DIXON

GROUNDWATER SYSTEM WATER QUALITY DATA Port Charlotte Area

Prepared By:
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CAMP DRESSER & McKEE INC.

Prepared For:
CHARLOTTE COUNTY UTILITIES DEPARTMENT

AUGUST 1995

CDM Camp Dresser & McKee Inc.

environmental services

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August 16, 1995

Mr. Richard E. Howell, Director
Charlotte County Utilities
20101 Peachland Blvd, Suite 301
Port Charlotte, FL 33954

Subject: Water Quality Study/Groundwater System - Port Charlotte Area
Charlotte County Wastewater System Expansion Program
CDM Project/DCN: 6073-120-PAF-WQUAL (Task 04)

Dear Mr. Howell:

As follow up to our meeting held on July 31st, 1995 regarding this subject, please accept the following data as our deliverable under Task 4 of our authorization. Fifteen (15) copies of the document are being transmitted for County's use and follow through with any finalization (or presentation of this information) to be performed at the direction of the County. Specific addresses for those sites identified in the study have been transmitted to you under separate cover in order to accommodate the preference for anonymity of those participants who volunteered for this sampling program in the Port Charlotte area.

Ardaman and Associates and Mote Marine Laboratory were the principal investigators that collected and analyzed the water quality data with CDM documenting these efforts and forwarding results that had been reported. No conclusions or statistical relationships with the ongoing sewer expansion program have been made as it may be most appropriate to conduct a "peer review" of this information prior to its widespread dissemination. Proposed individuals which have some background understanding of groundwater quality in the area and the septic tank systems are Mr. Bob Vincent, HRS; Mr. Ralph Montgomery, EQ Lab; Mr. Hans Zarbock, Coastal Environmental (SWIM Program); Dr. David Tomasko, SWFWMD (SWIM Program); Dr. Tom Frasier, Bender and Associates; Dr. Brian Lapointe, Harbor Branch Oceanographic Institute; and Mr. Keith Kibby, Lee County Laboratory Director.

This information may also be useful in comparison with the data recently collected by Lee County for the North Fort Myers area which examined the relationship between groundwater quality and septic tank systems.

With CDM's role in this endeavor to specifically be a reporting function, this concludes our efforts and our involvement under our current authorization to assist the County in the development/feasibility of a long-term monitoring program. If there are any questions or need for additional assistance, please do not hesitate to contact us.

Very truly yours,

CAMP DRESSER & McKEE INC.

S. John Calise, P.E.
Vice President

SJC/ghr

cc: Jerry H. Kuehn, Ardaman and Associates
Kellie Dixon, Mote Marine Laboratory
CCU Staff
CDM Team

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EXECUTIVE SUMMARY

This report culminates efforts begun in March, 1994 to improve the characterization of surface and ground water quality in Port Charlotte, Florida. Mote Marine Laboratory was asked to provide a Scope of Services for completing these objectives, and Ardaman and Associates was asked to assist in the implementation and design of a groundwater screening program to provide guidance in the design of a long-term groundwater monitoring program.

In general the water quality improved with distance from the drainfield. Since all of the OSDS were located in the front yard, the best water quality was observed at the more distant rear lot lines adjacent to the canal. However, the concentration of pollutants at the rear lot line remained significantly above the norm expected for background conditions in Florida. This suggest that a regional impact is occurring and diminishes the probability of obtaining local un-impacted groundwater samples for these sites. In essence, the "background" monitor wells at a given site may be impacted and exhibit elevated nutrient levels as a result of other OSDS sources which are further upgradient. Well locations, groundwater gradients and concentrations indicate that high concentrations of nitrogen (primarily organic) and phosphorus are leaving the property boundaries at all sites.

It should be noted that two of these installations were prior to the 1983 revisions to the regulations. These two sites had an average ammonia concentration of 21 mg/l nitrogen near the drainfield. The mean ammonia concentration in the groundwater adjacent to the drainfield of the remaining six sites constructed after the new regulations went into effect in 1983 was 8.2 mg/l nitrogen which also indicates incomplete nitrification.

A mix of sites with and without OSDSs is recommended to characterize expected groundwater quality in the absence of OSDSs. These results could be used to estimate the per lot contribution due to OSDSs and to monitor the dissipation of OSDS plumes. Planning level costs to implement the entire program are on the order of $55,000 per year for routine surface water or groundwater monitoring for a total of $110,000.

INTRODUCTION

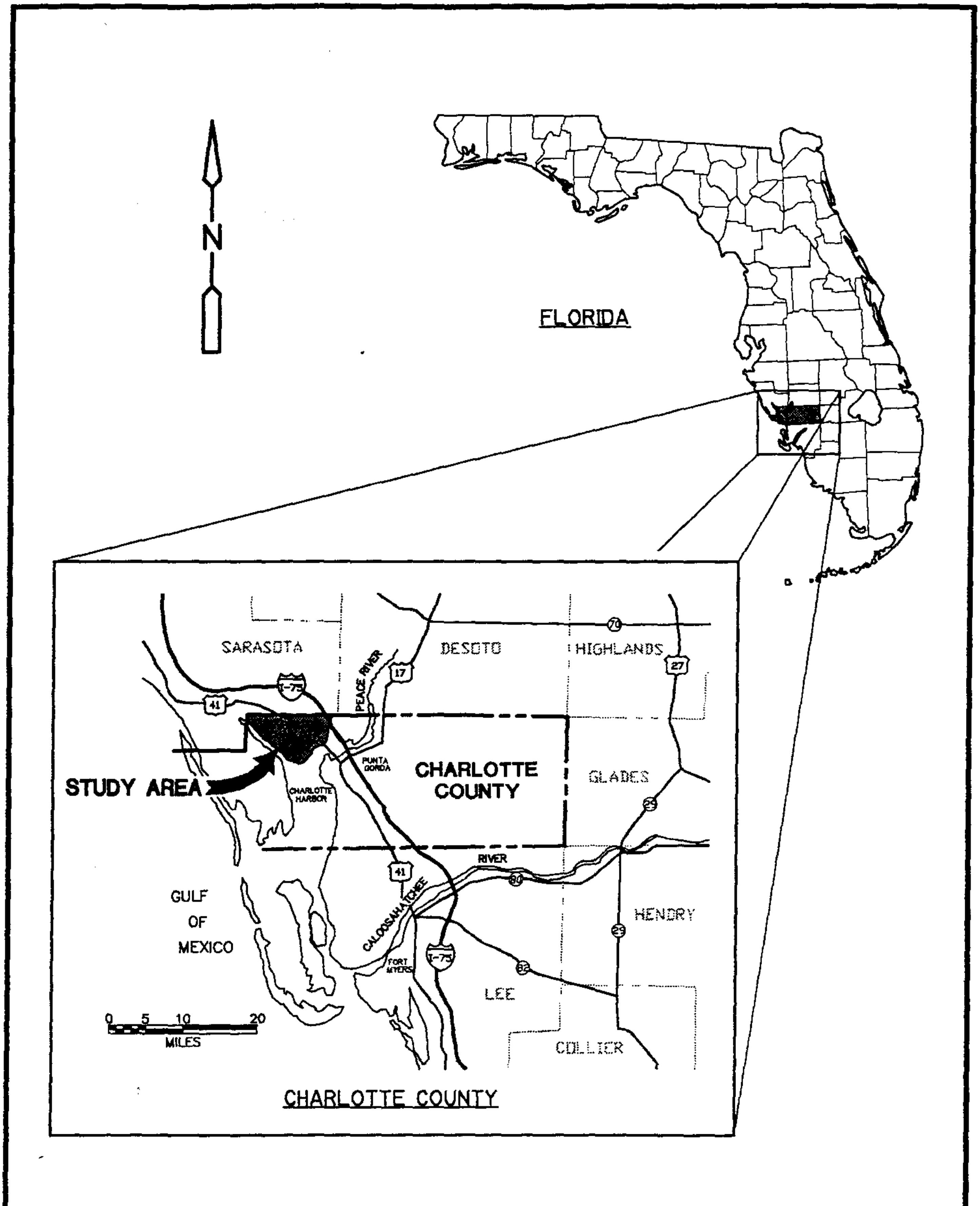
This report culminates efforts begun in March, 1994 to improve the characterization of surface and ground water quality in Port Charlotte, Florida. In the 1988 Comprehensive Plan, Charlotte County identified on site disposal system (OSDS) as a pollutant source and committed to providing central sewer facilities to ameliorate this pollutant source by the year 2000. In response to the commitment made to the State in Charlotte County's Comprehensive Plan in 1993, the County selected Camp Dresser and McKee, Inc. to design and construct a central wastewater treatment facility for select areas within the area of Port Charlotte. Due to the confusion over quantitative impacts of OSDS, the County requested a study of the status of the local waters. This study was developed in response to those concerns and included the following objectives;

- Monitor local surface waters and establish the status of surface and groundwater quality in Port Charlotte.

- Establish the trend of surface water quality in Port Charlotte from previous monitoring efforts.

- Design a long-term monitoring program for estimating the impact of OSDS on the environmental quality of Port Charlotte and Charlotte Harbor.

The general location of the study is given in Figure 1, and a chronology of events leading to the present report is given in Table 1. Mote Marine Laboratory (MML) was asked to provide a Scope of Services for completing these objectives, and Ardaman and Associates (Ardaman) was asked to assist in the implementation and design of a screening program for groundwater to provide guidance in the design of a long-term groundwater monitoring program.



PORT CHARLOTTE WATER QUALITY
STUDY AREA

Figure 1

TABLE 1 WATER QUALITY SAMPLING CHRONOLOGY		
March, 1994	-	Request proposal from MML for Status/Trends of Surface Water.
April	- -	Issue contract to Mote Marine Laboratory. CDM, Ardaman, and MML develop groundwater monitoring program.
May	- -	Issue contract to Ardaman & Associates. Develop draft homeowner questionnaire regarding septic tanks.
July	-	Refine questionnaire with County.
August	-	County distributes questionnaire.
September	-	Tabulate questionnaire results, select candidate addresses.
Nov/Dec	-	Resolve legal issues regarding sampling private property.
January, 1995	-	County contacts homeowners/obtain permission/obtain legal release.
February	-	Site visit by County/CDM/Ardaman to select sites.
March/April	-	Ardaman conducts sampling. Sends samples to MML for analyses.
June	- -	Receive quality results from MML. Receive site maps with well locations from Ardaman.

MML sampled both fresh water and salt water canals during the dry season pre-dawn hours when dissolved oxygen is expected to be the lowest. MML reported on their evaluation of historic data for trend analysis and current monitoring for status in August, 1994. The findings (MML, 1994) are as follows:

- Two thirds of the surface water readings of dissolved oxygen in freshwater canals were below the State criterion;
- Eighty percent of the bottom dissolved oxygen measured in the fresh water canal stations was in violation of the State criterion;
- High biological oxygen demand (BOD) was documented for some of the canal stations, as were high nutrient (nitrogen and phosphorus) levels;
- Bacterial counts were within the State criteria;
- Nitrogen is the nutrient controlling algal growth in the salt water stations;
- Most of the "Freshwater", and "Estuarine" stations were classified as "Fair" (on a scale of "Good, Fair, Poor");
- The high variability observed in the water quality measurements significantly reduces the probability of detecting changes in surface water quality without a long (e.g. 10 years) monitoring program.

The Mote study was unable to describe a rigorous statistical link with septic tanks alone, but a statistically defensible relationship of declining water quality with increased septic tanks and the number of total dwellings was documented.

A parallel program of groundwater monitoring was also developed specifically focused on the detection of septic tank plumes. The groundwater program also included monitoring the surficial aquifer downgradient of the East Port percolation pond in order to better characterize the loss of nitrogen as distance from the source increases. Ardaman and Associates completed the sampling and Mote Marine provided the laboratory analyses. The Ardaman report is included as Appendix A. The remainder of this report is focused on those results, and the development of a long-term monitoring plan provided by MML. Background and details of the proposed monitoring plan are provided in MML's report included as Appendix B.

Septic Tank Survey

In order to design the septic tank screening program, a questionnaire was developed by CDM and Charlotte County Utilities. A copy is included as Appendix C. The questionnaire was distributed to 431 canal-front residences by the County staff during August, 1994. A total of 48 questionnaires were returned to the County staff, and the results compiled into a database. The results are given in Table 2.

Survey Results

The respondents owned their homes for an average of 8.6 years with a range of 1-22 years. The age of the residences averaged 11 years. Forty six (96 percent) of the 48 respondents indicated that they are residents for 11 or more months per year. The average lot size of the responses was 133 feet deep by 83 feet wide (0.25 acres). The vast majority (94 percent) of the responses indicated that the septic tank was located in the front yard. One response indicated that the tank was located on the side yard, and two respondents did not know where their septic tanks were located.

Table 2

Summary of Questionnaire Responses

Response	Date Constructed	Years of Ownership	Months/yr Residence	Number Residents	Use Garbage Disposal	Use Dish Washer	Laundry Loads/wk	Septic Tank Location	Septic Tank Service	Problems Reported	Lot Size Deep	Lot Size Wide	Points Assign.
1	Sep-77	17	12	3		N	5	Front Yard			138	80	3
2	May-84	10	12	2	Y	Y	2	Front Yard			125	80	3
3	Jun-72	22	12	2			2	Not Sure			125	120	2
4	Apr-72	22	12	1			1	Front Yard			125	85	1
5	Feb-92	3	12	2	N	N	5	Front Yard			125	80	2
6	Jun-78	16	12	1	N	N	3	Front Yard			125	80	1
7	Dec-89	5	12	2	N	N	4	Front Yard			180	80	2
8	Jan-90	4	12	2	N	Y	9	Front Yard	1993		150	80	4.5
9	Apr-83	11	12	2	N	N	1	Front Yard			179	80	2
10	Jun-67	14	12	4		Y	6	Front Yard			130	80	3.5
11	Jun-87	1	12	3		Y	4	Front Yard			125	80	2.5
12	Jan-80	15	12	4			7	Front Yard	(Yes-No Date Given)		125	80	5
13	Jun-82	4	12	2	N	Y	6	Front Yard	1994		125	80	5.5
14	Jan-80	15	12	2	Y	Y	2	Front Yard			125	80	3
15	Oct-85	9	12	2	N	Y	4	Front Yard			190	120	2.5
16	Jan-88	6	12	2	Y	Y	3	Front Yard			125	80	2
17	Jan-93	2	12	2	N	N	4	Front Yard					2
18	Jun-85	9	6	2	Y	N	2	Front Yard					1.5
19	Oct-92	2	12	3	Y	Y	5	Front Yard			125	80	3
20	Aug-83	11	11	1	N	N	1	Front Yard			125	80	1
21	Jun-85	2	12	2	Y	N	2	Front Yard	1992	Toilet Flushing	125	80	3.5
22	Sep-84	10	12	2	N	Y	2	Front Yard	1993	Toilet Flushing	125	80	4.5
23	Oct-93	1	12	2	N	N	2	Front Yard			125	80	1
24	Feb-86	8	12	2	N	Y	2	Front Yard			125	80	1.5
25	Jun-86	8	12	4		Y	10	Front Yard	(Yes-No Date Given)	Flush/ Smell/Ponded Wat	125	80	4.5
26	Jun-83	3	11.4	2	N	N	5	Front Yard			150	80	3
27	Jul-83	11	12	3	Y	Y	3	Front Yard	1988		145	80	5
28	Jun-72	2	12	2		Y	4	Front Yard	(Yes-No Date Given)		150	80	5.5
29	Nov-79	15	11.4	1		Y	2	Front Yard	1989		125	80	3.5
30	Jun-78	1	12	3	Y	Y	5	Not Sure	1993		125	90	6
31	Jun-79	14	12	2	N	N	5	Front Yard			135	80	3
32	Jun-82	12	12	2	Y	Y	6	Front Yard	1984,1986,1988,1990,1992,1994		125	80	6
33	Nov-89	5	12	2	Y	Y	4	Front Yard			135	85	3
34	Jun-87	8	12	1	Y	Y	5	Front Yard					2
35	Jun-87	7	12	1	Y	N	4	Front Yard	1992				2.5
36	Dec-88	6	12	2	Y	Y	5	Front Yard	1994		125	80	5
37	Jul-89	5	12	2		Y	8	Front Yard			150	80	2.5
38	Nov-86	7	12	3	N	Y	5	Front Yard	1989,1992	Flush/ Smell/Ponded Wat.	124	75	4.5
39	Jul-86	8	12	2			3	Front Yard	1992	Drainfield backed up.	125	80	3
40	May-79	13	12	2		N	2	Front Yard			125	80	2
41	Jan-84	11	11	2	Y	Y	11	Front Yard			120	80	4
42	Jun-81	8	12	2	Y	Y	4	Front Yard	1990		125	80	6
43	Oct-81	13	11.3	2		N	2	Front Yard			125	80	2
44	Mar-94	1	3	2		N	1	Front Yard					1
45	May-80	14	12	2	N	N	2	Front Yard			125	80	2
46	Jun-70	7	11	2			7	Side Yard			125	80	3
47	Aug-85	9	12	2	Y	Y	2	Front Yard	1993		125	100	4
48	Mar-90	5	11.4	2	N	N	1	Front Yard			125	80	1
Avg. Age=	11.1 years												
	Average	8.6	12	2.1			4				133	83	

QUEST.XLS

Thirty three of those responding indicated that they had a garbage disposal, and of those 48 percent (16) indicated that they used the disposal. Nearly all (47) of the homes have a laundry washer, and the average number of wash loads per week was four. Ninety percent (43) of the homes are equipped with a dishwasher, and it is regularly used in 25 of those homes.

Collectively, there are 413 years (48 responses x 8.6 years ownership) of home ownership represented. Twenty three septic tank service calls were reported, but only five people identified problems with their septic tank. The remaining service calls are assumed to be routine maintenance and pump-out. Assuming that the remaining 18 service calls were routine maintenance, it is clear that the three year routine service interval recommended by local septage haulers is not conducted. On average less than half of the respondents have had any routine service during their ownership of the home, and the remaining owners have had only one routine service call during an average of nine years of ownership.

Site Selection

A review of the literature indicates that detection of a plume is difficult as distance from the drainfield increases. The present screening study was designed to characterize the spatial probability of detecting a plume. In order to accomplish this, a series of shallow monitor wells was established on 10-foot centers at the rear property boundary adjacent to the canal. It was anticipated that the number of wells exhibiting pollutant concentrations higher than the background wells would serve as an indicator of the probability of locating the plume with a lesser number of monitoring wells.

In order to develop complete the spatial evaluation, an attempt was made to select sites with a high probability of plume detection. Consequently, sites with above average age, number of residents, number of laundry loads per week and service of septic tanks were desired. An arbitrary scale was developed to evaluate the likelihood of locating a septic plume. The points assigned were as follows:

Point Assignment

Category	Points	Criteria
Septic Tank Service- Routine or Repair	2	Yes
Number Residents	1	Greater than 2
Age of House	1	Greater than 10 years
Laundry, Loads /Week	1	Greater than 4
Dish Washer Use	0.5	Yes
Garbage Disposal Use	0.5	Yes

The results are also included as Table 2. A short list of 16 residences was selected based on the ranking. County staff contacted each residence to ascertain if the owner would permit groundwater monitoring on their property. Two owners declined, and a site inspection of the remaining residences was made prior to the final selection. Those homes selected for monitoring are identified by the following response number and are represented by shading in Table 2.

Selected Sites

Response Number	Monitoring Site Number
32	1
47	2
25	3
27	4
41	5
35	6
12	7
38	8

Summary of Results

Details of the groundwater monitoring procedures and results are given elsewhere in this report. Generally, surficial samples were collected on either side of the drainfield and at two to three locations along the front lot line or right of way. A single temporary monitor well was established approximately half way between the front and rear lot lines, and a series of six to seven additional wells were established at the rear lot line, or in the right of way behind the house.

Hydraulic gradients were generally from the front of the house to the canal at the rear. However, at some sites the water table at the drainfield was mounded and flow was toward both the front and rear of the house. At two of the sites, the apparent gradient was from the canal. Neither the water quality, nor the hydraulic gradient exhibit a consistent pattern relative to the conditions measured at the drainfield, and it appears that other flow paths, and pollutant sources exist at several of the sites.

Nevertheless, in general the water quality improved with distance from the drainfield. Since all of the OSDS were located in the front yard, the best water quality was observed at the more distant rear lot lines adjacent to the canal. However, the concentration of pollutants at the rear lot line remained significantly above the norm expected for background conditions in Florida. This suggests that a regional impact is occurring and diminishes the probability of obtaining local un-impacted background samples for these sites. In essence, the "upgradient" background monitor wells at a given site may be impacted and exhibit elevated nutrient levels as a result of other sources (e.g. other OSDS) which are further upgradient.

The chemical analyses were conducted by Mote Marine Laboratory and the results are included as Appendix D. The samples contained fine particulate material which presented some difficulties during the analyses. Samples were analyzed as "total" samples (unfiltered). Re-analysis of four (one field blank, one duplicate and two samples) total phosphorus samples from site 8 was required, which occurred after the specified holding time as indicated in Appendix D.

Field blanks and sample replicates were collected and analyzed in accordance with Ardaman's Quality Assurance program. The QA results are given in Table 3 and indicate that the steps taken to eliminate the matrix problems encountered did not jeopardize the QA of the samples.

Table 3

Quality Assurance Results

Lab Blank	DATE	NH4-N	NO2+3-N	TKN	Tot-P
	04/17/95	<0.005	0.006	<0.05	0.07

Field Blanks	DATE	NH4-N	NO2+3-N	TKN	Tot-P
	03/27/95	<0.005	<0.005	<0.05	<0.05
	03/30/95	0.014	<0.005	<0.05	<0.05
	04/03/95	0.005	<0.005	<0.05	0.31
	04/05/95	0.006	<0.005	0.06	<0.05
	04/10/95	<0.005	<0.005	<0.05	<0.05
	04/12/95	<0.005	0.019	<0.05	<0.05
	04/17/95	0.006	<0.005	<0.05	0.07
	04/19/95	0.007	<0.005	<0.05	<0.05*

Duplicate Analyses

WELL	SITE	DATE	NH4-N	NO2+3-N	TKN	Tot-P
11	1	03/28/95	0.087	0.005	10.000	32.22
11	1	03/28/95	0.085	0.005	6.120	26.20
10	2	04/13/95	0.070	0.017	4.370	7.01
10	2	04/13/95	0.071	0.008	4.610	10.07
8	3	04/06/95	0.018	0.030	2.380	12.60
8	3	04/06/95	0.012	0.018	2.270	13.50
8	4	04/04/95	0.009	<0.005	4.550	26.32
8	4	04/04/95	0.013	<0.005	4.430	21.48
12	5	04/11/95	0.036	0.040	4.430	16.23
12	5	04/11/95	0.035	0.019	5.200	14.28
12	6	03/30/95	1.542	<0.005	11.210	5.63
12	6	03/30/95	1.528	<0.005	10.940	5.27
8	7	04/18/95	0.156	0.021	3.970	21.52
8	7	04/18/95	0.159	0.016	4.270	23.32
8	8	04/20/95	0.740	0.027	8.510	5.16
8	8	04/20/95	0.797	0.015	7.560	5.60*

* Analyzed after standard holding time.

The results vary widely, even on the same site. However, several general conclusions can be developed from the data and the summary of results given in the following table.

Summary of Results by Lot Location

| <-------------------Mean (mg//) --------------------> | <-------------Median (mg/l)-------> |

	Drain Field	Front Lot Line	Rear Lot Line	Drain Field	Front Lot Line	Rear Lot Line
Total N	21.62	12.63	7.92	9.03	8.54	5.40
Total P	26.43	57.04	14.80	21.61	26.19	11.67
NH_3-N	8.16	0.74	0.30	0.26	0.18	0.08
NO_{2+3}-N	0.62	0.04	0.04	0.10	0.02	0.02
Organic-N	12.84	11.83	7.58	5.93	6.33	5.24
TKN	21.00	12.57	7.88	8.27	8.51	5.33

The presence of high ammonia levels on either side of the drainfield indicates that nitrification is incomplete at some of the sites. It should be noted that two of these installations were prior to the 1983 revisions to the regulations. These two sites had an average ammonia concentration of 21 mg/l nitrogen near the drainfield. The mean ammonia concentration in the groundwater adjacent to the drainfield of the remaining six sites constructed after the new regulations went into effect is 1983 was 8.2 mg/l nitrogen which also indicates incomplete nitrification.

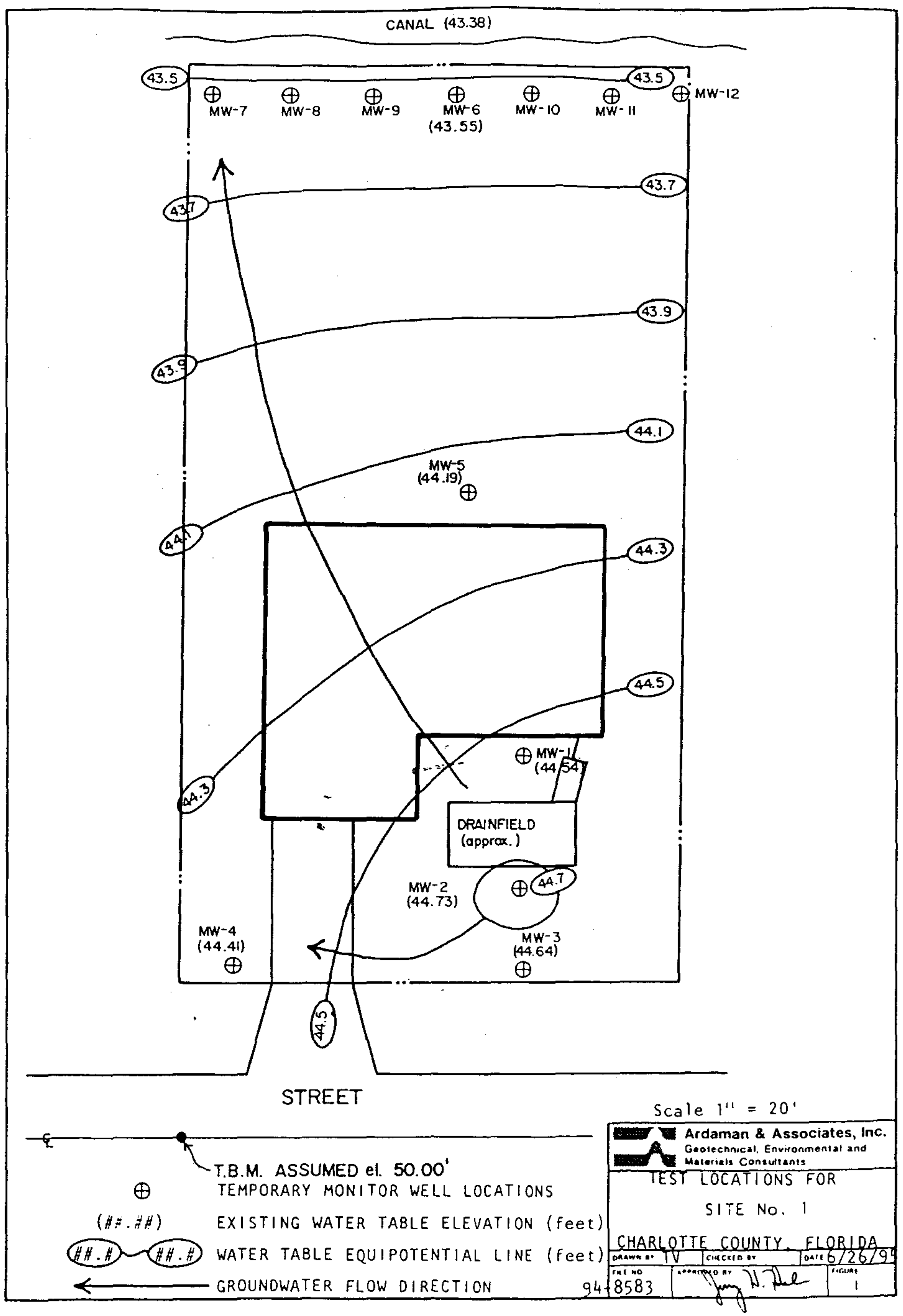
Many of the monitoring wells were actually installed in County right of way. Well locations, groundwater gradients and concentrations are given in Figures 2 through 9. The results indicate that high concentrations of nitrogen (primarily organic) and phosphorus are leaving the property boundaries at all sites.

Of the pollutants measured, only one has a numeric State groundwater standard. Consequently, alternate standards were needed for comparison. Comparison with typical, or expected values was determined to be the most appropriate evaluation using Florida data. The Water Quality Assurance Act passed in 1983 by the Florida Legislature required FDEP to *establish a ground water quality monitoring network designed to detect or predict contamination of the state's ground water resources* (FS 403.063). One of the goals of the monitoring program is to *establish the background and baseline ground-water quality of major aquifer systems in the state.* A Background Network consisting of 1600 wells throughout the state was identified from FDEP, USGS and water management district wells. The results are available through the Florida Geological Survey as Special Publication No. 34, 1992.

A comparison with Background Network results (Fla. Geological Survey, 1992) indicates that the median surficial groundwater concentration in the state is 0.06 mg/l of orthophosphate. SWFWMD research (as part of the Background Network) indicates that higher values of total phosphorus[1] (>0.5 mg/l) exist in Polk and Hardee Counties, and that moderate concentrations (reported as >0.1 mg/l) exist in a belt which parallels the coast. The values observed during the Port Charlotte surficial monitoring are orders of magnitude higher than these background values reported by others.

