Metropolitan Dade County, Florida

DEPARTMENT OF ENVIRONMENTAL RESOURCES MANAGEMENT

1983 GROUND AND SURFACE WATER MONITORING PROGRAMS:
Ambient Groundwater
Landfill Monitoring
Miami International Airport
Artesian Well at Chekika Hammock
General Canal Monitoring
Black Creek

DERM Technical Report 88-6

1983 GROUND AND SURFACE WATER MONITORING PROGRAMS

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Introduction

This report presents information and discusses results of programs the Dade County Department of Environmental Resources Management is currently conducting to ascertain the quality of the county's ground and surface waters. These programs include the Groundwater Quality Monitoring Network, Landfill Monitoring Program, Miami International Airport Water Quality Monitoring Network, Artesian Well Monitoring Program, Monthly Canal Monitoring Program, Intensive Canal Program, and Annual Pollutant Study.

The Groundwater Quality Monitoring Network features biannual (rainy and dry season) sampling for a wide array of parameters to characterize existing groundwater quality in the county and provide a data base to establish long-term trends.

Groundwater monitoring is conducted by DERM at the county's sanitary landfill (South Dade) as well as at two former disposal facilities (North Dade and 58th Street) under agreement with the Dade County Public Works Department. Private and municipal landfills are also required to submit monitoring data. Monitoring parameters include general contaminant indicators (ammonia nitrogen, specific conductance, pH, phenols) and those which are potential health hazards if present in significant concentrations (cadmium, chromium, lead). Additionally, pesticides and synthetic organic compounds are monitored on a site-specific basis.

In late 1983 DERM (in cooperation with Dade County Aviation Department) designed and began implementation of a water quality monitoring network at Miami International Airport. This step was necessitated by numerous spills of hydrocarbons and other hazardous substances in the past. The program is intended to characterize existing ground and surface water quality in and around Miami International Airport and act as a warning system for offsite migration of these substances.

The Canal Monitoring Program provides an overview of water quality on all of the county's major canal systems through monthly sampling and analysis of general physical and chemical parameters. A companion program is the Intensive Canal Study, where samples are taken monthly on one major canal per year for a comprehensive set of parameters. This program is designed to determine if any specific problems exist for that canal, as well as establishing baseline water quality for future studies. A third surface water program, the Annual Pollutant Study (sampled biannually), was initiated to provide a measure of the effects of increasing urbanization on the major canals of the county by comparing physical and chemical parameters at background and discharge stations along the canals. As the data base for this latter program is still somewhat sparse, it will be discussed in detail in future reports.

Groundwater Quality Monitoring Network

A complete description of Dade County's groundwater quality monitoring program has been presented in an earlier report (DERM, 1981a). Briefly, the network is designed to monitor the quality of groundwater in the county via biannual (rainy and dry season) sampling and analysis of routine parameters (field analyses, nutrients, major ions, indicator bacteria where appropriate, etc.) and analysis of more specific parameters (metals, volatile organics, pesticides and herbicides) on a less frequent basis. The objectives are to characterize existing groundwater quality in various land uses in Dade County and build a data base from which long-term trends might be discerned.

Results

The initial sampling of this network was done September, 1981, near the end of the rainy season. Subsequent events occurred for both dry and wet seasons in 1982 and 1983. Figure 1 shows the locations of these sites and Table 1 provides information about each of the wells.

The following parameters were analyzed:

Field analyses

- Specific conductance
- pH
- Alkalinity
- Temperature

Indicator bacteria (September, 1981, all shallow wells, less than 30 feet)

- Total coliform

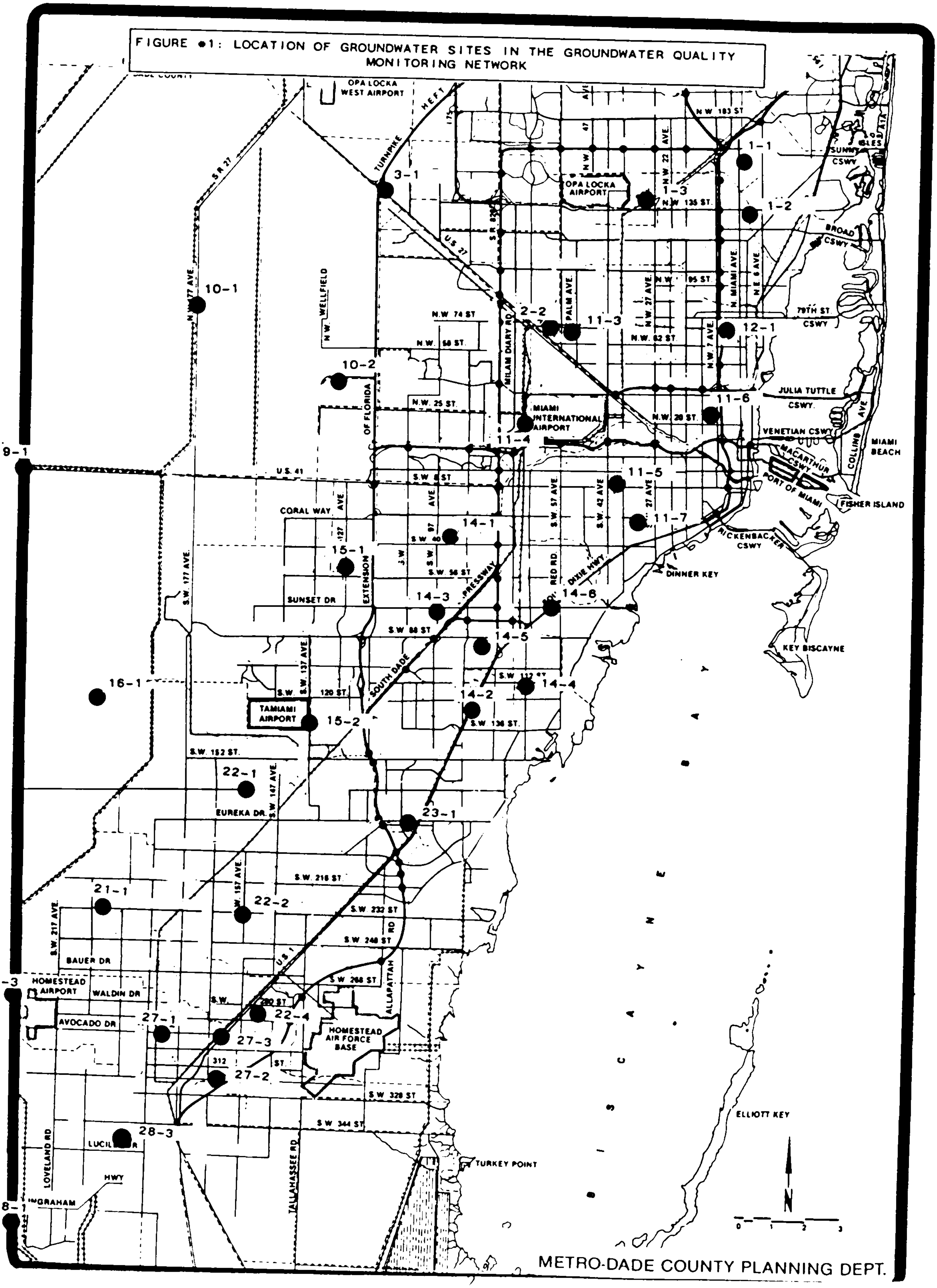


FIGURE #1: LOCATION OF GROUNDWATER SITES IN THE GROUNDWATER QUALITY MONITORING NETWORK

Table 1

Groundwater Sampling Sites

NETWORK #:	USGS #	DEPTH (Feet)	LAND USE	SEWERED	LOCATION
1-1B	G-1631	20	Residential	No	NE 2nd Ave.& 163 St.
C	G-1632	31			
D	G-1633	45			
1-2	G-430	97	Residential	No	Meml Hwy & NE 136-7 St.
1-3	(Opa-Locka WTP)	100	Residential	No	Burlington & Codadad (Opa-Locka)
2-2	GW-4	8	Bus., Residential	No	W 8th Ave.& 74 St(Hialeah)
3-1	G-1637	26	Recharge/Storage,Ind.	No	US 27,Opa-Locka W Airpt.
9-1A	G-3202	10	Residential		US 41 at Coopertown
B	G-3203	35	Recharge/Storage		
10-1	G-1488	20	Recharge/Storage	No	NW 177 Ave.& 72 St.
10-2	G-3103	21	Recharge/Storage	No	NW 120 Ave. & 42 St.
11-3	G-1610	10	Residential,Bus.	Yes	W 1st Ave.& 19 St(Hialeah)
11-4		60	Mia.Int'l Airport	Yes	NW 66 Ave.& 18 St.
11-5	GW-6	10	Residential	Yes	SW 37 Ave.& Ponce de Leon Blvd.
11-6		60	Industrial	Yes	NW 11 Ave. & 22 St.
11-7	F-179	77	Residential,Bus.		SW 32 Ave. & 24 Terr.
12-1	F-46	90	Residential	Yes	NW 5 Ave. & 69 St.
14-1	G-1609	60	Residential	Yes	SW 90 Ave. & 38 St.
14-2	G-553	91	Residential,Ind.	No	SW 89 Ave. & 128 St.
14-3	G-3073	20	Residential,Bus.		SW 97 Ave. & 72 St.
14-4	G-580A	22	Residential	No	SW 67 Ave. & 112 St.
14-5	G-1604	62	Residential,Bus.	No	SW 75 Ave. & 105 Terr.
14-6	F-319	20	Residential,Bus.	No	US 1 & SW 72 St.
15-1	G-958A	27	Residential,Undev.	No	SW 127 Ave. & 51 St.
15-2	G-858	20	Resid.,Undev.,Ind.	No	SW 137 Ave. & 128 St.
16-B	G-3189	21	Recharge/Storage		SW 207 Ave. & 120 St.
21-1	G-3108	15	Residential,Agric.		SW 202 Ave. & 232 St.
21-3	G-3177	22	Recharge/Storage, Agric.		SW 237 Ave. & 280 St.
22-1	G-1362	33	Residential,Agric.	No	SW 157 Ave. & 168 St.
22-2	G-614	18	Residential,Agric.	No	SW 157 Ave. & 232 St.
22-4	G-1486	20	Residential,Agric.	Yes	SW 152 Ave. & 284 St.
23-1	S-182	51	Residential,Agric.	Yes	SW 104 Ave. & 185 Terr.
27-1A	G-1615	12	Residential,Agric.	No	SW 182 Ave. & 296 St.
C	G-1617	36			
D	G-1618	45			
E	G-1619	61			
27-2		27	Residential	Yes	SW 162 Ave. & 320 St.
27-3		20	Undev., Bus.		US 1 & SW 296 St.
28-1B	G-3184	21	Recharge/Storage	No	SW 232 Ave. & 392 St.
28-3	G-864	20	Residential/Agric.	No	SW 192 Ave. & 352 St.

Fecal coliform

Fecal streptococci

Major inorganic ions

Calcium

Sodium

Potassium

Magnesium

Sulfate

Chloride

Fluoride

Nutrients

Ammonia

Total organic nitrogen

Nitrate

Nitrite

Total kjeldahl nitrogen

Ortho-phosphate

Total phosphorus

Pesticides (September, 1981)

Aldrin

Chlordane

Chlordane

DDE op'

DDE pp'

DDD op'

DDD pp'

DDT op'

Dieldrin

Endrin

Heptachlor epoxide

Volatile organic compounds

Vinyl chloride

Vinylidene chloride

Trans-1,2-dichbroethane

1,1-dichloroethene

Trichloro-methane

1,1,1-Trichloro-ethane

1,2-dichloroethane

Tetrachloro-methane

Trichloroethylene

Bromodichloromethane

Tetrachloroethylene

Chlorodibromo-methane

Chlorobenzene

Tribromo-methane

O,M,P-chlorotoluene

M,P-dichlorobenzene

O-dichlorobenzene

Lindane
Methoxychlor
Mirex
Toxaphene
Heptachlor

Herbicides (September, 1981)

2,4, -D
2,4,5, - TP (Silvex)

Other parameters

Total filterable residue
Phenols
MBAS (detergents)
Color
Turbidity

As mentioned above, analysis for trace metals, volatile organics, pesticides and herbicides are more specialized and time-consuming. These parameters will be done initially for all wells in the network (to establish baseline groundwater quality) and later on a more site-specific basis. Volatile organics were sampled for chemical analysis during the 1983 dry season sampling. An additional sampling for these compounds will occur during 1984, as will the initial sampling for trace metals.

Specific Conductance is the ability of a substance to conduct an electric current, and is reported in micromhos per centimeter at 25° Centigrade. The measurement provides an indication of ion concentration. Natural waters are not simple solutions, and contain a variety of both ionic and undissociated species. However, conductivity readings are very useful in a practical way as general indications of dissolved solids concentrations. Most recently, this parameter has been utilized for water quality planning in Everglades National Park (Flora and Rosendahl, 1981).

Conductivity readings were generally in the 350-700 micromho range, which is consistent with past groundwater information in Dade County (for example, see recent U.S. Geological Survey reports). The only specific values which fell out of this range were obtained at sites near the inland extent of seawater intrusion (11-6 and 11-7) and another site showing contamination from a flowing artesian well (21-1). The sparsely populated wetland areas in northwest Dade (10-1 and 10-2) showed values in the 500-700 mmho range (some stations in this area were influenced by nearby canals which contained more mineralized water -- see section on "Major Inorganic Ions", p. 7).

pH, or hydrogen-ion activity, is expressed in logarithmic units, the abbreviation "pH" representing the negative base -10 log of the hydrogen-ion activity in moles per liter.

Most groundwaters have a pH range from around 6.0 to 8.5, but there is much variation. In the network, values ranged from 6.70 to 7.14.

Alkalinity is defined as the capacity of a solution to neutralize acid at a specified pH value. In Dade groundwaters, nearly all alkalinity is produced by dissolved bicarbonate ions (see discussion under Major Inorganic Ions), and is expressed as equivalent concentrations of calcium carbonate.

In the groundwater network, alkalinity generally ranged from 150 mg/l to 300 mg/l. Levels thus far have appeared consistent for a given station. Some variation can be expected, as processes releasing carbon dioxide (such as sulphate reduction) can contribute to higher values of alkalinity.

Temperature ranged from 24.5 to 30.0° Centigrade for the wells sampled. It might be expected that the shallow wells would show the highest temperatures and the deeper ones lower temperatures; this holds true in some cases, but from the available data no trend is evident. At this time the above temperature range will be considered normal for the rainy season.

Indicator Bacteria (see also discussion under the Monthly Canal Program, p. 70). Total and fecal coliform and fecal streptococci were sampled (9/81) for twenty-two (22) shallow wells (less than 30 feet), since past experience has shown that bacteria in groundwater are generally short-lived and found close to the source of contamination. Results showed that no bacteria problems are evident in the network.

Major Inorganic Ions. The occurrence and proportions of the major inorganic ions impart some of the water's physical properties (hardness, dissolved solids, etc.). More complete background information with regard to major inorganic ions (and nutrients) in Dade's groundwater is presented in the report describing the groundwater network (DERM, 1981a, pp. 4-5) and the references contained therein.

The major dissolved cations (positively charged ions) include calcium, magnesium, sodium, and potassium; the major anions (negatively charged ions) are sulfate, chloride, fluoride and those ions (generally assumed to be carbonate and bicarbonate) contributing to alkalinity. Groundwater in Dade County is dominated by calcium and bicarbonate, with chloride, sulfate, potassium, sodium and magnesium being, for the most part, less significant. These ions are largely the dissolution products of the geologic materials comprising the aquifer (principally limestone). Carbonic acid, formed by carbon dioxide dissolving in the groundwater, leaches the limestone, forming large quantities of calcium bicarbonate.

In some portions of South Florida, particularly in undeveloped marshes such as the Water Conservation Areas, concentrations of the inorganic ions in groundwater reach a maximum at the end of the dry season and then decrease due to dilution (surface water often shows the opposite tendency, due perhaps to precipitation during the dry season). In the county network, however, no such trend was seen consistently, which may or may not be due to the lack of data collected thus far.

Calcium is the principal cation in most natural fresh waters. Concentrations in the network far exceed those of the other cations (magnesium, sodium, and potassium) combined. The element is widely distributed in the common minerals of rocks and soil.

Calcium concentrations averaged 95 mg/l for all events (range of 83 to 109), and average concentrations were slightly higher for the wet season (100 mg/l, with 94 mg/l for the dry). These slight variations are not considered significant at this time.

Magnesium can substitute for calcium (as in the mineral dolomite) and along with calcium is the principal source of hardness in water. Geochemical behavior, however, is substantially different -- magnesium ions are smaller and, therefore, have a stronger charge density and a greater attraction for water molecules.

Magnesium concentrations in the network were low (average of 4.3 mg/l) despite the fact that limestones generally contain a moderate amount of magnesium. Stations showing the highest concentrations were located near salt-intruded areas, i.e., 11-6 (average of 9.5 mg/l) and 11-7 (average of 22 mg/l), or sites in the northwestern and western background areas: site 3-1 (9.5 mg/l, probably influenced by canal water), 10-1 (9.2 mg/l), 9-1A (7.3 mg/l), and especially 10-2 (17.85 mg/l), which was heavily influenced by a wet season (1983) maximum of 55 mg/l, the highest concentration yet observed in the network. Dry and wet season average concentrations were nearly identical.

Sodium is the most abundant member of the alkali-metal group. When brought into solution, it tends to remain in that status. There are no important precipitation reactions that can maintain low sodium concentrations in the way that carbonate precipitation controls calcium concentration. Sodium is retained by adsorption onto mineral surfaces, especially those with high cation exchange capacities such as clays (which are rarely found in the Biscayne aquifer in Dade County).

Sodium concentrations generally were below 20 mg/l (all-station average of 26 mg/l) and were highest in the salt-intruded stations (11-6 and 11-7 averages of 57 and 157 mg/l), the northwestern and western wetland areas (3-1, 10-1, 10-2, and 9-1 ranging approx. 30-40 mg/l on the average), and some stations located in unsewered areas where septic tanks are utilized (e.g., 11-3, 14-1, 14-2, 14-3, 14-4, 14-5, 14-6, and 15-1).

Concentrations for the dry season samplings were approximately 32% higher than those of the wet season.

Potassium is another alkali metal, but behaves differently than sodium. Sodium tends to remain in solution rather persistently once it has been liberated from silicate mineral structures. Potassium is liberated with greater difficulty from these minerals and exhibits a strong tendency to be reincorporated into solid weathering products, especially certain clay minerals.

