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ESTIMATION OF THE ZONE OF INFLUENCE OF THE PORT MALABAR WELL FIELD PORT MALABAR, FLORIDA FOR VARIED WITHDRAWALS USING A NUMERICAL MODEL

BY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The St. Johns River Water Management District, at the request of the City of Palm Bay, provided technical assistance in defining the zone of influence for the existing Port Malabar well field. This zone of influence is defined as the area around the well field where drawdown equals or exceeds 0.5 foot. The zone of influence would be used as a means to establish a zoning classification around the well field to ensure water quality protection from potential contamination related to existing and future land uses.

A two-dimensional ground water flow model was used to predict the areal extent of the well field cone of depression in response to three pumping scenarios. The 0.5 foot drawdown contour was used to delineate the zone of influence. Three zones of influence were calculated. One is the result of pumping the production capacity of 5.2 mgd, the second is the result of pumping the well field at a maximum design capacity of 8.2 mgd (Geraghty and Miller, 1975), and a third condition was based on monthly average withdrawals from the well field (2.5 mgd). These capacities bracket the amount of water permitted by the SJRWMD (5.5 mgd).

Based on the model, the 0.5 foot contour for all three of the withdrawal rates extends into Harris Corporation property boundary, on which an identified area of ground water source of volatile organic compounds is located.

To further ensure maximum protection from contamination for the purposes of zoning, the extent of the zone of influence for the design capacity (8.2 mgd) could be extended an additional 600 feet beyond the 0.5 foot contour where the influence of the well field is minimal. This would provide protection under all conditions.

INTRODUCTION

At the request of the City of Palm Bay, the St. Johns River Water Management District agreed to provide assistance to the city in defining the zone of influence for the existing Port Malabar well field. For the purpose of this report, the zone of influence is defined as the area around the well field where drawdown equals or exceeds 0.5 foot.

The well field is owned and operated by General Development Utilities, Inc. (GDU), a subsidiary of General Development Corporation. In a few of GDU's potable water supply wells, it was discovered that high levels of volatile organic compounds were present. In one production well, concentrations as high as 3,943 ppb's have been found (CH_2M Hill, 1984). Citizens of Palm Bay have been concerned about the safety of the water supply and have petitioned the city to ensure the protection of its quality. To ensure water quality, Harris Corporation is taking remedial action to correct potential harm to the water resources.

DESCRIPTION OF THE MODELED AREA

Port Malabar's public supply well field is located southwest of Palm Bay between Palm Bay Boulevard on the north and Port Malabar Road on the south. Harris Corporation property, the location of the volatile organic compounds (CM_2Hill, 1984), is located just north of the well field (Figure 1). The Harris Corporation facilities cover an area of approximately 150 acres. This property had been a site of other activity prior to Harris Corporation ownership.

Geologic Setting

The surficial sands in the area are separated from the production zone by a semi-confining layer of fine sand, silts, and clays. The reported thickness of the confining layer is variable, ranging from 10 to as much as 40 feet and averaging about 20 feet. The principal aquifer, comprised of sand, shells, silt, and occasional stringers of limestone, ranges from 50 to 100 feet thick and averages about 80 feet (Geraghty and Miller, 1982). Below 100 to 110 feet lie the clays of the Hawthorn formation which form a lower confining unit with a thickness of up to 150 feet thick. A typical geologic well log for the Port Malabar area is given in Table 1.