There is a State groundwater standard of 10 mg/l nitrate nitrogen, and a health advisory at 1 mg/l. For comparison, the Background Network of State monitoring well results indicate

[1] The difference between orthophosphate phosphorus and total phosphorus concentrations in groundwater is negligible (Upchurch, 1992).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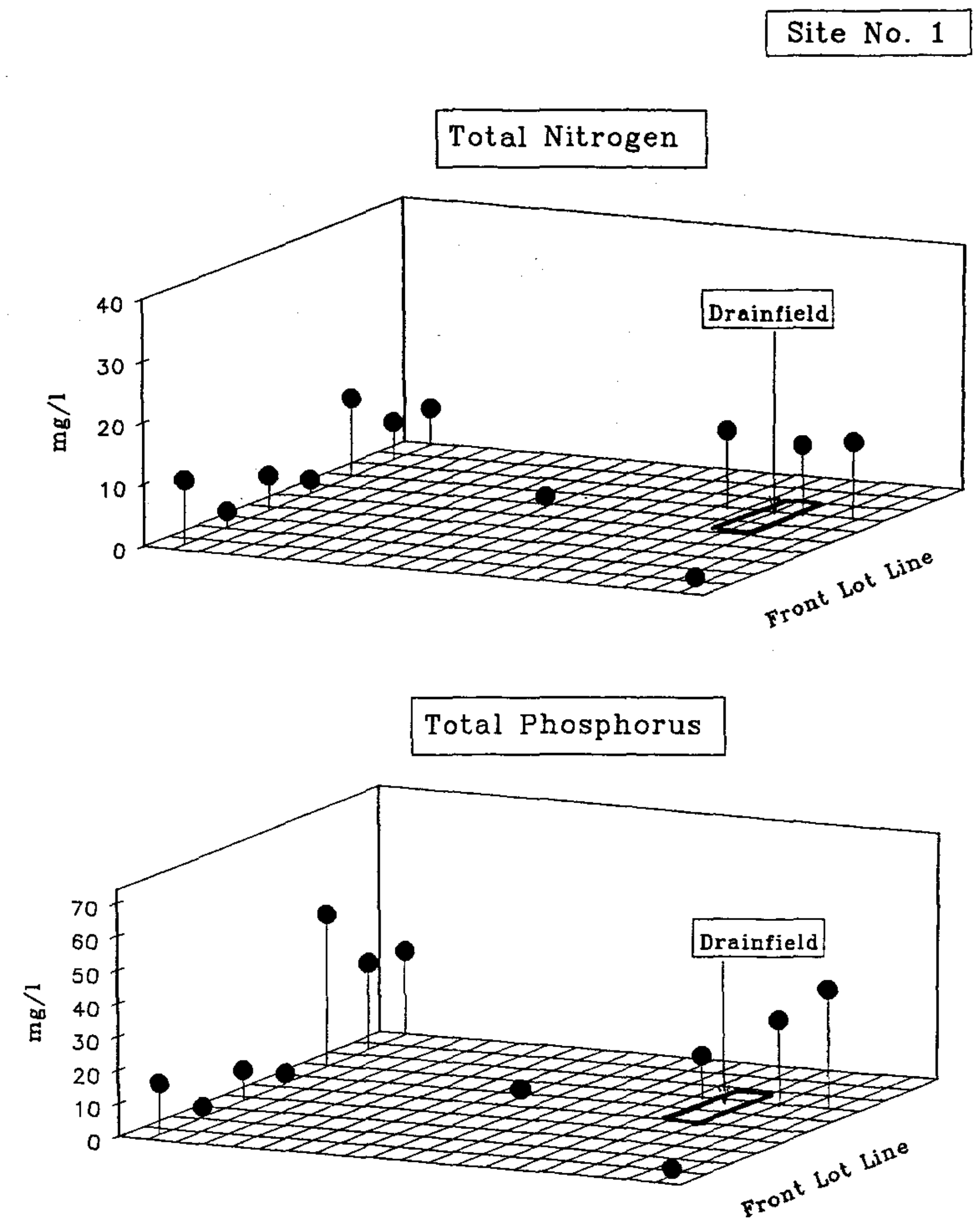
(approx.)
MW-2
(44.73)
44.7
MW-3
(44.64)
MW-4
(44.41)
44.5
STREET
Scale 1" = 20'
T.B.M. ASSUMED el. 50.00'
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet)
##.# ##.# WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 1
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
CHECKED BY
DATE 6/26/95
FILE NO 94-8583
APPROVED BY
FIGURE 1


Site No. 1
Total Nitrogen
mg/l
0
10
20
30
40
Drainfield
Front Lot Line
Total Phosphorus
mg/l
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30
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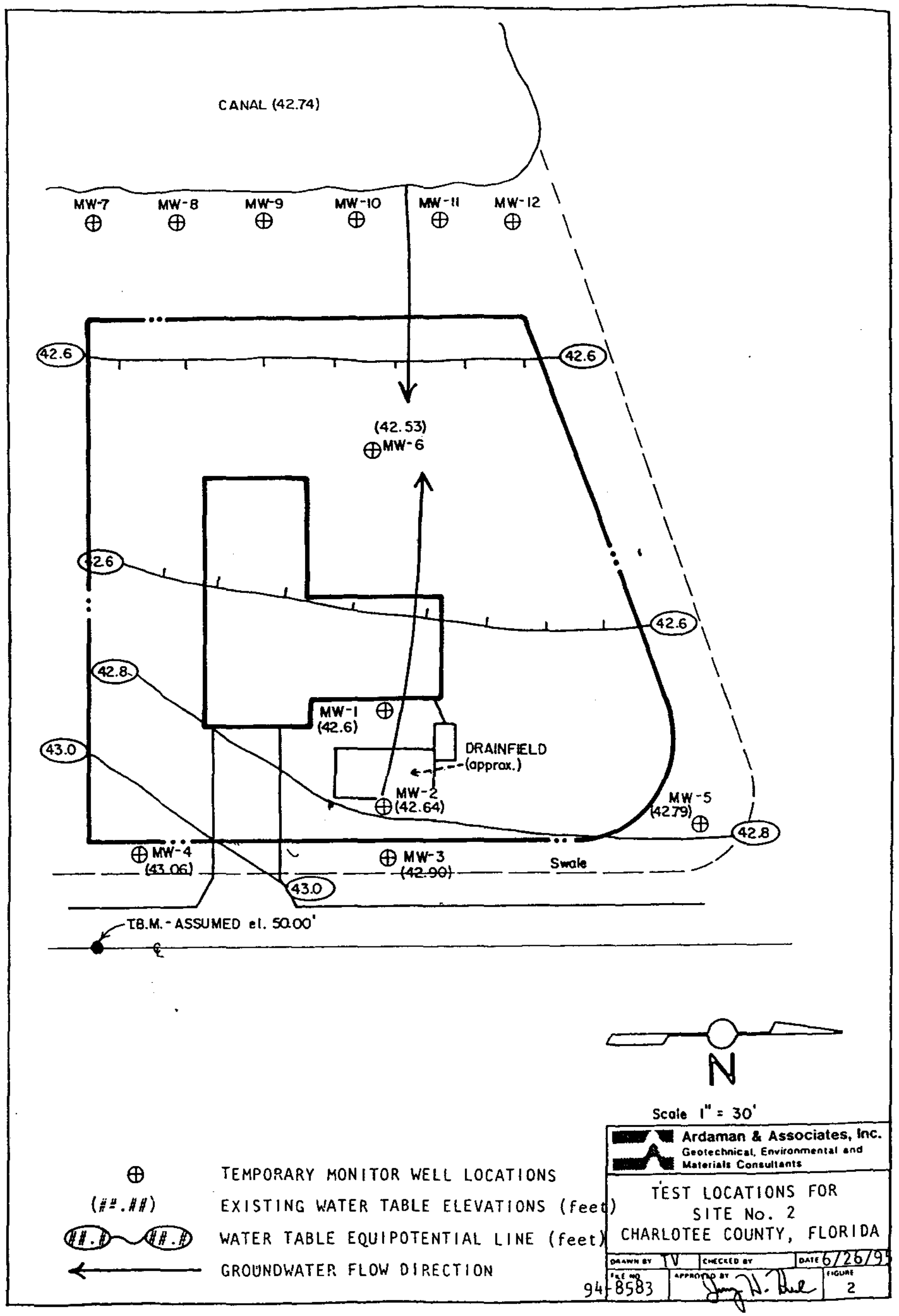
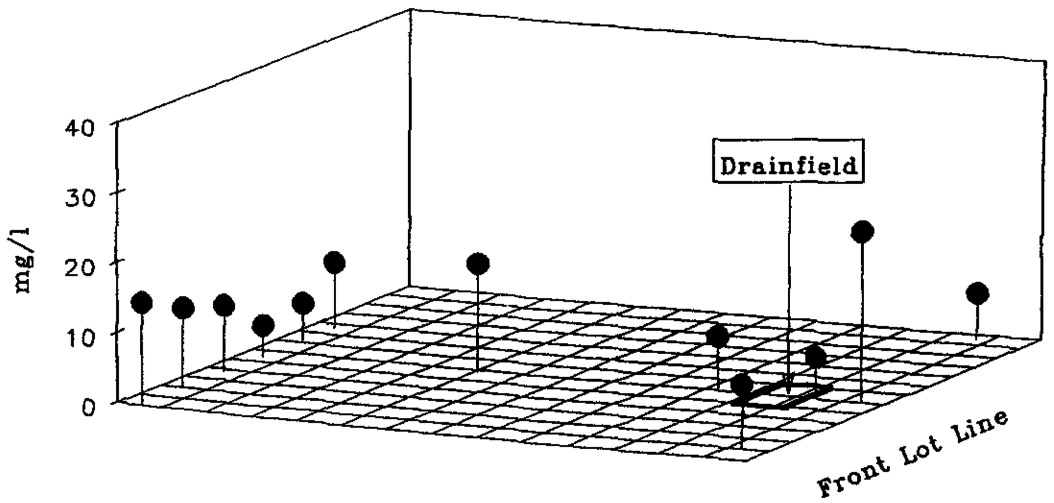
50
60
70
Drainfield
Front Lot Line

FIGURE 2



Site No. 2

Total Nitrogen



Total Phosphorus

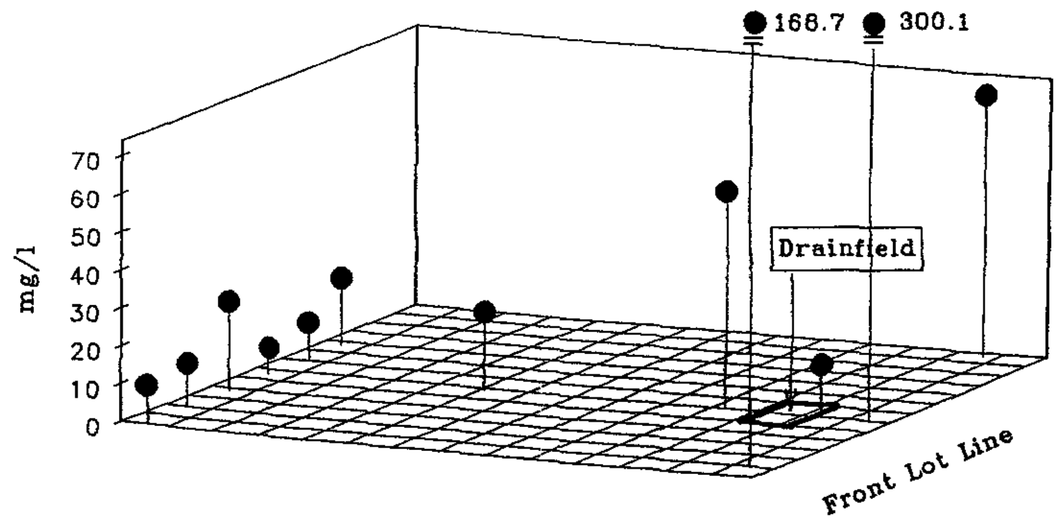
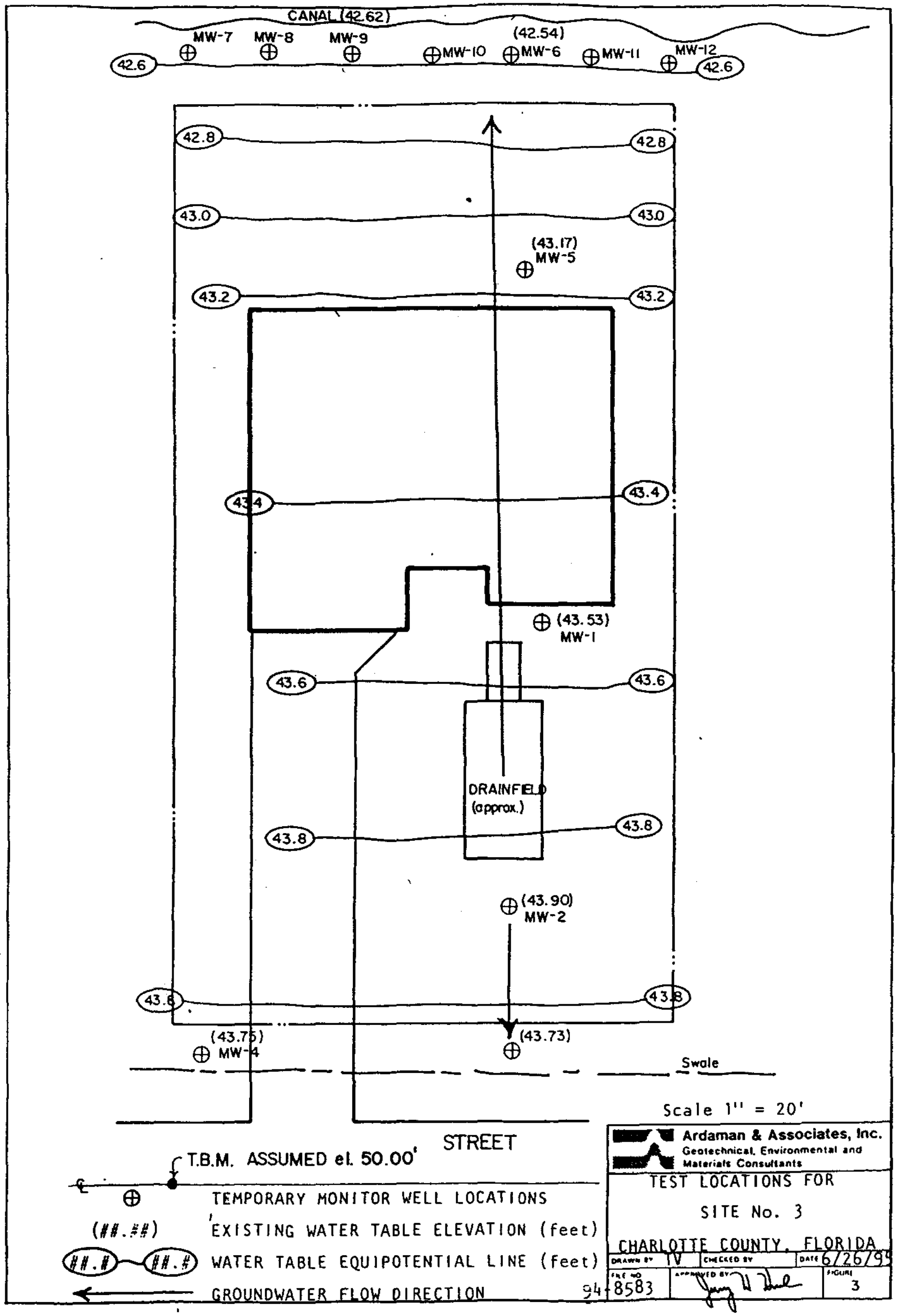


FIGURE 3



Site No. 3

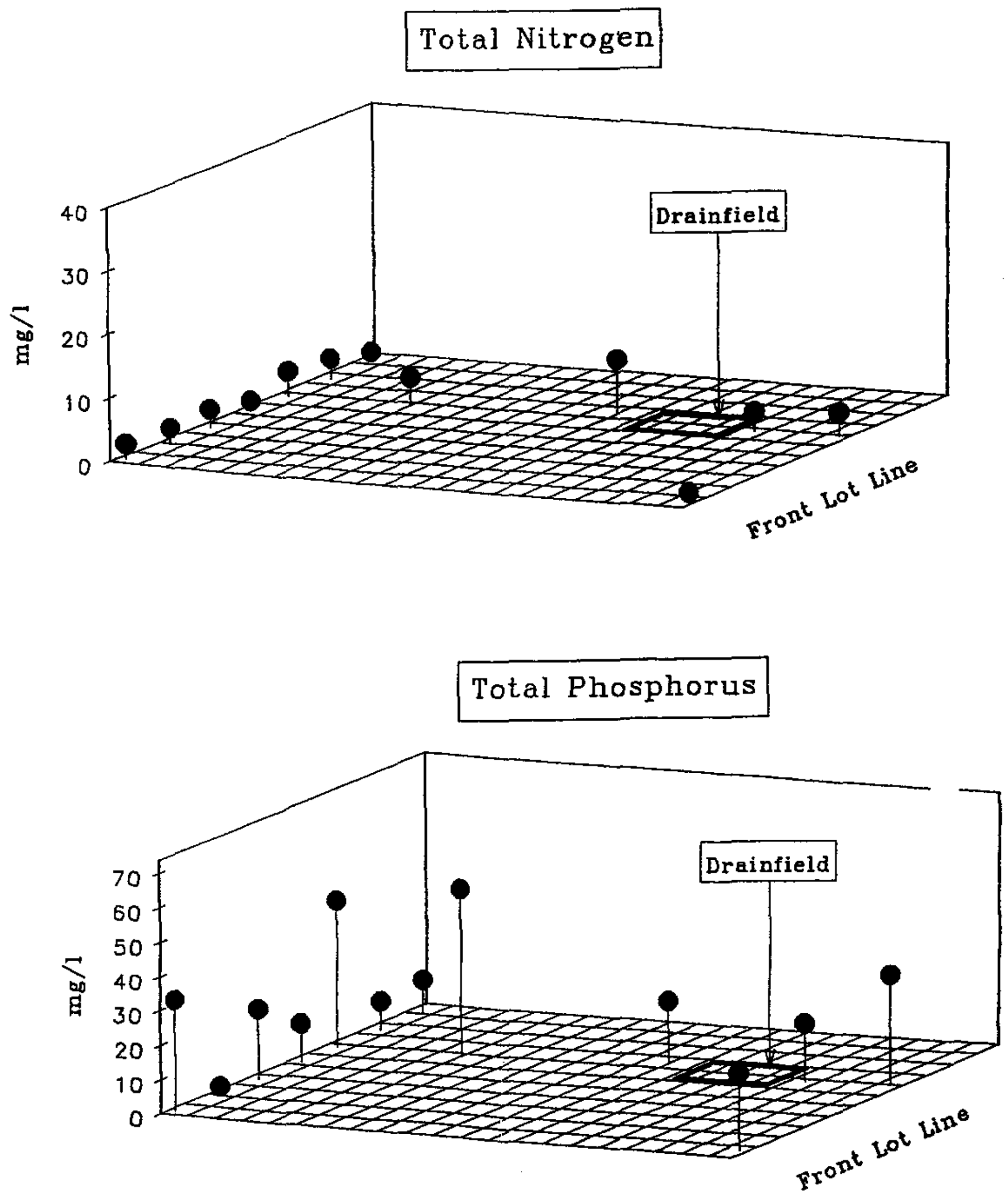
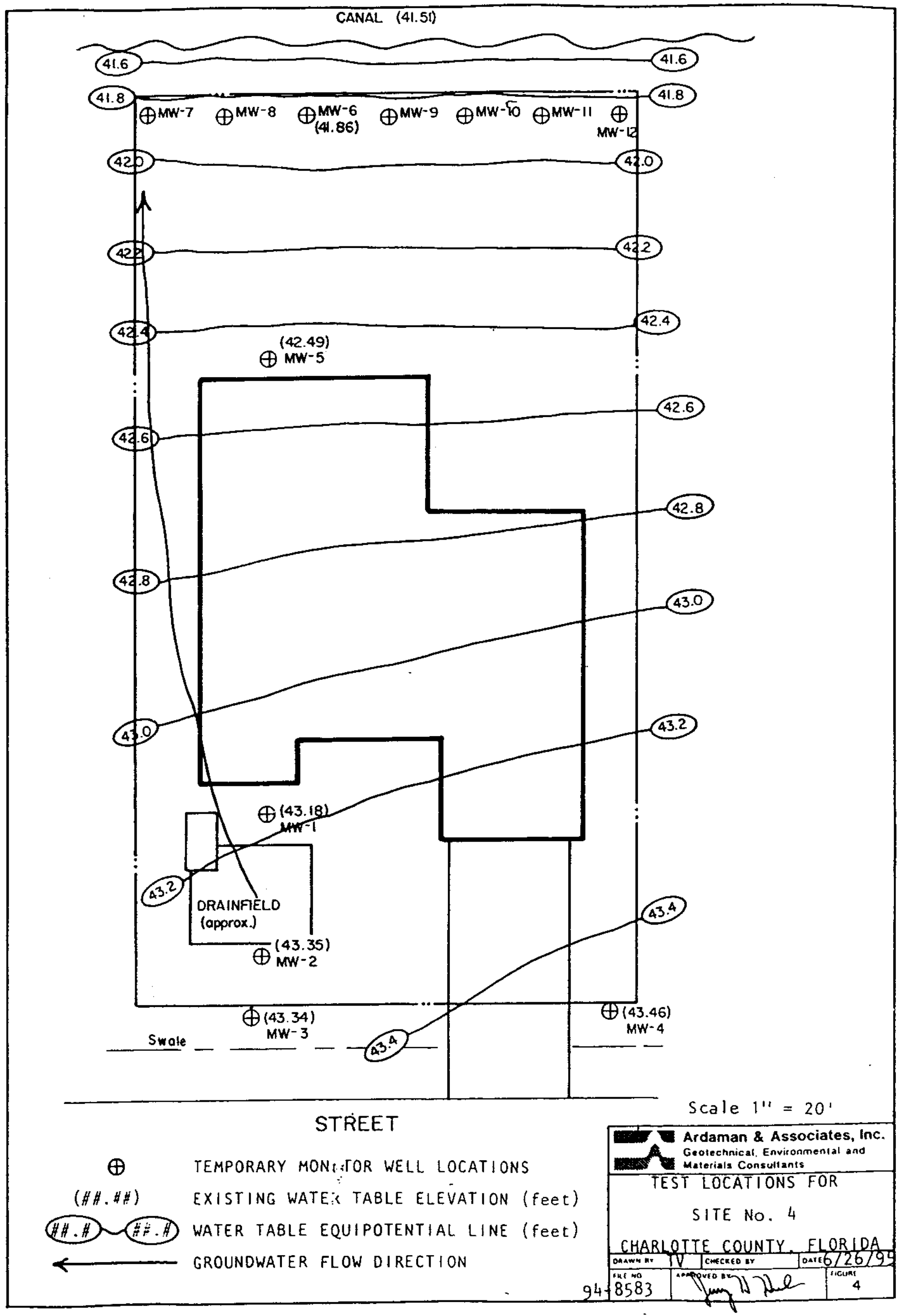


FIGURE 4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41.8
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MW-6 (41.86)
MW-9
MW-10
MW-11
MW-12
42.0
42.2
42.4
(42.49) MW-5
42.6
42.8
43.0
43.2
(43.18) MW-1
DRAINFIELD (approx.)
(43.35) MW-2
43.4
(43.34) MW-3
(43.46) MW-4
Swale
STREET
Scale 1" = 20'
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet)
WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 4
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
DATE 6/26/95
FILE NO 94-8583
FIGURE 4

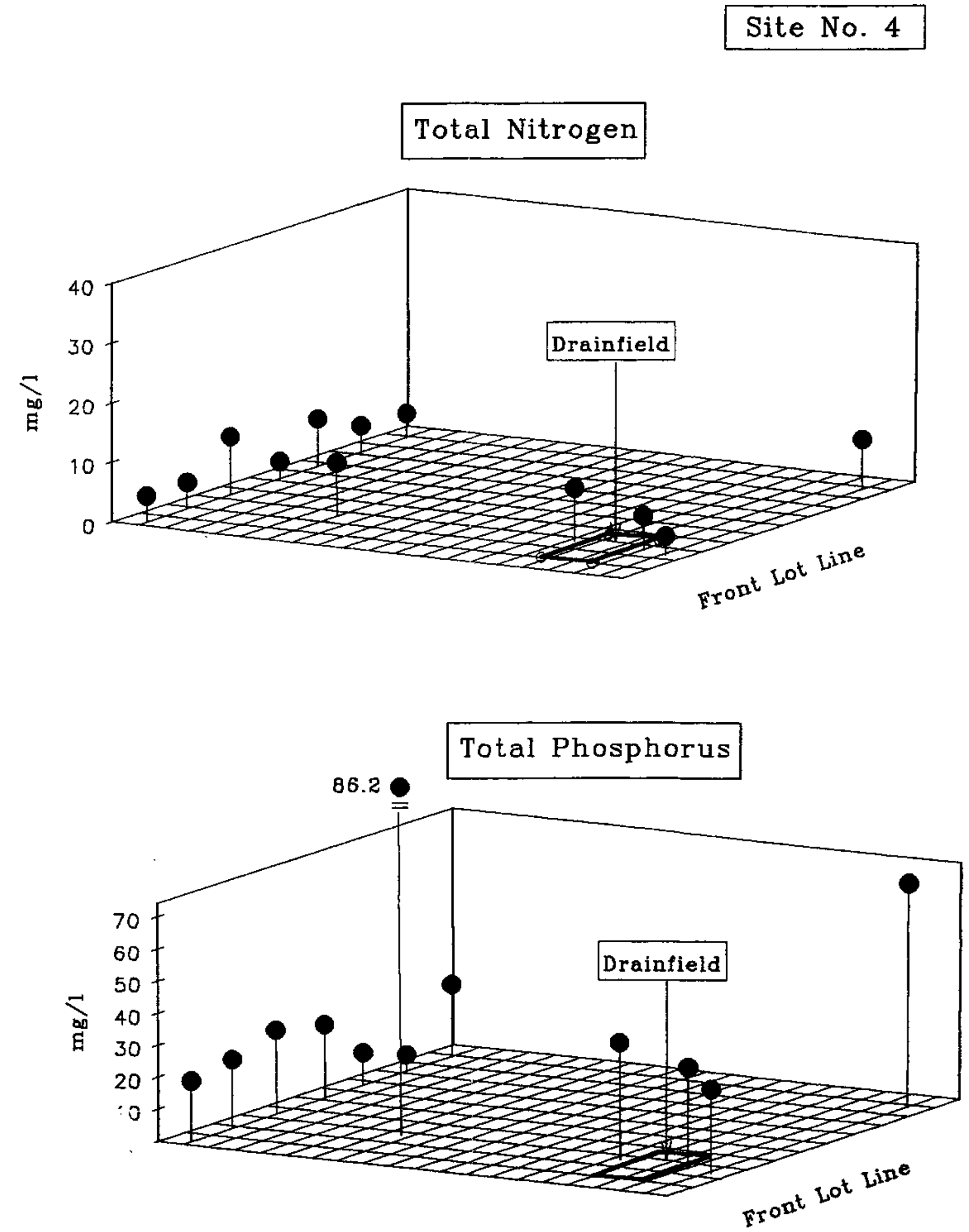
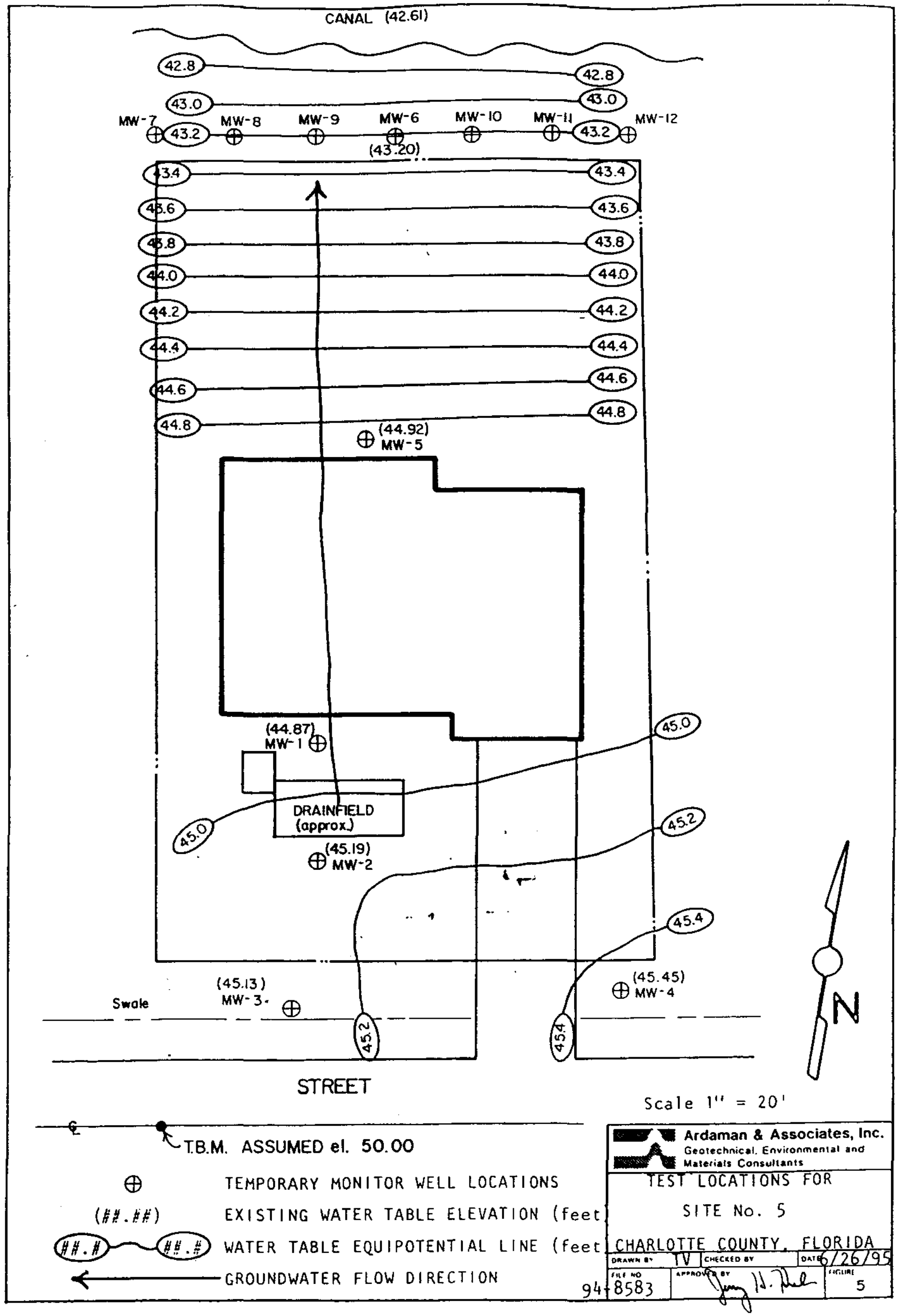

Site No. 4
Total Nitrogen
40
30
20
10
0
mg/l
Drainfield
Front Lot Line
Total Phosphorus
86.2
70
60
50
40
30
20
10
mg/l
Drainfield
Front Lot Line

FIGURE 5


CANAL (42.61)
42.8
43.0
43.2
MW-7
MW-8
MW-9
MW-6
MW-10
MW-11
MW-12
(43.20)
43.4
43.6
43.8
44.0
44.2
44.4
44.6
44.8
(44.92) MW-5
(44.87) MW-1
DRAINFIELD (approx.)
45.0
45.2
45.4
(45.19) MW-2
(45.13) MW-3
(45.45) MW-4
Swale
STREET
N
Scale 1" = 20'
T.B.M. ASSUMED el. 50.00
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet
##.# ##.# WATER TABLE EQUIPOTENTIAL LINE (feet
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 5
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
DATE 6/26/95
FILE NO 94-8583
FIGURE 5

