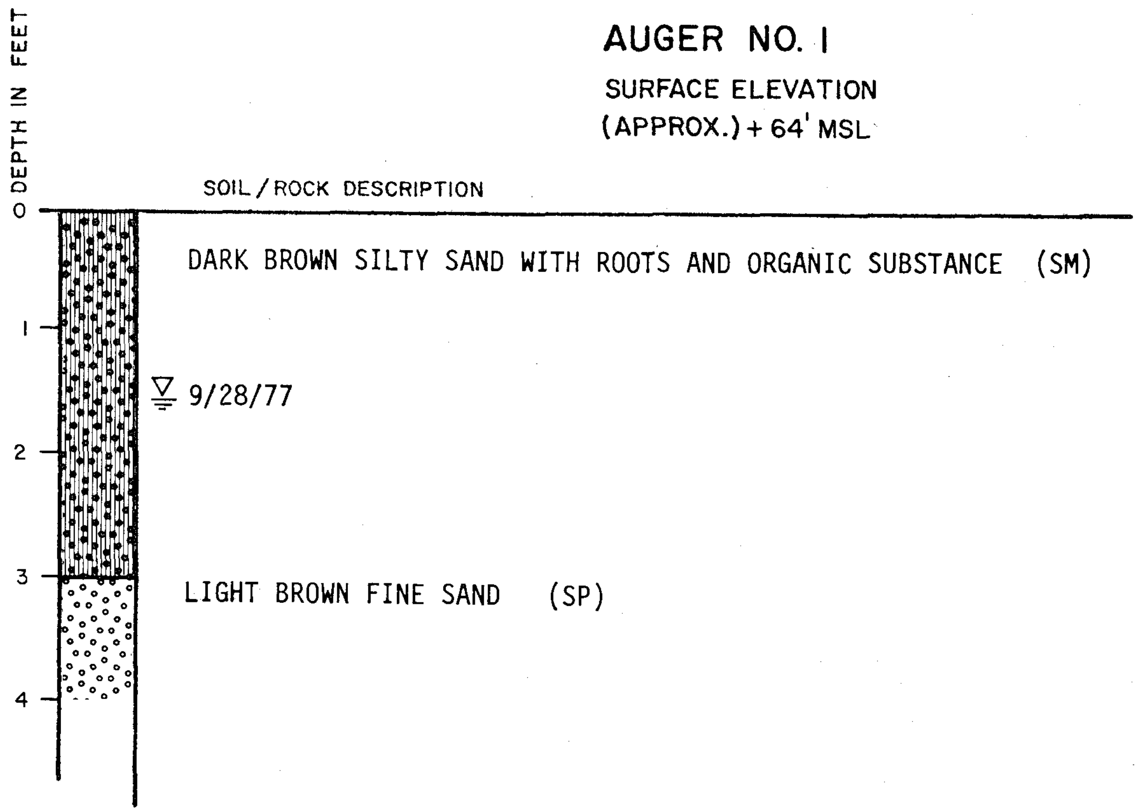
203-204' LIMESTONE, SANDY, DENSE, ABUNDANT SHELL CASTS

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)

