TECHNICAL PUBLICATION #80-2

January 1980

DRE 108

A DEMONSTRATION PROJECT ON WATER USE DATA COLLECTION STORAGE AND RETRIEVAL SYSTEM

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Technical Publication 80-2

A Demonstration Project on Water Use Data Collection Storage and Retrieval System

by

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"This public document was promulgated at an annual cost of $124.63 or $ .249 per copy to inform the public, governmental agencies and officials of the District's Demonstration Project on its Water Use Collection Storage and Retrieval System," RPD-189 180 5C

Resource Planning Department
South Florida Water Management District
West Palm Beach, Florida

January, 1980

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INTRODUCTION

The major function of the South Florida Water Management District (formerly Central and Southern Florida Flood Control District) in the past was mainly centered around operation and maintenance of flood control structures; however, since the passage of the Water Resources Act of 1972, Chapter 373, the function as well as the name of the District has changed. Presently, the District is responsible for total planning, management and operation of a complex water resource system covering approximately 16,000 square miles of area for both flood control and water supply purposes - often conflicting functions.

For sound planning, management and operation of a regional water resource system, a detailed account of the types of available supply such as rainfall, surface and subsurface outflows, water used by natural vegetation, supplemental water that has to be withdrawn for irrigating crops, and water used by municipalities, commerce, and industries is required. (The District historically collected data describing the quantity and quality of water that is available for multiple uses.) Information on water demand, especially the quantities of water being used by agricultural, industrial and commercial sectors of the economy, where the water is used and what quality changes result from these uses needs to be improved. As south Florida's fresh and brackish waters come under increasing stress from domestic, industrial, commercial, recreational and irrigational users, these water use data are required to resolve many critical problems involving water use, including: 1) comparison of current and projected water requirements; 2) development and comparison of alternative water management plans and programs; and 3) design and operation of individual water management projects. Good management of the available resources requires that both the available supplies and current uses be monitored closely.

A major problem in connection with water demand data is data management. Data must be stored, retrieved and disseminated in a suitable manner for the policy, planning, water use allocation and management activities dealing with south Florida's water resources. This will require a versatile and economical natural resource data base system. The state-of-the-art in computer sciences can currently provide an adequate basis for such a system.

To resolve the above stated problems, a cooperative program between the SFWMD and the United States Geological Survey (USGS) was initiated under the National Water Use Program. The objectives of this program are:

1. to collect and analyze information on all elements of water use
2. to investigate a computer storage and retrieval system for water use data which can be linked with the central data base system which the District is in the process of developing
3. to develop a methodology for merging water use data with other related hydrologic, meteorologic, hydrogeologic and other information
4. to input the water use data to the state and national water use data bank
5. to use the water use data in various water resources studies including planning, projections, allocations and modelling.

FLOW MEASURING POTENTIALS

Historically, mechanical devices such as commercial meters have been used to make water flow measurements through closed conduits. Commercial meters are generally classified as to type of operation (i.e., displacement type, velocity type or the bypass type). These meters record total volume, making it unnecessary to compute volume from the observed discharge records. Water that is measured in closed conduits with mechanical meters must be free of foreign matter.

The greatest limitation of the many commercial volumetric meters and adaptations of flow meters is their relatively high cost. It is probably unrealistic to assume, due to economic considerations, that all water users in south Florida would install commercial flow meters to determine the quantity of water being used. It is this factor that led to the investigation of indirect flow measuring devices which can monitor liquid levels or flow conditions without physical intrusion into a pipe, with new standards of reliability, ease of installation and economy beyond that of any previous liquid monitoring technique.

Ultrasonic Flow Meters

Ultrasonic flow meters are a totally different type of flow measuring device designed to measure the velocity of liquids containing entrained air or suspended solids.

Ultrasonic flow meters normally are of two types: a) doppler meters and b) transient type meters (Figures 1 and 2). The doppler flow meter has only one head and requires bubbles and sand in the flowing water; however, the transient type has two heads and requires clear water for the instrument to record the flow accurately.

The transient type flow meter normally utilizes two transducers mounted on opposite sides of the pipe as shown in Figure 1. An ultrasonic pulse is transmitted from transducer X to transducer Y at an angle of approximately 45^{o}. The speed of sound from X to Y represents the speed of sound of the liquid plus a contribution caused by the rate of flow. A pulse is then set from the transducer Y to transducer X which represents the speed of sound less the contribution due to rate of flow. When the Y to X speed is subtracted from the X to Y speed, the difference is proportional to flow rate (velocity). The alignment of the transducers is somewhat critical and must be accomplished

Time Base Flow

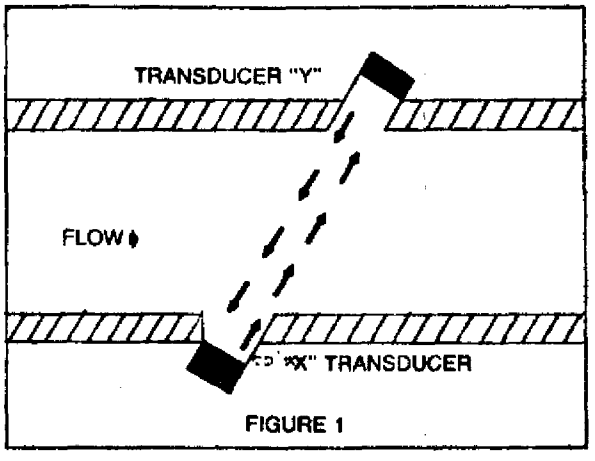


FIGURE 1

Tech/Sonics Doppler Flow

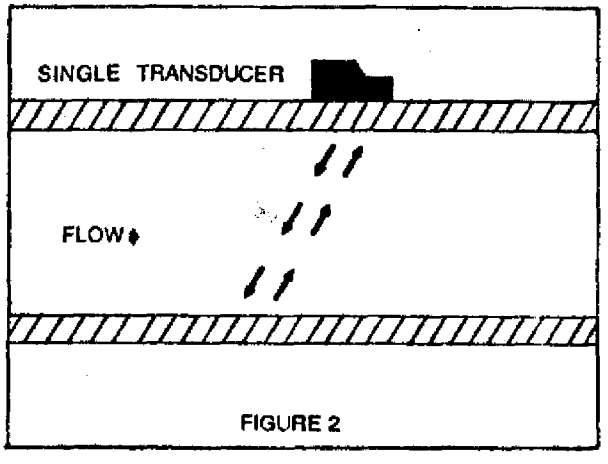


FIGURE 2

in a spool piece provided by the manufacturer or field mounted using special features. Since many industrial and municipal flows have a considerable amount of suspended solids or entrained air, the signal transmitted back and forth from each transducer can easily become reflected or scattered so that the flow meter becomes erratic and many times totally inoperative.

The basis of operation of the doppler flow meter is the doppler effect which is the apparent change in frequency of sound, light or radio waves caused by motion. For example, the pitch (frequency) of a train whistle seems to become higher as the train approaches and lower as the train moves away. The single transducer which is mounted on the outside of the pipe, as shown in Fig. 2, contains twin crystals encapsulated in an epoxy housing. One crystal is the transmitter and the other is the receiver. The transmitting crystal emits a continuous ultrasonic pulse or frequency into the liquid stream. When the transmitted frequency is reflected back to the receiving crystal from a moving object such as entrained air or suspended solids, the frequency will change in proportion to the speed or velocity of the object. The transmitter measures the difference in the transmitted and reflected frequencies which is proportioned to flow and provides a linear digital output.

Theoretical Development of the Doppler Flow Meters

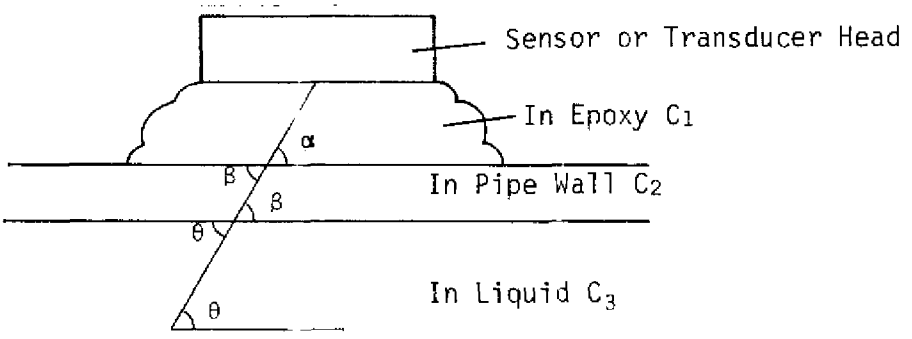


FIGURE 3. Transducer Head on a Pipe Wall

In Figure 3 is shown a transducer head on a pipe wall with the path of a single narrow ultrasonic beam through the pipe wall into the liquid.

Let;

C_3 = velocity of sound in the liquid

C_2 = velocity of sound in the pipe wall

C_1 = velocity of sound in the transducer head epoxy.

Typically C_3 in a liquid is 1500 m/sec, C_2 in PVC is 2300 or in metals is 3000 m/sec, and C_1 in the epoxy is 2000 m/sec.

Because the internal and the external walls of the pipe are parallel to one another, the two angles β are equal. Because the flow velocity, V, down the pipe is assumed to be parallel to the pipe walls, the two angles θ are also equal.

Using Snell's law of refraction one can relate α, β, and θ to the speed of the wave motion in the respective media. Snell's law concludes that the wave velocity (C) divided by the Cosine of the angles as labelled here is constant for any given ray passing from one medium to another. Therefore, for the epoxy to pipe walls interface, $C_1/\text{Cos } \alpha = C_2/\text{Cos } \beta$. For the pipe wall to liquid interface, $C_2/\text{Cos } \beta = C_3/\text{Cos } \theta$. This is shown in Figure 3, where the term $C_3/\text{Cos } \theta$ can be seen equal to $C_1/\text{Cos } \alpha$. The flow speed formulae can then be derived as follows:

$$V = \frac{(f_2 - f_1)}{f_1} \times \frac{C_1}{\text{Cos } \alpha} \times \frac{1}{2} \qquad (1)$$

Now, the expression for flow velocity no longer contains liquid dependent variables, but contains C_1, the velocity of sound in the transducer head epoxy, and the cosine of α which is set up in the manufacture of the head to be 60°. The flow meter measurement on this basis should therefore be independent of manufacturing variables in the transducer.

The result of all this theory is important only in that it concludes that the flow velocity of a liquid can be measured by multiplying the doppler frequency shift, $f_2 - f_1$, by various constants associated with the materials of manufacturers, the design of the transducer head and the design of the electronics. The flow meter can be seen to be independent of the liquid composition, temperature, and density of viscosity, theoretically; however, practical trials, tests and field experience to date have shown that the theory is not strictly correct. To a limited extent, the calibration is dependent on the liquid in the pipe. Practical tests have shown small variations in the different liquids; variations which are much smaller than the ratio of the respective speeds of sound, indicating that the refraction effects very nearly make the meter self-compensating.

Within a normal temperature range of $\pm 20^{0}$ f, the change in output was found to be in the order of 1 to 2%.

Time Recorder

Ultrasonic flow meters will measure only the velocity of flows. For temporal water use estimation, one requires time base analysis of water produced (quantity/time).

The Water Resources Division of the USGS has gained some preliminary experience in monitoring the running time of pumps, irrigation systems and other types of water producing or conveyance facilities by sensing their vibration levels. A vibration threshold sensor is used to enable a timing function which will accumulate and record the running time of the equipment. A physical coupling or contact is made to the machinery or pipe being monitored. The timing function is either on or off depending upon the sensitivity of sensor, and the duration of motion.

The cumulative timing record is stored in a memory and periodically read out when the unit is taken out of service. After the unit is read or

initialized, it can again be returned to service.

A holder or carrier is permanently attached to the machinery to allow repeated exchange of the vibration timer and also to activate the timer which is temporarily inoperative during shipping or transporting.

Once the flow velocity, the internal diameter of the discharge pipe,and the cumulative time a certain pump run is known, then water flow thru the pipe can be calculated by using the flow continuity equation, as follows:

$$Q = \frac{\Pi \cdot (ID)^2}{4} \cdot V \qquad (2)$$

Once the flow and the total cumulative running time is known, then the water use/period can be calculated.

INVESTIGATION OF A SUITABLE AND ECONOMIC WATER USE DATA STORAGE AND RETRIEVAL SYSTEM

A data base is a collection of logically related files containing both data and structural information.

Basically, there are three general types of data base management systems: a) hierarchial, b) network and c) relational. The hierarchial systems arrange the data in a "tree" structure similar to a family tree. Network systems emphasize sets of records which are limited by physical means. Relational systems depend on relational calculus and the storing of data in independent relations.

Presently there are more than 100 commercially available data base software packages on the market, and more new systems are being designed. The following tables present the Matrix of Major Data Base Software which are currently available for use.

FIGURE 4. MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-1

(SHEET 1 of 2)

VENDOR	NAME	Classification and Orientation	Hardware Minimum	Core and Operating System	Programming for DML	Data Structures	Secondary Indexing
Burroughs	DMS FORTE/2	Complex Structure Management	B1700	24K B1700 32K B3700 MCP	Host language	Conventional, List, File Linkage	Yes
Burroughs	DMS II	Generalized DB Management	B6700	120K words MCP	Host language built into COBOL and ALGOL	Conventional, List, File Linkage	Yes
CDC	MARS VI	Data Retrieval	CDC 6000 Cyber 70	Batch 65K words On-line 98K words	Self-contained	Conventional	Partial Inversion
CDC	CDCS	Codasyl (Eventually)	CDC 6000 Cyber 72	48K words SCOPE, NOS	Host language and self-contained	Conventional	In 1975
Honeywell	IDS	Complex Structure Management	H400 H600/6000	64K words GCOS	Host language (COBOL) for DML and DDL	Random, Net	NO
IBM	GROMP	Complex Structure Management	IBM 360/25	DOS 32K	Host language	Random, List	Separate Index
IBM	IMS/VS	Generalized DB/DC Management	IBM 370	OS/VS 512K	Host Language	Tree File Linkage	Yes
IBM	DIS/VS	Data Retrieval	IBM 370	OS/VS 192K Partition	Self contained	Sequential, Index Sequential, DL/1 Files	Only with DL/1
ICL	DMS2	Generalized Complex File Management	ICL 190 A	32K words	Self-contained	Generalized, Random, List	NO
ICL	1900 DBMS	Generalized File Management	ICL 1903T	128 words George III	Host language	Conventional	NO
ICL	2900 DMS	Generalized File Management	ICL 2970	750K System 8	Host language and self-contained	Conventional	In 1976
ICL	System 4 DBMS	Database Management	ICL System 4/70	256K 'J'	Host language	Conventional	NO
Unidata	Pholas	Codasyl	P1000 Siemens 4004 Unidata 7730	64K BS1000	Host language	Net, Sequential	Yes
Unidata	Socrate	Generalized Database Management	Iris 45	128K Siris	Self-contained and hosted subroutines	Sequential Index Random Transposed	Limited
Univac	DMS 1100	Codasyl	Univac 1106	128K words Exec 8	Host language (COBOL)	Net, Index Sequential	NO
Xerox	EDMS	Codasyl Orientation	Sigma 6	64 words CTS	Host language	Random, Net	Partial Inversion
Software AG	Adabas	Generalized Database Management	IBM 360/370 Siemens 4004 Univac 9400	OS/DOS 156K	Host language	Tree	"Associator" used for all retrieval
Cullinane	IDMS	Codasyl Subset	IBM 360/370 RCA Spectra 70 Univac series 90	128K	Host language (ANS COBOL)	Net	NO
Informatics	Mark IV	Generalized File Management	IBM 360/25 RCA Spectra 70 Univac 9400	DOS 48K OS 128K TDOS 65K	Self-contained Non-procedural	Sequential, Index Sequential, IBM DL/Files Total files	NO
General Motors Corporation	RDMS	Relational	IBM 360/67		Self contained	Relational: Third Normal Form	NO
Software Sciences Limited	Robot	Generalized Database Management	ICL 1900 Univac 9400	32K words 128K bytes	Self-contained	Transposed	NO
MRI	System 2000	Generalized Database Management	IBM 360/370 CDC 6000, Cyber 70, Univac 1100	256K OS 128K words Exec 8	Both self-contained and host language	Tree	Partial Inversion
Cincom	Total/7	Generalized Database Management	IBM 360/370, H/ 2000, RCA Spectra 70, NCR Century	64K	Host language	Random, List	NO

Source: "Database Systems: A Practical Reference," Ian Palmer, CACI Inc., London, England, 1975.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-1 (SHEET 2 of 2)

