APPENDIX 10.13.5

PROPOSED PLAN FOR THE RECOVERY AND USE OF MINERALIZED GROUNDWATER BY PUMPING AT THE DYER BOULEVARD SANITARY LANDFILL

PROPOSED PLAN FOR THE RECOVERY AND USE OF GROUND WATER BY PUMPING AT THE DYER BOULEVARD AND THE PROPOSED SITE 7 LANDFILLS

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PROPOSED PLAN FOR THE RECOVERY AND USE OF GROUND WATER BY PUMPING AT THE DYER BOULEVARD AND THE PROPOSED SITE 7 LANDFILLS

INTRODUCTION

The proposed plan and its rationale as described in this report was prepared for the Palm Beach County Solid Waste Authority and Hayden-Wegman/Barker, Osha & Anderson, A Joint Venture, by Geraghty & Miller, Inc. The purpose of the plan is to: (1) provide an efficient method of ameliorating the existing, relatively low degree of ground-water degradation at the Dyer Boulevard Sanitary Landfill, (2) prevent any possible degradation of ground water beneath the proposed Site 7 landfills, (3) provide water for cooling and boiler use at the proposed Site 7 Resource Recovery Facility, and (4) provide water for irrigation on the Dyer Landfill following its closure and on closed portions of the Site 7 landfills. The plan presented here includes a description of the existing plume of affected ground water at the Dyer Landfill and a description of the hydrogeologic characteristics of the area, based on all available information. That information was assessed and, with the aid of a ground-water flow model, a plan was formulated that includes recommended well locations and rates of pumping to remove any affected ground water from the shallow aquifer. This will ensure that the ground-water quality beneath Site 7 will remain in its natural condition, ensure minimal impact on proposed neighboring wells, and satisfy industrial and irrigation water demands.

SUMMARY

This report provides a plan for (1) the removal of mineralized ground water from beneath the Dyer Boulevard Landfill, (2) the creation of a cone of depression in the water table beneath the proposed Site 7 landfills to prevent any potential spread of leachate from those landfills, and (3) the use of the withdrawn water for industrial and irrigation applications. The extent of the plume of mineralized water beneath the Dyer Landfill was defined on the basis of concentrations of the chloride ion; the highest chloride concentration detected in the principal aquifer was 150 milligrams per liter. The hydraulic

properties of the aquifer were determined based on all available information.

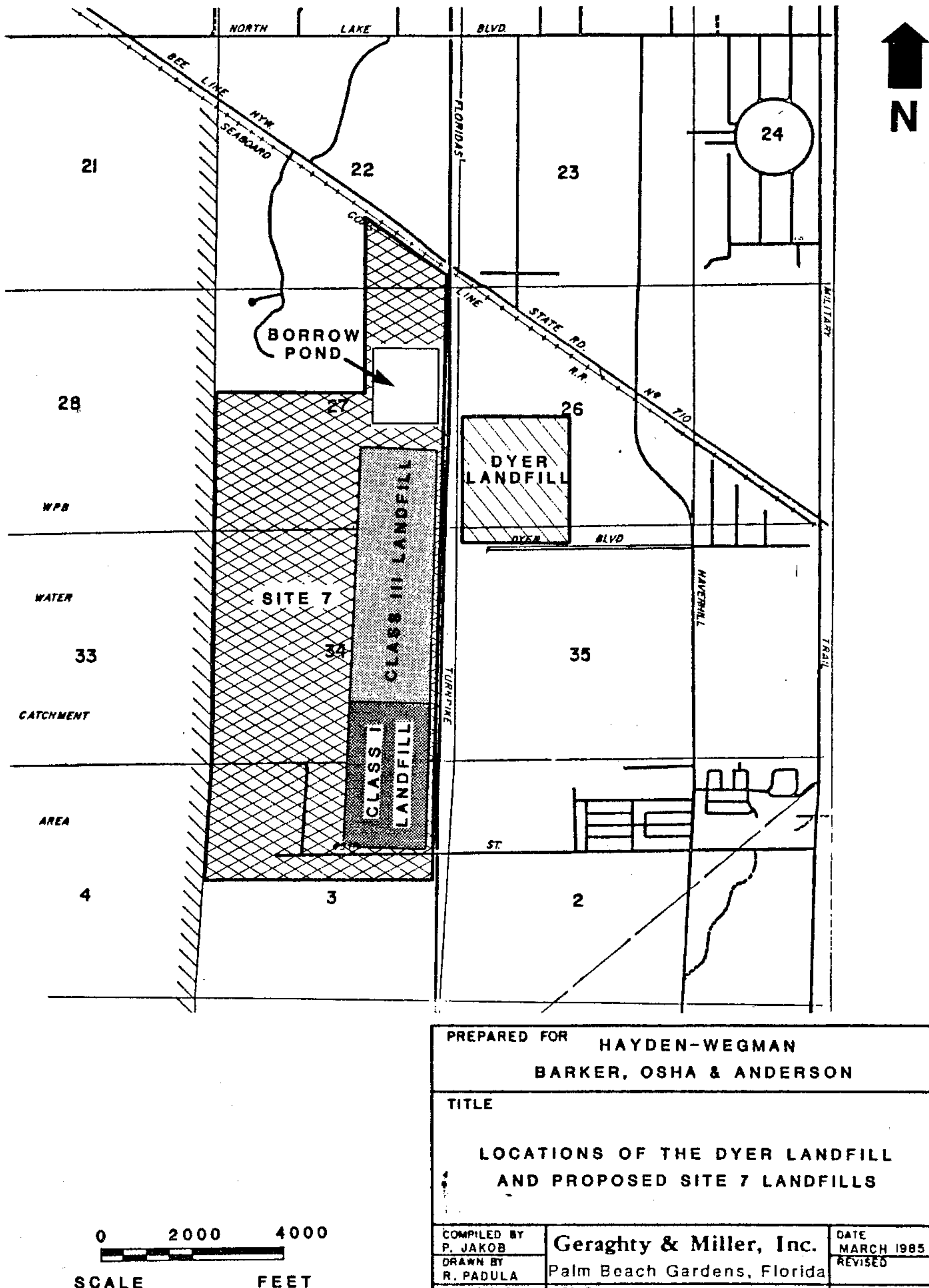
A ground-water flow model was employed to evaluate the effect of withdrawals. The model was calibrated against known data and conditions representative of average rainfall, evapotranspiration and recharge. Simulated pumping from "interceptor" wells was introduced into the model at strategic locations to evaluate their effectiveness in controlling the flow of ground water in areas of existing and potential degradation. Also incorporated in the model was pumping from major existing and proposed wells that could be affected by the interceptor wells. Dry-season conditions also were evaluated by reducing water availability and increasing pumping to near-maximum levels.

The evaluations indicate that interceptor wells can serve to control the flow of all potential leachate with only a minor effect on neighboring ground-water users. Locations, pumping rates, and designs for interceptor wells are recommended for use on Site 7 and on the Dyer Landfill property.

Background Information

The plan described below links a desirable ground-water withdrawal with a beneficial use of ground water. Water is proposed to be withdrawn where it has been degraded by leachate from the Dyer landfill and where it could be degraded (although it is very unlikely) from the Site 7 landfills. Use of the withdrawn water is proposed for cooling, in boilers, and for irrigation on Site 7. Water withdrawn from beneath the Dyer Landfill will be utilized for irrigation on that landfill and to meet water demands on Site 7. Figure 1 shows the relative locations of the landfills.