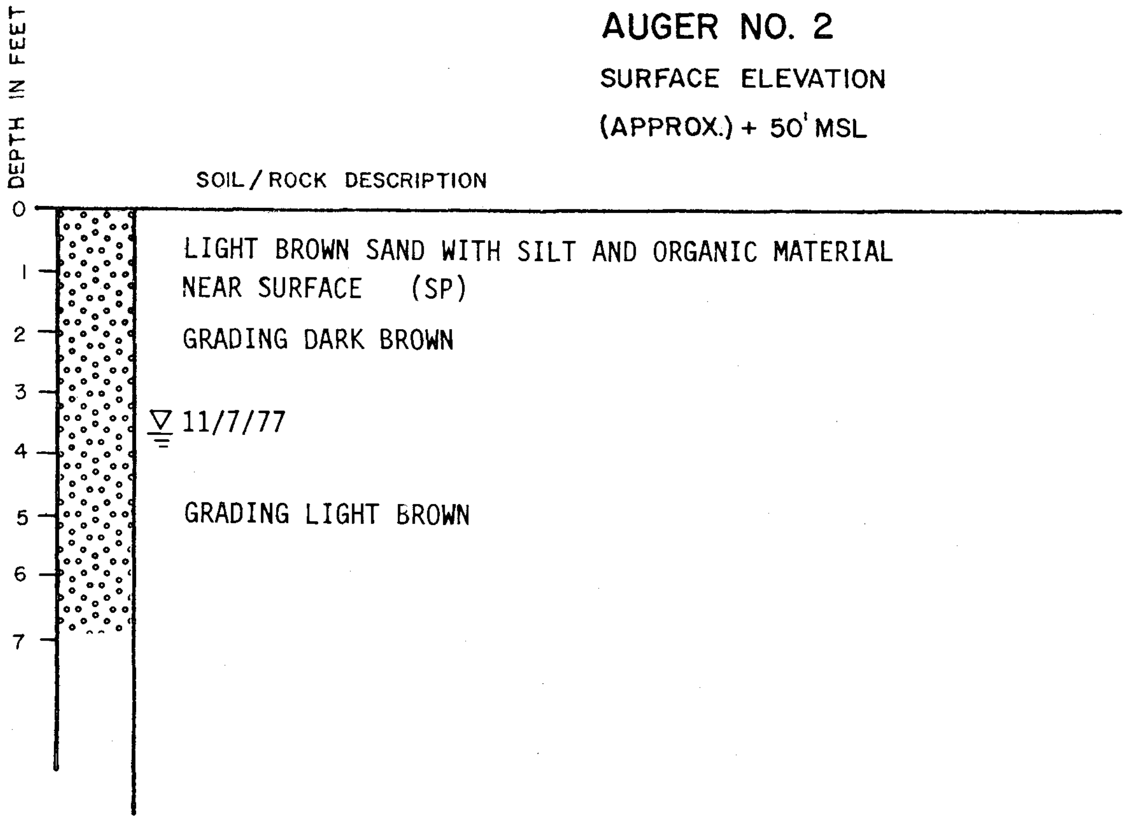

AUGER NO. 2
SURFACE ELEVATION
(APPROX.) + 50' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
7
LIGHT BROWN SAND WITH SILT AND ORGANIC MATERIAL NEAR SURFACE (SP)
GRADING DARK BROWN
11/7/77
GRADING LIGHT BROWN

Figure E-7.

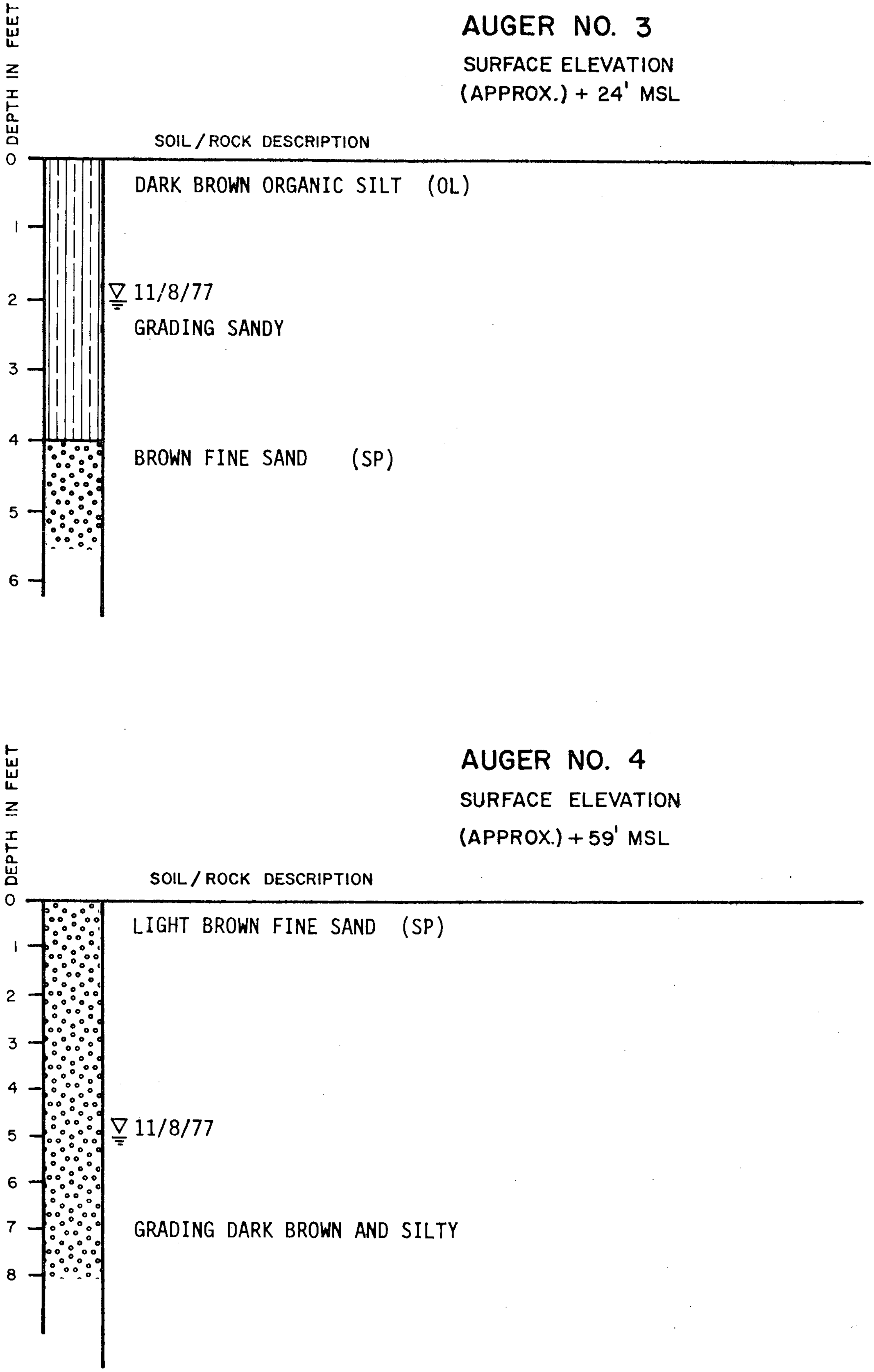

AUGER NO. 3
SURFACE ELEVATION
(APPROX.) + 24' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
DARK BROWN ORGANIC SILT (OL)
11/8/77
GRADING SANDY
BROWN FINE SAND (SP)
AUGER NO. 4
SURFACE ELEVATION
(APPROX.) + 59' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
7
8
LIGHT BROWN FINE SAND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

Figure E-8.

