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AN ENVIRONMENTAL EVALUATION OF DIRECT WATER REUSE IN THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

by
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PREFACE

The environment, including public health, is a primary concern when evaluating water reuse systems and techniques. Implementation of a direct reuse system in some areas of the District may be limited by certain environmental factors, unless strategies are incorporated to overcome these limitations and still provide environmental protection. This evaluative study is intended to review current environmental factors and considerations associated with direct nonpotable reuse via land application of domestic wastewater in the St. Johns River Water Management District.

The evaluation is restricted to direct reuse for two reasons. 1) In contrast to indirect reuse (i.e. surface water or aquifer recharge), the direct transmission and distribution of reclaimed water presents unique environmental and health problems which require further protective measures. 2) In contrast to indirect, direct reuse better conserves a primary water supply while satisfying a water use demand. Indirect reuse is an accepted form of wastewater disposal and, under certain circumstances, may even serve to benefit a water resource. Therefore, exclusion of indirect reuse from this evaluation is not to be construed otherwise.

Given the current state of technology and environmental awareness, it is possible for direct reuse to be implemented throughout the District. However, the District includes areas that exhibit varying degrees of direct reuse potential. A

District-wide asessment of this potential is based largely on the quality and quantity of primary water supplies, consumptive demand on these supplies, and the disposal methods of the major wastewater treatment plants ($\geq$ 1.0 MGD design capacity) approved or not approved by the Florida Department of Environmental Regulation (DER). Areas identified as having high direct reuse potential have stressed water supplies and major wastewater facilities which are directed by DER to seek alternatives to surface water discharge of effluent. Even in some areas that exhibit high potential, significant environmental factors may restrict or limit the operation of a direct reuse system unless, as previously stated, circumventive measures are instituted. A discussion of limiting environmental factors is part of this study, not an evaluation of circumventive measures.

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ABSTRACT

This report partially fulfills the technical requirements necessary for development of water management policy, plans, and permitting criteria regarding water reuse in the St. Johns River Water Management District. A discussion is provided pertaining to environmental and health aspects of direct reuse and an assessment of the potential for direct reuse in the District. The assessment of direct reuse potential, in terms of agricultural and urban irrigation with domestic wastewater treatment plant (WWTP) effluent, is based on location and treatment/disposal methods of major WWTP's, water supply and demand, land use, and environmental factors. In the interest of public health, effluent used in a direct reuse operation with unrestricted public access should be _pre_-treated, at minimum, to a tertiary level with disinfection. Nearly all of the major WWTP's can either operate at this level of treatment presently or can reach this level with additional chemical coagulation and/or filtration processes. Most of the major WWTP's are located in the south District region (Volusia, Marion, Lake, Seminole, Orange, Brevard and Indian River counties) in which several areas exhibit high direct reuse potential. This high potential is a result of the need to implement water conservation measures and alternatives to wastewater disposal in environmentally sensitive surface waters. Reuse may satisfy both needs simultaneously, but its implementation can be limited or restricted due to environmental factors. For example, direct reuse in Brevard County may be limited in certain areas west of the Indian River composed of poorly drained

soils and high water tables; and, restricted from those areas with numerous domestic or private wells unless measures are taken to prevent contamination of the surficial aquifer (the county's primary potable supply).

INTRODUCTION

Some local governments within the St. Johns River Water Management District (District) are revising portions of their 201 wastewater facility plans to comply with federal and state wastewater management regulations and with District policies and rules. The District's involvement in the local/regional 201 planning is legitimate by virtue of its responsibility to protect the water resource from deleterious impacts and to promote water conservation (Florida Water Resources Act of 1972, Chapter 373, _Florida Statutes_, Chapter 40C-1.07(9) of the District Rules). Reuse has been evaluated as one of several treated wastewater (effluent) disposal alternatives by local governments based on economic and environmental criteria while generally disregarding water conservation. In order to promote water conservation, the District's artificial recharge rule (Chapter 40C-5, _F.A.C._) requires those planning to dispose wastewater underground to develop a plan for reuse as an alternative or as an additional disposal method to minimize water consumption. Provisions have also been made in Chapter 40C-2, _F.A.C._, which require consumptive use permit applicants to evaluate and implement reuse techniques "to the degree which is financially, environmentally, and socially practicable". However, to properly and effectively evaluate permits, reuse criteria need to be developed or strengthened through clarification and specification with respect to environmental and public health concerns. Toward this end, technical information on the environmental and health aspects of direct reuse and its application in the District are essential.

The purpose of this report is to fulfill this technical prerequisite to some extent by providing an inventory and map of major domestic wastewater treatment plants (WWTP) in the District and determine the suitability of their effluents for reuse. Direct reuse potential in the District will be assessed based on major WWTP distribution and their current or projected treatment/disposal methods, regional water supplies and demand, land use, and degree of environmental sensitivity and health risk.

METHODOLOGY

Review of the scientific and technical literature is a necessary element in developing an understanding of the effects reuse may have on the environment and public health. The review takes a generic approach in so far as providing a discussion of basic environmental and health risk factors which all reuse technology and implementation plans must deal with in their designs. This is followed by an overview of actual reuse operations and environmental factors more regionally specific (i.e. central Florida) and, therefore, more applicable to an assessment of reuse potential in the District.

Domestic WWTP's within the District selected for evaluation must have a design capacity of 1.0 MGD or greater and handle domestic wastewater only. Facilities meeting these criteria would provide the potential user a constant water supply, the quality of which should pose a minimal risk to public health. These WWTP's are mapped and inventoried in this report with pertinent evaluative information. Further details on the WWTP selection and prioritization process for reuse evaluation are outlined (Appendix 1).

Direct reuse potential in the District is assessed according to level of wastewater treatment and disposal method, land use within 10 miles of the WWTP, soil properties, and hydrologic criteria such as location and quantity of and demand on potable water supplies, and potential for ground water contamination. Direct reuse potential in a particular region can also be profoundly influenced by governmental legislation and regulations. A brief summary of such governmental action relevant to the operation of a reuse system in the District is presented. Further coverage of Brevard County is warranted because it lies within a critical water conservation area and the county is currently pursuing its own reuse investigation to comply with a 40C-5 permit requirement.

The scope of this evaluation is further restricted to the following:

1. Review of environmental/health considerations and requirements only. Economics are not addressed.

2. Nonpotable use of treated wastewater, not potable use.

3. Reuse application to agricultural and general urban land use only. General urban is defined as low to high density residential and/or commercial development and open grounds maintained for human activity.

4. Slow-rate application of effluent as defined in the manual, Land Application of Domestic Wastewater Effluent in Florida (DER, 1983). A maximum rate of 2 in/wk is recommended, but higher rates may be approved by DER with proper substantiation. Areally, 150 to 300 acres are required for every 1 MGD of effluent.

5. Application of treated wastewater only; no sludge, sludge-amended wastewater or other nonpotable water application.

6. Direct reuse or the direct transmission of treated wastewater to various users rather than indirect reuse or eventual transmission of treated wastewater to users via aquifer or surface water recharge.

WASTEWATER CONTAMINANTS, PRE-APPLICATION TREATMENT AND LAND APPLICATION

A reuse system contains, basically, two elements, wastewater treatment and land application, which must be designed and operated in a manner that insures minimal public health risk and potential for environmental harm. Most researchers or authorities do not advocate nonpotable urban or agricultural application of domestic effluent unless it has been pretreated to at least a tertiary level (i.e. some biological process followed by chemical coagulation/precipitation and filtration) followed by disinfection. The reasons for this level of treatment are given in the following discussion on wastewater contaminants. Aside from the pre-application quality factor, other factors affecting urban and agricultural land application of effluent are discussed.

Biological Contaminants

Domestic wastewater contains variable concentrations of potentially harmful substances and organisms which must be removed or converted to a harmless state prior to any disposal or application. The organisms that should be removed or inactivated are classified in four major groups of pathogens - bacteria, viruses, protozoans, and helminths or parasitic worms (Table 1).

Enteric bacteria are the most common pathogens present in wastewater and, among the aforementioned groups of pathogens, are the most susceptible to destruction during secondary treatment and chlorination of wastewater (Akin et al, EPA). Not nearly as fragile are the protozoans (usually encysted in sewage) and the

TABLE 1. Pathogens Potentially Present in Raw Domestic Wastewater[1]

Organism	Disease
BACTERIA	
Shigella (4 spp.)	Shigellosis (bacillary dysentery)
Salmonella typhi	Typhoid fever
Salmonella (1,700 spp.)	Salmonellosis
Vibrio chlorae	Cholera
Escherichia coli	Gastroenteritis
Yersinia enterocolitica	Yersinosis
Leptospira (spp.)	Leptospirosis
Campylobacter	Gastroenteritis
VIRUSES	
Enteroviruses (71 types)	Gastroenteritis, heart anomalies, meningitis
Hepatitis A virus	Infectious hepatitis
Adenovirus (31 types)	Respiratory disease
Rotavirus	Gastroenteritis
Reovirus	Not clearly established
Gastroenteritis virus (Norwalk-type)	Gastroenteritis
PROTOZOA	
Endamoeba histolytica	Amebiasis (amoebic dysentery)
Giardia lamblia	Giardiasis
Balantidium coli	Balantidiasis (balantidial dysentery)
HELMINTHS	
Ascaris lumbricoides	Ascariasis
Ancylostoma duodenale	Ancylostomiasis
Necator americanus	Necatoriasis
Ancylostoma (spp.)	Hookworm
Strongyloides stereoralis	Strongyloidiasis
Trichuris trichiura	Trichuriasis
Taenia (spp.)	Taeniasis
Enterobius Vermicularis	Enterobiasis
Echinoccoccus granulesis	Hydatidosis
Schistosoma mansonii	Schistosomiasis

1. Quality Criteria for Water Reuse, 1982

helminths (nematodes and cestodes) (Quality Criteria for Water Reuse, 1982). A large number of the protozoan cysts and helminth ova do settle out during the treatment process, otherwise the secondary level of treatment including disinfection is ineffective in their destruction. Heat, dessication and/or coagulation-filtration methods have been shown to be effective, but are not generally used in secondary treatment since waterborne outbreaks of these pathogenic agents are uncommon in the United States (Akin et. al., EPA).

Viruses are receiving the most attention relative to the other three groups of pathogens because of the enormous health risk associated with even small, undetectable viral densities and the difficulty in their removal or inactivation (Table 2). At present, over 70 serotypes of enteric viruses are commonly found in domestic sewage, numbering in total approximately 500 viral units/100 ml (Quality Criteria for Water Reuse, 1982; California State Water Resources Board, 1978). These numbers are low in comparison to coliform bacteria densities. The coliform to virus ratio is 92,000:1 in raw sewage and 50,000:1 in "polluted" surface water (California State Water Resources Board, 1978). The fact that viruses are protected by a protein sheath and are found within or absorbed onto particulate matter makes secondary treatment with chlorination variably effective with removal efficiencies ranging from 0 to 99% (Engelbrecht and Lund, 1975). Domestic wastewater intended for urban or agricultural irrigation must be treated to a tertiary level (chemical coagulation and

TABLE 2. Enteric Viruses Potentially Present in Water[1]

Virus Group	No. of Types	Disease Caused
Enteroviruses		
Poliovirus	3	Paralysis, meningitis, fever
Echovirus	34	Meningitis, respiratory disease, rash, diarrhea, fever
Coxsackievirus A	24	Herpangina, respiratory disease, meningitis, fever
Coxsackievirus B	6	Myocarditis, congenital heart meningitis, anomalies, rash, fever, respiratory disease, pleurodynia
New enteroviruses	4	Meningitis, encephalitis, respiratory disease, acute hemorrhagic conjunctivitis, fever
Hepatitis type A	1	Infectious hepatitis
Gastroenteritis virus	?	Epidemic vomiting and diarrhea, fever
Rotavirus	?	Epidemic vomiting and diarrhea, chiefly of children
Reovirus	3	Not clearly established
Adenovirus	30	Respiratory disease, eye infections

1. Adapted from World Health Organization, 1979.

filtration) prior to disinfection to minimize the health risk associated with viruses.

Chemical Contaminants

Synthetic organics and heavy metals are the chemical contaminants in water which have prompted foremost public health and environmental concern because of their potentially toxic effects at relatively low concentrations and a low-level understanding of their environmental fate and long-term health effects. The major groups of interest among synthetic organics are the solvents, phenols, herbicides, pesticides, and chlorination products (California State Water Resources Board, 1978). These compounds are a minute fraction of the total organic loads in domestic wastewater influent; and, with the exception of chlorination products, are generally present at trace levels (<1mg/l; Quality Criteria for Water Reuse, 1982). The presence of synthetics at these levels does not warrant special attention; however, concentrations of these compounds are highly variable in domestic sewage and should be monitored routinely (a brief description of the organic determinations made as part of a routine monitoring is provided in Appendix 2).

Secondary treatment systems employing biological processes (e.g. activated sludge) can remove 60 to 90% of the synthetics or trace organics (Englande and Reimers, 1979). This high variability in trace organic removal raises concern when the effluent is transmitted or disposed in a manner which allows contact with the public or potable water supplies. Domestic sewage should, therefore, be treated to, at minimum, a tertiary level to significantly decrease the organic load (>90% removal). A decrease in organic content also increases the effectiveness of disinfection and removal of viruses (Chauduri and Engelbrecht, 1970) even with a reduction in the amount of chlorine disinfectant used (Hart and Vogiatzis, 1982). Concomitant with reductions in organic content and chlorine usage is the decreased production of chlorinated hydrocarbons (e.g. chloroform, $CHCl_3$) which have known carcinogenic properties. A reuse system which has the potential to contaminate potable water supplies with chlorinated domestic effluent may be required by DER (Chapter 17-22, F.A.C.) to monitor and meet standards for chlorinated hydrocarbons as well as other specific classes of potentially hazardous organics, pathogens and metals.

Heavy metal concentrations are also highly variable in secondary treated domestic effluent (Quality Criteria for Water Reuse, 1982; California State Water Resources Board, 1978). Secondary treatment consisting of biological and chemical processes range from less than 30% to greater than 90% in removal efficiencies for a host of metals (Quality Criteria for Water Reuse, 1982). The variability is controlled largely by influent metal concentrations followed by redox potential, pH, and levels of sulfides or sulfates and organics with which complexation and precipitation of several heavy metals occur (U.S. Department of Health, Education, and Welfare, 1965; Berthouex and Rudd, 1977). Upgrading secondary systems to tertiary or advanced treatment levels may not significantly improve removal efficiencies because of the dynamic chemical behavior exhibited by several metals during all levels of treatment. The treatment process itself can affect metal toxicity and bioavailability and, possibly, increase effluent concentrations of such metals as cobalt during chemical precipitation processes (Graeser, 1975) and zinc (California State Water Resources Board, 1978). Health officials and agriculturalists, being particularly wary of a plant's high susceptibility to metal toxicoses, are interested in maximum reduction or removal of arsenic, lead, cadmium and mercury which have no known biochemical function; and in minimizing concentrations of, but not necessarily removing, boron (a metalloid), copper, manganese, molybdenum and zinc which do function as plant micronutrients within restricted concentration ranges..