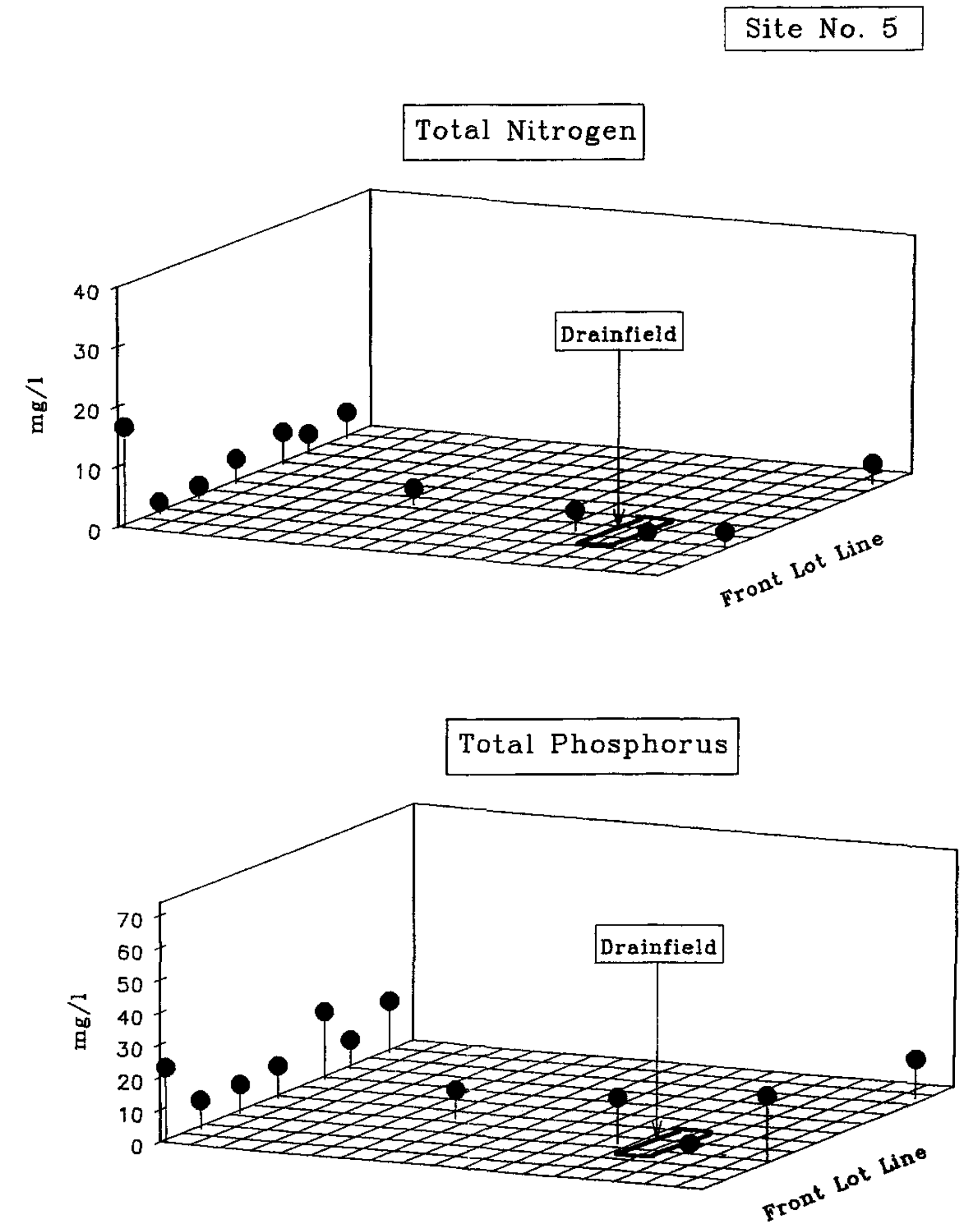
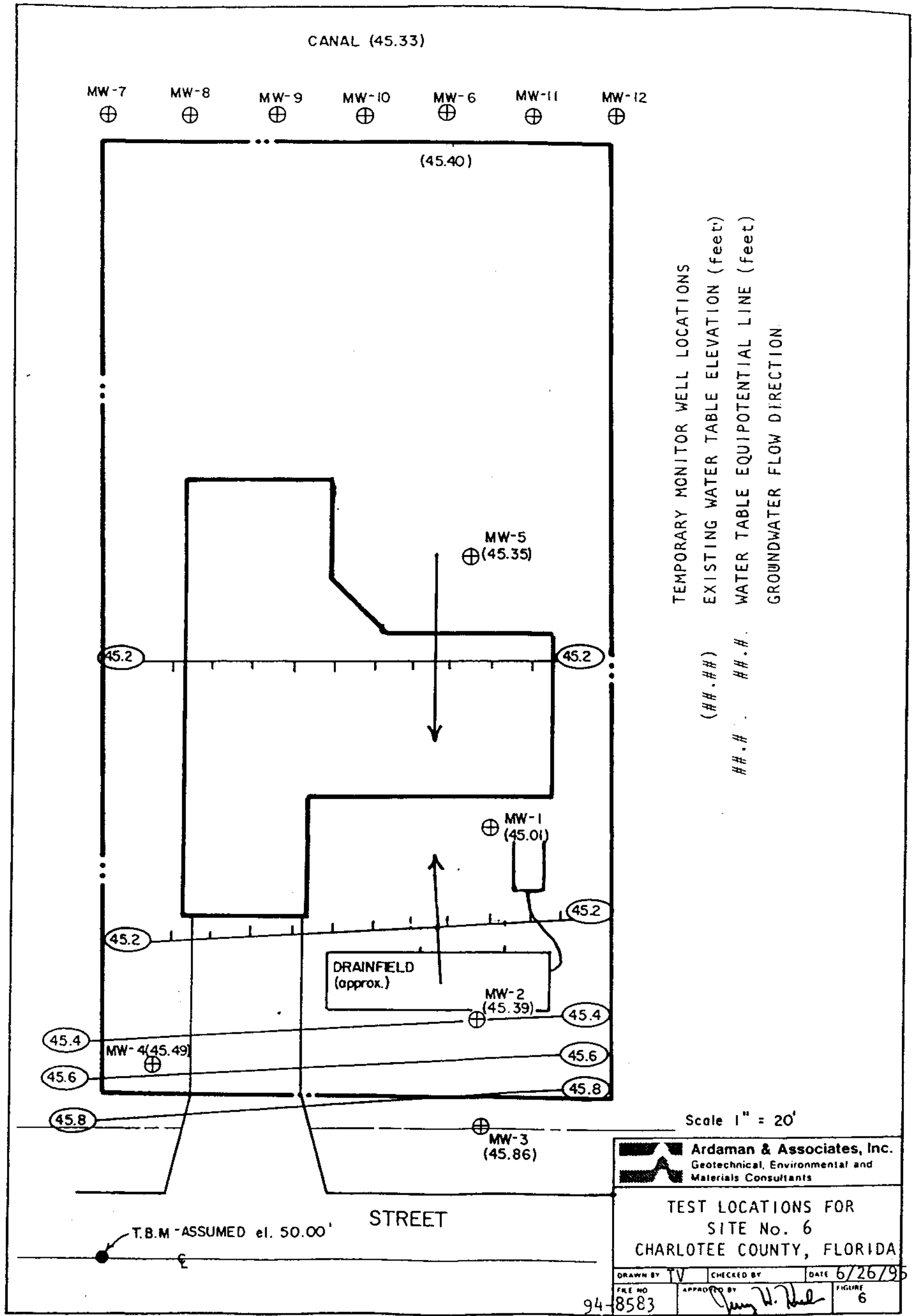
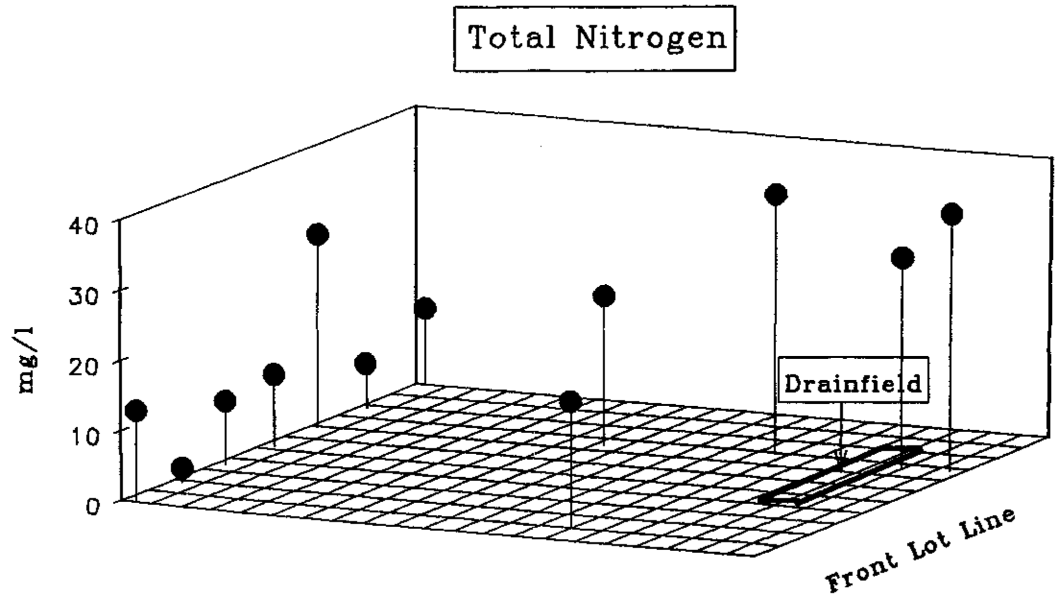

Site No. 5
Total Nitrogen
mg/l
0
10
20
30
40
Drainfield
Front Lot Line
Total Phosphorus
mg/l
0
10
20
30
40
50
60
70
Drainfield
Front Lot Line

FIGURE 6



Site No. 6



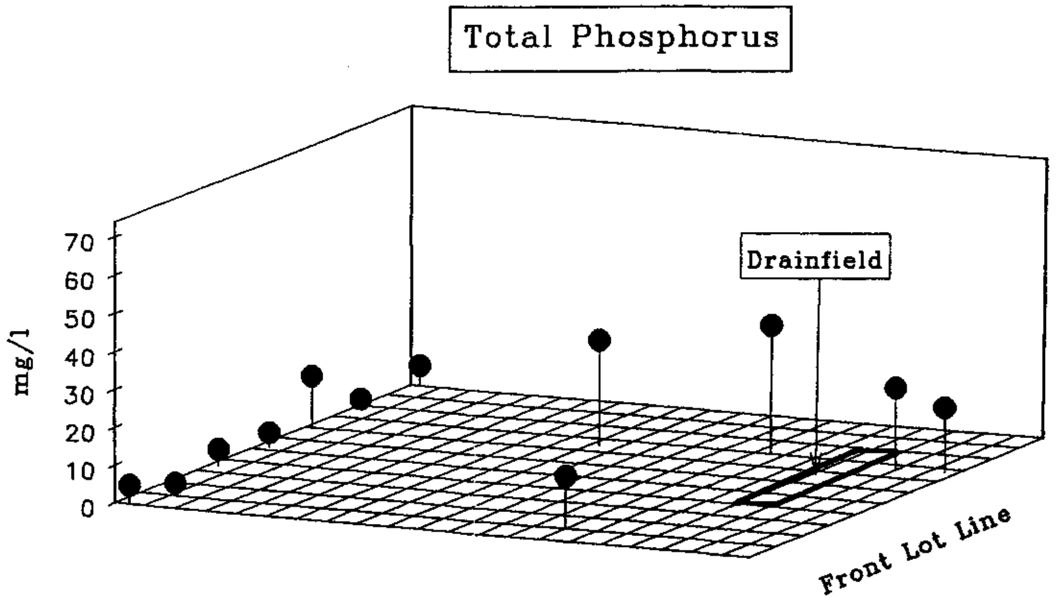
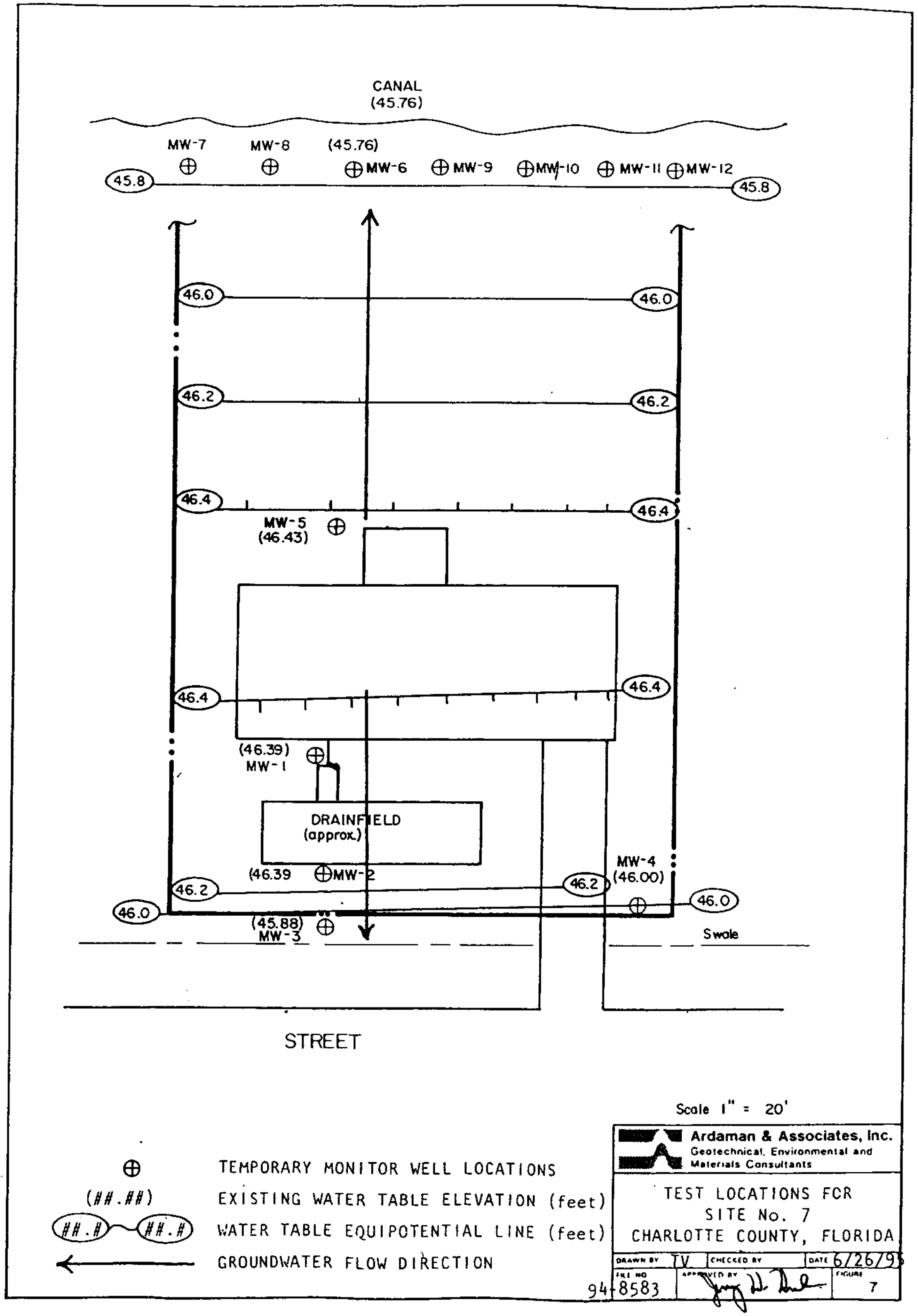


FIGURE 7


CANAL
(45.76)
MW-7
MW-8
(45.76)
MW-6
MW-9
MW-10
MW-11
MW-12
45.8
46.0
46.2
46.4
MW-5
(46.43)
(46.39)
MW-1
DRAINFIELD
(approx.)
(46.39
MW-2
MW-4
(46.00)
(45.88)
MW-3
Swale
STREET
Scale 1" = 20'
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet)
WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 7
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
DATE 6/26/95
FILE NO 94-8583
FIGURE 7

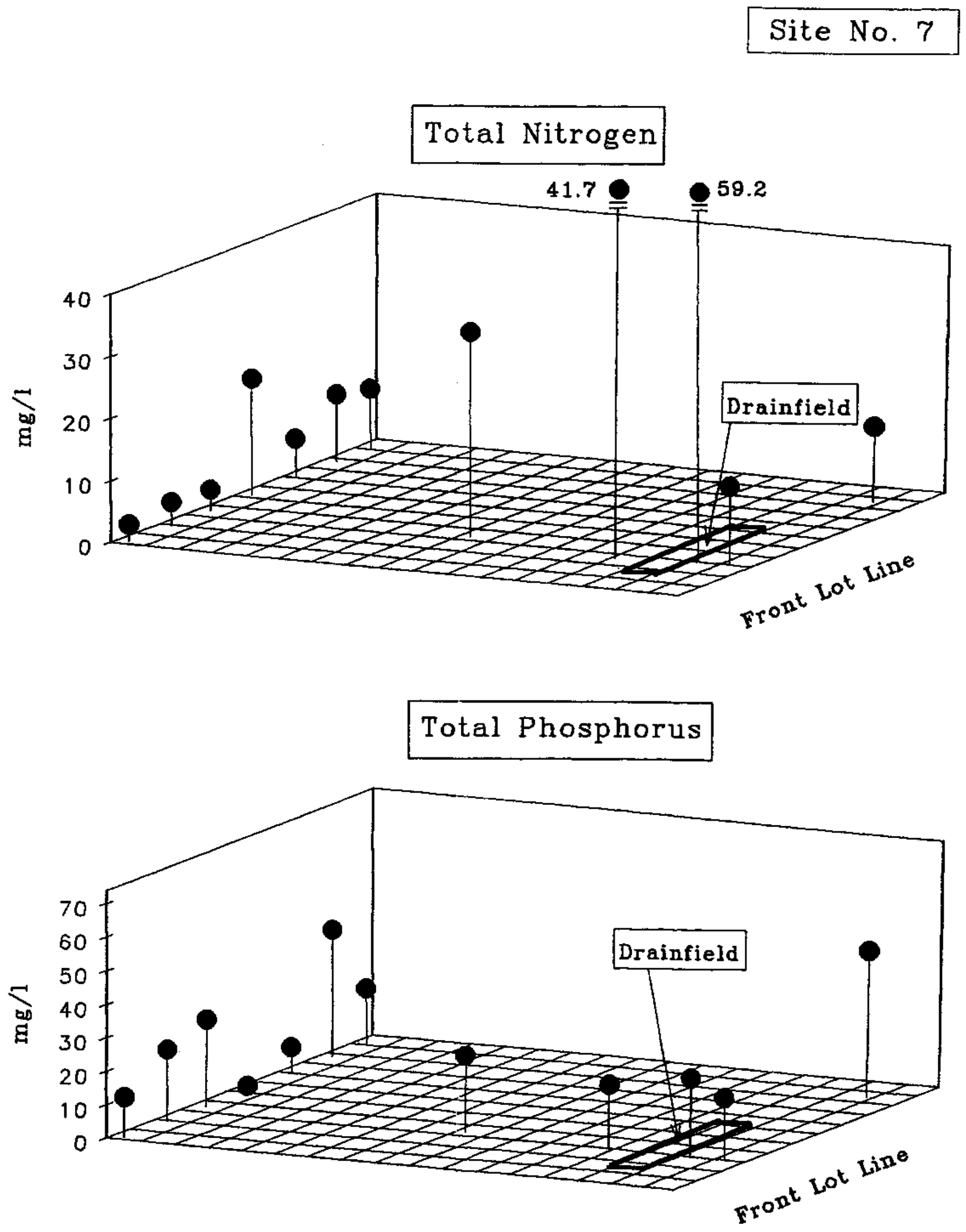
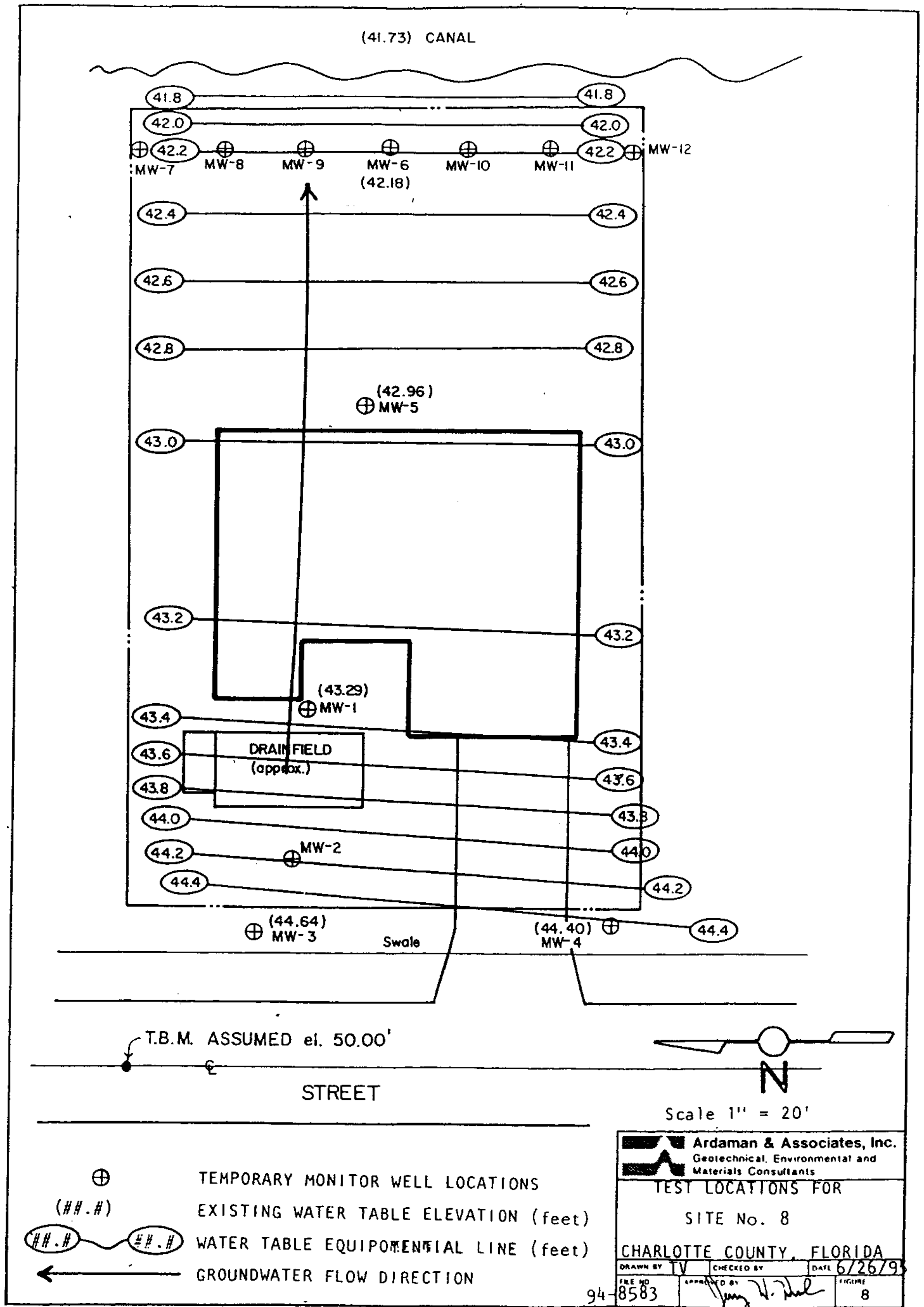

Site No. 7
Total Nitrogen
41.7
59.2
mg/l
0
10
20
30
40
Drainfield
Front Lot Line
Total Phosphorus
mg/l
0
10
20
30
40
50
60
70
Drainfield
Front Lot Line

FIGURE 8


(41.73) CANAL
41.8
42.0
42.2
MW-7
MW-8
MW-9
MW-6
(42.18)
MW-10
MW-11
MW-12
42.4
42.6
42.8
(42.96)
MW-5
43.0
43.2
(43.29)
MW-1
43.4
43.6
43.8
44.0
44.2
44.4
DRAINFIELD
(approx.)
MW-2
(44.64)
MW-3
Swale
(44.40)
MW-4
T.B.M. ASSUMED el. 50.00'
STREET
N
Scale 1" = 20'
TEMPORARY MONITOR WELL LOCATIONS
(##.#) EXISTING WATER TABLE ELEVATION (feet)
WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 8
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
DATE 6/26/95
FILE NO. 94-8583
FIGURE 8

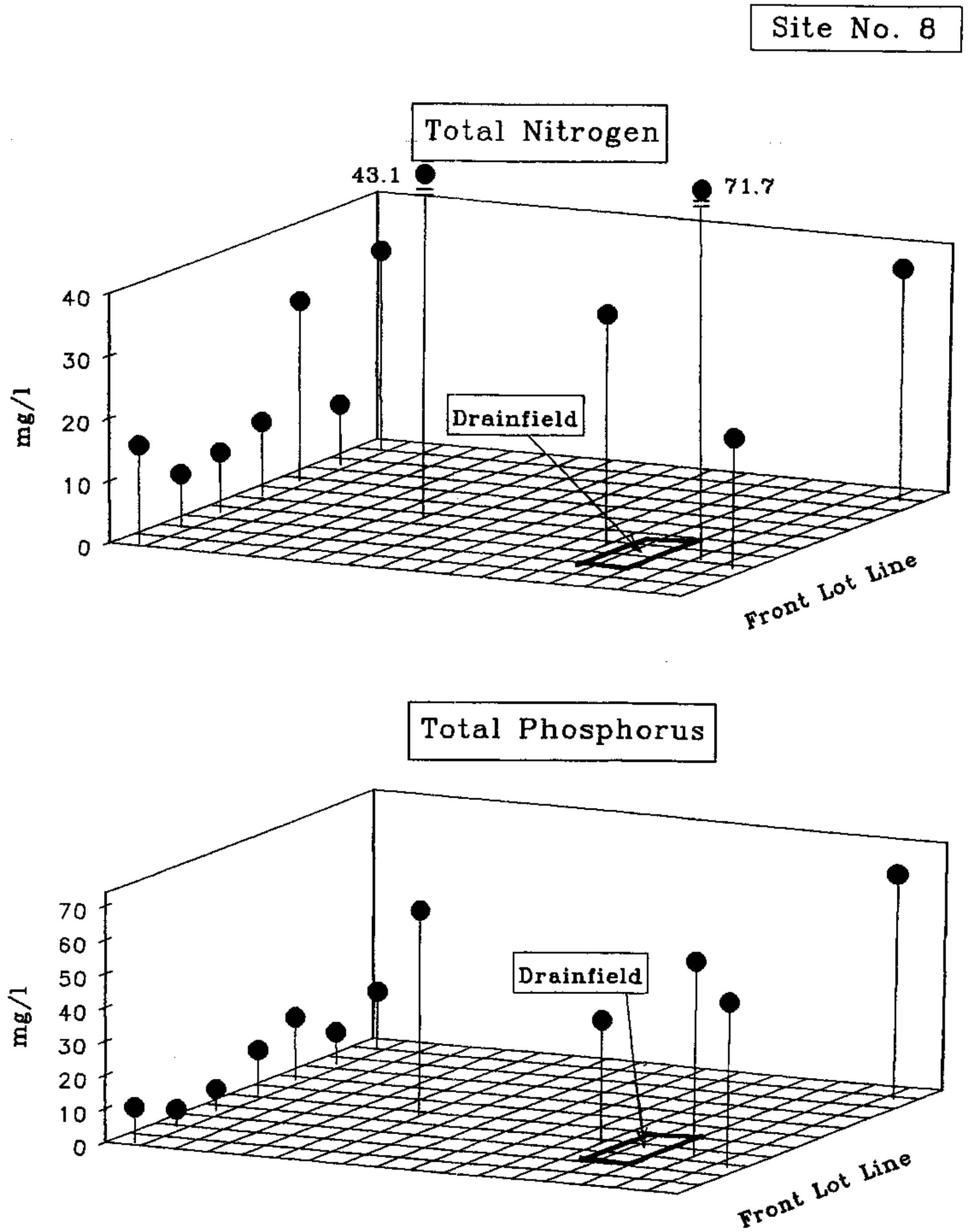

Site No. 8
Total Nitrogen
43.1
71.7
mg/l
0
10
20
30
40
Drainfield
Front Lot Line
Total Phosphorus
mg/l
0
10
20
30
40
50
60
70
Drainfield
Front Lot Line

FIGURE 9

that less than 1 percent of the surficial samples exceeded the State standard and that most of samples have no detectable nitrogen compounds.

Upchurch (1992) reports that SFWMD analyzed 577 background surficial samples and found a mean value of 0.4 mg/l ammonia nitrogen, which is exceeded by both the drainfield average and the front lot-line average of the current study. SFWMD also found an average TKN value of 0.8 mg/l (n = 20) in the surficial aquifer. This value which is exceeded by an order of magnitude for the drainfield, front lot-line and rear lot-line results of the present study.

The frequency of exceedance from typical background samples or regulatory criteria referenced by Upchurch (ibid) is given in the following table:

Percent of Exceedance From Expected Background Surficial Values

Criteria (mg/l)[1]	Front Lot Line (%)	Drain Field (%)	Rear Lot Line (%)	Overall (%)
TKN > 0.8	89	100	100	98
NH_3-N > 0.4	29	50	18	25
Tot. P>0.06	100	100	100	100
Tot. P >0.1	100	100	100	100
NO_{2+3}-N > 1.0	0	19	0	3
NO_{2+3}-N > 10.0	0	0	0	0

(1) See text, or Fla. Geologic Survey Pub. No. 34.

Another more direct comparison is taken from monitoring done in conjunction with the Sarasota Bay National Estuary Program. Monitor wells were installed in the surficial aquifer at a residence located on a salt water canal. The residence is served by central sewer. The lot is landscaped with St. Augustine grass which is regularly fertilized and maintained. The median total nitrogen observed (n= 8) at this site was 1.17 mg/l and the total phosphorus concentration was 0.07 mg/l.

As a part of the same National Estuary study, groundwater samples were obtained from a golf course which is irrigated with reclaimed water. The surrounding area is served by central sewer. Median groundwater values obtained (n = 8) for this site were 2.29 mg/l total nitrogen, 1.04 mg/l for total phosphorus and below detection limits (< 0.005 mg/l) for nitrite+nitrate nitrogen. Reclaimed water used for irrigation at this site averages around 10 mg/l of nitrogen. Routine groundwater monitoring for nitrite+nitrate at four golf courses in Manatee County irrigated with reclaimed water indicate that the majority of the observations (14 out of 18) were below the detection limits. (Total nitrogen results were not reported for these golf course sites.)

Most of the surficial groundwater measured during the present study was at the rear lot line (or ROW) where the surficial water is in direct hydraulic connection with the canal water. Based on the hydraulic gradient measured at most sites, the surficial groundwater is flowing into the canal systems. While a direct comparison cannot be made between groundwater and surface waters, it is informative to compare the observed groundwater concentrations with State-wide surface water values for lakes and streams. The State indices are based on analysis of thousands of observations throughout Florida waters. The results were converted to annual median values and then ranked. The percentile ranks of those observations for total nitrogen and total phosphorus are given below in units of mg/l.

Florida Stream Water Quality Percentiles(1)

Percentile	Total Nitrogen	Total Phosphorus
90	0.55	0.02
80	0.75	0.03
70	0.90	0.05
60	1.00	0.07
50	1.20	0.09
40	1.40	0.16
30	1.60	0.24
20	2.00	0.46
10	2.70	0.89

(1) Florida Water Quality Assessment. 1994 305(b)Report. FDEP, 1994.

Thus, only 10 percent of the State's streams have total nitrogen concentrations which are in excess of 2.70 mg/l or phosphorus in excess of 0.89 mg/l. By comparison, the respective mean Port Charlotte groundwater values adjacent to the canal are 7.92 mg/l total nitrogen and 14.80 mg/l total phosphorus.

East Port Monitoring Results

In addition to the groundwater monitoring at residential sites, Ardaman and Associates monitored the groundwater quality of three surficial wells downgradient of the East Port WWTF percolation ponds in late 1994. The purpose of this study component was to characterize a first-order decay of total nitrogen in Charlotte County soils. Three existing downgradient wells were sampled in August, September, November and December of 1994. MML provided the laboratory analyses, which are given in Table 4.

Ardaman and Associates measured the horizontal conductivity (ft/d) at each of the wells with both a constant and falling head permeability test, and estimated a range of porosity (e.g. 0.30-0.45). The permeability tests were averaged for each well. Those results are given below, along with the collection zone of each well, the downgradient distance to the nearest percolation pond, and the mean water elevation and quality monitored for each well.

	Well HP-1	Well HP-2	Well HP-3
Hydraulic Conductivity (ft/d)	16.0	11.5	14.0
Collection Zone (ft, NGVD)	28.5 -37.5	10.5 -19.5	20.0 - 29.0
Downgradient Distance (ft)	400	950	1280
Water Level (ft, NGVD)	6.10	4.43	3.60
Total Nitrogen (mg/l)	1.79	2.45	1.07

In order to establish a decay constant, the travel time must be estimated. The rate of groundwater flow was determined from the following equation :

$$q = K / 2x \ (h_o^2 - h^2)$$

where :

q = groundwater rate of flow (ft^3/ft-d) per unit width

h_o = height of water in pond, above surficial confining layer.

h = height of water level above confining layer at distance x from h_o.

x = distance between h_o and h (the distance from the edge of the percolation pond to monitor well.