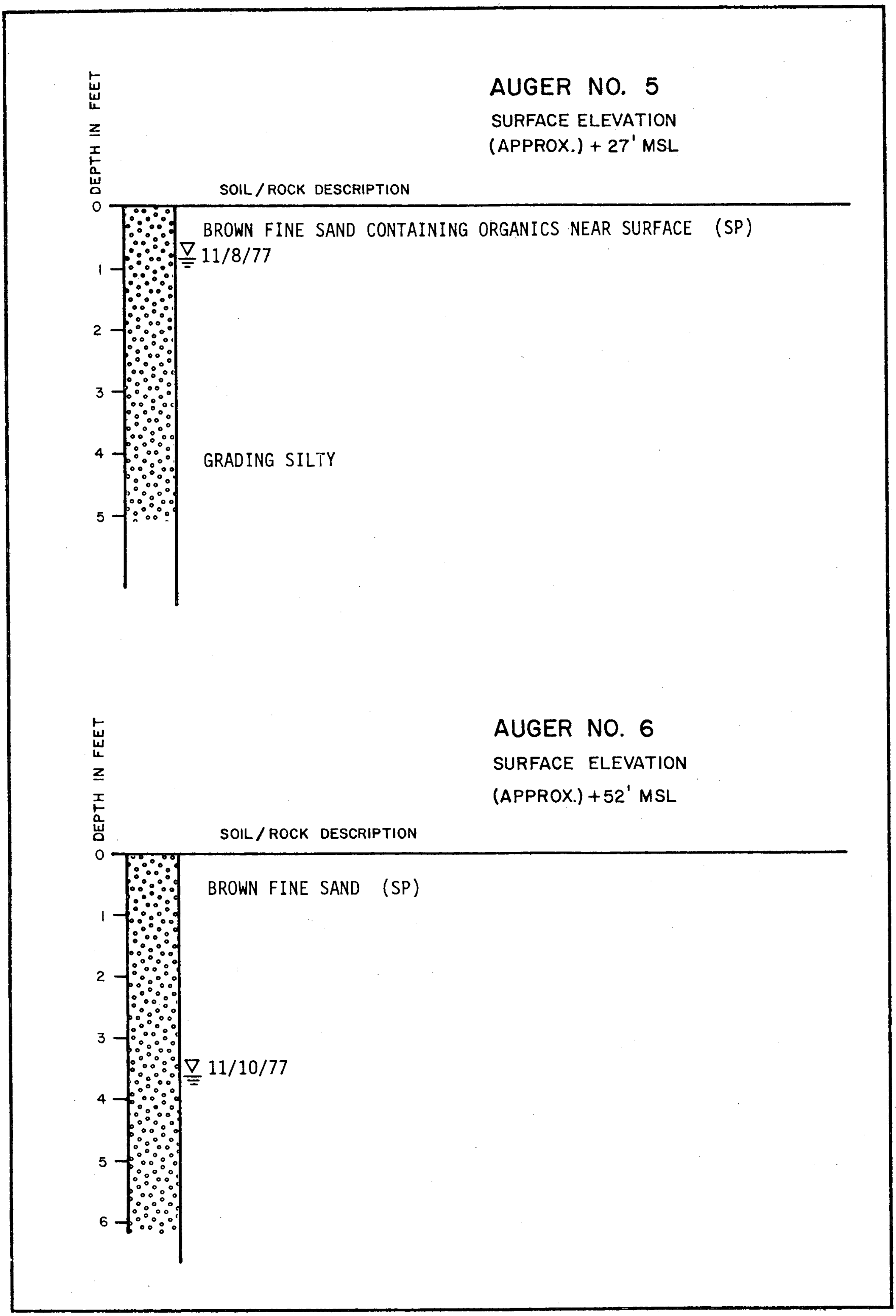
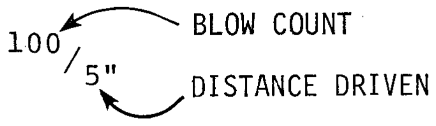

AUGER NO. 5
SURFACE ELEVATION
(APPROX.) + 27' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
BROWN FINE SAND CONTAINING ORGANICS NEAR SURFACE (SP)
11/8/77
GRADING SILTY
AUGER NO. 6
SURFACE ELEVATION
(APPROX.) +52' MSL
DEPTH IN FEET
SOIL / ROCK DESCRIPTION
0
1
2
3
4
5
6
BROWN FINE SAND (SP)
11/10/77

Figure E-9.

LEGEND TO BORING LOGS

■	D&M SAMPLE
◪	SPT SAMPLE
▨	BLANK SPT SAMPLE
TW ■	THIN WALL SAMPLE
P ■	D&M SAMPLE PUSHED



▽	NATURAL GROUND WATER TABLE
╪	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)