Domestic effluent discharged to surface waters sensitive to eutrophication is often pre-treated to advanced levels for specific, maximum removal of total nitrogen (TN) and total phosphorus (TP). Efforts toward further removal of TN and TP beyond that accomplished by secondary treatment may be unnecessary for reuse and, in fact, undesirable if fertilizer costs can be cut by irrigation with nutrient-laden effluent. Accompanying the irrigation of such effluent is the monitoring of potential receiving waters, surface or subsurface, for possible build-up of nutrients, especially nitrogen (DER, Chapters 17-3 and 17-6, F.A.C.).

Slow-Rate Land Application

The philosophy of many land application design and operation publications is that the land, its soil and vegetation, can be an effective medium for the simultaneous treatment and disposal of sewage. This philosophy does have merit but is limited in scope. For protection of water resources, land application of treated effluent designed to satisfy consumptive demands while preserving and conserving natural water supplies is paramount to its utility as just a treatment and disposal mechanism. In this regard, and for the sake of health protection, the importance of pre-application treatment of wastewater should be emphasized in reuse planning. Otherwise, the aforementioned design publications do provide adequate information on the biogeochemical and hydraulic characteristics and considerations important to the operation of an effective and environmentally safe land application system. There are common considerations that are examined for all slow-rate application systems regardless of land use. These include site selection or design variables (Table 3) that determine effluent loading rates and influence the application method chosen which will provide adequate ground coverage and minimize human exposure. Other considerations are a systems management program consisting of land management for the preservation of the biogeochemical integrity of soils and of vegetative or crop productivity, and environmental monitoring.

Effective monitoring includes pre- and post-application analyses of the effluent (Table 4) and the soil substrate which is checked against an established set of chemical and

TABLE 3. Effluent[1] Application Site Selection or Design Variables and Remarks Concerning Slow-Rate Application (SR)[2]

Variables	Remarks
Climate	
Rainfall frequency analysis	All climatic variables are important in determining hydraulic loading rates and buffer zone area.
Wind speed and direction	Precipitation + effluent = ET + infiltration
ET, annual and monthly	
Relative Humidity	
Topography	
Slope	0 to 12% grade for SR erosion control, maintain nutritive benefits
Surface drainage pattern	Determine nature and degree of on-and off-site surface water impacts
Flood potential	High potential may exclude or limit application
Soils	
Texture	Clay loams to sandy loams or moderately fine to coarse
Infiltration capacity	High surface infiltration capacity/ rate
Soil depth	At least 1 meter without restrictive layers for SR
Chemical properties	
Vegetation	Sites with plants that have good nutrient uptake capacity and high soil moisture tolerance are preferred (i.e. forage and turf grasses).

TABLE 3. Effluent[1] Application Site Selection or Design Variables and Remarks Concerning Slow Rate Application (SR)[2] (cont'd)

Variables	Remarks
Ground Water	
Depth to water table	High water table may exclude or limit application (<1.2 meters is undesirable).
Subsurface permeability	Moderate permeabilities (1.5 to 5.0 cm/h)
Subsurface drainage pattern	Determine nature and degree of on- and offsite groundwater impacts
Chemical properties	

1. Disinfected, tertiary treated domestic wastewater.

2. Information in table are from following sources:

   EPA, March, 1978. Application of Sludges and Wastewaters on Agricultural Land: A Planning and Educational Guide. B.D. Knezek and R. H. Miller (eds.) Washington, D.C.

   EPA. October, 1981. Process Design Manual for Land Treatment of Municipal Wastewater, Cincinnati, Ohio.

TABLE 4. Recommended Routine Analyses (*) for Domestic Effluent[1] Applied to Urban or Agricultural Lands

Parameters	Urban	Agriculture[2]
Coliform Bacteria	*	
Enteric Viruses	*	
Total dissolved solids		If levels >1250 ppm are suspected
Total suspended solids	*	
Conductivity	*[3]	If levels exceeding specific crop requirements are suspected(2-4mmhos/cm at 25°C)
Chlorides		If levels exceeding specific crop requirements are suspected(200-1200 ppm)
Major cations (Ca, K, Mg, Na)		*
Boron		*
Heavy Metals	*	*
BOD_5	*	*
COD	*	*
Specific classes of industrial organics	*	If detectable levels are suspected
THM's (chlorination products)	*	
pH	*	*
Total phosphorus	If real potential for eutrophication exists	*
Total nitrogen	*	*
Nitrite-Nitrate	*	*
Ammonia	*	*

TABLE 4. Recommended Routine Analyses (*) for Domestic Effluent[1] Applied to Urban or Agricultural Lands (cont'd)

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1. Tertiary treatment with disinfection.

2. Approximate values listed are from the following sources:

   EPA, March 1978, Application of Sludges and Wastewaters on Agricultural Land: A Planning and Educational Guide. B.D. Knezek and R. H. Miller (eds.). Washington, D.C.

   Black, C.A. 1968. Soil-Plant Relationships, 2nd ed., John Wiley and Son, Inc. New York. 792 pp.

3. If conductivity is considered high, then levels of chlorides and major cations should be measured.

epidemiological standards for various land use applications. Nutrient requirements and safe levels of potentially toxic substances for specific vegetation or crops have been investigated, as have best management practices (e.g. seasonal and site-specific application rates) to prevent their build-up in soil and waters. This fact coupled with the long history of successful agricultural application systems nationwide raises the level of confidence for safe, successful agricultural reuse operations in Florida. However, no epidemiological standards have been formally adopted on any governmental level in Florida for specific types of nonpotable reuse systems; the most important being urban reuse for which pathogen control is a primary concern. Despite the lack of such pre- and post-application standards, several urban and agricultural reuse operations have been permitted to operate in Florida on a case-by-case basis. An overview of some of these operations is provided with a focus on the level of pre-application treatment and environmental effects.

St. Petersburg: An Urban Reuse Operation

A water conservation and reuse model for the country, St. Petersburg is operating a municipal landscape irrigation system using highly treated effluent from domestic WWTP's with deep well injection as back-up during malfunction or wet periods (DER Permit #DO52-33080). The quality of the combined effluent, maximum discharge of 20 MGD from the 4 facilities, approaches AWT quality - 3 mg/l TN, 1 mg/l TP, 5 mg/l BOD, and 5 mg/l SS (AWWA Seminar Proceeding, 1975; William Johnson, Director of Utilities for St. Petersburg, personal communication, 1984). The quality is achieved through biological treatment, multimedia filtration, chlorination, and 14 MGD aerated storage (AWWA Seminar Proceedings, 1975). Effluent is spray irrigated on approximately 3,000 acres which includes school, government and commercial properties, parks and golf courses. Soils are characterized as Immokalee acid sands (pH 4 to 5) with little silt or clay and some organic matter (Reichenbaugh et al, 1979). Routine water quality monitoring involves pre-application analyses of WWTP effluent and post-application ground water analyses by a series of test and control wells. The scheduling and rate of application are intended to sufficiently mitigate surface runoff.

The success of this reuse program is reflected in the city's water use from 1951 to 1983 (Figure 1). Potable consumption in St. Petersburg has stabilized since the first year of reuse operation (1977), despite an increase in population. In addition, one golf course has realized an annual 50% savings on fertilizer costs from effluent irrigation (AWWA, 1983).

Some potential effects on water quality from effluent application in St. Petersburg are summarized below.

Cherry, R.N., D.P. Brown, J.K. Staner, and C.L. Goetz, 1973.

1. High rates of application (4 to 11 in/wk on a 4 acre site) on these sandy soils do require subsurface drainage to prevent surface ponding or soil saturation.

2. The subsurface drainage (5 feet below surface) contained high levels of TN (6 mg/l) and TP (3 mg/l). Percolation through the sandy soils to the subsurface drains was too rapid to allow sufficient time for biogeochemical processes to reduce TN and TP to levels acceptable for surface water discharge.

Wellings, F.M., A.L. Lewis, and C.W. Mountain, 1974.

1. Secondary treatment plus disinfection does not yield virus-free effluent.

2. There were detectable levels of effluent virus in ground water samples taken at 5, 10, and 20 foot depths. This indicates that aeration and sunlight (spraying) and percolation through 20 feet of sandy soil are not totally effective in killing virus in secondary, chlorinated effluent.

3. Viral densities increased in ground water samples taken after heavy rains. It was hypothesized that an increase in solubilization of organic matter led to an increase in virus desorption.

Reichenbaugh, R.C., D.P. Brown, and C.L. Goetz, 1979.

1. Comparison of two grassy plots with sandy soils, one drained (drain tiles placed 5 feet below surface maintaining water levels at 3 feet below surface) and the other undrained, showed poor N removal for the drained plot relative to the undrained.

2. The subsurface drains apparently negated any impact to ground water quality below 5 feet; whereas, the undrained plot showed significant changes at 10 feet and below with increases in pH and TP, chlorides, and total coliform (no fecal coliform below 5 feet).

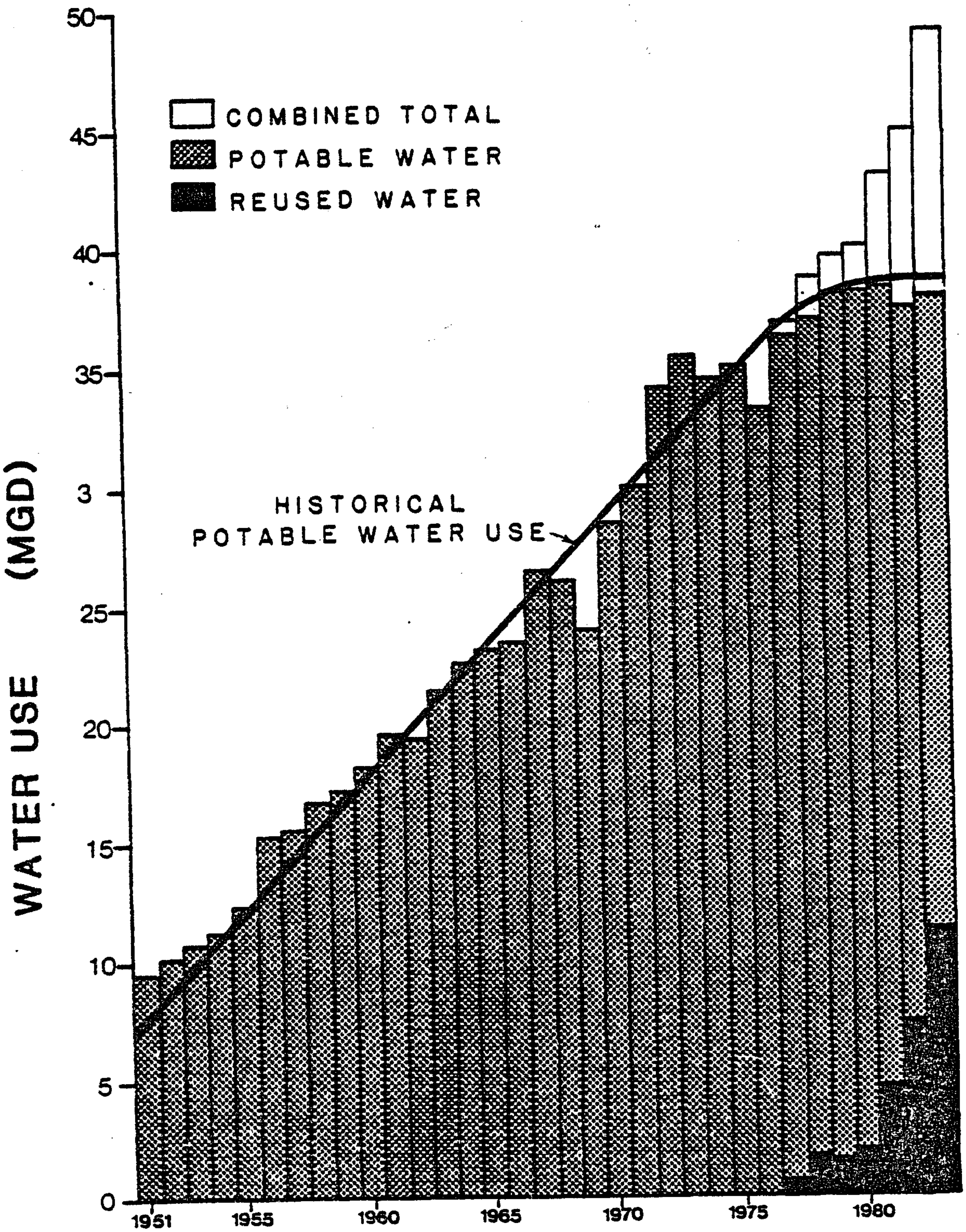

Figure 1. **ST.PETERSBURG RECORD OF WATER USE**
(Memorandum from W. D. Courser to Governing Board members of Southwest Florida Water Management District, March 1, 1984)

3. Ground water from the drained plot revealed an increase in nitrates, chlorides, and pH at the 5 foot depth, but organic N levels were less than pre-irrigation levels at all depths.

4. Down gradient from the drained plot, ground water chlorides increased with no significant change in pH, TP, or TN levels. Down gradient from the undrained plot, ground water chlorides and pH increased with no change in TP or TN levels.

5. Subsurface drains should be discouraged in areas with sandy soils. The pH of the effluent should approximate the application site ground water pH (an increase in pH may cause solubilization of soil humates thereby releasing P). An irrigation rate of 4 in/wk is maximum in the St. Petersburg area.

Water Conserv II: A Cooperative Water Conservation Effort by Orlando, Orange County and Citrus Growers (Rice, K.C. et. al., 1984 and Boyle Engineering Corp., 1983)

The Conserv II project, operational in its first phase by mid-1984, is designed to distribute 50 MGD of tertiary treated effluent over 12,000 to 15,000 acres of citrus underlain by moderately to excessively well-drained soils. The use of this reclaimed water for citrus production and the system design itself solves several problems:

1. In compliance with the requirement for zero discharge into Lake Tohopekaliga by 1988, the McLeod Rd. WWTP (Orlando) and the Sand Lake Rd. WWTP (Orange County) will redirect their effluent discharges from Shingle Creek, a tributary to the lake, to the west county area as combined effluent for citrus irrigation.

2. The combined effluent is expected to be a dependable, "inexhaustible" source for the citrus growers. This is particularly important during periods of drought, as an aid to freeze protection, and as a means to reduce withdrawals from the Floridan.