Because the industrial and irrigation demands for water are well quantified, the plan is predicated primarily on the demand. Two mgd (million gallons per day) of water are required for use in the cooling



PREPARED FOR HAYDEN-WEGMAN BARKER, OSHA & ANDERSON			
TITLE LOCATIONS OF THE DYER LANDFILL AND PROPOSED SITE 7 LANDFILLS			
COMPILED BY P. JAKOB	Geraghty & Miller, Inc.		DATE MARCH 1985
DRAWN BY R. PADULA	Palm Beach Gardens, Florida		REVISED
CHECKED BY P. JAKOB	SCALE	SHOWN	FIGURE 1

system and for boiler water on Site 7. In addition, approximately 1.2 mgd will be needed to irrigate grass on the Dyer Landfill following its closure and on the Site 7 landfills before and following their closure. The irrigation water is estimated to be necessary during three months of the dry season of each year (Mark Hammond, Palm Beach County Solid Waste Authority, personal communication). A single interconnected system of wells that tap the shallow aquifer will be installed to meet these water demands.

The principal criteria for selecting the location of wells is that the mineralized water beneath the Dyer Landfill be removed and any future water-quality degradation at Site 7 be prevented by the constant removal of ground water beneath the Site 7 landfills. This can be accomplished most effectively by defining the areal distribution and movement of the relatively poor-quality water (existing and potential), then pumping strategically located wells to remove the mineralized water.

Definition of the Area of Mineralized Water Beneath the Dyer Landfill

The site of the Dyer Boulevard Sanitary Landfill was previously a rock pit and open dump. Conditions for the generation of a leachate were favorable when the open dump existed. Since 1976, the site has been managed as a sanitary landfill. Ground-water monitoring to determine the presence of leachate began in about 1970 and was expanded considerably in 1976 by the USGS (U.S. Geological Survey). Between 1980 and 1983, monitoring was conducted by private analytical laboratories. In early 1984, the USGS once again became involved in ground-water monitoring at the landfill.

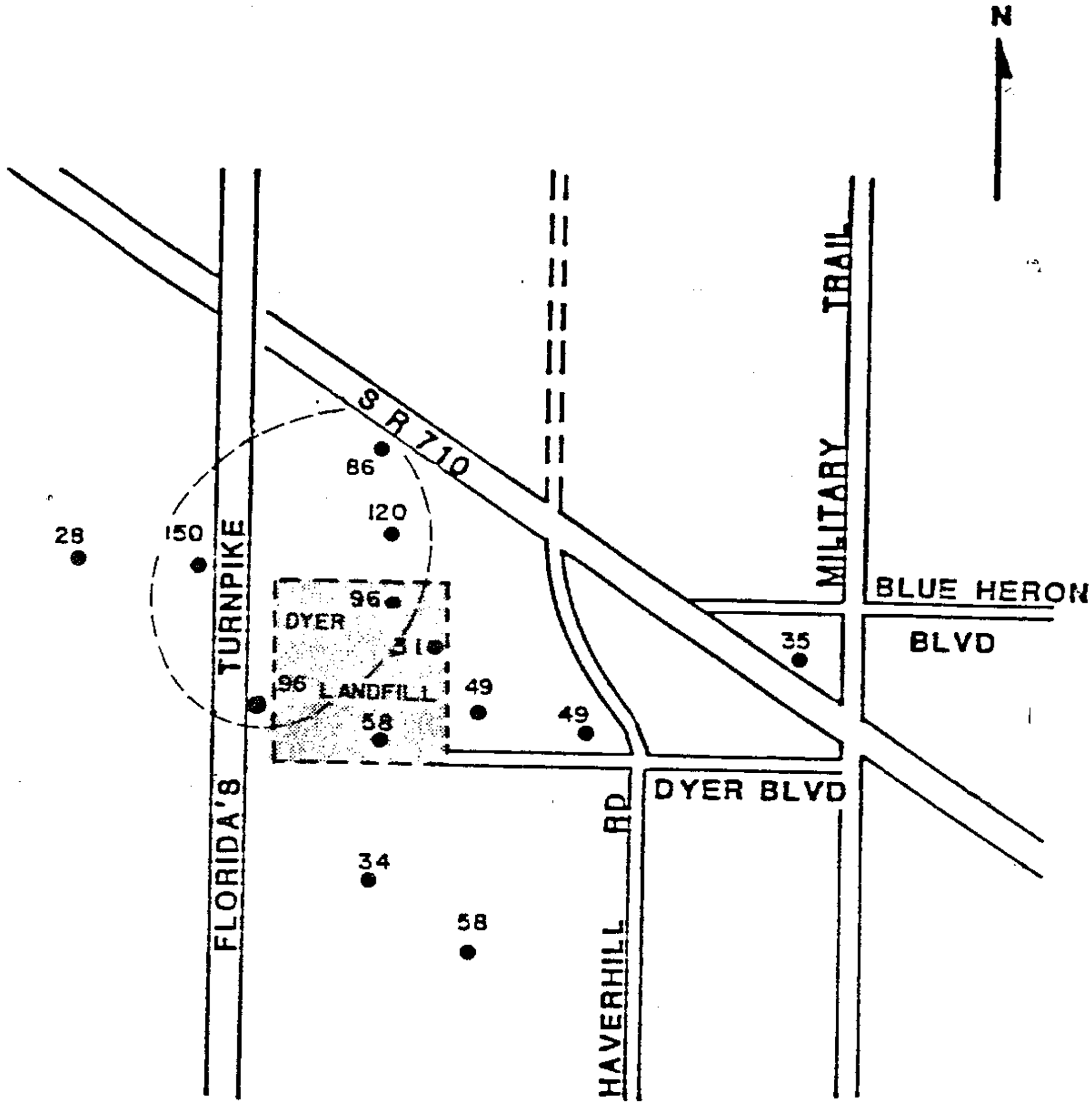
The boundaries of the area affected by leachate were defined by determining where ground water contains relatively high concentrations of chemical constituents that can be associated with landfill leachate. The chemical quality of ground water is determined by the analysis of samples collected from monitor wells open to the shallow aquifer system. The dissolved chemical constituent of ground water that is probably the most reliable indicator of the development and growth of a leachate plume is the chloride ion; this is because of its propensity to remain unaffected in ground-water solution. Use of the chloride ion as an indicator also would result in a conservative estimate of the plume extent; the more objectionable contaminants that may be contained in a landfill leachate would lie in a plume of smaller extent due to ion adsorption and related processes. Furthermore, chloride is the constituent for which the most data are available. In the vicinity of the landfill, the shallow aquifer system includes unconsolidated sand and shell deposits that occur to depths of about 55 feet, and consolidated, relatively more permeable (often cavity-riddled) sandstone, that occurs between about 55 and 95 feet (principal aquifer).

The first step in defining the extent of the chloride plume was to determine the background concentration of chloride found in the aquifer system underlying the landfill site before disposal operations began. Chloride concentrations found in the area at the time of subsequent samplings were then compared to the background concentration. The extent of the plume at the time of each sampling then was estimated as the area where concentrations were significantly greater than the background level.

The most suitable data for establishing the background level are those collected from wells open to the principal aquifer. The earliest data from that zone are for the early 1970's (Miller and Lietz, 1976), which is about the time the dumping at the site began. Data from the cited publication show that chloride concentrations ranged from 22 mgl (milligrams per liter) at Well 636, in December 1972, to 44 mgl at Well 589, in December 1970. Although these data indicate a range in chloride concentrations of 100 percent (from 22 to 44 mgl), the concentrations are low and considered natural. Three other wells in the area, first sampled in 1974, had chloride concentrations between 36 and 47 mgl. The background level was taken as the average of these five wells, about 40 mgl.