Data Independence			Query/Report Generator	On-line Multi-access	Backup and Recovery	Privacy	Tuning and Optimization	Experience of Use
Number of Levels	Level of Detail	Time of Binding						
1; DDL only	Record	Compilation	Reporter	Possible with NDL	Checkpoints and logging	NO	Restructure utility	6 years
1; DASDL only	Item	Schema compilation	Reporter	Yes with NDL	Automatic recovery to checkpoint	File level	Some facilities	1½ years
1; DDL only	Item	Access	Yes	Yes	Log of transactions	File level		over 6 years
2; schema/sub-schema when implemented	Item	Access	Yes	Yes with OC software	Rollback	File level	Reorganization utility	2 years
1; DDL only	Item	Compilation	Yes	NO	Manual recovery	Record level	Limited	10 years
1; DDL only	Item	Compilation	NO	NO	NO	NO		5 years
2; DBD and PSB	Segment	File open	IQF	Yes has full OC facilities	Automatic recovery of on-line work	File level	Monitors and simulators	20 users in UK 6 years
1; DDL only	Item	Access	Yes	Limited		Full facilities		6 years
2; physical and logical files	Item	Access	Some report facilities	NO	Manual recovery	Only through GEORGE III	Very limited	4 years
2; DDL and DRL	Item	Subschema compilation; Program load	On-line inquiry system	NO	Batch recovery	Full facilities	Some statistics collected	On controlled release
3; VODL DDL SCL	Item	Subschema compilation; Program load	Yes	Yes	Utilities	File level	File placement	None
2; data dictionary and entity streams	Item	Access	NO	Yes, via Driver, but no direct updating	Batch recovery	Full facilities	Limited	8 users 3 years
3; SSL schema and subschema	Item	Mainly on access	NO	Yes with Asmus	By utility	On files, schema subschema	Restructure utility	1½ years
2; structure and sous-structure	Item	Compilation	Query facilities	Yes, with own OC facilities	Rollback to check-point	Sous-structure	Reorganize utility	2 years
1; schema DDL	Item	Compilation	In future release	Yes, with TIP and CMS	Rollback and automatic quick recovery	Only through Exec 8	Limited	3 years 120 users
2; schema and subschema	Record	Compilation	In future release	Yes, with TP and CNM	Automatic recovery of on-line programs	Full facilities	Limited	2 years
1; dictionary only	Item	Access	Adascript Query Language	Yes, with a TP monitor	Logging and checkpoint	Full facilities	Statistics	70 users 3 years
2; schema/ subschema	Item	Partly compilation, Partly access	Culprit, report generator	Yes, with a TP monitor	Rollback and recovery utilities	Full facilities	Some statistics collected	40 users 3 years
1; file definition forms	Item	Schema Compilation	Yes	Limited	Checkpoint	NO	Optimizing speed or store	700 users 6 years
1; DDL only	Relation	Access	Only tabulations and graphs	Yes	Programmer-controlled checkpoint	NO		3 years
1; dictionary only	Item	Access	Some report facilities	Under Development	Restart	At file and vector levels	NO	1 year
1 in self-contained; 2 in host language	Item	Access	Report Writer Feature	Immediate Access Feature	Manual recovery	Full facilities	NO	3 years
1; DDL only	Element	Access	Yes, Socrates	Possible with Environ.	Automatic recovery of on line work	File level	Limited	800 users

Source: "Database Systems: A Practical Reference," Ian Palmer, CACA Inc., London, England, 1975.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-2 (SHEET 1 of 5)

System	ADABAS	DATACOM/DB	DBMS-10
Vendor	Software AG of North America	Insyte Datacom Corporation	Digital Equipment Corp
Current number of users	Over 200	60	Approximately 60
CONFIGURATION			
CPU's supported	S/360, 370, Amdahl, Itel, CDC Omega, Siemen, 4004	System/360, 370	DECsystem-10
Operating systems	DOS, DOS/VS, OS, OS/VS	DOS, DOS/VS, OS, VS1, SVS, MVS	TOPS 10
Minimum memory requirements	200K bytes	32K bytes plus buffer space	32K 36 bit words
DATA BASE FEATURES			
Data base organization	Network with full inversion	Inverted file	Hierarchical, network
Application languages	COBOL, FORTRAN, PL/1 Assembler	Any language with a CALL facility	COBOL, FORTRAN
Data base languages	ADAMINT—high level programming interface	DATAQUERY	DDL, DML
Access methods supported	ADAM	Proprietary access method	Random, index sequential, sequential, direct
Variable-length segments	Yes	Yes	Yes
Data base security	Password for up-date, at file and field level, encryption	Password, terminal validation	Area privacy locks, subschema, system security
System accounting facilities	File and space statistics, log of command activity	File access and buffer usage statistics	Utilization statistics
RECOVERY FEATURES			
Checkpoint/restart	Yes	Automatic at OPEN	Yes
Data base integrity	Autorestart function	Verification of DB at OPEN time	Before/after imaging, automatic backup/recovery
OTHER SYSTEM FEATURES			
Concurrent batch/on-line	Yes	Yes	Yes
Concurrent application program access	Yes	Yes	Yes
Inquiry/retrieval facility	ADASCRIPT+ inquiry/reporting language	Yes	IQL
Report generator	ADAWRITER	Interface to standard report writers	COBOL Report Writer
Data dictionary support	ADABAS Dictionary (due to be released 12/77)	Directory only, not complete dictionary	Limited
Telecommunications interfaces	Complete TP monitor and most other popular monitors	DATACOM/DC, CICS, and others	Yes
PRICE (basic system, no options)	Basic system—$60,000. Full System: DOS—$112,000, OS—$132,000	DOS, DOS/VS—$34,000, OS, OS/VS—$40,000	Purchase only—$27,500. Annual maint—$2,750
COMMENTS	ADABCOMP is available for bill of material processor applications	DATACOM/DB and DC are designed to complement each other. DB can access up to 16 data elements in a single CALL. Will also run with EDOS operating system replacement	The latest version of DBMS-10 is Version 5. For Version 3 users, there is a conversion utility available. DBMS-10 is a CODASYL-type data base management system

Source: "A Buyer's Guide to Data Base Management Systems," DATAPRO Research Corporation, Delran, New Jersey, October 1977.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-2 (SHEET 2 of 5)

System	DBMS-20	DL/1 DOS/VS	DM-IV/I-D-S-II
Vendor	Digital Equipment Corp.	IBM	Honeywell
Current number of users	Approximately 40	Datapro estimates approximately 300	500—I-D-S-I, 25—I-D-S-II
CONFIGURATION			
CPU's supported	DECsystem-20	S/370 Models 125 and up	Honeywell Series 60, 600, 6000, Level 66
Operating systems	TOPS 20	DOS/VS	GCOS
Minimum memory requirements	64 512-word pages	98K bytes—batch (avg.), 183K bytes with CICS (avg.)	12K words plus buffers
DATA BASE FEATURES			
Data base organization	Network, hierarchical	Hierarchical (sequential and direct)	Hierarchical, network, random, index sequential
Application languages	FORTRAN, COBOL	COBOL, PL/1, Assembler	COBOL 74
Data base languages	DDL, DML	Data Language/1	Data Definition Language, DML
Access methods supported	Direct, sequential, index sequential, random	VSAM and SAM	All CODASYL-supported access methods
Variable-length segments	Yes	Yes	Yes
Data base security	System-level file security, subschema locks, privacy locks	Password lockout at data set level	Password, privacy keys to field level
System accounting facilities	Utilization statistics	Stand-alone—No, with CICS—Yes	Yes
RECOVERY FEATURES			
Checkpoint/restart	Yes	Yes	Yes
Data base integrity	Automatic backup/recovery, before/after imaging	Transaction logging for backout and recovery	Rollback and automatic recovery
OTHER SYSTEM FEATURES			
Concurrent batch/on-line	Yes	With CICS	Yes
Concurrent application program access	Yes	With CICS	Yes
Inquiry/retrieval facility	IQL	No	Procedural Language Processor, Interactive I-D-S-II
Report generator	COBOL Report Writer	No	Query and Report Processor
Data dictionary support	Limited	No	DB Access and Control System
Telecommunications interfaces	Yes	CICS/DOS/VS	TPS, DM-IV/TP
PRICE (basic system, no options)	Purchase only—$27,500, Annual maint.—$2,500.	Monthly license only, $395/month	$692/month (includes COBOL 74)
COMMENTS	DBMS-20 is a CODASYL-type data base management system designed specifically to take advantage of the DECsystem-20 hardware features.	There is a DL/1 Entry subset available for smaller users. The product is constantly being upgraded with new features and enhancements.	DM-IV is a total DBMS concept with I-D-S-II as the data manager. I-D-S-II is a CODASYL-type DBMS. Some conversion capabilities were made available for I-D-S-I users in the 3rd quarter of 1978, additional aids will be available in late 1977 and 1978.

Source: "A Buyer's Guide to Data Base Management Systems," DATAPRO Research Corporation, Delran, New Jersey, October 1977.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-2 (SHEET 3 of 5)

System	DMS II	DMS/90	DMS-1100
Vendor	Burroughs Corp	Sperry Univac	Sperry Univac
Current number of users	Over 150 on B 6700/7700 Series	Approximately 20	Approximately 500
CONFIGURATION			
CPU's supported	Versions for any Burroughs system from B 1700 through B 7700	Univac Series 90, Series 70 (virtual)	Any Univac 1100 Series
Operating systems	MCP	OS/3, VS/9	1100 Operating System (EXEC 8)
Minimum memory requirements	180K bytes for B 6700	90/30—131K bytes; larger systems—262K bytes	15K words plus buffers
DATA BASE FEATURES			
Data base organization	Link, network, ring, hierarchical	Network, hierarchical	Network, hierarchical
Application languages	COBOL and ALGOL	COBOL, FORTRAN, Assembler	COBOL, FORTRAN, Assembler
Data base languages	DASDL	DDL, DML	DDL, DML
Access methods supported	All MCP-supported access methods	All CODASYL-supported access methods	All CODASYL-supported access methods
Variable-length segments	Yes	No	Yes
Data base security	Password capability and item-level security	Logical record locks, password	System-level file security
System accounting facilities	System log	Yes	Yes
RECOVERY FEATURES			
Checkpoint/restart	Yes	Yes	Yes
Data base integrity	Audit trail and transaction logging	Before/after imaging	Audit trail, before/after imaging
OTHER SYSTEM FEATURES			
Concurrent batch/on-line	Yes	Yes—VS/9, No—OS/3	Yes
Concurrent application program access	Yes	Yes—VS/9, No—OS/3	Yes
Inquiry/retrieval facility	INQUIRY Language	VS/9—UNIQUE, OS/3—none	Query Language Processor
Report generator	REPORT II, AUDIT-REPORTER	None	COBOL Report Writer
Data dictionary support	None	Yes	Yes
Telecommunications interfaces	NDL and MCS	VS/9—yes, OS/3—no	Yes
PRICE (basic system, no options)	$24,000 for larger version, prices vary for subsets	No charge to Univac customers	No charge to Univac customers
COMMENTS	DMS II facilities are incorporated into Burroughs higher level languages. DMS II is also integrated to some degree with the MCP operating system	DMS/90 is a CODASYL oriented DBMS. It interfaces with the operating system for many of the DBMS facilities. Enhancements are continually being added	DMS 1100 is a CODASYL-oriented DBMS. As is DMS 90, its sister DBMS for the Univac Series 90 systems, it uses many of the operating system data management features and facilities, and offers highly flexible networking features

Source: "A Buyer's Guide to Data Base Management Systems," DATAPRO Research Corporation, Delran, New Jersey, October 1977.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-2 (SHEET 4 of 5)

System	IDMS	IMS	INQUIRE
Vendor	Cullinane Corp.	IBM	Infodata Systems, Inc
Current number of users	300	Datapro estimates about 1000	70
CONFIGURATION			
CPU's supported	System/360, 370, DEC PDP-11	System/360, 370	S/360, 370, Amdahl Series 470
Operating systems	DOS, DOS/VS, OS, VS1, SVS, MVS	IMS-2—OS, OS/VS IMS/VS—OS/VS	OS, VS1, SVS, MVS, CMS
Minimum memory requirements	55K bytes plus 10K for each batch job, 2K for on-line jobs	IMS-2—128K bytes and up (DS), $12-768K (DB/DC). IMS/VS—90K and 350K	40K bytes—single user application program, 130K—INQUIRE language
DATA BASE FEATURES			
Data base organization	Hierarchical, network	Hierarchical (sequential and direct)	Network, hierarchical
Application languages	COBOL, PL/1, ASM, FORTRAN, RPG II	COBOL, PL/1, Assembler	COBOL, PL/1, Assembler, FORTRAN
Data base languages	DDL, DML	Data Language/1	INQUIRE User Language
Access methods supported	BDAM	VSAM, ISAM, OSAM, BSAM, VTAM, SAM	ISAM, VSAM, BDAM
Variable-length segments	Yes	Yes, with VSAM	Yes
Data base security	Password protection and subschema	Password and terminal access control	Password protection to field level
System accounting facilities	Automatic logging of system statistics	System Log Analysis tape and utilities	Accounting data base and retrieval routines
RECOVERY FEATURES			
Checkpoint/restart	Utilities supplied, automatic with TP	With IMS/DC	Warm restart capability
Data base integrity	Via prohibitive access	Transaction backout logging	Automatic logging and backout, image utilities
OTHER SYSTEM FEATURES			
Concurrent batch/on-line	Yes	Yes	Yes
Concurrent application program access	Yes	Yes, in DB/DC mode	Yes
Inquiry/retrieval facility	On-Line Query	IQF; with GIS product	User language multi-key facility
Report generator	CULPRIT, EDP/AUDITOR	GIS program product	Via User Language
Data dictionary support	Integrated Data Dictionary (IDD)	An FDP is available for IMS-2 users	EDIT Data Dictionary
Telecommunications interfaces	Shadow II, CICS, and most other monitors	CICS and IMS/DC	CICS, TSO, IMS/DC, CMS through Data Management Supervisor
PRICE (basic system, no options)	$42,000 rental and lease also available	Monthly license only IMS-2 - $646/mo.; IMS/VS—$950/mo	$39,500—entry level; $80,000—full capability, monthly lease available
COMMENTS	CODASYL-type DBMS. IDD extends built-in dictionary to handle all user files and data sets. Central and subset versions available	All enhancements and changes are being incorporated into the VS version. Up to 255 segment types per logical record with 15 levels are supported. Several fine-tuning facilities have recently been added	User-oriented system with open-ended data structures. Provides customized macro language and document retrieval capabilities. Uses relational data association principles

Source: "A Buyer's Guide to Data Base Management Systems," DATAPRO Research Corporation, Delran, New Jersey, October 1977.

FIGURE 4 (CONT'D) MATRIX OF MAJOR DATA BASE SOFTWARE AVAILABLE-2 (SHEET 5 of 5)

System	MODEL 204	SYSTEM 2000	TOTAL
Vendor	Computer Corp. of America	MRI Systems Corp.	Cincom Systems, Inc.
Current number of users	41	Approximately 150	Approximately 2000
CONFIGURATION			
CPU's supported	S/360, 370, Amdahl 470 Series, Itel AS, CDC Omega	S/360, 370, Amdahl 470 Series, CDC, and Univac 1100 Series	Most major minicomputers, medium- and large-scale computers
Operating systems	OS, VS1, SVS, MVS	OS, VS1, SVS, MVS, DOS/VS, SCOPE, KRONOS, NOS, EXEC 8, CSTS	All associated operating systems
Minimum memory requirements	120K bytes plus buffer space	140-200K bytes—IBM; 32K words—Univac; 20K words—CDC	From 8K on minis to 40K bytes on S/370
DATA BASE FEATURES			
Data base organization	Hierarchical, network, relational	Hierarchical, network	Network
Application languages	COBOL, FORTRAN, PL/1, Assembler	FORTRAN, COBOL, PL/1, Assembler	COBOL, FORTRAN, PL/1, Assembler, RPG II
Data base languages	IFAM/II	DDL, IMMEDIATE	DBDL, DML
Access methods supported	QSAM, EXCP level	All standard IBM access methods	BDAM, DAM, VSAM
Variable-length segments	Yes	Yes	Physical—no, logical—yes
Data base security	Password and log-in protection to field level	Password lockout, assigned authority	Down to field level
System accounting facilities	Multi-user accounting log and utilities	Logs, statistics and estimation tools	Logging and statistics
RECOVERY FEATURES			
Checkpoint/restart	Yes	Yes	Yes
Data base integrity	Rollback and audit trail	Transaction log, activity audit, rollback	Logging, dump and restore
OTHER SYSTEM FEATURES			
Concurrent batch/on-line	Yes	Yes	Yes
Concurrent application program access	Yes	Yes	Yes
Inquiry/retrieval facility	User Language (with stored requests)	System 2000 Query/Update facility	For Honeywell, Harris, and NCR systems
Report generator	User Language	Yes	SOCRATES
Data dictionary support	User defined	Control 2000	Cincom's Data Dictionary
Telecommunications interfaces	Self-contained TP, CICS, Intercomm	TP 2000, CICS, TSO, Intercomm	ENVIRON/1, CICS, TASK/MASTER, Intercomm
PRICE (basic system, no options)	From $50,000 to $100,000 depending on configuration; rental and lease available	$30,000; rental and lease available	From $10,000 upward. IBM DOS—$34,000, OS—$45,000, rental and lease available
COMMENTS	Supports up to 250 physical files which can be cross-referenced by a single user. Multi-threading TP. There is a French-language version.	Contains a Multi-Thread option which can handle up to 9 strings simultaneously. Can define multiple data base consisting of up to 1,000 components on 32 hierarchical levels.	TOTAL is available on more mainframes than any other DBMS. It supports up to 32 levels of data elements and up to 65,000 files.