Concentrations of potassium tend to be much lower than those of sodium in most natural waters, and this was true in Dade's network (all-station average of 5 mg/l). The (relatively) high occurrences showed some of the same tendencies as sodium, that is, at stations just inland of the salt front (11-6) and stations influenced by septic tank effluent (11-3 and 14-1). Additionally, some sites in south Dade showed elevated concentrations, possibly resulting from fertilizer application (28-1, and 21-3).

In a departure from the tendencies of sodium, potassium concentrations were nearly identical from wet to dry seasons.

Sulfate concentrations were found to vary greatly over the county. This is largely due to the fact that the chemistry of sulfur in groundwater is controlled by many factors, particularly the presence of anaerobic bacteria and availability of oxygen, but also by pH, other dissolved ions in solution, and plant utilization. Although much sulfur might be available in the environment, the reduction of sulfate to sulfide by anaerobic bacteria can lower the sulfate concentration.

The highest concentrations appeared at stations 11-6 and 11-7 (averages of 55 and 85 mg/l respectively), which are located near the inland extent of seawater intrusion, site 21-1 (87 mg/l), which is influenced by a flowing artesian well in Chekika Hammock State Park, and site 1-2 (42 mg/l) in north Dade (located adjacent to and influenced by the Biscayne canal), and some stations in south Dade, notably 22-1 (70 mg/l), 22-2 (59 mg/l), and 28-3 (53 mg/l). In general, sulfate concentrations in south Dade are considerably higher than those in north Dade. This is due to the greater permeability of the aquifer in south Dade, allowing oxidation of sulfide to sulfate, as well as to agricultural enrichment.

The samplings thus far show no wet-dry season trend, and though there is much variation in sulfate concentration from site to site, concentrations tend to be fairly consistent at individual sites from one sampling event to the next.

Chloride shows a more subdued chemical behavior in groundwater when compared to the other major ions. Chloride ions do not significantly enter into oxidation or reduction reactions, form no important solute complexes with other ions, do not form salts of low solubility, are not significantly adsorbed on mineral surfaces, and play few vital biochemical roles. The circulation of chloride ions in the hydrologic cycle is largely through physical processes. As such, this ion can be utilized as a measure of certain sources of pollution, such as septic tanks, dumps, and industrial contamination.

Average chloride concentration for the network was 58.6 mg/l; highest concentrations were observed at the following: 11-6 and 11-7

(266 and 565 mg/l, respectively, influenced by seawater intrusion), 21-1 (115.5 mg/l, artesian well influence), 9-1A&B (83 & 80.5 mg/l, influenced by mineralized water flowing from the north through the L-67A Canal, then westward along the Tamiami Canal via the S-12 structures), and 3-1 (affected by the Miami Canal as it enters Dade County after flowing south through agricultural areas and Water Conservation Area 3A). Chloride concentrations in the background areas of northwest Dade (sites 10-1 and 10-2) averaged approximately 75 mg/l. No seasonal trend has surfaced for chloride.

Fluoride concentration was also examined. This constituent is naturally occuring and sometimes larger amounts may be derived from deeply-buried residues left from former invasions of the sea. Though detected at all localities (all-station average of 0.19 mg/l), only one site in the network showed a fluoride concentration approaching 1 mg/l (11-7, 1983 wet season, 0.98 mg/l). No seasonal trend appeared, and though some stations consistently showed higher concentrations than others, data at this time is insufficient to account for this.

Nutrients are essential for the growth, maintenance, and regeneration of life. Certain nutrients (such as oxygen, hydrogen, and carbon) are abundant and generally available in sufficient amounts. Nitrogen and phosphorus compounds, however, are sometimes limited in their concentration and distribution. The nitrogen and phosphorus species analyzed in the groundwater sampling are listed on page 3. Although nitrogen and phosphorus are naturally occurring, they also may be added to the groundwater system via contamination from septic tanks, dumps, stormwater runoff, sewage effluent, and fertilizer application.

The dominant nitrogen species depends largely upon the geology and soils of the area. In the northern part of the county there is a greater proportion of sand to limestone, which lowers permeability and facilitates reducing conditions, leading to the formation of ammonia. Additionally, decaying organic matter in the muck soil of the (undeveloped) northwestern portion of the county produces ammonia and organic nitrogen. In south Dade, the highly permeable limestone substrata promotes oxidation, which favors the occurrence of nitrate. Agricultural practices in this part of the county also contribute nitrate.

The southernmost stations (grids 21, 22, 23, 27, and 28 on figure 1) show low ammonia concentrations with higher nitrates (at least partially due to fertilizer application). Conversely, stations north of grids 21-22-23 show higher levels of ammonia with lower nitrates. Total organic nitrogen concentration appears similar for both areas (approximately 0.70 mg/l).

Site 2-2 in Hialeah is an exception to the above tendency, showing nitrate concentrations around 1.5-2.0 mg/l with low (less than 0.23 mg/l) ammonia. Site 11-5 (central Dade) exhibits similar tendencies. Interestingly, site 2-2 is one of two sites in the network (two sampling events, 9/81 and 4/82) with nitrite concentrations above detectable limits.

Stations located proximal to septic tanks have exhibited higher nitrogen concentrations in samplings to date. Sites 11-3 and 14-1 (both included in a past USGS septic tank study - Pitt and others, 1975) register consistently elevated ammonia levels. Site 27-1 (also included in the above referenced USGS study) is the only site in south Dade to record an event with an ammonia concentration greater than 1 mg/l (4/82 sampling, 2.10 mg/l). This site is the only one in the overall network with elevated concentrations of both ammonia and nitrate (most likely a combination of contributions from fertilizer application and septic tank effluent).

Ortho-phosphate and total phosphorus concentrations are low throughout the network. Ortho-phosphate, which is readily assimilated by plants, averaged 0.018 mg/l in the wet season and 0.020 for the dry season sampling. Most of this nutrient is complexed with calcium ions, which chemically binds the phosphorus to limestone.

Total phosphorus, which includes phosphorus tied up in living cells and in detrital material, averaged 0.024 for the wet season and 0.030 for the dry.

Obviously, these numbers are very low and delineation of any trend is difficult at best. In the undeveloped (background) parts of northwest Dade (sites 3-1, 10-1, and 10-2), ortho-phosphate and total phosphorus concentrations are even lower than the averages given above (of the nutrients, phosphorus is generally the limiting factor in these wetland areas). Using this as an indication, the septic tank monitoring stations (1-1, 2-2, 11-3, 14-1, and 27-1) generally exhibit elevated concentrations.

Chlorinated Insecticides and Herbicides. Chlorinated insecticides were analyzed at all sites (9/81) and those detected are listed as follows:

Site	Compound(s) present
1-1	0.001 ug/l p.p.'DDE
1-2	0.001 ug/l Dieldrin
1-3	0.0026 ug/l Dieldrin
11-3	0.002 ug/l Dieldrin
12-1	0.001 ug/l Dieldrin

No other detections were recorded at any other site (detection limits are given in Table 2 for the substances examined).

The herbicides 2,4-D and 2,4,5-TP (Silvex) were analyzed for all sites with no detections.

Volatile Organic Compounds were sampled during the 1983 dry season at more than half of the wells in the network (concentrating mainly on the shallow wells). A few very low occurrences were noted (see Table 3).

An additional sampling of these compounds will occur in 1984 at selected stations.

Table 2

Detection Limits for

Chlorinated Insecticides and Herbicides (ug/l)

Chlorinated Insecticides:

Lindane	0.0005
Aldrin	0.0005
Heptachlor Epoxide	0.0010
o,p-DDE	0.0010
p,p-DDE	0.0010
-chlordane	0.0010
-chlordane	0.0010
O,p-DDD	0.0010
p,p-DDD	0.0025
o,p-DDT	0.0025
Dieldrin	0.0010
Endrin	0.0025
Methoxychlor	0.0075
Mirex	0.0035
Toxaphene	0.010
Heptachlor	0.005

Herbicides:

2,4-D	0.001
2,4,5 TP(Silvex)	0.001

Table 3

Detections of Synthetic Organic Compounds
at DERM Groundwater Stations
(5/83)

PARAMETER (in ug/l)	STATION 10-2	STATION 11-5	STATION 11-7	STATION 14-1	STATION 23-1	STATION 27-2	STATION 27-38
Vinyl Chloride			0.25				
Vinylidene Chloride							
Trans 1,2-Dichloroethene				.05			
1,1-Dichloroethane			.04	.13			.11
Cis 1,2-Dichloroethene			1.76	6.27			
Trichloromethane		.93			.10	.03	.09
1,1,1-Trichloromethane 1,2-Dichloroethene Tetrachloromethane	.08						Trace
Trichloroethylene			1.21	.05		.12	
Bromodichloromethane							.41
Tetrachloroethylene					.13	.15	Trace
Chlorodibromomethane							
Chlorobenzene							
Tribromomethane							
o,m,p-Chlorotoluene							
m,p-Dichlorobenzene							
o-Dichlorobenzene							

Other Significant Parameters. In addition to the parameters already mentioned, turbidity, color, total filtrable residue, methyl-blue activated substances (MBAS), and phenols were also examined.

Turbidity in groundwater is generally used to determine well damage or construction residue. Turbidity was examined for the 1982 and 1983 samplings and levels generally stayed below the 10.0 NTU mark. There were some higher occurrences, however, and more data is needed.

Color is a physical property which has no chemical significance. Color (reported in platinum-cobalt units) tended to be highest (40-80 pcu) in the northern and northwestern areas, and lowest (5-30 pcu) in the central and southern parts of the county.

The higher colors tend to be the result of leaching of organic debris. However, the color number is purely empirical and has no direct connection with the actual amount of organic material present.

Total Filtrable Residue is the anhydrous residue of the dissolved substances in water. Water with several thousand mg/l of dissolved solids is generally not potable, and the U.S. Public Health Service recommends that the maximum concentration of dissolved solids not exceed 500 mg/l in drinking water (this is also Dade County's standard). Generally, most industrial users will not tolerate concentrations higher than 1000 mg/l. Water with less than 1000 mg/l of dissolved solids is considered non-saline, with concentrations of 1000 to 3000 mg/l being considered slightly saline.

All stations in the network showed average levels well below 1000 mg/l, save for 11-5 (average of 1470 mg/l), 11-6 (840 mg/l), and 11-7 (1145 mg/l). The trend for the latter two correlates with chloride and specific conductance results, and is doubtless due to the location of these stations with respect to the salt front. 11-5 showed low chloride and conductance levels, but did report the highest turbidity in the network (by an order of magnitude). It is possible that this well has been damaged or is receiving surface runoff.

MBAS can persist in waters which have been contaminated by sewage effluents. One mg/l is sufficient to cause a noticeable froth in water, and higher concentrations can be a serious problem. All results were well below this level, with the exception of the dry season 1983 value at 11-7 (0.984 mg/l). Until further clarification comes from future samples at this site, the value will be considered anomalous.

Phenols indicate a broad spectrum of organic substances. The source of phenolic compounds may be naturally occurring or from industrial waste, domestic sewage, or pesticides. An excess of phenols may cause odor in water supplies, although health limits are orders of magnitude higher (3 mg/l - the numbers discussed in this section of the report are all much smaller, in ug/l).

Previous groundwater investigations in Dade and Broward Counties have indicated that phenol concentrations, even in background areas, are consistently high. This is verified by the results of the groundwater sampling thus far. Phenols are high in samples from background areas (Sites 3-1, 10-1, and 10-2). These stations are located in the Area B floodplain (between Krome Avenue and the Palmetto Expressway), which is an area receiving the major overflow from the Everglades. Before development, this overflow went through the Miami River. The vegetation of the area consists largely of melaleuca trees, an exotic species which invades wetlands and serves as a source of phenolic compounds. Results to date indicate an average level of 7.5 ug/l for stations 3-1 and 10-1, and 4.7 for station 10-2. The network as a whole averaged 5.3 ug/l.

Results approaching 10 ug/l (and sometimes greater) are also seen at some stations in the sparsely populated areas of south Dade, including agricultural lands. Some stations near residential areas around the Snapper Creek Canal had lower levels than had been reported from previous studies (Snapper Creek Intensive Canal Study in DERM, 1981b, p. 19). Highest concentrations in the network thus far have been obtained at station 11-7 (38.8 ug/l in 9/82 and 22.5 ug/l in 5/83). No seasonal trend has evidenced itself in the results thus far.

In summary, phenol levels can be characterized as high throughout Dade County, although not nearly approaching health limits. It has been speculated these high levels, even in background areas, may be due in part to exotic vegetation.

Landfill Monitoring Program

Dade County Department of Environmental Resources Management is presently conducting a groundwater monitoring program at three county landfills: North Dade, N.W. 58th Street (Main) and South Dade. The program consists of 10 parameters sampled from 48 multi-depth wells on a quarterly basis, and supplemented as results warrant.

The program encompasses existing sites that lack groundwater quality protection and includes a sanitary landfill (South Dade) with a low-permeability underliner and leachate collection system. Hence, the monitoring program has two purposes:

a.) Interpretive monitoring for the existing North Dade and 58th Street sites to assess the extent of contamination and evaluate the effectiveness of remedial measures. Wells are located upgradient (background) and downgradient to the apparent extent (leading edge) of contamination. The wells typically are placed in multi-depth clusters to provide a vertical cross-section of the aquifer.

b.) Detective monitoring is used at the new South Dade Landfill to insure that the contaminant system is performing properly. Wells are located at shallow depths around the perimeter of the site as an "early warning" system for the detection of any failures or improper operation.

Water samples are collected from the monitoring wells for ten (10) parameters on a quarterly basis. These parameters were selected from past experience as being indicators of landfill contamination and/or potential health threats if found in significant concentrations:

Ammonia Nitrogen	Chemical Oxygen Demand
Total Organic Nitrogen	Cadmium
pH	Chromium
Phenols	Mercury
Conductivity	Lead

Other parameters (pesticides/volatile halogenated compounds) are also monitored on a site specific basis.

Evaluation of the effect of the landfills on groundwater quality can be determined by a comparison of background and downgradient data. Background data represents normal water quality in the area. Downgradient data indicates any detrimental influence of the landfill operation.

Contaminants resulting from the landfill are subject to dilution and attenuation and usually decrease in concentration with increased downgradient distance from the site. It should also be noted that contaminant release and groundwater flows are affected by seasonal precipitation infiltration, duration and intensity of operations, and other complex factors. Therefore, it is usually necessary to accumulate a substantial data base to make a meaningful interpretation regarding water quality trends.

It should be noted that DERM (Department of Environmental Resources Management) has identified 51 present and former disposal sites in Dade County. (DERM, 1983, Residual Effects of Former Solid Waste Sites in Dade County - Phase I Report.) Seven of the 51 sites presently submit monitoring data to DERM for review. Four additional sites will be monitored by DERM during 1984 in conjunction with the aforementioned study of solid waste sites. Only landfill sites monitored by DERM are included in this report.

North Dade Landfill

Data collected during 1981-83 indicates that landfill contaminants are migrating toward the south. Monitoring well cluster N-2A located on the landfill's south boundary displayed the greatest effects of this phonomenon with elevated levels of ammonia, conductivity, COD, phenols and chromium recorded from 1981-83. Well clusters N-5A and N-7, also south of the landfill but across Snake Creek Canal, displayed elevated amounts of the primary leachate indicators from 1981-83 though not as severe as in well cluster N-2A. Downgradient cluster N-8 (southeast of the disposal facility) showed no indication of contamination during this time.

Herbicides and pesticides attributed to landfill activity were not detected.

58 Street (Main) Landfill

Well cluster M-4a, located within 58 Street Landfill boundaries reported concentrations of ammonia nitrogen, conductivity, COD and chromium significantly higher than background during 1981-83 and elevated levels of phenols from 1982-83. This cluster monitors pollutants emanating from the landfill.

Downgradient well clusters M-5a and M-6a, located directly east of the landfill, also indicated an influence from the disposal site during 1981-83, although not as severe as displayed in well cluster M-4a.

Remaining clusters M-7a, M-8, M-9 and M-10, further east and southeast, also displayed occasionally elevated concentrations of the primary leachate indicators.

Some herbicides and pesticides were detected in individual samplings during this time, however these concentrations were within recommended criteria.

South Dade Landfill

Well cluster S-4/4a, located along the eastern perimeter of the South Dade Landfill, monitors pollutants migrating from landfill where background concentrations of most of the primary leachate indicators repeatedly have been exceeded from 1981-83. Concentrations of ammonia nitrogen, COD and phenols have consistently been reported above background in this cluster.

The remaining perimeter well clusters, S-2 and S-3, also demonstrated pollutants from the disposal site in various degrees, although concentrations were not as severe as displayed in cluster S-4/4a.

Downgradient cluster S-5 experienced elevated concentrations of the indicator parameters intermittently during the three years. However, since this cluster monitors a salt water intruded area, it is possible that salt water influences are reflected in the data results.

Some herbicides and pesticides were detected in individual samplings during this time, however these concentrations were within recommended ground water quality standards.

In summary, the background contaminant levels associated with landfill operations have been observed at monitoring wells immediately downgradient from the three discussed landfill sites. However, at no time have metal concentrations exceeded Dade County groundwater quality standards. Herbicide and pesticide levels, although detected at the 58 Street and South Dade Landfills, never exceeded recommended groundwater quality standards criteria.

The North Dade Landfill

The North Dade landfill, located on 300 acres near the northern boundary of Dade County at N.W. 47th Avenue and 216th Street, commenced operation in the early 1950's. Originally, garbage and trash were deposited upon the existing ground surface as well as in excavated trenches of various depths. Cover was applied on an infrequent basis.

Recent operations consist of placing trash over a previously deposited area in the western portion of the site and the application of frequent cover. This facility ceased accepting of garbage in July 1981 and formally closed to all waste in March 1982.

A recently closed landfill is located directly east of the North Dade facility. The Florida Turnpike lies along the site's northern boundary and Snake Creek is on the southern border. Agricultural activity is conducted to the west of the site.