Additional wells were installed in the area during 1977 and sampled periodically between 1977 and 1979 by the USGS. Analyses of these samples showed that chloride concentrations had increased significantly in some wells. A chloride concentration 100 percent greater than the background concentration of 40 mgl was chosen to distinguish the plume from the unaffected area; such a contrast in concentrations is too great to be attributed to natural fluctuations. A map showing chloride concentrations in the principal aquifer during 1978-79 is shown in Figure 2. A plume is defined on the map in a small area centered north of the landfill in which chloride concentrations had more than doubled. Samples from the sand and shell deposits that overlie the principal aquifer also were collected in the period 1978-79. Figure 3 shows the approximate area in which the sand and shell deposits are estimated to contain chloride concentrations in excess of 80 mgl. The area outlined on Figure 3 includes the single data point where the chloride exceeded 80 mgl and the approximate area of the original landfill - the western half of the existing landfill. Although the area over which the 80-mgl concentration occurs in the sand and shell deposits is smaller than in the principal aquifer, the concentration in that area is higher. This is because lateral spreading and dilution of the leachate can occur more rapidly in the underlying materials of relatively higher permeability.

Most well-sample analyses conducted after 1979 were of non-conservative constituents. Consequently, there are no significant data available to establish the present extent of the plume on the basis of chloride concentration. However, measurements of the specific conductance of samples pumped from several wells open to the aquifer were made as recently as 1984. Recognizing that the specific conductance is approximately proportional to the chloride concentration of a water sample, specific conductance also can be used to estimate the extent of the plume. The pre-1979 average background level of specific conductance was estimated to be 765 umhos/cm (micromhos per centimeter) by Fischer (1980, p.30). Figure 4 shows the specific conductance of ground-water samples collected in 1982 and the area where specific conductance has increased above the background level. It can be seen



LEGEND

86 ● CHLORIDE CONCENTRATION IN MGL OCCURRING BETWEEN JUNE 1978 AND APRIL 1979 (MONITOR-WELL SAMPLING DEPTHS, 42 TO 96 FEET BELOW GRADE)

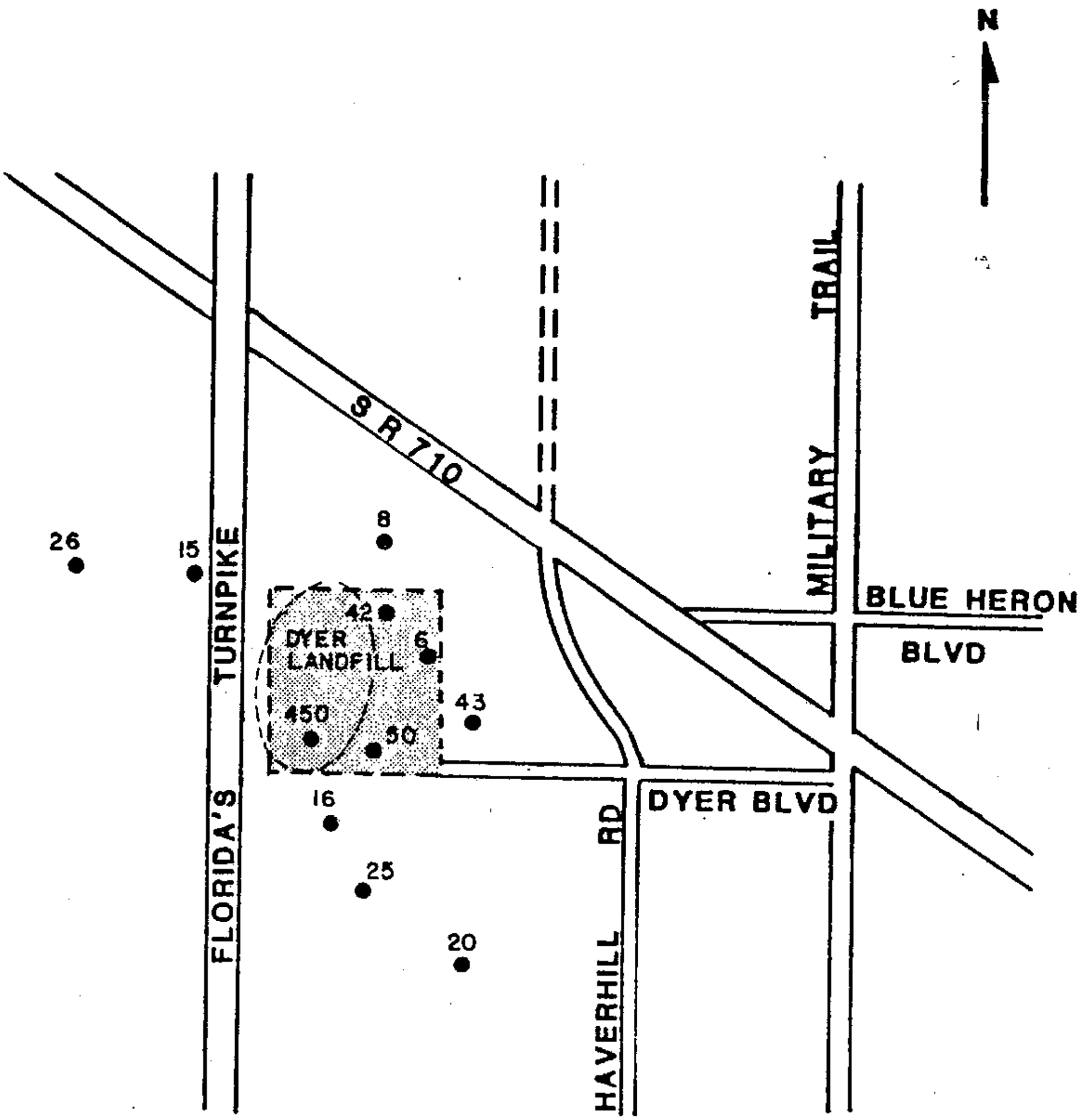
– – – 80 - MGL ISOCHLOR

0 2500
FEET

PREPARED FOR HAYDEN-WEGMAN/BARKER, OSHA & ANDERSON

TITLE CHLORIDE CONCENTRATIONS IN THE PRINCIPAL AQUIFER 1978 - 79

COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE JULY 1984
DRAWN BY Y. DIMICK	Palm Beach Gardens, Florida	REVISED March 85
CHECKED BY P. JAKOB	SCALE SHOWN	FIGURE 2



LEGEND

450
● CHLORIDE CONCENTRATION IN MGL OCCURRING BETWEEN JUNE 1978 AND APRIL 1979 (MONITOR-WELL SAMPLING DEPTHS, 12 TO 37 FEET BELOW GRADE)