3. Cost savings should be realized by the growers in terms of energy (no need for pumped withdrawals from ground water sources) and fertilizer applications.

4. The distribution system includes rapid infiltration basins (RIB's) which will serve as a disposal alternative when irrigation demand is low, a supply when demand is high, and as an aquifer recharge mechanism.

Treatment consists of conventional activated sludge followed by alum flocculation, filtration and chlorine disinfection.

Pilot testing and various analyses indicate good treatment effectiveness in reducing contaminants within DER's effluent quality criteria for the project (90% removal BOD_5, 5 mg/l SS, 1 mg/l combined chlorine residual after 15 min., and nondetectable fecal coliforms and viruses). Agronomic analyses show safe levels of potentially toxic substances with the possible exception of boron (1.0 mg/l reported). An irrigation rate of 1 in/wk will augment the annual average of 52 inches of rainfall by 48 inches (or 100 in/yr total).

Leesburg: An Agricultural Reuse Operation (Conference on Reuse and Protection of Florida's Water, 1984).

A secondary treatment facility (DER #3035M00571 in WWTP inventory), employing an activated sludge process, applies 2.5 MGD of chlorinated effluent to 320 acres at an average rate of 2 in/wk. The application site, approximately 8 miles from the WWTP, produces Coastal Bermuda grass regularly harvested for use by local cattle ranchers and dairy farmers.

Altamonte Springs: Project APRICOT, A Prototype Realistically Innovative Community of Today (Gilbertson, 1984; Newnham, 1983).

Presently in the planning stage, this project's objective is to provide effluent from the municipal WWTP for landscape irrigation, fire protection, lake level control, and by transmission via a "dual plumbing system" for toilet tanks, laundry facilities, and car washing. It is planned to increase the WWTP design capacity from 7.5 to 10 MGD with reclaimed water useage peaking at 5.0 MGD. The effluent is treated to AWT standards with additional chemical coagulation/sedimentation (alum) and filtration.

Cocoa Beach: An Urban Reuse Operation (Hart, 1984; Hart, D., Asst. Supt., Cocoa Beach WWTP, Personal Communication, February, 1985).

The municipal secondary WWTP (DER #3005M00413) underwent expansion in 1980 to double its design capacity to 6.0 MGD and upgrade treatment processes to a tertiary level. Upgrading included additional digester capacity, dissolved air flotation unit, automatic backwash sand filters. A portion of the effluent is disposed on a local golf course at nearly 3/4 in/wk on 125 acres. The remainder is discharged to polishing ponds on the golf course before entering the Banana River.

STATE REGULATIONS AND STANDARDS

Department of Environmental Regulation

Chapter 17-40, F.A.C., expresses the importance for DER and the District to coordinate their efforts toward development and execution of water policy programs and rules. Chapter 17-40.03, F.A.C., states, "Water management programs, rules and plans.... shall seek to promote water conservation...and the use and reuse of water of the lowest acceptable quality for the purpose intended.". However, DER regards conservation of water quantity as a secondary benefit when evaluating reuse as a disposal method for WWTP's; the primary concern being protection of environmental quality and public health. According to Chapter 17-6, F.A.C., reuse is perceived solely as a land application disposal/treatment method. A minimum level of pre-application treatment is required by DER for land application (17-6.060 and 17-6.080), but more advanced treatment may be required for the protection of public health and water quality (17-6.040 and 17-6.080).

Pre-application treatment for slow-rate application in areas where public access is "restricted" (e.g. some agricultural lands) shall result in an effluent meeting, at minimum, a secondary and basic disinfection level of quality. The minimum level of pre-application treatment for slow-rate land application with unrestricted public access is stated in the technical manual, Land Application of Domestic Wastewater Effluent in Florida (1983) as referenced by Section 17-6.040(4)(q), F.A.C.:

> "...waste treatment more stringent than secondary shall result in an effluent prior to land application containing..."

1) Not more than 20 mg/l BOD or 90% removal of BOD, whichever is more stringent; and not more than 5 mg/l TSS after appropriate disinfection and pH control.

2) No detectable fecal coliforms (high-level disinfection criteria); however, as an alternative, other methods for insuring protection from virus may be approved by the department.

Additional requirements by the State to be met prior to and during operation of slow-rate application systems are:

1) Buffer zones - A minimum of 500 feet shall be maintained between land application site and existing or future shallow water supply wells or Class I or II waters. The minimum distance may be reduced to 200 feet for restricted public access if Class I reliability is provided (Land Application of Domestic Wastewater Effluent in Florida, 1983).

2) Subsurface drainage - The system must..."provide for 36 inches of unsaturated soil thickness during the time when irrigation is not practiced...". To accomplish this, an underdrain system may be installed; however, the underdrain effluent..."may be restricted by surface water quality considerations pursuant to additional treatment" (Land Application of Domestic Wastewater Effluent in Florida, 1983).

3) Ground water quality - "...land application shall not result in further degradation of background water quality." [17-6.080(3)(d)]. Land application effluent reaching subsurface aquifer shall be free from "man-induced substances" which pose a danger to indigenous organisms, the public health and welfare, or contaminate adjacent waters (17-3.402).

4) Aerosol drift - No land application operation shall be permitted within 100 feet of outdoor eating, drinking, or bathing facilities [17-6.180(2)(j)].

5) Agricultural applications - a. Inactivation or removal of all pathogens is required prior to effluent application to crops intended for direct human consumption. b. Dairy cattle may not graze on an effluent-irrigated pasture until 15 days after application.

Department of Health and Rehabilitative Services

The DHRS has no policy or set of environmental or epidemiological regulations and standards for reuse operations. The department's Epidemiology Research Center in Tampa has provided assistance to DER's promulgation of rules and standards for land application of wastewater. Dr. Flora M. Wellings (personal communication, 1984), the authoritative voice at the Center, is concerned with the use of secondary treated effluent in "remote" areas, the minimum level of treatment accepted by DER. It is her opinion that pre-application treatment should be upgraded to tertiary or AWT standards with a restriction on viral densities to below detectable limits for all land application systems.

ASSESSMENT OF DIRECT REUSE POTENTIAL IN THE DISTRICT

WWTP Distribution and Description

The basis for this part of the assessment includes the District WWTP inventory (Table 5), developed from DER's Ground Water Pollution Source Inventory and additional information from DER, local environmental agencies, and WWTP managers, and the geographical locations of these inventoried facilities (Figure 2).

Domestic treatment plants with a design capacity of 1.0 MGD or greater are confined to the most densely populated urban areas. Baker, Bradford, Osceola, Okeechobee and Polk counties do not have WWTP's within District boundaries that meet the design capacity requirement. Therefore, these five counties have very low potential for reuse on a major scale and, consequently, are eliminated from further evaluation. The south District region, consisting of Volusia, Marion, Lake, Seminole, Orange, Brevard, and Indian River counties, claims 45 of the 66 WWTP's inventoried which translates to 63% of the total design capacity of 255 MGD for all inventoried facilities. This percentage closely reflects the population distribution in the District, 61% of the total residing in the south District counties (Marella and Ford, 1983). According to population projections (Marella and Ford, 1983) the south District region will continue to handle the bulk of the domestic effluent over the next 30 years; the volume of which will increase most dramatically in Seminole followed by Orange and Volusia counties.

TABLE 5. Inventory of Domestic Wastewater Treatment Plants with a Design Capacity of 1 MGD or Greater in the St. Johns River Water Management District

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This inventory is an index to the map (Figure 2) showing locations of these facilities. The WWTP numbers on the left margin correspond to the numbered symbols on the map designating facility location and ownership within each county. The two series of ten-digit numbers are the SJRWMD and DER codes, respectively, defining each WWTP listed. General treatment method, effluent discharge site, and DER surface water discharge restrictions (ND = no discharge; WLA = wasteload allocations defined or pending), if available, are provided below for each facility. The SJRWMD code is explained in Appendix 1.A.

ALACHUA

1. 0110730506 310M01665 Gainesville (Kanapaha WWTP)
AWT to Recharge Well; WLA.

2. 0110930509 3101M00222 Gainesville
Trickling filter to Sweetwater Branch and Paynes Prairie (Alachua Sinkhole); WLA.

3. 0110330509 3101S00709 Gainesville
Contact Stabilization with Trickling Filters to L. Alice; No Loading Limitations Required.

BREVARD

1. 0510330509 3005M00201 Melbourne
Activated Sludge and Trickling Filter (High Rate) to Crane Cr.; ND.

2. 0510130505 3005M02329 W. Melbourne
Contact Stabilization with Tertiary Filter to Polishing Pond then Indian R.; ND.

3. 0510330509 3005M00200 Melbourne
Activated Sludge and Trickling Filter to Eau Gallie R.; ND.

4. 0510230505 3005P02746 Palm Bay
Contact Stabilization with Polishing Pond to Indian R.; ND.

5. 0510130505 3005C00208 Indian Harbor Bch.
Contact Stabilization to Perc./Evap. Ponds; ND.

6. 0510230509 3005C02319 Satellite Bch.
Complete Mix to Polishing Ponds then Indian R.; ND.

TABLE 5. (Continued)

7. 0510330507 3005C02330 Melbourne Bch.
Contact Stabilization to Sprayfield and Indian R.; ND.

8. 0510130509 3005F00128 Patrick AFB
Conventional Activated Sludge to Banana R.; WLA.

9. 0510130509 3005F00135 Patrick AFB
Conventional Activated Sludge to Banana R.; WLA.

10. 0510630509 3005M00413 Cocoa Bch.
Contact Stabilization with Filtration and Nutrient Removal, to Golf Course and Banana R.; WLA.

11. 0510230509 3005M00302 Rockledge
Anaerobic/Aerobic Process to Indian R.; WLA.

12. 0510230509 3005M01167 Cocoa
Activated Sludge to Indian R.; WLA.

13. 0510230509 3005M01158 Cape Canaveral
Oval Oxic/Anoxic to Banana R.; WLA.

14. 0510230509 3005M01162 Titusville
Activated Sludge to Indian R.; WLA.

15. 0510130509 3005M00336 Titusville
Complete Mix with Chlorination to Indian R., WLA.

CLAY

1. 1010130509 3110M01826 Orange Pk.
Contact Stabilization to St. Johns R.; WLA.

2. 1010430509 3110P05475 Orange Pk.
Extended Aeration to St. Johns R.; WLA.

DUVAL

1. 1610230509 3116F00252 Mayport USN
Activated Sludge with Chlorination to St. Johns R.; WLA.

2. 1610330509 3116F00260 Jax NAS
Activated Sludge and Oxidation Pond to St. Johns R.; WLA.

3. 1610330509 3116M00293 Jacksonville Bch.
Contact Stabilization to St. Johns R. ICWW/Golf Course; WLA.

4. 1610130509 3116M00314 Ft. Caroline
Contact Stabilization to St. Johns R.; WLA.

5. 1610130509 3116M00473 Atlantic Bch.
Contact Stabilization to Pablo Cr.; WLA.

TABLE 5. (Continued)

6. 1613530509 3116M01973 Jacksonville (Buckman)
Activated Sludge to St. Johns R.; WLA.

7. 1610530509 3116M05144 Jacksonville, S.W. Dist.
Diffused Air or Pure O_2 Complete Mix to St. Johns R.; WLA.

8. 1610230509 3116M04537 Jacksonville, Cedar Hills
Activated Sludge and Trickling Filter to Cedar R.; WLA.

9. 1610430509 3116P01316 Jacksonville, Monterey
Extended Aeration to St. Johns R.; WLA.

10. 1610130509 3116P01970 Jacksonville Hgts.
Activated Sludge with Nitrification and Chlorination to Ortega R.; WLA.

11. 1610230509 3116P05360 Jacksonville, Royal Lakes
Contact Stabilization with Auto Backwash-Sandfilter to St. Johns R.; WLA.

FLAGLER

1. 1810230507 3118P01697 Palm Coast
Extended Aeration to Polishing Perc. Pond to Spray Field.

INDIAN RIVER

1. 3110430509 5131M03103 Vero Bch.
Activated Sludge with Chlorination to Indian R.; WLA.

LAKE

1. 3510330505 3035M00571 Leesburg
Activated Sludge to Polishing Pond and Land Application; ND.

2. 3510230505 3035M00920 Eustis
High Rate Trickling Filter to Perc. Pond and Spray Irrigation; ND.

MARION

1. 4210230505 3042M01125 Ocala
Trickling Filter to Perc. Ponds.

2. 4210430505 3042M03535 Ocala
Contact Stabilization with Perc./Evap. Ponds and Spray Field.

TABLE 5. (Continued)

NASSAU

1. 4510230509 3145M01839 Fernandina Bch.
Contact Stabilization and Chlorination to Amelia R., WLA.

ORANGE

1. 4810230505 3048C00334 Orlando
Carrousel Oxidation Ditch Treatment to Perc. Ponds.

2. 4810130507 3048C00335 L. Buena Vista
Step Aeration, Filtration, and Hi Level Disinfection.

3. 4810130509 3048C00545 Orlando
Contact Stabilization to Ditch to Little Econ; ND.

4. 4810130509 3048C03717 Orlando
Contact Stabilization to Impoundments and Ditch to Little Econ; ND.

5. 4810230505 3048M01387 W. Garden
AWT with N and P Removal to Impoundments, Marsh and L. Apopka; ND.

6. 4810230507 3048M01915 Apopka
Complete Mix Activated Sludge to Holding Tank and Land Application.

7. 4810130505 3048P00279 Ocoee
Contact Stabilization to Perc. Ponds.

8. 4811530505 3048P04600 Orlando
Extended Aeration to Impoundments and Land Application.

PUTNAM

1. 5410230509 3154M01836 Palatka
Contact Stabilization to St. Johns R.; WLA.

ST. JOHNS

1. 5510230509 3155M00811 St. Augustine
Complete Mix Activated Sludge to Matanzas R.; WLA.

2. 5510330509 3155M00939 St. Augustine
Complete Mix Activated Sludge to Matanzas R.; WLA.

SEMINOLE

1. 5910130507 3059C01810 Casselberry
Activated Sludge to Spray Field and Impoundments.

2. 5912430509 3059M00254 Oviedo (Iron Bridge)
AWT with Rotating Bio. Disc to Econ R.; WLA.

TABLE 5. (Continued)

3. 5910630509 3059M01119 Sanford
Activated Sludge and Complete Mix to L. Monroe; ND.

4. 5910830509 3059M01771 Altamonte Spgs.
AWT to Little Wekiva R.; WLA.

5. 5910130505 3059M02641 Casselberry
Contact Stabilization to Perc./Evap. Ponds; ND.

6. 5910230505 3059P02840 Lake Mary
Contact Stabilization to Impoundment.