The Biscayne aquifer is approximately 100 feet thick in this area. The aquifer in North Dade consists of alternating layers of limestone and sand. Groundwater movement is to the southeast, with some southerly influence imposed by the Snake Creek Canal. (McKenzie, 1982)

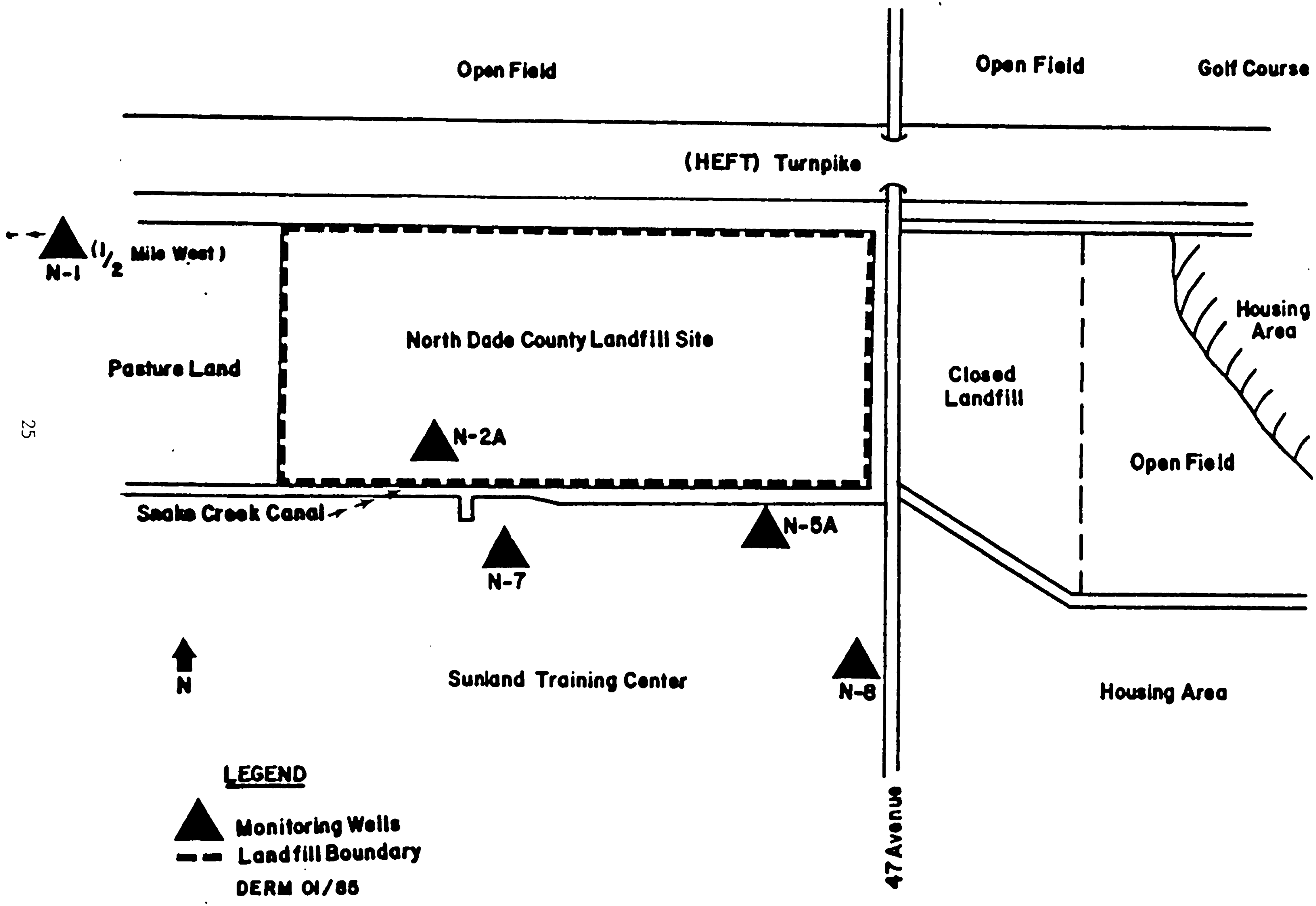
Location of Monitoring Wells

Location of the groundwater monitoring wells was based on the results of a 1978 U.S.G.S. sampling program resistivity survey and knowledge of current operations. The current groundwater monitoring program consists of five multi-depth well clusters as follows:

Well Clusters	Well Depths (Below Surface)	Comments
N-1	23' & 47'	Original U.S.G.S. wells used for background data (black iron casing).
N-2A	30' & 65'	New wells installed in 1980-81 approximately 100 feet north of original U.S.G.S. Cluster N-2. N-2A wells drilled deeper due to its location along the southern perimeter of the landfill site in an area of previously deposited solid waste. (Cased with PVC pipe.)
N-5A	25' & 48'	New downgradient well cluster located 200 feet south of original U.S.G.S. Cluster N-5. (Cased with PVC pipe), south-southeast of landfill, south of Snake Creek.
N-7	25' & 60'	New downgradient well cluster, (cased with PVC pipe) located south of landfill and south of Snake Creek.
N-8	25' & 60'	New downgradient well cluster, (cased with PVC pipe), located approximately ¼ mile southeast of landfill.

See Figure [2] for location of monitoring wells

FIGURE 2 Groundwater monitoring wells for the North Dade Landfill



Sampling at the North Dade landfill began in April 1981, utilizing the new replacement well clusters. Subsequent samples have been taken on a quarterly basis through 1983. Data evaluation will include a comparison of 1981, 1982 and 1983 parameter concentrations.

Data Discussion

Ammonia Nitrogen (NH_3-N)

Background ammonia nitrogen concentrations at well cluster N-1 were generally consistent, ranging from 1.50 - 1.88 mg/l over the three year monitoring period with an average of 1.67 mg/l.

Well cluster N-2A, located along the landfill's southern boundary, exhibited high levels of ammonia nitrogen. Concentrations 50-65 times background were reported at the shallow well (30'). Deeper well N-2A(65) produced concentrations approximately 15 times background values.

Ammonia levels 1.6 to 4 times background values were detected at well N-5A(48), located southeast of the landfill. All other wells reported background ammonia concentrations.

Wells N-2A(30) and N-5A(48) exhibited decreasing NH_3-N concentrations during the three year period. Well N-2A(65) average ammonia levels varied slightly from 1981 to 1983.

It should be noted that inconsistencies appeared in the October, 1981 ammonia data, with most wells (including background) depicting values two to three times above other reported data. Due to the apparent skewing of the October ammonia data, it was not considered in this evaluation.

Conductivity (Specific Conductance)

Average conductivity values at background well cluster N-1 varied annually from 606 to 713 umhos/cm during the three year period. Due to this data range, downgradient well concentrations were compared with background values during each respective year.

Well cluster N-2A reported average conductivity levels two to three times background values at both the shallow (30') and deep monitoring wells (65'). Well N-5A(48) slightly exceeded background data in 1981. 1983 conductivity values in the aforementioned wells are lower than 1981 levels.

All other wells exhibited background conductivity values.

Chemical Oxygen Demand (COD)

Background well cluster N-1 reported annual average COD values from 47 to 62 mg/l from 1981 through 1983.

Both wells at cluster N-2A displayed COD values two to three times background concentrations during the three year period. Concentrations decreased from 1981 to 1983 at these wells.

Downgradient wells N-5A(25), N-5A(48) and N-7(25) reported COD values exceeding background concentrations during the three year period. Well N-5A(25) decreased in COD concentrations from 1981 to 1983 while data from wells N-5A(48) and N-7(25) vacillated during the same period.

Phenols

Generally, phenolic concentrations increased in all monitoring wells from 1981 through 1983. Background well N-1 reported averages of 2 ug/l in 1981 and 7.2 ug/l in 1983. Due to the variable data during the three year period, downgradient concentrations were compared with their respective annual background levels.

Shallow and deep wells at well cluster N-2A exhibited phenols three to seven times their corresponding background levels during 1981 through 1983. These wells also increased in average concentrations over the three year period.

With the exception of one elevated phenol sample in 1982 at well N-5A(48), all other monitoring data were within background values.

Cadmium (Cd) values from the North Dade monitoring wells in 1981 and 1982 were near or below detectable limits (0.1 ug/l). Wells N-2A(65) and N-8(25) reported elevated Cd concentrations during one sampling in 1983 which may have been an anomaly.

Chromium (Cr) background levels from 1981-1983 averaged 2 ug/l.

Wells at cluster N-2A (shallow and deep) reported Cr concentrations 2 to 13 times their corresponding background values during the three year period. A decrease in concentrations at all other well sites was reported during this time period.

Well N-5A(25) displayed Cr values exceeding background levels which gradually increased from 1981 to 1983.

No chromium concentrations exceeded the Dade County groundwater standard of 0.05 ug/l during the three year period.

Mercury (Hg) values from background well cluster N-1 averaged 0.3 ug/l from 1981-83.

Wells N-2A(30), N-5A, N-7 and N-8 reported above-background values only during the third sampling event in 1981. In 1983, with the exception of third quarter Hg results at well N-2A(65), all other mercury data approximated background.

Lead (Pb) values generally vacillated during 1981 and 1983. Pb data from background well cluster N-1 exceeded downgradient values in 1981 and appears inconsistent with the 1982-83 average data range of 1.5 ug/l at this site.

1982 lead data were generally more consistent and displayed values approximating background at all well locations.

Third quarter sampling in 1983 exhibuted elevated lead values at almost all wells at the North Dade site. Excluding these samplings, only well N-2A(30) displayed concentrations slightly in excess of background data.

The lead groundwater standard of 0.05 mg/l was not exceeded at any well site during 1981-83.

Chlorinated Insecticides and Chlorophenoxy Herbicides

Except for background well N-1(23) which reported 0.0016 ug/l op'-DDE in October 1981, no insecticides or herbicides have been detected during the 1981-1983 monitoring period.

Data Summary

Well cluster N-2A, located on the southern perimeter of the North Dade site consistently reported substantially above-background concentrations for ammonia nitrogen, conductivity, chemical oxygen demand, phenols and chromium during 1981 through 1983. Lead (Pb) values were also elevated at the shallow well N-2A(30). Phenols and Lead concentrations increased at this well cluster during 1981-1983 while conductivity, COD and chromium values declined. Ammonia nitrogen concentrations decreased at the shallow well (30') while varying slightly at the deeper well (65') during this period.

Downgradient well clusters N-5A and N-7, located south of Snake Creek, also indicated an influence from the disposal site during 1981 through 1983, although not as severe as displayed in well cluster N-2A. Chemical oxygen demand concentrations exceeding background levels were present in shallow and deep wells at cluster N-5A and the shallow well at N-7. Average COD concentrations declined during the three year period at well N-5A(25), but remained approximately constant at wells N-5A(48) and N-7(25).

The deep well N-5A(48) was the only well in the cluster which displayed excess levels of ammonia nitrogen and conductivity. These levels declined from 1981-1983.

Above-background chromium values were observed at shallow well N-5A(25). Chromium concentrations increased during this period.

Downgradient cluster N-8 displayed no indication of contamination associated with the landfill during 1981-83.

In summary, above-background contaminant levels associated with the landfill operation have been observed at monitoring wells immediately downgradient from the site. However, no metal concentrations exceeded groundwater standards and no herbicides or insecticides were detected during 1981 through 1983 that could be attributed to the former landfill activity.

N.W. 58th Street (Main) Landfill

The one square mile facility, located near N.W. 58th Street and 87th Avenue, commenced operations in 1952. Originally, waste was placed in shallow trenches with cover materials applied on an infrequent basis. As operations were improved, waste was placed over previously filled areas and a low-permeability material (calcium carbonate) was used for under- and overlayment to minimize precipitation leaching.

The landfill closed to solid waste disposal October 1, 1982 and operated as a clean construction/demolition site until final closure in 1985.

The 58th Street landfill is located in a multi-use area with warehousing and industry to the east, commercial use along the southern boundary, a solid waste recovery plant on the west and a major quarrying operation to the north. The site is underlain by the Biscayne aquifer which is comprised of alternating layers of permeable limestone and sand to a depth of approximately 70-100 feet.
Groundwater movement is generally to the east with a slight northeastern influence from the Medley Wellfield during intermittent pumpage. (Due to the influence of industrial activities on groundwater quality, the Medley Wellfield was recommended closed in 1982.)

Well Locations

The Groundwater Monitoring Program conducted by DERM commenced in July 1980, utilizing existing operational wells installed by the U.S. Geological Survey in 1973. The original wells were replaced and site locations were expanded during 1981. The present program consists of eight multi-depth well clusters identified as follows:

Well Clusters	Well Depths (Below Surface)	Comments
M-2	10' & 40'	Original U.S.G.S. well cluster. (Cased with black iron pipe.)
M-4A	20', 40', 64'	New cluster, located 200 feet north of original U.S.G.S. Cluster M-4. Wells drilled deeper due to deposited solid waste. (Cased with PVC pipe.)
M-5A	10', 30', 60'	New cluster, located 200 feet north of original U.S.G.S. cluster M-5. (Cased with PVC pipe.)
M-6A	10', 30', 60'	New cluster, located 200 feet north of original U.S.G.S. cluster M-6. (Cased with PVC pipe.)
M-7A	15', 30', 60'	New cluster, located 50 feet east of original U.S.G.S. cluster M-7. Shallow well drilled additional 5' depth to accommodate maximum drawdown of nearby Medley Wellfield. (Cased with PVC pipe.)
M-8	10', 30', 60'	New well cluster. (Cased with PVC pipe.)
M-9	10', 30', 60'	New well cluster. (Cased with PVC pipe.)
M-10	10', 30', 60'	New well cluster. (Cased with PVC pipe.)

See Figure [3] for location of DERM and U.S.G.S. wells

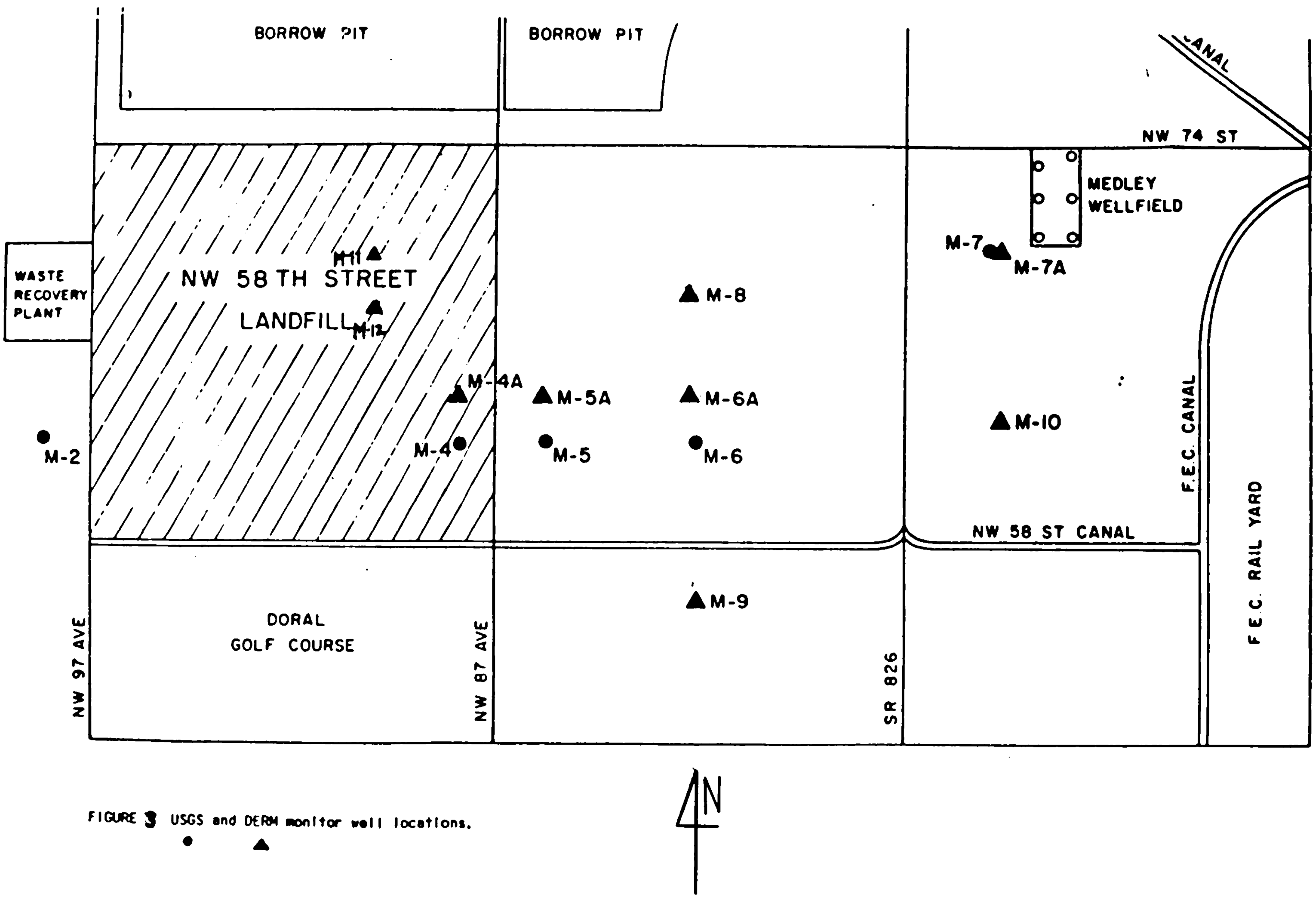


FIGURE 3 USGS ● and DERM ▲ monitor well locations.

Data Discussion

Ammonia Nitrogen

Background well cluster M-2, located west of NW 97 Avenue at approximately 64 Street, reported consistent annual average ammonia nitrogen concentrations ranging from 0.7 - 0.8 mg/l over the three year monitoring period.

Well cluster M-4a, located at the eastern portion of the landfill, displayed ammonia concentrations 20-100 times background. Concentrations increased slightly in all wells within this cluster from 1981-1983.

Ammonia levels slightly increased or remained constant from 1981-1983 for cluster M-5a, located approximately 1/4 mile downgradient from the landfill. Average yearly concentrations were 3-4 times background values.

Wells M-6a(10,30) vacillated slightly from 1981-1983. M-6a(60) slightly increased over the three year period. Wells in this cluster (approximately 1/2 mile downgradient) exhibited ammonia levels 20 times background concentrations.

Cluster M-7a, located 1½ miles northeast of the landfill, displayed concentrations similar to background for wells M-7a(30) over the three years and M-7a(15) for 1982-83. Elevated ammonia levels (1.8 mg/l) were recorded in 1981 for M-7a(15). M-7a(60) remained consistent over the three years with concentrations approximately 5 times background.

Well cluster M-8 is located approximately 1/2 mile to the northeast of the disposal site. Wells M-8(30) and M-8(60) displayed increasing concentrations from 1981-83. Concentrations within shallow well M-8(10) vacillated slightly from 1981 to 1983. All wells exhibit levels approximately 10-40 times background concentrations.

Concentrations of ammonia in the wells of cluster M-9 remained constant or slightly increased over the three years. The cluster, located 1/2 mile southeast of the site, displayed background concentrations in wells M-9(30) and M-9(60), while M-9(10) reported concentrations approximately 2-2.5 times background from 1981-83.