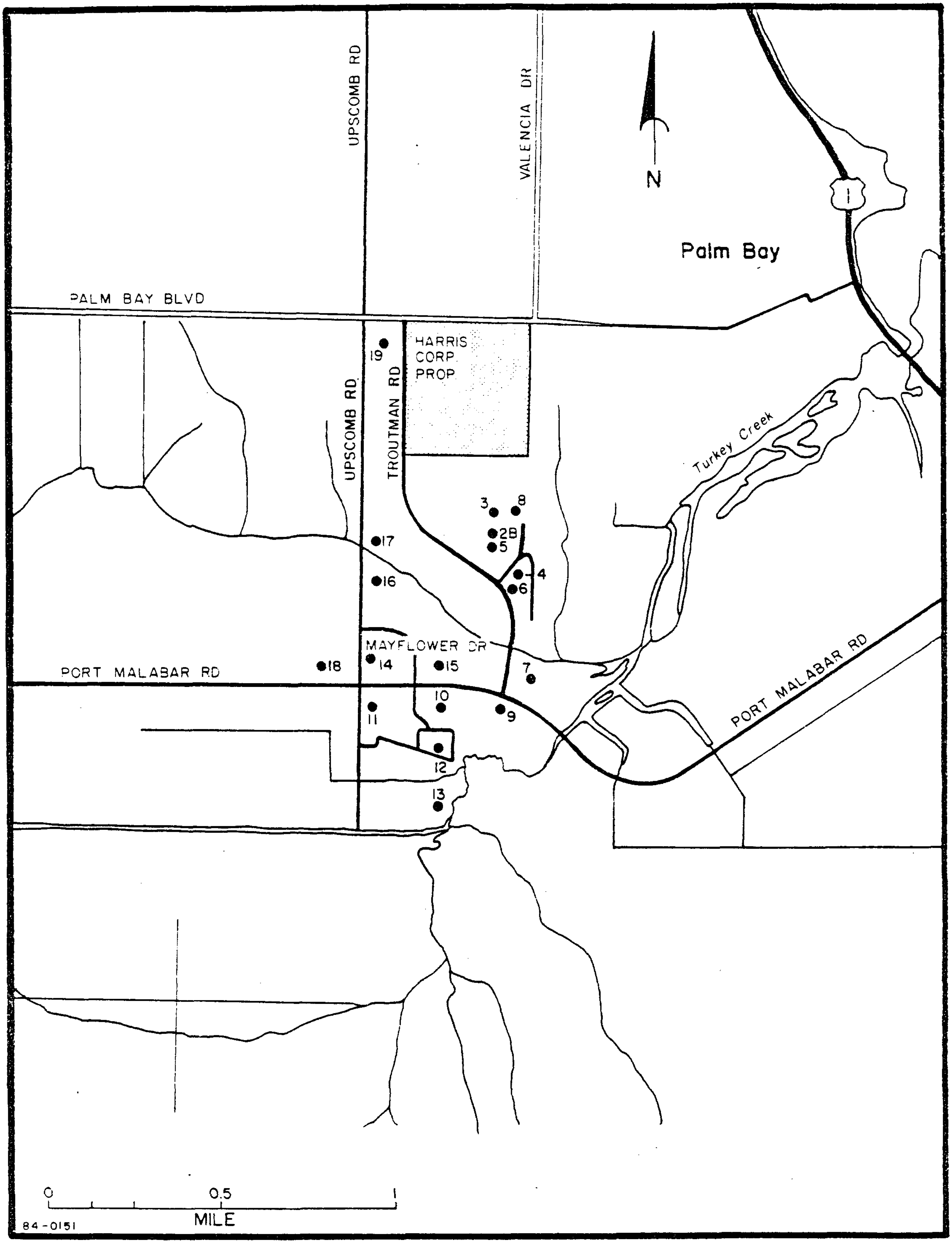

Figure 1. Map Showing Port Malabar's Well Field at Port Malabar, Florida

TABLE 1

GEOLOGIC LOG OF TEST WELL 73-1
PORT MALABAR, FLORIDA

Well 73-1	Depth (feet)
Sand, very fine to fine grained, white	0 - 6
Clay, white to gray	6 - 27
Sand, very fine to medium grained, gray, trace of large shells	27 - 38
Coquina, trace of very fine to medium grained and gray clay	38 - 57
Shells and clay, interbedded, gray, trace of fine grained sand	57 - 68
Shells and sand, very fine to medium grained, light gray, trace of gray clay	68 - 83
Marl, gray, trace of shells	83 - 104
Marl, gray	104 - 118
Marl and limestone, phosphatic, trace of white clay	118 - 128
Clay, green, soft	128 - 129
Total depth	129

DESCRIPTION OF MODEL

The USGS Finite-Difference Flow Model for Aquifer Simulation in Two Dimensions (Trescott et al, 1976) was used to simulate the imposed stress of 18 wells withdrawing at a design capacity of 5.2 mgd, maximum design capacity of 8.2 mgd, and monthly average withdrawals from the well field (2.5 mgd). The ground water flow system at Port Malabar was conceptualized in this model as a leaky artesian system. Sources of water include the water-table aquifer and the constant head boundary located along the western periphery of the grid. This model requires that the elevation of the water table be fixed and recharge to the lower aquifer is the product of the head differential between the water table and the lower aquifer and the leakage coefficient of the confining layer. The leakage coefficient is the recharge rate per unit area per unit head differential. A representative value of 0.108 gpd/ft^2 was used in this analysis (Geraghty and Miller, 1982). The averaged transmissivity value for the shallow rock aquifer of 12,000 gpd/ft (Geraghty and Miller, 1982) was used throughout the model except at production wells where transmissivity values were calculated (Table 2).