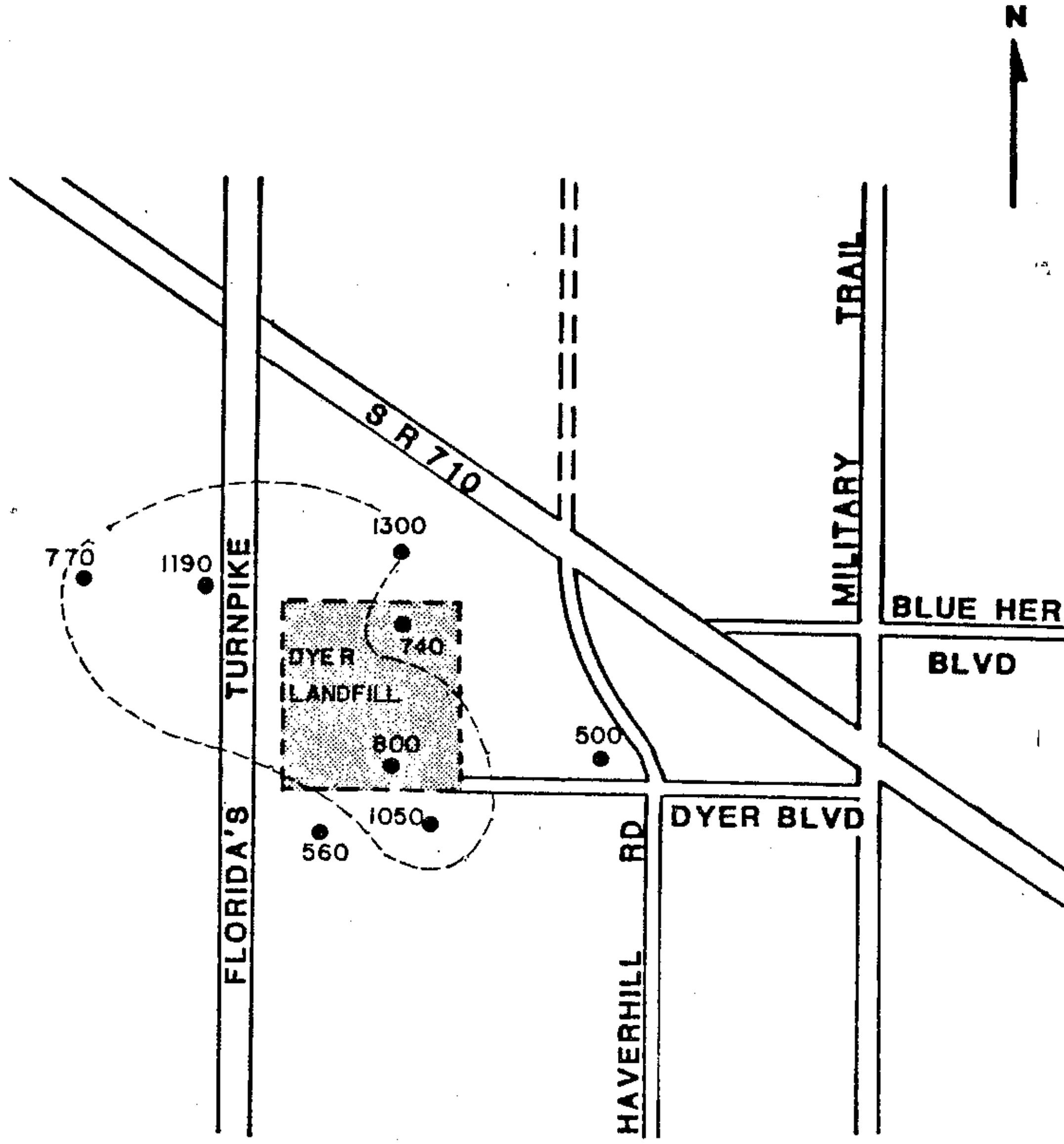
80 - MGL ISOCHLOR

0 2500
FEET

PREPARED FOR
HAYDEN-WEGMAN/BARKER, OSHA & ANDERSON

TITLE
CHLORIDE CONCENTRATIONS IN THE SAND AND SHELL BEDS, 1978 - 79

COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE JULY 1984
DRAWN BY Y. DIMICK	Palm Beach Gardens, Florida	REVISED March 85
CHECKED BY P. JAKOB	SCALE SHOWN	FIGURE 3



LEGEND

1300 ● SPECIFIC CONDUCTANCE IN MICROMHOS PER CENTIMETER (MONITOR-WELL SAMPLING DEPTHS, 42 TO 80 FEET BELOW GRADE)

AREA WHERE SPECIFIC CONDUCTANCE EXCEEDS BACKGROUND LEVEL OF 765 MICROMHOS PER CENTIMETER

0 2500
FEET

PREPARED FOR
HAYDEN-WEGMAN/BARKER, OSHA & ANDERSON

TITLE
SPECIFIC CONDUCTANCES IN THE PRINCIPAL AQUIFER, APRIL 1982

COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE JULY 1984
DRAWN BY Y. DIMICK	Palm Beach Gardens, Florida	REVISED March 85
CHECKED BY P. JAKOB	SCALE SHOWN	FIGURE 4

from Figure 4 that none of the samples from the eight wells tapping the principal aquifer showed a specific conductance twice background. Specific conductance data collected in 1984 showed no expansion of the area where levels exceed background. This lack of growth despite continuing landfill operation may be explained by a reduction in the rate of leachate generation following placement of the final cover on the oldest part of the landfill and greater dilution of leachate already in the aquifer due to additional rainfall recharge during the early 1980's.

Ground-water quality data were generated in early 1984 in an investigation conducted by Geraghty & Miller, Inc. (report in preparation) west of the landfill and Florida's Turnpike. Two samples taken from the principal aquifer showed chloride concentrations of 30 and 65 mgl and specific conductance values of 492 and 1080 umhos/cm, respectively. The well with the higher chloride concentration and specific conductance is located about 200 feet west of Florida's Turnpike and directly west of the landfill. In detailed analyses of more than 150 chemical parameters, including the "priority pollutants", samples taken at the same time showed no signs of pollution by organic chemicals.

The available data discussed above indicate that mineralized water presently lies in an area that is centered slightly north and west of the midpoint of the original landfill area as shown on Figure 2. This northwestern displacement of a portion of the plume probably results from the presence of the slurry route between the borrow pond (Figure 1), west of the Turnpike, and the northern edge of the Dyer Landfill. The slurry (of water, sand, shell, and crushed limestone) is pumped from the borrow pond in a pipeline to the landfill where the solids (cover material for the landfill) settle on stockpiles. Water that drains from the stockpiles is then routed to an open ditch on the east side of the Turnpike, then is returned to the borrow pond by pipeline. A significant portion of water used in this operation is lost enroute by evaporation and seepage. The evaporation tends to concentrate the dissolved material in the return route and in the aquifer beneath the route. The portion of the plume extended to the northwest from the landfill underlies the slurry route.

Based on the present location of the body of mineralized water, interceptor wells should be located approximately in the northeast and southeast corners of the Dyer Landfill. Wells in these locations will intercept flow along the natural eastward gradient and reverse the slight north and south components of flow. The area of influence of interceptor wells can be estimated using the hydrogeologic parameters, the transmissivity and storage coefficient, in a "calibrated" ground-water flow model.

Definition of Hydrogeologic Parameters

Investigations that included four short-term pumping tests and monitoring of water levels in wells tapping the principal aquifer (between 60 and 90 feet) and the sand and shell beds (between 5 and 15 feet) were conducted by Geraghty & Miller, Inc., during 1984 on Site 7 (west of Florida's Turnpike from the Dyer Landfill). These investigations revealed that the transmissivity of the shallow aquifer is approximately 101,000 gpd/ft (gallons per day per foot) and that the aquifer responds as an unconfined aquifer having a storage coefficient of about 0.20. East of Florida's Turnpike near Haverhill Road and about 3000 feet south of the Dyer Landfill, Fischer (1980) determined a transmissivity 82,000 gpd/ft. At a site southeast of the Dyer Landfill near Military Trail, the South Florida Water Management District (Staff Report, Modification to Permit No. 50-00460-W) concluded that the transmissivity of the shallow aquifer is about 80,000 gpd/ft, based on data from a test conducted by Barker, Osha and Anderson. The District also concluded that the storage coefficient is 0.20. In the District staff report cited, the results of a computer model were presented in which the shallow aquifer was described as having a transmissivity of 100,000 gpd/ft west of Haverhill Road and 80,000 gpd/ft east of Haverhill Road. The entire area was described as an unconfined aquifer with a storage coefficient of 0.20. This description is substantially consistent with all known information.

Site 7 and Dyer Landfill Water Demands

The demand for industrial uses at the Site 7 Resource Recovery Facility will be 2 mgd (million gallons per day) continuously through its useful life. The maximum irrigation water demand at Site 7 for closed portions of landfill will be about 0.6 mgd just prior to the time of closure; this corresponds to an application rate of about 0.6 inches per week on 273 acres. The Site 7 facility will be closed after 22 years of operation. The maximum irrigation water demand for the Dyer Landfill following closure (in 1987) also will be 0.6 mgd; this figure also corresponds to an application rate of 0.6 inches per week on 265 acres. Thus, the peak demand for water at Site 7 and the Dyer Landfill will be 3.2 mgd. These irrigation requirements are supplementary in nature and are estimated to prevent the loss of plants on the landfills during the dry season. The irrigation demands cited will be met for three months of the six-month dry season. An outline of water demands relative to the life of the Site 7 project is provided on Table 1.