M-10, located 1½ miles east of the site, showed a slight increase in ammonia levels from 1982-1983. During this time, wells M-10(10) and M-10(30) reported ammonia levels slightly elevated above background while concentrations within the deeper well M-10(60) were approximately 8 times background concentrations. During 1981, cluster concentrations were unusually high, averaging between 5-10 times background values.

Conductivity

Average conductivity values at well cluster M-2 (background) varied from 460 to 525 umhos/cm during the period 1981 through 1983.

Well cluster M4-A reported the highest conductivity values during the evaluation period. Shallow well M4-A(20) displayed conductivity levels four times background concentrations. The mid-depth (30') and deep (64') wells also reported higher conductivity values, with three and two times background levels, respectively. The values at this cluster generally increased from 1981 to 1983.

Only one downgradient well, M7-A(30), displayed background values throughout the 1981-1983 period. All other downgradient wells displayed higher overall levels during this period ranging from slightly above background to four times background levels. Generally, downgradient levels increased from 1981 to 1982 and slightly decreased or remained constant from 1982 to 1983.

pH

Anomalous values were detected in well M-7a(15) from 1981 to 1983 ranging from 10.0 - 11.5 pH units. These values surpass background data of approximately 7.2 pH units and groundwater quality standards of 6.0 - 8.5 units. In addition well M-7a(30) displayed slightly elevated values ranging from 7.4 - 9.4 pH units over the three year period.

Chemical Oxygen Demand (C.O.D.)

Background COD values averaged over the three year period from 50 mg/l for the shallow wells to 40 mg/l for the deep wells. Downgradient well clusters M-4A, M-5A, M-6 and M-8 displayed consistent data for the three years averaging 1½ - 2 times background. Sample analyses from well clusters M-7a, M-9 and M-10 resulted in COD concentrations below background from 1981-1983. An anomaly occurred during the second sampling quarter 1981 for well M-9(60) in which the concentration of COD was three times background. All other M-9(60) sampling episodes produced data less than background.

Phenols

Generally, phenolic concentrations increased in all monitoring wells from 1981 through 1983. Background well cluster M-2 reported concentrations of 2 ug/l in 1981 to 6.9 ug/l in 1983. Due to the variable data during the three year period, downgradient concentrations were compared with their respective annual background levels. During 1981 most downgradient concentrations were within background ranges with the exception of M-5a(10) which yearly average 23 ug/l, and M-7a(15) and M-7a(30) which resulted in yearly averages of 56 ug/l and 12 ug/l respectively. During 1982-1983 well clusters M-9 and M-10, and well M-7a(60) produced data slightly above background. All other wells during this time were 2 - 6 times background averages with well cluster M-4A displaying the highest three year average.

Cadmium

Values from the 58th Street monitoring wells were generally near or below detectable limits (0.1 ug/l) in 1981-1983. Exceptions occurred in the third quarter 1983 for M-7a(15,60). Concentrations of 66 mg/l and 5.6 ug/l respectively were reported.

Chromium

Background levels from 1981-1983 averaged 1 ug/l with the exception of well M-2(10) which in 1982 displayed a yearly average of 2.2 ug/l.

During the three year monitoring period all downgradient wells displayed erratic concentrations of chromium ranging from 1 - 19 ug/l in 1981, 0.6 - 16.3 ug/l in 1982 and 0.8 - 5.6 ug/l in 1983. Well clusters M-9 and M-4A exhibited the highest average concentrations. However, as noted, chromium concentrations have been decreasing over the three years, reaching their lowest concentrations during 1983. At no time during this time period have chromium concentrations exceeded the groundwater quality standard of .05 mg/l.

Mercury

All wells for the three year period displayed mercury concentrations at or near the detection limit during most of the sampling quarters. Anomalous readings occurred in four wells during the third quarter 1981 in which the anomalous data ranged from 0.7 - 1.7 ug/l. During the first quarter 1981, M-9(10) displayed an elevated value of 2.3 ug/l. During 1982, M-8(10) (second quarter) and M-8 (30) (fourth quarter) recorded elevated results of 0.7 and 1.7 ug/l respectively, and in 1983, wells M-5a(30) (third quarter) and M-9(10) (first quarter) also displayed mercury concentrations exceeding background (0.7 and 1.7 ug/l respectively). During the three years, elevated concentrations fell to within background during succeeding sampling episodes.

Lead

Lead concentrations for 1981 range from 1.0 - 10.7 ug/l with yearly average background concentrations ranging from 2.9 ug/l (10' well) to 1 ug/l (40' well).

All 60' wells (with the exception of M-4a(60) which monitors groundwater directly under the landfill) as well as M-4a(20), M-8(10) and M-8(30) were within background values during 1981. All other downgradient wells were 2 - 5 times their respective backgrounds, but remained within the groundwater quality standard. Well M-9(60) displayed the highest lead concentrations during this year.

During 1982-83 background wells displayed concentrations less than 1 ug/l. Most downgradient wells displayed values equivalent to background with the exception of M-9(60). The groundwater quality standard was not exceeded during this period.

Chlorinated Insecticides and Chlorophenoxy Herbicides

During 1981 the pesticide op'-DDE was detected in wells M-4a(20) and M-4a(40) at .003 ug/l each. Pesticide pp'-DDE was detected in well M-7a(15) at .002 ug/l and in well M-9(10) at .008 ug/l. 1982 reported a decrease in pesticides detected. Additionally, background well M-2(10) was detected as having .06 ug/l of the herbicide 2,4-D during 1982 sampling. No herbicides or chlorinated insecticides were detected in 1983. Of the herbicides and pesticides detected, none exceeded applicable water quality standards.

Data Summary

Well cluster M-4a, located within 58th Street Landfill boundaries, consistently reported substantially above background concentrations of ammonia nitrogen, conductivity, COD and chromium during 1981-1983, and phenols from 1982-1983. COD remained consistent throughout the three years while chromium decreased. The remaining parameters increased in concentrations. Additionally, during 1981, lead concentrations were elevated but fell to within background during 1982-1983.

Downgradient well clusters M-5a and M-6a, located east of the landfill, also exhibited contaminants from the disposal site during 1981-1983, although not as severe as displayed in well cluster M-4a. Ammonia nitrogen, conductivity and COD were elevated in both clusters for the three years. Additionally, phenols were elevated from 1981-1983 for cluster M-5a, and from 1982-1983 for M-6a. Lead was elevated in 1981 for both clusters decreasing to within background levels for 1982-1983. Chromium concentrations, although above background values, decreased in concentration from 1981-1983 for M-5a and M-6a.

Well cluster M-7a displayed elevated concentrations of ammonia nitrogen, conductivity, chromium and lead intermittently over the three years. NH_3 was elevated in shallow well M-7a(15) during 1981 only, and in well M-7a(60) during the three monitored years. Conductivity was elevated in the 15 and 60 foot wells from 1981-1983 while remaining within background levels for the 30 foot well. pH was elevated in the 15 foot and 30 foot wells during all three years. Lead was elevated in all wells during 1981 only. Chromium decreased with time although remained above background. In addition, phenols were elevated and increased in concentration over the three years.

Ammonia nitrogen, conductivity, COD and chromium were elevated from 1981-1983 in cluster M-8. Phenols were elevated in these wells from 1982-1983 only, remaining within background ranges during 1981. Chromium, although elevated, decreased in overall concentration over the three years.

Clusters M-9 and M-10 displayed elevated values for ammonia nitrogen, conductivity and chromium for all wells in 1981-1983. However, in cluster M-9, only the shallow well exhibited ammonia nitrogen data above background. For both clusters, chromium concentrations decreased over the three years. Lead concentrations were elevated in all wells in 1981 and intermittently elevated from 1982-1983. Additionally, mercury concentrations were intermittently elevated for cluster M-9 over the three years.

Herbicide and pesticide sampling resulted in the detection of pp'-DDE in wells M-4a(20) and M-4a(40), and pp'-DDE in wells M-7a(15) and M-9(10) during 1981. In 1982 pp'-DDE was detected in well M-7a(15) and the herbicide 2,4-D was detected in well M-2(10). No herbicides or pesticides were detected in 1983.

In summary, above background contaminant levels associated with the landfill operation have been observed at monitoring wells immediately downgradient from the site. However, no metal concentrations exceed groundwater quality standards. Some herbicides and pesticides were detected in individual samplings during this time, however these concentrations were within recommended groundwater quality standards.

The South Dade Landfill

The South Dade landfill, located at S.W. 97th Avenue and 248th Street, has been in operation since 1979. This 185 acre site is permitted by the State Department of Environmental Regulation as a sanitary shredded waste landfill facility. The landfill site contains an underlying low permeability marl liner with an under drain/perimeter drain leachate collection and recycling system. The site operated as a sanitary landfill for its first two years, until completion of the adjacent shredding facility (9/10/81). Shredding of the waste can expedite the decomposition process as well as controlling vectors and odors, thereby precluding the need for daily cover.

The facility is bounded by ditches and canals to the north, south and west. A mangrove wetland area lies to the east. A major sewage treatment facility is on the north side of Black Creek Canal. Several former landfill areas are located to the south and southwest.

Hydrogeologic Information

The landfill site contains one to six feet of marl of low permeability. The Biscayne aquifer is comprised of a moderately permeable limestone to a 14 foot depth, underlain by alternating layers of highly permeable limestone and sandstone. The base of the aquifer is approximately 120 feet in this area.

During the wet season ground water flow is generally seaward (east); however, ground water is influenced by the water levels in adjacent canals. See Labowski and Waller (1988) for a complete discussion of the hydrology of this area.

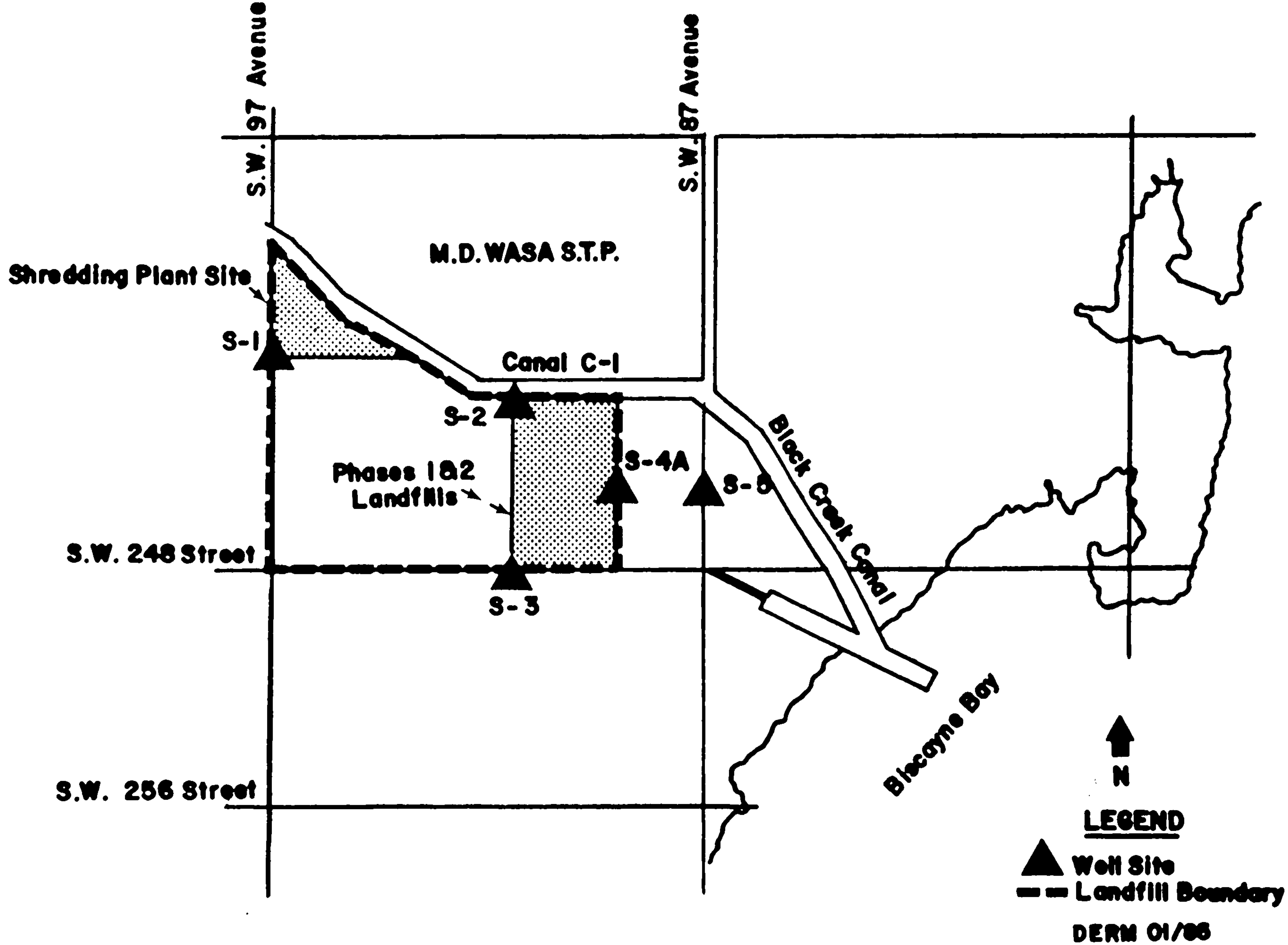
The present monitoring program consists of five multi-depth well clusters as follows:

Well Clusters	Well Depths (Below Surface)	Comments
S-1	5', 10', & 20'	Background cluster, cased with PVC pipe.
S-2	5', 10', & 20'	Cased with PVC pipe.
S-3	5', 10', 20', & 60'*	Cased with PVC pipe.
S-4A	8', 13', & 23'	Installed in 1981 approximately 50' south of original S-4 cluster. Cased with PVC pipe and grouted.
S-5	5', 10', & 20'	Cased with PVC pipe.

*Installed during 3rd quarter 1983 to assess impact of salt water intrusion

See Figure [4] for location of monitoring wells

FIG. 4 DADE COUNTY SOUTH DADE LANDFILL MONITORING WELLS



Data Discussion

Ammonia Nitrogen

Averaged yearly background ammonia nitrogen concentrations at well cluster S-1 were generally consistent, ranging from 0.60 - 0.80 mg/l over the three year monitoring period with the exception of well S-1(10), which in 1981 had an unusually high yearly average of 2.19 mg/l. An anomaly in the fourth quarter contributed to this high year average. All other quarters in 1981 were consistent.

Well cluster S-2, located outside the landfill's north boundary, displayed slightly elevated concentrations of ammonia nitrogen from 1982 through 1983 as compared to S-1. Background concentrations were recorded during 1981.

On the southern boundary of the landfill, ammonia nitrogen levels for well cluster S-3(5,10,20) demonstrated concentrations above background (1.2 - 3.6 times, and 1.7 - 3.4 times) for the 5' and 10' wells throughout the three year period. S-3(20) remained within background concentrations through 1982, but exceeded background by 4.4 times in 1983. All wells remained consistent throughout 1982, increasing in 1983.

During the third quarter 1981, well cluster S-4 (5,10,20), located directly east of the landfill, was abandoned and well cluster S-4a(8,13,23) was installed nearby. Throughout the three year periods, elevated concentrations of ammonia nitrogen averaged from 4-7 times (5', 8' wells), 10 - 14 times (10', 13' wells) and 6 - 17 times (23' well) background for the area; concentrations for all wells increased with time.

S-5, located east of the landfill and bordering Biscayne Bay, exhibited ammonia levels comparable to background in both the 10' and 20' wells through 1983, whereas during 1981 these wells exceeded background by approximately 1.5 percent. Well S-5(5') has been dry during most sampling episodes. Since the S-5 cluster monitors a sea water intruded area, it is probable that the salt water influences are reflected in data results.

Landfill leachate is routinely sampled from the leachate collection system at this site. Average ammonia nitrogen concentration in the leachate was comparable to background from 1982-1983. The leachate was not analyzed in 1981.

Conductivity

Due to salt-water intruded aquifer below and downgradient from the landfill, no disposal site influences can be evaluated. Generally, conductivity values increase with depth and in an easterly direction (towards Biscayne Bay). However, overall conductivity averages are higher in 1981 than in 1982. Conductivity data is not available for 1983. The average yearly conductivity for leachate during 1982-83 ranges from 9300 - 11,133 umhos.

Chemical Oxygen Demand (COD)

Background well cluster S-1 reported annual average COD values from 6-21 mg/l from 1981 through 1983. Most wells have reported elevated COD values 2 - 5 times background with well clusters S-4/S-4a displaying the greatest concentrations consistently. Well cluster S-5, while elevated during 1981-1982, revealed an average yearly decrease in 1983 comparable to background. Cluster S-4a, while remaining above background, did show a decrease in values over the three years. Wells S-2(10) and S-3(5) have resulted in data equalling background during the three years reported. S-5(5) has been consistently dry.

During 1983 the leachate yearly COD average is approximately 1200 mg/l.

Phenols

Generally, phenolic concentrations increased in all monitoring wells from 1981 through 1983. Background well S-1 reported an average of 2 ug/l in 1981 to 7.7 ug/l in 1983. Due to the variable data during the three year period, perimeter well concentrations were compared with their respective annual background levels. During 1981, all perimeter well concentrations were within background ranges. In 1982-83, well clusters S-4a and S-5 exceeded phenolic concentrations 2 - 9 times background, and in 1983, well cluster S-3 also produced results significantly above background.

In 1982-83 yearly average for leachate is 495.7 - 1118 ug/l. 1981 leachate data was not available.

Cadmium

During 1981, cadmium concentration (including background) were elevated throughout the year. Average concentrations for the three monitored depths are 1.21 ug/l (shallow), .915 ug/l (middle), .86 ug/l (deep). During the first quarter of 1981 all shallow well results were higher than their averages. Additionally, wells S-4(10) first quarter, S-4(20) third and fourth quarter, S-5(10) third quarter, and S-5(20) third and fourth quarter all exceed their yearly averages, and are considered anomalous.

Values from the South Dade monitoring wells in 1982 and 1983 were near or below detectable limits (0.1 ug/l) with the exception of S-3(60) which, during the third and fourth quarters 1983, resulted in a value of 0.6 ug/l.

Over the three year period, cadmium values never exceeded Dade County standards.

The leachate yearly average ranges from 1.5 ug/l - 9.2 ug/l for 1982-1983, increasing with time. 1981 data was not available.

Chromium

Background levels from 1981 - 1983 averaged 2 ug/l with the exception of well S-1(5) which in 1981 displayed concentrations from 3.3 - 15.7 throughout the monitored year.