Source: "A Buyer's Guide to Data Base Management Systems," DATAPRO Research Corporation, Delran, New Jersey, October 1977.

All the data base systems listed in Table 1 are alpha-numeric; however, water use is alpha-numeric associated with areal data. For example: a wellfield (collection of wells) supplies water to the inhabitants of a service area; a well is used to irrigate so many acres of a particular crop.

The CADDS-3 (Computervision) system is presently being used to automate a mapping system. The CADDS-3 system is capable of handling mapping applications and associated features including map alignment, polygon identification, map rectification, area calculation, summary by land use, map paneling, map sectioning, 3-D data base, full edit capability, 256 layers of information storage and data smoothing.

The CADDS-3 system's 3-D data base is highly associative and flexible. Unlike most graphic data bases, the CADDS-3 package has the ability to ascribe to any element of entity non-graphical properties such as well locations, well properties, pumpage, water quality and other associated parameters.

Additionally, each entity can be placed on any one of the 256 layers available within a drawing or a land use map. The contents of any combination of layers can be made visible, as well as editable or non-editable. This unique capability provides the user with a means of storing different classes of data (alpha-numeric, geometric, etc.) within one map, and extracting any subset of data via the appropriate layer list.

Additionally, CADDS-3 system hardware and software support asynchronous, synchronous and bi-synchronous communications with most major CPU manufacturer's main frames. In the future, when the District procures a central processing unit, data can be transferred from one computer to another without any major obstacle.

Based on the versatility and capability of the CADDS-3 data base system,

this demonstration project will be used to investigate, store and retrieve water use data.

Demonstration Project - CADDS-3 Data Base System

In order to determine the capability and the accuracy of the sonic flow meters and the sonic timers, as well as the Computervision Data Base (CADDS-3) System, a demonstration project was designed for Lee County in southwest Florida. Lee County was chosen as the demo project site since:

1. A water use and supply planning effort is presently going on in this area.
2. Water resources data and other data is being collected and analyzed in support of "1" above.
3. The land use data has already been digitized and stored in the Computervision data storage files.

In order to familiarize the readers, a brief synopsis of Lee County information is presented.

Lee County

Lee County, located on the southwest coast of Florida, encompasses approximately 1,005 square miles or 643,200 acres of land; out of which 787 square miles is land and 218 square miles is inland water (Figure 4).

Due to the southerly location of the county, a warm climate and a high annual rainfall (average 53 inches) are typical. Average monthly temperatures range from a low of 61.3 in December to a high of 82.1^{o}F in August. (3)

In the year 1950, the county had an estimated resident population of 23,404, which has increased to 172,300 (1977). It is reported that southwest Florida presently is one of the fastest growing regions in the State. (6)

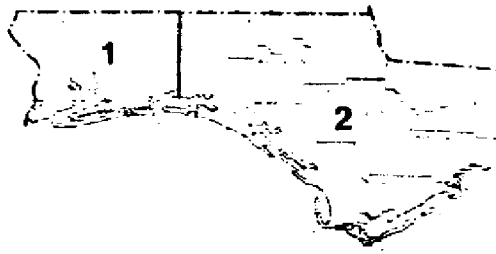
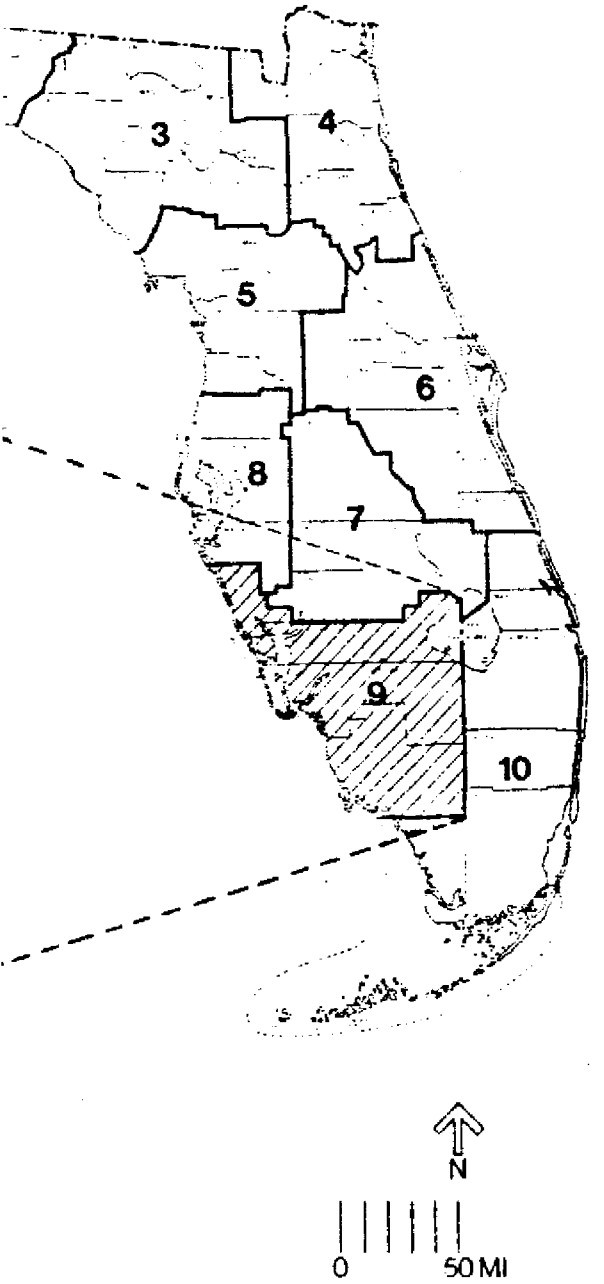


FIGURE 5. LEE COUNTY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Water Resources

Except for a small portion of the total water, the principal source of water supply in Lee County for domestic, commercial, industrial and municipal uses is groundwater.

Groundwater in Lee County is obtained from wells that tap one or more of the principal water bearing zones (Figure 5). In order of increasing depths, there are water table aquifers, and the water bearing zones or units in the Tamiami Formation, the upper and the lower parts of the Hawthorn Formation and the Tampa Limestone. (2)

Water Use

The most recent data concerning county water use indicates that on a gross average 94.08 million gallons of water was used from surface and ground water sources. (7) It was estimated that 68 percent of the total water used was utilized for agricultural purposes. Industry (lime rock processing) utilized 10 percent while domestic uses accounted for the remaining 22 percent. As can be seen, agriculture in the County is the largest water user; however, the total water used by agriculture is just an estimate calculated by use of various empirical equations, and not actual measured usage figures. It can be stated there is no way of knowing how much water is actually being pumped and used by agricultural, industrial, or commercial enterprises, since they are not measured at the present time.

Obviously, the only way to find out how much water is being pumped and used by different users is to conduct the needed studies and measurements. As pointed out earlier, no permanent water meters can be installed due to excessive costs; therefore, the alternate route to find out how much water is being pumped by different users is by the use of indirect flow measuring devices. This demonstration project is being undertaken to test whether indirect flow meters can be effectively used for measuring various water

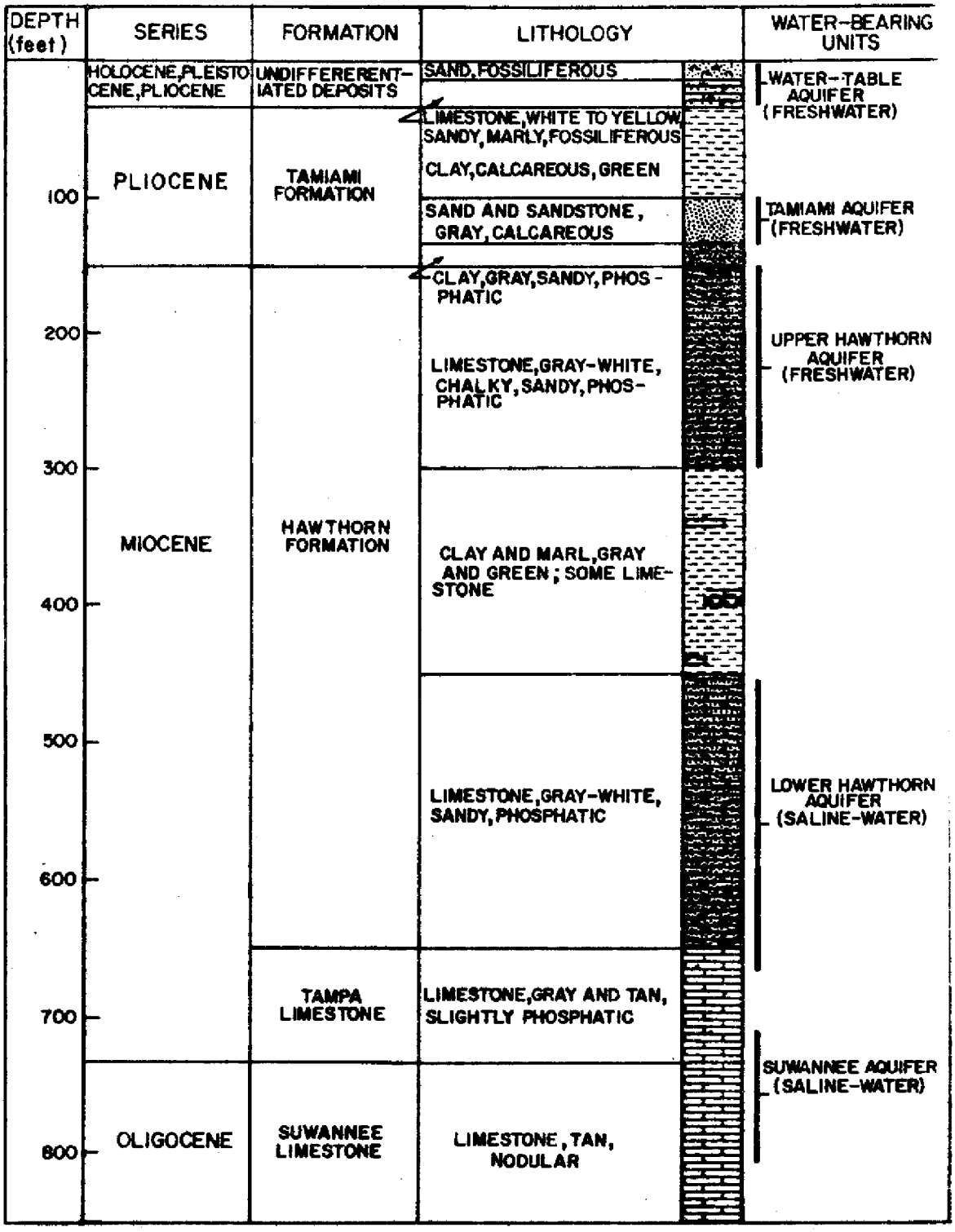

FIGURE 6. GENERALIZED SECTION SHOWING THE GEOLOGIC FORMATIONS, LITHOLOGY AND WATER-BEARING UNITS UNDERLYING LEE COUNTY.

uses, in addition to the investigation of an economic and versatile data base system.

Land Use Classification

In the past it was difficult to keep track of land use changes. However, with the in-house Computervision system it is now possible to update land use changes in a relatively short time.

Land use can be classified into several levels. Level I classification is made for aggregated usage; and Level III for detailed breakdown. Presented in tabular form are the three levels of general land use classification presently used by the District. When the land use classification of a city, county or a basin is undertaken, not all of the detailed classifications may exist for that particular area.

Land Use Classification for the City of Cape Coral

For lack of space, a typical Level III land use classification for the City of Cape Coral, instead of for Lee County, is presented in Table 2. The City of Cape Coral encompasses approximately 101.06 square miles of area, the breakdown of which is presented in Table 2.

TABLE 2. LAND USE AND LAND COVER CLASSIFICATION SYSTEM

LEVEL I	LEVEL II	LEVEL III
(U) Urban & Built-Up Land	(UR) Residential	(URSL) Single-Family, Low Density (Under 2 D.U./gross acre)
		(URSM) Single-Family, Medium Density (2 to 5 D.U./gross acre)
		(URSH) Single-Family,High Density (over 5 D.U./gross acre)
		(URMF) Multi-Family Bldg.
		(URMH) Mobile Homes
		(UCHM) Hotel-Motel
	(UC) Commercial & Services	(UCPL) Parking lot
		(UCSC) Shopping Center
		(UCSS) Sales & Services
		(UCCE) Cultural & Entertainment
		(UCMC) Marine Commercial (Marinas)
	(UI) Industrial	(UIJK) Junkyard
	(US) Institutional	(USED) Educational
		(USMD) Medical
		(USRL) Religious
		(USMF) Military
		(USCF) Correctional
		(USGF) Governmental (other than military of correctional)
	(UT) Transportation	(UTAP) Airports
		(UTAG) Small grass airport
		(UTRR) Railroad yards & terminals
		(UTPF) Port facilities
		(UTOG) Oil & gas storage
		(UTEP) Electrical Power Facilities
		(UTTL) Major Transmission lines
		(UTHW) Major Highways & Rights-of-way
		(UTWS) Water Supply Plants
		(UTSP) Sewerage Treatment Plants
		(UTSW) Solid Waste Disposal
		(UTRS) Broadcasting or receiving towers

	(UO) Open and Others	(UORC) Recreational Facility (UOGC) Golf Courses (UOPK) Parks (UOCM) Cemeteries (UOUN) Open and undeveloped within urban area (UOUD) Open under development
(A) Agriculture	(AC) Cropland	(ACSC) Sugar Cane (ACTC) Truck Crops (ACRF) Rice Fields
	(AP) Pasture	(APIM) Improved Pasture (APUN) Unimproved Pasture
	(AM) Orchards, groves, vineyards, nurseries, ornamental, and horticultural Areas	(AMCT) Citrus (AMTF) Tropical Fruits (AMSF) Sod Farms (AMOR) Ornamentals
	(AF) Confined Feeding Operations	(AFFL) Cattle Feed Lots (AFDF) Dairy Farms (AFFF) Fish Farms (AFHT) Horse Training & Stables (AFPY) Poultry
(R) Rangeland	(RG) Grassland	
	(RS) Scrub and Brushland	(RSPP) Palmetto Prairies (RSSB) Brushland
(F) Forested Uplands	(FE) Coniferous	(FEPF) Pine Flatwoods (FESP) Sand Pine Scrub (FECF) Commercial Forest (Pine)
	(FO) Non-Coniferous	(FOAP) Australian Pines (FOBP) Brazilian Peppers (FOPA) Palms (FOSO) Scrub Oak (FOOK) Oak (FOCF) Commercial Forest
	(FM) Mixed Forested	(FMTW) Temperate Hardwoods (FMCG) Cabbage Palms/Oaks (FMPO) Pine/Oak (FMTH) Tropical Hammocks (FMOF) Old fields forested (FMCD) Coastal dunes (FMPC) Pine/Cabbage Palm

(W) Wetlands	(WF) Forested Fresh	(WFCY) Cypress
		(WFWL) Willow
		(WFME) Melaleuca
		(WFSB) Scrub & brushland
		(WFMX) Mixed forested
	(WN) Non-Forested Fresh	(WNSG) Sawgrass
		(WNCT) Cattail
		(WNBR) Bullrush
		(WNWC) Wire Cordgrass
		(WNAG) Mixed Aquatic Grass
		(WNWL) Water Lily Sloughs
	(WS) Forested Salt	(WSRM) Red Mangrove
		(WSBW) Black & White Mangrove
	(WM) Non-Forested Salt	
	(WX) Mixed Forested & Non-Forested Fresh	(WXPP) Pine & Wet Prairies
		(WXCP) Cypress domes and wet prairies
		(WXHM) Hardwood & Marsh
(H) Water	(HC) Rivers, Streams, Canals	
	(HO) Open fresh water	
	(HM) Open Marine water	
	(HE) Bays & Estuaries	
(B) Barren land	(BB) Beaches	
	(BP) Extractive (Strip Mines, Quarries, & gravel pits)	
	(BS) Spoil Areas	
	(BL) Levees	

TABLE 3: LAND USE CLASSIFICATION FOR THE CITY OF CAPE CORAL

Land Use Classification	Acreage (Acres)
Single-family, Low Density (under 2 D.U./gross acre)	4,967
Single-family, medium Density (2 to 5 D.U./gross acre)	3,246
Multi-family	54
Mobile homes	36
Sales & Services	310
Cultural & Entertainment	32
Junkyard	265
Educational	68
Medical	26
Religious	20
Electrical Power Facilities	2
Water Supply Plants	2
Sewage Treatment Plants	2
Recreational Facility	16
Golf Courses	439
Cemeteries	31
Open & Undeveloped within urban area	488
Open under development	35,230
Improved Pasture	2,437
Unimproved Pasture	557
Palmetto Prairies	194
Pine Flatwoods	5,853
Old Field Forested	515
Pine/Cabbage Palm	252
Mixed Forested	7
Non-Forested Fresh	174
Red Mangrove	175
Black & White Mangrove	4,970
Non-Forested Salt	718
Pine & Wet Prairie	1,220
Rivers, Streams & Canals	761
Open Fresh Water	684
Bays & Estuaries	133
Barren Land	769
Beaches	73
Extractive (Strip Mines, Quarries, & Gravel Pits)	16
Spoil Areas	26
TOTAL	64,676

Aggregated Water Use - City of Cape Coral

Presently, the utility department of the City of Cape Coral supplies water for residential, commercial and multiple uses based on meter size. Presented in Table 4 is water use, by aggregated land use, for the month of May 1978, as tabulated and reported by the utility company.