On Site 7, all landfill areas (313 acres) except the last two landfill cells (20 acres each) will be irrigated during the same period of project operation as other water demands also are met. (About 20 years into project operations, about 273 acres of the Site 7 landfills will be closed and will require irrigation.) Upon complete closure of the Site 7 landfills, water previously used for cooling and in boilers will be used for irrigation to the extent needed. Also upon closure, the ground-water quality beneath all landfills will be evaluated and the ground-water monitoring plan for the landfills will be modified accordingly. The modifications may include the cessation or reduction of pumping from the interceptor wells, the installation of additional monitor wells and/or changing monitoring frequencies, and the implementation of state-of-art monitoring techniques that may be available at that time.

TABLE 1

WATER DEMANDS AT SITE 7
AND DYER LANDFILL DURING
AND AFTER THE USEFUL LIFE OF
SITE 7 LANDFILLS

Facility	Year of Demand from Project Start			
	1 to 22		greater than 22	
	Wet Season	Dry Season	Wet Season	Dry Season
Site 7 - Resource Recovery Facility and Landfills				
a) cooling and boiler water	2 mgd	2 mgd	None	None
b) irrigation water	None	0 to 0.6 mgd	None	0.6 mgd
Dyer Landfill				
a) irrigation water	None	0.6 mgd	None	0.6 mgd

Notes:
- demands are expressed in million gallons per day (mgd)
- expected useful life of Site 7 facilities is 22 years
- dry-season irrigation water demands are peak demands, estimated to be necessary for three months of the six-month dry season (November through April)

Because the supplemental irrigation will be applied only when necessary between dry-season rainfalls, the rainfall will be relied upon to satisfy approximately one-half of the dry season irrigation demand. The average six-month dry-season rainfall is 18 inches (Mac Vicar, 1981); however, rainfall duration and intensity varies considerably. If 8 of 18 inches is utilized effectively for grass irrigation, rainfall also will provide 0.6 inches per week (8 inches per 13 weeks) to the landfills, as applied to three months of the six-month dry season.

Because it is necessary to extract water continuously from the Dyer Landfill plume of mineralized water for effective removal of that plume, wells placed on the Dyer Landfill property will be pumped continuously; discharge will be used at the Site 7 facility during the wet season and for irrigation during the dry season. In summary, an interconnected system of wells should be pumped at a rate of 2 mgd for nine months of the year and 3.2 mgd for (the equivalent of) three months of the year. A practical representation of the total demand, for the purpose of hydrogeologic modeling, is to consider the wet-season (six months) demand to be 2 mgd and the dry-season (six months) demand to be 2.3 mgd. The total volume of water withdrawn in the representative model will be the same as the total volume expected to be withdrawn in reality.

Design of the Interceptor Well System

The locations and pumping rates of wells in the interceptor well system were determined on the basis of the ground-water flow direction, the proposed presence of the Site 7 landfills, and the known presence of the Dyer Landfill leachate plume. In the area of investigation, ground water flows dominantly eastward; well sites therefore were selected east of the proposed Site 7 landfills and Dyer Landfill. Such placement of wells ensures that natural flow gradients will reinforce the change in ground-water gradients caused by pumping and thereby capture ground water that is known to be or may be degraded.

Another consideration in determining the "location" of interceptor wells is that they tap the appropriate vertical interval. Figures 2 and 3 indicate that at depths less than about 37 feet, leachate at the Dyer Landfill is limited to the landfill area; however, some off-site migration occurs through the deposits below depths of 42 feet. The predominant leachate flow path is apparently downward into the principal aquifer from the water table underlying the landfill, then laterally into off-site areas through the principal aquifer. The concentration of chloride in the principal aquifer decreases with distance from the landfill due to dispersion and dilution by precipitation recharge. Accordingly, wells pumping from the sand and shell deposits above 37 feet would be most effective immediately beneath the landfill because a greater concentration of leachate, per gallon of water pumped, could be removed from the ground-water flow system. Wells tapping the sand and shell deposits, however, would be ineffective in intercepting leachate already in the principal aquifer. Another disadvantage is that such wells would have to be constructed through the landfill. Therefore, wells tapping the principal aquifer will provide the most efficient and beneficial leachate removal.

In order to optimize the design of the interceptor well system, ground-water flow was simulated with a computer model (Prickett and Lonnquist, 1971). The aquifer parameters (transmissivity and storage coefficient) used were basically the same as those used by the SFWMD (South Florida Water Management District) as cited above. Interceptor well locations east of the landfill areas were selected and pumping rates were varied on a trial-and-error basis until an optimum number of wells were located and pumped at such rates to adequately intercept all potential leachate.

The flow system simulated is bounded on the west by the WCA (West Palm Beach Water Catchment Area) where a constant head of 17.0 feet above NGVD (National Geodetic Vertical Datum) was utilized to represent a dry-season level. Water levels in the WCA generally are maintained between 17.5 and 18.5 feet above NGVD. The eastern boundary of the model is the Earman River (C-17) where a constant head of 7.0 feet above NGVD was input. This level is indicated to be the approximate dry-season elevation on maps by Land and others (1973) and by Rodis and Land (1976). The northern and southern boundaries of the model correspond to east-west lines located 5000 feet north of Blue Heron Boulevard and 9000 feet south of 45th Street, respectively. The northern and southern boundaries are sufficiently distant from the area of interest to have no significant effect on the model. The model employed nodal areas 1000 feet on each side. Figure 5 depicts the area evaluated with the flow model.

The model first was calibrated to conform with the approximate existing distribution of ground-water levels as determined in the Site 7 area by Geraghty & Miller, Inc., and as reported by Fischer (1980) and Land and others (1973). These conditions include dry-season boundaries (described above) but are regarded as representing average water-availability conditions. The process of model "calibration" refers to the trial-and-error method by which unknown or generalized parameters such as the evapotranspiration, recharge, and boundary conditions are adjusted to the point where (together with the known parameters of transmissivity and storage coefficient) the operation of the model reproduces the known distribution of ground-water levels in the modeled area. Evapotranspiration from the water table was incorporated in the model as a variable function of the depth of the water table below land surface. The maximum rates of evapotranspiration from the water table and factors controlling the variable rate of evapotranspiration are shown on Figure 5. The evapotranspiration was first estimated with the use of a method and data provided by Dohrenwend (1971). The depth of zero water-table evapotranspiration was approximated based on a report by the U.S. Army Corps of Engineers (1955), and adjusted to reflect the variable types of vegetation (deep or shallow root systems) in the area modeled. The gross annual rate of ground-water recharge was initially estimated to be 30 inches per year (this figure was ultimately used) based on work by Camp, Dresser & McKee (1980). The evapotranspiration and recharge rates were repeatedly

Constant Head Boundary

Florida's Turnpike

Dyer Landfill

Constant Head Boundary

No-Flow Boundary

Site 7

Site 7 Landfill

45th Street

170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	$\boxed{121}$	116	$\boxed{109}$	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	$\boxed{121}$	$\boxed{116}$	109	99	87	70
170	160	152	147	143	140	138	136	134	$\boxed{133}$	$\boxed{131}$	$\boxed{130}$	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	$\boxed{125}$	121	116	109	99	87	70
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170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70
170	160	152	147	143	140	138	136	134	133	131	130	128	125	121	116	109	99	87	70

No-Flow Boundary

101,000 | 80,000

Transmissivity, in gallons per day per foot

0.20

Storage Coefficient

30

Gross Ground-Water Recharge, in inches

57 | 48

Maximum Ground-Water Evapotranspiration, in inches

17 | 16 | 15 | 14 | 13 | 12

Land-Surface Elevation, in feet above NGVD

10 | 9 | 8 | 7

Ground-Water Evapotranspiration Cut-Off Elevation, in feet above NGVD

LEGEND

☐ PRODUCTION WELL, CITY OF RIVIERA BEACH (SHADING INDICATES PROPOSED WELL)