7. 5910230509 3059003243 Longwood
Contact Stabilization, Partial Discharge to Underdrain, To Sweetwater Cr.; WLA.

8. 5910130507 3059P10286 Winter Spgs.
Contact Stabilization to Spray Field Via Pond.

9. 59102_ _ _05 3059P97824 Altamonte Spgs.
Impoundment (Incomplete Description); WLA.

VOLUSIA

1. 6410130509 3064M00704 Holly Hill
Contact Stabilization with Chlorination to Halifax R.; WLA.

2. 6411230509 3064M00707 Daytona Bch., Bethune
Contact Stabilization to Halifax R.; WLA.

3. 6410630509 3064M01776 Port Orange
Activated Sludge to Rose Bay then Halifax R.; WLA.

4. 6410430509 3064M01788 Ormond Bch.
Activated Sludge to Halifax R.; WLA.

5. 6411030509 3064M02142 Daytona Bch. W.
Activated Sludge with 75% Nitrification and Tertiary Filters to Halifax R. and Golf Course; WLA.

6. 6410130509 3064M01435 Edgewater
Extended Aeration and Nitrification to Indian R.; WLA.

7. 6410430509 3064M01531 New Smyrna Bch.
Complete Mix Activated Sludge to Indian R., Ponce De Leon Inlet; WLA.

8. 6410430509 3064M06162 Deland
Activated Sludge to St. Johns R.; WLA.

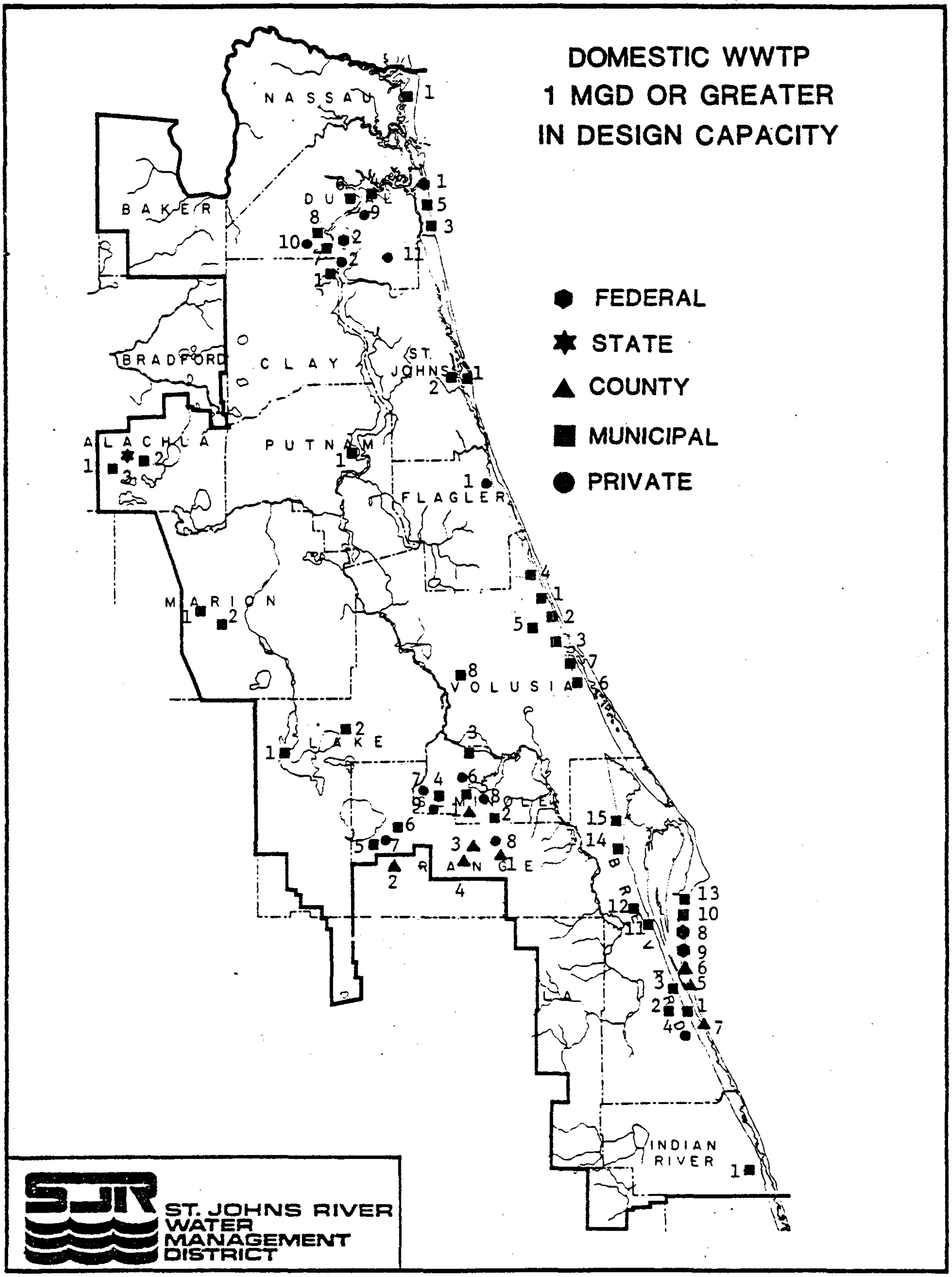

Figure 2. Location of WWTP's listed in the District Inventory. More accurate locations are provided on county DOT maps.

Duval County heads the list of effluent dischargers with a combined maximum outflow of 59 MGD or 23% of the cumulative discharge from all plants inventoried. Duval's eleven major plants dispose their effluent to surface waters, with the St. Johns River being the direct or eventual recipient. In fact, 91% of the maximum potential outflow of 94 MGD from the major plants in the north District region (Nassau, Duval, Clay, St. Johns, Putnam, Alachua and Flagler counties) is discharged to surface waters. In the south District region, a smaller percentage, 70% of the total outflow, is discharged to surface waters. The remainder is disposed in percolation/evaporation ponds or by land application. This discrepancy in regional percentages is simply due to the fact that, as a result of DER "zero discharge" directives and pressure from other environmental organizations, a significant number of major plants in the southern region have either adopted or will adopt other disposal methods as an alternative to surface water discharge. Most facilities in the north District region, however, have no such impetus to redirect effluent from surface waters since they are permitted by DER to continue within specified wasteload allocations (WLA) or some effluent quality limitations.

There are 12 major WWTP's in the District which utilize slow-rate land application solely or in combination with another disposal method. Five of these can be classified as water reclamation plants because a portion, if not all of their effluent, is used in a direct reuse capacity (Table 6).

TABLE 6. MAJOR DOMESTIC WASTEWATER TREATMENT PLANTS PRESENTLY ENGAGED IN DIRECT WATER REUSE

COUNTY	WWTP# AND LOCATION	APPLICATION SITE	EFFLUENT USE (MGD)[2] FOR IRRIGATION
Brevard	7. South Bchs.	Golf Course	0.75
	10. Cocoa Bch.[1]	Golf Course	0.30
Duval	3. Jax Bch.	Golf Course	0.15
Lake	1. Leesburg[1]	Agriculture	2.50
Volusia	5. Daytona Bch.,W.	Golf Course	0.85

1 Brief description of reuse operation provided in preceding section on slow-rate land application.
2 DER Ground Water Pollution Source Inventory, 1984.

Two other plants, the Altamonte Springs AWT and South Beaches Plant, are planning to shunt effluent to residential/commercial communities mostly for lawn irrigation. The Eustis plant will be spray irrigating grass fields, regularly harvested for cattle feed, as is being done in Leesburg.

With respect to DER's minimum pre-application treatment requirement, nearly all WWTP's inventoried can provide an effluent adequate for most agricultural operations and, with the addition of a tertiary treatment process prior to disinfection, for most urban landscapes. Thus, reuse is technologically feasible but the main limiting factors for its implementation in various areas in the District are hydrologic factors, most importantly, potable water supply and use.

Potable Water Supply and Use

Areas in the District which have sufficient potable water supplies for present and projected needs and, currently, have relatively low rates of water consumption include all of Alachua, Clay, and Nassau counties, a majority of Putnam and Marion counties (excluding their easternmost areas) and the northern portion of St. Johns County (Frazee and McClaugherty, 1980; SJRWMD, Water Resources Dept. Map Series 10; Marella, 1984). Total water consumption for these areas is less than 17% of the District total (Marella, 1984); and the quality of this supply, predominantly ground water, is excellent (Figure 3). These areas have no incentive to implement reuse as a conservation method (Figure 4), or as an effluent disposal alternative since the major WWTP's are permitted to discharge to surface waters (except the Kanapaha plant in Gainesville, an AWT-Floridan aquifer disposal system). Additionally, Alachua, Putnam, Clay and Marion counties contain areas in which the shallow aquifer is the primary potable water supply and potential recharge of the Floridan aquifer is high (Figures 5 and 6). These characteristics dictate the need for stringent effluent quality standards and monitoring controls if land application is used.

Duval County and the south District counties of Lake, Orange, and Seminole have potable ground water supplies of sufficient quantity to meet high and increasing rates of consumption (Water Resources Dept. Map Series 10; Marella, 1983 and 1984). Nevertheless, water conservation measures are encouraged in these three south District counties. Reuse, as one of these measures,

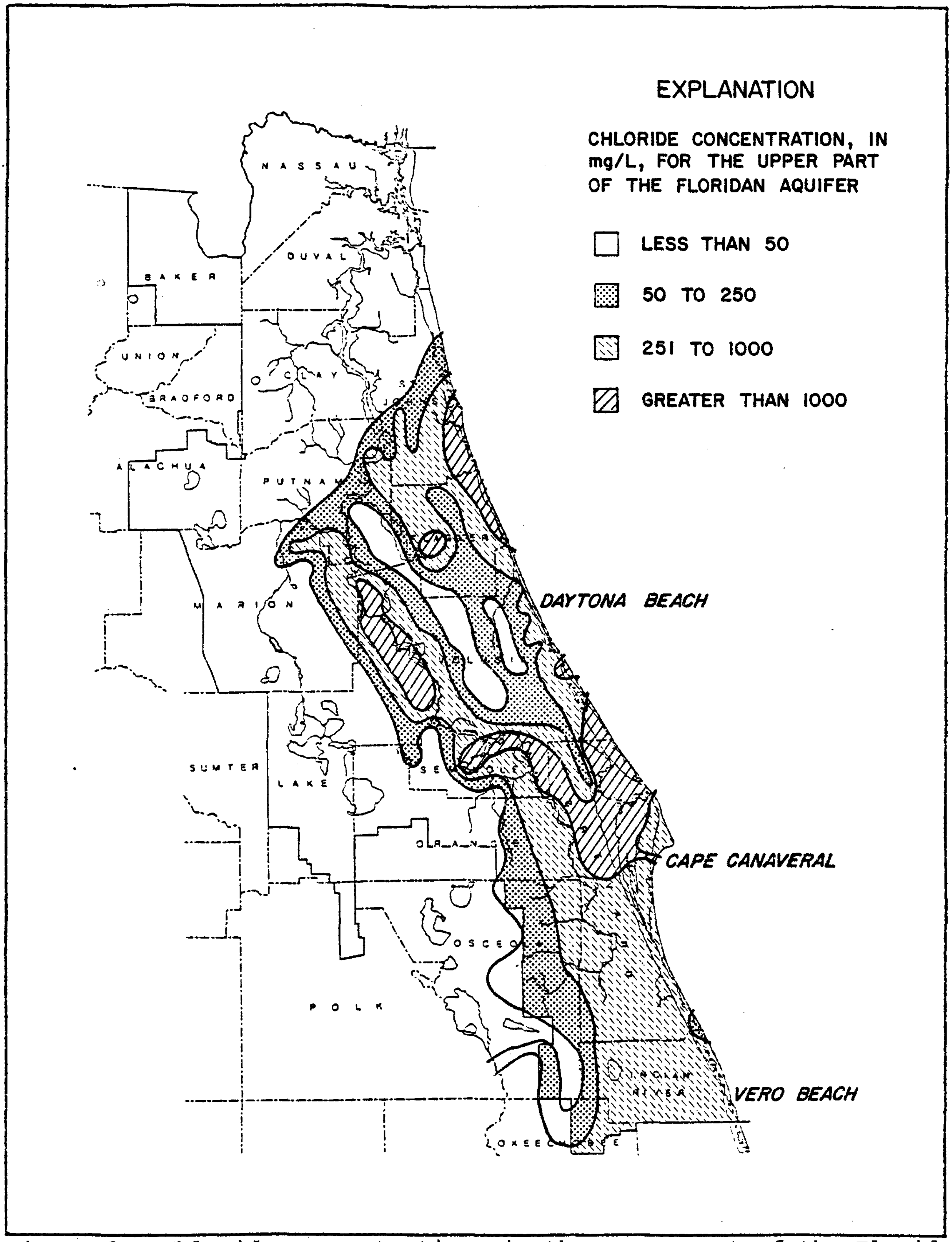

Figure 3. Chloride concentrations in the upper part of the Floridan aquifer (Johnson, R. et al, 1981). Potable waters shall not exceed a chloride concentration of 250 mg/l (DER, Chapter 17-3, F.A.C.).