K = hydraulic conductivity (ft/d)

Table 4

East Port WWTP Water Quality Results

Station	Date	NO_{2+3}-N (mg/l)	NH_4-N (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)
Lab Blank	08/02/94	<0.005	<0.005	<0.05	<0.05	0.17
Field Blank	08/04/94	<0.005	0.010	<0.05	<0.05	0.14
Field Blank	09/09/94	<0.005	<0.005	<0.05	<0.05	<0.05
Field Blank	11/04/94	<0.005	<0.005	<0.05	<0.05	<0.05
Field Blank	12/19/94	<0.005	0.008	<0.05	<0.05	<0.05
Pond	08/04/94	<0.005	<0.005	3.70	3.70	4.43
HP-1	08/03/94	0.055	0.302	1.51	1.57	3.61
HP-2	08/04/94	0.029	0.049	2.43	2.46	8.93
HP-3	08/04/94	0.042	0.186	0.87	0.91	3.49
Pond	09/09/94	<0.005	0.040	1.96	1.96	3.88
HP-1	09/09/94	0.012	0.320	2.02	2.03	5.04
HP-2	09/09/94	<0.005	0.142	4.77	4.77	30.30
HP-3	09/09/94	0.014	0.222	1.90	1.91	13.25
Pond	11/04/94	<0.005	0.028	1.50	1.50	1.39
HP-1	11/04/94	0.014	0.382	1.59	1.60	2.23
HP-2	11/04/94	<0.005	0.373	1.12	1.12	5.66
HP-3	11/04/94	<0.005	0.329	0.68	0.68	2.50
Pond*	12/19/94	0.019	0.690	4.60	4.62	2.48
HP-1	12/19/94	0.011	0.445	1.83	1.84	4.99
HP-2	12/19/94	0.010	0.342	1.42	1.43	4.63
HP-3	12/19/94	<0.005	0.295	0.76	0.76	2.94

* Pond Filled. Sample taken from ditch at same location.

Velocity at the monitor well can be determined from the following equation;

$$v = q / (P * h)$$

where:

v = velocity (ft/d) and

P = porosity (taken as 0.38)

A range of pond elevations was evaluated to bracket operations at the East Port facility. In practice, the water level in the percolation ponds ranged from a foot below top of berm, to pond bottom during dry conditions. The mean bottom elevation (9.3 ft NGVD) of the southerly three percolation ponds was used as the lower limit. The upper limit was set at 11.0 ft NGVD, which is a foot below the lowest elevation of the berms.

The reported thickness of the surficial aquifer (See Ardaman & Associates literature review in Appendix A) ranges from 20 to over 100 feet thick. Values of 20 and 80 feet were evaluated in order to set reasonable limits for a reference datum for h and h_o.

Table 5 gives the range of estimated velocities for the various conditions evaluated. These values were coupled with the water quality results to derive an estimate of the total nitrogen decay rate. For purposes of this evaluation, the mean total nitrogen (3.89 mg/l) recorded on the monthly operating reports for the sampling period was used. Travel times were derived by dividing the distance by the velocity, and the first order decay rate was determined with the following equation :

$$k = -\ln (C / C_o) / t$$

where :

C = concentration in monitor well

C_o = concentration in pond.

The results are also given in Table 5. For comparison with other studies, the regional evaluation completed for the Sarasota Bay National Estuary Program was based on a value

Table 5

East Port WWTP Monitor Well Results[1]

	Groundwater Velocity (ft/d)	
Pond El = 9.30	**Surficial Thickness = 20 '**	**Surficial Thickness = 80'**
Well HP-1	0.34	0.32
Well HP-2	0.17	0.15
Well HP-3	0.19	0.16
Pond El = 11.00	**Surficial Thickness = 20 '**	**Surficial Thickness = 80'**
Well HP-1	0.57	0.51
Well HP-2	0.25	0.21
Well HP-3	0.26	0.22

	Total Nitrogen Decay Constant (1/d)	
Pond El = 9.30	**Surficial Thickness = 20 '**	**Surficial Thickness = 80'**
Well HP-1	0.00067	0.00062
Well HP-2	0.00006	0.00005
Well HP-3	0.00018	0.00015
Pond El = 11.00	**Surficial Thickness = 20 '**	**Surficial Thickness = 80'**
Well HP-1	0.00111	0.00099
Well HP-2	0.00009	0.00007
Well HP-3	0.00025	0.00020

(1) See Text for Assumptions and Water Quality Data.

of 0.0006 d^{-1} compiled from observed in-stream values. A subsequent Sarasota County study resulted in a range of values (0.002 - 0.008 d^{-1}) obtained from nine wells downgradient from a percolation pond in Sarasota. Hydraulic conductivity assumed in that study was 16 ft/d, with a permeability of 0.30. Surficial thickness was set at 60 feet for the Sarasota Bay evaluations.

Recommendations for Future Monitoring

Mote Marine Laboratory developed a long-term surface and groundwater monitoring program for the County. The full report is included as Appendix B, and the recommendations are summarized below.

Monitoring surface water quality in Port Charlotte over a short time frame is not an effective tool to describe water quality changes resulting from a change from OSDS to central sewer. Other factors (fertilizer applications, irrigation etc.) associated with urbanization cause considerable variability in the results and confound the interpretation of the data. A power analysis of a similar data set collected in Sarasota and Charlotte counties was conducted by MML (1994) to determine the power of a monthly sampling program to detect changes. For the analysis, it was assumed that five years of monitoring preceded the change and five years of monthly monitoring followed the change. Using the variability of the observed local data as an input, the minimum change in total nitrogen that could be detected in salt water stations after 10 years of monthly monitoring was estimated at 20 percent. The freshwater stations were more stable, and under the same conditions, a 12 percent change would be detectable.

If a "before and after" evaluation of water quality is desirable for local managers and the public, a long-term (e.g. 5-10 years) surface water monitoring program will be necessary. Because the ability to detect changes in the estuarine stations is relatively poor, salt water stations are not included in the recommended plan. In order to minimize the scope of this program component, sampling at only the most downstream freshwater location of the individual canals is recommended. Monthly sampling is desirable at 10-12 sites.

One of the limitations of conventional water quality monitoring is that the source of the pollutant is often undefined. For reasons previously described, this is particularly true for urban settings. There is a technique which is based on the ratio of nitrogen isotopes which may distinguish the source of nitrogen. While expensive, this technique has been used to determine if the nitrogen source is OSDS effluent, fertilizer or un-impacted groundwater. If source identification is important, it is recommended that this technique be used in conjunction with a groundwater monitoring program. It is recommended that this component of the program be conducted twice over the course of a long-term monitoring.

If documentation of groundwater clean-up following installation of central sewer is important, then continued groundwater monitoring is recommended at 8-10 sites, with up to seven wells at each site. A mix of sites with and without OSDSs is recommended to characterize expected groundwater quality in the absence of OSDSs. These results could be used to estimate the per lot contribution due to OSDSs and to monitor the dissipation of OSDS plumes. Quarterly sampling is recommended, and the duration will be dependent on the length of time required for plume dissipation following abandonment of the OSDS.

The proposed monitoring plan focuses on several aspects of water quality in Port Charlotte. Budget, and the need to know about those aspects will dictate which components will be implemented. Planning level costs to implement the entire program are on the order of $55,000 per year for routine surface water or groundwater monitoring (total of $110,000 for both), with an additional $45,000 per isotopic source determination. Determination of the nitrogen source(s) is anticipated to be conducted twice over the course of a long-term program.

REFERENCES

FDEP, 1994. Florida Water Quality Assessment, 1994 305(b) Report. Prepared by Florida Department of Environmental Protection.

Florida Geological Survey, 1992. Florida's Ground Water Quality Monitoring Program. Background and Hydrogeochemistry. Edited by G.L. Maddox, J.M. Lloyd, T.M. Scott, S.B. Upchurch and R. Copeland. Florida Geological Survey Special Publication No. 34.

MML, 1994. Characterization of Port Charlotte Water Quality and Comparison to other Southwest Florida Canal Systems. Mote Marine Laboratory Technical Report No. 391.

Upchurch, S.B., 1992. Quality of Water in Florida's Aquifer Systems. Chapter IV In: Florida Ground Water Quality Monitoring Program.

Appendix A

HYDROGEOLOGIC DATA REVIEW AND GROUNDWATER SAMPLING FOR CHARLOTTE COUNTY WASTEWATER SYSTEM EXPANSION PROGRAM

BY

ARDAMAN AND ASSOCIATES, INC.

CHAR.8B/3
8/15/95

HYDROGEOLOGIC DATA REVIEW AND GROUNDWATER SAMPLING FOR "CHARLOTTE COUNTY WASTEWATER SYSTEM EXPANSION PROGRAM," CHARLOTTE COUNTY, FLORIDA

Ardaman & Associates, Inc.

OFFICES

Orlando, 8008 S. Orange Avenue, Orlando, Florida 32809, Phone (407) 855-3860
Bartow, 1525 Centennial Drive, Bartow, Florida 33831, Phone (813) 533-0858
Cocoa, 1300 N. Cocoa Blvd., Cocoa, Florida 32922, Phone (407) 632-2503
Fort Lauderdale, 3665 Park Central Boulevard, North, Pompano Beach, Florida 33064, Phone (305) 969-8788
Fort Myers, 9970 Bavaria Road, Fort Myers, Florida 33913, Phone (813) 768-6600
Miami, 2608 W. 84th Street, Hialeah, Florida 33016, Phone (305) 825-2683
Port Charlotte, 740 Tamiami Trail, Unit 3, Port Charlotte, Florida 33954, Phone (813) 624-3393
Port St. Lucie, 1017 S.E. Holbrook Ct., Port St. Lucie, Florida 34952, Phone (407) 337-1200
Sarasota, 2500 Bee Ridge Road, Sarasota, Florida 34239, Phone (813) 922-3526
Tallahassee, 3175 West Tharpe Street, Tallahassee, Florida 32303, Phone (904) 576-6131
Tampa, 1406 Tech Boulevard, Tampa, Florida 33619, Phone (813) 620-3389
West Palm Beach, 2511 Westgate Avenue, Suite 10, West Palm Beach, Florida 33409, Phone (407) 687-8200

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

August 15, 1995
File No. 94-8583

TO: Camp, Dresser & McKee, Inc.
20101 Peachland Boulevard, Unit 207
Port Charlotte, Florida 33954

Attention: Mr. John Calise, P.E.

SUBJECT: Hydrogeologic Data Review and Groundwater Sampling for "Water Quality Study for Charlotte County Wastewater System Expansion Program," Charlotte County, Florida

Gentlemen:

As authorized by Mr. S. John Calise, P.E. and in accordance with our proposal dated May 12, 1994, we are pleased to present the results of our hydrogeologic data review and groundwater sampling programs for the project referenced above. Our study included the following tasks:

1. Surficial aquifer characterization - literature search.
2. Groundwater sampling at eight (8) residential lots with on-site sewage disposal (septic tank) systems.
3. Percolation pond water and groundwater sampling at the Eastport Wastewater Treatment Plant site.
4. Developing a long-term groundwater monitoring program.

This report presents the results of our study and has been prepared for the exclusive use of Camp, Dresser, & McKee, Inc. and their client, in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

We appreciate the opportunity to be of your assistance on this project. Please do not hesitate to contact us when we may be of further service or if you should have questions concerning this report.

Very truly yours,

Ardaman & Associates, Inc.

Jerry H. Kuehn, P.E.
Project Engineer
Eng. Reg. No. 35557

Gary H. Schmidt, P.E.
Vice President
Eng. Reg. No. 12305

JHK/GHS:nh

cc: Mr. Mike Heyl (CDM, Sarasota)

TABLE OF CONTENTS

1.0 INTRODUCTION

The purpose of this study was to collect and provide hydrogeologic and groundwater quality data for the "Water Quality Study for the Charlotte County Wastewater System Expansion Program" being performed by Camp, Dresser & McKee (CDM). This study is part of that larger study and has included a review of available literature to characterize the surficial aquifer in the study area, groundwater sampling at eight (8) residences having on-site sewage disposal systems adjacent to canals, and groundwater sampling at the Eastport Wastewater Treatment Plant site. Based upon this data, a long-term groundwater monitoring plan can be developed.

For this study, CDM determined sampling locations at the Eastport Wastewater Treatment Plant Site and identified residential lots at which sampling could be performed. It was the responsibility of Ardaman & Associates, Inc. to install temporary monitor wells at the residential lots and to perform groundwater sampling in the field.

2.0 SURFICIAL AQUIFER CHARACTERIZATION

Physical and chemical properties of the surficial aquifer in the vicinity of Port Charlotte, Florida have been characterized based upon information from various sources, including the United States Geological Survey (USGS), the United States Department of Agriculture's Soil Conservation Service (SCS), the Southwest Florida Water Management District (SWFWMD), the Florida Geological Survey and other sources. This section of the report will summarize this information and present a discussion of the topographic setting, physical characteristics and background water quality for the surficial aquifer.

2.1 Location and Topographic Setting

The eight (8) residential lots at which groundwater sampling was performed were located within the north-central portion of the city of Port Charlotte, within an area located to the south of Peachland Boulevard, west of Kings Highway, north of Midway Boulevard and east of Forest Nelson Boulevard. These sites are located within Sections 9, 10, 11, 12 and 15, Township 40 South, Range 22 East.

Groundwater sampling was also performed at the Eastport Wastewater Treatment Plant site. This site is located southeast of Port Charlotte in Section 20, Township 40 South, Range 23 East.

According to Brooks (1981), the northern portion of Port Charlotte lies within the DeSoto Slope area and the southern portion of Port Charlotte lies within the Barrier Island Coastal Strip area of the Southwestern Flatwoods District of the Florida Physiographic Section. The DeSoto Slope is a gently sloping plane of wet prairie and flatwoods, with the surface drainage systems disrupted by swamps. The Barrier Island Coastal Strip is lower in elevation than the DeSoto Slope and consist of coastal flatwoods bordered by lagoons and islands of recent origin.

2.2 Hydrogeology of the Surficial Aquifer

The hydrogeology of the area is defined by the geology of the subsurface as it relates to aquifers and confining beds which underlie the area. The generalized hydrogeologic cross section for Charlotte County, as reported by SWFWMD (1988), is presented in Table 1 of Appendix I. Scott (1988), however, has since raised the Hawthorn Formation to group status, with the Hawthorn Group including not only those strata identified as the Hawthorn Formation on Table 1, but also the Bone Valley Formation and Tamiami Formation within the (previously) undifferentiated deposits overlying the Hawthorn Formation, and the Tampa Limestone underlying the Hawthorn Formation. The geologic sequence, in ascending order from Paleocene to Holocene age, therefore includes the Paleocene age Cedar Key Formation; the Eocene age Oldsmar Formation, Avon Park Formation and Ocala Limestone; Oligocene age Suwannee Limestone; Miocene to early Pliocene age Hawthorn Group, Pliocene to Pleistocene age terrace deposits; and surficial sands of Holocene age.

The surficial unconfined (water table) aquifer and underlying artesian aquifers comprise the aquifer system at the site. Separate aquifers are hydraulically separated by confining beds (aquicludes) of very low permeability located between the aquifers. The principal hydrogeologic units are the surficial aquifer, intermediate aquifers and confining beds, Floridan aquifer, and sub-Floridan confining unit. In this report we will present a general description and typical properties only for the surficial aquifer, as the underlying artesian aquifers are not directly relevant to this water quality study.

The surficial aquifer consists of the relatively permeable strata of marine and non-marine quartz sand, clayey sand, shell, shelly marl, and phosphorite, with occasional stringers of marl and limestone, primarily within the surficial sand and terrace deposits. The surficial aquifer extends from the land surface to the top of the upper confining unit of the Hawthorn Group.

Wolansky (1983) indicates the surficial aquifer to be approximately 80 to 100 feet thick in the area. Our previous explorations in the general vicinity, as documented by Ardaman (1994a) and Ardaman (1994b) indicate the surficial aquifer thickness to be greater than our maximum boring depth of 75 feet, but that the surficial aquifer may locally contain clayey sand layers of relatively low permeability, which may locally reduce the effective thickness of the aquifer. Others report the surficfial aquifer thickness to be in the range of 20 to 60 feet in the vicinity. Surficial aquifer thicknesses reported in various references are listed in Table 2 of Appendix I.

Other reported hydrogeologic properties for the surficial aquifer, including transmissivity, horizontal and vertical hydraulic conductivity, specific yield (storage coefficient) and porosity are also listed in Table 2 of Appendix I. The transmissivity of the surficial aquifer is reported to range from approximately 500 to 10,000 feet^2 /day, with an average of approximately 1300 to 2140 feet^2 /day. The horizontal hydraulic conductivity of the surficial aquifer is reported to range from 0.0028 to greater than 1,000 feet/day, with an average of 17 to 53 feet/day. It should be noted that the horizontal hydraulic conductivities reported by Ardaman (1994a) and Ardaman (1994b) are based upon test results only for the upper 20 feet of the aquifer and are not representative of the entire aquifer thickness. The vertical hydraulic conductivity is indicated to range from 0.12 x 10^{-5} to 15 feet/day with an average of approximately 2 feet/day. The specific yield of the aquifer is indicated to range from 0.05 to 0.3, with an average of approximately 0.2. In addition, Ardaman (1994a) and Ardaman (1994b) listed estimated soil porosities for the upper portion of the aquifer, based upon soil texture and the water content of saturated soil samples. Porosity was estimated to be in the range of 0.30 to 0.45.

2.3 Chemical Characteristics of the Surficial Aquifer

Typical concentrations of chloride, nitrate and sulfate within the surficial aquifer in the Port Charlotte vicinity are listed in Table 3 of Appendix I. The literature search indicated that typical background concentrations of chloride range from 20 to 1100 mg/L, nitrate concentrations are generally less than or equal to 0.1 mg/L and sulfate concentrations range from 0 to 250 mg/L. Our literature search did not reveal any background concentrations for other nitrogen compounds, phosphorous or other nutrients.

3.0 GROUNDWATER SAMPLING AT RESIDENTIAL SITES

Our scope of work included defining site-specific hydraulic gradients, installing and sampling temporary monitor wells at eight (8) residences. The residential site selection and groundwater sampling programs are described in the following sections.

3.1 Residential Site Selection

CDM selected fourteen (14) residential sites for potential use in the groundwater sampling program. All fourteen (14) of the sites selected by CDM were on a canal and the septic system was located in front of the house (i.e. the septic system in the front yard and the canal along the rear lot boundary). Subsequently, a site visit to each of these was performed by Mr. Mike Heyl of CDM and Mr. Jerry H. Kuehn, P.E., of Ardaman & Associates, on February 9, 1995, for the purpose of selecting eight (8) of these sites for the sampling program.

Eight (8) sites were selected based upon visual observations of site drainage, topography and accessibility. An attempt was made to eliminate sites that may have complex groundwater flow patterns or difficult access. Favored were sites that apparently would have the primary groundwater flow direction (i.e. hydraulic gradient) from the septic system area towards the canal, without relatively deep roadside swales or other drainage features which may greatly alter or complicate groundwater flow patterns. Also favored were sites where monitor well locations would be least restricted by buildings, vegetation or other features.

The selection process revealed that nine (9) of the fourteen (14) potential sites were more favorable. Eight (8) of these nine (9) sites were randomly selected for sampling, with one (1) as an alternate should we be unable to sample one of the sites for any reason. Later, during the sampling program, it was discovered that one of the selected sites had rock strata at shallow depth. As the stainless steel drive-point wells could not be driven through the rock, this site was abandoned and the alternate site was sampled. The sampled sites are identified as Site Nos. 1 to 8.

3.2 Groundwater Sampling at Residential Sites

Twelve (12) temporary monitor wells were installed at each of the eight (8) sites to determine water table levels and obtain groundwater samples. The monitor well construction consisted of a 2-foot length of 1.25-inch diameter, stainless steel, wire-wound screen (0.006-inch wide screen openings) with a stainless steel drive-point at the tip. The screen was threaded onto a 1.25-inch diameter, stainless steel casing and driven into the ground to a depth of approximately 2 feet below the existing water table level. The monitor well locations are shown on the attached Figures 1 to 8 and selected installation data (depths and elevations) are listed in Table 4 of Appendix I.

At each site, wells MW-1 through MW-6 were installed first. The water levels within the wells were then allowed to stabilize and the well elevations were determined. By subtracting the stabilized water level readings from the well casing top elevation, the water table elevation was determined relative to a vertical datum. The water table elevations were used to assess groundwater flow directions, and to assist in selecting additional well locations. These wells were then sampled before or concurrently with the installation of the second set of six (6) wells at each site. The stainless steel well strings (screen and casings) were reused at each site and were thoroughly cleaned before each reuse.

It should be noted that a separate vertical datum was used at each of the eight (8) sites and that the datum is not equivalent to Northern Geodetic Vertical Datum (NGVD). The vertical datum used was an assumed road crown elevation of 50.00 feet at each site. The location of the datum point is shown on the respective Figure 1 to 8.

After installation, the monitor wells were purged and then sampled utilizing a Teflon bailer. The sampling equipment cleaning, well purging and sample collection procedures were in accordance with our firm's Comprehensive Quality Assurance Plan (CompQAP) No. 900305G, as approved by the Florida Department of Environmental Protection (FDEP). Samples were collected to be analyzed for nitrite plus nitrate nitrogen, ammonia nitrogen, organic nitrogen, and total phosphorous. The samples were transported to Mote Marine Laboratory for analysis. In addition, measurements of pH, temperature and specific conductance were made in the field by our personnel at the time of sampling. The results of these field measurements are summarized in Table 5 of Appendix I. The results of the Mote Marine Laboratory chemical analyses are included in Appendix II.

An equipment blank sample and a duplicate sample were also obtained from each of the eight (8) sites, for quality control purposes. The equipment blank sample was prepared by pouring analyte-free water, supplied by Mote Marine Laboratory, into the precleaned bailer, then transferring the water to the appropriate sample containers. Duplicate samples consisted of a second sample obtained from one of the monitor wells at each site.

3.3 Groundwater Flow Direction and Gradient

The existing water table elevation (relative to an assumed datum, not equivalent to NGVD) was determined at selected temporary monitor well locations and within the adjacent canal, in order to determine existing groundwater flow directions and gradients at each site. These data were used to develop a water table potentiometric contour map for each site, which are shown on the attached Figures 1 to 8. The groundwater flow direction and gradient for each site were derived from the respective map. The generalized groundwater flow direction(s) at each site is shown by the arrow(s) on the respective Figure.

At Site Nos. 4, 5 and 8, the groundwater flow direction appeared to be consistently from the on-site sewage disposal system (OSDS) area towards the adjacent canal. At these sites, nearly all the water from the OSDS tends to move towards the canal, although not necessarily in a straight line. A portion of the water is likely removed from the site by evapotranspiration from vegetated areas prior to reaching the canal, however.

At Site Nos. 1 and 3, the primary gradient appears to be from the OSDS area towards the canal, although there is also some gradient from the OSDS area towards the roadside swale. This is probably due to groundwater mounding induced by groundwater recharge from the OSDS, or due to water table drawdown effects of the roadside swale. This means that at these two (2) sites, a portion of the water from the OSDS moves towards the canal, while the remainder moves in other directions.

At Site Nos. 2 and 6, the groundwater flow direction appears to be initially from the OSDS area towards the canal, but at some point between the OSDS and the canal, the groundwater flow direction is no longer towards the canal. The groundwater flow direction near the canal appears to be from the canal towards land. At both of these sites, the water table surface was relatively flat, varying only by approximately 0.5 to 0.8 feet between any two measured points, with the water table level relatively close to the canal water level. It should be noted that our study was performed during the relatively dry portion of the year, when water table levels are typically near their annually lowest levels. During the wet season, which typically occurs during the months of June through September, water table levels would likely be significantly higher than at the time of our study and higher than the canal water level, probably resulting in a groundwater flow direction that is more consistently towards the canal.

At Site No. 7, the groundwater flow direction near the OSDS was apparently from the OSDS area towards the roadside swale. Between the building and the canal, the groundwater flow direction was towards the canal, however. Similar to Site Nos. 2 and 6, the water table was relatively flat at the site with a maximum head difference of approximately 0.7 feet between any two points of measurement, and groundwater flow directions may be more consistently towards the canal during the wet season when water table levels are higher.

The maximum hydraulic head difference and the hydraulic gradient (i) of groundwater flow from the OSDS's to the adjacent canal are summarized in Table 6 of Appendix I. Listed are both a range of hydraulic gradients and the average hydraulic gradient between the system and the canal. If the groundwater flow direction was not from the OSDS all the way to the canal, no average hydraulic gradient is listed as an average value would have no meaning in this case.

The groundwater flow directions and gradients presented in this report are based upon water table levels encountered at the time of our field explorations, during the period of March 28 to April 20, 1995. Groundwater flow directions and gradients may vary as water table and/or canal water levels fluctuate due to seasonal variations in the amount of rain fall, on-site sewage disposal system discharge rates and other factors.

4.0 GROUNDWATER SAMPLING AT EASTPORT WASTEWATER TREATMENT PLANT SITE

Groundwater samples were also collected from an existing percolation pond and three (3) existing test wells (piezometers) at the Eastport Wastewater Treatment Plant site, to provide data to CDM for estimating the total nitrogen decay constant. In addition, water level readings were made at the time of each sampling in order to estimate the hydraulic gradient at the site. The results of in situ permeability tests previously performed within the subject piezometers will also be presented.

4.1 Groundwater Sampling

The percolation pond and piezometer (HP-1 to HP-3) sampling locations are shown on the attached Figure 9. The piezometer construction consisted of a length of 2-inch diameter 0.010-inch slotted PVC pipe connected to a 2-inch diameter solid PVC riser. Each piezometer had a screen length of 9 feet. The piezometers were installed within a 4.5-inch diameter borehole, with the annular space between the piezometer pipe and the borehole walls backfilled with 6/20 graded silica sand to above the slotted screen. A bentonite pellet seal was installed above the silica sand and the remaining annular space to ground surface was grouted. Selected installation data (depths and elevations) are listed in Table 7 of Appendix I. These piezometers were installed by Ardaman & Associates, Inc. in January 1994, as documented by Ardaman (1994c).

The percolation pond and piezometers were sampled at one to two month intervals during August to December 1994. The piezometers were sampled utilizing a separate, precleaned teflon bailer for each piezometer. The sampling equipment cleaning, piezometer purging and sample collection procedures were in accordance with our firm's Comprehensive Quality Assurance Plan (ComQAP) No. 900335G, as approved by the FDEP. Samples were collected to be analyzed for nitrite plus nitrate nitrogen, ammonia nitrogen, total Kjeldahl nitrogen and total phosphorous. The samples were transported to Mote Marine Laboratory for analysis. In addition, field and measurements of pH, temperature and specific conductance were made in the field by our personnel at the time for sampling. The results of these field measurements are summarized in Table 8 of Appendix I. CDM also provided us with the results of Mote Marine Laboratories chemical analyses, which are included in Appendix II of this report.

An equipment blank sample was also obtained for each sampling event for quality control purposes. The equipment blank was prepared by pouring analyte free water, supplied by Mote Marine Laboratory, into the precleaned bailer, then transferring the water to the appropriate sample containers.

4.2 Groundwater Flow Direction and Gradient

As reported by Ardaman (1994c), the groundwater flow direction at the subject site is to the south towards the Peace River. To determine groundwater flow gradients at the site, the existing water table elevation at each piezometer was determined at the time of each sampling. The water table elevation and hydraulic gradients are summarized in Table 9 of Appendix I.

The hydraulic gradients were calculated assuming the groundwater flow direction to be due southward from the percolation pond towards the Peace River and, therefore, represent the hydraulic gradient from an east-west line drawn through HP-1 to an east-west line drawn through HP-2, and from the east-west line drawn through HP-2 to an east-west line drawn through HP-3.

4.3 Hydraulic Conductivity

In situ permeability tests were previously performed by our firm at HP-1 through HP-3, as documented by Ardaman (1994c). Both constant-head and falling-head permeability tests were performed within each piezometer. The constant-head tests indicated horizontal hydraulic conductivities (k_H) of 17 feet/day, 10 feet/day, for HP-1 to HP-3, respectively. The falling-head permeability test indicated a k_H of 7 feet/day, 13 feet/day and 10 feet/day for HP-1 to HP-3, respectively. It should be noted that these tests represent the hydraulic conductivity of the soils within the collection zone of the respective piezometer, which are listed in Table 7 of Appendix I. The shallowest collection zone was from a depth of 10.5 to 19.5 feet below the ground surface at HP-2.

Based upon data documented by the Soil Conservation Service (1984), the surficial soils are reportedly more permeable than the deeper (greater than 10 feet) soils tested by our firm. The Soil Conservation Service (1984) indicates these surficial soils to have a hydraulic conductivity between 12 and 40 feet/day in the top 3 feet, between 1 to 4 feet/day to a depth of 4.5 feet and 12 to 40 feet/day to a depth of about 6.5 feet.

Based upon the Soil Conservation Service data and our field explorations at the site, we estimate that the surficial sands within the top 2 to 5.5 feet have an average horizontal hydraulic conductivity greater than 12 feet/day. The average horizontal hydraulic conductivity is estimated to be about 10 feet/day between a depth of 10 feet to 30 feet, and about 7 feet/day between a depth of 30 to 40 feet below the ground surface.

5.0 LONG-TERM GROUNDWATER MONITORING PLAN

Our scope of work included preparing a recommended groundwater monitoring plan for the residential sites discussed in Section 3.0 of this report. To-date, however, the objective of such a monitoring plan has not been clearly defined. If the objective is to attempt to locate and monitor a contaminant plume, one would select for monitoring one or more of the sites at which a contaminant plume appears to be present and most clearly defined. If the objective is to monitor a broader range of conditions, one might select for monitoring a site which appears to have a more clearly defined plume, as well as a site which apparently does not have a well defined plume, and perhaps a third site with conditions somewhere between the first two sites. This report will, therefore, present a more generalized discussion of each of the eight (8) sites relative to its potential for long-term groundwater monitoring. Once the groundwater monitoring objectives have been better defined, a specific monitoring program may then be recommended.

CDM provided the results of the chemical analyses of groundwater samples performed by Mote Marine Laboratories, for our review. This data is included in Appendix II of this report.

As the orientation of the site refers the site varies with respect to north, the direction convention used in this report will be as follows. Right and left refers to the right-hand and left-hand directions if one were standing in the street facing the residence. Front refers to the side of the lot nearest the street and rear refers to the side of the lot nearest the canal (opposite from front).

In addition, references to a contaminant plume refer to a plume emanating from the subject OSDS, unless expressly stated otherwise. The fact that a contaminant plume was not clearly defined at some sites does not infer that groundwater contamination was not detected, but rather that the plume is not well defined due to monitor well placement, groundwatser flow directions, contamination from a neighboring OSDS or other nearby sources, or other factors.

5.1 Site Assessments

<u>Site No. 1</u>

There is no clearly defined containment plume at the site, although total nitrogen and total phosphorous concentrations were elevated near the OSDS and at the right-rear corner of the lot and, to a lesser extent, at the left-rear corner of the lot. Considering the groundwater flow direction indicating on Figure 1, the elevated concentrations at the left-rear may indicate a plume from the OSDS, and the elevated concentrations at the right-rear may indicate a plume from the neighbor's OSDS to the right of Site No. 1. The groundwater flow direction may also explain why total N and total P were relatively low a MW-5, near the center of the lot, as the plume from the subject OSDS may be moving to the left of MW-5, and the plume from the neighbor's to the right of MW-5.