During 1981 all downgradient monitoring wells displayed erratic concentrations of chromium throughout the year ranging from 1 - 15.7 ug/l. Concentrations stabilized during 1982 with all perimeter wells falling within background averages, except S-4a(8) and S-5(10) which had anomalous results, raising their yearly averages to 4.1 ug/l and 6.0 ug/l respectively.

Elevated chromium concentrations in perimeter wells were detected in 1983 as compared to background. Perimeter wells yearly averaged from 3.7 - 16.7 ug/l (shallow wells), 1.3 - 2.4 ug/l (middle wells), and 1.0 - 1.7 ug/l (deep wells) with S-4a(8) displaying the greatest yearly average (16.7 ug/l). All values remained within the groundwater quality standard during this period.

1982-83 yearly average for leachate was 56.1 ug/l - 86.3 ug/l, decreasing in 1983. 1981 data was not available.

Mercury

All wells for the three year period displayed mercury concentrations at or near the detection limit during most of the sampling quarters. Anomalous readings occurred during the first quarter 1981 in which the data ranged from .2 ug/l to .8 ug/l. However during the second quarter 1981 all well results were below detection limits.

Leachate yearly average ranged from 0.4 ug/l - 0.9 ug/l during 1982-83 increasing during 1983. 1981 mercury data for the leachate was unavailable.

Lead

Lead concentrations for 1981 were above detectable limits with yearly average background concentrations from 6.18 ug/l (20' well) to 15.53 ug/l (5' well). All perimeter wells were 2 - 4 times background during this year except for S-3(10,20) and S-4a(13) which were equal to or less than background. During 1982 all yearly averages fell below the detection limit of 1.0 ug/l, and are equivalent to background except for S-2(10), S-4a(8), and S-5(20) which has yearly averages of 3.3 ug/l, 4.7 ug/l and 2.4 ug/l respectively. The higher values recorded in 1982 decreased in 1983. However, these wells displayed increased values during 1983; S-1(5) (3.7 ug/l), S-2(10) (1.9 ug/l), S-3(60) (42.3 ug/l), S-4a(8) (4.0 ug/l) and S-5(10) (1.3 ug/l). Lead concentrations were within groundwater quality standards for all wells during the three years.

The leachate yearly average ranged from 13.6 ug/l - 26.4 ug/l during 1982-83, increasing with time. Leachate data was not available during 1981.

Chlorinated Insecticides and Chlorophenoxy Herbicides

No herbicides or chlorinated insecticides were detected in 1981-1982. During 1983 2,4,5 TP was detected in well S-3(10) at a concentration of 0.10 ug/l. S-3(20) was reported to contain 0.30 ug/l of 2,4 D, and 0.003 ug/l of op'-DDE was reported in well S-4a(8). However, these concentrations remained within recommended criteria.

Data Summary

Well cluster S-4/4a, located along the eastern perimeter of the South Dade landfill, repeatedly reported above background concentrations for most measured parameters in one or more of its wells during the three year period.

During 1981-1983 all wells of cluster S-4a reported ammonia nitrogen, chemical oxygen demand and phenols in concentrations exceeding background. Cadmium concentrations were exceeded in this cluster during 1981. Chromium was elevated only in well S-4a(8) during 1981.

Elevated concentrations of lead were detected in cluster S-4a during 1981 with the exception of S-4a(13) which had an average concentration below background for that period. During 1982-83 lead was above background concentrations in well S-4a(8) only.

No mercury was detected in these wells during the three years, while cadmium was not detected in 1982-1983.

Well S-4a(8) contained trace amounts of the insecticide op'-DDE during 1983.

Well S-2 presented slightly elevated ammonia concentrations from 1981-1983. Mercury, phenols and COD values remained equivalent to background concentrations during this time period. During 1981, cadmium results were anomalously high, returning to within background during 1982-1983. Lead and chromium concentrations were elevated during 1981 for this cluster, remaining elevated in 1982-1983 for well S-2(10) and stabilizing to background for well S-2(20).

Well cluster S-3 displayed elevated concentrations of ammonia nitrogen and COD throughout the three year period. S-3(5) and S-3(60) produced elevated lead concentrations in 1981, and elevated chromium concentrations were recorded for all wells at this time. During 1983 all wells in this cluster produced elevated phenol results, and S-3(60) displayed above background lead concentrations. Analysis of water samples from S-3(10) and S-3(20) showed the presence of 2,4,5 TP and 2,4 D respectively during this same year.

1981-1983 recorded COD, phenols, cadmium, and chromium concentrations exceeding background for well cluster S-5 with COD concentrations decreasing, yet remaining elevated during 1983.

Ammonia nitrogen values were above background during 1981 while decreasing to within background levels from 1982-83. Lead exceeded background for the cluster during 1981, but was high only in well S-5(20) during 1982, and well S-5(10) in 1983. Since this cluster monitors a sea water intruded area, it is possible that salt water influences are reflected in the data.

In summary, above background contaminant levels associated with landfill operations have been observed at monitoring wells immediately downgradient from the site. However, no metal concentrations exceed groundwater quality standards. Some herbicides and pesticides were detected in individual samplings during this time; however these concentrations were within recommended groundwater quality standards.

Miami International Airport Monitoring Program

In late 1983, DERM (in cooperation with Dade County Aviation Department) designed and began implementation of a water quality monitoring network at Miami International Airport (MIA). This program was initiated in response to spills of fuel and other hazardous materials which have resulted in water quality problems in the past. Previous notions that hydrocarbons were insoluble in groundwater have been refuted in recent literature and in DERM's experience. The program is intended to characterize existing ground and surface water quality in and around MIA and act as a warning system for off-site migration of these substances. Monitoring is concentrated on groundwater, but several surface water stations are situated on major canals (Tamiami and FEC) and smaller drainage canals within the airport.

Hydrology and Geology

Previous work (including studies relating to the Hialeah-Miami Springs wellfields and USGS research) indicate three zones of high permeability in the Biscayne aquifer in the vicinity of MIA:

1) a thin, shallow zone within the oolitic Miami Formation (northern and eastern edge of the area only),

2) a thicker, highly cavernous and solution-riddled zone within the Fort Thompson Formation, with greatest hydraulic conductivity from approximately 50 to 65 feet,

3) a zone in the Buckingham Formation, approximately 80 to 90 feet near the airport.

Previous experience (supported by USGS work in South Florida) indicates a high degree of vertical interconnection among these permeable zones, and excellent vertical as well as horizontal hydraulic conductivity within the aquifer.

Groundwater flow has traditionally been toward the wellfields, even in times of lower pumpage (as interpreted from 1940's and 1950's USGS water level contour maps). However, with the wellfields pumping at a very low rate (5 to 10 MGD as scheduled for 1984), flow will likely follow the regional gradient eastward. To verify this three continuous water level recorders have been emplaced within MIA (see figure 5). This task has been subcontracted to the USGS for correlation with other water level recorders in their county-wide network. To supplement these continuous recorders, tape readings are taken at each station during sampling.

As a general guideline, groundwater monitoring concentrated on the shallow permeable zone within and proximal to the airport, and the deep zone east (regional groundwater gradient) and north-northwest (the direction of the wellfields). The intermediate zone (which shows the greatest hydraulic conductivity) is monitored throughout the area.

In order to verify the presence of these zones and gain additional information on the hydrogeologic characteristics of the aquifer in this vicinity, a geologic test well was drilled near the west-central edge of the airport (figure 5). This allows for stratigraphic correlation with all newly drilled monitoring wells. The wells were drilled using dual tube reverse air circulation rotary, a method which provides for intact continuous geologic samples and (if desired) discrete depth water samples.

Results of the test well (depicted by columnar section in figure 6) show the following:

1) the shallow permeable zone (Miami Formation) is not present at this locale; subsequent drilling of monitoring wells confirmed its presence in the eastern edge of the study area.

2) the first highly permeable zone occurred at 40 feet, with zones of very high hydraulic conductivity at 55 to 60 feet and 75 to 80 feet.

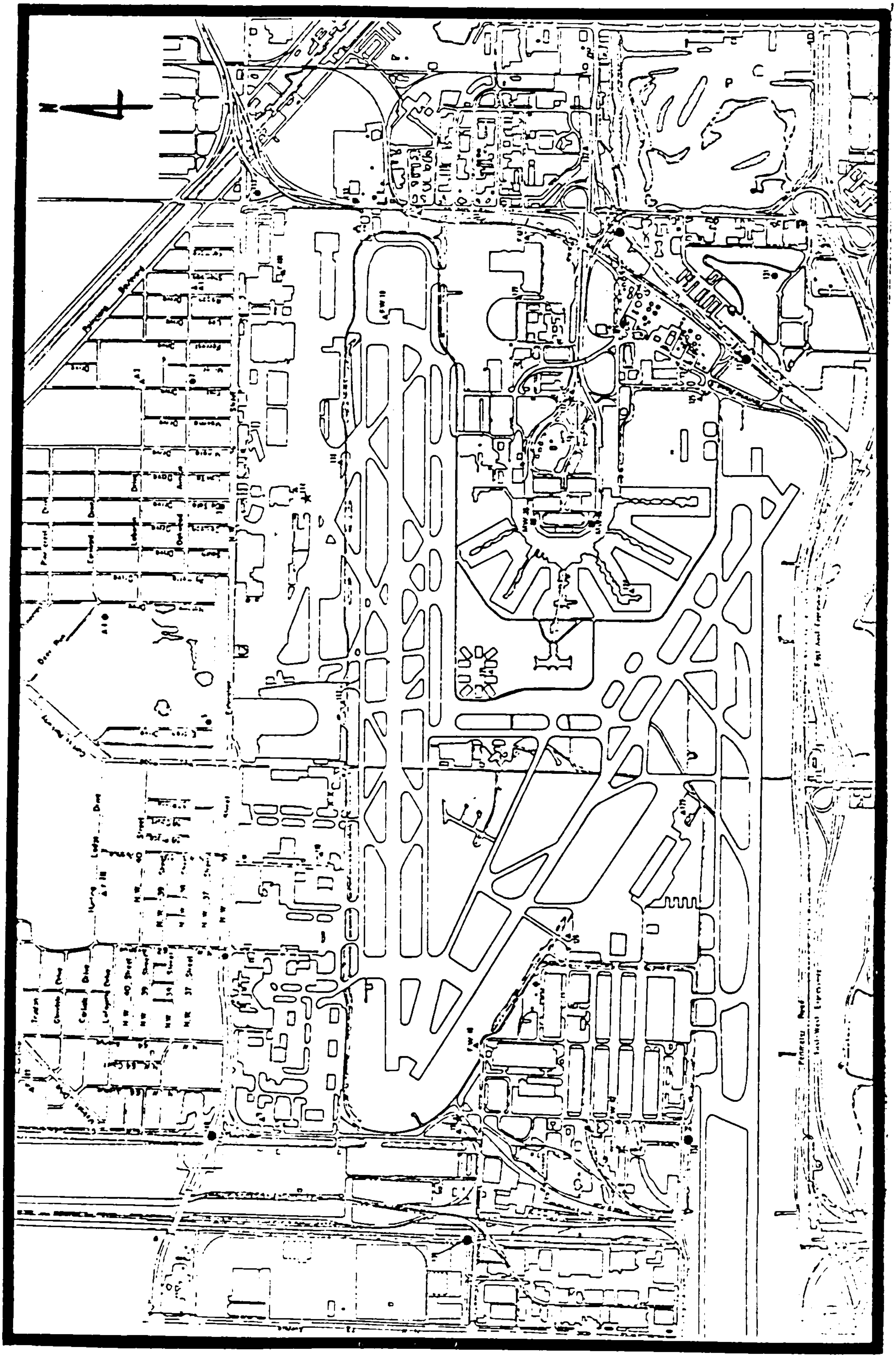
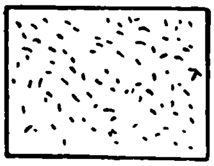


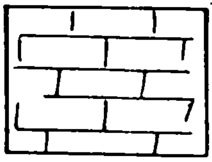
FIG. 5

KEY :

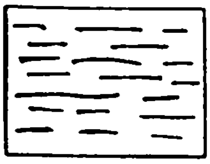
Sandstone
Sand or Silt



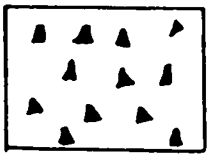
Limestone
or Carbonate



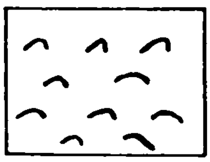
Clay or
Mudstone



Phosphate



Fossils or
Shell Hash



Gastropods

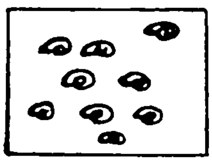
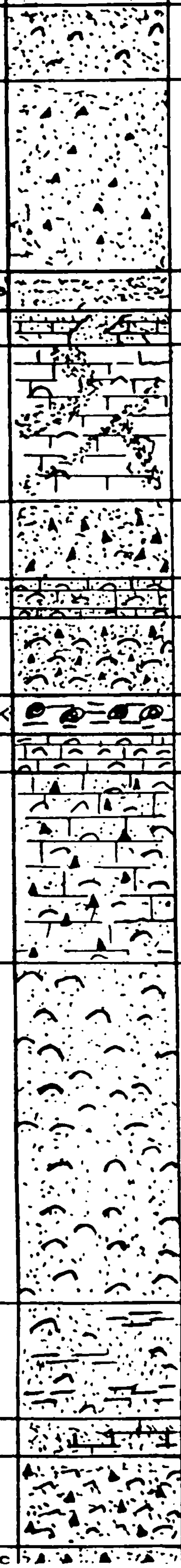


Figure 6.
Columnar Section
of Miami
International
Airport



Lithologic Description	Geologic Column	Depth (Ft. below surface)
Quartz sand, fine grained, tan to brown; minor fossils; some fill		10
Quartz sand, fine to medium grained, tan to gray; minor phosphate; poor K		35
Sand & sandstone, quartz, fine to medium, friable		40
Qtz sand, fine to med.; linestone, fossils		45
Limestone, dense to cavernous, white to gray, some mineralization, minor fossils, some quartz sand; good to very good K		65
Quartz sand, fine to medium, gray, phosphatic, calcite cemented		75
Sandy limestone, cavernous, v. fossil., v. good K		80
Quartz sandstone, fine grained, fossiliferous, phosphatic		90
Mudstone, fine grained, brown, gastropods; poor K		95
Limestone, gray, quartzose, coquinoid; good K		100
Sandy limestone, medium grained quartz sand and shell hash; phosphatic; reduced K @ 100 feet; water has odor		125
Quartz sand, fine to medium, Lt. gray to gray; shell hash; minor silt, green		170
Quartz sand, fine to medium, Lt. gray to gray; shell hash; clay lenses, green		185
Silt, carbonate, green; no water flow		190
Shell hash; sand & sandstone, fine grained, black phosphatic nodules gray, fossiliferous;		202
Quartz sandstone, fine grained, friable, phosphatic		

NETWORK #	DEPTH (feet)	LOCATION	COMMENTS
A-1 (S) (D)	51 86	Oakwood & Ragan (M.S.)	CH_2M Hill Site (A-1)
A-3 (S) (D)	51 88	East Drive & Labaron (M.S.)	CH_2M Hill Site (A-3)
A-4 (S) (D)	18 50	Deer Run & Eastward (M.S.)	CH_2M Hill Site (A-4)
2 (S) (D)	12 55	East Drive & Oakwood (M.S.)	DCAD Wells
3 (S) (D)	12 55	De Leon Drive & 36 St (M.S.)	DCAD Wells
5 (S) (D)	12 55	Eldron Drive & 37 St. (M.S.)	DCAD Wells
7 (S) (D)	12 55	N.W. 62 Avenue & 36 St.	DCAD Wells
9 (D)	55	3445 N.W. 67 Avenue	DCAD Wells
MW-35	15	Buslane, Departure Entrance Concourse "D"	DCAD Wells
MW-36	15	Buslane, Departure Entrance Concourse "F"	DCAD Wells
F-441	57	Hunting Lodge Drive, West of 59 Avenue (M.S.)	USGS No. Fire Well
F-409	58	Pine Court & Whitehorn St. (M.S.)	USGS No. Fire Well
F-481	56.4	E.A.L.-36 St., S. of Bldg. 18	USGS No., Fire Well
F-483	59.6	P.A.A.- Le Jeune Rd., E. of Aircraft Maintenance Structure	USGS No., Fire Well
FW-10		East End of Runway 9L27R	DCAD Fire Well
FW-46		N.E. of Bldg 2121, Airfield Side of Fence	DCAD Fire Well
FW-42		N.W. 66 Avenue & 19 St., W. of Bldg. 2143	DCAD Fire Well
113 (S) (D)	20 65	Off Le Jeune Road & 36 St., between Hywy 112 E. Ramps	DERM Wells
114 (6" USGS) (1½")	54 60	S. of P.A.A. Flight Academy	DERM Wells
115	60	Le Jeune Rd., E. of Runway 9L27R	DERM Well
116	58	Perimeter Rd., S. of E.A.L. Bldg. 24 & P.A.A. Flight Academy	DERM Well
117	59	Perimeter Rd., S. of "New" DCAD 36 St. Bldg	DERM Well
118	59	W. Side Taxiway at Butler Aviation	DERM Well
119 (6" USGS) (1½")	54 56	N.W. 67 Avenue & 25 St.	DERM Wells
120	62	N. of Cargo Spot 9	DERM Well
121	82	Loading Area West of Concourse "D"	DERM Well
122	65	N. of Field Lighting Vault No. 2	DERM Well
123 (6" USGS) (1½")	56 62	In Island at Entrance to M.I.A.	DERM Wells
124	60	Concourse "F", Gate 10, at Edge of Apron	DERM Well
125	62	In Delta Parking Lot near E. Gate, at Canal	DERM Well
126 (S) (D)	55 90	North Corner (Grass Island) of Tank Farm	DERM Wells
127	62	S.E. Corner of P.A.A. Hanger/Office Bldg.	DERM Well
131 (S) (D)	20 45	NW 42 Court & 14 St. (Inside DCAD Parking Lot)	DERM Well
132	50	NW 39 Avenue & 21 St.	DERM Well
133	20 50	Baker Aviation School, Grass Island, Le Jeune Road	DERM Wells
136	—	Tamiami Canal at Le Jeune Rd.	Canal Station
137	—	Surface Water Skimmer (S.E.)	Surface H_2O
138	—	Surface Water Skimmer (S.W.)	Surface H_2O
139	—	F.E.C. Canal at 25 St.	Canal Station
140	—	F.E.C. Canal at 36 St	Canal Station

Table 4.
Miami International Airport Water Quality Monitoring Sites

3) permeability dropped off dramatically at 100 feet.