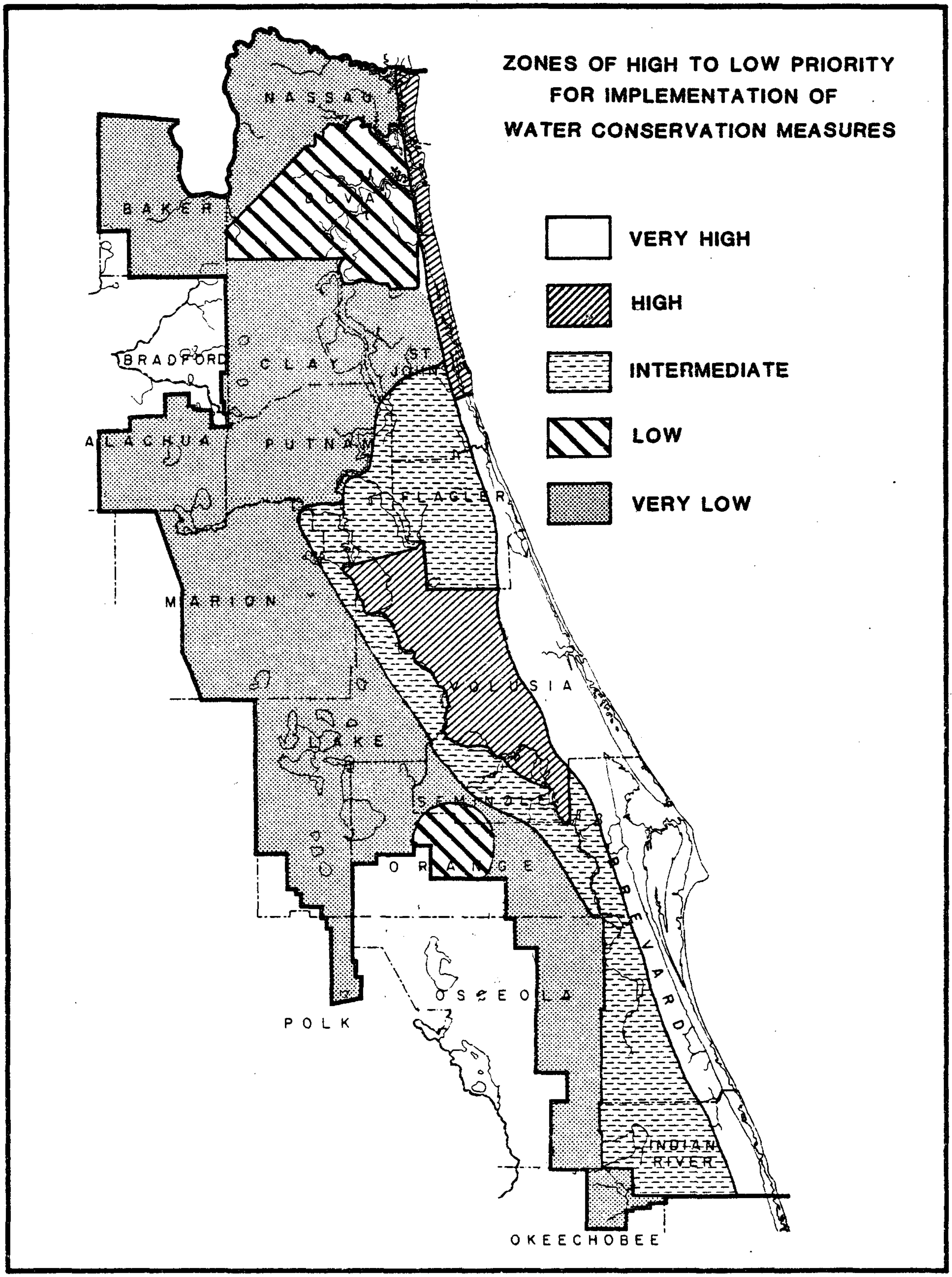
ZONES OF HIGH TO LOW PRIORITY
FOR IMPLEMENTATION OF
WATER CONSERVATION MEASURES
VERY HIGH
HIGH
INTERMEDIATE
LOW
VERY LOW
NASSAU
BAKER
DUVAL
BRADFORD
CLAY
ST JOHNS
ALACHUA
PUTNAM
FLAGLER
MARION
VOLUSIA
LAKE
SEMINOLE
ORANGE
BREVARD
OSCEOLA
POLK
INDIAN RIVER
OKEECHOBEE

Figure 4.

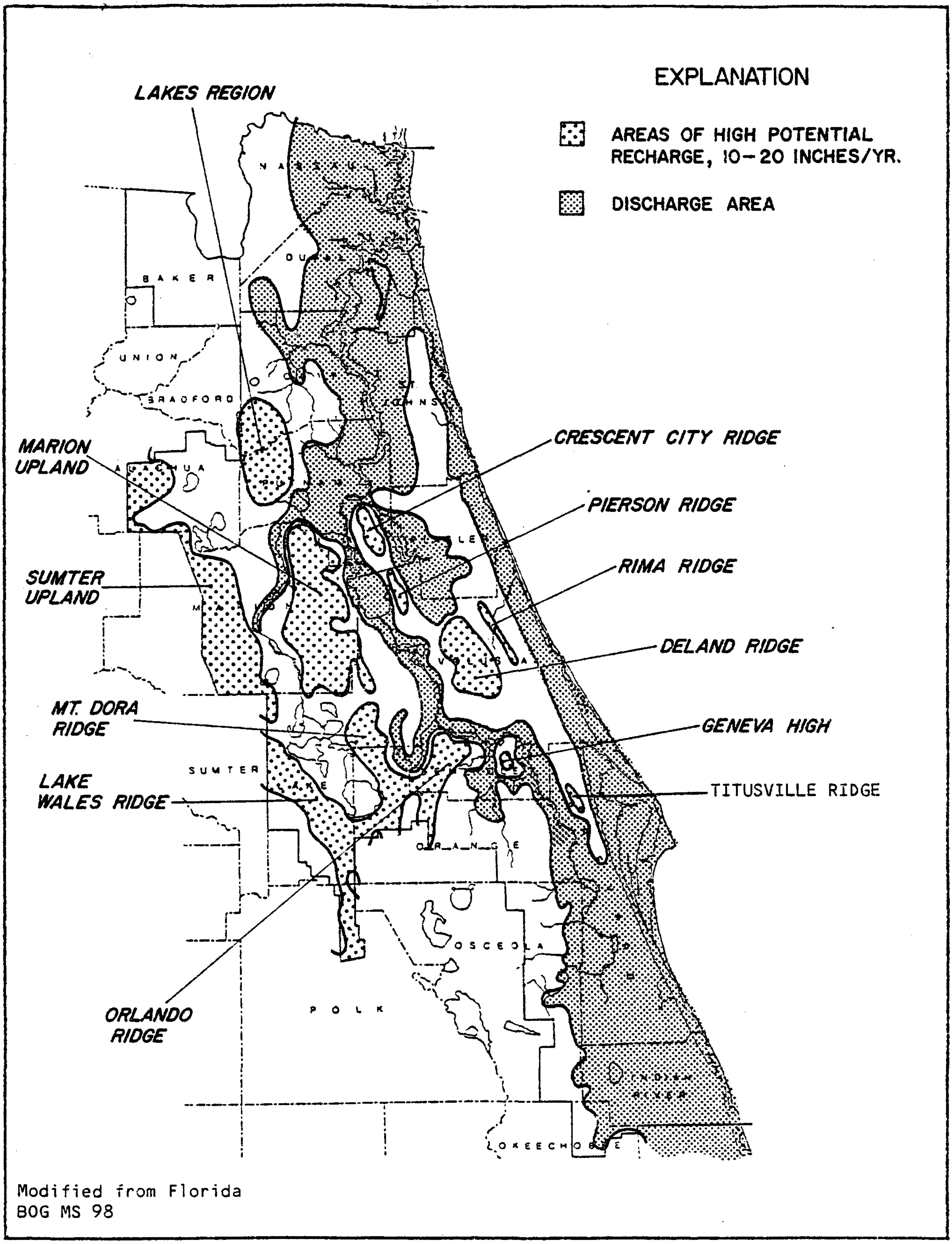

Figure 5. Areas of high potential recharge and discharge of the Floridan aquifer (Johnson, R. et al, 1981).

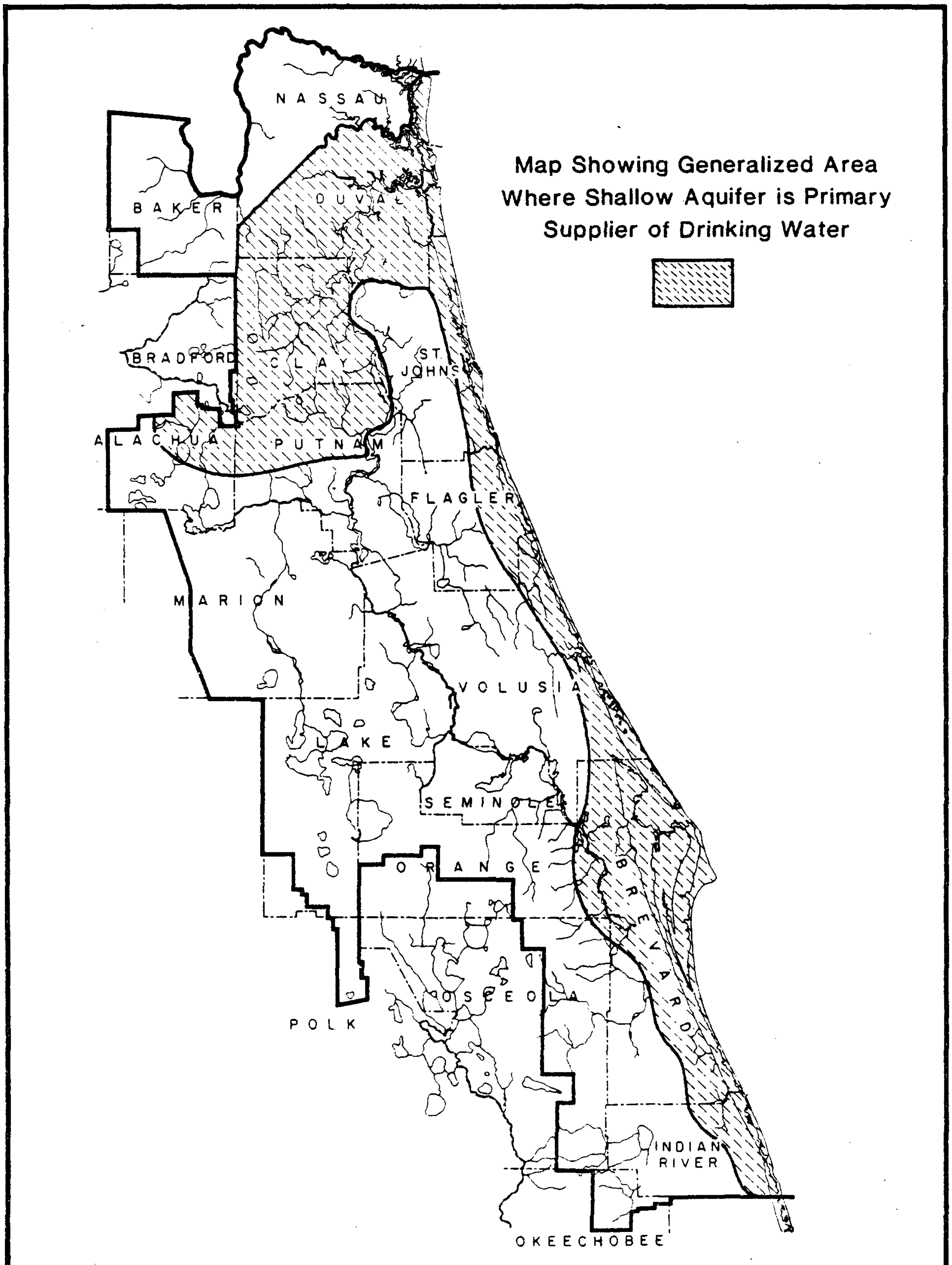

Figure 6. Map was conceived during initial phase of a well monitoring network project requested by DER (Dewey, D., Division of Resource Evaluation, SJRWMD, 1984).

is becoming more attractive since it also serves as an alternative to surface water discharge which is largely restricted in Lake, Orange, and Seminole counties. Duval, like its neighboring counties, have not been pressured to consider alternatives to surface water disposal nor to actually pursue water conservation measures (Figure 4).

Conservation measures deserve highest consideration in the coastal zone, especially the area extending from St. Johns County southward to the District boundary (Figure 4). This area is experiencing heavy population growth (Marella and Ford, 1983) with very limited potable water supplies (Water Resource Dept. Map Series 10, Figure 3). The coastal counties of Volusia and Brevard have great direct reuse potential because of limited potable sources and on the number and distribution of their major WWTP's (Figure 2). South Brevard County has shown considerable interest in direct reuse as an effluent disposal method since the main receiving waters, the Banana and Indian rivers in the Melbourne area, are restricted from WWTP discharge.

Based on this study's evaluative criteria and the preceding information, the highest direct reuse potential is found in the south District counties of Lake, Orange, Seminole, Volusia, Indian River, and Brevard (Figure 7). Lake County is included because effluent from its only two major WWTP's (Table 5) are intended for agricultural irrigation.

Generally, agricultural irrigation with domestic effluent is preferred over urban because of the expansive acreage available for adequate dispersal, public exposure is low, and the soil and

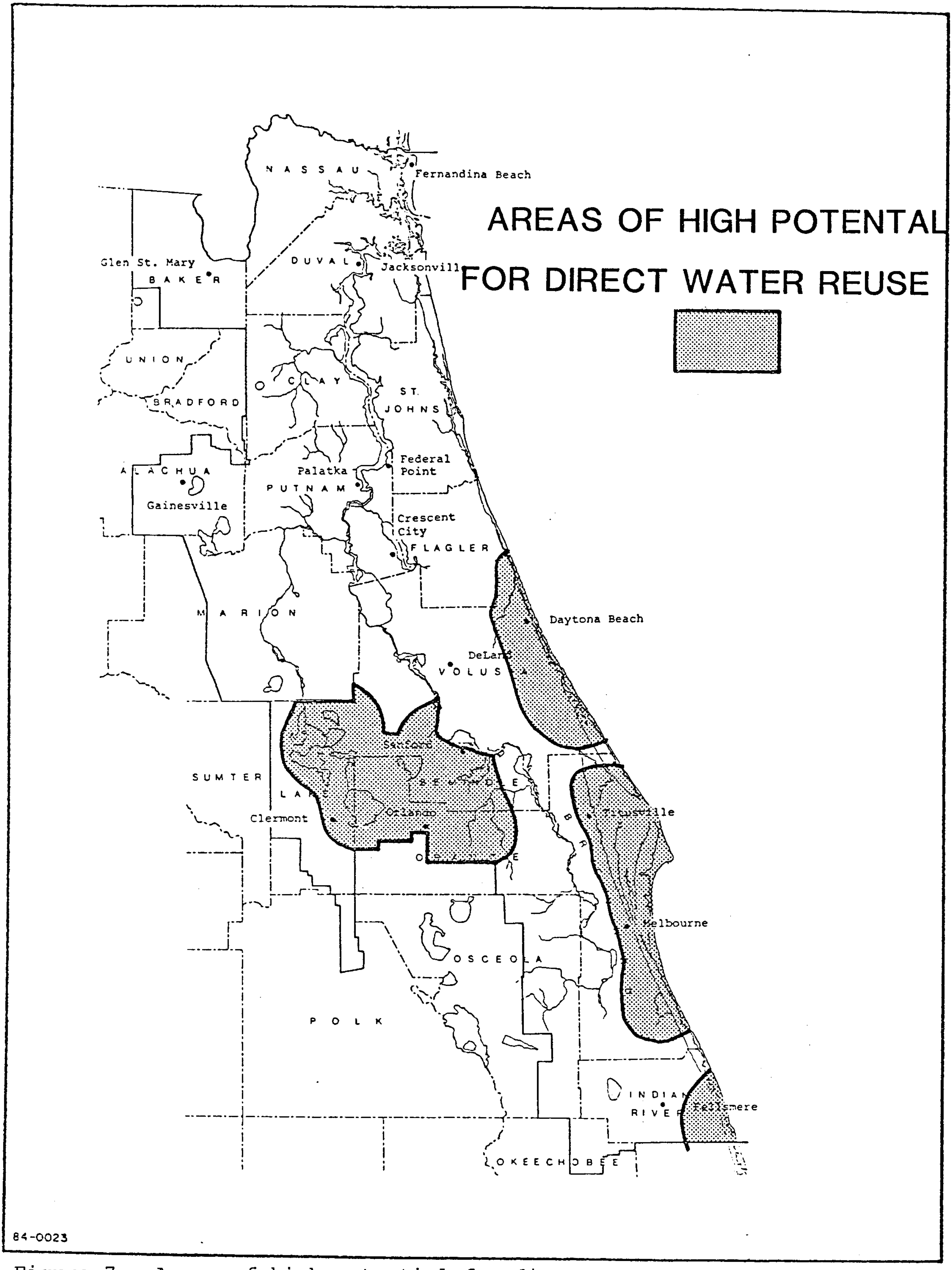

Figure 7. Areas of high potential for direct water reuse. Assessment is based on the criteria stated in the methodology, p. 3.