This site is not recommended for long-term groundwater monitoring as off-site wells would likely be required to attempt to locate a containment plume.

Tank No. 2

The sampling program did not locate a clearly defined contaminant plume at this site. This may be because the groundwater flow directions at this site may change seasonally. Referring to Figure 2, there was a relatively small groundwater seepage gradient at the time of our field exploration, although groundwater flow directions appear to be towards the canal within the area near the OSDS, but away from the canal within the area near the canal. For this reason, the groundwater quality detected at MW-7 through MW-12 (the monitor wells along the rear lot line) may have been more indicative of the quality of water seeping from the canal into the aquifer, rather than from the aquifer into the canal.

This site may not be desirable for long-term groundwater monitoring, as a large number of wells would be required in order to trace a contaminant plume which likely changes directions throughout the year.

Site No. 3

A contaminant plume appears to be reasonably well defined at this site. The plume appears to be moving nearly directly from the OSDS to the rear of the lot, crossing MW-1, MW-5 and approximately centered on MW-6, although the field readings for specific conductance indicate that the plume may also be detectable at MW-10, MW-11 and MW-12. The total N concentrations detected were reasonably consistent with a degrading plume, although total P concentrations were more erratic, but were highest at MW-5 and MW-6. The elevated total P concentration at the left-rear corner of the lot (MW-7) may be indicative of a plume from the neighbor's OSDS to the left of the subject site.

This site would be a good candidate for long-term groundwater monitoring of a site expected to have a definable contaminant plume.

Site No. 4

A contaminant plume has apparently been detected moving across MW-1, MW-5 and approximately centered on MW-6, but the plume is not as well defined as at Site No. 3. The relatively high total N and total P concentrations detected at MW-4 may be influenced by a neighboring OSDS. The plume has probably also been detected at MW-7, MW-8 and MW-5. Considering the groundwater flow direction depicted on Figure 4, a portion of the plume may move across the left lot boundary, at least during portions of the year.

This site is also a good candidate for long-term monitoring of a site which may have a definable contaminant plume. Site No. 3 would be preferable, however, as its plume apparently is more centered on the site and there may be less influence from neighboring OSDS's.

Site No. 5

A contaminant plume may have been detected moving across MW-6 and, perhaps, MW-10. The total N and total P concentrations were elevated at MW-1 and MW-5 (located downgradient from the OSDS and upgradient from MW-6), but were substantially less than the concentrations at MW-6, however. The plume was, therefore, not clearly defined by the sampling program.

This site may be acceptable for long-term groundwater monitoring, but may not have a clearly definable contaminant plume.

Site No. 6

This site appears to have a reasonably well defined contaminant plume moving across MW-1, MW-5 and MW-6, although the groundwater flow directions encountered at the time of our field explorations, as shown on Figure 6, indicate that there is relatively little hydraulic gradient and that groundwater flow directions may be periodically from the canal into the aquifer. As is the case with Site No. 2, we expect that groundwater flow directions at the site vary significantly as the water table rises and falls in response to seasonal rainfall variations.

Due to the expected seasonal variation in the groundwater flow direction, long-term groundwater monitoring would likely require a large number of wells.

Site No. 7

A contaminant plume was not clearly identified by the sampling program at this site, although total N, total P and specific conductance data are elevated at some locations. Total N data indicates a plume moving across MW-1, MW-5 and MW-9. The total P data, however, indicates the lowest total P concentration at MW-9, with the highest at MW-4 and MW-11. The specific conductance is also elevated near MW-11, at the right- rear corner of the site.

The reason for the inconsistencies in the data may be due to the relatively low hydraulic gradient at the site and the groundwater flow directions. At the time of our study, as shown on Figure 7, the groundwater flow direction near the OSDS was towards the swale at the front of the site, although the groundwater flow direction in the back yard was towards the canal at the rear of the site. As was the case with Site Nos. 2 and 6, groundwater flow directions probably vary significantly due to water table fluctuations caused by seasonal variations in the amount of rainfall. This site may not, therefore, be desirable for long-term groundwater monitoring.

Site No. 8

A contaminant plume appears to be reasonably well defined at this site, moving from the OSDS across MW-1, MW-5 and approximately centered on MW-10. The elevated total N and total P concentrations detected at MW-4 and MW-12 may be due to a neighboring OSDS to the right of the subject site.

This site is well suited for long-term groundwater monitoring of a site which likely has a definable contaminant plume.

5.2 Summary

Sites 3, 4 and 8 are most suitable for long-term groundwater monitoring of sites expected to have a well defined groundwater contaminant plume. Sites 3 and 8 are preferable to No. 4, where a portion of the plume may at least periodically move off-site to the left.

Site No. 5 is also suitable for long-term groundwater monitoring, but the contaminant plume may not be as readily definable as at the three (3) sites described above.

Site Nos. 2, 6 and 7 may not be desirable for long-term groundwater monitoring, due to groundwater flow directions which may change significantly, depending upon water table levels and rainfall. A relatively large number of wells would be required to monitor these sites.

Site No. 1 is not recommended for long-term groundwater monitoring, since off-site wells may be required in order to identify a contaminant plume.

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APPENDIX I

Table 1
HYDROGEOLOGIC FRAMEWORK OF THE
SOUTHERN WEST-CENTRAL FLORIDA GROUNDWATER BASIN

System	Series	Stratigraphic unit	General lithology	Major lithologic unit	Hydrogeologic unit
Quaternary	Holocene and Pleistocene	Surficial sand, terrace sand, phosphorite	Predominantly fine sand; interbedded clay, marl, shell, limestone, phosphorite	Sand	Surficial aquifer
Tertiary	Pliocene	Undifferentiated deposits[1]	Clayey and pebbly sand; clay, marl, shell, phosphatic	Clastic	Confining bed INTERMEDIATE AQUIFER AND CONFINING BEDS
	Miocene	Hawthorn Formation	Dolomite, sand, clay, and limestone; silty, phosphatic	Carbonate and clastic	Aquifer
		Tampa Limestone	Limestone, sandy, phosphatic, fossiliferous; sand and clay in lower part in some areas		Confining bed
	Oligocene	Suwannee Limestone	Limestone, sandy limestone, fossiliferous		FLORIDAN AQUIFER SYSTEM
	Eocene	Ocala Limestone	Limestone, chalky, foraminiferal, dolomitic near bottom	Carbonate	
		Avon Park Limestone[2]	Limestone and hard brown dolomite; intergranular evaporite in lower part in some areas		Upper Floridan aquifer Middle confining unit
		Lake City Limestone and Oldsmar Limestone[2]	Dolomite and limestone, with intergranular gypsum in most areas	Carbonate with evaporites	Lower Floridan aquifer
	Paleocene	Cedar Keys Limestone[2]	Dolomite and limestone with beds of anhydrite		Lower confining unit

[1]Includes all or parts of Caloosahatchee Marl, Bone Valley Formation, Alachua Formation, and Tamiami Formation.

[2]Since this report was prepared, the Avon Park, Oldsmar, and Cedar Keys Limestones have been changed to the Avon Park, Oldsmar, and Cedar Keys Formations. The Lake City Limestone has been abandoned, and the rocks are included in the lower part of the Avon Park Formation (Miller, 1984).

-from SWFWMD (1988)

Table 2

TYPICAL HYDROGEOLOGIC PROPERTIES OF THE SURFICIAL AQUIFER NEAR PORT CHARLOTTE, FLORIDA

Source*	Thickness [feet]	Transmissivity [ft^2/day]	Horizontal Hydraulic Conductivity [ft/day]	Vertical Hydraulic Conductivity [ft/day]	Specific Yield & Storage Coefficient	Porosity
Ardaman, 1994a and 1994b	>75 -----	----- -----	0.14 to 16** (1.0 to 3.7)**	0.0066 to 11 -----	0.15 to 0.25 (0.2)	0.3 to 0.45 -----
SWFWMD, 1988	25 to 50 -----	----- (2139)	0.0028 to >1000 -----	0.12×10^{-5} to 13 -----	0.05 to 0.3 -----	----- -----
Sutcliffe, 1975	20 to 60 (40)	----- (2140)	----- (53)	----- -----	----- -----	----- -----
Wolansky, 1983	80 to 100 -----	500 to 10000 (1300)	7 to 133 (17)	1.5 to 15 (2)	0.05 to 0.25 (0.2)	----- -----

* See "References" section of this report.
** For upper 20 feet of aquifer, only.
< Less than.
> Greater than.
() Numbers in parenthesis are average values, when given.

Table 3

TYPICAL WATER QUALITY OF SURFICIAL AQUIFER NEAR PORT CHARLOTTE, FLORIDA

Source*	Chloride [mg/L]	Nitrate [mg/L]	Sulfate [mg/L]
Joyner & Sutcliffe, 1976	130 to 240	-----	8 to 20
Maddox, et. al., 1992	50 to >250	<0.1 to 0.1	10 to >100
SWFWMD, 1988	25 to >250	-----	<25 to 250
Sutcliffe, 1975	20 to 1100	-----	0 to 22
Wolansky, 1988	90 to >250	-----	<25 to 50

* See "References" section of this report.
< Less than.
> Greater than.

Table 4

MONITOR WELL INSTALLATION DATA FOR RESIDENTIAL SITES

Well Location	Top Elev. (feet)	Ground Elev. (feet)	Total Depth (feet)	Water Table Elev. (feet)
Site No. 1				
MW-1	53.24	51.7	8.5	44.54
MW-2	51.43	50.9	7.0	44.73
MW-3	51.44	49.9	6.0	44.64
MW-4	50.21	49.7	7.0	44.41
MW-5	51.94	51.2	9.5	44.19
MW-6	45.85	44.4	4.0	43.55
MW-7	---	---	3.7	---
MW-8	---	---	4.0	---
MW-9	---	---	4.2	---
MW-10	---	---	4.5	---
MW-11	---	---	4.2	---
MW-12	---	---	4.3	---
Site No. 2				
MW-1	54.34	51.6	9.8	42.64
MW-2	52.04	51.4	9.3	42.64
MW-3	49.50	48.5	6.5	42.90
MW-4	49.86	49.8	7.4	43.06
MW-5	48.99	48.2	6.7	42.79
MW-6	52.23	52.1	9.8	42.53
MW-7	---	---	1.5	---
MW-8	---	---	2.5	---
MW-9	---	---	3.4	---
MW-10	---	---	3.1	---
MW-11	---	---	3.1	---
MW-12	---	---	2.7	---

Notes: Elevations are relative to an assumed datum, not NGVD.
Total depth is depth below ground surface.

Table 4, cont'd.

MONITOR WELL INSTALLATION DATA
FOR RESIDENTIAL SITES

Well Location	Top Elev. (feet)	Ground Elev. (feet)	Total Depth (feet)	Water Table Elev. (feet)
Site No. 3				
MW-1	52.88	51.5	8.7	43.53
MW-2	51.20	50.6	9.4	43.90
MW-3	50.25	49.6	6.7	43.73
MW-4	50.00	49.3	6.8	43.75
MW-5	52.07	51.4	9.3	43.17
MW-6	46.64	46.1	4.5	42.54
MW-7	---	---	3.9	---
MW-8	---	---	4.1	---
MW-9	---	---	4.5	---
MW-10	---	---	4.3	---
MW-11	---	---	3.3	---
MW-12	---	---	4.1	---
Site No. 4				
MW-1	52.18	51.6	9.4	43.18
MW-2	51.25	50.6	9.3	43.35
MW-3	50.34	49.6	9.3	43.34
MW-4	49.50	49.4	7.4	43.46
MW-5	52.14	51.1	8.9	42.49
MW-6	44.71	43.9	9.2	41.86
MW-7	---	---	3.8	---
MW-8	---	---	3.7	---
MW-9	---	---	4.2	---
MW-10	---	---	3.9	---
MW-11	---	---	4.2	---
MW-12	---	---	3.6	---

Notes: Elevations are relative to an assumed datum, not NGVD.
Total depth is depth below ground surface.

Table 4, cont'd.

MONITOR WELL INSTALLATION DATA
FOR RESIDENTAIL SITES

Well Location	Top Elev. (feet)	Ground Elev. (feet)	Total Depth (feet)	Water Table Elev. (feet)
Site No. 5				
MW-1	53.17	53.0	9.8	44.87
MW-2	52.79	52.0	9.2	45.19
MW-3	50.17	49.3	6.7	45.13
MW-4	50.25	49.6	6.8	45.45
MW-5	54.37	49.8	10.9	44.92
MW-6	47.20	45.6	3.4	43.20
MW-7	---	---	3.5	---
MW-8	---	---	3.4	---
MW-9	---	---	3.6	---
MW-10	---	---	3.5	---
MW-11	---	---	3.2	---
MW-12	---	---	3.8	---
Site No. 6				
MW-1	53.26	51.8	8.5	45.01
MW-2	52.34	51.2	8.8	45.39
MW-3	49.16	48.0	3.8	45.86
MW-4	49.67	49.2	7.0	45.49
MW-5	54.11	52.1	8.0	45.35
MW-6	47.13	46.6	4.5	45.40
MW-7	---	---	2.3	---
MW-8	---	---	2.3	---
MW-9	---	---	2.3	---
MW-10	---	---	2.3	---
MW-11	---	---	4.0	---
MW-12	---	---	3.5	---

Notes: Elevations are relative to an assumed datum, not NGVD.
Total depth is depth below ground surface.

Table 4, cont'd.

**MONITOR WELL INSTALLATION DATA
FOR RESIDENTIAL SITES**

Well Location	Top Elev. (feet)	Ground Elev. (feet)	Total Depth (feet)	Water Table Elev. (feet)
Site No. 7				
MW-1	52.24	51.7	6.9	46.39
MW-2	51.33	50.5	6.7	46.39
MW-3	49.54	49.0	6.9	45.88
MW-4	50.51	49.5	6.5	46.00
MW-5	54.35	51.8	7.4	46.43
MW-6	49.49	48.7	6.7	45.76
MW-7	---	---	4.9	---
MW-8	---	---	5.5	---
MW-9	---	---	4.8	---
MW-10	---	---	5.7	---
MW-11	---	---	6.9	---
MW-12	---	---	6.8	---
Site No. 8				
MW-1	53.09	52.1	9.0	43.29
MW-2	52.16	51.8	9.6	---
MW-3	51.29	50.8	9.5	44.64
MW-4	51.20	50.3	9.1	44.40
MW-5	52.43	51.4	11.5	42.96
MW-6	46.43	45.4	6.5	42.18
MW-7	---	---	3.6	---
MW-8	---	---	3.3	---
MW-9	---	---	6.1	---
MW-10	---	---	5.6	---
MW-11	---	---	4.1	---
MW-12	---	---	3.8	---

Notes: Elevations are relative to an assumed datum, not NGVD.
Total depth is depth below ground surface.

Table 5

FIELD MEASUREMENTS OF WATER QUALITY INDICATORS
FOR RESIDENTIAL SITES

Well Location	Date	Temperature (degrees C)	Specific Conductance (µS/cm)	pH
Site No. 1				
MW-1	3/28/95	22.3	1166	7.14
MW-2	3/28/95	23.5	990	7.20
MW-3	3/28/95	23.2	666	7.18
MW-4	3/28/95	23.4	731	7.09
MW-5	3/28/95	22.6	1051	6.72
MW-6	3/27/95	23.3	900	6.09
MW-7	3/28/95	21.5	783	7.36
MW-8	3/28/95	22.0	758	7.38
MW-9	3/28/95	22.6	855	7.27
MW-10	3/28/95	22.9	896	7.24
MW-11	3/28/95	22.4	783	7.27
MW-12	3/28/95	22.8	700	7.11
Site No. 2				
MW-1	4/14/95	22.0	1205	6.97
MW-2	4/12/95	26.4	995	6.59
MW-3	4/12/95	23.3	809	7.38
MW-4	4/12/95	23.3	1096	7.08
MW-5	4/12/95	22.6	823	7.19
MW-6	4/14/95	22.6	1130	7.06
MW-7	4/13/95	23.8	908	7.20
MW-8	4/13/95	23.8	642	7.19
MW-9	4/13/95	22.9	787	7.10
MW-10	4/13/95	22.7	675	7.26
MW-11	4/13/95	22.8	692	7.20
MW-12	4/13/95	23.7	644	7.25

Table 5, cont'd.

FIELD MEASUREMENTS OF WATER QUALITY INDICATORS FOR RESIDENTIAL SITES

Well Location	Date	Temperature (degrees C)	Specific Conductance (µS/cm)	pH
Site No. 3				
MW-1	4/5/95	23.4	1093	7.26
MW-2	4/5/95	23.6	964	6.97
MW-3	4/5/95	23.1	633	7.05
MW-4	4/5/95	22.3	619	7.28
MW-5	4/5/95	23.4	---	7.20
MW-6	4/5/95	22.9	1183	7.32
MW-7	4/6/95	21.8	796	6.98
MW-8	4/6/95	21.8	820	7.12
MW-9	4/6/95	22.0	907	7.20
MW-10	4/6/95	22.3	1112	7.27
MW-11	4/6/95	22.2	1183	7.60
MW-12	4/6/95	22.0	1019	7.45
Site No. 4				
MW-1	4/3/95	22.5	1920	6.80
MW-2	4/3/95	22.5	832	6.48
MW-3	4/3/95	23.1	880	6.01
MW-4	4/3/95	22.8	580	6.90
MW-5	4/3/95	23.2	760	7.16
MW-6	4/3/95	22.4	884	7.25
MW-7	4/4/95	22.1	894	6.10
MW-8	4/4/95	22.1	770	6.45
MW-9	4/4/95	22.5	586	6.95
MW-10	4/4/95	21.9	574	7.10
MW-11	4/4/95	21.6	668	7.15
MW-12	4/4/95	22.2	765	7.20

Table 5, cont'd.

FIELD MEASUREMENTS OF WATER QUALITY INDICATORS
FOR RESIDENTIAL SITES

Well Location	Date	Temperature (degrees C)	Specific Conductance (µS/cm)	pH
Site No. 5				
MW-1	4/10/95	25.0	824	6.76
MW-2	4/10/95	23.0	835	7.19
MW-3	4/10/95	23.0	1167	7.16
MW-4	4/10/95	22.0	586	7.23
MW-5	4/10/95	23.5	922	6.65
MW-6	4/10/95	22.0	839	7.59
MW-7	4/11/95	23.6	960	7.85
MW-8	4/11/95	24.7	900	7.70
MW-9	4/11/95	23.5	900	7.64
MW-10	4/11/95	24.5	867	7.60
MW-11	4/11/95	23.4	793	7.34
MW-12	4/11/95	24.0	774	7.14
Site No. 6				
MW-1	3/30/95	22.7	178	5.12
MW-2	3/30/95	22.1	425	5.15
MW-3	3/30/95	22.3	189	4.80
MW-4	3/30/95	22.3	188	3.94
MW-5	3/30/95	22.7	430	4.53
MW-6	3/30/95	22.8	217	5.06
MW-7	3/30/95	23.6	230	5.50
MW-8	3/30/95	23.5	480	5.47
MW-9	3/30/95	23.1	585	5.30
MW-10	3/30/95	22.8	246	5.15
MW-11	3/30/95	22.5	210	4.92
MW-12	3/30/95	22.1	207	4.82

Table 5, cont'd.

FIELD MEASUREMENTS OF WATER QUALITY INDICATORS FOR RESIDENTIAL SITES

Well Location	Date	Temperature (degrees C)	Specific Conductance (μS/cm)	pH
Site No. 7				
MW-1	4/17/95	25.2	1181	5.61
MW-2	4/17/95	24.4	1345	6.37
MW-3	4/1795	24.1	945	6.23
MW-4	4/17/95	25.0	505	6.22
MW-5	4/17/95	23.6	730	6.28
MW-6	4/17/95	23.4	649	6.48
MW-7	4/18/95	23.6	553	5.67
MW-8	4/18/95	23.6	557	6.27
MW-9	4/18/95	24.0	740	6.38
MW-10	4/18/95	23.9	870	6.53
MW-11	4/18/95	23.7	1101	6.71
MW-12	4/18/95	23.8	864	6.77
Site No. 8				
MW-1	4/19/95	25.1	300	5.10
MW-2	4/19/95	24.8	550	5.22
MW-3	4/19/95	23.7	480	5.96
MW-4	4/19/95	24.5	62	5.88
MW-5	4/20/95	24.0	324	5.07
MW-6	4/20/95	23.2	376	4.86
MW-7	4/20/95	22.8	174	5.70
MW-8	4/20/95	23.1	156	4.88
MW-9	4/20/95	23.2	248	4.78
MW-10	4/20/95	23.0	127	4.70
MW-11	4/20/95	22.8	134	4.72
MW-12	4/20/95	22.8	114	4.93

Table 6

GROUNDWATER FLOW GRADIENT FROM ON-SITE SEWAGE DISPOSAL SYSTEM TO CANAL

Site No.	* Max. Hydraulic Head Difference (feet)	** Range of Hydraulic Gradient (foot/foot)	*** Average Hydraulic Gradient (foot/foot)
1	1.35	0.0074 to 0.0105	0.0083
2	0.53	-0.0034 to 0.0018	-----
3	1.36	0.0069 to 0.0167	0.0103
4	1.95	0.0089 to 0.0400	0.0126
5	2.84	0.0034 to 0.0400	0.0193
6	0.85	-0.0080 to 0.0129	-----
7	0.67	-0.0011 to 0.0120	-----
8	2.91	0.0069 to 0.0500	0.0172

* Maximum hydraulic head difference between any two water level measurements at monitor wells and canal.

** Negative value indicates gradient from canal to OSD system.

*** No value given if flow direction is not towards canal for full distance between OSD system and canal.

Table 7

PIEZOMETER INSTALLATION DATA
FOR EASTPORT W.W.T.P. SITE

Piezometer No.	Top of Casing Elev. (feet, NGVD)	Ground Surface Elev. (feet, NGVD)	Depth of Collection Zone (feet)
HP-1	11.6	8.6	28.5 - 37.5
HP-2	10.2	7.2	10.5 - 19.5
HP-3	8.4	5.4	20.0 - 29.0

Note: Depth of collection zone listed as depth below ground surface.

Table 8

FIELD MEASUREMENTS OF WATER QUALITY INDICATOR PARAMETERS AT EASTPORT W.W.T.P. SITE

Date	Location	Temperature (degrees C)	Specific Conductance (μS/cm)	pH
8/3 to 8/4/94	Pond	28.2	238	5.97
	HP-1	23.8	978	6.14
	HP-2	25.2	257	5.52
	HP-3	23.7	486	6.03
9/9/94	Pond	---	---	---
	HP-1	23.6	925	6.18
	HP-2	25.3	566	7.64
	HP-3	23.8	469	6.30
11/4/94	Pond	27.8	703	6.30
	HP-1	24.1	961	6.13
	HP-2	24.6	649	5.97
	HP-3	23.2	485	6.29
12/19/94	Pond*	19.5	788	7.35
	HP-1	22.2	977	6.42
	HP-2	23.2	750	6.19
	HP-3	21.7	497	6.36

* Pond has been removed, sample from taken from 2' deep ditch at approx. same location.

Table 9

WATER LEVELS AND HYDRAULIC GRADIENTS AT EASTPORT W.W.T.P. SITE

Date	Location	Water Table Depth (feet)	Water Table Elevation (feet, NGVD)	Hydraulic Gradient (foot/foot)
8/3 to 8/4/94	HP-1	5.45	6.2	-----
	HP-2	5.40	4.8	0.0027
	HP-3	4.65	3.8	0.0020
9/9/94	HP-1	4.90	6.7	-----
	HP-2	5.25	5.0	0.0033
	HP-3	4.13	4.3	0.0014
11/4/94	HP-1	5.51	6.1	-----
	HP-2	6.01	4.2	0.0037
	HP-3	5.04	3.4	0.0016
12/19/94	HP-1	6.18	5.4	-----
	HP-2	6.50	3.7	0.0033
	HP-3	5.47	2.9	0.0016

Note: Water table depth is listed as depth below top of casing.

APPENDIX II

LABORATORY CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES FROM RESIDENTIAL SITES

WELL	SIT	DATE	NH4N	NO23N	TKN	Tot-N	TOT-P	TEMP	COND	pH
	LAB	04/17/95	<0.005	0.006	<0.05		0.07			
	2	04/12/95	<0.005	0.019	<0.05		0.05			
	5	04/10/95	<0.005	<0.005	<0.05		<0.05			
	3	04/05/95	0.006	<0.005	0.06		<0.05			
	7	04/17/95	0.006	<0.005	<0.05		0.07			
	4	04/03/95	0.005	<0.005	<0.05		0.31			
	8	04/19/95	0.007	<0.005	<0.05		*<0.05			
	6	03/30/95	0.014	<0.005	<0.05		<0.05			
	1	03/27/95	<0.005	<0.005	<0.05		<0.05			
1	1	03/28/95	0.180	4.674	8.27	12.94	13.31	22.30	1166	7.14
2	1	03/28/95	0.256	1.704	9.96	11.66	26.18	23.50	990	7.20
3	1	03/28/95	0.177	0.046	12.44	12.49	35.85	23.20	666	7.18
4	1	03/28/95	0.109	0.006	0.70	0.71	0.81	23.40	731	7.09
5	1	03/28/95	0.042	0.011	1.98	1.99	2.85	22.60	1051	6.72
6	1	03/27/95	0.086	0.006	2.20	2.21	3.10	23.30	900	6.09
7	1	03/28/95	0.076	0.006	10.30	10.31	15.35	21.50	783	7.36
8	1	03/28/95	0.070	0.005	2.53	2.54	3.10	22.00	758	7.38
9	1	03/28/95	0.072	0.005	5.66	5.67	9.12	22.60	855	7.27
10	1	03/28/95	0.097	0.005	12.80	12.81	45.93	22.90	896	7.24
11	1	03/28/95	0.087	0.005	10.00	10.01	32.22			
11	1	03/28/95	0.085	0.005	6.12	6.13	26.20	22.40	783	7.27
12	1	03/28/95	0.291	0.005	6.08	6.09	25.44	22.80	700	7.11
1	2	04/14/95	0.928	0.107	7.68	7.79	57.34	22.00	1205	6.97
2	2	04/12/95	0.061	0.029	5.99	6.02	13.75	26.40	995	6.59
3	2	04/12/95	0.776	0.089	24.06	24.15	300.11	23.30	809	7.38
4	2	04/12/95	0.339	0.022	9.21	9.23	168.73	23.30	1096	7.08
5	2	04/12/95	0.242	0.038	6.57	6.61	69.62	22.60	823	7.19
6	2	04/14/95	0.083	0.105	15.52	15.63	20.82	22.60	1130	7.06
7	2	04/13/95	0.124	0.017	14.47	14.49	9.95	23.80	908	7.20
8	2	04/13/95	0.083	0.005	11.43	11.44	11.67	23.80	642	7.19
9	2	04/13/95	0.162	0.016	9.46	9.48	23.66	22.90	787	7.10
10	2	04/13/95	0.070	0.017	4.37	4.39	7.01	22.70	675	7.26
10	2	04/13/95	0.071	0.008	4.61	4.62	10.07			
11	2	04/13/95	0.045	0.005	5.23	5.24	9.60	22.80	692	7.20
12	2	04/13/95	0.079	0.020	9.45	9.47	18.02	23.70	644	7.25
1	3	04/05/95	3.516	0.071	8.30	8.37	18.00	23.40	1093	7.26
2	3	04/05/95	0.171	0.254	2.89	3.14	17.29	23.60	964	6.97
3	3	04/05/95	0.029	0.028	3.74	3.77	32.50	23.10	633	7.05
4	3	04/05/95	0.005	0.015	1.35	1.37	22.75	22.30	619	7.28
5	3	04/05/95	0.015	0.022	3.82	3.84	47.91	23.40		7.20
6	3	04/05/95	0.023	<0.005	3.99	3.99	42.96	22.90	1183	7.32
7	3	04/06/95	0.020	0.016	2.46	2.48	32.55	21.80	796	6.98
8	3	04/06/95	0.018	0.030	2.38	2.41	12.60	21.80	820	7.12

LABORATORY CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES
FROM RESIDENTIAL SITES

WELL	SIT	DATE	NH4N	NO23N	TKN	Tot-N	TOT-P	TEMP	COND	pH
8	3	04/06/95	0.012	0.018	2.27	2.29	13.50			
9	3	04/06/95	0.033	0.092	2.79	2.88	20.35	22.00	907	7.20
10	3	04/06/95	0.015	0.124	1.66	1.78	11.23	22.30	1112	7.27
11	3	04/06/95	0.358	0.059	3.18	3.24	8.63	22.20	1183	7.60
12	3	04/06/95	0.017	0.017	1.71	1.73	9.73	22.00	1019	7.45
1	4	04/03/95	2.547	2.252	6.78	9.03	36.62	22.50	1920	6.80
2	4	04/03/95	<0.005	0.046	5.87	5.92	31.52	22.50	832	6.48
3	4	04/03/95	0.008	0.385	2.82	3.21	26.19	23.10	880	6.01
4	4	04/03/95	0.052	0.026	8.51	8.54	70.30	22.80	580	6.90
5	4	04/03/95	0.093	0.158	8.60	8.76	86.22	23.20	760	7.16
6	4	04/03/95	0.039	0.015	9.71	9.73	26.34	22.40	884	7.25
7	4	04/04/95	0.007	0.124	4.28	4.40	18.86	22.10	894	6.10
8	4	04/04/95	0.009	<0.005	4.55	4.55	26.32			
8	4	04/04/95	0.013	<0.005	4.43	4.43	21.48	22.10	770	6.45
9	4	04/04/95	0.027	<0.005	3.05	3.05	23.33	22.50	586	6.95
10	4	04/04/95	0.009	<0.005	8.14	8.14	10.17	21.90	574	7.10
11	4	04/04/95	<0.005	<0.005	4.46	4.46	5.18	21.60	668	7.15
12	4	04/04/95	<0.005	0.022	4.26	4.28	23.09	22.20	765	7.20
1	5	04/10/95	0.040	0.186	3.21	3.40	14.54	25.00	824	6.76
2	5	04/10/95	<0.005	0.025	0.87	0.90	2.22	23.00	835	7.19
3	5	04/10/95	0.005	<0.005	2.94	2.94	20.89	23.00	1167	7.16
4	5	04/10/95	0.037	0.045	3.48	3.53	12.20	22.00	586	7.23
5	5	04/10/95	<0.005	1.009	1.77	2.78	8.90	23.50	922	6.65
6	5	04/10/95	0.147	0.056	16.57	16.63	23.13	22.00	839	7.59
7	5	04/11/95	0.043	0.036	1.90	1.94	8.80	23.60	960	7.85
8	5	04/11/95	0.086	0.428	1.67	2.10	8.75	24.70	900	7.70
9	5	04/11/95	0.062	0.270	3.78	4.05	9.99	23.50	900	7.64
10	5	04/11/95	0.092	0.068	5.33	5.40	21.06	24.50	867	7.60
11	5	04/11/95	0.111	0.021	3.44	3.46	8.89	23.40	793	7.34
12	5	04/11/95	0.036	0.040	4.43	4.47	16.23	24.00	774	7.14
12	5	04/11/95	0.035	0.019	5.20	5.22	14.28			
1	6	03/30/95	1.346	0.005	37.17	37.18	34.46	22.70	178	5.12
2	6	03/30/95	0.265	0.006	30.03	30.04	21.61	22.10	425	5.15
3	6	03/30/95	0.675	<0.005	36.78	36.78	17.30	22.30	189	4.80
4	6	03/30/95	0.375	<0.005	18.18	18.18	14.02	22.30	188	3.94
5	6	03/30/95	2.488	0.008	21.26	21.27	27.99	22.70	430	4.53
6	6	03/30/95	0.653	0.005	27.66	27.67	14.18	22.80	217	5.06
7	6	03/30/95	0.331	<0.005	12.95	12.95	4.67	23.60	230	5.50
8	6	03/30/95	0.067	<0.005	2.10	2.10	0.33	23.50	480	5.47
9	6	03/30/95	0.093	<0.005	9.09	9.09	4.42	23.10	585	5.30
10	6	03/30/95	0.081	<0.005	10.40	10.40	4.00	22.80	246	5.15
11	6	03/30/95	0.110	<0.005	6.42	6.42	2.87	22.50	210	4.92
12	6	03/30/95	1.542	<0.005	11.21	11.21	5.63			