4) material resembling the aquiclude (green very fine quartz sand and carbonate silt, no water flow) was observed at 185-190 feet; water flow resumed at 190 feet and continued to 205 feet (T.D.). Thus, while the base of the aquifer was not encountered, it can be reasonably inferred that the base lies not very far below this depth.

Site Selection

Site selection for the program was dictated by the following:

1) The aforementioned considerations of geology and hydrology

2) Past occurrences of floating or dissolved hydrocarbon and synthetic organic compounds (including results from DERM samplings, DCAD monitoring and a recent EPA Biscayne Aquifer study)

3) Areal coverage of the airport

4) Accessibility and safety

All ground and surface water monitoring stations are shown in figure 5, with detailed information for each site in table 4.

Monitoring Parameters

The following water quality parameters were selected for inclusion in the MIA monitoring program (all chemical analyses will be performed by the DERM laboratory, under standard quality control procedures):

Parameter	Frequency
1) Dissolved Hydrocarbons	Monthly
2) Synthetic Organic Compounds	Monthly
3) Methyl Blue Active Substances (detergents)	Quarterly
4) Phenols	Quarterly
5) Trace Metals	Biannually

6) Other significant parameters, including nutrients and major ions initially as a baseline measurement and later as necessary (possibly annually).

7) Field parameters (specific conductance, pH, temperature and water level measurements) are taken with each sampling.

Additionally, the program will include floating hydrocarbon measurements conducted at wells drilled to monitor specific major spills. This monitoring will be modified periodically.

In summary, DERM's Miami International Airport Water Quality Monitoring Program provides for 50 sampling locations and in excess of 1,768 analyses annually plus the piezometry of the monitoring wells. The network is not intended to be inflexible; sites can be dropped if continued analysis appears unnecessary, and can be added to accommodate future problems.

Artesian Well Monitoring Network

Studies by the U.S. Geological Survey is the late 1970's (Waller, 1982) revealed that a flowing artesian well located tapping the Floridan aquifer at Chekika Hammock State Park in southwest Dade (figure 7) was contaminating the overlying nonartesian Biscayne aquifer with saline water. In early 1982 the Florida Department of Natural Resources, acknowledging this problem, agreed to plug the well. Recognizing the recreational value of the well in maintaining a swimming area within the park, the state and Dade County agreed that a substitute nonartesian supply well would be designed and put into production for continued use of the swimming area.

DERM assumed sampling of the USGS monitoring well in early 1982 to determine any changes in groundwater contamination. Additionally, this continued acquisition of background data prior to plugging of the well and subsequent monitoring after plugging should yield quantitative information on attenuation and dispersion mechanisms in the Biscayne aquifer.

Background

S-524 (locally known as the Grossman well) was drilled in 1944 by the Miami Shipbuilding Company to a depth of 1248 feet and cased (12-inch) to 440 feet. Later (1958) an 8-inch plastic liner was placed in the upper 80 feet and cemented to reduce leakage through the corroded iron pipe. Artesian pressure ranges between 40 and 45 feet above sea level or about 30 feet above land surface (Healy, 1975). The well has been flowing continuously since it was drilled.

The initial flow rate at land surface in 1944 was 2,300 gallon/minute, but had decreased to about 1,000 gallon/minute in 1968 (Beaven and Meyer, 1978). Chloride concentration of the artesian water increased from 970 mg/l in 1944 (Meyer, 1971) to 1,300 mg/l in 1963 (Beaven and Meyer op.cit.) and remained essentially the same in 1979 (Waller, 1982). Results of DERM's monitoring to the end of 1983 (six sampling

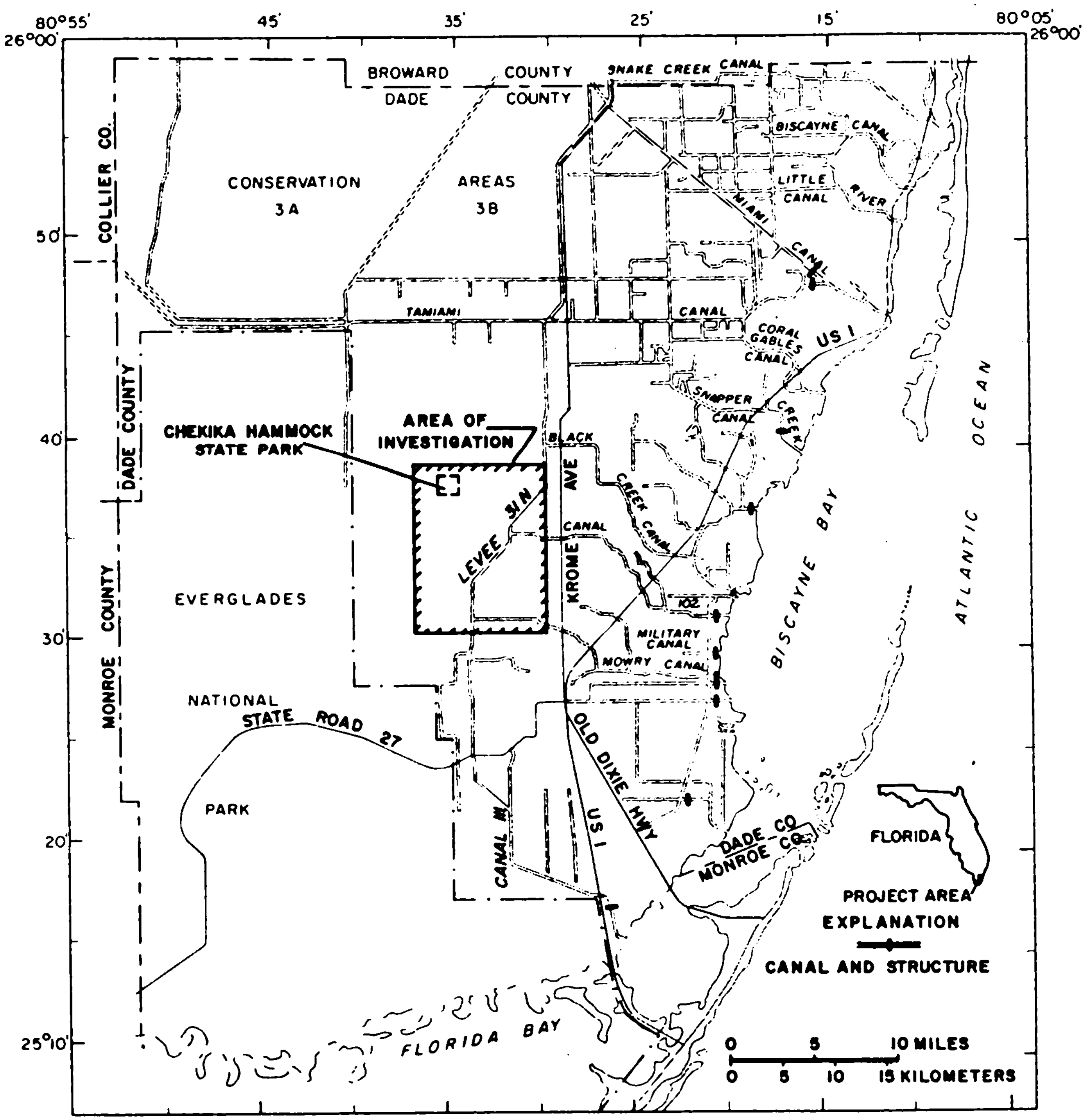


Figure 7.—Location of Chekika Hammock State Park and the area of investigation in Dade County, Florida.

events) show increased concentrations (maximum 2200mg/l) in all but one of the samples.

In the swimming area water from the well flows freely over a manmade cascade into a clay-lined lake which overflows into a shallow basin and enters the surrounding Everglades marsh. The lake level is artificially maintained at about 9 feet above sea level or about 3 to 6 feet above the water table (Waller, op.cit.).

Geology and Hydrology

A generalized geologic cross-section (figure 8) through the park and to the southeast indicates that the Biscayne aquifer ranges in thickness from about 43 feet at the Grossman well to about 70 feet 7 miles southeast. The aquifer in this vicinity is comprised of the Miami and the Fort Thompson Formations, but locally may include some of the (relatively) more permeable sands and shelly marls of the Tamiami Formation. Soil cover consists of a thin layer of marl and peat. The uniform composition of the Biscayne in this area allows for fairly homogeneous vertical mixing of the plume within the aquifer (Waller, op.cit.).

Regional groundwater flow in this part of Dade County is southeast, but appreciable dispersion to the south occurs due to seasonal variation in flow (Schneider and Waller, 1980). The L-31N Canal, which penetrates the upper 15 feet of the aquifer and intersects the plume, appears to have no effect on its shape (Waller, op.cit.).

Monitoring Network

The USGS monitoring network was designed to incorporate results from a geophysical survey as well as the regional flow information mentioned above. After the initial investigation in 1979, some wells were destroyed or plugged. Nonetheless, a sufficient number of wells and surface water sampling sites are still available to adequately supplement the USGS study and allow for a continued quantitative analysis of the growth and areal extent of the artesian plume.

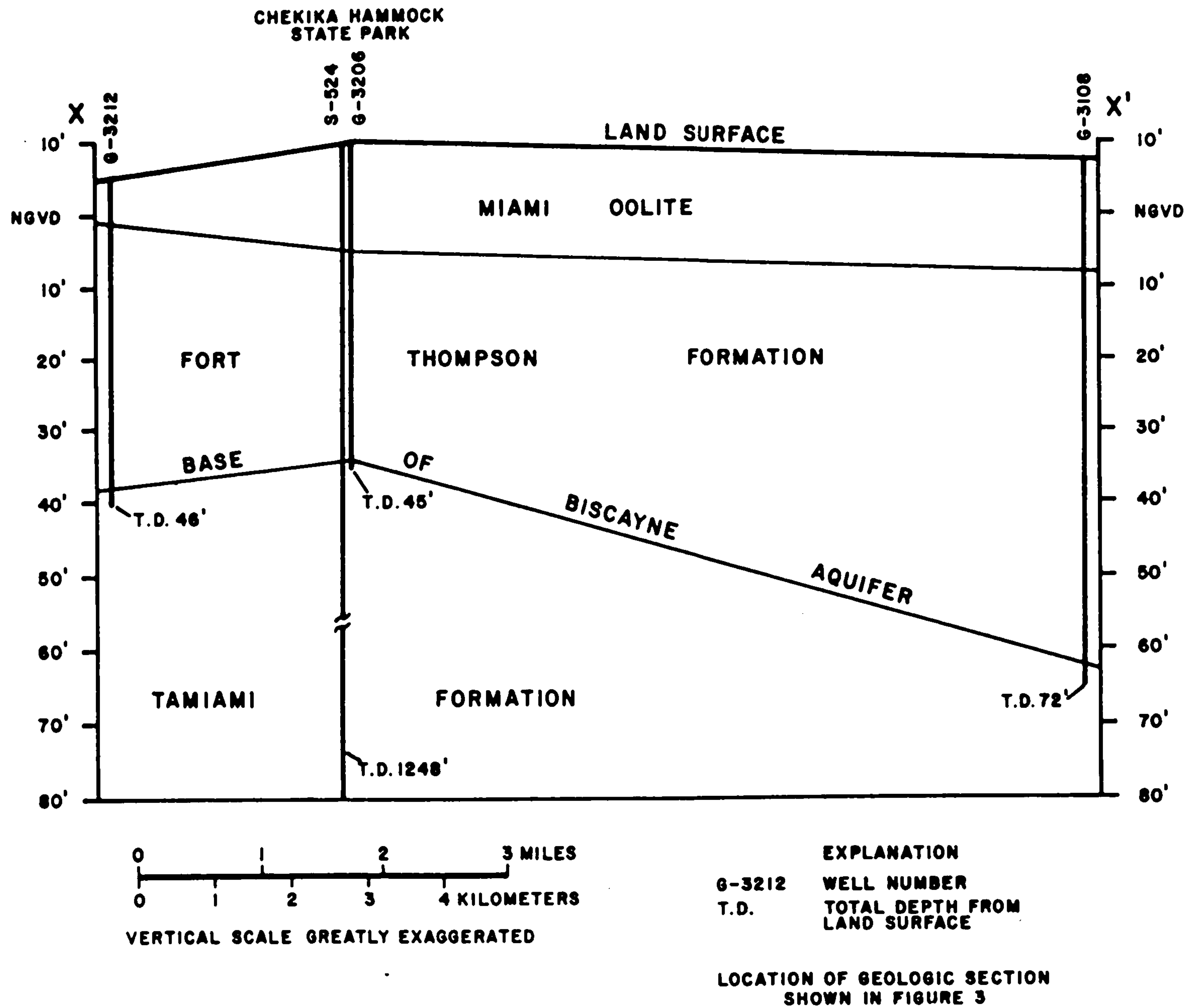


Figure 8.—Geologic section X-X' of the Biscayne aquifer.

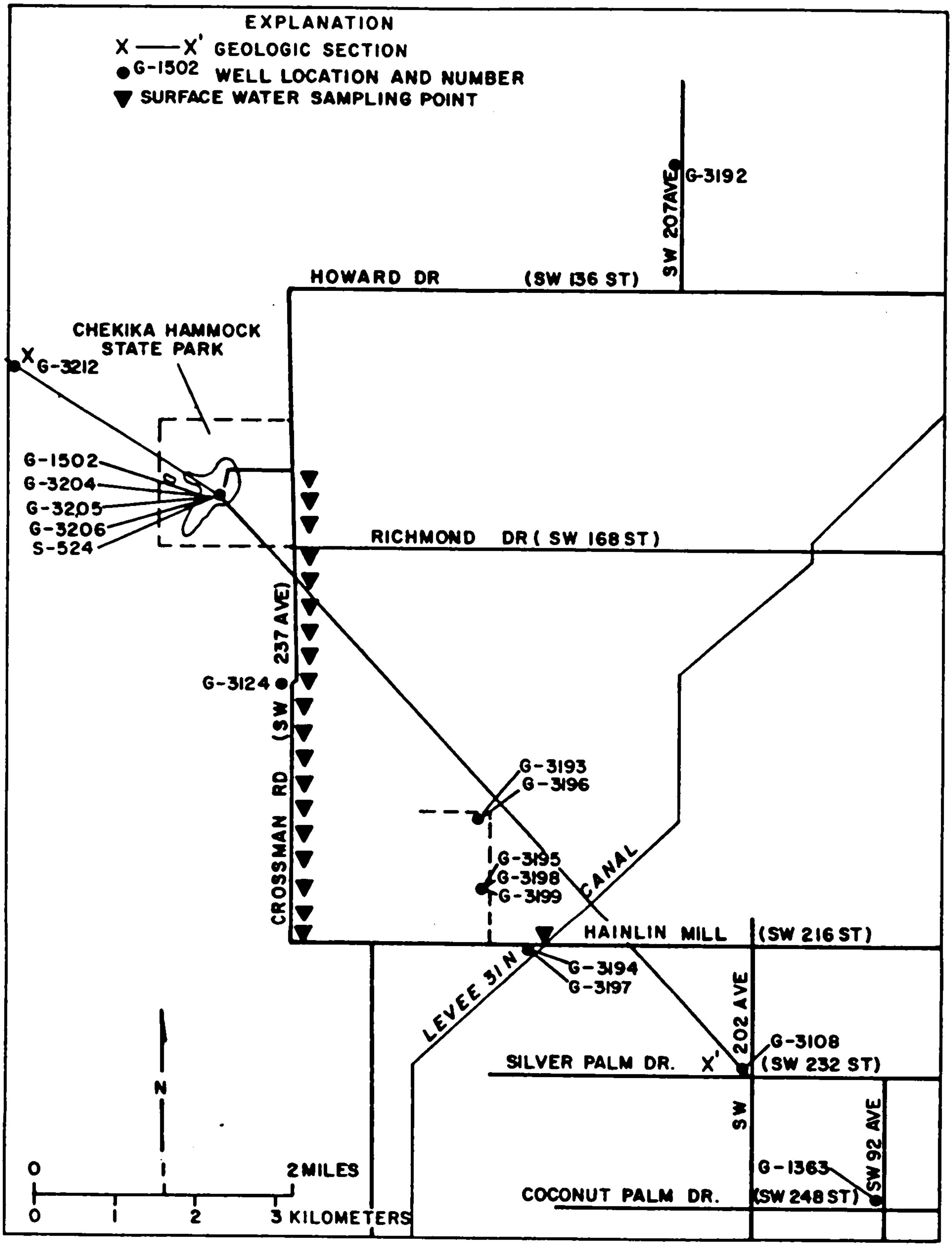


Figure 9.—Location of ground-water and surface-water sampling stations and geologic section X-X'.

The sites sampled by DERM are depicted in figure 9. During the course of sampling two multi-depth wells at one site (G-1393 and G-3196) were destroyed and two of three multi-depth wells (G-3198 and G-3199) at a second site were plugged. As these sites were located proximal to the center of the plume, and considering the uniform nature of the aquifer referred to above, it is believed that the one remaining well (G-3195) shows representative concentrations of this vicinity (Waller, written communication; also Table 7). A downgradient well (G-3108) was destroyed prior to DERM's monitoring, but a shallow substitute (G-3108A) at the same location was sampled. The extreme downgradient well (G-1363) in Waller's study is still intact for sampling.

The plume, as defined by USGS, extends about 7 miles southeast from the Grossman well and its width ranges from 1 to 2 miles.

Results and Discussion

The water quality parameters analyzed by DERM include chloride, specific conductance, and temperature from all sampling sites differs each sampling event. Some pH measurements (field) are also included. These results are depicted in Tables 5 and 6; Table 7 summarizes previous data (Waller 1982) for comparison.

Chloride concentrations from S-524 are somewhat higher than those reported by Waller and earlier authors (Beaven and Meyer, 1978), although specific conductance levels were consistent with Waller's samplings. Nearby wells G-3204 and G-3205 (both located within the park) also show higher chloride and conductance levels than previously reported. G-3204 (12') shows no seasonal trend; G-3205 (40') shows a seasonal pattern opposite that reported by Waller, with higher chlorides in the dry season. However, conductance levels for this well were similar for both seasons.