TABLE 4. WATER USE BY CLASSIFICATION FOR MAY 1978, CITY OF CAPE CORAL

Classification	Monthly Use (Gallons)	Daily Use (Gallons)
Residential (5/8" meter)	39,947,890	1,288,641
Residential (1" meter)	1,891,300	61,009
Residential (2" meter)	24,000	774
Commercial	6,791,280	
Multiple	8,325,810	
TOTAL	56,980,280	

Additionally, within the City there are two golf courses whose average yearly allocations, as permitted by the District, are presented in Table 5.

TABLE 5. WATER ALLOCATION FOR GOLF COURSES - CITY OF CAPE CORAL

	Acres	Yearly Alloc.	Avg. Daily	Gal/Acre
1. Cape Coral Exec. C.C.	29	6288905	17,230	594
2. Cape Coral C.C.	187	40731250	111,592	596
				595

Water Use by Land Use Classification - City of Cape Coral

Even though the water use reported by the city and the permit application are aggregated, the water use for different land use classifications can be broken down (based on national averages).

Water use figures presented in Table 6 are abstracted from the Water Well Handbook by Anderson. (1).

TABLE 6. WATER CONSUMPTION REQUIREMENTS

Public Buildings:

Hotels and Schools	0.8 gal. per min. per fixture
Apartment Buildings	0.3 " " " " "
Hospitals	0.4 " " " " "
Office Buildings	0.7 " " " " "
Mercantile Buildings	0.6 " " " " "

Standard Fixtures (Flow of Water):

Bath	10 gallons per minute
Lavatory	5 " " "
Tank Closets	5 " " "
Valve Closets	30 " " "
Shower	5 " " "
Sink	10 " " "
Laundry Tub	10 " " "
Garden Hose (3/4" nozzle)	5 " " "
Continuous Drinking Fountain	1½ " " "

Standard Fixtures (Contents):

Bathtub	30 gallons
Shower (each)	30 "
Lavatory	1½ "
Flushing water closet	6 "

Farm-Domestic (Daily Requirements):

Each member of family, for all purposes including kitchen, bath, etc.	100 gallons
Each Horse	10 "
Each Steer or Dry Cow	12 "
Each Cow Producing Milk	25-30 "
Each Hog	2 "
Each Sheep	1½ "
Each 100 Chickens	4 "

Industrial Requirements (Approximate):

Steel, highly finished	65,000 gals. per finished ton
Aluminum	960 gals. per pound ingot
Oil Refining	770 gals. per 42-gal. barrel
Paper Manufacture	30 gals. per pound of paper
By-product Coke	3,600 gals. per ton of coal
Coal Washing	200 gals. per ton of coal
Distilling	300-600 gals. per bu. mashed grain
Cotton--fiber to fabric	37 gals. per pound of goods
Cotton Cloth Processing	5-18 gals. per pound of goods
Tanning	800 gals. per 100 lb. hide
Brewing	470 gals. per barrel

Agricultural Requirements (Approximate):

Tomato Canning	60 gals. per bushel tomatoes
Corn Canning	1,100 gals. per ton of corn in husk
Meat Packing	6,000 gals. per ton on the hoof
Dairying	5 gals. per gallon of milk
Corn Syrup	30-40 gals. per bushel corn

Additionally, a recent report by Kim, J. E. and R. H. McCuen (AWWA, Feb. 1977 issue) cite the following figures for different commercial usage.

Items	Water Use
Restaurant (gal/chair)	24
Hospital (gal/bed)	200
Motel (gal/unit)	50
Laundromat (gal/machine)	400
Barber Shop (gal/chair)	55
Beauty Salon (gal/station)	95
Schools (gal/student)	6
Office (gal/sq. ft.)	.09
Banks & retail stores (gal/sq. ft.)	.05
Dept. Store (with Lunch Counter) (gal/sq.ft.)	.08
Dept. Store (without Lunch Counter) (gal/sq.ft.)	.04
Service Stations (gal/sq. ft.)	.18
Car Washes (gal/sq. ft.)	4.9

Theoretical Water Use by Land Use Classification

After having the level III land use classification as well as the national average water use figures for different usage, it can be attempted, on a theoretical basis to calculate the water use for feasible land use classification. An example is given below. The units used will be (ft^3/ft^2).

Examples:

USRL - Single Family Low Density under 2.0 D.U./Ac.

Land use classification for the City of Cape Coral shows 4967 acres under URSL classification (Table 3). A look at Table 4 shows that residential water usage (5/8" meter) for the month was 39,947,890 gallons. On a daily basis it is equivalent to 259.4 gallons/acre. As there are 2 dwelling units/acre, the average water is 129.7 gallons/d.u. In the cu. ft./sq. ft. unit, the water use of a single family low density housing unit would be .000842.

URSL = .000842

URSM - Single Family Medium Density (2 - 5 D.U./Ac.)

Acres - 3,246

Daily water used for the month of May 1978 - 1,915,300 on a daily basis,

is equivalent to 590 gallons/acre. Assuming 3.5 dwelling units/acre, the average water use per dwelling unit would be 168 gallons. In cubic ft./sq. ft. the water use of a single family medium density housing would be .000184.

URSM = .000184

UOGC + APIM - Golf Course and Improved Pasture

Acres - 439 acres and 2537 acres

The daily average withdrawal for a golf course or improved pasture is 647 gallons/acre = .00198 cu.ft./ft.^{2}

UOGC = .00198

APIM = .00198

USED - Educational

Acres - 68

As per the City Planning Dept. there are 600 school children in the City of Cape Coral at present.

Using Kim & McCuen's estimated water use of 6.0 gallons per student; the total daily use would be 3600 gallons.

$$\frac{3600}{7.48 \times 68 \times 43{,}560} = .000001625 \text{ ft.}$$

USED = .000001625 cu.ft./ft.^{2}

USRL - Religious

Acres - 20 acres.

There is no water use number available for the religious classification; as a realistic value, the water use for an office which is .09 gallons/sq. ft., will be used. Therefore, USRL water use will be .09/7.48 = 0.1203 cu.ft./ft^2.

URSL = .01203

UTWS - Water Supply Plants

Acres - 2

Using the same office water use

USRL = .01203 cu. ft./ft.^{2}

UTSP - Sewerage Treatment Plants

Acres - 4

UTSP = .01203 cu.ft./ft.^{2}

UORC - Recreational Facility

Acres - 16

Assume 5000 people use the recreational facility on a daily basis. There is no published water use figure, so that 6 gallons per person will be assumed.

Total daily water use = 30,000 gallons

Water use in ft^3/ft^2 = .00575

UORC = .00575 ft^3/ft^2

UOCM - Cemeteries

Acres - 31 acres

Assume 25% of the area irrigated. Using the water use figures for improved pasture.

$$\frac{647}{7.48} \times \frac{1}{.25 \times 31} \times \frac{1}{43{,}560} = .000256$$

UOCM = .000256 cu.ft/ft.^{2}

Presented in Table 7 is the land use, acreage and water use for each land use classification.

TABLE 7 : LAND USE, ACREAGE & ESTIMATED WATER USE FOR THE CITY OF CAPE CORAL

Land Use Classification	Acreage (Acres)	Water Use (cu.ft./sq.ft.)
1. Single family, low density (under 2 d.u./gross acres)	4967	.000842
2. Single family, med. density (2-5 d.u./gross acres)	3246	.000184
3. Multi-family	54	-
4. Mobile homes	36	-
5. Sales & Services	310	-
6. Cultural & Entertainment	32	-
7. Junkyard	265	-
8. Educational	68	.000001625
9. Medical	26	-
10. Religious	20	.01203
11. Electrical Power Facilities	2	-
12. Water Supply Plants	2	.01203
13. Sewage Treatment Plants	2	.01203
14. Recreational Facility	16	.00575
15. Golf Courses	439	.00198
16. Cemeteries	31	.000256
17. Open & Undeveloped Within Urban Area	488	-
18. Open under Development	35,230	-
19. Improved Pasture	2,537	.00198
20. Unimproved Pasture	557	-
21. Palmetto Prairies	194	-
22. Pine Flatwoods	5,853	-
23. Old Field Forested	515	-
24. Pine/Cabbage Palm	252	-
25. Mixed Forested	7	-
26. Non-forested Fresh	174	-
27. Red Mangrove	175	-
28. Black & White Mangrove	4,970	-
29. Non-forested salt	718	-
30. Pine & Wet Prairie	1,220	-
31. Rivers, Streams & Canals	761	-
32. Open Fresh Water	684	-
33. Bays & Estuaries	133	-
34. Barren Land	769	-
35. Beaches	73	-
36. Extractive (Strip Mines, Quarries & Gravel Pits)	16	-
37. Spoil Areas	26	-

As can be seen from Table 7 all the land use classification cannot be tied with water use, since no water use number exists presently for many of these classifications. This is especially true of native vegetation.

All the water use data was tied with the appropriate land use information in the Computervision (CADDS-3) System. They are presented in Appendix A.

Results

In Appendix A locational information on rainfall stations, wellfields, etc., are presented. The alpha-numeric data associated with the above, such as the rainfall records, well depths, well pumpages, water quality, etc., cannot be presented in tabular form at present due to the lack of an on-line printer. The alpha-numeric data can only be displayed on the computer console at this time.

A three dimensional plot of calculated water use for individual land use classifications, superimposed on the land use map of Cape Coral, is shown in the Appendix. This map shows the location of heavy water use (high peaks) in some parts of the city's service area. This plot is very useful for water management work. During water shortage periods these are the areas where reduction in water usage should take place. Incidentally, these peaks are for golf courses and single family residential uses.

Conclusions

CADDS-3 as a data base management for water use is a sophisticated system where alpha-numeric data can be tied with locational and land use information. The system has a limited storage capability and as the number of data points starts to grow, the system can overload.

When the District procures a central data processing system, these two systems should be linked for maximum flexibility and utilization. The CADDS-3 System hardware and software can support asynchronous, synchronous and bi-synchronous communications with most major CPU manufactueres' mainframes (IBM 360, IBM 370, UNIVAC 1108, Honeywell 6000, CDC 6600, XDS Signa 7, DEC PDP-15, SIEMENS 4004, SINGER MS 6000). In this way, any water resources studies, historic, hydrologic, water use or other data can be transferred from the central system to the CADDS-3 system and tied together with land use information.

DEMO PROJECT - FLOW METERS AND TIMERS

The City of Cape Coral, except for the two golf courses and a small percentage of improved pasture, does not have extensive agricultural activities. However, in Lee County there are more than 40,000 acres of irrigated land; at least 15,000 acres of which is in District water use consumptive permits. Presented below in Table 8 are the different types of agricultural crops grown in the county which are under District permit.

TABLE 8: DIFFERENT TYPES OF IRRIGATED CROPS IN LEE COUNTY

Types of Crops	Acres
Nursery (container & field grown)	845
Citrus	3,250
Improved Pasture	5,421
Golf Courses	887
Avocados	400
Small vegetables	3,280
Tomatoes	775
Potatoes	608
	15,484

Nursery, Improved Pasture and Golf Courses are irrigated on an annual basis. The rest of the crops are seasonal and irrigated only during the season.

Flow Measurements and Timers Installation

The field work on installing the timers and taking flow measurements started in May, during which time the irrigation of seasonal crops had already ceased. Additionally, due to heavy rainfall, virtually all irrigation activity was stopped; therefore timers could not be installed during this demonstration project on all the irrigated crops in Lee County. As stated earlier nursery and golf courses are irrigated on an annual basis and it was decided to test the timers and also measure the flows for these two irrigation activities.

According to the District's consumptive use permit file listing of Feb. 27, 1979, there are 10 nursery farms and 10 golf courses in Lee County pumping in excess of 100,000 gallons of water per day. Twenty-two (22) sonic timers were installed near the pumps to measure the number of hours these pumps run. Most of the timers were installed on May 9, 10 and 11 and a few of them were installed on the 18th and 30th of the month. In the following table is presented the timer number, installed date and time, timer removal date and time, number of days, estimated time the pump ran (estimations from farmers or golf course superintendents) read out time in hours and percentage of readout time vs. estimated time (Table 9). Flow velocity was measured by use of sonic flow meters. The readings are within 90% of the actual flow velocity.

TABLE 9. WATER USE PROGRAM; RESULTS ON TIMER INSTALLATION

TIMER NO.	INSTALLED DATE/TIME	REMOVED DATE/TIME	NO. OF DAYS	ESTIMATED TIME, HOURS	READOUT TIME HOURS	READOUT/ ESTIMATED TIME %	GENERAL COMMENTS
779	5-10-79 1030	8-2-79 843	84	570	592	104	4% underestimate
766	5-10-79 1400	8-1-79 1245	83	996	999	100	
776	5-9-79 1443	8-1-79 1555	84	96	101	105	5% underestimate
747	5-9-79 1405	8-1-79 1554	84	96	56	58	
717	5-30-79 1414	8-1-79 1315	63	756	857	113	
740	5-11-79 1145	8-1-79 1524	-	-	-	-	
714	5-18-79 1028	8-1-79 1237	75	900	944	105	
778	5-9-79 1507	8-1-79 1600	85	498	552	111	
770	5-10-79 1330	8-2-79 1180	85	2014	1988	99	
724	5-24-79 1458	8-2-79 1200	70	-	52	-	bad timer
689	5-30-79 1414	8-1-79 1315	63	-	3000	-	bad timer
773	5-10-79 1500	8-2-79 1120	84	150	149	99	
768	5-10-79 1027	8-2-79 950	84	58	63	109	
725	5-24-79 1458	8-2-79 1200	70	-	1635		bad timer
730	6-7-79 1830	8-1-79 1413	54	210	220	105	
720	5-30-79 1530	8-1-79 1335	63	610	609	100	
761	5-10-79 1027	8-2-79 950	84	190	193	102	

TABLE 9 (Cont'd). WATER USE PROGRAM; RESULTS ON TIMER INSTALLATION

TIMER NO.	INSTALLED DATE/TIME	REMOVED DATE/TIME	NO. OF DAYS	ESTIMATED TIME, HOURS	READOUT TIME HOURS	READOUT/ ESTIMATED TIME %	GENERAL COMMENTS
765	5-9-79 1800	8-2-79 920	84	300	-	-	wiped
764	5-9-79 1820	8-2-79 925	84	300	166	55	
775	5-10-79 1258	8-2-79 1055	85	300	302	101	
777	5-10-79 1107	8-2-79 1010	85	907	901	99	
780	5-10-79 1118	8-2-79 1030	85	440	434	99	

Results

Out of the 22 vibration timers installed in the field, 4 timers became inoperative due to internal electrical shorts, pump removal, or disconnection. The rest of the timers were read and the pumping times were within 90% of the range of time estimated by the farmers. The flow recorded is also within range.

Conclusions

Based on the above results it can be concluded that 1) flow estimates can effectively be made by use of ultrasonic flow meters, 2) quantity of water used can be estimated by use of both flow meters and timers, and 3) water use data can be tied together with land use information for decision making processes, using the Computervision's data base system.

As this demo project has shown the feasibility of this program, next year the project will encompass the whole of the Lower West Coast (Lee, Collier, Hendry, Glades, and Charlotte counties) for collection, analyzing, and storing the water use data.