NOTE: EACH NODE REPRESENTS AN AREA 1000 FEET BY 1000 FEET. HEADS ARE INDICATED AT EACH NODE IN TENTHS OF FEET ABOVE NGVD

PREPARED FOR HAYDEN-WEGMAN

BARKER, OSHA & ANDERSON

TITLE GROUND-WATER FLOW MODEL PARAMETERS AND CALIBRATED HEADS/ STEADY-STATE CONDITIONS, NO PUMPING

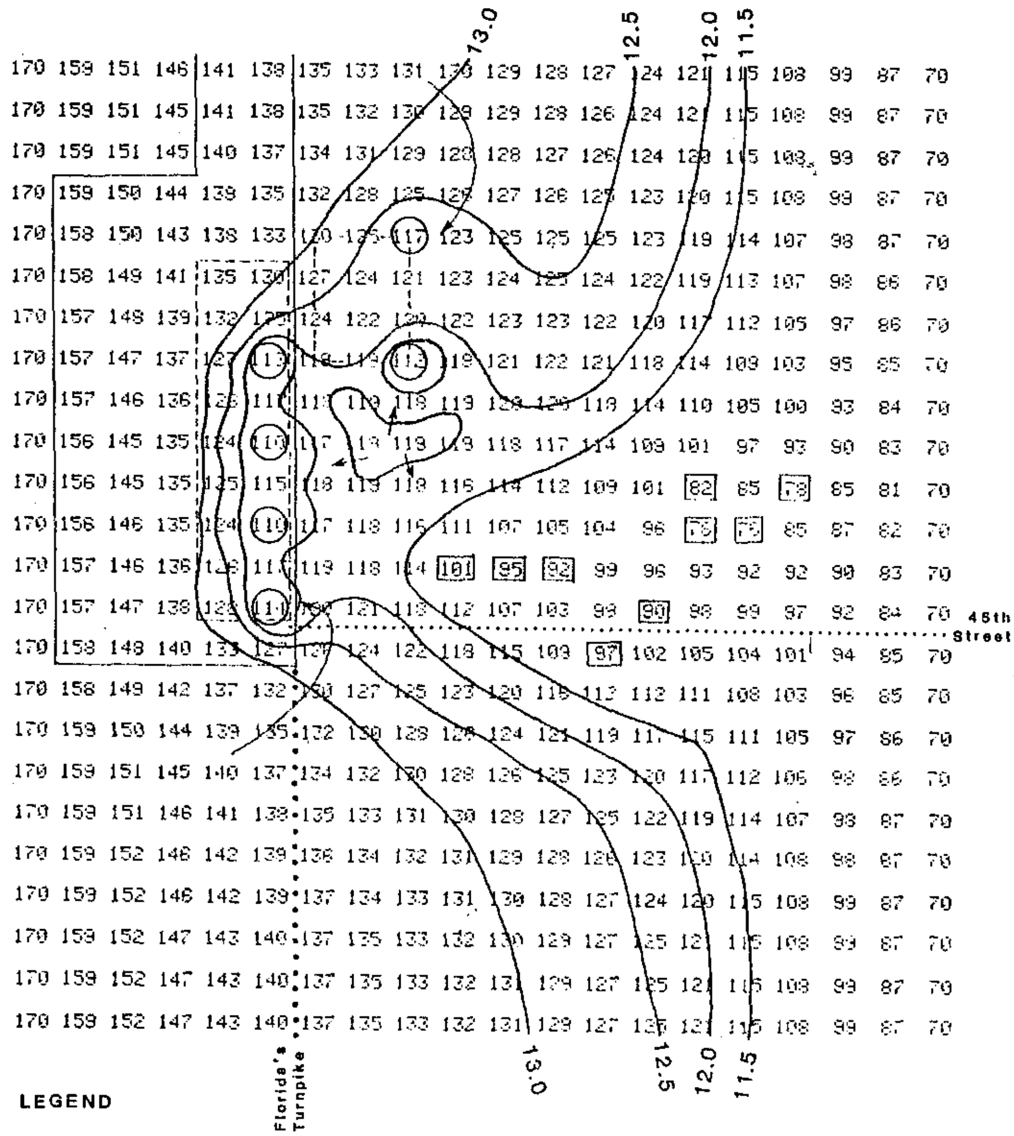
COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE MARCH '85
DRAWN BY R. PADULA	Palm Beach Gardens, Florida	REVISED
CHECKED BY P. JAKOB	SCALE	FIGURE 5

adjusted to enable calibration of the model and therefore are regarded as representative of the modeled area.

Another consideration that was incorporated into the model was pumpage from four existing wells and five wells proposed for the City of Riviera Beach by Barker, Osha & Anderson, Inc. The use of the proposed wells is currently being considered by the SFWMD. The existing and proposed well locations also are shown on Figure 5; they will extract about 3 mgd on an annual average basis and a peak of about 8 mgd during the dry season. Interceptor well locations and pumping rates were selected with use of the flow model so that any existing or potential leachate would not reach the RB (Riviera Beach) wells and so that the interceptor wells would not significantly reduce the capability of the RB wells to produce water.

Following "calibration" of the ground-water heads to known conditions and a steady-state (one that does not change with time) flow configuration (heads shown on Figure 5), six interceptor wells and nine RB wells were incorporated in the model simulating average water-availability conditions and total withdrawal rates of 2 mgd and 3 mgd, respectively. The distribution of heads, also at steady state, while pumping at these rates is shown on Figure 6. Six wells were determined to comprise the most efficient interceptor well system under these conditions. The interceptor wells remove all water from known and potential areas containing leachate and do not significantly impact the RB wells.

To test the effect of pumping interceptor wells and RB wells at times of dry-season demand, the flow model was evaluated beginning with heads shown on Figure 6 at time-zero, and by pumping the interceptor wells at a total of 2.6 mgd and the RB wells at a total of 3.825 mgd for a six-month period. Time-zero in this case is a condition representative of the end of average water-availability conditions and six months of pumping at 2 mgd and the start of the dry season. Gross aquifer recharge was estimated to be 3.5 inches over the six-month dry season.



LEGEND

13.0 GROUND-WATER CONTOUR IN FEET ABOVE NGVD

INTERCEPTOR WELL

PRODUCTION WELL, CITY OF RIVIERA BEACH (SHADING INDICATES PROPOSED WELL)

DIRECTION OF GROUND-WATER FLOW

NOTE: EACH NODE REPRESENTS AN AREA 1000 FEET BY 1000 FEET, HEADS ARE INDICATED AT EACH NODE IN THENTHS OF FEET ABOVE NGVD