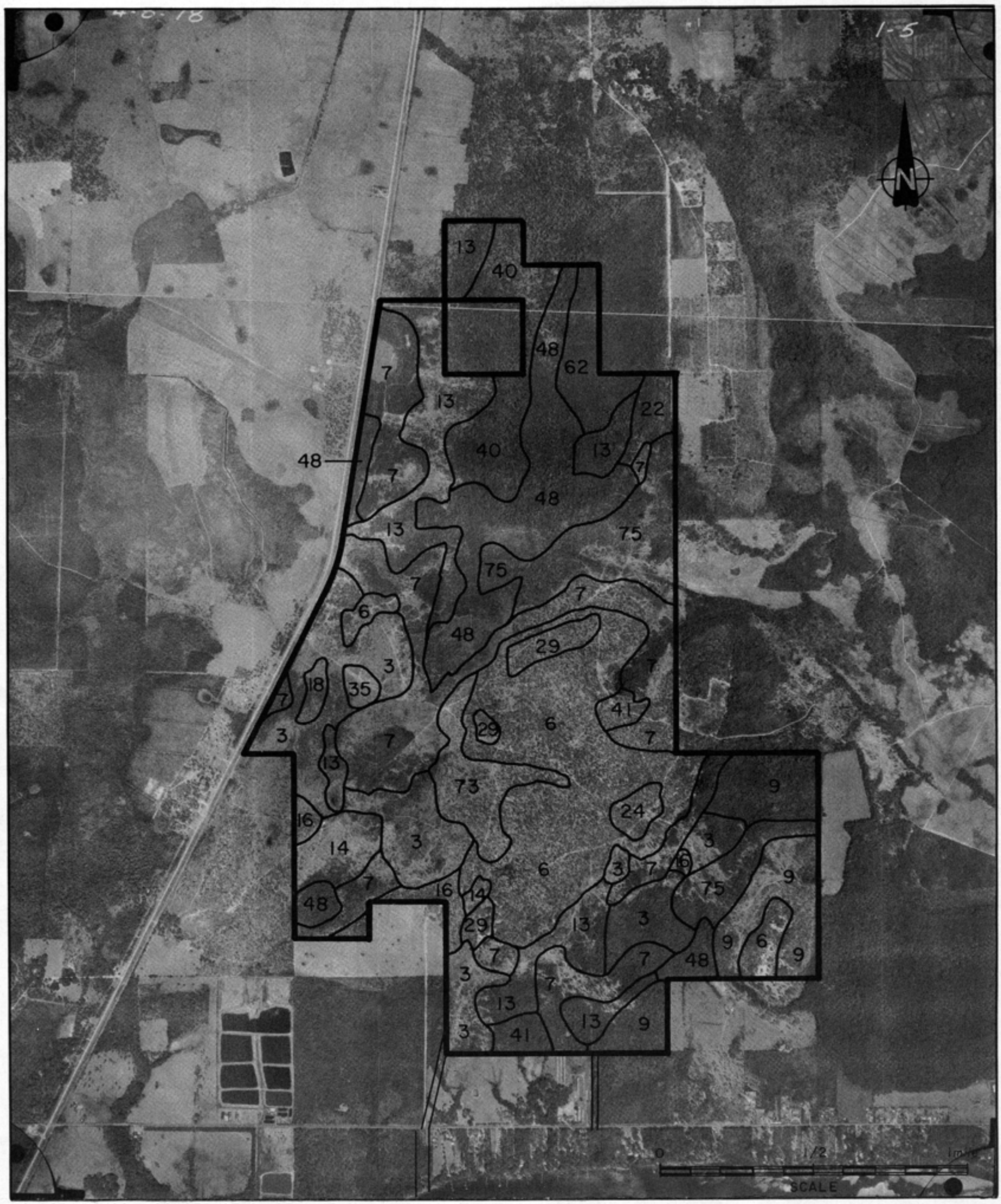
σ_3 = CONFINING PRESSURE (TSF)