crop management routine exercised by most farmers can usually accommodate a controlled effluent application rate. In terms of irrigated acreage and possible sites for effluent application, improved pasture and citrus are the predominant agriculture within a 10 mile vicinity of the inventoried WWTP's in Orange, Seminole, Brevard, and Indian River counties (refer to Appendix 3 for a more detailed summary of various agriculture lying within 10 miles of individual WWTP's). In Volusia County, the availability of irrigated agricultural lands is low, but not so with urban landscapes. In contrast, the only major facility in Indian River County (Vero Beach) is virtually surrounded by citrus. The irrigation rates are so high (Marella, 1984) that even full effluent discharge of 4 MGD from this municipal plant could only contribute 5 to 10% of the daily demand; but it may provide a constant supply during drought or for freeze protection. Regardless of the type of direct reuse used, land application of effluent in the coastal areas will require additional safeguards to protect the surficial aquifer, the primary potable water supply (Figure 6). Seminole and Orange counties may pursue either urban or agricultural reuse. Both types of land use are available and the average daily water consumption rate of each are comparable (Marella, 1984).

Ultimately, direct reuse potential may be limited by environmental factors such as soil characteristics, depth to water table, and proximity of application site to surface waters. There is considerable acreage in Seminole and Orange counties in which the low-permeable nature of the soils and/or the fluctuating water table (USDA, 1969) may not be conducive to effluent application. In fact, one of the major discharge areas in the District extends southward from the Volusia coastal and middle St. Johns River basin through most of Brevard and Indian River counties. This area consists of either sandy soils with a water table that normally fluctuates 0 to 30 inches below the surface or organic soils that, if not artificially drained, are frequently saturated (USDA, 1969).

Brevard County

Brevard County's daily water use in 1983 averaged 258 million gallons, the second highest among all counties in the District (Marella, 1984). At most, less than 12% of this demand may be satisfied by reclaimed water useage if all 15 major WWTP's in the county contributed their total effluent discharge (Figure 8, Table 5). Environmentally, the main limiting factors for direct reuse application sites in Brevard are soil type, depth to water table and potential for ground water contamination. The sand ridge soils of Brevard (Figure 9) are most conducive to effluent spray irrigation because of its sandy texture, relatively high infiltration capacity and low water table (approximately 60 inches below surface, USDA, 1969). Other soil regions in the county are generally poorly drained and have high water tables (0 to 30 inches, USDA, 1969).

Land use on the sand ridges is mostly urban, whereas agriculture is a major land use in the other soil regions.

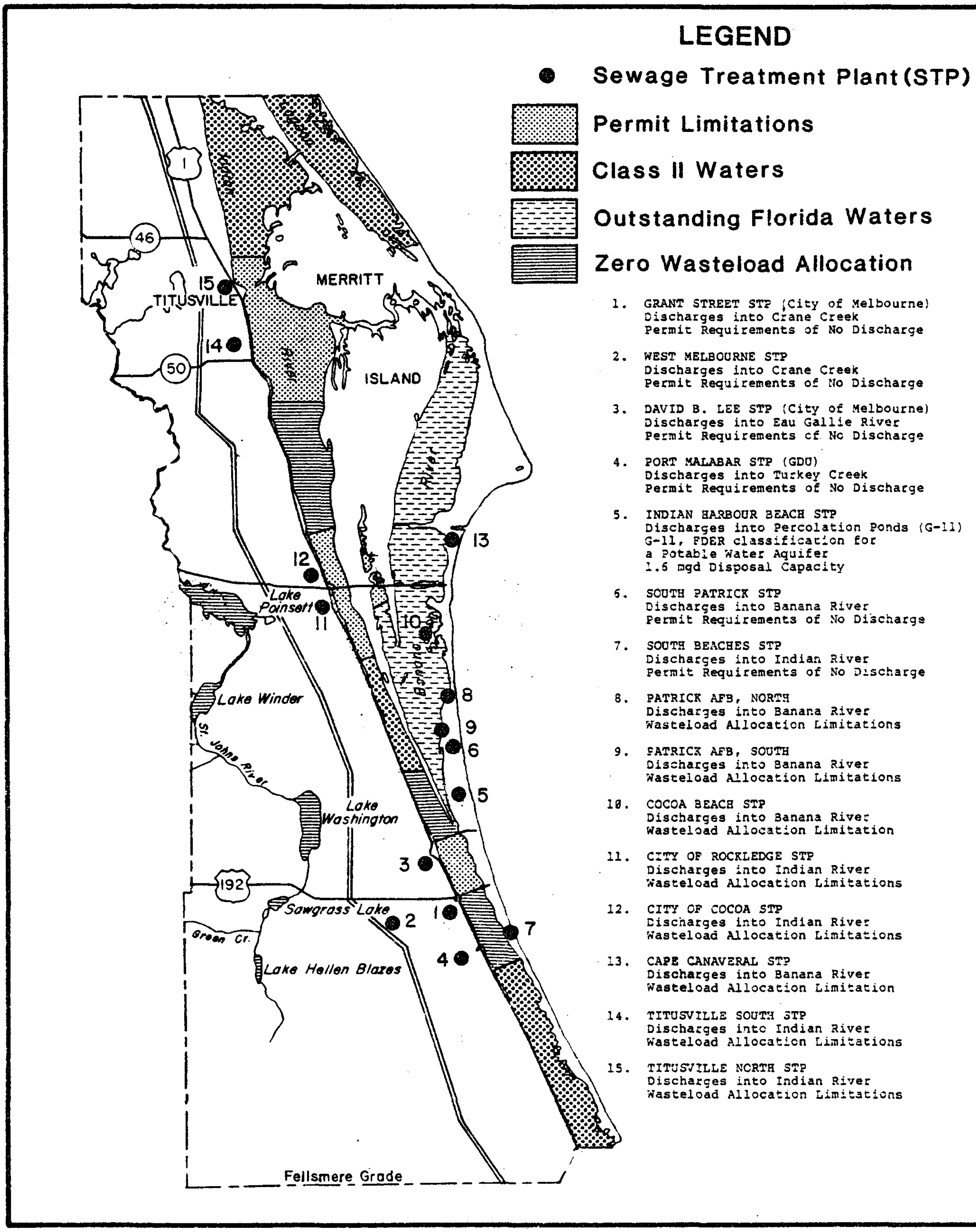

Figure 8. Location of WWTP's in Brevard County and pre-1985 information on disposal methods of the WWTP's.

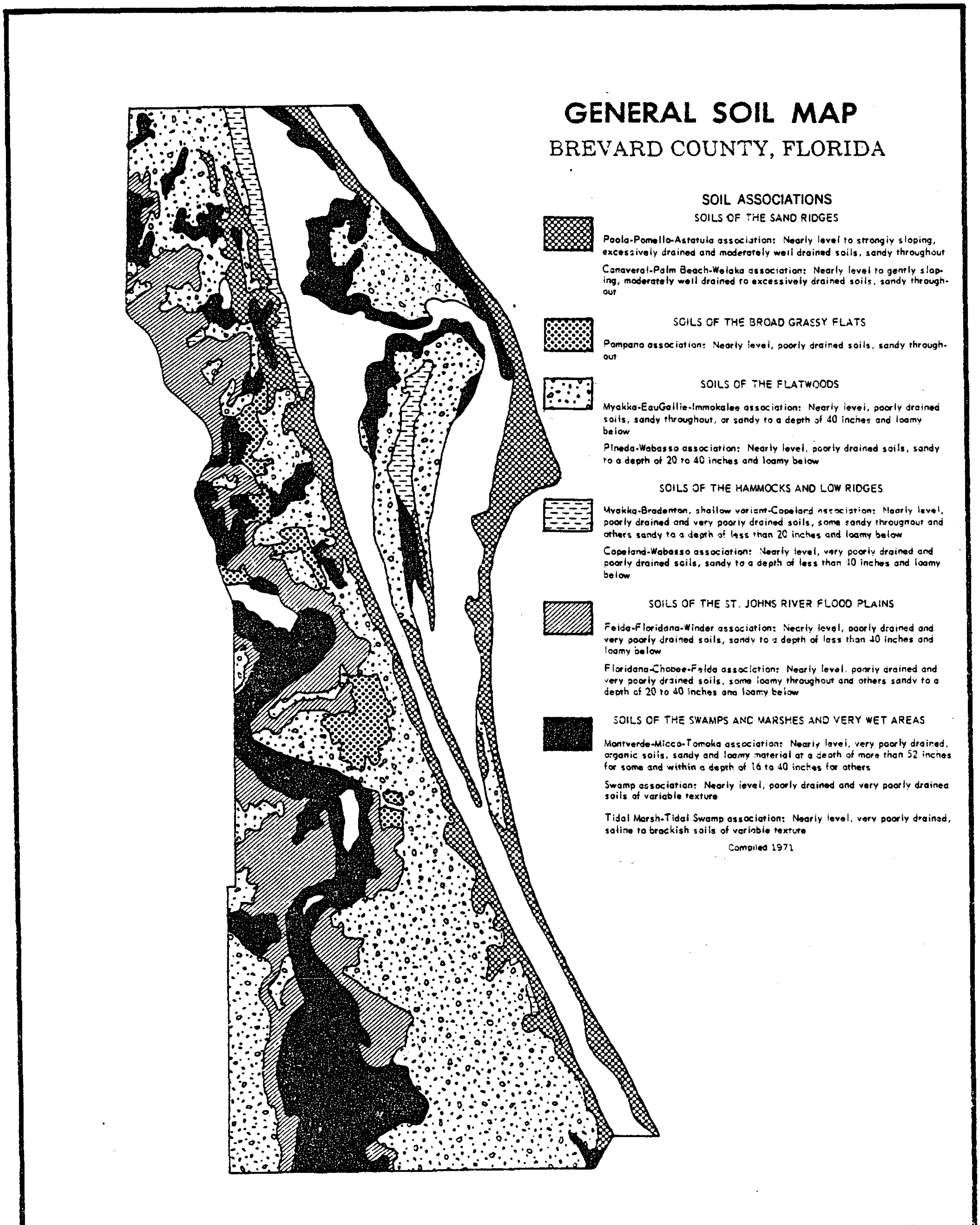

Figure 9. General soil map of Brevard County; simplified version of USDA soil survey map, 1971.

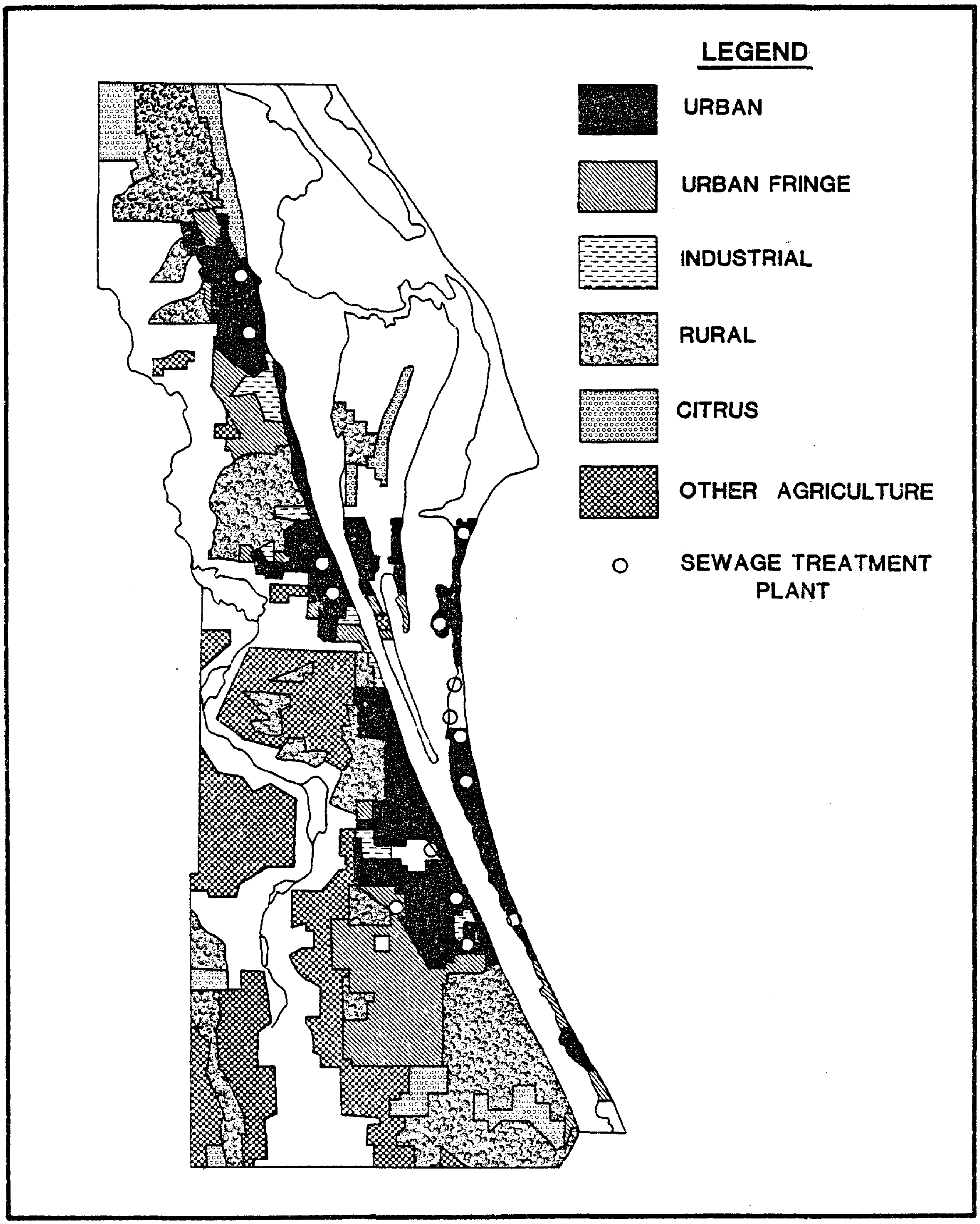

Figure 10. General land use in Brevard County.