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3. Florida Statistical Abstract. 1976

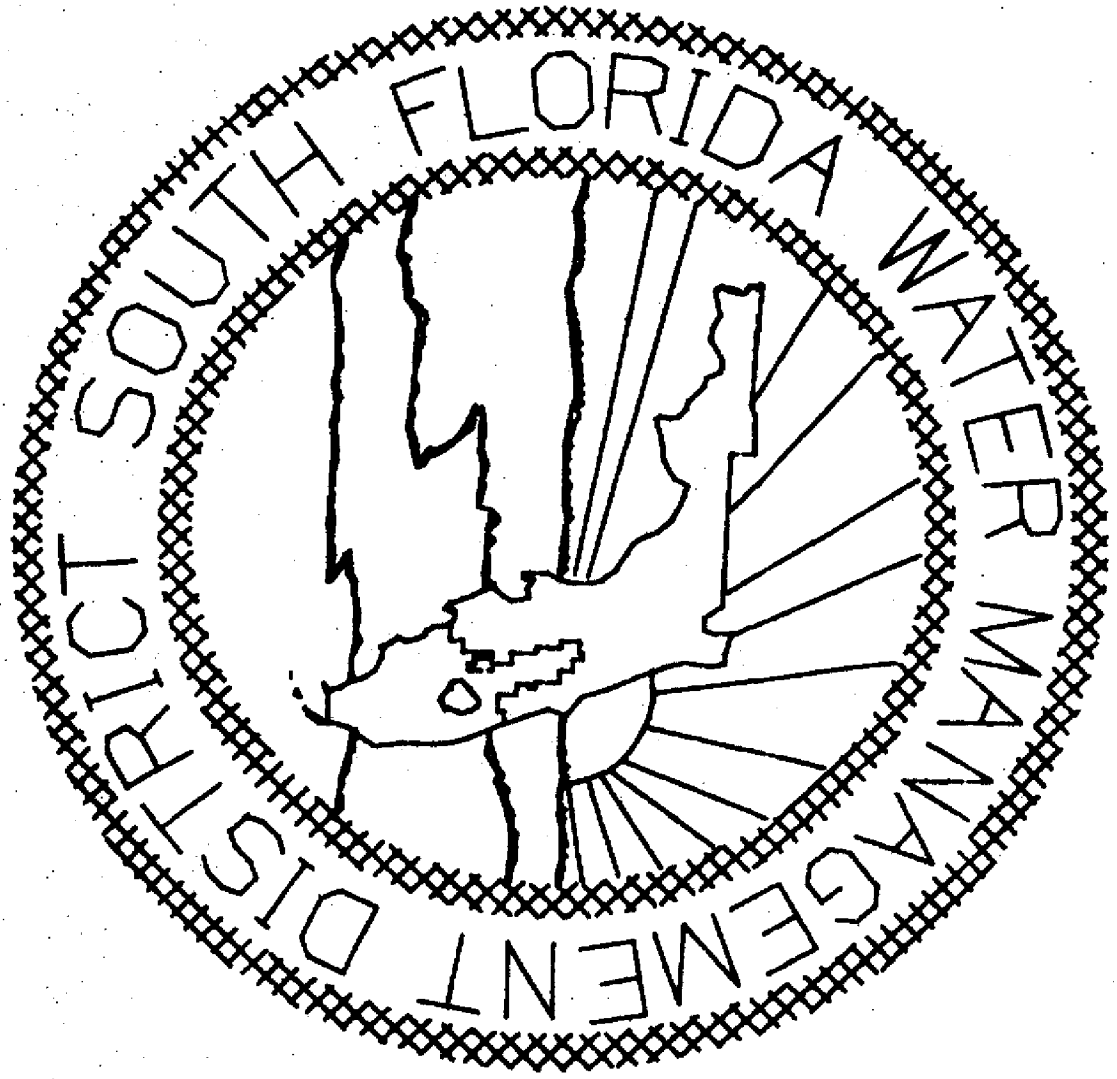
4. Ian Palmer. 1975. Data Base Systems: A Practical Reference. CACI Inc. London, England.

5. Kim, J.E. and R. H. McCuen. 1977. AWWA. Feb. Issue.

6. Post, Buckley, Schuh & Jernigan. 1976. Master Water Plan for Lee County.

7. U. S. Geological Survey. 1976. Estimated Water Use in Florida.

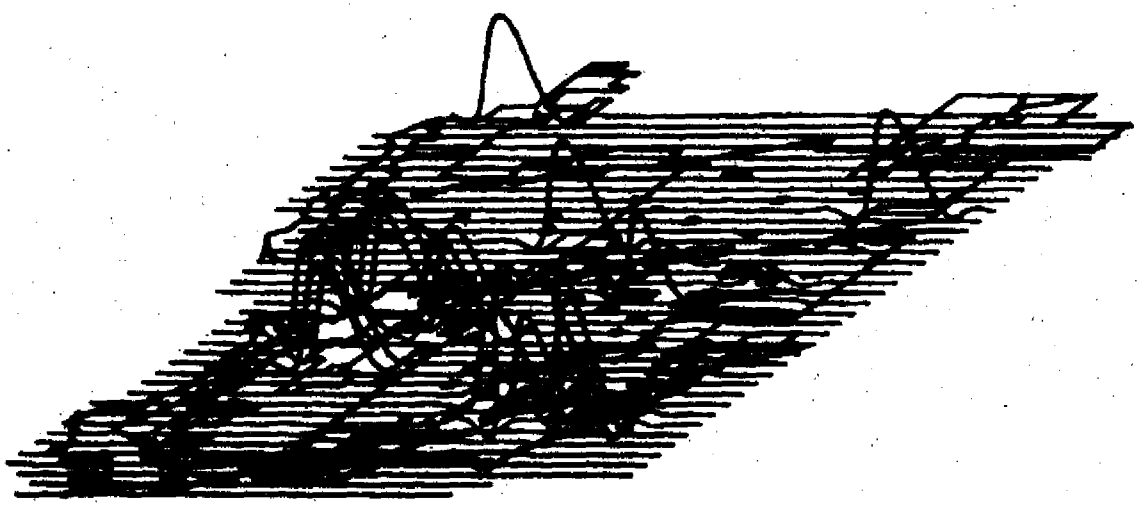
APPENDIX



LAND USE AND LAND COVER DATA

AND

SURFACE SHOWING WATER RUN BY LAND USE CATEGORY

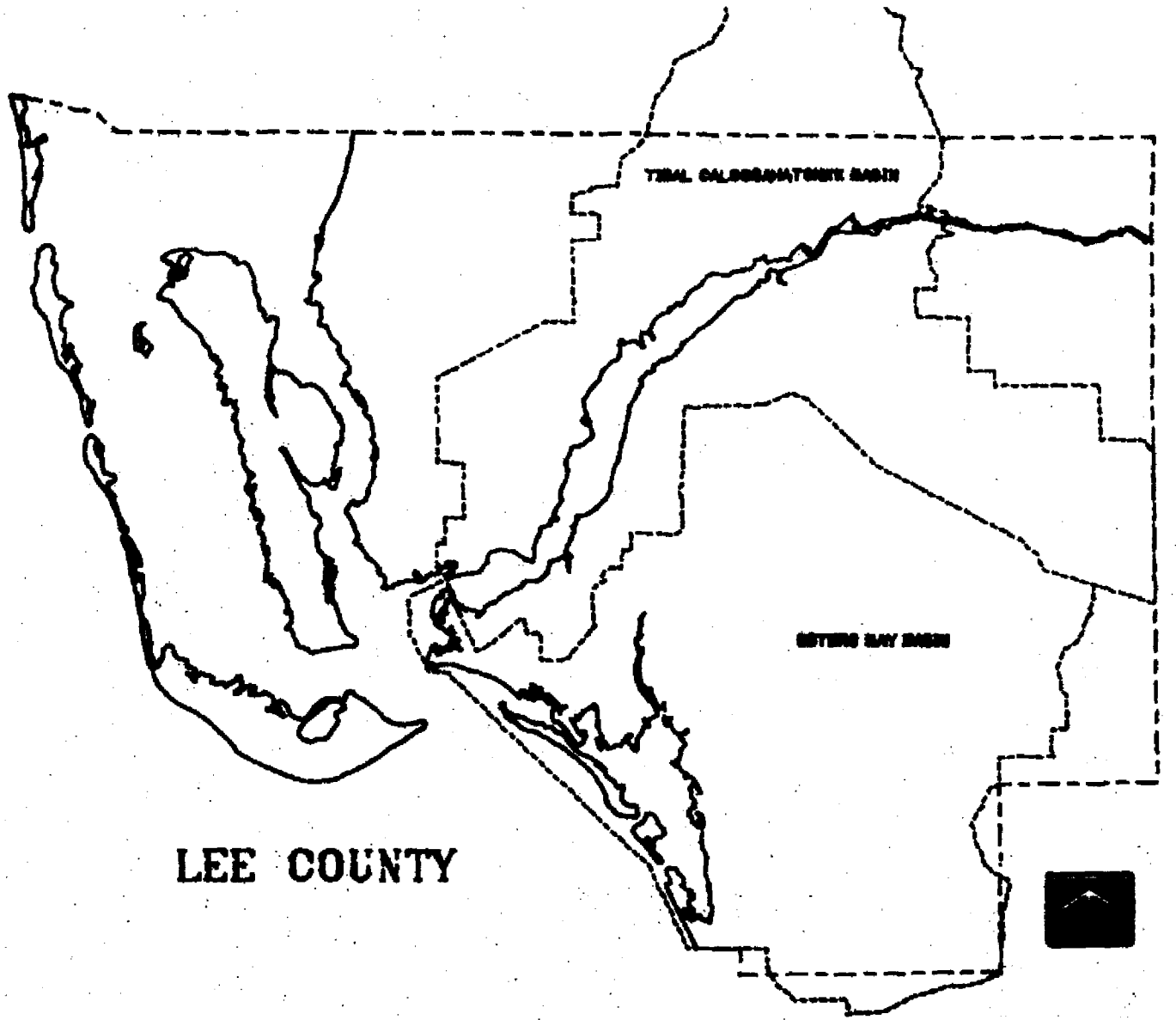


PILOT WATER USE DATA SYSTEM

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

AND

UNITED STATES GEOLOGICAL SURVEY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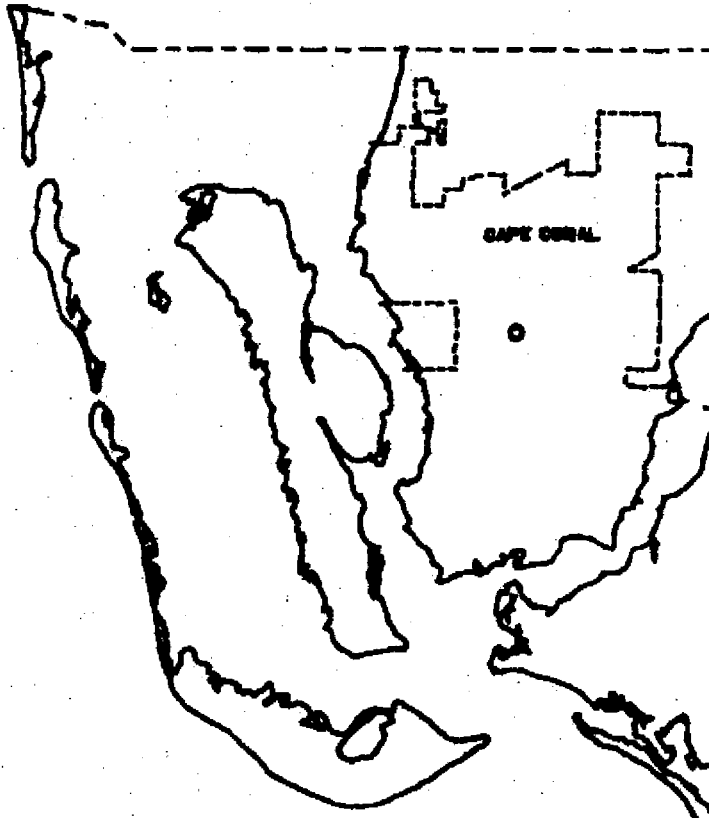
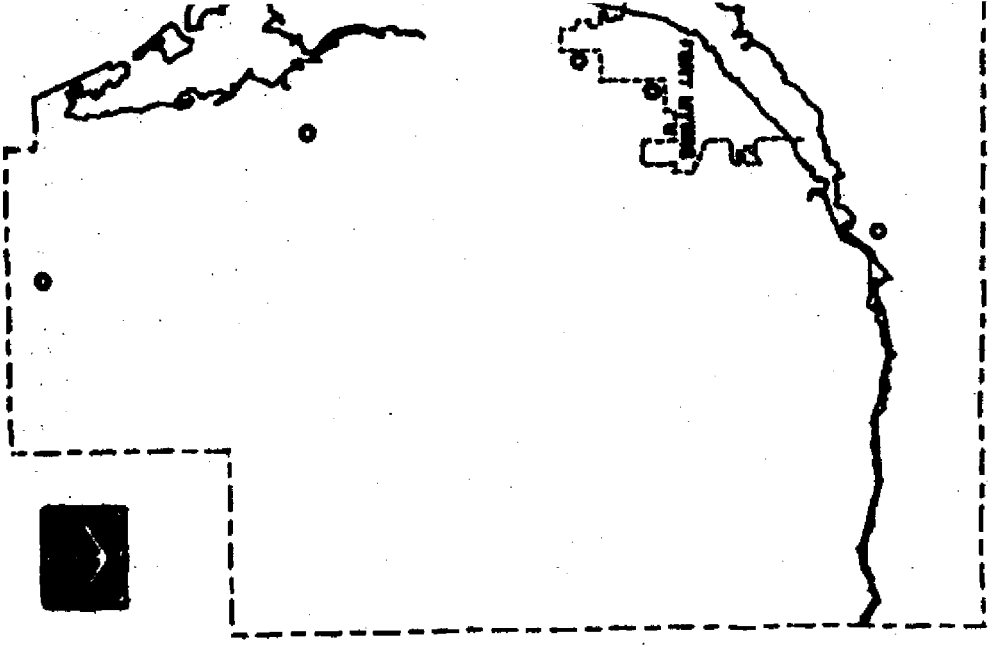
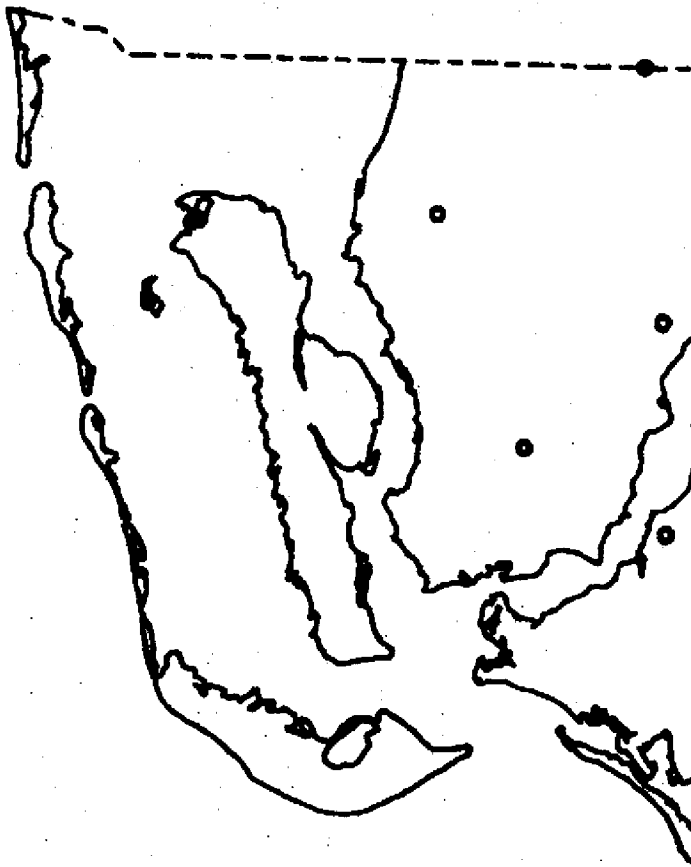