Several factors may account for the differences over the past few years. Although it is possible that the larger data base may

Table 5

Summary of Monitoring Results 1982-83: Chloride (mg/l)

Station	Average	Maximum	Minimum	Avg.Dry Season	Avg.Wet Season
S-524 (Grossman Well)	1588	2200	1220	1581	1600
G-3204 (12')	64	72	54	67	60
G-3205 (10')	1090	1935	90	1205	860
G-3124 (12')	87	127	59	80	100
G-3195 (12')	120	175	100	125	108
G-3108A (15')	119	128	108	122	115
G-1363 (32')	42	48	35	43	41
Surface Water; Grossman Canal at:					
168th St.	47	90	32	49	39
184th St.	239	273	200	230	273
200th St.	162	212	66	150	212
216th St.	158	230	68	152	183

Table 6

Summary of Monitoring Results, 1982-1983: Specific Conductance (mmhos/cm @25°C)

Station	Average	Maximum	Minimum	Avg.Dry Season	Avg. Wet Season
S-524 (Grossman Well)	4925	5150	4600	4850	5075
G-3204 (12')	593	625	552	581	613
G-3205 (40')	3333	4600	750	3450	3100
G-3124 (12')	628	800	490	594	695
G-3195 (12')	769	800	690	758	793
G-3108A (15')	876	950	780	850	915
G-1363 (32')	646	700	605	629	680
Surface Water; Grossman Canal at:					
168th St.	456	670	390	465	420
184th St.	1093	1165	970	1075	1165
200th St.	843	1015	600	814	960
210th St.	835	1120	580	826	870

Table 7
Summary of USGS Monitoring Results (1978-79)
(Chekika State Park & Vicinity)
(from Waller, 1982)

Well No.	Date of Collection	Chloride (mg/l)	Sp. Cond. (mmhos/cm)
S-524	10/27/78	1200	5080
(Grossman Well)	3/14/79	1300	4800
G-3192	9/6/78	21	480
(bckground, 41')	4/18/79	19	500
G-3204	9/12/78	53	550
(13')	4/19/79	31	520
G-3205	9/12/78	970	3750
(44')	4/19/79	54	620
G-3199	9/7/78	190	1160
(48')	4/18/79	190	1130
G-3198	9/7/78	190	1150
(21')	4/18/79	180	1160
G-3108	1/23/76	41	650
(71')	2/20/76	43	655
	8/24/76	52	680
G-3124	3/14/79	126	880
(10')			
G-1363	3/14/79	24	560
(33')			

re-define patterns seen in the area, it should be kept in mind that irregular rainfall could also account for this variability. More likely is the probability that the two wells are more affected by a mounding effect from the artesian well (the wells are located just north of S-524).

However, the data do seem to indicate an increase in mineral concentrations within the plume.

In the central portion of the plume, shallow well G-3195 (12') shows lower chlorides and conductivities than previously reported. Further downgradient G-3108A (12') shows higher levels of these parameters than Waller's G-3108 (71'). This could indicate some vertical inhomogeneity in the aquifer in this area; however, the irregular rainfall could also explain this increase. The extreme downgradient well in the network G-1363 (32'), considered by Waller in 1979 to be unaffected by the plume, now shows elevated chloride and conductance levels; the results are definitely above background. As is true of G-3195 and G-3108A, this well shows little seasonal variation.

The southerly component of flow during the rainy season (Schneider and Waller, 1980) is illustrated by well G-3124 (12') and the surface water samples taken from the Grossman Canal, a borrow ditch adjacent to S.W. 237 Avenue. Chloride concentrations and specific conductance are higher for the rainy season for all of these sites except for the surface water station at 168th St. (immediately south of the park). At all stations, however, levels are higher than previously reported.

Summary

Overall results indicate that the plume has increased both in degree of mineralization and areal extent. Some indications show that seasonal variations and dispersion of the plume vertically through the aquifer may be more complex than initially reported. Other complications such as variation in rainfall and an insufficient data base preclude definitive conclusions on these possibilities.

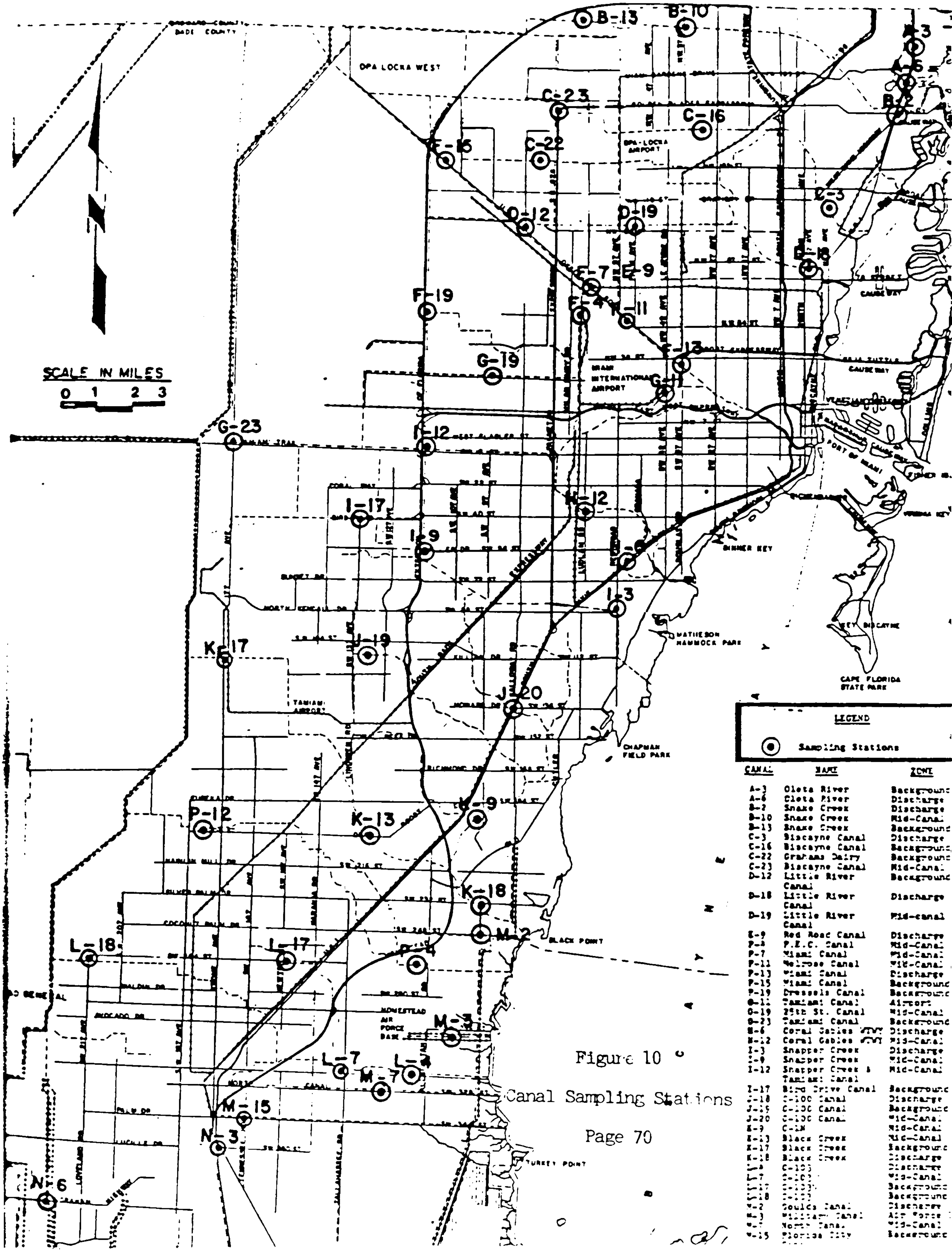
Canal Monitoring Program

Dade County's Canal Monitoring Program (DERM, 1979) is designed to present an overview of water quality for the County's major surface water systems by monthly sampling and analysis of physical and chemical parameters. Stations are located on each canal so as to obtain samples which are representative of background conditions (little affected by man), mid-canal conditions (which are representative of the predominant land use(s) along the canal and may or may not show the effects of contamination), and discharge points, which are representative of the quality of inland waters entering Biscayne Bay. The latter also serve to measure the inland extent of seawater intrusion and give indications whether or not salinity gates are functioning effectively.

The canals sampled in the network include the following (Figure 10):

1.	Oleta River	A series
2.	Snake Creek Canal	B series
3.	Biscayne Canal	C series
4.	Little River Canal	D series
5.	Miami Canal	F series
6.	Tamiami Canal	G series
7.	Coral Gables Waterway	H series
8.	Snapper Creek Canal	I series
9.	C-100 Canal	J series
10.	Black Creek Canal	K series
11.	C-103 Canal	L series
12.	Goulds Canal System	M series
13.	C-102 Canal	P series

Four additional stations on the Black Creek Canal (K-2, K-14, K-15, K-16) are provided for this year's Intensive Canal Study (See Figure 11 for locations).



LEGEND

◉ Sampling Stations

CANAL	NAME	ZONE
A-3	Oleta River	Background
A-6	Oleta River	Discharge
B-2	Snake Creek	Discharge
B-10	Snake Creek	Mid-Canal
B-13	Snake Creek	Background
C-3	Biscayne Canal	Discharge
C-16	Biscayne Canal	Background
C-22	Grahams Dairy	Background
C-23	Biscayne Canal	Mid-Canal
D-12	Little River Canal	Background
D-18	Little River Canal	Discharge
D-19	Little River Canal	Mid-canal
E-9	Red Road Canal	Discharge
F-4	F.E.C. Canal	Mid-Canal
F-7	Miami Canal	Mid-Canal
F-11	Melrose Canal	Mid-Canal
F-13	Miami Canal	Discharge
F-15	Miami Canal	Background
F-19	Dressels Canal	Background
G-11	Tamiami Canal	Airport
G-19	25th St. Canal	Mid-Canal
G-23	Tamiami Canal	Background
H-6	Coral Gables WW	Discharge
H-12	Coral Gables WW	Mid-Canal
I-3	Snapper Creek	Discharge
I-9	Snapper Creek	Mid-Canal
I-12	Snapper Creek & Tamiami Canal	Mid-Canal
I-17	Bird Drive Canal	Background
J-18	C-100 Canal	Discharge
J-19	C-100 Canal	Background
J-20	C-100 Canal	Mid-Canal
K-9	C-1N	Mid-Canal
K-13	Black Creek	Mid-Canal
K-17	Black Creek	Background
K-18	Black Creek	Discharge
L-4	C-103	Discharge
L-7	C-103	Mid-Canal
L-17	C-103	Background
L-18	C-103	Background
M-2	Goulds Canal	Discharge
M-3	Military Canal	Air Force
M-7	North Canal	Mid-Canal
M-15	Florida City Canal	Background

Figure 10

Canal Sampling Stations

Parameters

The following parameters are analyzed monthly as an indication of general water quality:

Indicator Bacteria:

- Total coliform
- Fecal coliform
- Fecal streptococci

Specific conductance

Dissolved oxygen

NO_x (nitrate + nitrite)

Transparency (Secchi disk)

Additionally, water depth and temperature, and general field observations (wind speed and direction, canal flow, cloud cover, air temperature and any other pertinent water conditions) are recorded for each station.

Results and Discussion

Indicator bacteria Most natural aquatic systems contain bacteria, some of which are due to natural causes (such as wildlife and soil), and some of which are pathogenic. Pathogenic bacteria may enter water bodies through discharge of domestic sewage into the waterway and from stormwater or agricultural runoff. Certain non-pathogenic bacteria (coliforms and fecal streptococci) are used as indicators of pathogens. The number of these bacteria indicate the degree of contamination, and their ratios may indicate the source.

Coliform bacteria are the most commonly used indicators of domestic sewage and runoff entering a water body. This group of bacteria includes Escherichia coli, a variety of intermediary species from warm-blooded animals. Coliform bacteria also include a variety of species occurring naturally in soils.

Fecal streptococci are found in greater numbers within the intestines of warm-blooded animals than in human intestines. The ratios of fecal coliform to fecal streptococci give an indication of the source of contamination (Geldreich and Kenner, 1969).

As reported in previous years (DERM, 1981b, 1982), high total and fecal coliform concentrations are the major surface water problem in the County at the present time (Table 8 shows these concentrations and Table 9 provides the 1982 data for comparison). Stations traditionally showing high total and/or fecal coliform levels were also sampled for fecal streptococci. The fecal coliform/fecal strep ratios (utilized in other surface water quality investigations in South Florida, e.g. Waller and Miller, 1982) show that nearly all of these stations indicate contamination from human sources, which may include surrounding land uses, sewage disposal, stormwater runoff and drainage systems, and septic tanks.

Indicator bacteria levels fluctuate greatly during the course of the year; it would be expected that high concentrations due to stormwater would fall off greatly in these canals during the dry season. This is supported by the 1983 data, which showed that total coliform levels averaged approximately 1000 MPN/100 ml during the period from June through October, but only approximately 550 MPN/100 ml for the other 7 months. The same trend was noted for fecal coliform (200 and 100 MPN/100 mls, respectively). However, this has not always been as clearly displayed by past data, and it should be remembered that many factors interface.

Dissolved Oxygen on some major canals did not meet the applicable standard (at least 4 mg/l) at all times, but this does not necessarily

Table 8

1983 Levels of Indicator
Bacteria in Major Canals

Canal System	No. of Stations	Total Coliform	Fecal Coliform (MPN/100ml)	Fecal Strep	*
Oleta River	2	1111	321	56	(1)
Snake Creek	3	573	147	34	(3)
Biscayne Canal	4	1544	153	35	(3)
Little River Canal	3	1330	551	73	(2)
Red Road Canal	1	2272	638	91	(1)
Miami Canal	4	1879	500	94	(2)
Tamiami Canal	2	678	145	18	(1)
Coral Gables Waterway	2	2962	1419	82	(2)
Snapper Creek Canal	3	613	197	41	(1)
C-100 Canal	3	257	91	18	(1)
Black Creek Canal	7	250	44	52	(7)
C-103 Canal	4	343	37	18	(1)
Goulds Canal	4	1469	170	34	(4)
Card Sound	1	778	137	--	
C-111 Canal	1	165	29	--	
C-102 Canal	2	414	44	--	
Overall Canal System Average	46	616	128	46	

(*) = number of stations where Fecal Strep was sampled.

indicate a problem. Low D.O. levels can result in eutrophic conditions, but as water is continually released through control structures, this problem seldom occurs in Dade County. D.O. levels are lower in the South Florida surface water system than in other surface water systems due to the close hydraulic interaction between the canals and the groundwater, which contains little dissolved oxygen. The variation of D.O. levels through the county, with the lowest levels seen in north Dade and the highest levels observed in south Dade canals, is consistent with geologic conditions in the county. The predominantly sandy substrata in the north allows much less oxygen to mix with the groundwater than the highly porous limestone in the south.

The overall average D.O. level for all stations in the network was 3.7 mg/l, slightly less than the 4.0 mg/l level obtained for the past two years, and remained consistent throughout.

Specific conductance values for Dade canals generally range from 400 to 800 mmhos/cm (at 25° C.), with a system-wide mean of about 650. These levels reflect the calcium bicarbonate equilibrium system (discussed in the groundwater section, p. 7). Saturation with respect to calcium bicarbonate can contribute as much as 300 mmhos to the overall value. Conductivity values greater than 1000 mmhos/cm occur at stations located near the inland extent of seawater intrusion, including stations A-3 and A-6 (Oleta River), and H-6 (Coral Gables Waterway).

Conductance levels tended to be lower in the wet months, probably due to dilution by rainfall.

Nitrate and Nitrite (NO_x) occur as different oxidation states of nitrogen. In general, the oxidation of organic nitrogen in air can be expected to produce nitrite (N^{+3} oxidation state) and finally nitrate (N^{+5} form). Nitrite tends to be very unstable, short-lived, and oxidizes immediately to nitrate.

Nitrogen in the form of dissolved nitrate is a major nutrient for vegetation, and the element is essential to all life. Certain species of bacteria in soil and blue-green algae and other micro-biota occuring in water can extract nitrogen from air and convert it to nitrate. Some nitrate occurs in rainfall. Also, as explained in the Groundwater Section of this report (See p. 11), the oxidizing or reducing capability of the strata will determine whether nitrate or ammonia is the dominant nitrogen species in groundwater. This refers only to background water quality, and not contributions by man.

As shown in Table 9, nitrate levels in south Dade canals exceed those in north Dade, due mainly to the agricultural activity in this area. South Dade canals showing the highest nitrate concentrations were the C-103, Goulds, and C-102 systems (background stations at these canals show considerably lower levels than those downgradient). These concentrations compare with those in the Everglades Agricultural Area south of Lake Okeechobee.

Transparency. Secchi disk readings have shown that south Dade canals have a greater degree of transparency than those in north Dade. This is a result of higher color contributed from the better-developed soil cover in the north. Lowest Secchi disk readings are seen in canals flowing through the Water Conservation Areas, including the Miami, Tamiami, and Snake Creek canals. The peat and muck soil of the Conservation Areas contribute organic matter which adds color to canal waters, reducing transparency.

Transparency is also low at discharge stations (including those in south Dade), probably as a result of increased turbidity and contributions from seawater.

Table 9

NO_x Levels on Major

Dade County Canals for 1983

	(mg/l)
Oleta River	0.23
Snake Creek Canal	0.23
Biscayne Canal	0.22
Little River Canal	0.20
Red Road Canal	0.09
Miami Canal	0.12
Tamiami Canal	0.18
Coral Gables Waterway	0.28
Snapper Creek Canal	0.14
C-100 Canal	0.10
Black Creek Canal	0.13
C-103 Canal	1.80
Goulds Canal System	1.36
C-111 Canal	0.27
Card Sound Canal	0.05
C-102 Canal	1.50
Overall Canal System Average	0.48

Intensive Canal Study

The Dade County Department of Environmental Resources Management (DERM) annually samples one major canal and analyzes an extensive set of physical and chemical parameters. This program can detect water quality problems of a specific nature extending beyond the Monthly Canal Monitoring Program, and establishes baseline water quality for the county's surface water systems. Canals studied thus far in the program include Snapper Creek (1980), Miami Canal (1981), and the Tamiami and Dressels Canals (1982).

Black Creek was the subject of the 1983 ICS. This major canal is located adjacent to the South Dade Sanitary Landfill, and its upgradient reaches flow through the agricultural lands of south Dade. The specific objectives of the study (beyond establishing baseline water quality for the canal) were to ascertain whether the landfill and/or the agricultural activities were contributing contaminants to the Canal. Choice of sampling stations reflected this.

Site Location (figure 11)

Stations K-13, K-17, and K-18 are part of DERM'S Monthly Canal Monitoring Network; additional sites for this study include K-2 (downgradient the landfill, west of the salinity gate), K-14 (agricultural area near Black Creek Linear Park), and K-15 and K-16 (agricultural area east of Krome Avenue).