PREPARED FOR HAYDEN-WEGMAN BARKER, OSHA & ANDERSON

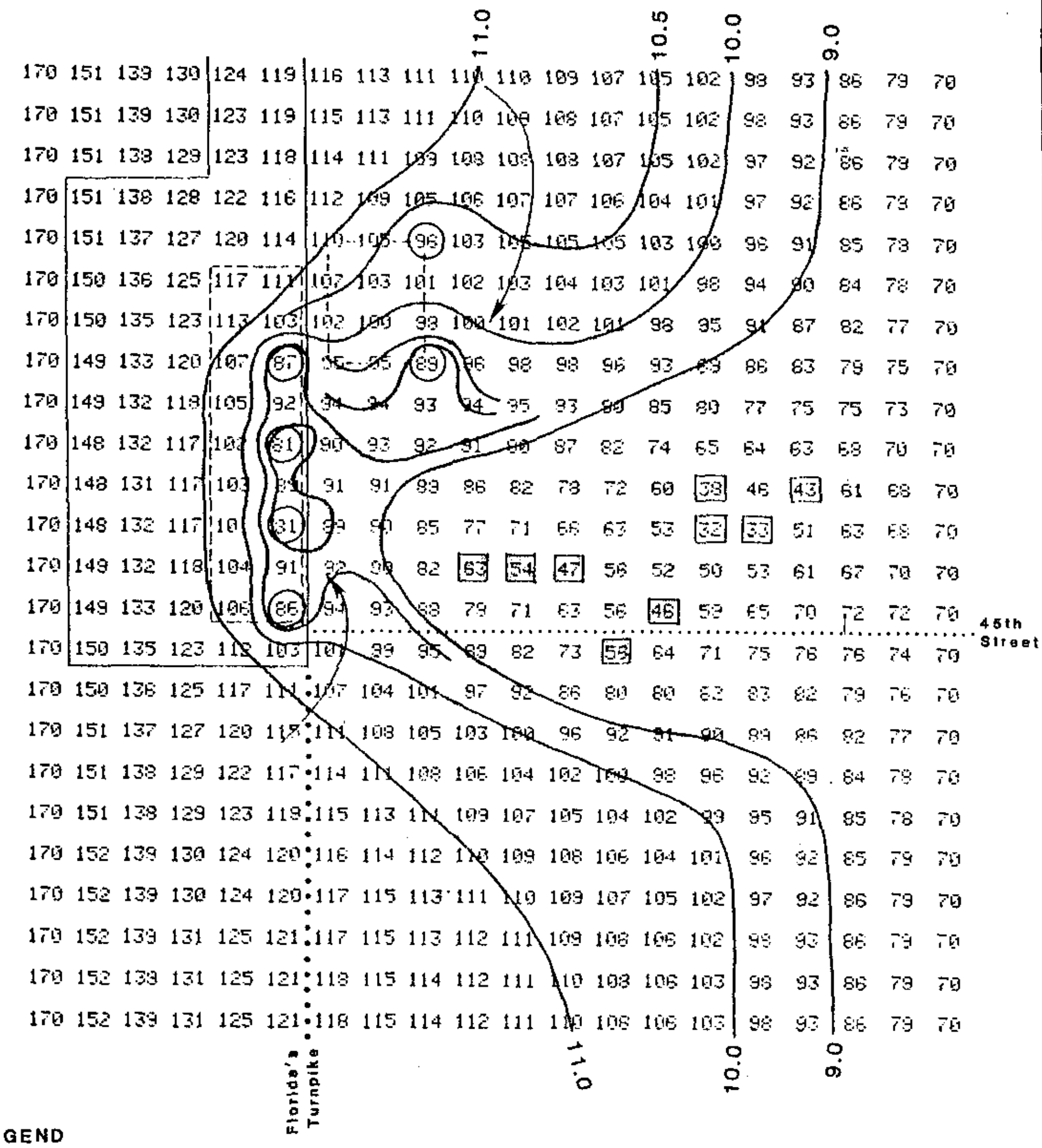
TITLE GROUND-WATER CONTOURS WITH WET-SEASON PUMPING FROM ALL WELLS SHOWN/AVERAGE RECHARGE RATE, STEADY-STATE CONDITIONS

COMPILED BY P. JAKOB | Geraghty & Miller, Inc. Palm Beach Gardens, Florida | DATE MARCH '85
DRAWN BY R. PADULA | | REVISED
CHECKED BY P. JAKOB | SCALE | FIGURE 6

This amount of recharge is one-half the rainfall expected during a 1-in-10-year dry-season drought (SFWMD, unpublished data). The 2.6-mgd withdrawal is the average dry-season demand for the interceptor wells. The 3.825-mgd withdrawal is 27.5 percent higher than the average demand of 3 mgd. This percentage increase above average corresponds to the percentage increase during the peak month of 1984, compared to annual average, experienced in the RB water system. It is considered to be the maximum peak-season demand and to impose the maximum probable stress on the aquifer over the six months tested on the model. A six-month period is regarded as the maximum continuous time that both well fields would be pumped at maximum-month rates.

Under the conditions described, the distribution of ground-water heads developed by the model after 180 days (and shown on Figure 7) indicates that ground water cannot flow from the area of the Site 7 landfills toward the proposed RB wells. On the basis of this analysis, it is concluded that no potential Site 7 leachate could flow toward the RB wells. The reason for this is that the heads near the locations of the Site 7 interceptor wells are lower than heads in the direction of the proposed RB wells. Thus, a ground-water divide is present, preventing leachate migration toward the proposed RB wells.

Figure 7 shows that pumping the interceptor wells during the dry season at maximum rates for a period of six months also prevents the known Dyer Landfill leachate from migrating toward the existing and proposed RB wells. Although a ground-water divide does not exist between the plume and the RB wells, ground water originating in the area of the plume will flow dominantly toward the interceptor wells as opposed to the RB wells. A minor quantity of ground water originating near the southern border of the landfill could flow toward the RB wells at a very low velocity and under the influence of a very low ground-water gradient. Because of the low velocity (less than 0.07 feet per day), such ground-water flow would not persist long enough for elements of the plume to reach the RB wells before average water-availability conditions are re-established as depicted on Figure 6. The effectiveness of the interceptor wells is



LEGEND

—10.0 GROUND-WATER CONTOUR IN FEET ABOVE NGVD

◯ INTERCEPTOR WELL

☐ PRODUCTION WELL, CITY OF RIVIERA BEACH (SHADING INDICATES PROPOSED WELL)

⟶ DIRECTION OF GROUND-WATER FLOW

NOTE: EACH NODE REPRESENTS AN AREA 1000 FEET BY 1000 FEET, HEADS ARE INDICATED AT EACH NODE IN THENTHS OF FEET ABOVE NGVD

PREPARED FOR	HAYDEN-WEGMAN BARKER, OSHA & ANDERSON
TITLE	GROUND-WATER CONTOURS WITH DRY-SEASON PUMPING FROM ALL WELLS SHOWN/DRY SEASON RECHARGE RATE, AFTER SIX MONTHS OF CONTINUOUS PUMPING