Citrus and improved pasture are the predominant agriculture in terms of total acreage farmed and average daily water use. The only irrigated agriculture of suitable size within 10 miles of a major WWTP is citrus, located on Merritt Island and north of Titusville (Figures 8 and 10). Aside from citrus irrigation, urban landscape and golf course irrigation are other alternatives for reuse, particularly in developing areas in the sand ridge region (urban fringe, Figure 10). A possible limitation to effluent irrigation in some urban areas is the large number of domestic wells. These should be plugged or capped prior to effluent application to prevent surficial aquifer contamination (Figure 6).

Recognizing the need to conserve water quantity and to eliminate surface water discharge from several WWTP's, Brevard County, through its Water Resources Department, conducted reuse feasibility studies for Merritt Island and the South Beaches area. The findings of these studies are discussed in two reports adopted by the Board of County Commissioners in 1983: Reclaimed Water: Uses for Merritt Island and South Beaches Wastewater Reuse. Both reports concluded that the best use for reclaimed water of domestic origin is agricultural or urban landscape irrigation, preferrably restricted to sites with relatively well-drained soils and a low water table (at least 3 feet below surface, Chapter 17-6.040(4)(q), F.A.C.).

The four county WWTP's on Merritt Island have individual design capacities of less than 1.0 MGD and, consequently, are not listed in the District Inventory (Table 5). However, it should be mentioned that there are plans for these facilities to be converted to pump stations to transmit wastewater to a new regional plant with a 3.25 MGD capacity (Brevard County 201 Executive Summary, 1983). The effluent will be deep well injected with an option to implement reuse as a service to several citrus growers or new urban developments in the north central area of the island (Brevard County Water Resources Department, 1983; Striffler, 1984). Several citrus grove owners in this area of the island have indicated interest in a reuse irrigation system, primarily as a replacement of the ground water presently used which has elevated chloride levels (Figure 3).

The South Beaches reuse scenario calls for effluent being conveyed from the South Beaches WWTP (Plant #7, Figure 8; Table 5) southward to the rapidly developing residential areas between Melbourne Beach and Melbourne Shores for lawn irrigation. This reuse operation will complement the current spray irrigation of effluent on the Spessard Holland Golf Course (Melbourne Beach) and the deep aquifer injection system being designed to handle additional wastewater from the Indian Harbor Beach and South Patrick WWTP's (Plants #5 and #6, respectively, Figure 8; Table 5) (Brevard County Environmental Services, 1984). The South Beaches plant is being upgraded to at least a tertiary level with the installation of 3.0 MGD filters.

The South Brevard Water Authority (SBWA) evaluated reuse in its development of a comprehensive water conservation program for south Brevard County. Based primarily on environmental and economic considerations, the SBWA water conservation program report (1984) concluded that reuse implementation in south Brevard is limited. No reuse system has been planned for the area of south Brevard west of the Indian River (south mainland) but will soon be experienced in the urban South Beaches area, as previously described. Reuse potential is reduced on the south mainland due to the lack of or accessibility to suitable acreage for spray irrigation with respect to size, soil and ground water conditions (SBWA, 1984). Poorly drained soils and a high water table, characteristic of most of the south mainland (USDA, 1969) necessitates large tracts of land for adequate effluent dispersion and percolation (a minimum of 300 acres/1.0 MGD). According to the SBWA, underdrains are a discouraged solution to this problem because of the potential discharge to surface waters. The availability of irrigated agricultural acreage for long-term effluent irrigation is too low and the cost of constructing an urban irrigation system is too high to justify these alternatives. Golf course irrigation on the south mainland was also considered a nonviable alternative primarily because non-potable ground water is presently used for irrigation and, therefore, is not among the potable supply uses which the SBWA conservation program intends to reduce. Currently, effluent disposal by deep well injection is proposed for the four major WWTP's on the south mainland (Plants #1, 2, 3 and 4, Figure 8) (Bob Massarelli, SBWA Executive Director, personal communication, 12-17-84).

On the north mainland, no plans have been made to implement reuse as a disposal method for any of the four municipal WWTP's, Rockledge, Cocoa, north and south Titusville (Plants #11, 12, 14 and 15, Figure 8; Tables 5 and 7). A DER construction permit for a 1.0 MGD regional WWTP near Mims describes a tertiary treatment design for the purpose of reuse, if appropriate application sites can be found (Chuck Striffler, Brevard County Environmental Services Coordinator, personal communication, 11-9-84).

On the central barrier island, the City of Cocoa Beach is planning an expansion of their reuse system, golf course irrigation (Plant #10, Figure 8; Tables 5 and 7), to include urban lawn irrigation (Stephen Kintner, Director of Brevard County Resources Department, personal communication, 12-21-84). The Patrick Air Force Base and Cape Canaveral facilities (Plants #8, 9 and 13, Figure 8; Tables 5 and 7) will continue disposal in the Banana River within discharge limitations set by DER (Table 7).

TABLE 7. Summary of Wastewater Disposal Methods
North Brevard County

Plant Name	Plant Type	Present Design Flow (MGD)	Future Design Flow (MGD)	Parameter	Permit Limits (MG/L)	Wasteload Allocation (MG/L)	Actual Plant Info (MG/L)	Discharge Point
N. Titusville	Conv. Activ. Sludge (A/O)	1.67	2.75	BOD	90% (18)	90%	90%	Indian River
				SS	90% (24)	90%	90%	
	Anaerobic Digester			P	1.0	1.0	1.0	
				N	25	25	25	
S. Titusville	Conv. Activ. Sludge	3.5	3.5	BOD	90% (12)	90%	90%	Indian River
	Anaerobic Digester			SS	90% (24)	90%	90%	
				P	1.0	1.0	1.0	
				N	25	25	25	
Patrick AFB, N & S	Conv. Activ. Sludge	2.0	?	BOD	NC	NC	?	Banana River
				SS	NC	NC		
				P	12174 lbs/yr.	NC		
				N	72726 lbs/yr.	NC		
Rockledge	Aerobic/Anaerobic/ Anoxic	1.5	2.25	BOD	20	30	30	Indian River
				SS	20	30	30	
				P	-	4.9	40.6 lb/day	
				N	-	13.8	114.8 lb/day	
Cocoa	Schreiber Activ. Sludge	2.5	?	BOD	20	30	20	Indian River
				SS	30	30	20	
				P	-	2.3	2	
				N	-	24.8	17-20	
Merritt Island	Oxidation Ditch	6.0	6.0	BOD	20	None	NA	Deep Well + Reuse Facilities Are Included in the Plant Design
				SS	20			
				P	-			
				N	-			
Cape Canaveral	Carousel Oxidation Ditch Activ. Sludge	1.8	1.8	BOD	20	30	14.2	Banana River
				SS	20	30	14.2	
				P	-	1.3	0.61	
				N	-	24.9	11.8	
Cocoa Beach	Conv. Activ. Sludge Contact Stabilization	6.0	6.0	BOD	8	30	?	Banana River + the City Plans to Provide for Some Reuse of Wastewater
				SS	8	30		
				P	-	2.5		
				N	-	15.2		

Table was prepared by the Brevard County Water Resources Department, December 28, 1984, and modified to include DER information on the two Patrick AFB plants which are treated as one discharge.

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Appendix 1. WWTP Selection and Prioritization Process for Reuse Evaluation

A. WWTP Selection

1. Mapping and I.D. coding of WWTP's will be a simultaneous process.

2. I.D. codes will provide information essential in the review process and only those facilities with I.D. codes will be subject for review. Codes used in I.D. are adopted from Code List (attached) for DER Groundwater Pollution Source Inventory.

3. I.D. codes will be assigned to facilities which comply with the following criteria for reuse potential. (Criteria are adopted from the attached DER code list.)

    a. Facility status must be active (A). (Any other status designations, I or K, are criteria for immediate rejection.)

    b. Facility type must be a 1 or 5.

    c. Facility must have a design capacity or effluent volume of 1 MGD or more.

    d. Types of wastes handled must be a 300 series type (305, 310, 315, 320).

    e. Disposal methods: reject facilities for review which are coded LS and HZ.

4. A ten digit I.D. code will be used to ease computer storage and handling during review process. First two digits will identify county BY DER code number, third digit identifies facility type, the fourth and fifth digits refer to the design capacity (MGD), sixth through eighth digits identify waste type handled, and the ninth and tenth identifies the disposal method.

Appendix 1. WWTP Selection and Prioritization Process for Reuse Evaluation (continued)

Example: Ø51Ø13Ø5Ø9
Ø5 Brevard County
1 Domestic
Ø1 1 MGD
3Ø5 Domestic

Ø9 Surface water discharge

5. After the computer has run through the selection criteria, the output will be a listing of facilities which have reuse potential. Each facility in the list will be identified by Lat.-Long., site name or no., and the I.D. code, e.g. (Ø51Ø13Ø5Ø9).

B. Prioritization for Reuse Evaluation

1. Facilities designated for high priority review:

   a. located in area with high water demand.
   b. area has limited water-use resource.
   c. no effluent discharge to surface waters.
   d. highest priority given to those facilities whose effluent is not permitted to be discharged to surface water bodies and meet the first two criteria.

2. Facilities designated for intermediate priority review:

   a. high water demand
   b. limited water-use resources
   c. permitted to discharge with wasteload allocation requirement.

3. Low priority review or no review

   a. high (or low) water demand
   b. nonlimited water-use resources or-
   c. located in an area in which landspreading has already been rejected.

Appendix 1. WWTP Selection and Prioritization Process for Reuse Evaluation (continued)

DER CODE LIST

A. DER Districts and Counties within them (Dist. & Co. Part of GMS-ID)

1. District 30, St. Johns River - PID's 308 and 330:

   a. 05 - Brevard
   b. 35 - Lake
   c. 42 - Marion
   d. 48 - Orange
   e. 49 - Osceola
   f. 59 - Seminole
   g. 64 - Volusia

2. District 31, Northeast - PID's 304, 306 and 334:

   a. 01 - Alachua
   b. 02 - Baker
   c. 04 - Bradford
   d. 10 - Clay
   e. 12 - Columbia
   f. 15 - Dixie
   g. 16 - Duval
   h. 18 - Flagler
   i. 21 - Gilchrist
   j. 24 - Hamilton
   k. 34 - Lafayette
   l. 38 - Levy
   m. 40 - Madison
   n. 45 - Nassau
   o. 54 - Putnam
   p. 55 - St. Johns
   q. 61 - Suwannee
   r. 62 - Taylor
   s. 63 - Union

3. District 51, Southeast Branch - PID 302:

   a. 31 - Indian River
   b. 43 - Martin
   c. 47 - Okeechobee
   d. 56 - St. Lucie

B. Type of Ownership (Responsible Authority Type. Part of GMS-ID)

1. C - County
2. F - Federal
3. M - Municipal
4. P - Private
5. S - State

Appendix 1. WWTP Selection and Prioritization Process for Reuse Evaluation (continued)

C. Facility Type:

1. 1 - Domestic
2. 2 - Industrial
3. 3 - Solid Waste
4. 4 - Dredge and Fill
5. 5 - Drainage Well
6. 6 - Drinking Water Supply
7. 7 - Hazardous Waste
8. 8 - Non-Point Source
9. 9 - Un-Sanctioned

D. Facility Status

1. A - Active
2. I - Inactive
3. K - Closed, but still Monitored

E. Disposal Methods (Code Prints on Reports - GMST25 and GMSB25:

1. 00 AC - Accidental Spill, Leak, etc.
2. 01 BU - Burial
3. 02 DR - Drainfield
4. 03 EN - Encapsulation
5. 04 HZ - Hazardous Waste
6. 05 IM - Impoundment
7. 06 IN - Injection
8. 07 LA - Land Application
9. 08 LS - Land Spreading
10. 09 SD - Surface Water Discharge
11. 10 VR - Volume Reduction/Resource Recovery
12. 11 OT - Other (Including "Dredge and Fill" and "None" for Public Water Supply)

F. Types of Wastes Handled (Code Prints on Reports - GMST25 and GMSB25):

1. Solid, Non-Hazardous (100's)

   a. 105 - Agricultural
   b. 110 - Residential
   c. 115 - Commercial
   d. 120 - Hospital/Clinical
   e. 125 - Mining
   f. 130 - Industrial

2. Sludges (200's)

   a. 205 - Water Treatment/Lime Softening
   b. 210 - Septic Tank
   c. 215 - Air Scrubber

Appendix 1. WWTP Selection and Prioritization Process for Reuse Evaluation (continued)

d. 220 - Industrial/Commercial
e. 225 - Domestic
f. 230 - Incinerator Residue
g. 235 - Ion Exchange
h. 295 - Hazardous Sludge

3. Wastewater (300's)

a. 305 - Domestic
b. 310 - Industrial
c. 315 - Reject Water
d. 320 - Cooling Water

Appendix 2. Monitoring of Organic Groups

Initial monitoring of organics in effluent may consist of determinations of gross constituent groups classified by the following analytical parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and carbon absorption-extractable methods (CCE, CAE). The first three determinations, BOD, COD, and TOC are nonspecific tests subject to interference but do measure a majority of the biodegradable and, in the case of COD and TOC, a significant amount of the refractory or nonbiodegradable organics such as phenols (Standard Methods, 1981; State of California, 1978). Secondary treatment which includes either mixed aeration, activated sludge or contact stabilization has a mean removal efficiency of approximately 99% for BOD, 86% for COD, and 84% for TOC materials (Cooper, 1981); or, in terms of effluent concentrations, 15 to 25 mg/l BOD, 40 to 70 mg/l COD, and 15 to 25 mg/l TOC (State of California, 1978).

Greater specificity in the determination of levels of synthetics in effluent, prior to reuse, may be necessary since BOD, COD, or TOC tests do not measure such constituents to a high degree of assurance. The carbon chloroform extract, CCE, and carbon alcohol extract, CAE, analyses differentiates the organics into either a chloroform or alcohol soluble class of compounds. These analyses provide a better estimate of the level of contamination by any of several organics as a group - insecticides, herbicides, solvents, waste hydrocarbons as well as natural substances (Standard Methods, 1981). Even this level of analyses may not be sufficient to monitor synthetics in effluent used in urban or agricultural irrigation. An effluent with a CCE concentration of 1.0 mg/l or greater should be analyzed further for specific trace organics to ascertain whether additional treatment is needed (Table 1A).