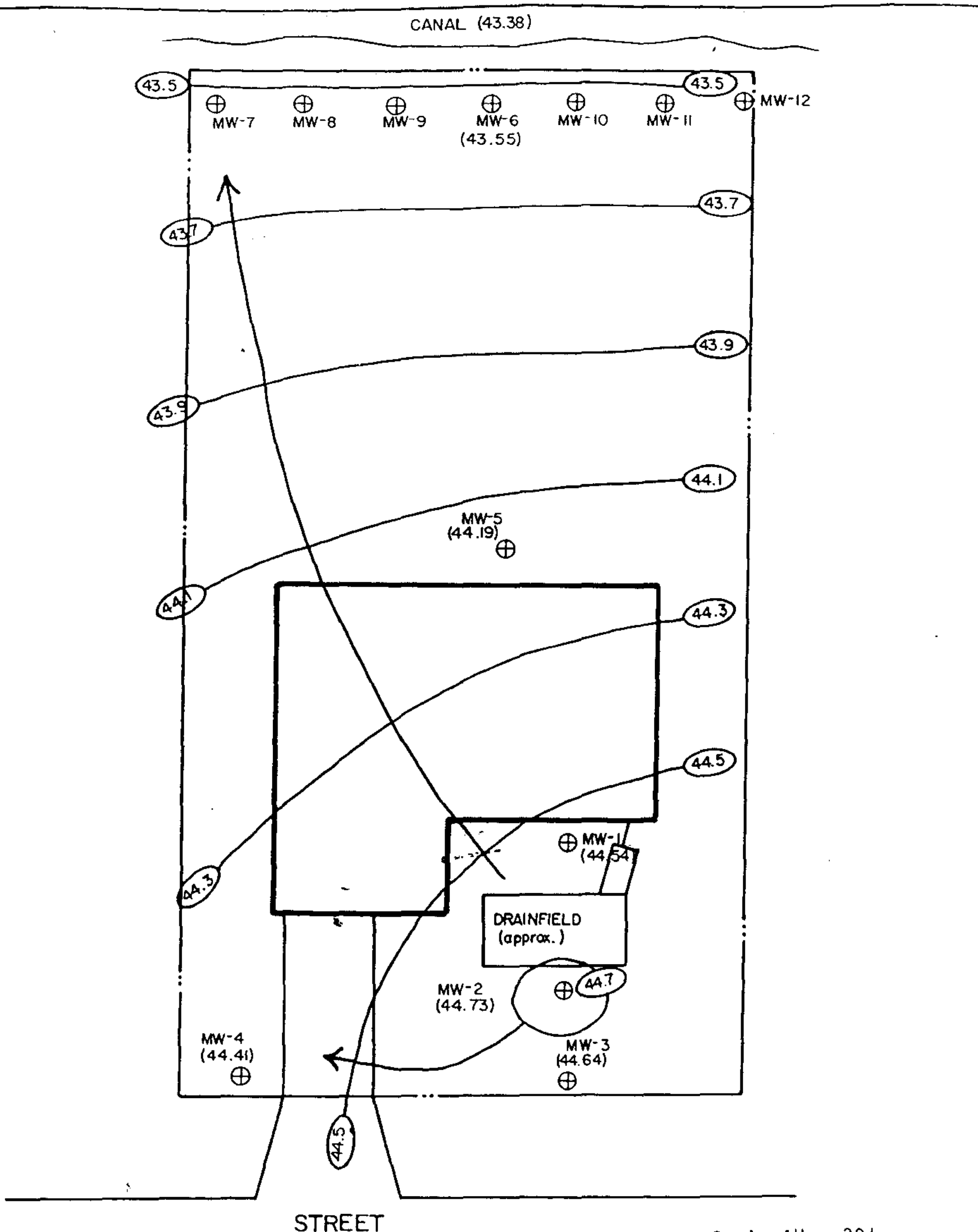
LABORATORY CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES
FROM RESIDENTIAL SITES

WELL	SIT	DATE	NH4N	NO23N	TKN	Tot-N	TOT-P	TEMP	COND	pH
12	6	03/30/95	1.528	<0.005	10.94	10.94	5.27	22.10	207	4.82
1	7	04/17/95	35.820	0.121	41.60	41.72	19.14	25.20	1181	5.61
2	7	04/17/95	47.776	0.035	59.13	59.17	23.10	24.40	1345	6.37
3	7	04/17/95	7.219	0.023	12.53	12.55	18.21	24.10	945	6.23
4	7	04/17/95	1.192	0.019	12.21	12.23	43.98	25.00	505	6.22
5	7	04/17/95	10.002	0.056	33.10	33.16	23.03	23.60	730	6.28
6	7	04/17/95	0.145	0.020	3.51	3.53	26.11	23.40	649	6.48
7	7	04/18/95	0.166	0.020	2.78	2.80	11.98	23.60	553	5.67
8	7	04/18/95	0.156	0.021	3.97	3.99	21.52	23.60	557	6.27
8	7	04/18/95	0.159	0.016	4.27	4.29	23.32			
9	7	04/18/95	0.112	0.106	18.71	18.82	1.43	24.00	740	6.38
10	7	04/18/95	0.015	0.240	6.01	6.25	7.88	23.90	870	6.53
11	7	04/18/95	0.104	0.037	10.88	10.92	38.36	23.70	1101	6.71
12	7	04/18/95	0.075	0.048	9.61	9.66	16.74	23.80	864	6.77
1	8	04/19/95	14.191	0.105	36.79	36.90	36.50	25.10	300	5.10
2	8	04/19/95	23.511	0.151	71.54	71.69	57.83	24.80	550	5.22
3	8	04/19/95	0.959	0.135	20.84	20.98	49.12	23.70	480	5.96
4	8	04/19/95	0.385	0.085	37.32	37.41	67.13	24.50	62	5.88
5	8	04/20/95	14.144	0.110	42.98	43.09	60.85	24.00	324	5.07
6	8	04/20/95	3.351	0.026	11.90	11.93	13.34	23.20	376	4.86
7	8	04/20/95	0.674	0.019	15.74	15.76	*10.48	22.80	174	5.70
8	8	04/20/95	0.740	0.027	8.51	8.54	5.16	23.10	156	4.88
8	8	04/20/95	0.797	0.015	7.56	7.58	*5.60			
9	8	04/20/95	1.435	0.038	9.59	9.63	*6.58	23.20	248	4.78
10	8	04/20/95	2.864	0.030	28.99	29.02	18.76	23.00	127	4.70
11	8	04/20/95	0.525	0.027	9.77	9.80	9.51	22.80	134	4.72
12	8	04/20/95	0.646	0.049	31.91	31.96	16.70	22.80	114	4.93

* Analyzed after standard holding time.

Eastport WWTP Water Quality Results

Station	Date	NO2+3- (mg/l)	NH4-N (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)
Lab Blank	08/02/94	<0.005	<0.005	<0.05	<0.05	0.17
Field Blank	08/04/94	<0.005	0.010	<0.05	<0.05	0.14
Field Blank	09/09/94	<0.005	<0.005	<0.05	<0.05	<0.05
Field Blank	11/04/94	<0.005	<0.005	<0.05	<0.05	<0.05
Field Blank	12/19/94	<0.005	0.008	<0.05	<0.05	<0.05
Pond	08/04/94	<0.005	<0.005	3.70	3.70	4.43
HP-1	08/03/94	0.055	0.302	1.51	1.57	3.61
HP-2	08/04/94	0.029	0.049	2.43	2.46	8.93
HP-3	08/04/94	0.042	0.186	0.87	0.91	3.49
Pond	09/09/94	<0.005	0.040	1.96	1.96	3.88
HP-1	09/09/94	0.012	0.320	2.02	2.03	5.04
HP-2	09/09/94	<0.005	0.142	4.77	4.77	30.30
HP-3	09/09/94	0.014	0.222	1.90	1.91	13.25
Pond	11/04/94	<0.005	0.028	1.50	1.50	1.39
HP-1	11/04/94	0.014	0.382	1.59	1.60	2.23
HP-2	11/04/94	<0.005	0.373	1.12	1.12	5.66
HP-3	11/04/94	<0.005	0.329	0.68	0.68	2.50
Pond	12/19/94	0.019	0.690	4.60	4.62	2.48
HP-1	12/19/94	0.011	0.445	1.83	1.84	4.99
HP-2	12/19/94	0.010	0.342	1.42	1.43	4.63
HP-3	12/19/94	<0.005	0.295	0.76	0.76	2.94



Scale 1'' = 20'

℄ T.B.M. ASSUMED el. 50.00'

⊕ TEMPORARY MONITOR WELL LOCATIONS

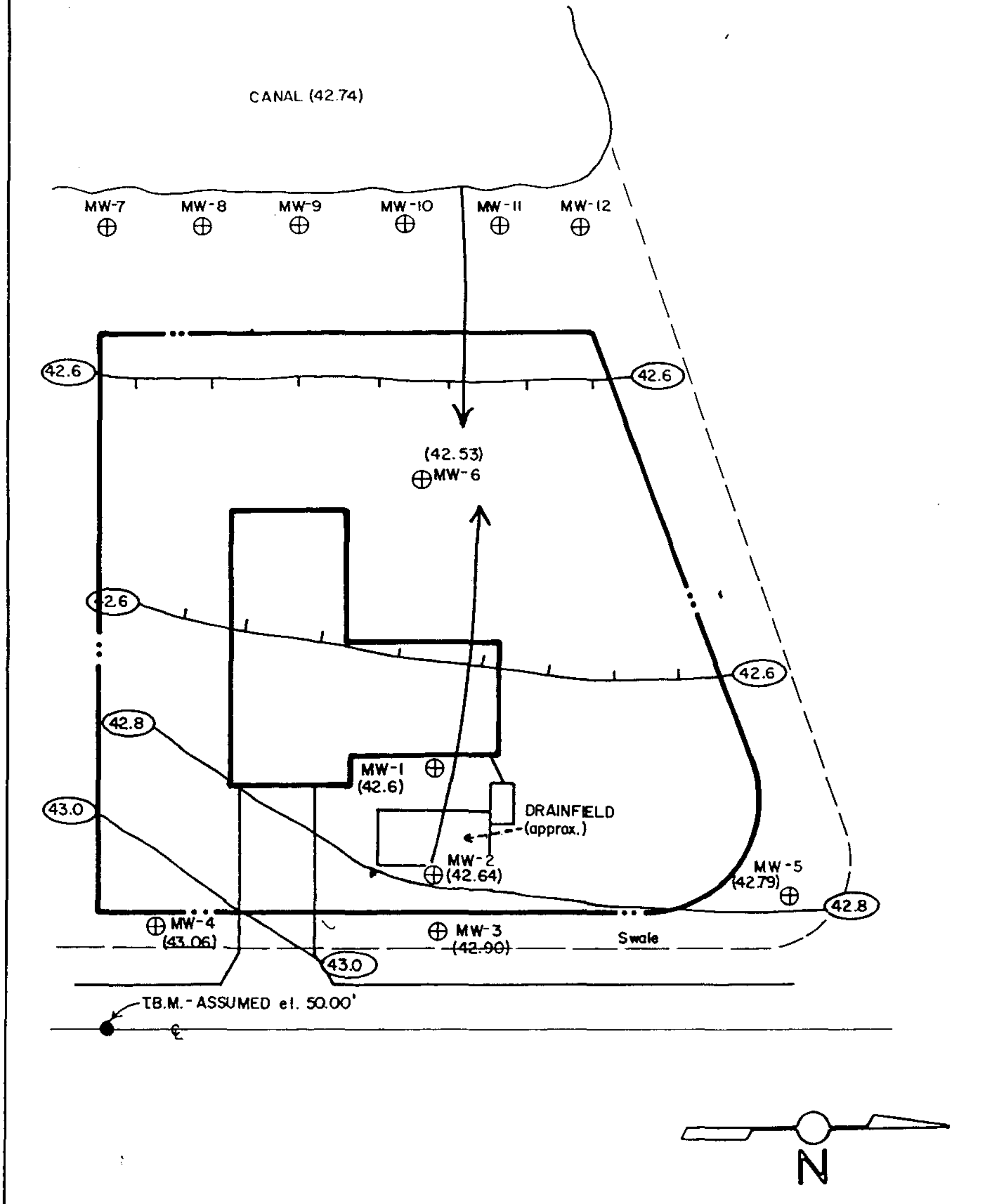
(##.##) EXISTING WATER TABLE ELEVATION (feet)

(##.#)—(##.#) WATER TABLE EQUIPOTENTIAL LINE (feet)

← GROUNDWATER FLOW DIRECTION

Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants			
TEST LOCATIONS FOR SITE No. 1 CHARLOTTE COUNTY, FLORIDA			
DRAWN BY TV	CHECKED BY		DATE 6/26/95
FILE NO 94-8583	APPROVED BY [signature]		FIGURE 1

1422684



⊕ TEMPORARY MONITOR WELL LOCATIONS

(##.##) EXISTING WATER TABLE ELEVATIONS (feet)

(##.#)~(##.#) WATER TABLE EQUIPOTENTIAL LINE (feet)

← GROUNDWATER FLOW DIRECTION

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

TEST LOCATIONS FOR
SITE No. 2
CHARLOTEE COUNTY, FLORIDA

DRAWN BY	CHECKED BY	DATE
TV		6/26/95

FILE NO.	APPROVED BY	FIGURE
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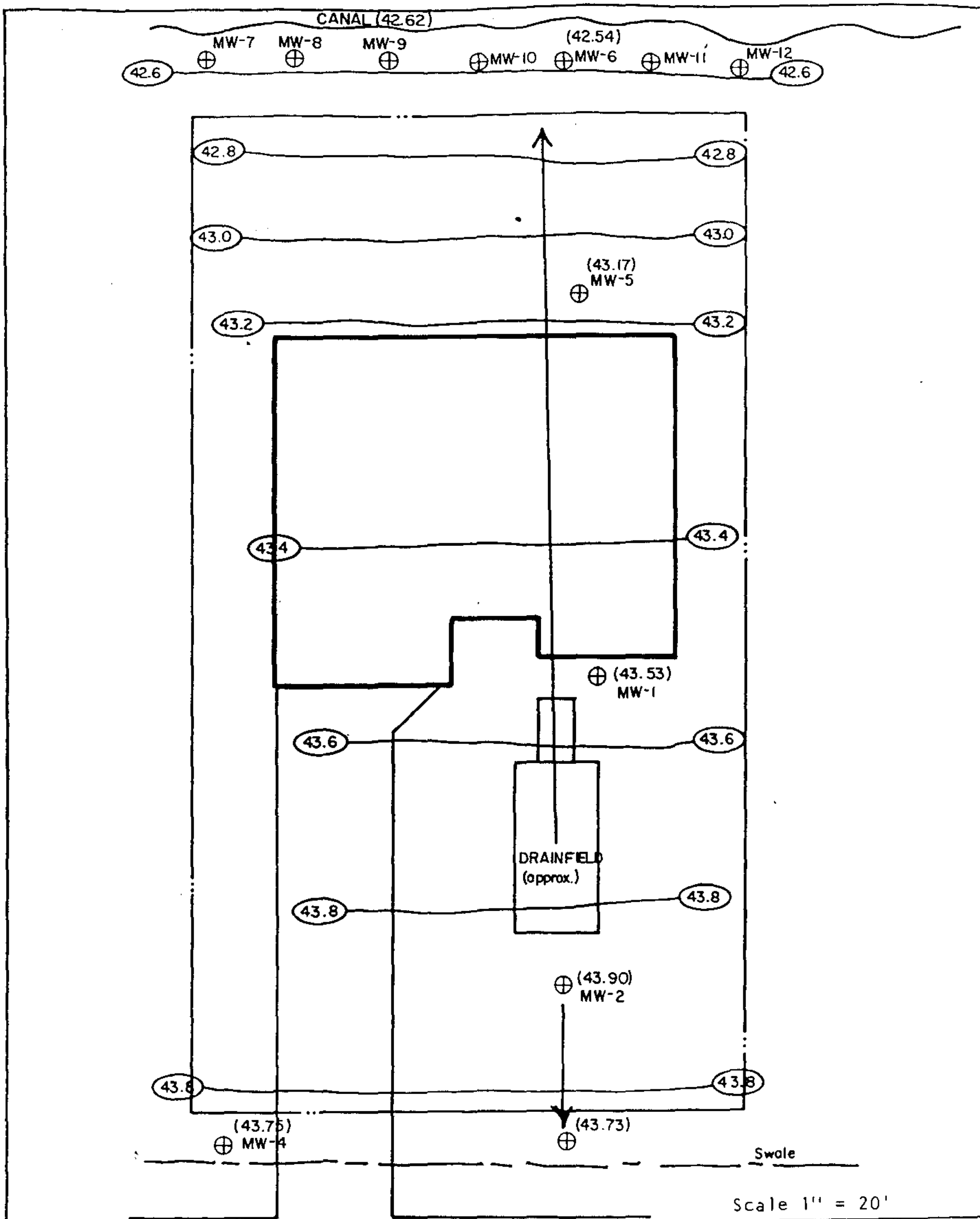
422684



Scale 1'' = 20'

T.B.M. ASSUMED el. 50.00'

⊕	TEMPORARY MONITOR WELL LOCATIONS
(##.##)	EXISTING WATER TABLE ELEVATION (feet)
##.# ~ ##.#	WATER TABLE EQUIPOTENTIAL LINE (feet)
←	GROUNDWATER FLOW DIRECTION

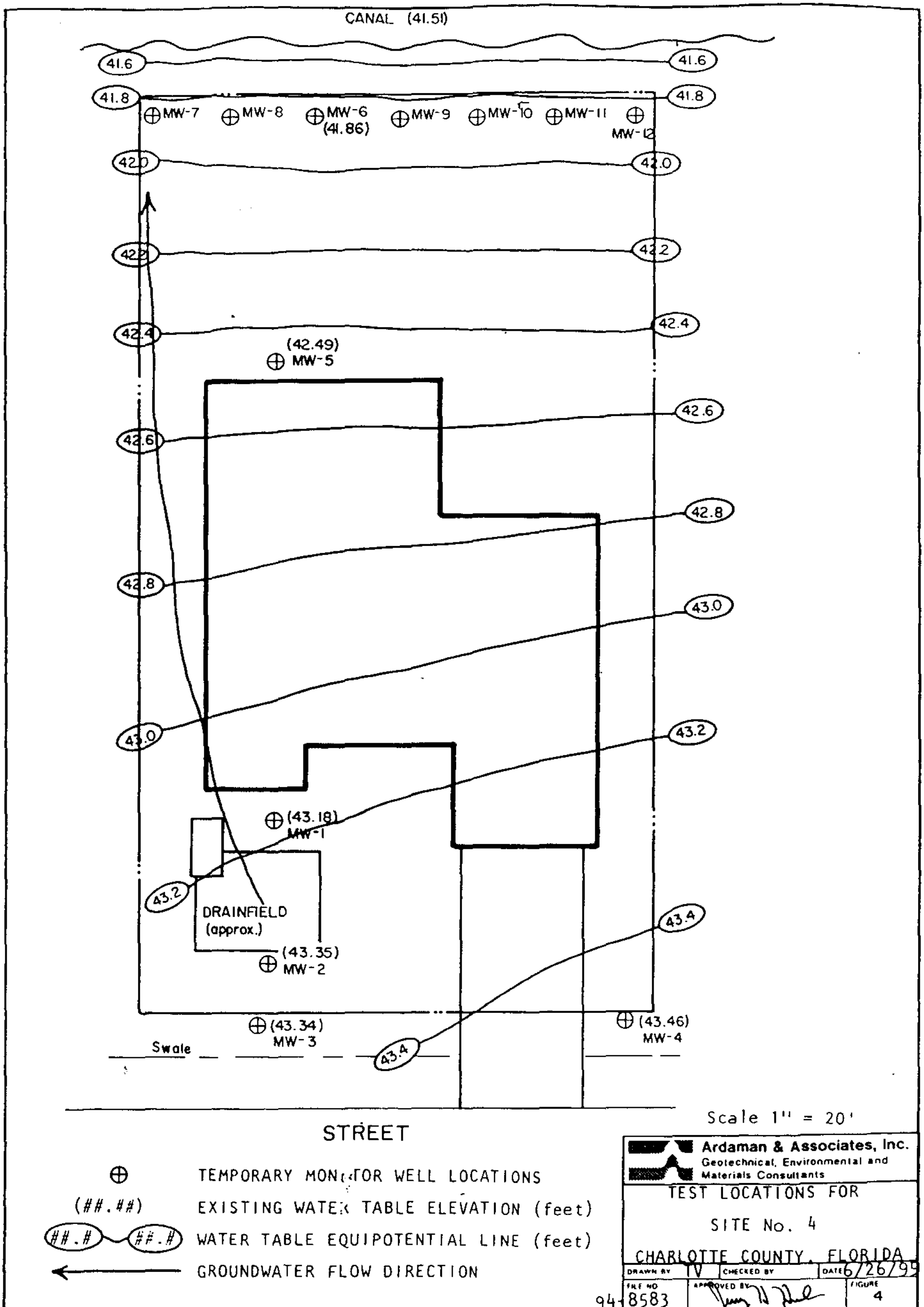
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

TEST LOCATIONS FOR
SITE No. 3
CHARLOTTE COUNTY, FLORIDA

DRAWN BY	CHECKED BY	DATE
TV		6/26/9

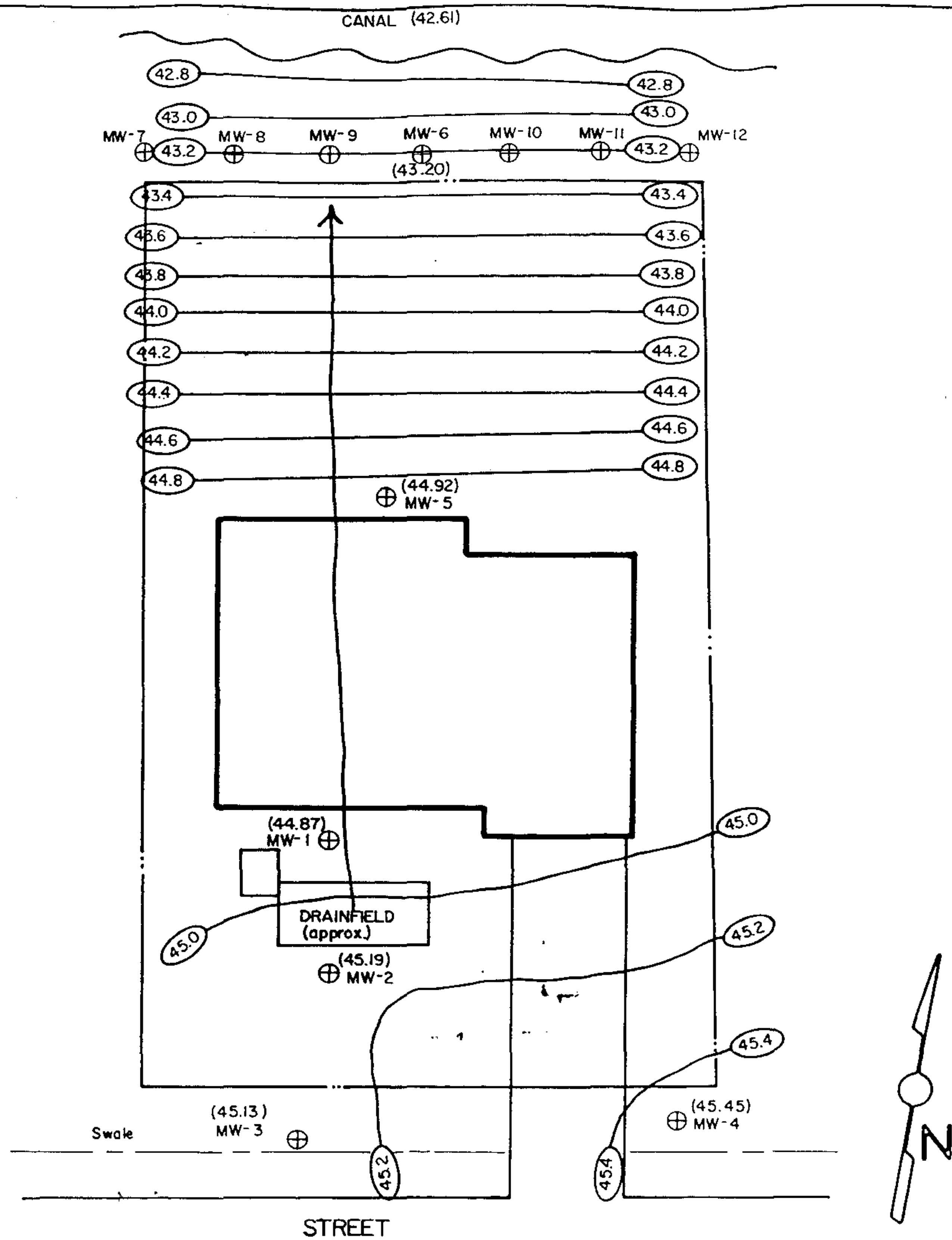
FILE NO	APPROVED BY	FIGURE
94-8583		3

422684



CANAL (41.51)
41.6
41.6
41.8
41.8
MW-7
MW-8
MW-6
(41.86)
MW-9
MW-10
MW-11
MW-12
42.0
42.0
42.2
42.2
42.4
42.4
(42.49)
MW-5
42.6
42.6
42.8
42.8
43.0
43.0
43.2
43.2
(43.18)
MW-1
DRAINFIELD
(approx.)
(43.35)
MW-2
43.4
43.4
(43.34)
MW-3
(43.46)
MW-4
Swale
STREET
Scale 1" = 20'
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet)
##.# ##.# WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 4
CHARLOTTE COUNTY, FLORIDA
DRAWN BY TV
CHECKED BY
DATE 6/26/95
FILE NO 94-8583
APPROVED BY
FIGURE 4

122684



Scale 1'' = 20'

T.B.M. ASSUMED el. 50.00

⊕	TEMPORARY MONITOR WELL LOCATIONS
(##.##)	EXISTING WATER TABLE ELEVATION (feet)
##.# ~ ##.#	WATER TABLE EQUIPOTENTIAL LINE (feet)
←	GROUNDWATER FLOW DIRECTION

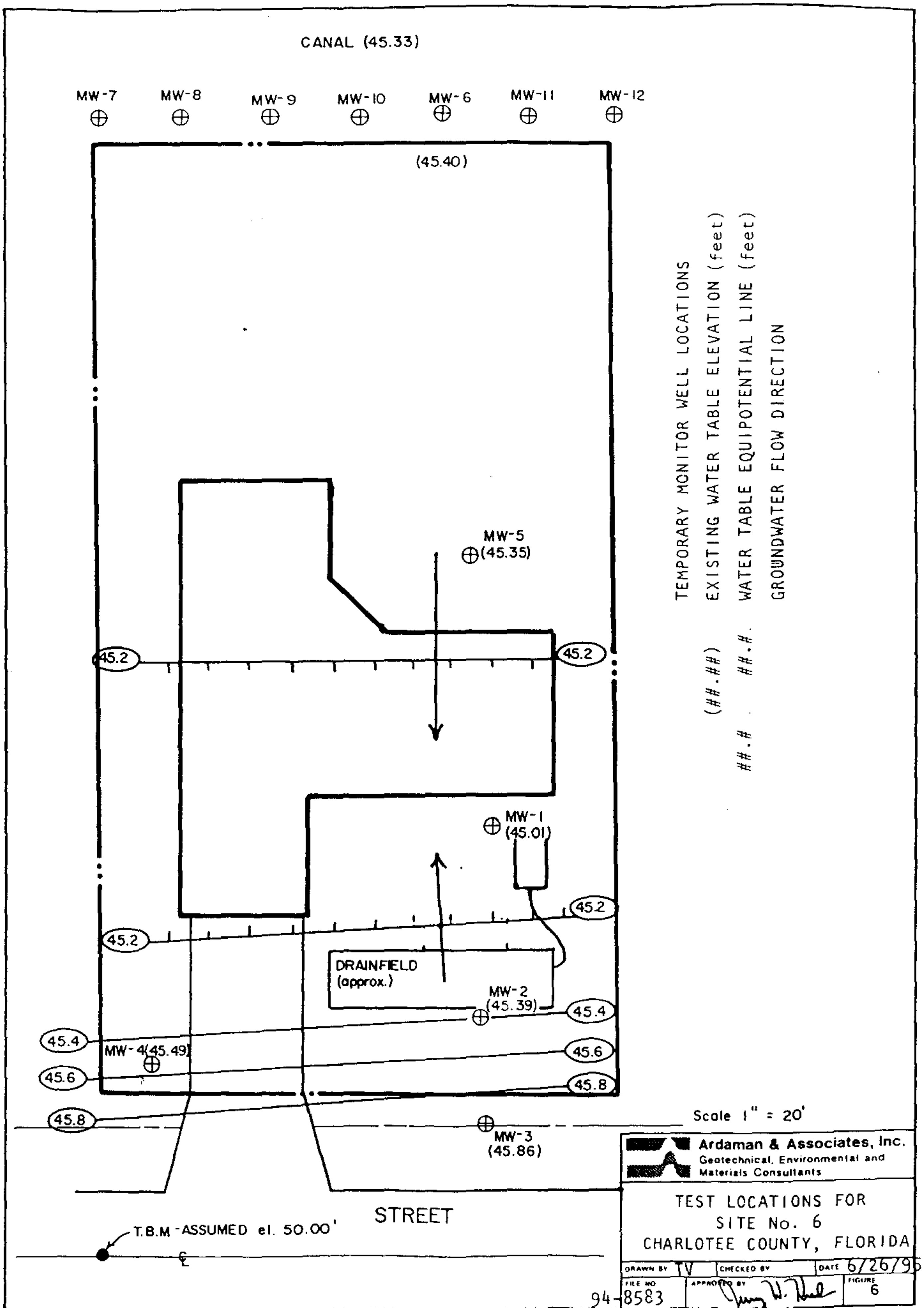
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