LEE COUNTY

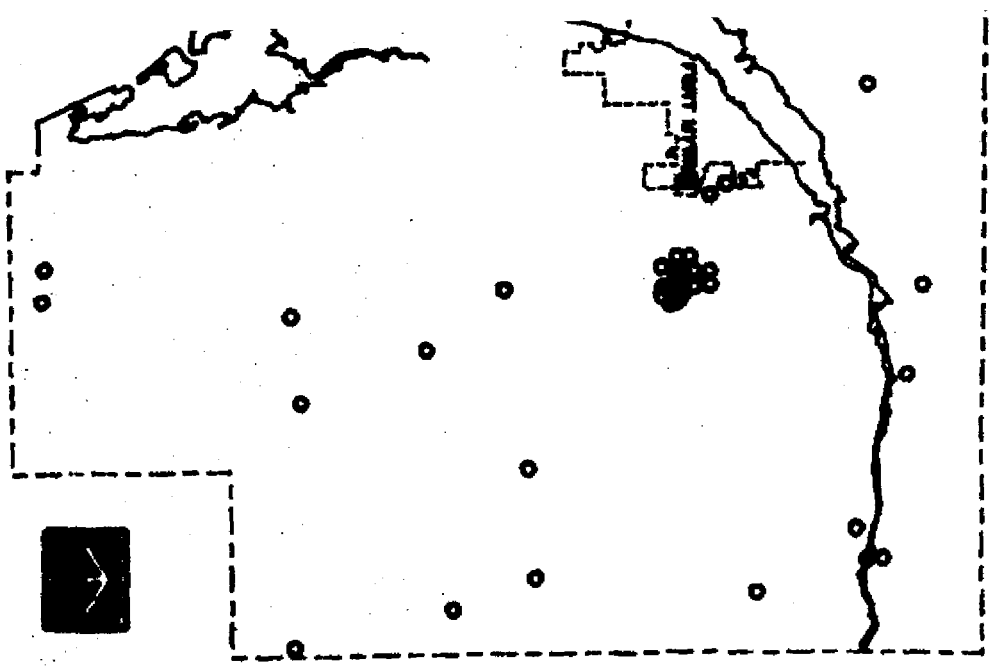
RAINFALL STATIONS

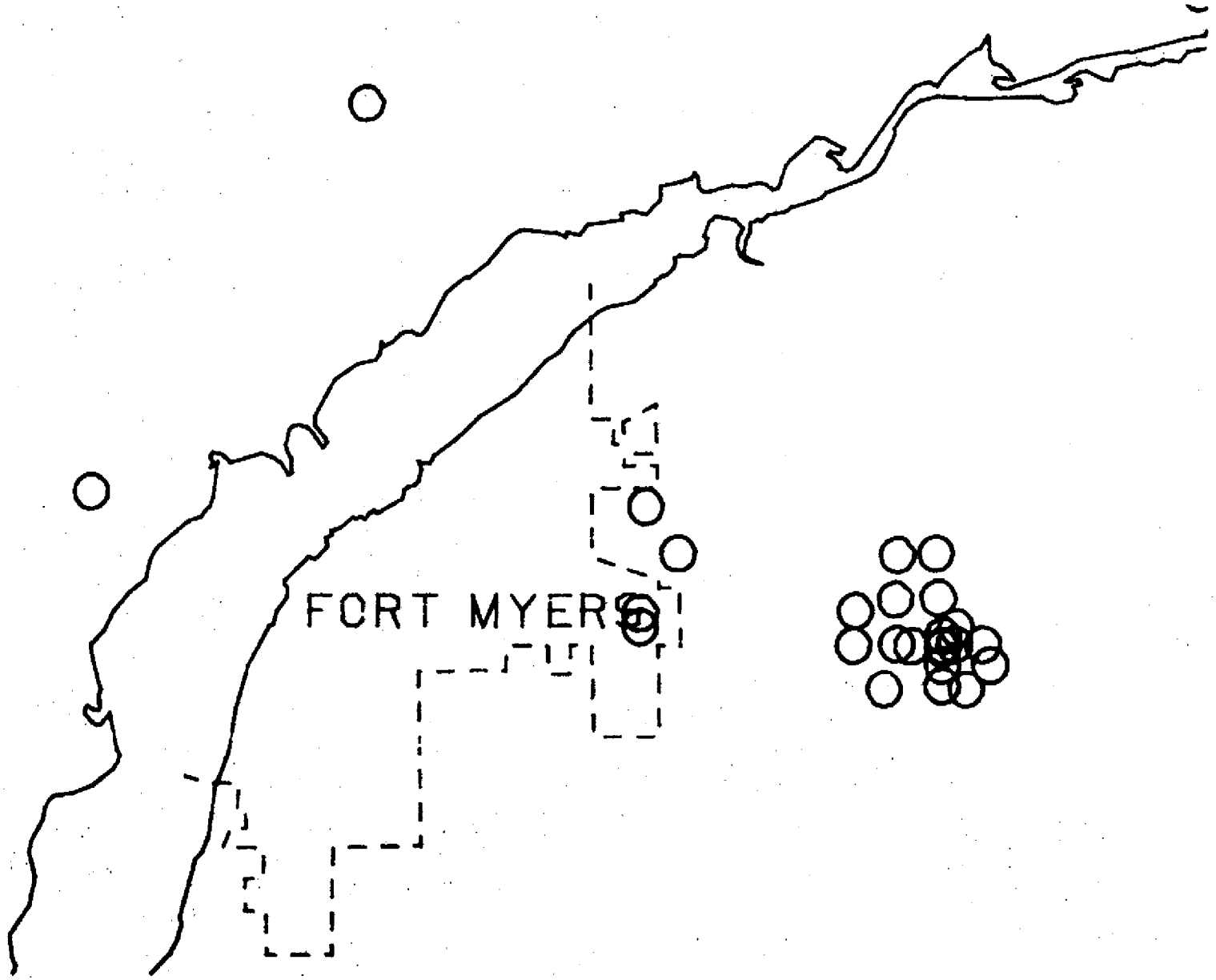




LEE COUNTY

WATERTABLE WELL LOCATIONS

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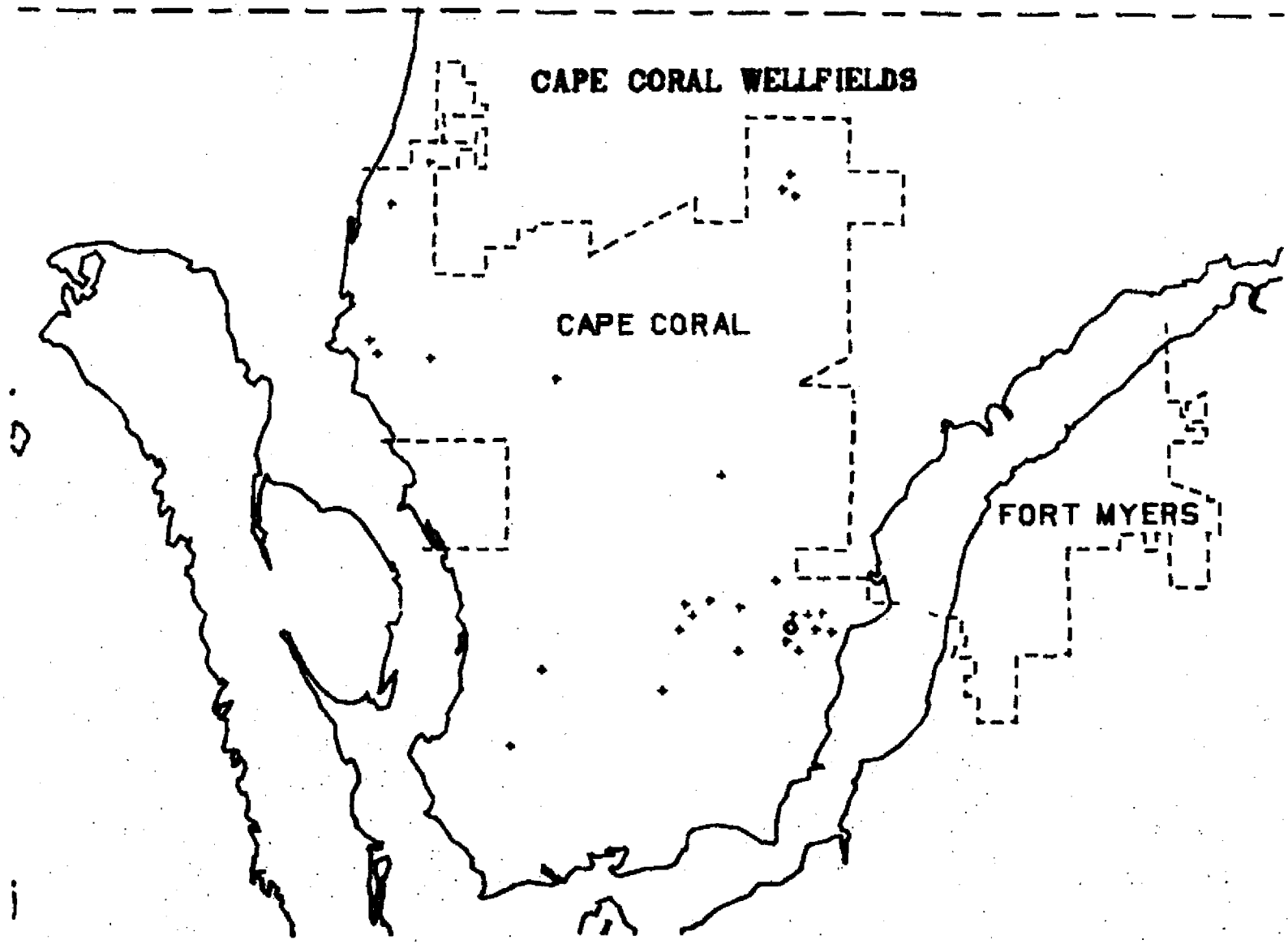
CAPE CORAL WELLFIELDS
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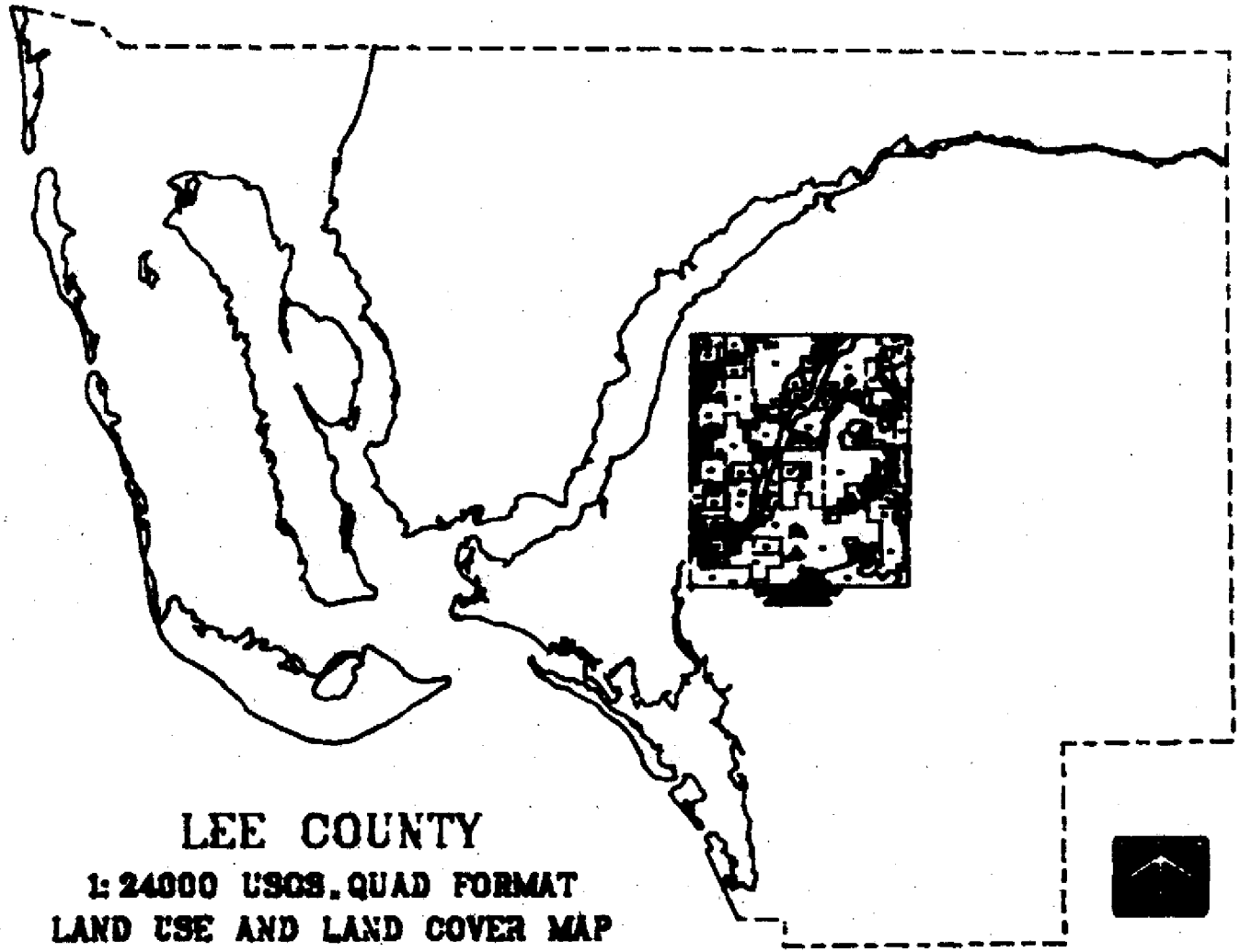
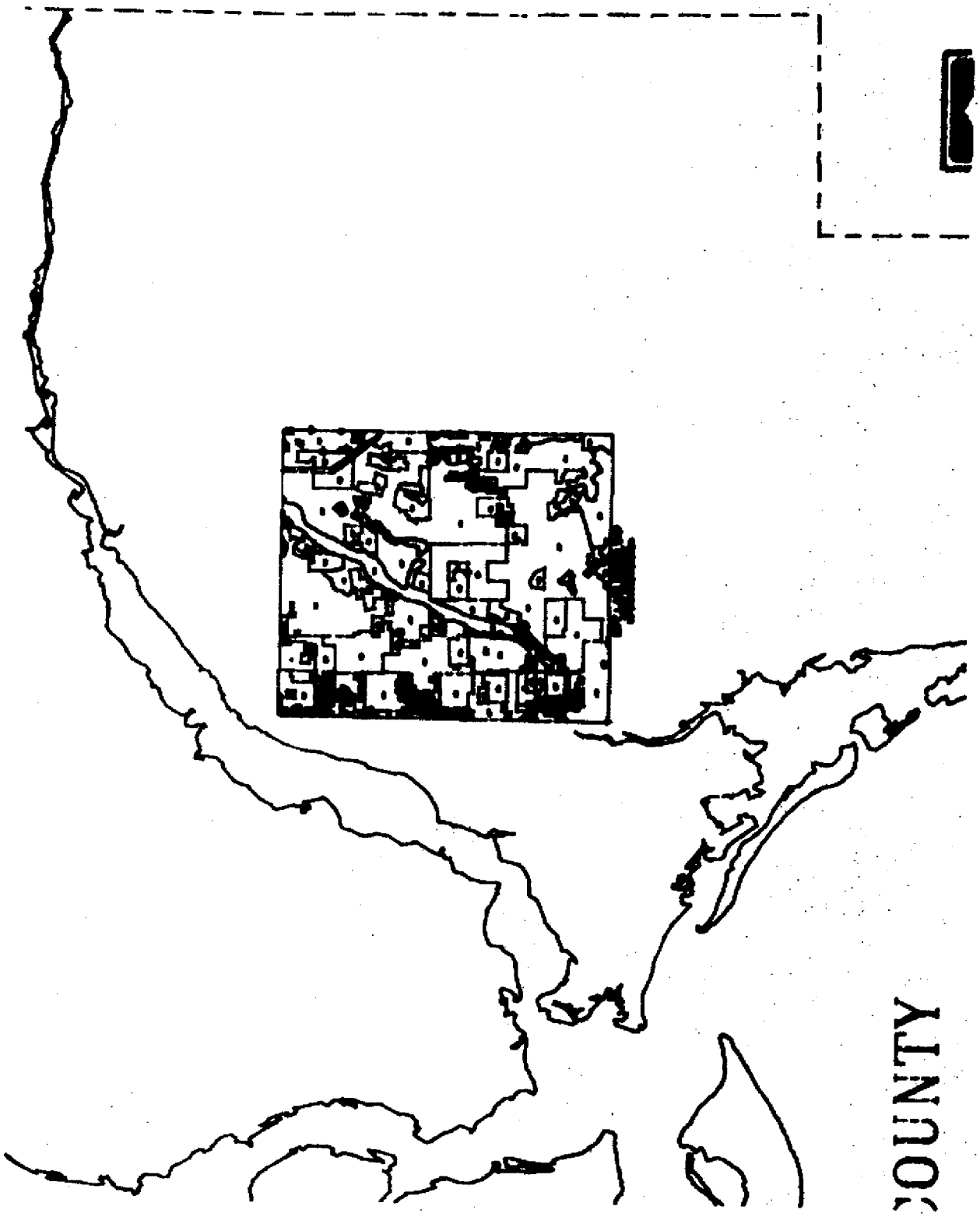