Parameters

The following parameters were analyzed for Black Creek Canal:

Physical Parameters

- Depth
- Specific conductance

Oxygen-Related Parameters

- Dissolved oxygen
- Biochemical oxygen demand

Total filtrable residue

Turbidity

Chemical oxygen demand

Indicator Bacteria

Total coliform

Fecal coliform

Fecal streptococci

Macronutrients

Ammonia nitrogen

NOx

Total organic nitrogen

Ortho-phosphate

Total phosphorus

Major Inorganic Ions

Calcium

Sodium

Magnesium

Potassium

Chloride

Sulfate

Fluoride

Alkalinity

Trace Metals

Silver

Arsenic

Cadmium

Chromium

Copper

Mercury

Lead

Selenium

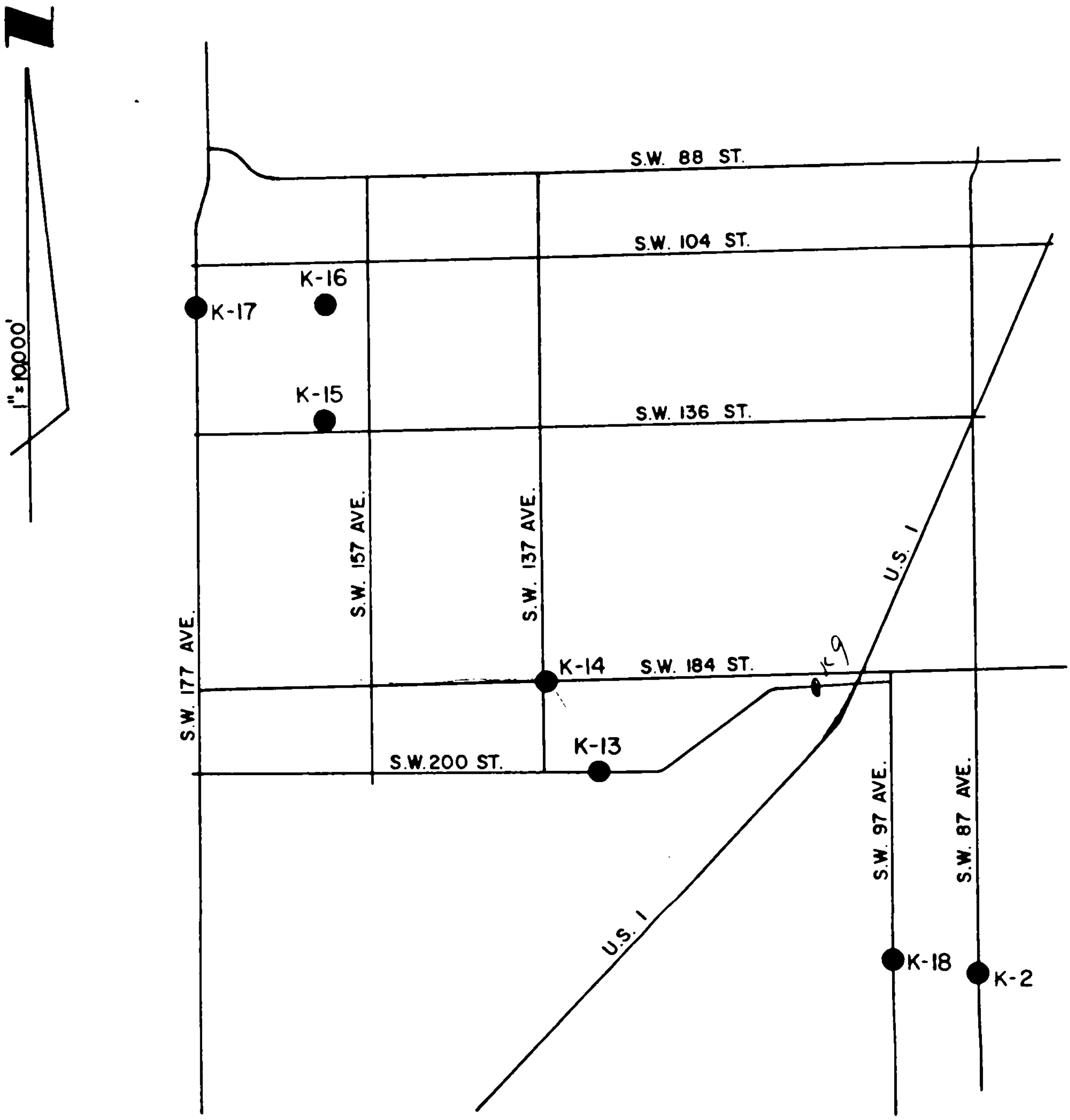
Zinc

Chlorinated Pesticides and Herbicides

Other significant Water Quality Parameters

Phenols

Methyl Blue Active Substances (detergents)



1983 Sampling Stations
on Black Creek Canal

Figure 11

Results and Discussion.

Physical Parameters include depth, specific conductance, total filtrable residue, and turbidity.

Depth in the Black Creek Canal generally ranged between 3.0 and 4.5 meters, with maximum measurements occurring at K-14 and minimums at K-2 and K-17. Depth was held fairly constant year round at individual sites, with no discernible seasonal trend.

Specific conductance (see also discussion on major inorganic ions) averaged about 500 mmhos/cm at all stations but K-2, where levels averaged about 600. This station is near the salinity gate, so some higher values can be expected. Maximum values for most stations occurred in the latter half of the dry season (March and April) with minimums at the start of the rainy season (June) and the early portion of the dry season (November through January).

Total filtrable residue (dissolved solids) showed a similar trend as conductance, with maximum average values observed at station K-2 (near 400 mg/l), with other stations averaging between 300 and 350. Lowest levels generally occurred at the height of the wet season, with maximums during the dry.

Oxygen-related parameters include dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand.

Dissolved oxygen showed average levels between 2.5 and 5.0 mg/l. Downgradient stations revealed the highest levels (K-2, K-18, K-14), while those upgradient (K-17, K-16, K-15) showed the lowest. Average levels for the canal as a whole were nearly the same as the Monthly Canal Monitoring Program average of 3.7 mg/l. No samples were taken in April, May and June, so no seasonal trend can be discerned.

Biochemical oxygen demand is a measure of the amount of oxygen consumed in a given volume of water during a specific time period (in this case, five days). These oxygen-consuming materials primarily include bacteria, plankton, and detrital material. Relatively high BOD levels indicate oxygen- demanding materials in canals. These sites may be undergoing de- oxygenation, and in turn may be characterized by noxious odors, lack of diversity in aquatic organisms, and limited uses of the canal. If BOD does not exceed 4 mg/l, however, organic loading is usually not deemed a problem.

BOD showed an all-station average of less than 2 mg/l, with a fairly narrow range of 1 to 4, and tended to be highest during the wet months and lowest during the dry.

Chemical oxygen demand is utilized as a general measure of pollutants and indicates everything in a sample which can be oxidized (including inert materials when made soluble.).

COD was lowest at the downgradient stations (K-2, average 17 mg/l, and K-18, average 20 mg/l) and highest along the upper reaches, averaging 32-33 mg/l for K-13, K-14, and K-15, and approaching 40 mg/l at stations K-17 and K-16. Highest levels were seen during the earlier months of the year, decreasing thereafter.

Indicator bacteria (total and fecal coliform and fecal streptococci) levels were highest at K-2 (average 672 and 84 MPN per 100 ml for total and fecal coliform, respectively) and much lower at other stations; the canal collectively showed lower levels than most other county canals (Table 8, p. 73).

Fecal streptococci was also sampled for at K-2 and K-18 year-round (other stations intermittently). Low levels were observed in nearly all instances.

Macronutrients (ammonia-nitrogen, NO_x, total organic nitrogen, ortho-phosphate, and total phosphorus).

Ammonia is a naturally occurring nutrient which (when found in sufficiently high concentrations) indicates contamination from sources such as landfills, dumps, and septic tank effluent. This reduced form of nitrogen is rarely found in south Dade surface or ground waters in concentrations approaching 1.0 mg/l; in north Dade, canal concentrations commonly exceed this level due to contributions from peat and muck soils.

Mean ammonia concentrations for Black Creek Canal stations averaged from 0.25 to 0.56 mg/l, and at no time exceeded 1.0 mg/l. Average levels dropped from background station K-17 (0.56 mg/l) to stations K-2 and K-18 (0.25 mg/l). These low downgradient concentrations indicate no contribution from upgradient sources (see also the following discussion on NO_x).

Maximum levels at downgradient stations (K-2 and K-18) occurred during the dry season, with some secondary peaks in some wet season months. Maximum levels at other stations occurred early in the year. This is probably due to lack of dilution by rainfall.

NO_x is a combined analysis for nitrate and nitrite. This parameter represents nitrate almost exclusively, as nitrite concentrations in Dade canals have been very low when analyzed separately in the past. This is especially true in south Dade due to prevailing oxidizing conditions.

NO_x levels showed a trend opposite that observed for ammonia, with minimums (0.10 mg/l) occurring at background station K-17, and increasing downgradient to 0.30 mg/l at K-2 and K-18. The highest mean concentration of all stations occurred at K-16, but this was heavily influenced by a single high value of 3.6 mg/l in January, which may be anomalous.

This observed trend, when viewed in conjunction with the ammonia results, indicates conversion of the reduced species to nitrate during the course of residence in the system. This is as expected given the oxidizing conditions in the canal. The all-station mean NO_x concentration of 0.125 mg/l is lower than that of the Monthly Canal Program (0.48 - see table 9). Maximums for nearly all stations were observed in January, when concentrations for four stations were 1.00 mg/l or more, the only month this occurred. Levels were much lower during the rest of the year, thus no seasonal trend appears evident.

Total organic nitrogen past data indicate that TON concentrations for Dade canals are rarely below 0.7 mg/l, and this is consistent with that obtained from Black Creek Canal. Mean concentrations varied between 0.80 and 1.10 mg/l, and generally decreased from background to downgradient stations. This could be due to uptake, sedimentation, and dilution, but as the range is narrow, no conclusion can be reached.

Seasonally, TON concentrations were highest during the dry season, decreasing in the wetter months.

Ortho-phosphate concentrations for all stations were less than 0.010 mg/l, except K-18 (average 0.020), which was influenced by a maximum of 0.140 mg/l in January. This level was not approached by any station at any time.

As concentrations were low throughout the year, no seasonal trend is obvious; maximums occurred in January and February.

Total phosphorous concentrations were also very low, ranging from 0.010 mg/l at the upgradient stations to 0.030 at K-18 and 0.025 at K-2. Both of these stations were influenced by maximums (0.1 mg/l) in January. As was the case for ortho-phosphate, all station average maximums occurred during January (0.042) and February (0.025).

Major Inorganic Ions include:

Calcium, sodium, magnesium, and potassium (cations); and chloride sulfate, flouride, and those ions (i.e. carbonate and bicarbonate) contributing to alkalinity (anions). For additional general information, refer to the discussion in the Groundwater portion of this report (p. 7).

Analyses for major ions was added to the ICS program for the first time in 1983 and were sampled for in May, except for fluoride and alkalinity (monthly). In future studies, a second sampling (September or October) will be added.

Calcium is the dominant cation in Dade's ground and surface waters. Concentrations varied within a narrow range (70.5 to 88.7 mg/l) and averaged 80.5 mg/l.

Sodium showed consistent levels at upgradient stations K-17 through K-13 (range of 29.5 to 35.0 mg mg/l), reached a minimum value at K-18 (18 mg/l), and a maximum at K-2 (84.0 mg/l). The latter may be due to the influence of seawater near the salinity gate.

Magnesium concentrations ranged from 7.0 to 8.0 mg/l at all stations save for K-2 (2.8 mg/l). As referred to earlier, this ion (along with calcium) contributes to hardness.

Potassium is an alkali metal which also serves as a major nutrient for plants. High levels of this ion can reflect contributions from fertilizer application, septic tanks, and other sources of contamination. Concentrations were low for Black Creek Canal stations, ranging from 2.1 mg/l (K-17) to 4.1 mg/l (K-15).

Chloride, the principal anion for Dade's waters, showed a narrow range along the upper reaches of the canal (average of 64 mg/l for K-17 through K-13) and lower levels downgradient (42 mg/l at K-2 and K-18). This trend is opposite of that expected and does not correlate with the tendencies observed for sodium or groundwater monitoring results. Additional data would be required to more fully assess this occurrence.

Sulfate concentrations tended to be low upgradient (5.5 mg/l at K-17) and increase along the course of the canal to maximums (24 mg/l) at K-18 and K-2. This probably indicates conversion of sulfite contributed by upgradient wetland areas to sulfate during the course of residence in the canal.

Fluoride (sampled monthly) showed a narrow mean range through the network (0.16 to 0.19 mg/l) and no station-to-station variation. Levels were highest during the dry season and 50 to 75% lower during the wetter months (July through November).

Alkalinity, as mentioned earlier, reflects dissolved bicarbonate ion concentration and is expressed as equivalent concentration of calcium carbonate. Monthly sampling showed little variation from station to station, as well as at individual sites. Mean concentrations ranged from 180 mg/l (K-17) to 197 mg/l (K-18). Highest levels at all sites occurred during the dry season, decreasing into the wetter months.

Trace Metals were sampled quarterly and included silver, arsenic, cadmium, chromium, copper, mercury, lead, selenium, and zinc. Unless otherwise noted, all concentrations are expressed in micrograms per liter (ug/l).

Silver was at or below detectable limits (0.1 ug/l) at all stations for all samplings save for a single occurrence of 0.2 ug/l at K-13 (April).

Arsenic showed a greater range, but exceeded 10 ug/l only at two sites, K-2 (13.1 in April) and K-14 (14.2 in January). All- station averages were highest in January (5.3 ug/l) and lowest in August (1.0 ug/l).

Cadmium levels were everywhere low, exceeding 1.0 ug/l only at the April analysis of K-2 (1.5).

Chromium did not exceed 1 ug/l at any site.

Copper was detected at all sites, but nowhere exceeded 4.6 ug/l. In general, samples obtained during the wet season showed lower concentrations than those of the dry.

Mercury levels were at or below detectable limits (0.2 ug/l) for all analyses save for the July and October events at K-2 (0.5 ug/l).

Lead concentrations were below 1.0 ug/l at all stations along the upper reaches of the canal. Some higher occurrences were noted for downgradient K-18 and K-2 (mean concentrations of 1.35 and 2.05, respectively). The consistent lower levels upgradient suggest some contribution of this metal from activities of the landfill; however, these levels obtained are still quite low. Seasonally, the dry season (January) event showed a tendency for the highest values, but no significance can be attached to this observation at this time.

Selenium (two samplings, January and April) was not detected at any site.

Zinc (reported in mg/l) was detected at all sites. No discernible pattern was observed along the canal, with highest mean concentrations occurring at K-14 and K-18 (0.17 and 0.13 mg/l, respectively), and lowest at K-15 and K-16 (0.05 mg/l). The October and January all-station results tended to be higher (0.16 mg/l) than those in April and July (0.02 mg/l).

Chlorinated Pesticides and Herbicides (see table 2, p. 14) were sampled in March and August, with no detections.

Other Significant Water Quality Parameters sampled for in the course of this study were Phenols and MBAS (detergents).

Phenols were sampled and analyzed monthly (no December sample) and showed a wide range. As referred to elsewhere in this report (p. 17), this parameter appears to be highly variable throughout Dade County. All stations showed maximums greater than 10 ug/l; however, the only significantly high concentration was one of 120 ug/l at K-14 in March. This result could be anomalous as this level was not approached by any other analysis at this or any other station.

Geometric means for concentrations ranged from 0.9 ug/l at K-17 to 6.0 ug/l at K-15 (nearby station K-16 showed a lower mean concentration, 1.2 ug/l). No trend or pattern appears evident from station to station. Seasonally, highest all-station averages occurred near the end of the dry season (11.2 and 15.1 ug/l in March and April, respectively), decreasing greatly at the start of the rainy season (0.4 in June and 0.3 in July).

MBAS (January, February, March, July, September, and December) concentrations were low for all stations, averaging 0.025 mg/l for all stations, and nowhere exceeding 0.070 mg/l. These levels are so low that no trend (seasonally or station-to-station) can be observed.

Summary

Black Creek Canal was studied in 1983 to (1) obtain baseline water quality data for this canal and (2) ascertain whether sources located along the canal, such as the South Dade Sanitary Landfill or agricultural activity, were affecting the canal.

Results obtained were consistent with past data for south Dade canals and related groundwater data and revealed no significant degradation of water quality along the course of the canal. Ammonia-nitrogen concentration, an indication of contamination from landfill activities, was lower at stations proximal to the sanitary landfill than at upgradient wetland and agricultural areas. This is probably due to oxidation of ammonia to nitrate during residence in the canal system. Concentrations of other macro nutrients (NO_x, ortho phosphate, total phosphate and potassium) which serve as indicators of contamination from agriculture and fertilizer application were also low. Analyses of chlorinated pesticides and herbicides, trace metals, indicator bacteria, and other water quality parameters revealed no significant problems. Some slightly elevated concentrations of lead were noted at stations near the South Dade Landfill, but these levels were still quite low.

1983 Summary

The current ground and surface water monitoring programs conducted by the County have the dual purpose of detecting problems which currently exist and of establishing baseline water quality for the evaluation of potential future changes within these systems.

The bi-annual Groundwater Monitoring Program is designed to characterize existing groundwater quality throughout the County and serve as a basis for delineating long-term trends. The program provides background information for special studies and gives indications of the effect of various land uses on groundwater quality.

The program has proven effective in discerning influences on groundwater from sources such as agriculture, septic tanks, saltwater intrusion, urbanized area runoff, mineralization from canal waters and a flowing artesian well, and seasonal fluctuations in concentrations of major inorganics. Naturally occuring phenol concentrations are high throughout the County but probably do not indicate a specific pollution problem, although future data is necessary to establish proper relationships.

Monthly sampling and analysis of general physical and chemical parameters for the County's major surface water systems are accomplished in Dade County's Canal Monitoring Program. Water quality problems consistent with past years stem from high levels of indicator bacteria resulting from stormwater drainage and other interrelated factors. However, since the primary function of the canal system is as a drainage vehicle, corrective measures are limited.

Elevated nitrate levels in south Dade County may be indicative of a potential pollution problem; however, these levels are consistent with other South Florida agricultural areas and further monitoring is indicated.

DERM's Intensive Canal Study annually samples one major canal and analyzes an extensive range of physical and chemical parameters. The subject canal for 1983 was the Black Creek Canal. The goal was to (1) ascertain whether the canal was experiencing any contamination from the nearby landfill or agricultural activities and (2) establish baseline levels for this canal. No significiant contamination levels were detected within the canal and many parameters were found to be lower than in other areas of the County.

The Annual Pollutant Study was initiated by DERM in 1981, and designed to measure the impact of urbanization on Dade County's surface waters. Early results show that most of Dade County's water is well within the guidelines for water quality standards; however, several more years of data are necessaary in order to establish documental trends.

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