TABLE 2

TRANSMISSIVITY VALUES FOR PRODUCTION WELLS IN GALLONS PER DAY PER FOOT (GERAGHTY AND MILLER)

Well Number	Transmissivity
2B	9,800
11	17,160
12	12,100
13	10.200
14	11,000
15	9,600
16	7,600
17	15,800
18	10,500
19	15,600

Water table elevation is estimated to be five feet below land surface. An average confining bed thickness of 20 feet, as reported by Geraghty and Miller (1982), is used throughout the modeled area.

In addition to the constant head boundary located along the western periphery of the model grid, no-flow boundaries were placed along the northern, southern, and eastern sides of the grid. These boundaries were chosen due to lack of data to describe natural flow boundaries. The grid was expanded and boundaries located far enough from the well field so there would be no effect in the area of interest from the no-flow boundary. A variable grid was constructed to maximize resolution on concentrated drawdowns. Simulated withdrawals for the 18 wells were run to steady-state. Under this condition, recharge is balanced by discharge and no change in storage occurs in the aquifer.

Pumping rates used for each of the wells for 5.2 and 8.2 mgd withdrawals are shown in Table 3. The pumping rate 5.2 mgd was derived from Geraghty and Miller (1982). The additional 3 mgd to achieve the 8.2 design capacity was proportionally divided among the 18 wells.

The standard procedure in modeling a ground water system includes refining initial estimates of aquifer properties until the model accurately reproduces an observed water level configuration. The Port Malabar well field lacked water level data with which to do such a calibration. For this reason, a more simplistic approach was taken. Aquifer properties previously defined were used in the model without refinement. The model was then run to obtain a steady-state water level configuration for the study area under unstressed conditions (no pumping). The resulting water level configuration was subsequently used as a starting condition for simulation of stressed conditions (pumping). These simulations were also run to steady-state. The final head differential between the unstressed and stress water levels represent the drawdown associated with the particular pumping conditions used. Therefore, without reliable water levels with which to test the accuracy of the model, these results should not be considered as exact. However, they do provide an estimate of the expected drawdowns given the conditions used.

TABLE 3

MODELED PRODUCTION WELL WITHDRAWAL RATES

Well Number	Withdrawal Capacity of 5.2 mgd Pumping Rate in cfs	Well Field Capacity of 8.2 mgd Pumping Rate in cfs
2B	0.22	0.48
3	0.33	0.59
4	0.33	0.59
5	0.39	0.65
6	0.36	0.62
7	0.33	0.59
8	0.33	0.59
9	0.36	0.62
10	0.56	0.82
11	0.36	0.62
12	0.57	0.83
13	0.40	0.66
14	0.33	0.59
15	0.51	0.77
16	0.56	0.82
17	0.89	1.15
18	0.53	0.79
19	0.61	0.87

AQUIFER RESPONSE

Drawdown Analysis for 5.2 Million Gallons Per Day

Drawdowns resulting from withdrawals of 5.2 mgd are illustrated in Figure 2. The limit of the cone of depression is elliptical in configuration. The influence extends 11,000 feet (2.1 miles) from north to south; from east to west the cone of influence extends beyond 8,000 feet (1.5 miles). The greatest drawdowns of 25 feet are centered around wells 16 and 17 on the north side of the well field and wells 10 and 15 along Port Malabar Road. As much as 5 feet of drawdown extends into the boundary of Harris Corporation property. The input data for the model, the withdrawal rate of 5.2 mgd, can be found in Appendix A.