LEE COUNTY

1:24000 USGS. QUAD FORMAT

LAND USE AND LAND COVER MAP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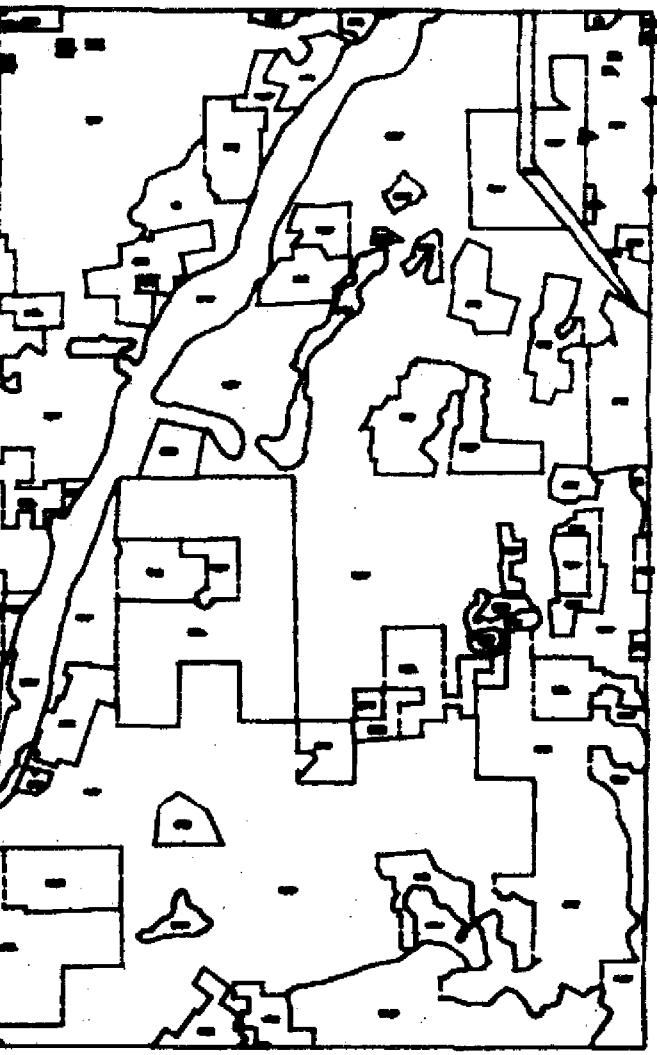

1977 LAND COVER MAP
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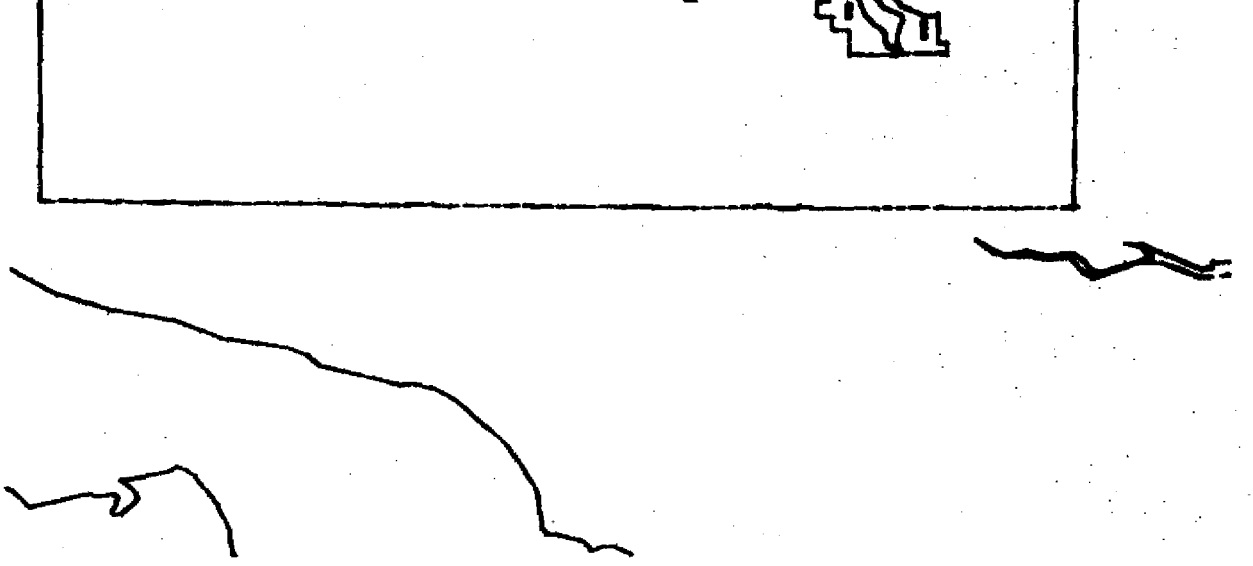

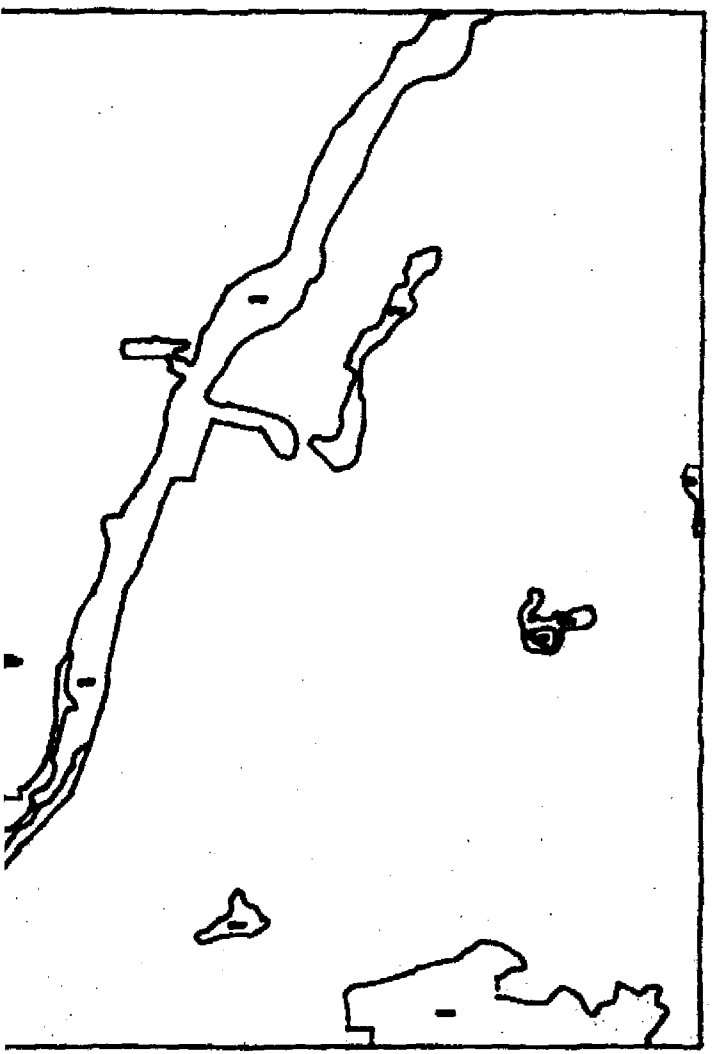

1977 LAND COVER MAP
FORT MEYERS SE

DATA EXTRACTED FROM U.S.G.S. QUADS
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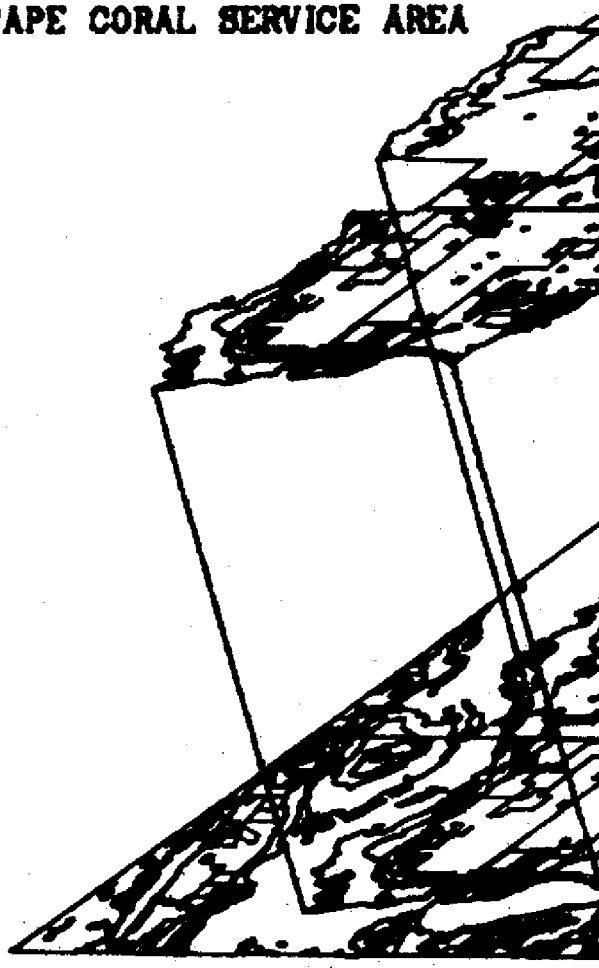
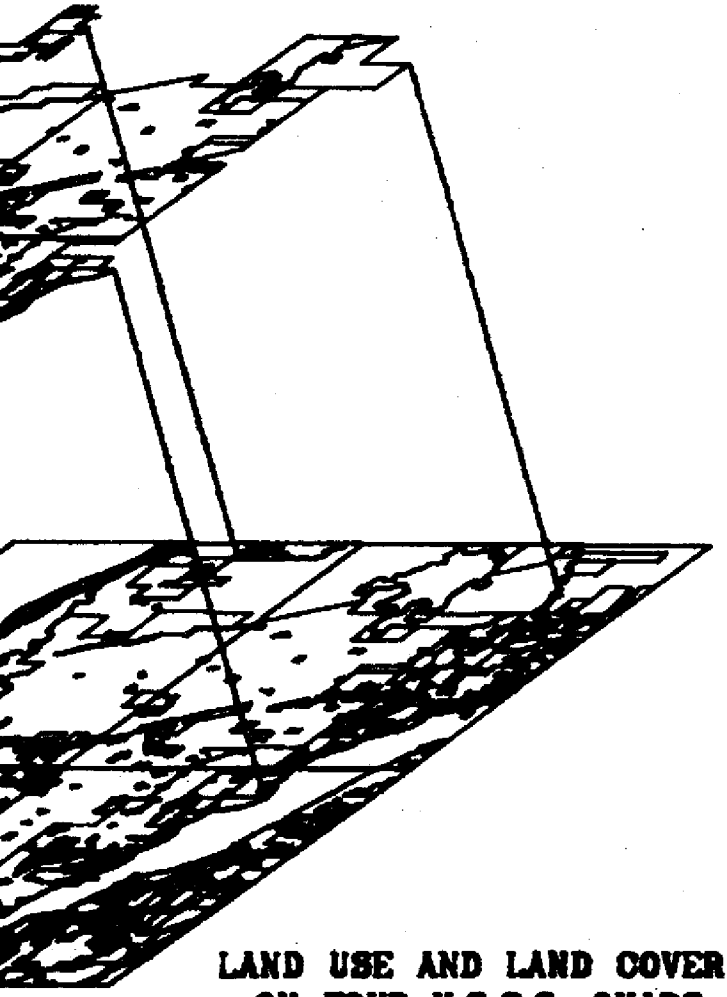
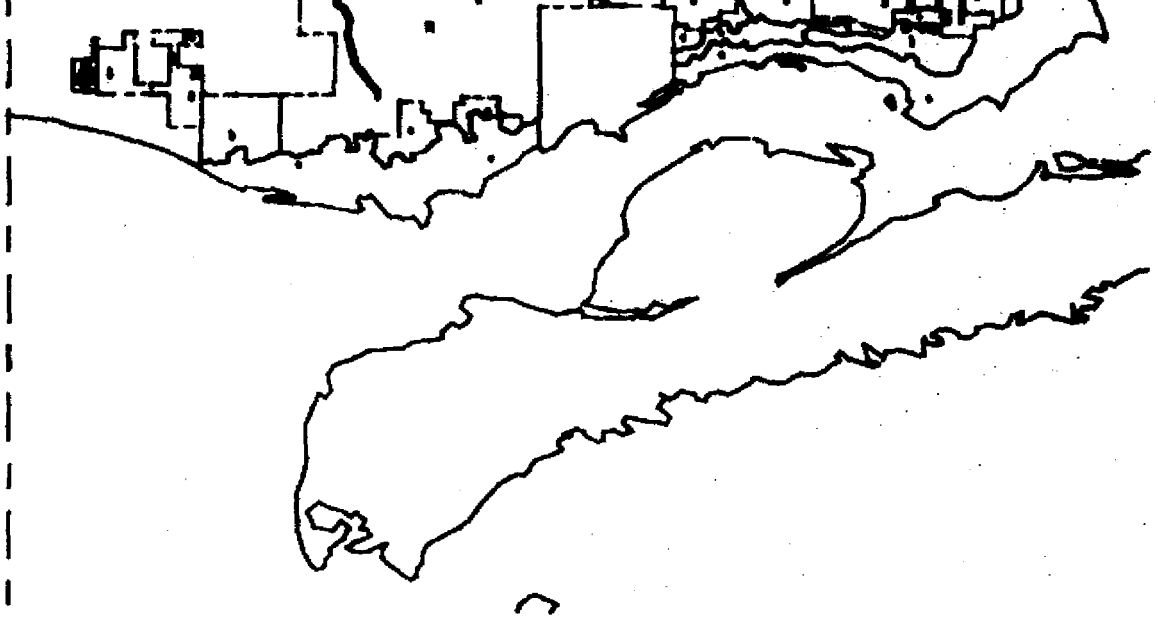
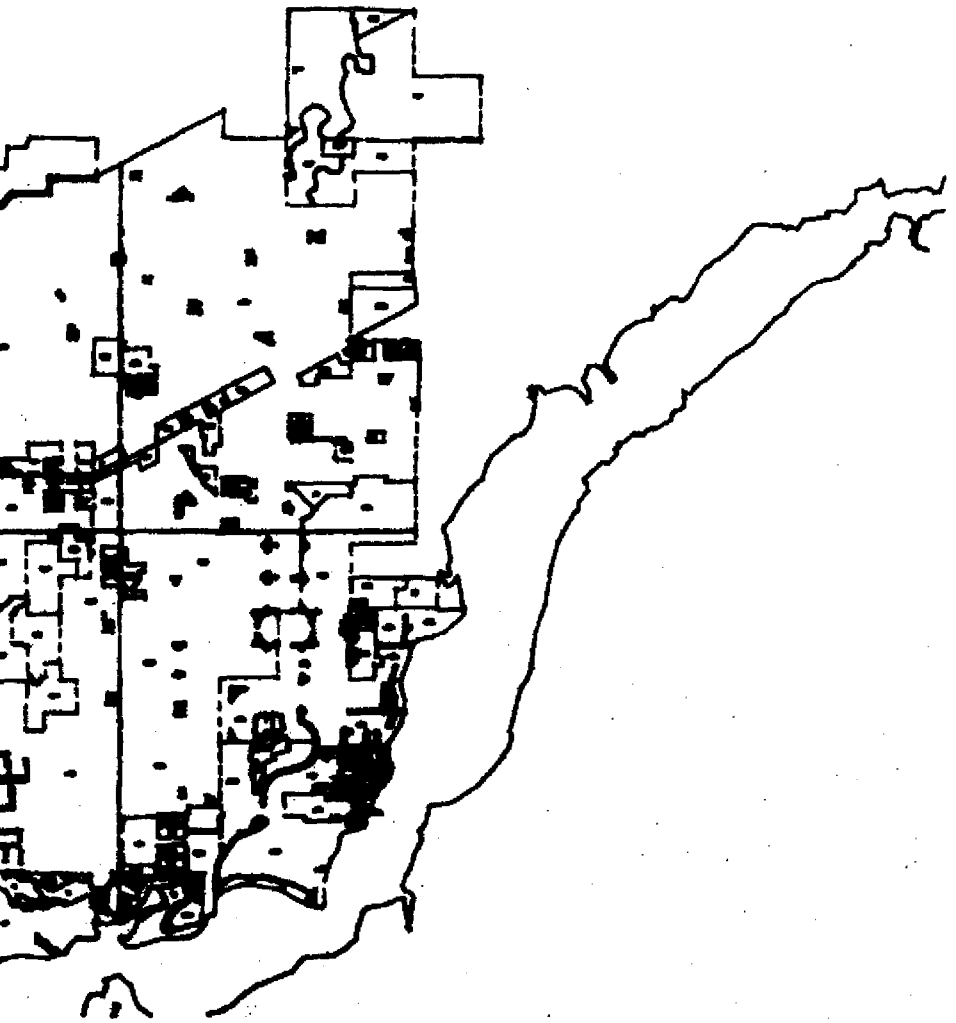