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

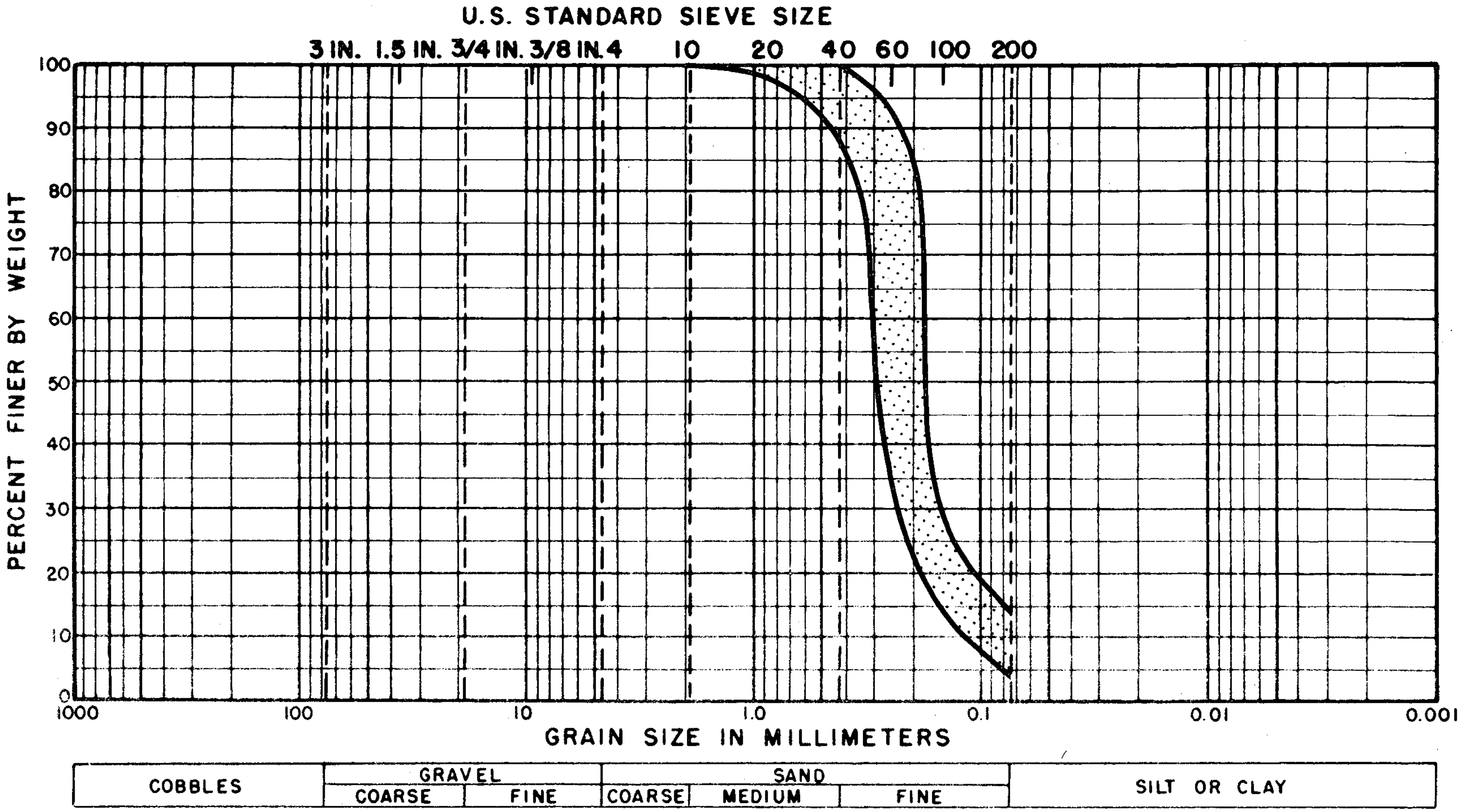


Figure E-12. Gradation Envelope - Layer 1.

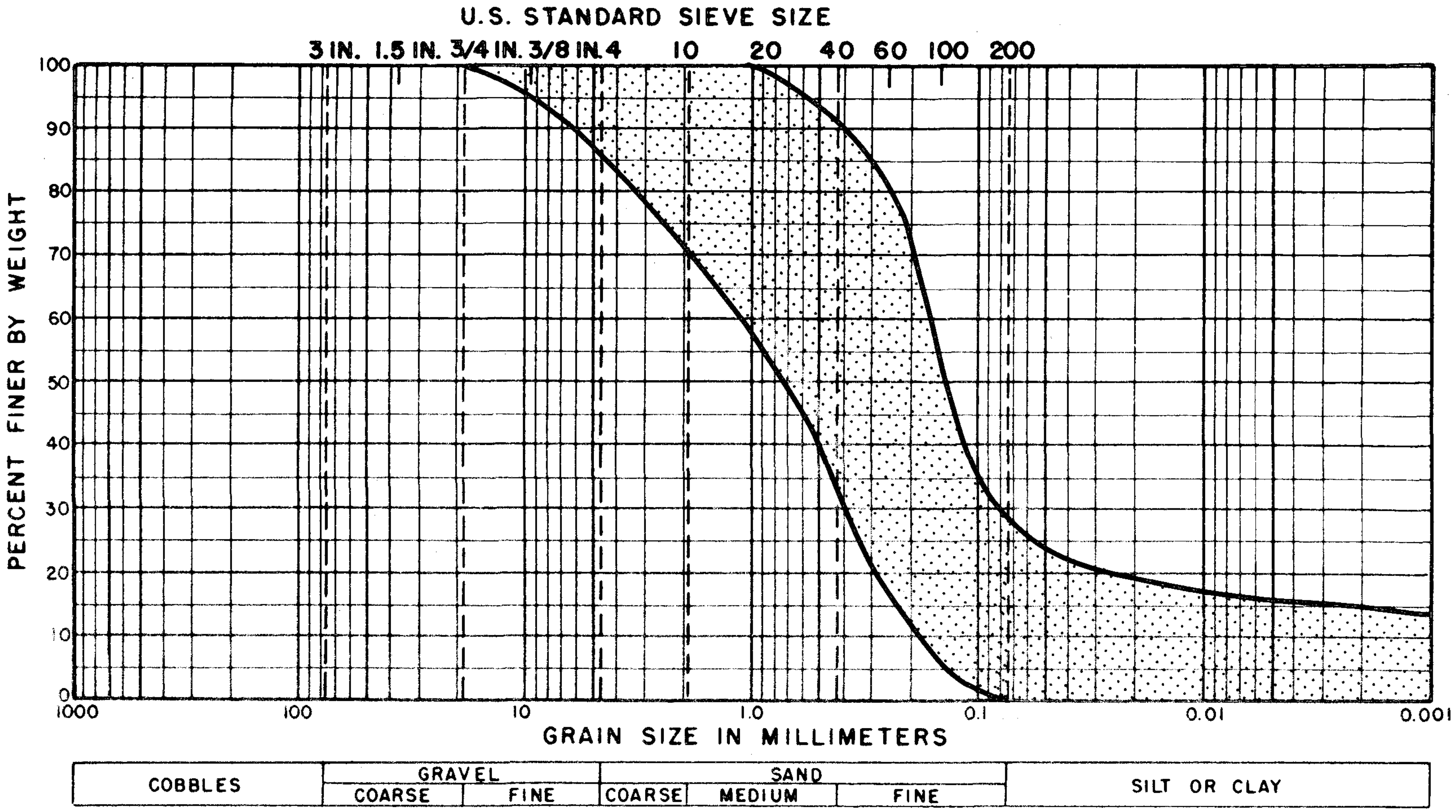


Figure E-13. Gradation Envelope - Layer 2.