TEST LOCATIONS FOR
SITE No. 5
CHARLOTTE COUNTY, FLORIDA

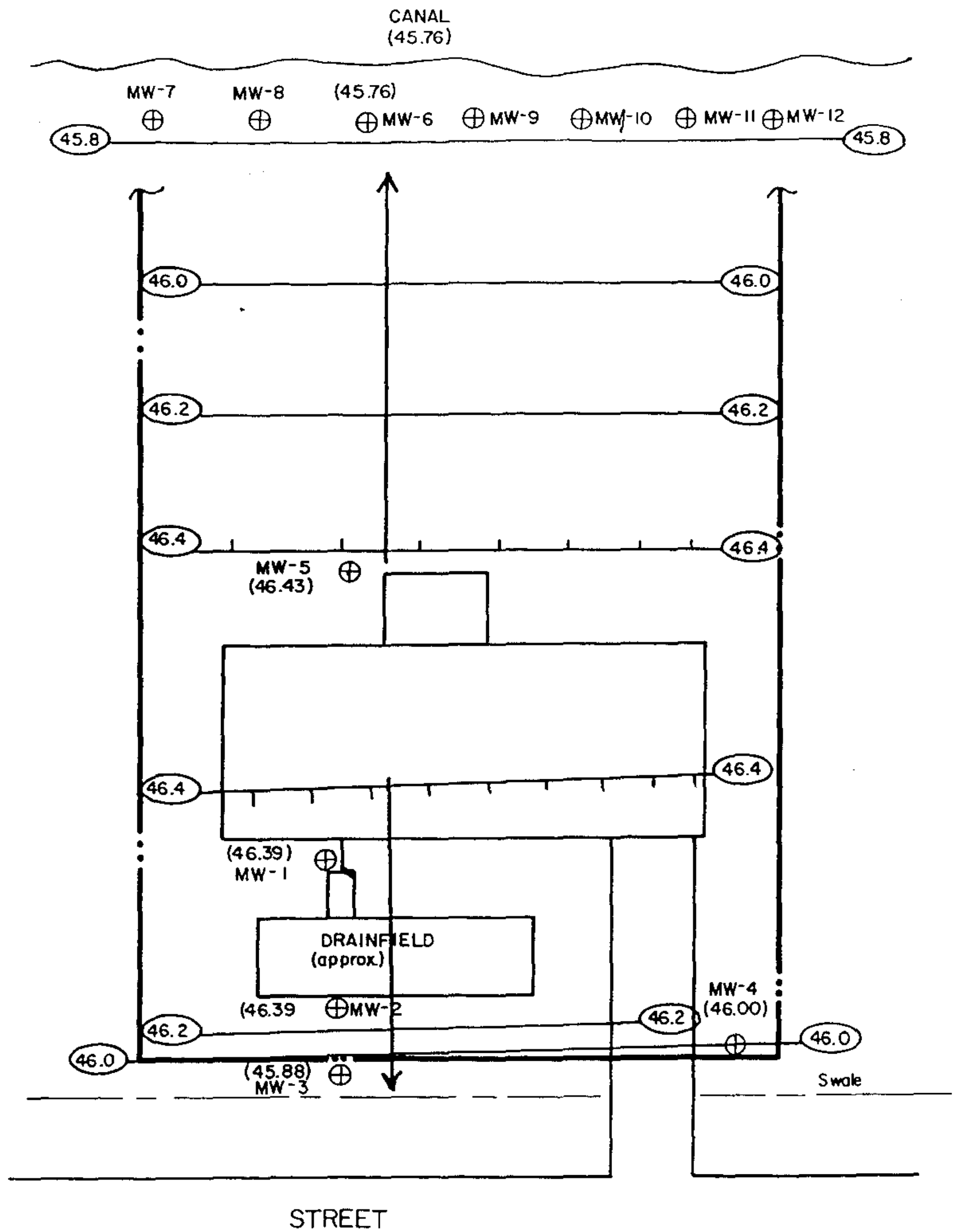
DRAWN BY	CHECKED BY	DATE
TV		6/26/95

FILE NO	APPROVED BY	FIGURE
94-8583	[signature]	5

122684



CANAL (45.33)
MW-7
MW-8
MW-9
MW-10
MW-6
MW-11
MW-12
(45.40)
MW-5 (45.35)
MW-1 (45.01)
45.2
DRAINFIELD (approx.)
MW-2 (45.39)
45.4
MW-4 (45.49)
45.6
45.8
MW-3 (45.86)
STREET
T.B.M - ASSUMED el. 50.00'
Scale 1" = 20'
TEMPORARY MONITOR WELL LOCATIONS
(##.##) EXISTING WATER TABLE ELEVATION (feet)
##.# WATER TABLE EQUIPOTENTIAL LINE (feet)
GROUNDWATER FLOW DIRECTION
Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants
TEST LOCATIONS FOR
SITE No. 6
CHARLOTEE COUNTY, FLORIDA
DRAWN BY TV
CHECKED BY
DATE 6/26/95
FILE NO 94-8583
APPROVED BY
FIGURE 6



Scale 1" = 20'

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

⊕ TEMPORARY MONITOR WELL LOCATIONS

(##.##) EXISTING WATER TABLE ELEVATION (feet)

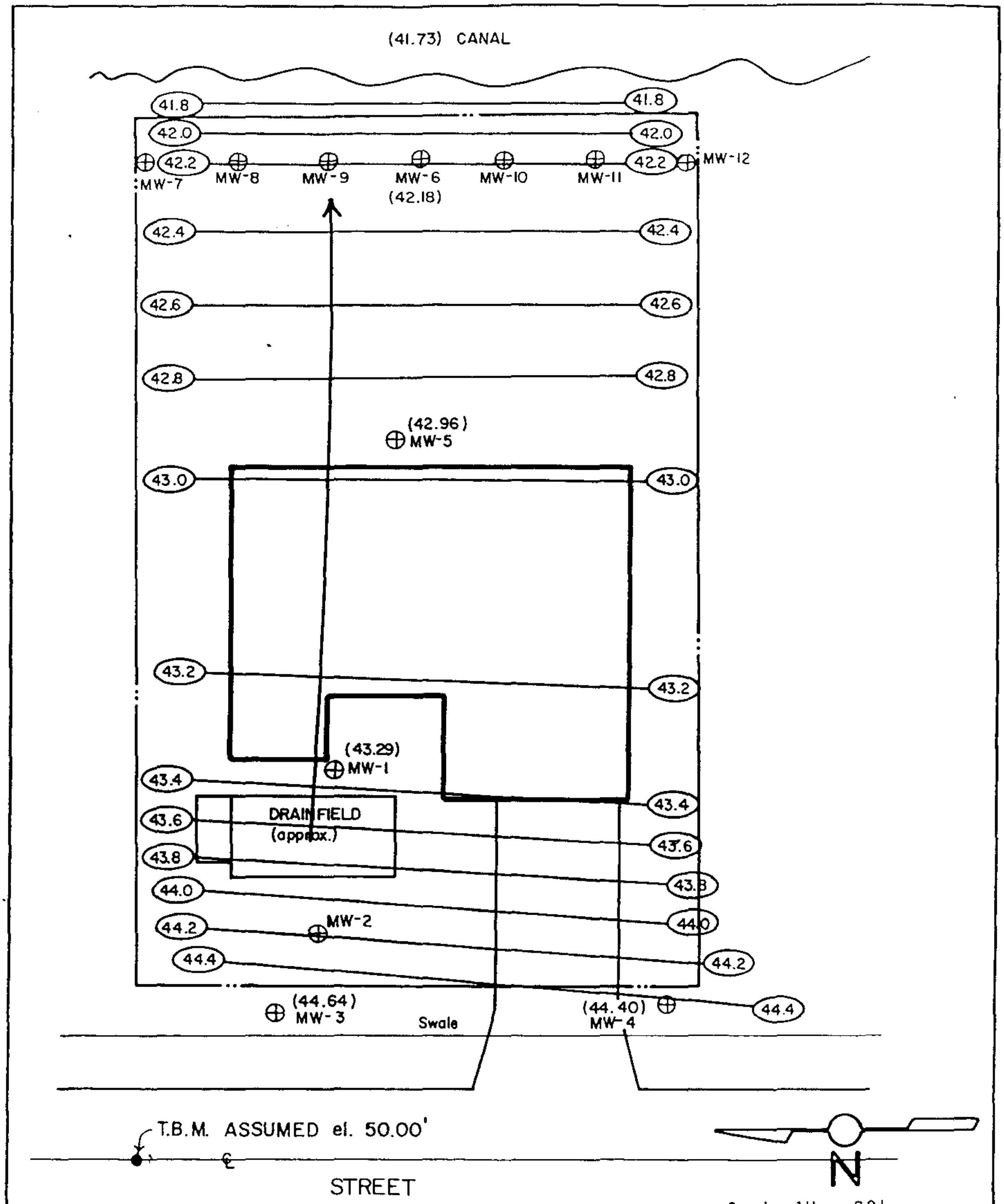
(##.#)~(##.#) WATER TABLE EQUIPOTENTIAL LINE (feet)

← GROUNDWATER FLOW DIRECTION

TEST LOCATIONS FOR
SITE No. 7
CHARLOTTE COUNTY, FLORIDA

DRAWN BY	CHECKED BY	DATE	FIGURE
TV		6/26/95	7
FILE NO 94-8583	APPROVED BY [signature]		

122684



Scale 1" = 20'

⊕ TEMPORARY MONITOR WELL LOCATIONS

(##.#) EXISTING WATER TABLE ELEVATION (feet)

(##.#)~(##.#) WATER TABLE EQUIPOTENTIAL LINE (feet)

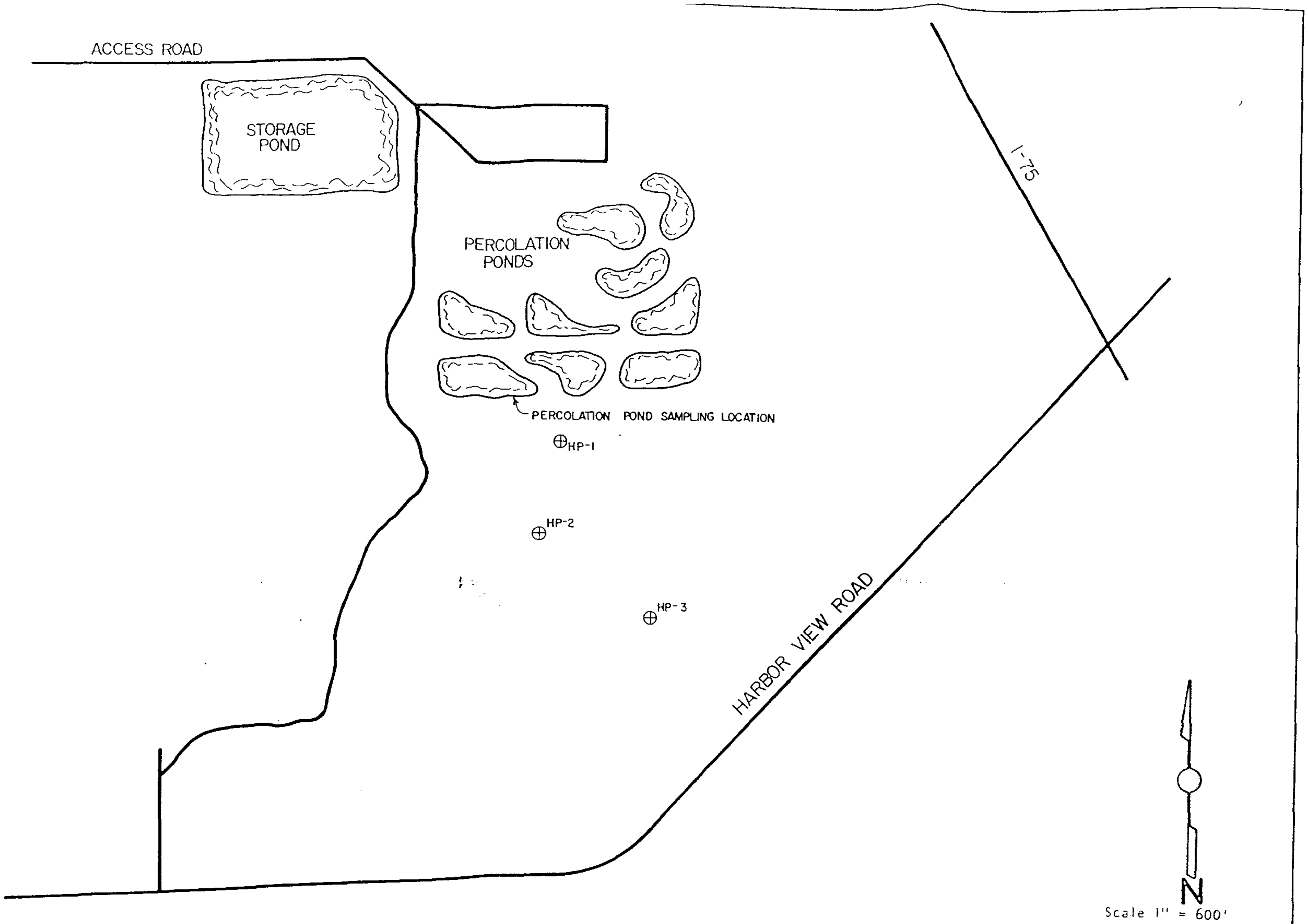
← GROUNDWATER FLOW DIRECTION

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

TEST LOCATIONS FOR
SITE No. 8
CHARLOTTE COUNTY, FLORIDA

DRAWN BY	CHECKED BY	DATE	
TV		6/26/95	
FILE NO	APPROVED BY		FIGURE
94-8583	[signature]		8

422684



⊕ HP - PIEZOMETER AND HORIZONTAL PERMEABILITY TEST LOCATIONS

Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing

TEST LOCATIONS FOR
CHARLOTTE COUNTY
EAST PORT WWTP
CHARLOTTE COUNTY, FLORIDA

DRAWN BY	CHECKED BY	DATE
TV		6/26/95
FILE NO. 94-8583	APPROVED BY	

FIGURE 9

Appendix B

PROPOSED SURFACE AND GROUNDWATER QUALITY MONITORING PROGRAM FOR PORT CHARLOTTE, FLORIDA

BY

MOTE MARINE LABORATORY, INC.

CHAR.8B/3
8/15/95

PROPOSED
SURFACE AND GROUNDWATER QUALITY MONITORING PROGRAM
for
Port Charlotte, Florida

Submitted To:

CAMP DRESSER & McKEE, INC.
20101 Peachland Boulevard
Unit 201
Port Charlotte, Florida 33954

Submitted By:

MOTE MARINE LABORATORY
1600 Ken Thompson Parkway
Sarasota, Florida 34236
L. Kellie Dixon, Principal Investigator

July 28, 1995

Mote Marine Laboratory Technical Report #433

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I. EXECUTIVE SUMMARY

The following monitoring program for the town of Port Charlotte is designed to monitor the results of a management action, specifically the replacement of on-site septic disposal systems with centralized sewer services. Information is also gathered to assess long term trends in surface water quality at selected locations and to generate information on the overall loadings of nutrients from freshwater canals to estuarine or tidal waters. The program design avoids duplication with other sampling programs, and recognizes natural variability in water quality, as well as the likelihood of detecting significant change.

Groundwater monitoring in shallow wells located on the banks of canals will be used to document changes in groundwater quality and potential loadings to surface waters during the conversion of on-site septic disposal systems to centralized sewage treatment. Approximately 50 wells will be sampled quarterly, and data examined for trend over time.

Surface water samplings will provide information for water quality index computation, trend analyses, and loading computations at canal discharges into the tidal waters of Charlotte Harbor. Samples will consist of monthly 24-hour composite samples, plus flow determinations, at approximately 12 locations.

Both surface and groundwater investigations should start as soon as possible and should be continued for approximately ten years. Monitoring costs will be approximately $110,000 per year excluding site installation costs.

Isotopic investigations, performed initially and again only after a number of years, may provide further information on the sources of nitrogen in surface waters. Initial isotopic investigations will cost approximately $45,000.

II. BACKGROUND

Study Area and Waste Disposal Practices

The study area consists of the town of Port Charlotte, located on Charlotte Harbor on the southwest coast of Florida (**Figure 1**) between the mouths of the Myakka and Peace Rivers. Port Charlotte was founded in 1955, when General Development Company purchased 80,000 acres and erected the first building (Henderson, 1984). Since then, as it is one of the major developments in the county, the population growth of the town has paralleled the population growth of Charlotte County. The population in 1990 was recorded as near 80,000; projections for 2000 and 2020 are 96,000 and 123,000, respectively (SWIM, 1993).

The adjacent Charlotte Harbor is the second largest estuary in Florida (approximately 270 square miles) and supports highly productive sport and commercial fisheries, as well as providing habitat for more than thirty threatened or endangered species (SWIM, 1993). Although the Harbor is relatively undeveloped compared to Tampa Bay, land use adjacent to the Harbor is predominantly (40 percent) classified as residential. Large areas have been platted, with minimal roadway construction, although the densities of completed residences in many areas is low.

At the northern boundary of Port Charlotte, the Cocoplum Waterway collects drainage from the City of North Port and forms a major east-west canal system between Sarasota and Charlotte Counties. The Cocoplum Waterway also provides water to the canal system of Port Charlotte in at least nine locations. Flow in the Port Charlotte canals is primarily to the south, with surface waters eventually transported to Charlotte Harbor. Water control structures at a number of locations along the canals effectively limit the upstream penetration of salt water and biota. The canal systems were originally built for water supply, flood control, and to increase the land available for development by providing additional drainage, fill material, and by lowering water tables. Canal systems such as these effectively transport water, but are frequently the site of water quality problems associated with increased loads of nutrients, metals, organic compounds, and low dissolved oxygen levels (SWIM, 1993; Florida Department of Natural Resources, 1983; Sarasota Bay National Estuary Program, 1993).

Currently sewered areas within the Port Charlotte Utility Unit boundaries include a number of separate areas (**Figure 2**). The remaining areas are served by individual OSDS (on-site disposal systems). Soil types in the study area are predominantly sandy, level and poorly drained. The study area of Port Charlotte includes nearly 15,000 permitted septic tanks, of which nearly 10,000, or approximately 66 percent, were installed prior to 1983. The typical design-life of these systems has been estimated at fifteen to twenty years (Scalf *et al.*, 1977), and as a result, many of the OSDS may be approaching the limit of their effective life.

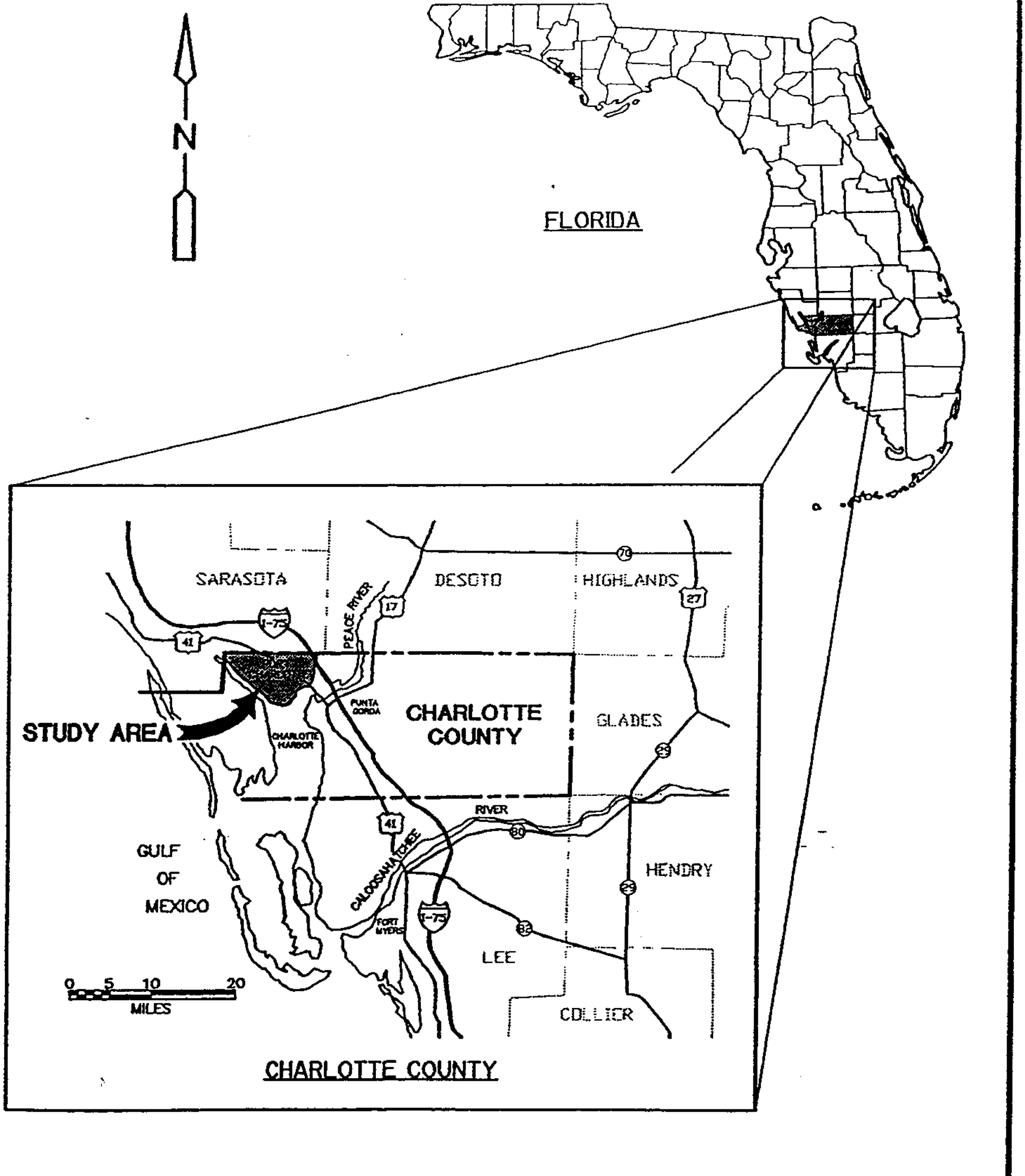

Figure 1. Port Charlotte Study Area.

Monitoring Plan Context

As population growth and development continues throughout the Charlotte Harbor area, environmental stresses will also continue to grow. Future nitrogen loading to Charlotte Harbor due to increased runoff from urban areas and increased wastewater production in 2020 has been estimated at 2.5 times the nitrogen load currently delivered to Charlotte Harbor by the Myakka River (Hammet, 1988). Additional inputs of nitrogen into a nitrogen limited system such as the Harbor, will likely result in overproduction of phytoplankton, benthic macro-algae, and epiphytes, increased dissolved oxygen stress, and decreased sea grass coverage and health. The Harbor already experiences periods of dissolved oxygen stress during periods of salinity stratification (Fraser, 1986).

Projected growth in the Charlotte Harbor region, with attendant potential increases in nutrient loadings to a nitrogen limited harbor, have resulted in a number of management plans and efforts designed to limit or minimize nutrient inputs to the estuary. Efforts generally center on the reduction or elimination of point sources (industrial, domestic waste treatment), followed by improvements in non-point source control (stormwater runoff). Septic systems that are adjacent to surface waters, while classed as non-point sources, have the potential to provide significant loads of nutrients, with subsequent reductions in nearby water quality. Failed septic systems can contribute both increased levels of nutrients, as well as bacteria, viruses, and human pathogens. Consequently, the Port Charlotte Utility Unit has proposed extending sewerage collection and disposal systems to additional areas indicated on **Figure 2**, which primarily includes the more densely populated areas that are currently unsewered.

Due to confusion over the quantitative impacts of septic tanks, and a relative lack of water quality information for the many freshwater and tidal canals in Port Charlotte, Mote Marine Laboratory (MML) implemented a reconnaissance sampling program in the spring and early summer of 1994 (Hayward, *et al.*, 1994) to provide background data for the region. A total of 32 canal stations were monitored, including areas served by OSDSs and sewered areas; urban and undeveloped areas; and salt water canals as well as freshwater canals. Data on nutrient concentrations and other eutrophication-related parameters were gathered during pre-dawn and early morning hours to document worst case conditions of dissolved oxygen, to provide information on the current water quality in the canal system during the dry season, and to identify any areas with acute water quality problems. The reconnaissance study was not designed to specifically assess the impacts of septic systems on canal water quality. While some areas had good water quality overall, many areas were classified as either fair or poor, with instances of high nitrogen concentrations, high oxygen demands, and low levels of dissolved oxygen.

A screening program for groundwater quality was also conducted in 1995 by Camp Dresser & McKee, Inc., Ardaman & Associates, Inc., and Mote Marine Laboratory. In this investigation, a series of temporary monitor wells were installed both along the canal bank, and along a postulated disposal plume (based on estimated groundwater movement) of a residential OSDS. An upgradient location was also included. A total of eight canal-side homes were investigated, sampling each location on a single date during the spring of 1995. Groundwater samples were primarily analyzed for nutrients. Analyses detected

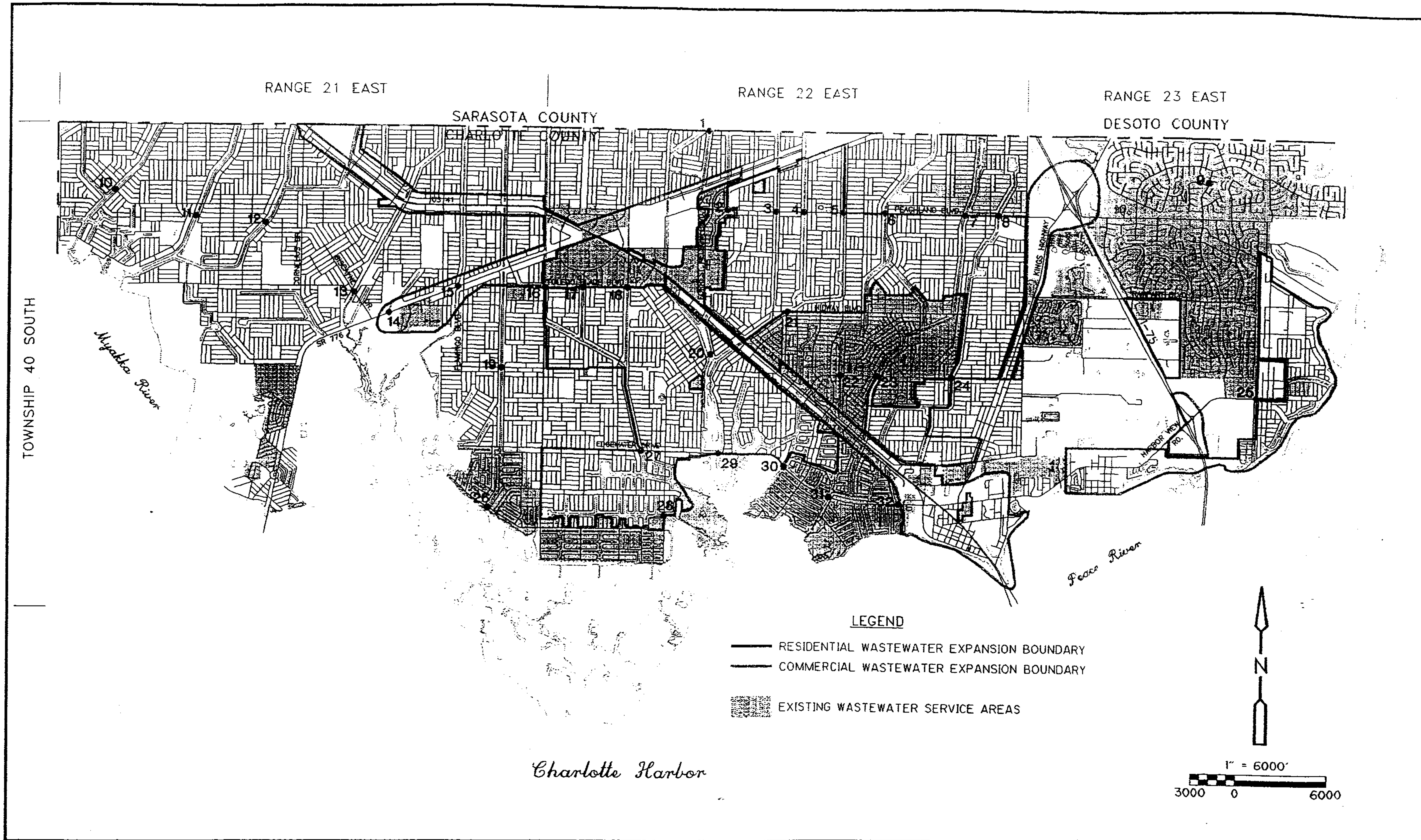

Figure 2. Existing and Proposed Wastewater Service Areas.

substantial quantities of both nitrogen and phosphorus in shallow groundwaters, with typically one of the canal-side wells evidencing higher concentrations, indicating that some portion of the disposal plumes reached areas immediately adjacent to surface water canals.

Following the surface and groundwater reconnaissance investigations, a long term monitoring plan, the subject of this document, was to be designed using the new data, knowledge of existing programs elsewhere in the Harbor, and selected goals.

Ongoing Monitoring Programs

Other governmental entities are also active in the Charlotte Harbor region. Water withdrawals for potable uses have resulted in a long-term water quality monitoring of the Peace River and selected locations in Lower Charlotte Harbor, primarily conducted by Environmental Quality Laboratory (EQL). The Surface Water Improvement and Management (SWIM) Program of the Southwest Florida Water Management District (SWFWMD) is also conducting an ongoing sampling program of the main body of the Harbor in conjunction with the Florida Department of Environmental Protection (FDEP) and EQL. Recently, Charlotte Harbor was nominated and adopted as a National Estuary, and additional attention may be focussed on the estuarine portions of the Harbor in the coming years. The City of North Port also conducts a routine monitoring program at a number of stations within it's canal system.

III. MONITORING PROGRAM OBJECTIVES

The following monitoring program for the town of Port Charlotte is designed to monitor the results of a management action, specifically the replacement of OSDSs with centralized sewer services. Information is also gathered to assess long term trends in surface water quality at selected locations and to generate information on the overall loadings from of nutrients from freshwater canals to estuarine or tidal waters. The program design avoids duplication with other sampling programs, and recognizes natural variability in water quality, as well as the likelihood of detecting significant change.

Specific objectives within the monitoring plan, discussed in more detail below, are 1) to document changes in groundwater quality and potential loadings to surface waters during the conversion of on-site, residential septic systems to centralized sewage treatment and disposal, 2) to provide information for water quality index computation, trend analyses, and loading computations at canal discharges into the tidal waters of Charlotte Harbor, and 3) to provide estimates of sewage-derived nitrogen in canals, using natural isotopic abundances.

Monitoring of groundwater adjacent to the surface water canals addresses the question of septic influences on surface waters at the most direct level. Changes in waste disposal practices will be most evident in groundwater before dilution by surface waters. Seasonal fluctuations in groundwater quality may still be apparent due to changing water table levels and rainfall influences, but variations attributed to diurnal and seasonal biologically-mediated processes should not be present. Groundwater quality, however, may take some time before change is apparent, depending on the rates of groundwater movement, size of the existing plume, and the amount of mixing the plume is subject to. Any loadings from septic systems, therefore, are expected to decline only gradually over time. As a result, this monitoring should be expected to extend over a period of years.

Surface water quality monitoring in the case of Port Charlotte is not an effective tool to definitively identify water quality changes attributable to changing waste treatment practices. Many processes (rainfall quality and quantity, biological activity, adjacent fertilizer applications, irrigation practices, and land use) contribute nutrient loadings and oxygen demanding materials to surface waters, and as a result, surface water quality values typically vary widely over time, depending on the range and seasonality of influences. Estuarine areas, in which the tides result in physical exchange with differing water masses, have even wider fluctuations in water quality. It is conceivable that over the period in which septic influences are reduced, some other variable may experience a long term increase (changing land use or increased rainfall, for example), resulting in no net change in water quality.

Despite the short-term variations in surface water quality, however, both managers and the public desire a yardstick of water quality to evaluate the results of management activities as a group and to determine whether water quality is sufficient to meet designated uses. Because of the expected variation, this information can only be obtained by monitoring for a long period of time (five to ten years) to discern general temporal trends.