Drawdown Analysis for 8.2 Million Gallons Per Day

Withdrawals from the well field at maximum design capacity (8.2 mgd) increased the overall zone of influence by 30 percent in relation to the 5.2 mgd pumping response. The magnitude of drawdown also increased 23 percent at wells 10 and 15 (Figure 3). The extent of the zone of influence is greatest on the south side of the well field. The 0.5 foot contour on the west side of the well field extends the same distance as did the withdrawal of 5.2 mgd. This may be due to the constant head source located on the western boundary of the grid that describes the regional flow in the shallow rock aquifer. Drawdowns simulated from the

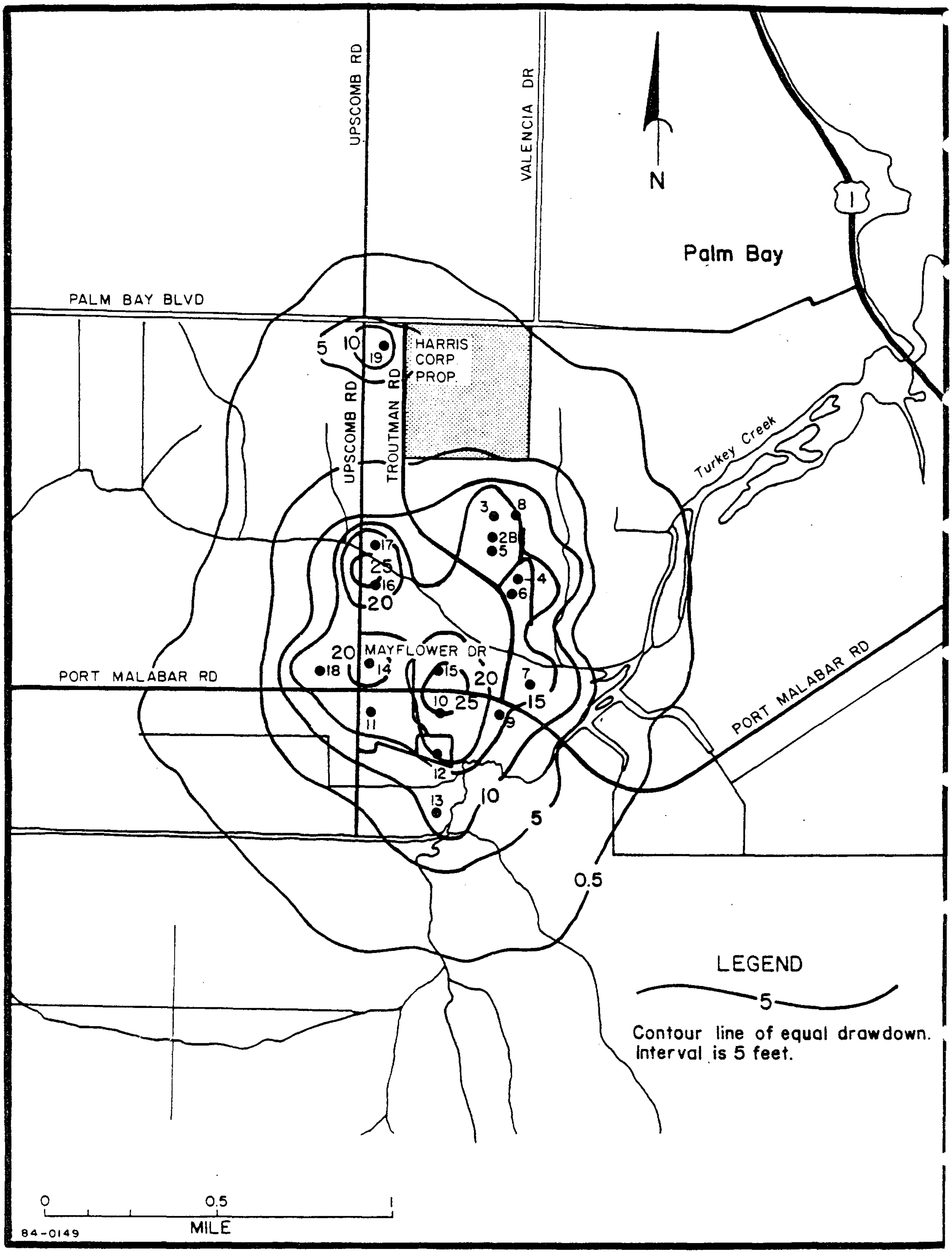

Figure 2. Drawdown Contours from Pumping 5.2 mgd in Shallow Rock Aquif
in Port Malabar Well Field