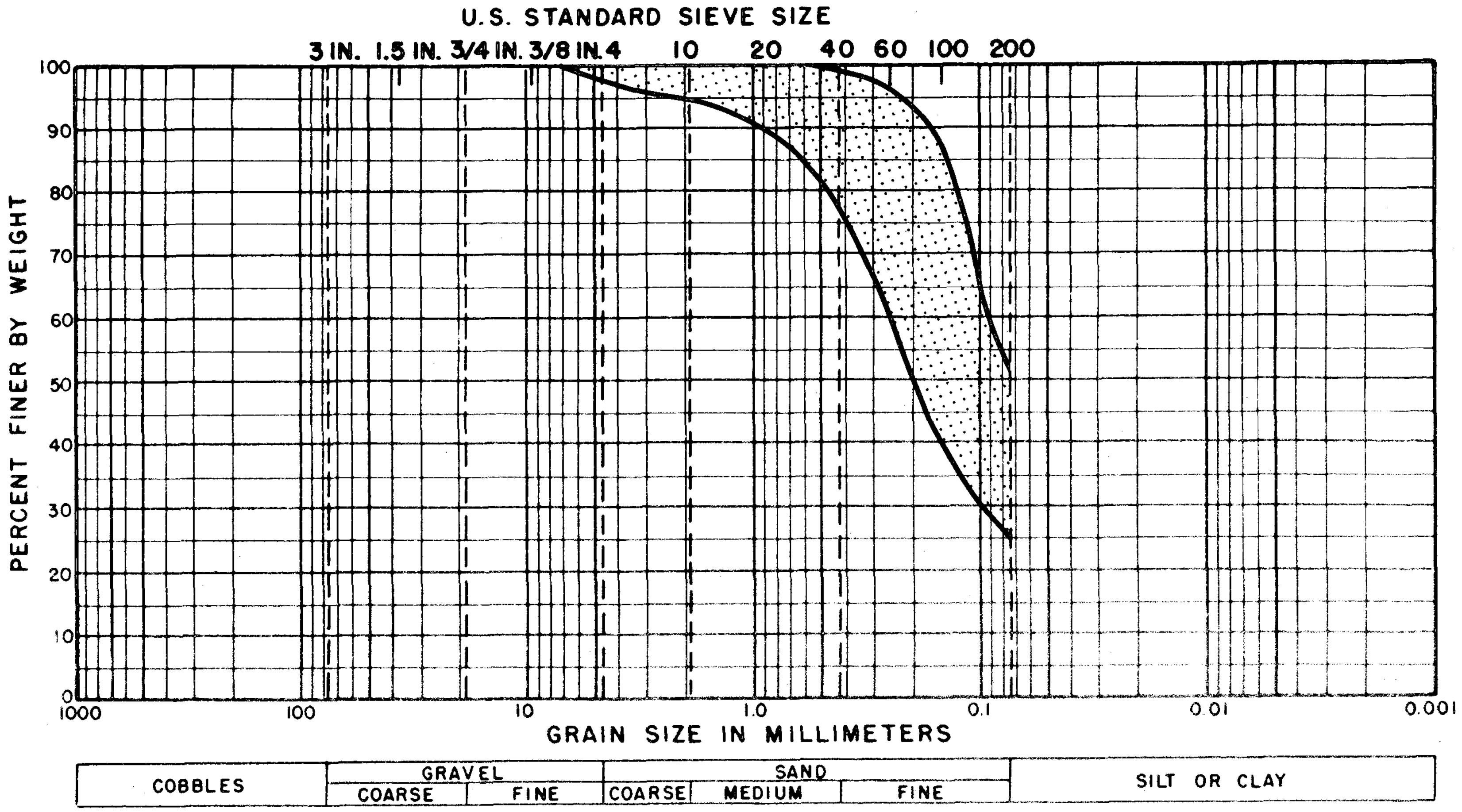


Figure E-14. Gradation Envelope - Layer 3.