Given the projected length of the monitoring program, and financial realities, it is suggested to limit the scope of the surface water monitoring to freshwater stations alone. Previous work (Hayward, *et al.*, 1994) indicated that estuarine surface water quality data was more variable that non-saline surface waters, most likely as the result of tidal variations and the resultant varying water masses at a given sampling location. As a result the statistical power to detect significant temporal changes is much reduced, and monitoring programs must extent over a longer period of time before changes can be identified. Status and trends of saline stations in the Harbor are the subject of extensive monitoring efforts supported by the SWFWMD-SWIM/FDEP/EQL Program. Areas which will not be covered by either the proposed or the SWIM monitoring are the estuarine and tidal canals within Port Charlotte.

Again in the interests of limiting the scope of the program, it is further recommended that stations to be sampled be limited to the most downstream salinity control structures of individual canal systems. Data from a monitoring program so designed will not represent "average" water quality over the Port Charlotte area, as these stations will not be a random subsampling of all possible freshwater sites. The data, however, will represent the water quality of freshwater discharging to the tidal, or estuarine canals and Charlotte Harbor, and will include areas which are already sewered, which may be sewered in the near future, and which are not currently scheduled for centralized sewer service. In addition, the basins represented by the salinity control structures comprise a large portion of Port Charlotte, and, with relatively few stations, sampling efforts can emphasize more frequent collections. The water quality information so gathered can also be coupled with flow estimates to provide site-specific loading estimates that will be very useful for estimates of water quality impacts in the lower portions of the canals and in Charlotte Harbor.

Isotopic analyses represent a screening level investigation with a low level of effort which can potentially provide substantial information regarding the source of nitrogen in surface waters at the present time. The technique, performed on relatively infrequent intervals, identifies the relative proportions of various naturally-occurring isotopes of nitrogen, or other elements. For nitrogen, the relative proportion of ^{15}N ($\delta^{15}N$) is increased with increasing trophic level due to increased rate constants and reaction kinetics of the lighter ^{14}N. As a result, $\delta^{15}N$ values can be indicative of nitrogen source whether it be from OSDS effluent, inorganic fertilizers, unimpacted groundwater, or atmospheric deposition. When sources are widely varying in $\delta^{15}N$, the values in the receiving waters can be used to estimate proportional contributions. When more than two sources are present, isotopic abundances of other elements (carbon, sulfur) assist in solving for a unique solution.

Similar investigations for the west coast of Florida have successfully used the technique to allocate waste sources between either human or animal wastes and inorganic fertilizers (Jones and Upchurch, 1993), as $\delta^{15}N$ values for inorganic fertilizers and atmospheric sources are near 0 part per thousand (ppt), uncontaminated groundwaters are between +5 to +6 ppt, while $\delta^{15}N$ for human and animal wastes are near 20 ppt. The task could be repeated in a number of years to evaluate changes in nitrogen sources as areas are converted to centralized sewer and septic plumes dissipate.

Monitor Wells

The proposed groundwater monitoring program would continue and expand on facets of the previous reconnaissance investigation. In both control (undeveloped) and potentially impacted locations (i.e. homes with septic systems), shallow wells should be installed on canal banks and monitored at a frequency to allow trend analysis. Sites can be located on either saline or freshwater canals. It will be essential to obtain a permanent easement or other guarantee of access to ensure that the site can be monitored for the duration of the monitoring. Between eight and ten sites should be monitored, with sites particularly selected in areas scheduled for installation of centralized waste disposal facilities. The resultant groundwater quality data can also be used for estimation of nutrient loadings to surface waters.

A each site, a number of wells (four to five) will be installed along the banks of the canal. Wells located both in the drainfield and at midpoints would permit estimates of percent removal rates of nutrients. Monitor wells would be permanently installed, with screens appropriately sized to limits solids in collected samples and screens extending along the bore to collect integrated groundwater samples from near water table elevations to either the depth of the adjacent canal or to an impermeable layer. All groundwater samples should be filtered (0.45 micron) and analyses to be performed should include the parameters listed in **Table 1**.

Table 1.	Parameters for groundwater monitoring.
Nitrogen	
ammonium	
nitrate-nitrite	
total Kjeldahl	
Phosphorus	
Total	
Ortho	
Conductivity	
Chloride	
Sulfate	
Calcium	
Magnesium	
Potassium	
Sodium	

Sample collection protocols would include measurement of the relative water levels in both well and canal. These data will permit the calculation of potential transport at each well site using hydraulic conductivity and transmissivity data determined during well installation. More detailed loading estimates could be generated from a continuous record of canal water levels, coupled with the periodic analyses of groundwater quality. In addition to the groundwater quality of individual wells, total loadings per lot could be determined through the integration of the results from each monitor well along the entire property line.

Wells and adjacent canal waters would be sampled on an established frequency (minimum quarterly) and data from either individual wells, lot loading totals, or other reduced data, examined over time to determine temporal trends in groundwater quality and loadings from OSDS to the surface waters of Port Charlotte. Temporal trends will be of especial interest in areas converted from OSDS to centralized sewer service. Rates of surficial groundwater movement should also be calculated for estimates of rates of change following OSDS removal, and to generate realistic estimates of the minimum length of the proposed monitoring program.

An alternate statistical design to temporal trend is possible, but with a reduced likelihood of detecting significant changes. Under the second design, a number of samples (eight to ten) are collected quarterly before OSDS removal, but no samples are collected during the time estimated for septic plumes to dissipate. Sampling is recommenced when plumes are calculated to have returned to background, and an additional eight to ten samples collected. Data analysis consists of site-by-site comparisons of the two groups of data, but differences before and after OSDS removal may be small compared to normal seasonal variations. Additionally, organic particulates near the drainfield will continue to remineralize and the calculation of plume dissipation may be subject to large uncertainties. This alternative is not recommended.

Composite Surface Water Samples

Surface water samples will be collected from immediately upstream of the most downstream salinity control structures on any of the canals, approximately eight to ten locations within Port Charlotte. Stations should also be added to quantify water quality of the Cocoplum Waterway, since it discharges into so many of the Port Charlotte canals. The City of North Port's data could be reviewed for selection of this station, and sampling potentially coordinated. Data will be used to determine the water quality of freshwater delivered to the lower portion of Port Charlotte and eventually to Charlotte Harbor. Stations sampled could include either all available stations, or could consist of a random subset of the available stations, if funding levels necessitated. The random subset sacrifices some statistical power, but acknowledges the financial realities of a commitment to a long term monitoring program. Potential locations appear in **Figure 3**.

Pilot portions of the sampling program would collect 12 samples, one every 2 hours, over a 24 hour period at each station, to evaluate the degree of fine-scale variation in canal water quality. Assuming significant differences to exist among samples of a site, subsequent samples would consist of 24 hour composites at each site to integrate fine-scale variability. (Should significant differences among samples at a site not exist, then single grab samples would be sufficient for subsequent collections.) Instrumental parameters, secchi depths, and bacteria samples would be measured or collected on deployment or retrieval of composite samplers.

Sampling at all selected stations would not have to be performed synoptically; any one of several randomized schedules could be performed, thus permitting more efficient use of field personnel and equipment. The analytical suite would be comparable to that determined in previous work (**Table 2**) with additions to permit calculations of standard water quality indices and trophic information. Measurements of flow determined simultaneously would be valuable and would permit loadings calculations from the analytical concentration data. Loading information could provide additional support for basin prioritization and prove invaluable for efforts in Charlotte Harbor to link desired natural resources with water quality and watershed loadings.

Sampling frequency will, to a large extent, be determined by available budget. More frequent samplings increase the probability that changes in water quality, if present, will be detected. Bi-monthly sampling events represent a minimum approach, with a strong recommendation for monthly samplings. Additional information which should be retrieved or tabulated periodically would include basin rainfall data, number of OSDSs per basin, basin hydrologic characteristics, land usage, and seawall or bank condition.

Data will be evaluated for temporal trends using concentrations and loads of individual parameters. In addition, indices (water quality index, trophic state index) will be subject

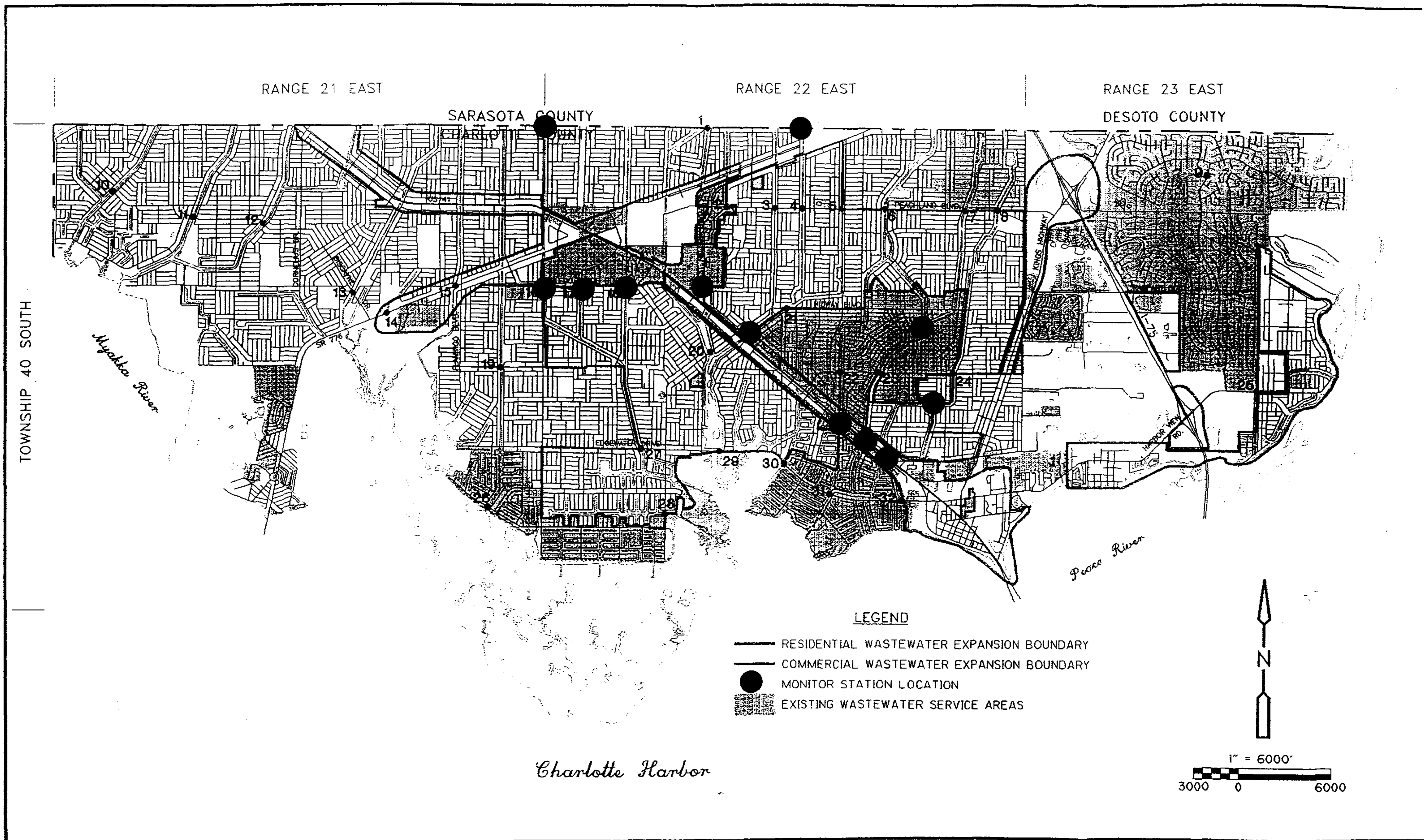

Figure 3. Potential Surface Water Monitoring Sites.

to trend analysis. Indices provide useful summaries of a variety of parameters and simplify presentation and tracking of overall water quality.

Power analyses performed on a STORET data set with similar variability to Port Charlotte data collected by MML (Hayward, *et al.*, 1994) indicated that the probability of detecting a 25% change in nitrogen concentration, with five years of monitoring before and after the change, was 84% for a monthly sampling program and only 74% for a bi-monthly sampling program. Thus it is important to plan for the commitment of resources over a sufficient length of time, and for a sufficient sampling frequency, in order to achieve the desired expectations of any monitoring plan.

Table 2. Sampling parameters for composite surface water samples.

Dissolved oxygen
Conductivity
Secchi depth
Temperature
pH
Biochemical oxygen demand
Color
Chlorophyll *a*
Nitrogen
Ammonia
Nitrate-nitrite
Total Kjeldahl
Phosphorus
Ortho
Total
Bacteria

<u>Isotopic Analyses</u>

Isotopic analyses should be performed to examine the sources of nitrogen in canal surface waters. A summer and a winter sampling (wet season and dry season) should be conducted to obtain data on periods of minimum and maximum primary productivity. Sampling stations would consist of a number of the groundwater monitoring sites (four to six), with each site in a different canal system. Sites chosen would ideally be towards the downstream end of non-tidal, freshwater, dead end canals. If canals samples receive flow from other systems (i.e. the Cocoplum Waterway, then additional samples should be collected of this input. Samples from sites on estuarine canals or with substantive flow from other canals may have effects diluted due to transport. In all events, data interpretations should be less ambiguous under conditions of low flow, and in regions where land use is relatively consistent, i.e. either all homes served by OSDS, or where very few residences were present.

At each of the groundwater sites, samples for isotopic analyses should be collected both from the monitor well identified from previous analyses as having the highest concentrations of nutrients, and in the immediately adjacent canal waters. Groundwater samples should be filtered through 0.45 μ filters, and the filtrate analyzed. Surface water samples should be filtered with both dissolved and particulate (phytoplankton and detritus) fractions subject to analyses. Additional samples of canal sediments should collected at each site, and, if budget allows, rainfall samples collected for processing similar to dissolved samples.

Isotopic analyses should consist of both ammonium, nitrate-nitrite, and organic nitrogen for dissolved samples. Particulate samples will be analyzed without speciation. In addition to the analysis of isotopic ratios, the fractions should be quantified for ammonia, nitrate-nitrite, and organic nitrogen (total Kjeldahl nitrogen), suspended solids, and chlorophyll through standard wet chemical techniques. As funding allows, samples could also be processed for isotopes of sulfur and oxygen, to assist in distinguishing between atmospheric, uncontaminated groundwater, and inorganic fertilizer sources.

Data interpretation would consist of a comparison of $\delta^{15}N$ values between the various species of nitrogen, various fractions, and locations at a site, together with comparisons of canal water constituents between developed and undeveloped areas. Correlations would be attempted of $\delta^{15}N$ values with numbers or densities of existing OSDS

IV. DISCUSSION

It should be emphasized that the monitoring for both ground and surface waters is a periodic sampling of a highly variable system which is driven by many uncontrolled as well as some potentially unknown factors. In order to detect statistically significant temporal trends, it is critical that monitoring programs (of both ground and surface waters) be continued for a sufficient period of time. Isotopic investigations, which are comparatively more expensive than other parameters per event, are not proposed for routine monitoring of temporal trends, per se, but are an effort to assess the degree of the problem (nitrogen from OSDSs) at a particular point in time. The isotopic analyses would likely, however, be repeated at some much later date, when groundwater monitoring indicated dispersal of plumes from OSDSs. A repetition of the isotopic analyses would be even more desirable at this time, if preliminary trend analyses at surface water stations indicated no substantive changes in canal water quality, implying nitrogen from other sources.

Duration and Timing

The forgoing description of the monitoring plan has already included some discussion and rationale to extend the surface water monitoring over an approximate ten year period. The ten year period was based on a power analysis of a ten year data set of comparable data obtained from the STORET data system and allows the detection of a

25% change in nitrogen concentrations with only minimal confidence. The reasons are based on the degree of natural variability in water samples, i.e. the more variable the system that is sampled, the harder it is to identify significant differences. The recommended monitoring plan has made every effort to limit the variability of surface water samples collected (freshwater, 24 hour composites, and frequent sampling), and so trends may be visible in a slightly shorter period of time. Groundwater samples are also expected to demonstrate slightly lower levels of variability (thus the quarterly monitoring schedule for this portion of the monitoring). It is important, nevertheless, to recognize the potential duration of the monitoring and the enter the program with realistic expectations and sufficient financial resources. If more confidence in results is desired, or a smaller change to be detected, than sampling programs and frequency must be adjusted accordingly.

Particularly when the impacts of a single event are of interest, it is desirable to have as much data from before the event as from afterwards. Accordingly, both surface and groundwater monitoring programs should begin as soon as possible to collect sufficient information from prior to installation of additional centralized waste treatment. The surface water monitoring, since it is not designed to specifically quantify the results of sewer expansion is less critical, but the information provided by this portion of the plan is generally of higher public interest.

Isotopic analyses, identifying proportional sources of nitrogen in canals at a particular time, could be conducted at any time prior to sewer expansion. As a summer and winter sampling is recommended, sampling approximately six to nine months prior to construction would be sufficient. Follow-on sampling using this technique would take place a number of years following construction, the exact timing of which is dependent on results of groundwater monitoring, calculated rates of groundwater movement, and nutrient exchange rates in the various canals.

<u>Approximate Costs</u>

The following monitoring costs are estimates only and provided merely for planning purposes. Once financial resources are identified, more precise estimates can be prepared which will reflect the final number of stations, analyte list, and sampling frequency. Economies of scale may be possible by combining groundwater monitoring with the isotopic investigations. In-kind services from County departments may also reduce costs.

Groundwater (quarterly sampling) and surface water (monthly sampling) monitoring components will require approximately $55,000 per year each, exclusive of initial site installation and capital equipment costs (monitor wells and composite samplers). Isotopic analyses are estimated to cost near $45,000 to sample and analyze a wet and a dry season for $\delta^{15}N$ only.

V. SUMMARY

The recommended monitoring program consists of both groundwater and surface water components. Quarterly groundwater samplings in approximately 50 shallow wells will provide information for trend analysis and nitrogen load calculations, linking groundwater quality with the expansion of centralized sewer services. Monthly surface water samplings at approximately 12 locations will provide information for loadings to Charlotte Harbor and collect sufficient information to use water quality indices to track overall water quality at discharge points. Both surface and groundwater investigations should begin as soon as possible and should be planned to continue for a ten year period. Isotopic investigations, performed initially and again only after a number of years, may provide further information on the sources of nitrogen in surface waters.

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Appendix C

SEPTIC TANK QUESTIONNAIRE

Charlotte County Utilities
Port Charlotte Wastewater Program
Questionnaire For Residents Using Septic Tanks

1) When was your home constructed? ____________________
(Approx. date)

2) How long have you lived in the house? ____________ Yrs.

3) How many months a year do you reside in the house? ________ Mos.

4) Is the house vacant during any portion of the year? ___Yes ___No

A) How Long?: ______________________________
Months/Days

B) If you are not a full time resident, please circle which months you typically live in the house:

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

5) How many people live in the house? _____

6) Do you have a garbage disposal? ___Yes ___No

If yes, do you routinely use it? ___Yes ___No

7) Do you have a dishwasher? ___Yes ___No

If yes, do you routinely use it? ___Yes ___No

8) Do you have a clothes washer? ___Yes ___No

On average, how many loads of laundry do you wash in a week? ___

9) Where are your septic tank and drainfield located?

a) Front yard ____
b) Back yard ____
c) Not sure ____

10) Have you ever experienced difficulties with your septic tank?

___Yes ___No

If yes, please identify the type of problem:

a) Toilet will not, or is slow to, flush ______
b) Ponded or pooled water in vicinity of septic tank or drainfield ______
c) Sewerage smell in vicinity of septic tank or drainfield ______

d) Other ______________________________ ______
(Use separate sheet if necessary)

e) When did this problem occur? ______________________

11) Have you ever had your septic tank system pumped out, or serviced in any manner? ___Yes ___No

If yes, please give dates for the type of service required.

______________pump out ______________drainfield repair

______________drainfield replacement

______________tank repair ______________tank replacement

12) Do you live adjacent to a canal? ___Yes ___No

a) If yes, how large is your lot? (e.g. 125 x 80 ft) ____X____

b) Does the canal have a seawall? ____Yes___No

c) About how far is your drainfield from the water? ____ft(approx)

d) Has your property ever flooded? ___Yes ___No

If yes, please give dates or indicate the number of times that water from the canal extended onto your lawn.____________

13) Do you have an on-site irrigation well? ___Yes ___No

If yes, is it greater than 50 ft. deep? ___Yes ___No

14) How can we reach you for more information?

Telephone number ____________ Best time to call?______________

Name ________________________________

Service Address ________________________________

____

Mailing Address (if different): ________________________________

____

Appendix D

MONITORING RESULTS - TOTAL CHEMICAL

WELL	SITE	DATE	NH4N	NO23N	TKN	Tot-N	TOT-P	TEMP	COND	PH	Location
1	1	03/28/95	0.180	4.674	8.27	12.94	13.31	22.30	1166	7.14	Drainfield
2	1	03/28/95	0.256	1.704	9.96	11.66	26.18	23.50	990	7.20	Drainfield
3	1	03/28/95	0.177	0.046	12.44	12.49	35.85	23.20	666	7.18	Front
4	1	03/28/95	0.109	0.006	0.70	0.71	0.81	23.40	731	7.09	Front
5	1	03/28/95	0.042	0.011	1.98	1.99	2.85	22.60	1051	6.72	Mid
6	1	03/27/95	0.086	0.006	2.20	2.21	3.10	23.30	900	6.09	Rear
7	1	03/28/95	0.076	0.006	10.30	10.31	15.35	21.50	783	7.36	Rear
8	1	03/28/95	0.070	0.005	2.53	2.54	3.10	22.00	758	7.38	Rear
9	1	03/28/95	0.072	0.005	5.66	5.67	9.12	22.60	855	7.27	Rear
10	1	03/28/95	0.097	0.005	12.80	12.81	45.93	22.90	896	7.24	Rear
11	1	03/28/95	0.087	0.005	10.00	10.01	32.22				Rear
11	1	03/28/95	0.085	0.005	6.12	6.13	26.20	22.40	783	7.27	Rear
12	1	03/28/95	0.291	0.005	6.08	6.09	25.44	22.80	700	7.11	Rear
1	2	04/14/95	0.928	0.107	7.68	7.79	57.34	22.00	1205	6.97	Drainfield
2	2	04/12/95	0.061	0.029	5.99	6.02	13.75	26.40	995	6.59	Drainfield
3	2	04/12/95	0.776	0.089	24.06	24.15	300.11	23.30	809	7.38	Front
4	2	04/12/95	0.339	0.022	9.21	9.23	168.73	23.30	1096	7.08	Front
5	2	04/12/95	0.242	0.038	6.57	6.61	69.62	22.60	823	7.19	Front
6	2	04/14/95	0.083	0.105	15.52	15.63	20.82	22.60	1130	7.06	Mid
7	2	04/13/95	0.124	0.017	14.47	14.49	9.95	23.80	908	7.20	Rear
8	2	04/13/95	0.083	0.005	11.43	11.44	11.67	23.80	642	7.19	Rear
9	2	04/13/95	0.162	0.016	9.46	9.48	23.66	22.90	787	7.10	Rear
10	2	04/13/95	0.070	0.017	4.37	4.39	7.01	22.70	675	7.26	Rear
10	2	04/13/95	0.071	0.008	4.61	4.62	10.07				Rear
11	2	04/13/95	0.045	0.005	5.23	5.24	9.60	22.80	692	7.20	Rear
12	2	04/13/95	0.079	0.020	9.45	9.47	18.02	23.70	644	7.25	Rear
1	3	04/05/95	3.516	0.071	8.30	8.37	18.00	23.40	1093	7.26	Drainfield
2	3	04/05/95	0.171	0.254	2.89	3.14	17.29	23.60	964	6.97	Drainfield
3	3	04/05/95	0.029	0.028	3.74	3.77	32.50	23.10	633	7.05	Front
4	3	04/05/95	0.005	0.015	1.35	1.37	22.75	22.30	619	7.28	Front
5	3	04/05/95	0.015	0.022	3.82	3.84	47.91	23.40		7.20	Mid
6	3	04/05/95	0.023	<0.005	3.99	3.99	42.96	22.90	1183	7.32	Rear
7	3	04/06/95	0.020	0.016	2.46	2.48	32.55	21.80	796	6.98	Rear
8	3	04/06/95	0.018	0.030	2.38	2.41	12.60	21.80	820	7.12	Rear
8	3	04/06/95	0.012	0.018	2.27	2.29	13.50				Rear
9	3	04/06/95	0.033	0.092	2.79	2.88	20.35	22.00	907	7.20	Rear
10	3	04/06/95	0.015	0.124	1.66	1.78	11.23	22.30	1112	7.27	Rear
11	3	04/06/95	0.358	0.059	3.18	3.24	8.63	22.20	1183	7.60	Rear
12	3	04/06/95	0.017	0.017	1.71	1.73	9.73	22.00	1019	7.45	Rear
1	4	04/03/95	2.547	2.252	6.78	9.03	36.62	22.50	1920	6.80	Drainfield
2	4	04/03/95	<0.005	0.046	5.87	5.92	31.52	22.50	832	6.48	Drainfield
3	4	04/03/95	0.008	0.385	2.82	3.21	26.19	23.10	880	6.01	Front
4	4	04/03/95	0.052	0.026	8.51	8.54	70.30	22.80	580	6.90	Front
5	4	04/03/95	0.093	0.158	8.60	8.76	86.22	23.20	760	7.16	Mid
6	4	04/03/95	0.039	0.015	9.71	9.73	26.34	22.40	884	7.25	Rear
7	4	04/04/95	0.007	0.124	4.28	4.40	18.86	22.10	894	6.10	Rear
8	4	04/04/95	0.009	<0.005	4.55	4.55	26.32				Rear
8	4	04/04/95	0.013	<0.005	4.43	4.43	21.48	22.10	770	6.45	Rear
9	4	04/04/95	0.027	<0.005	3.05	3.05	23.33	22.50	586	6.95	Rear
10	4	04/04/95	0.009	<0.005	8.14	8.14	10.17	21.90	574	7.10	Rear
11	4	04/04/95	<0.005	<0.005	4.46	4.46	5.18	21.60	668	7.15	Rear
12	4	04/04/95	<0.005	0.022	4.26	4.28	23.09	22.20	765	7.20	Rear
1	5	04/10/95	0.040	0.186	3.21	3.40	14.54	25.00	824	6.76	Drainfield
2	5	04/10/95	<0.005	0.025	0.87	0.90	2.22	23.00	835	7.19	Drainfield

WELL	SITE	DATE	NH4N	NO23N	TKN	Tot-N	TOT-P	TEMP	COND	PH	Location
3	5	04/10/95	0.005	<0.005	2.94	2.94	20.89	23.00	1167	7.16	Front
4	5	04/10/95	0.037	0.045	3.48	3.53	12.20	22.00	586	7.23	Front
5	5	04/10/95	<0.005	1.009	1.77	2.78	8.90	23.50	922	6.65	Mid
6	5	04/10/95	0.147	0.056	16.57	16.63	23.13	22.00	839	7.59	Rear
7	5	04/11/95	0.043	0.036	1.90	1.94	8.80	23.60	960	7.85	Rear
8	5	04/11/95	0.086	0.428	1.67	2.10	8.75	24.70	900	7.70	Rear
9	5	04/11/95	0.062	0.270	3.78	4.05	9.99	23.50	900	7.64	Rear
10	5	04/11/95	0.092	0.068	5.33	5.40	21.06	24.50	867	7.60	Rear
11	5	04/11/95	0.111	0.021	3.44	3.46	8.89	23.40	793	7.34	Rear
12	5	04/11/95	0.036	0.040	4.43	4.47	16.23	24.00	774	7.14	Rear
12	5	04/11/95	0.035	0.019	5.20	5.22	14.28				Rear
1	6	03/30/95	1.346	0.005	37.17	37.18	34.46	22.70	178	5.12	Drainfield
2	6	03/30/95	0.265	0.006	30.03	30.04	21.61	22.10	425	5.15	Drainfield
3	6	03/30/95	0.675	<0.005	36.78	36.78	17.30	22.30	189	4.80	Front
4	6	03/30/95	0.375	<0.005	18.18	18.18	14.02	22.30	188	3.94	Front
5	6	03/30/95	2.488	0.008	21.26	21.27	27.99	22.70	430	4.53	Mid
6	6	03/30/95	0.653	0.005	27.66	27.67	14.18	22.80	217	5.06	Rear
7	6	03/30/95	0.331	<0.005	12.95	12.95	4.67	23.60	230	5.50	Rear
8	6	03/30/95	0.067	<0.005	2.10	2.10	0.33	23.50	480	5.47	Rear
9	6	03/30/95	0.093	<0.005	9.09	9.09	4.42	23.10	585	5.30	Rear
10	6	03/30/95	0.081	<0.005	10.40	10.40	4.00	22.80	246	5.15	Rear
11	6	03/30/95	0.110	<0.005	6.42	6.42	2.87	22.50	210	4.92	Rear
12	6	03/30/95	1.542	<0.005	11.21	11.21	5.63				Rear
12	6	03/30/95	1.528	<0.005	10.94	10.94	5.27	22.10	207	4.82	Rear
1	7	04/17/95	35.820	0.121	41.60	41.72	19.14	25.20	1181	5.61	Drainfield
2	7	04/17/95	47.776	0.035	59.13	59.17	23.10	24.40	1345	6.37	Drainfield
3	7	04/17/95	7.219	0.023	12.53	12.55	18.21	24.10	945	6.23	Front
4	7	04/17/95	1.192	0.019	12.21	12.23	43.98	25.00	505	6.22	Front
5	7	04/17/95	10.002	0.056	33.10	33.16	23.03	23.60	730	6.28	Mid
6	7	04/17/95	0.145	0.020	3.51	3.53	26.11	23.40	649	6.48	Rear
7	7	04/18/95	0.166	0.020	2.78	2.80	11.98	23.60	553	5.67	Rear
8	7	04/18/95	0.156	0.021	3.97	3.99	21.52	23.60	557	6.27	Rear
8	7	04/18/95	0.159	0.016	4.27	4.29	23.32				Rear
9	7	04/18/95	0.112	0.106	18.71	18.82	1.43	24.00	740	6.38	Rear
10	7	04/18/95	0.015	0.240	6.01	6.25	7.88	23.90	870	6.53	Rear
11	7	04/18/95	0.104	0.037	10.88	10.92	38.36	23.70	1101	6.71	Rear
12	7	04/18/95	0.075	0.048	9.61	9.66	16.74	23.80	864	6.77	Rear
1	8	04/19/95	14.191	0.105	36.79	36.90	36.50	25.10	300	5.10	Drainfield
2	8	04/19/95	23.511	0.151	71.54	71.69	57.83	24.80	550	5.22	Drainfield
3	8	04/19/95	0.959	0.135	20.84	20.98	49.12	23.70	480	5.96	Front
4	8	04/19/95	0.385	0.085	37.32	37.41	67.13	24.50	62	5.88	Front
5	8	04/20/95	14.144	0.110	42.98	43.09	60.85	24.00	324	5.07	Mid
6	8	04/20/95	3.351	0.026	11.90	11.93	13.34	23.20	376	4.86	Rear
7	8	04/20/95	0.674	0.019	15.74	15.76	*10.48	22.80	174	5.70	Rear
8	8	04/20/95	0.740	0.027	8.51	8.54	5.16	23.10	156	4.88	Rear
8	8	04/20/95	0.797	0.015	7.56	7.58	*5.60				Rear
9	8	04/20/95	1.435	0.038	9.59	9.63	*6.58	23.20	248	4.78	Rear
10	8	04/20/95	2.864	0.030	28.99	29.02	18.76	23.00	127	4.70	Rear
11	8	04/20/95	0.525	0.027	9.77	9.80	9.51	22.80	134	4.72	Rear
12	8	04/20/95	0.646	0.049	31.91	31.96	16.70	22.80	114	4.93	Rear

* Analyzed after standard holding time.