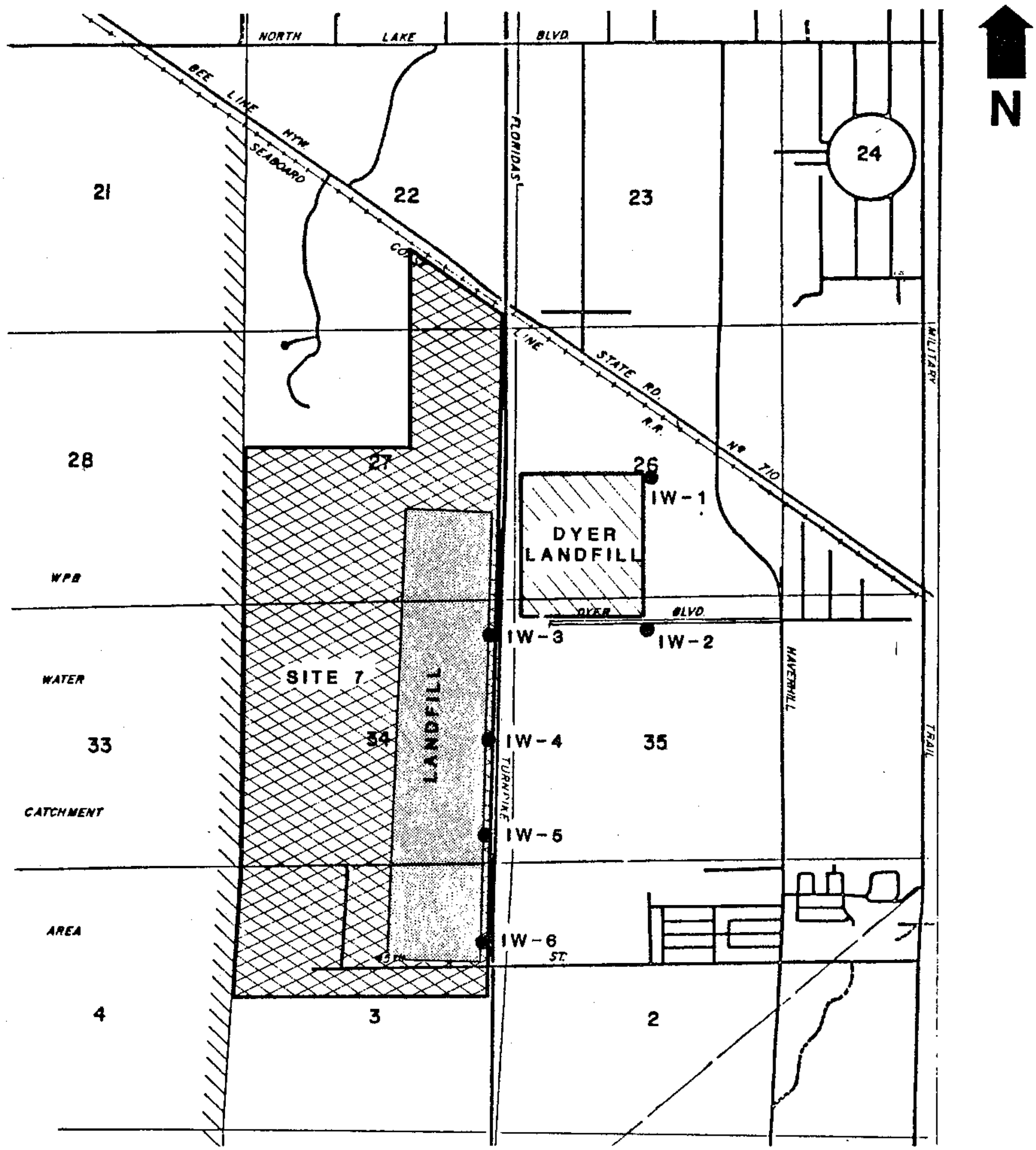
COMPILED BY P JAKOB	Geraghty & Miller, Inc.	DATE MARCH '85
DRAWN BY R PADULA	Palm Beach Gardens, Florida	REVISED
CHECKED BY P JAKOB	SCALE NONE	FIGURE 7

thus demonstrated even under conditions of prolonged pumping at peak-month rates during a 1-in-10-year drought.

To test the extent of drawdown in the RB wells due to pumping the interceptor wells at the end of the dry season, the same model configuration as described immediately above was run without the interceptor wells. The highest resulting head in the vicinity of the RB wells was only 0.4 feet higher at the end of dry-season pumping. Compared to the available drawdown in the RB wells (likely to be about 50 feet), the 0.4 feet of drawdown in the RB wells caused by the interceptor wells is less than one percent - an insignificant impact.

Operation of the interceptor wells will not adversely impact other neighboring ground-water users. Besides the RB wells, the nearest possible wells that could be affected are private wells located about 0.5 miles north from the most northern interceptor well. These private wells would experience a drawdown of about 0.2 feet due to pumping the interceptor wells after 180 days of dry-season pumping; this is not a significant impact. It is concluded from the ground-water model that six interceptor wells, in the locations and operating at pumping rates as described above, will: (1) intercept ground water known to be degraded and that which potentially may be degraded, (2) provide an industrial water supply for the Site 7 facilities, (3) provide irrigation water for the Dyer Landfill and Site 7 landfills, and (4) have no significant impact on existing and proposed wells of the City of Riviera Beach or private wells nearby.

The recommended locations of interceptor wells are shown on Figure 8. These locations can be adjusted by a few hundreds of feet without significantly affecting their performance; this may be necessary to avoid co-location with existing or other planned structures. The recommended average rates of pumping of the interceptor wells is shown on Table 2. Wells should be equipped with pumps capable of pumping 500 gpm (gallons per minute) each in order to provide managerial flexibility. Each of the four interceptor wells west of the Turnpike



LEGEND

● IW-1 INTERCEPTOR WELL AND NUMBER

0 2000 4000

SCALE FEET

PREPARED FOR	HAYDEN-WEGMAN BARKER, OSHA & ANDERSON
TITLE	RECOMMENDED LOCATIONS OF INTERCEPTOR WELLS

COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE MARCH 1985
DRAWN BY R. PADULA	Palm Beach Gardens, Florida	REVISED
CHECKED BY P. JAKOB	SCALE SHOWN	FIGURE 8

TABLE 2

RECOMMENDED PUMPING SCHEUDLE
FOR INTERCEPTOR WELLS

Well	Wet Season	Dry Season
IW 1 and 2	500 gpm* for 10 hours per day for Site 7 use	500 gpm for 10 hours per day for Site 7 use or alternatively for irrigation on Dyer Landfill
IW 3, 4, 5 and 6	500 gpm for 11.67 hours per day for Site 7 use	500 gpm for 21.67 hours per day for Site 7 use; 0.6 mgd is designated for irrigation on Site 7 landfills
Total Pumping Rate	2.0 mgd**	3.2 mgd

* gallons per minute
** million gallons per day

will be pumped at an average of 0.35 mgd during the wet season and 0.65 mgd during three months of the dry season. Each of the two interceptor wells at the Dyer Landfill will pump at an average of approximately 0.30 mgd.

Previous work conducted by Geraghty & Miller, Inc. (1982), south of the landfill indicated that interceptor wells well tapping the principal aquifer should be designed with a well screen and gravel pack. Well construction should be preceded by a pilot hole to determine the exact vertical interval for installation of the well screen; that interval should be approximately between 50 and 100 feet below grade. The well should be constructed with a grouted casing having a diameter of at least 12 inches extending from land surface to about 50 feet below grade. The well casing annulus should be grouted in its entire length to protect against entry of surface water. The well screen should have a diameter of at least 6 inches; it should be installed through the casing and be fitted on top with a riser pipe of the same diameter as the well screen and have a length of about 15 feet. The riser pipe should be situated inside the bottom portion of the casing. A suitable gravel pack should be installed in the annular space outside the well screen and about one half the height of the riser pipe. With an estimated well-friction loss in head of 5 feet, pumping any of the wells at a rate of 500 gpm would produce a drawdown in the well of approximately 15 feet.

Respectfully submitted,
GERAGHTY & MILLER, INC.

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B. J. Bermes

Boris J. Bermes
Senior Scientist

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GROUND-WATER LEVEL ELEVATIONS
in feet above mean sea level

Date	Time	Well 1	Well 2	Well 3	Well 4
7/11/84	am	14.56	14.12	14.29	16.48
	pm	--	14.06	14.19	16.46
7/12/84	am	14.56	14.08	14.02	16.64
	pm	14.53	14.05	13.96	16.55
7/13/84	am	14.54	14.07	--	16.61
	pm	14.51	14.01	--	16.50
7/14/84	am	14.51	14.02	--	16.56
	pm	14.48	13.98	--	16.49
7/15/84	am	14.49	14.01	--	16.59
	pm	14.45	13.96	--	16.45
7/16/84	am	14.47	13.97	13.88	16.51
	pm	14.41	13.89	13.76	16.36
7/17/84	am	14.41	13.90	13.82	16.45
	pm	14.38	13.85	13.71	16.32
7/18/84	am	14.38	13.85	13.77	16.39
	pm	14.33	13.78	13.64	16.24
7/19/84	am	14.34	13.78	13.70	16.15
	pm	--	13.83	13.78	--
7/20/84	am	--	13.64	13.81	--
	pm	--	13.79	14.21	--
7/21/84	am	--	13.90	14.21	--
	pm	--	13.97	14.36	--
7/22/84	am	--	13.98	14.48	--
	pm	--	14.06	14.44	--
7/23/84	am	--	14.05	14.43	--
	pm	--	14.14	14.55	--
7/24/84	am	--	14.12	14.48	--