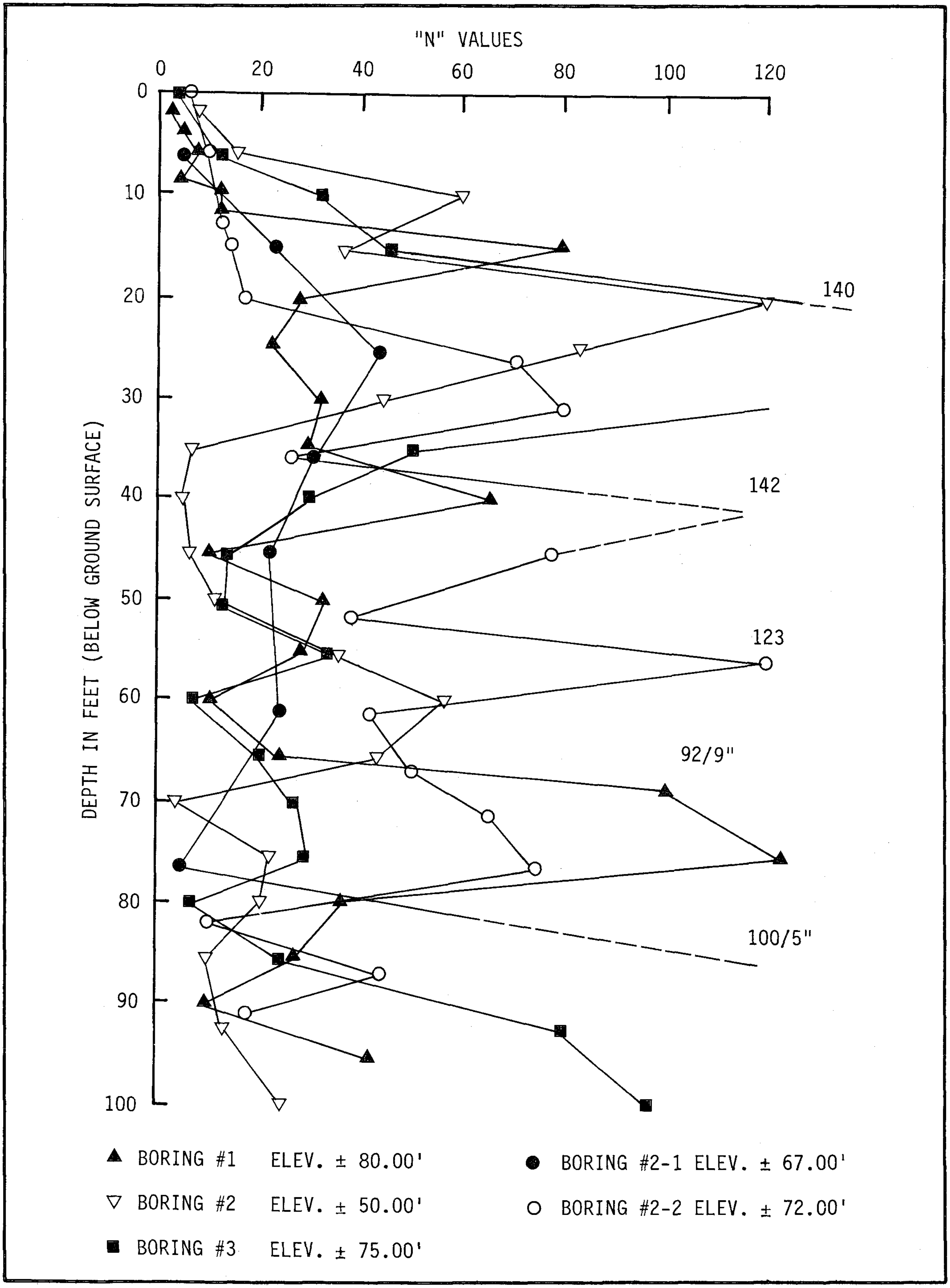


Figure E-15. Measured SPT Blow Counts vs Depth.