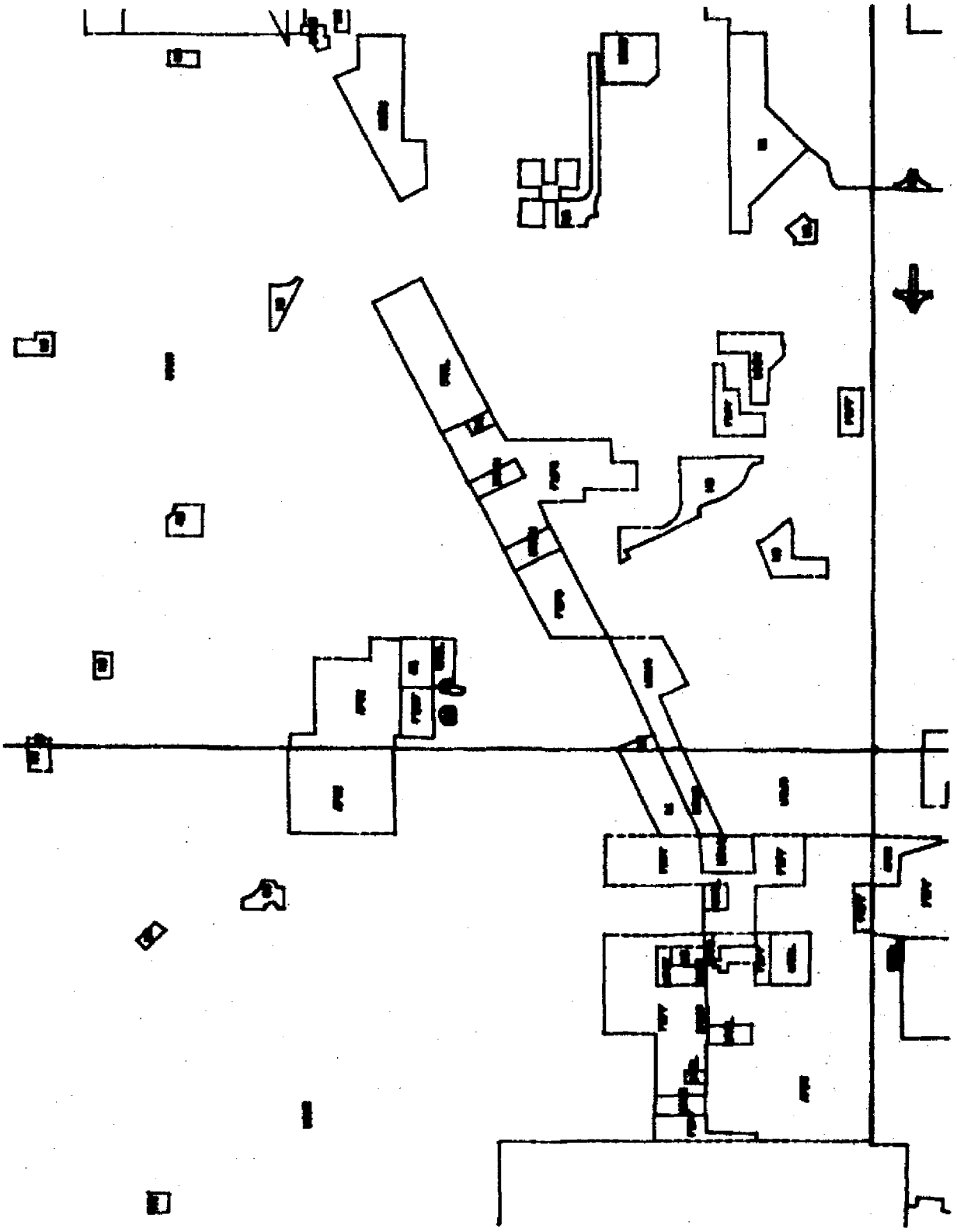


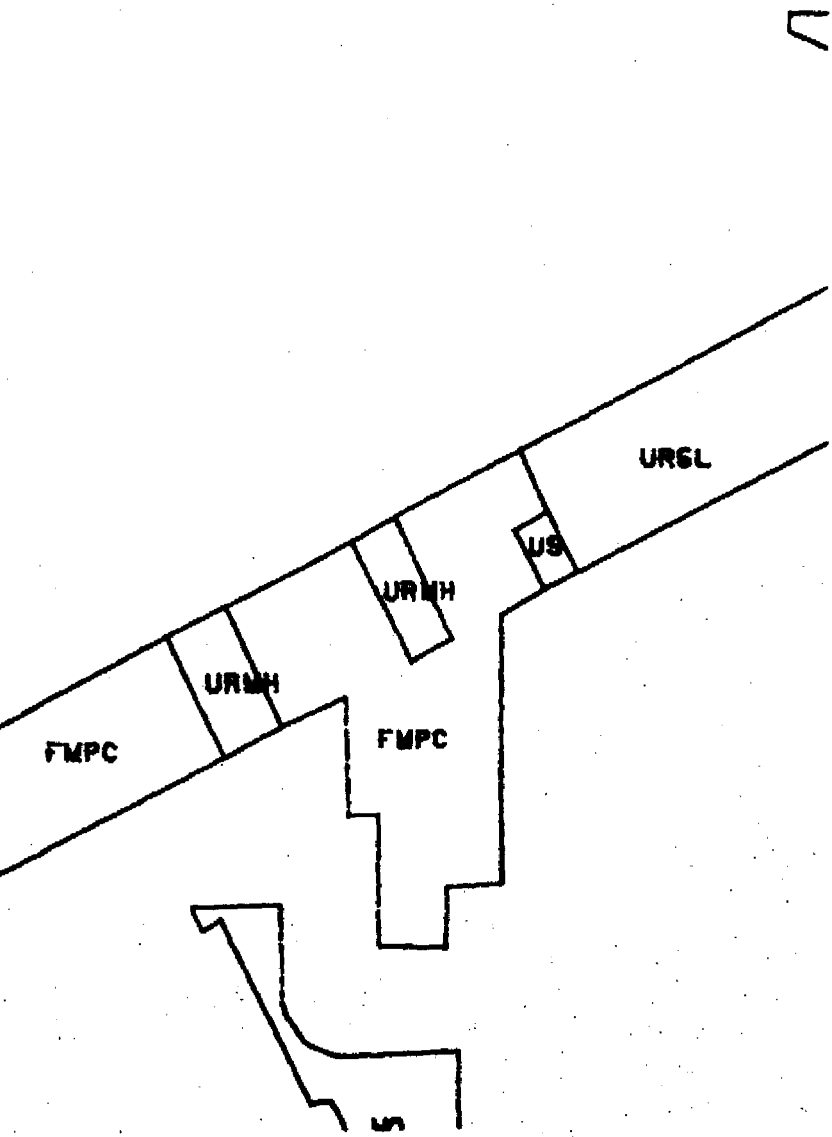
LAND USE AND LAND COVER
ON FOUR U.S.G.S. QUADS



LAND USE AND LAND COVER DATA



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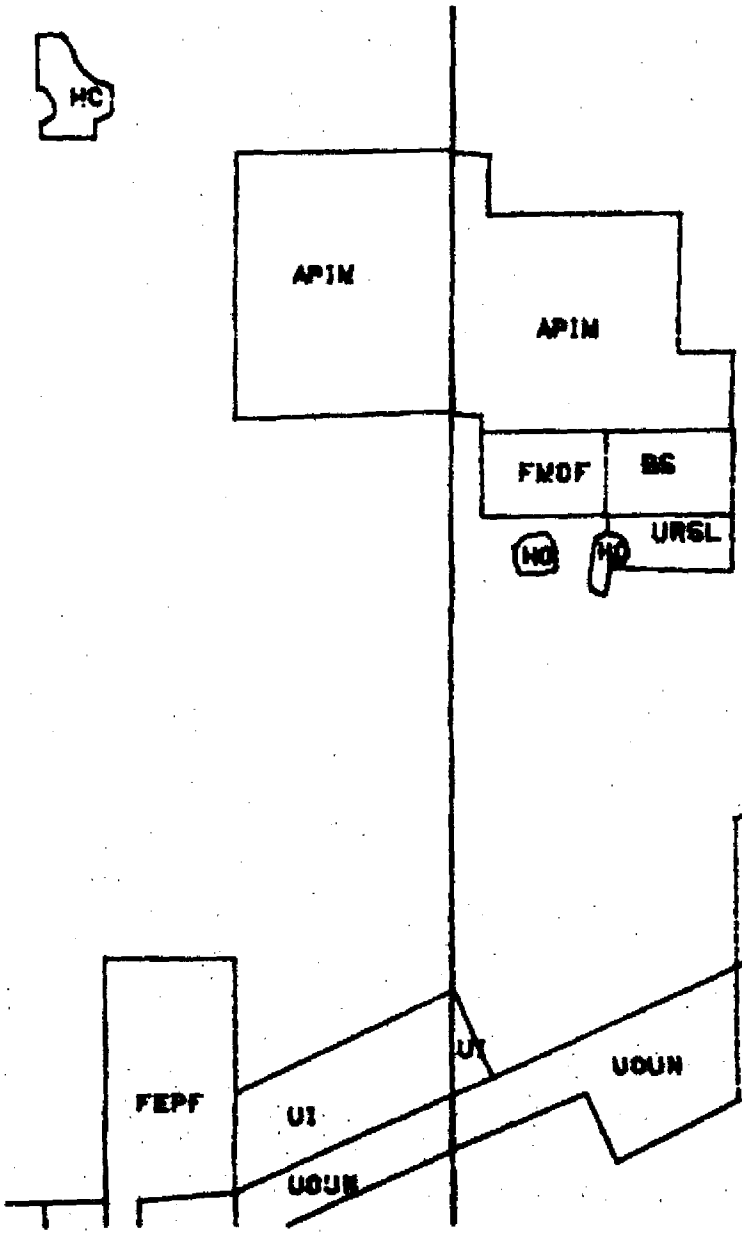
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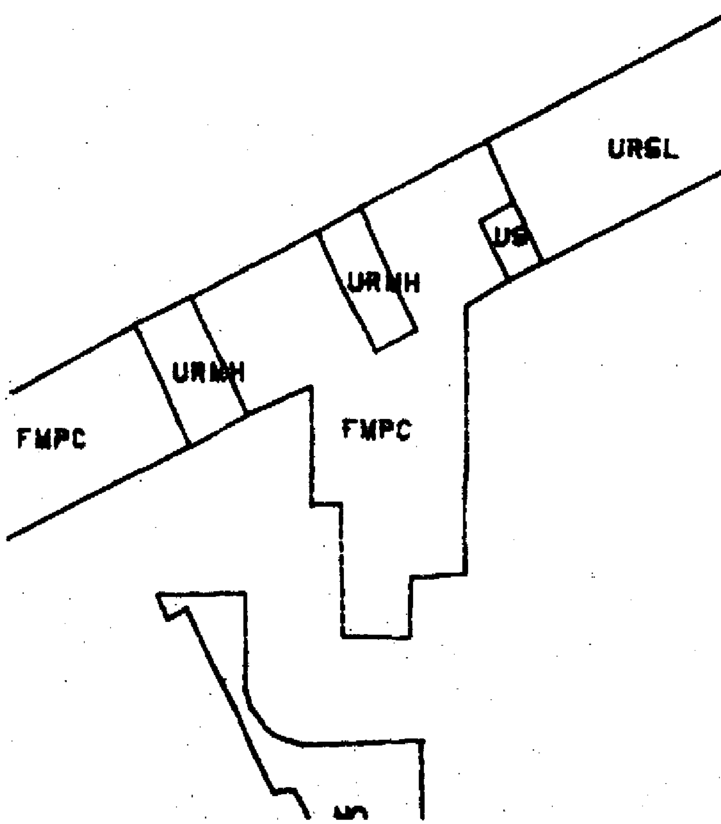
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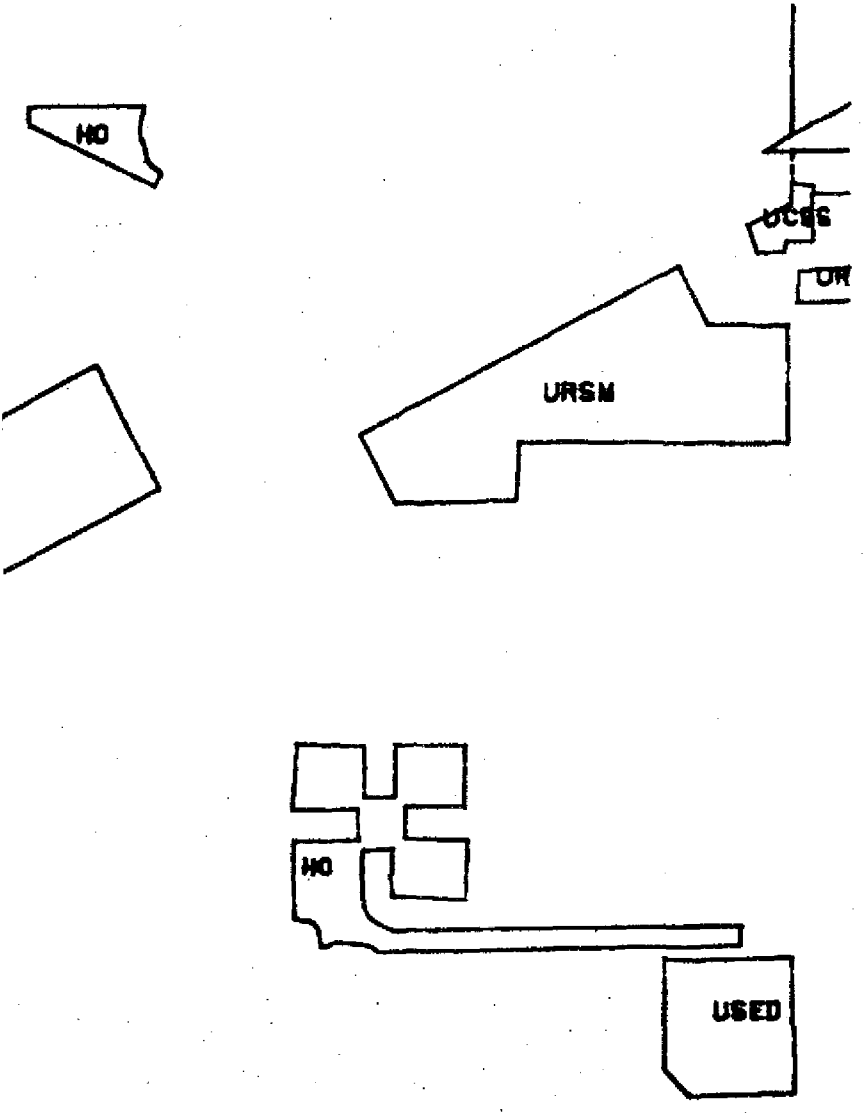
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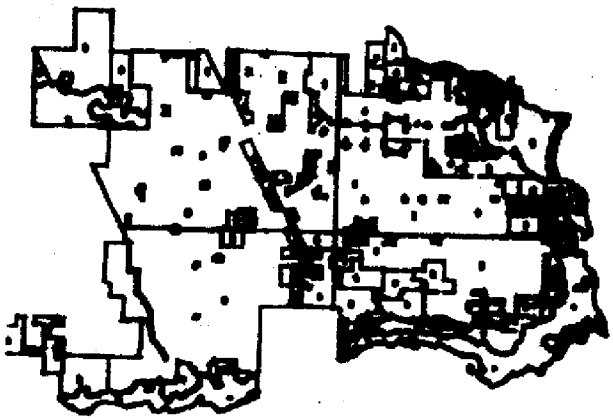

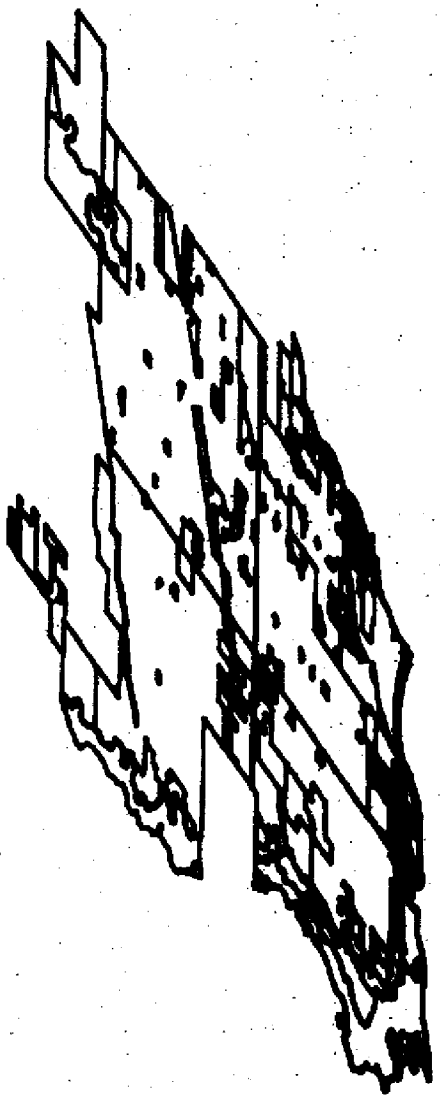

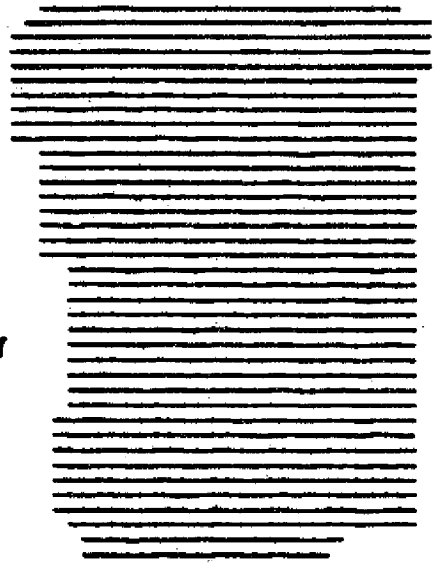

SURFACE SHOWING WATER USE BY LAND USE CATEGORY