TABLE 1A. Concentrations of CCE in Various Classes of Water[1]

Class of Water	CCE, x, mg/l	N
Well water	0.1	2
Spring-fed pond	0.1	3
Finished water[2] from lightly polluted surface water	0.3	10
Finished water from moderately polluted surface water:		
Summer	0.4	11
Winter	0.5	5
Finished water from heavily polluted surface water:		
Summer & Autumn	0.9	9
Winter	1.2	9

1. Information taken from Standard Methods, 1981, p. 476.
2. Finished water equivalent to effluent from a potable water treatment plant.

Appendix 3. A Listing of USGS Quads and Agricultural Land Use Within 10 Miles of Individual WWTP'S (District WWTP Inventory, Table 5) for Brevard, Orange, Seminole, and Volusia Counties

LAND USE TYPES

A	=	Aquaculture
C	=	Citrus
D	=	Dairy
F	=	Fernery
G	=	Federal Government Property
IP	=	Improved Pasture
R	=	Rangeland
R/W	=	Rangeland/Woodland
S	=	Sod Farm
U	=	Urban
V	=	Vegetable Crops

Land use information was collated from the following sources: Division of Resource Evaluation (Water Resources Department), Department of Executive Planning and Coordination, and the East Central Florida Regional Planning Council.

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
BREVARD	1. 0510330509	MELBOURNE	MELBOURNE E.	U
			MELBOURNE W.	IP, C
			DEER PARK SE	IP
			DEER PARK NE	IP
			EAU GALLIE	IP
			TROPIC	U
			SEBASTIAN NW	C
			GRANT	U
			FELLSMERE NW	IP, C
	2. 0510130505	W. MELBOURNE	MELBOURNE W.	IP, R/W, C
			DEER PARK SE	IP
			DEER PARK NE	IP
			EAU GALLIE	IP
			TROPIC	U
			MELBOURNE E.	U
			GRANT	U
			FELLSMERE NW	IP, C
	3. 0510330509	MELBOURNE	MELBOURNE W.	

For a list of quads and land use for this WWTP, see WWTP #2.

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
BREVARD	4. 0510230505	PALM BAY	MELBOURNE E.	
	For a list of quads and land use for this WWTP, see WWTP #1.			
	5. 0510130505	INDIAN HARBOR BEACH	TROPIC	U
			EAU GALLIE	IP
			DEER PARK NE	IP
			COCOA	IP, C
			COCOA BEACH	U
			MELBOURNE E.	U
			MELBOURNE W.	IP, C, R/W
			DEER PARK SE	IP
			GRANT	U
	6. 0510230509	SATELLITE BEACH	TROPIC	
			DEER PARK NE	IP
			EAU GALLIE	IP
			LAKE POINSETT	IP, R/W, C
			COCOA	IP, C, R/W
			COCOA BEACH	U
			MELBOURNE E.	U

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
BREVARD	6. 0510230509	SATELLITE BEACH (cont'd)	MELBOURNE W.	IP, C, R/W
			DEER PARK SE	IP
	7. 0510330507	MELBOURNE BEACH	MELBOURNE E.	U
			MELBOURNE W.	IP, C, R/W
			EAU GALLIE	IP
			TROPIC	U
			SEBASTIAN NW	C
			GRANT	U
			FELLSMERE NW	IP, C
	8. 0510130509	PATRICK AFB	TROPIC	
	For a list of quads and land use for this WWTP, see WWTP #6.			
	9. 0510130509	PATRICK AFB	TROPIC	
	For a list of quads and land use for this WWTP, see WWTP #6.			
	10. 0510630509	COCOA BEACH	COCOA	IP, C, R/W
			LAKE POINSETT	IP, R/W, C
			SHARPES	IP

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
BREVARD	10. 0510630509	COCOA BEACH (cont'd)	COURTENAY	C
			CAPE CANAVERAL	G
			COCOA BEACH	U
			TROPIC	U
			EAU GALLIE	U, IP
			DEER PARK NE	IP
	11. 0510230509	ROCKLEDGE	COCOA	IP, C, R/W
			LAKE POINSETT	IP, R/W, C
			LAKE POINSETT SW	R/W
			SHARPES	IP
			COURTENAY	C
			CAPE CANAVERAL	U, G
			COCOA BEACH	U
			TROPIC	U
			EAU GALLIE	IP
			DEER PARK NE	IP
	12. 0510230509	COCOA	COCOA	

For a list of quads and land use for this WWTP, see WWTP #11.

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
BREVARD	13. 0510230509	CAPE CANAVERAL	CAPE CANAVERAL	G, U
			COURTENAY	C
			SHARPES	IP
			ORSINO	G
			FALSE CAPE	G
			COCOA BEACH	U
			EAU GALLIE	IP
			COCOA	IP, C, R/W
	14. 0510230509	TITUSVILLE	TITUSVILLE	TICO AIR-PORT, R/W
			TITUSVILLE SW	R/W, IP
			AURANTIA	C, R/W, BREVARD CO. GAME REFUGE
			MIMS	R/W, IP, C
			WILSON	G
			ORSINO	G
			COURTENAY	C
			SHARPES	IP
	15. 0510130509	TITUSVILLE	TITUSVILLE	

For the list of quads and land use for this WWTP, see WWTP #14.

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
ORANGE	1. 4810230505	ORLANDO	OVIEDO SW	R/W, IP, C
			ORLANDO E.	C, IP
			CASSELBERRY	IP, R/W, C
			OVIEDO	R/W, IP, V, C
			GENEVA	C, R/W, IP
			BITHLO	R/W, IP, C
			NARCOOSSEE NE	IP, R/W, C
			NARCOOSSEE NW	R/W, C, IP
			PINE CASTLE	C, R/W, IP
	2. 4810130507	LAKE BUENA VISTA	WINTER GARDEN	C
			CLERMONT E.	C
			APOPKA	V, C
			FOREST CITY	C
			ORLANDO E.	C, IP
			ORLANDO W.	C, IP
	3. 4810130509	ORLANDO	ORLANDO E.	C, IP
			ORLANDO W.	C, IP
			FOREST CITY	C, IP

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
ORANGE	3. 4810130509	ORLANDO (cont'd)	CASSELBERRY	R/W, IP, C
			OVIEDO	V, IP, C, R/W
			BITHLO	R/W, C, IP, V
			OVIEDO SW	R/W, IP, C
			NARCOOSSEE NW	R/W, C, IP
			PINE CASTLE	C, R/W, IP
			LAKE JESSAMINE	C
	4. 4810130509	ORLANDO	ORLANDO E.	C, IP
			ORLANDO W.	C, IP
			CASSELBERRY	IP, C
			OVIEDO	V, IP, R/W
			OVIEDO SW	R/W, C
			NARCOOSSEE NW	R/W, C, IP
			PINE CASTLE	C, R/W, IP
			LAKE JESSAMINE	C
	5. 4810230505	WINTER GARDEN	WINTER GARDEN	C
			CLERMONT E.	C
			ASTATULA	V, C
			APOPKA	V

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
ORANGE	5. 4810230505	WINTER GARDEN (cont'd)	FOREST CITY	U
			ORLANDO W.	U
			LAKE LOUISA	C
	6. 4810230507	APOPKA	APOPKA	V, F, IP, C
			ASTATULA	V, C
			SORRENTO	C, F, R/W
			SANFORD SW	R/W
			FOREST CITY	C, IP, R/W, F
			CASSELBERRY	C
			ORLANDO E.	C
			ORLANDO W.	C, IP
			WINTER GARDEN	C
			CLERMONT E.	C
	7. 4810130505	OCOEE	WINTER GARDEN	
	For the list of quads and land use for this WWTP, see WWTP #5.			
	8. 4811530505	ORLANDO	OVIEDO SW	
	For the list of quads and land use for this WWTP, see WWTP #1.			

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
SEMINOLE	1. 5910130507	CASSELBERRY	CASSELBERRY	IP, R/W, C, V
			FOREST CITY	C, IP, R/W, F
			SANFORD SW	R/W, IP
			SANFORD	R/W, C, V, IP
			OSTEEN	C, V, R/W, IP
			OVIEDO	IP, C, V, R, A
			OVIEDO SW	R/W, C, IP
			ORLANDO E.	C, IP
			ORLANDO W.	C, IP
	2. 5912430509	OVIEDO	OVIEDO SW	R/W, C, IP
			OVIEDO	IP, C, R/W, V, A
			CASSELBERRY	R/W, IP, C, V
			SANFORD	R/W, IP
			OSTEEN	IP, R/W, C, V
			OSCEOLA	C, R/W, IP
			GENEVA	IP, R/W, C, S
			BITHLO	R/W, IP, C
			NARCOOSSEE NW	R/W, IP,C
			PINE CASTLE	R/W
			ORLANDO E.	C, IP

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
SEMINOLE	3. 5910630509	SANFORD	SANFORD	R/W, IP, C, V
			SANFORD SW	R/W, IP
			PINE LAKES	R/W
			ORANGE CITY	U
			LAKE HELEN	U
			OSTEEN	IP, C, R/W, V
			OVIEDO	IP, V, C, A
			CASSELBERRY	R/W, IP, C, V
			FOREST CITY	IP, R/W, C
	4. 5910830509	ALTAMONTE SPRINGS	FOREST CITY	C, IP, R/W, F
			APOPKA	F, IP, R/W, C
			SORRENTO	C, F, R/W
			SANFORD SW	R/W, IP
			SANFORD	R/W, C
			CASSELBERRY	R/W, IP, C, V
			OVIEDO	IP, V, C
			ORLANDO E.	C, IP
			ORLANDO W.	C, IP
			WINTER GARDEN	C

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
SEMINOLE	5. 5910130509	CASSELBERRY	CASSELBERRY	R/W, IP, C, V
			FOREST CITY	IP, R/W, C, F
			SANFORD SW	R/W, IP
			SANFORD	R/W, C, IP
			OSTEEN	V, C, R/W
			OVIEDO	IP, R/W, V, C, A
			OVIEDO SW	R/W, C, IP
			ORLANDO E.	C, IP
			ORLANDO W.	C, IP
	6. 5910230505	LAKE MARY	CASSELBERRY	R/W, IP, C, V
			FOREST CITY	IP, R/W, C, F
			SANFORD SW	R/W, IP
			SANFORD	R/W, IP, C, V
			OSTEEN	V, C, R/W, IP
			OVIEDO	IP, R/W, V, C, A
			OVIEDO SW	C, IP
			ORLANDO E.	C
			ORLANDO W.	C

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
SEMINOLE	7. 5910230505	LONGWOOD	FOREST CITY	IP, C, R/W, F
			APOPKA	IP, F, R/W
			SORRENTO	C, F, R/W
			SANFORD SW	R/W, IP
			SANFORD	C, V, IP
			CASSELBERRY	R/W, IP, C, V
			ORLANDO E.	U, C, IP
			ORLANDO W.	U, C, IP
			WINTER GARDEN	C
	8. 5910130507	WINTER SPRINGS	OVIEDO	IP, R/W, V, A
			CASSELBERRY	R/W, IP, C, V
			FOREST CITY	C
			SANFORD	R/W, IP, C, V
			OSTEEN	V, R/W, C
			OSCEOLA	R/W, IP, C
			GENEVA	IP, R/W, C, S
			BITHLO	C, R/W, IP
			OVIEDO SW	R/W, IP, C
			ORLANDO E.	U

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
SEMINOLE	9. 59102_ _ _ 05	ALTAMONTE SPRINGS	FOREST CITY	
	For the list of quads and land use for this WWTP, see WWTP #4.			
VOLUSIA	1. 3064M00704	HOLLY HILL	DAYTONA BEACH	U
			DAYTONA BEACH NW	R/W
			ORMOND BEACH	U
			PORT ORANGE	U
			SAMSULA	R/W
			DAYTONA BEACH SW	R/W
			FAVORETTA	R/W
			FLAGLER BEACH E.	U
			NEW SMYRNA BEACH	U
	2. 3064M00707	DAYTONA BEACH/BETHUNE	DAYTONA BEACH	U
			DAYTONA BEACH NW	R/W
			FAVORETTA	R/W
			ORMOND BEACH	U
			PORT ORANGE	U
			NEW SMYRNA BEACH	U
			SAMSULA	R/W
			DAYTONA BEACH SW	R/W

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
VOLUSIA	3. 3064M01776	PORT ORANGE	PORT ORANGE	U
			DAYTONA BEACH	U
			DAYTONA BEACH NW	R/W
			FAVORETTA	R/W
			ORMOND BEACH	U
			NEW SMYRNA BEACH	U
			SAMSULA	R/W
			DAYTONA BEACH SW	R/W
	4. 3064M01788	ORMOND BEACH	ORMOND BEACH	U
			FAVORETTA	R/W
			FLAGLER BEACH W.	R/W
			FLAGLER BEACH E.	U
			PORT ORANGE	U
			DAYTONA BEACH	U
			DAYTONA BEACH NW	R/W
	5. 3064M02142	DAYTONA BEACH W.	DAYTONA BEACH	U
			DAYTONA BEACH NW	R/W

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
VOLUSIA			LAKE DIAS	
			FAVORETTA	R/W
			ORMOND BEACH	U
			PORT ORANGE	U
			NEW SMYRNA BEACH	U
			SAMSULA	R/W
			DAYTONA BEACH SW	R/W, IP
			DELAND	R/W, IP, C
	6. 3064M01435	EDGEWATER	EDGEWATER	R/W
			LAKE ASHBY	R/W, IP, V
			SAMSULA	R/W
			PORT ORANGE	U
			NEW SMYRNA BEACH	U
			ARIEL	
			OAK HILL	C
			MAYTOWN	R/W, IP
			OSCEOLA	R/W

Appendix 3. (continued)

COUNTY	SJRWMD WWTP#	GENERAL LOCATION	USGS QUADS AND AGRICULTURAL LAND USE WITHIN 10 MILES OF WWTP	
VOLUSIA	7. 3064M01531	NEW SMYRNA BEACH	NEW SMYRNA BEACH	U
			SAMSULA	R/W
			DAYTONA BEACH	U
			PORT ORANGE	U
			ARIEL	
			EDGEWATER	R/W
			LAKE ASHBY	R/W, IP
	8. 3064M06162	DELAND	DELAND	R/W, IP, C, D
			LAKE WOODRUFF	R/W, IP
			PIERSON	R/W, IP
			LAKE DIAS	IP, R/W, C
			DAYTONA BEACH NW	R/W
			DAYTONA BEACH SW	R/W, IP, C
			LAKE HELEN	R/W, IP
			SANFORD	R/W, IP
			PINE LAKES	
			ORANGE CITY	R/W
			OSTEEN	R/W, IP, C
			SANFORD SW	R/W