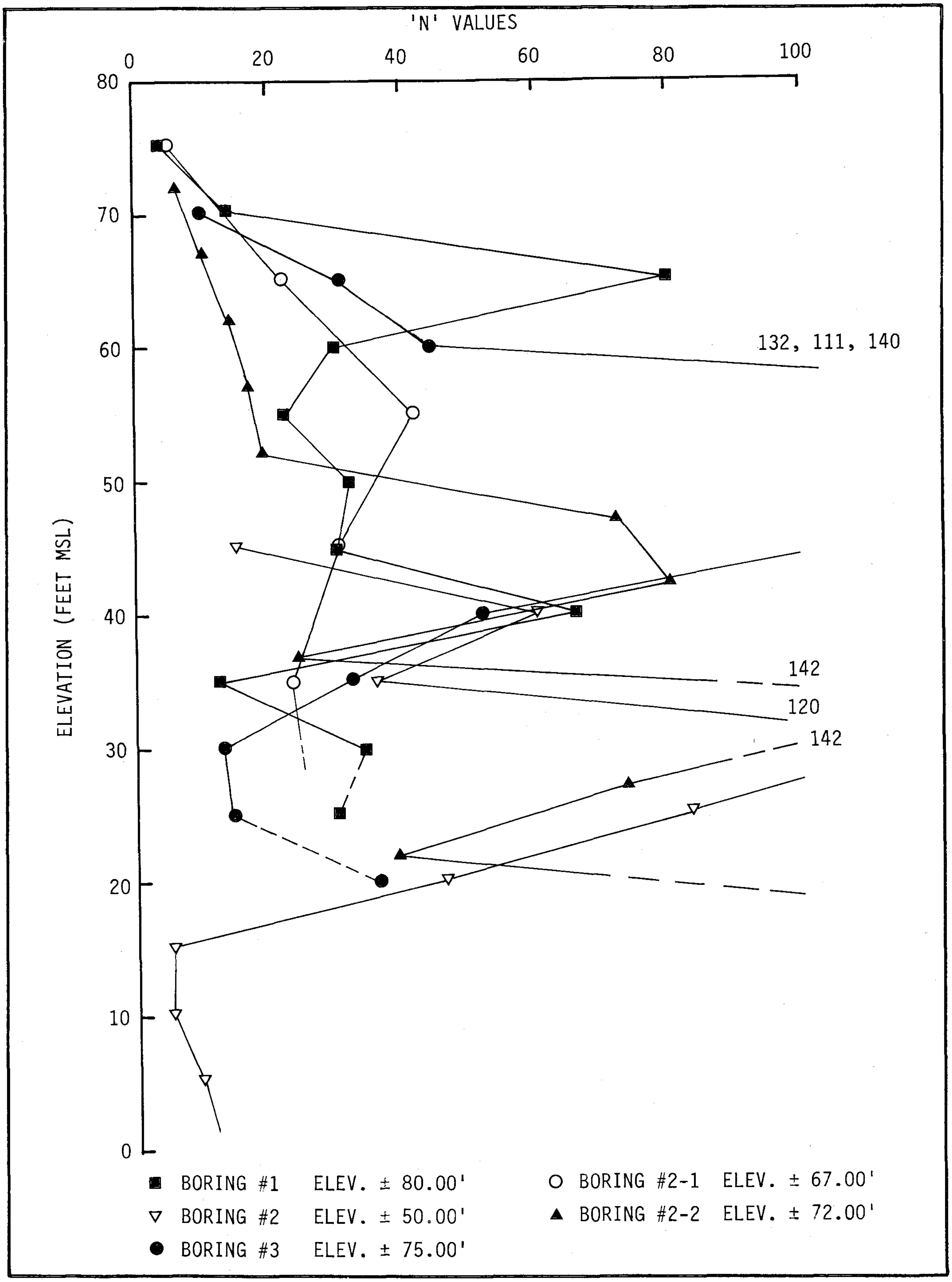


Figure E-16. Measured SPT Blow Counts vs Elevation.

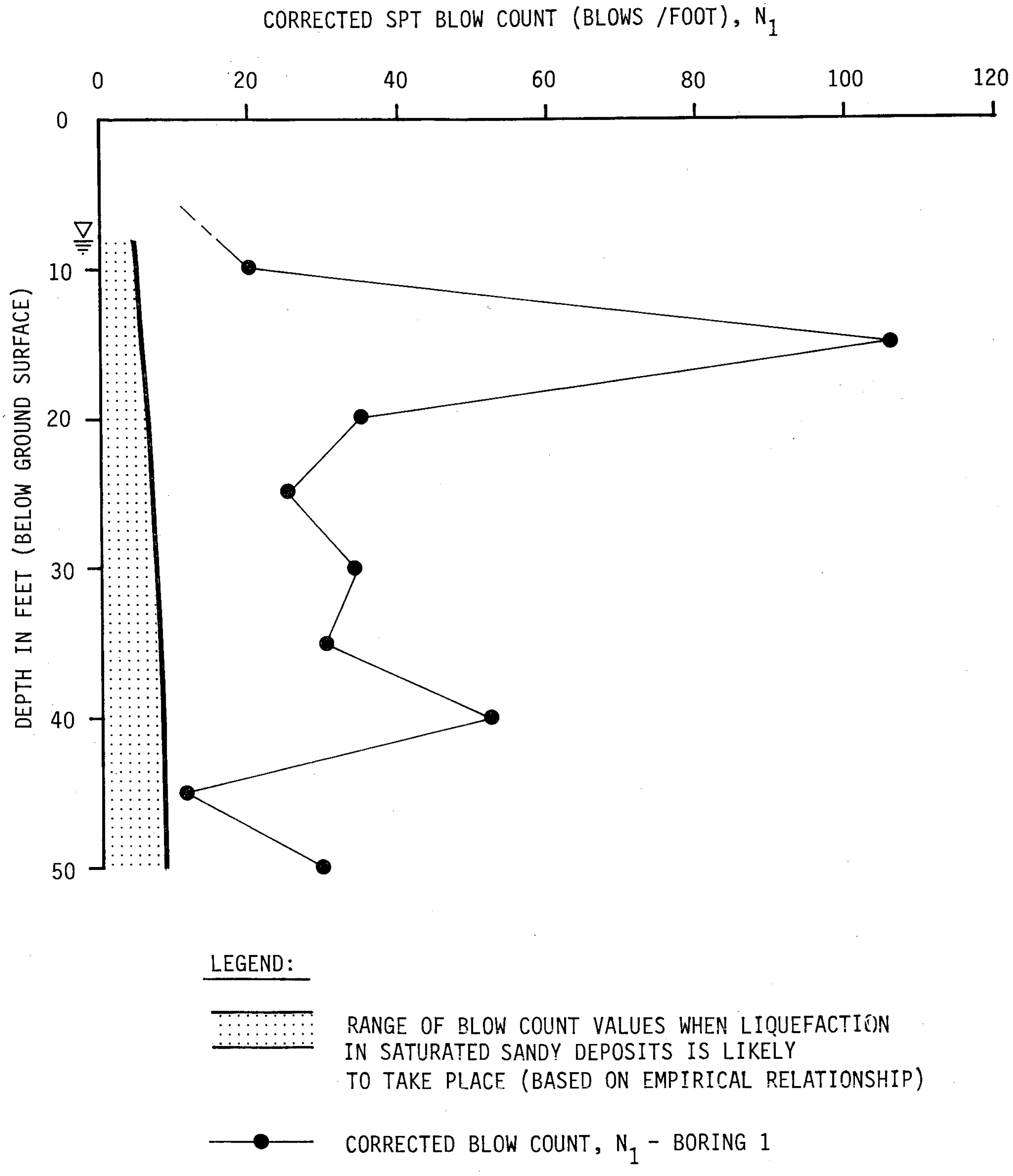


Figure E-17. Corrected Standard Penetration Resistance, N_1.