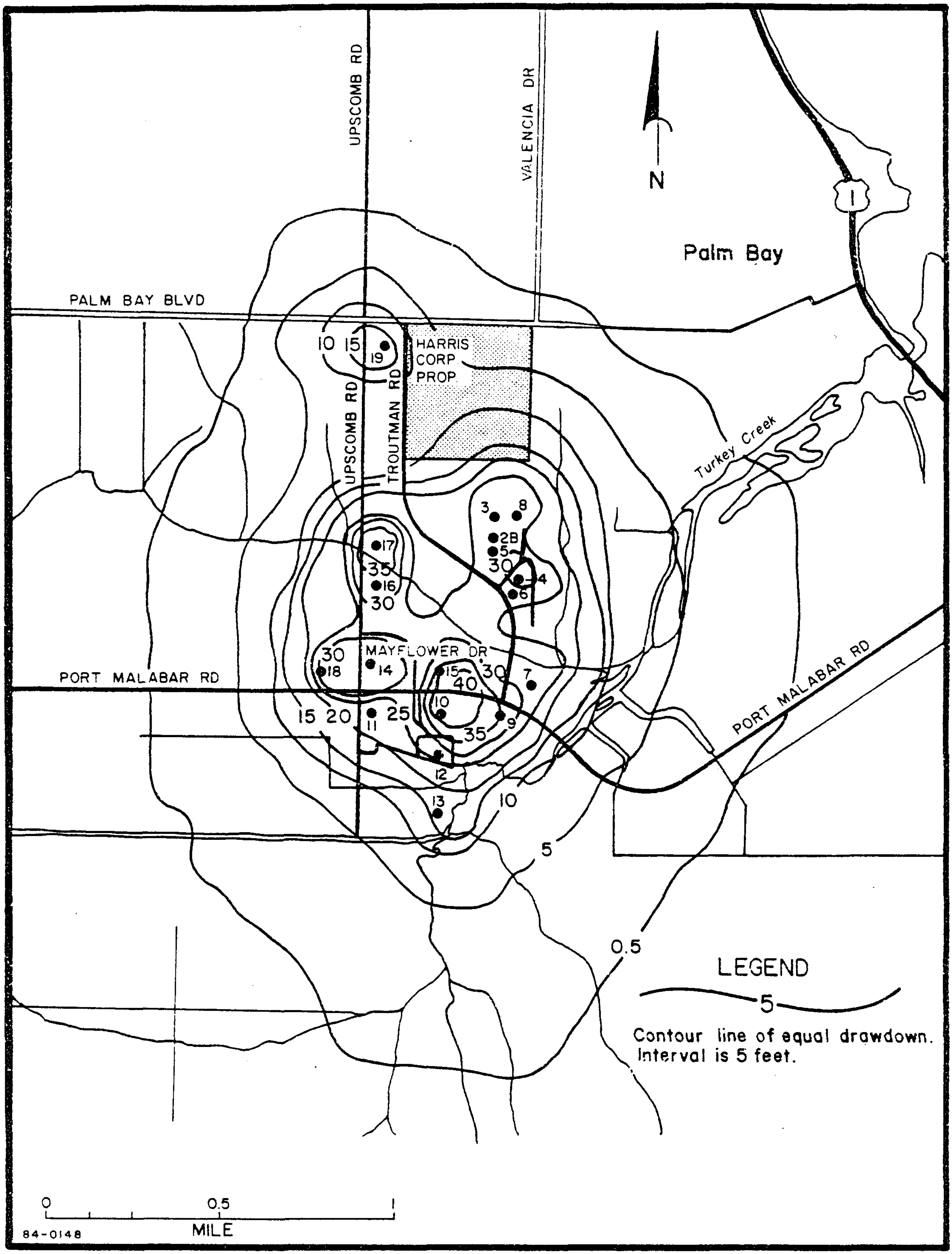

Figure 3. Drawdown Contours from Pumping 8.2 mgd in Shallow Rock Aquifer in Port Malabar Well Field.

withdrawal of 8.2 mgd indicate water levels are lowered an additional 15 feet along the southern boundary of Harris Corporation property. The influence of the 5 feet drawdowns are felt over 80 percent of the Harris property.

Steady-state conditions represent the hydro-dynamics of the well field when it reaches equilibrium. The well field may never reach steady-state under real conditions. Therefore, the predicted drawdowns represent a worst case scenario. Levels and drawdowns have been calculated in each of the production wells for 5.2 mgd and 8.2 mgd (Table 4).

TABLE 4

CALCULATED HEAD AND DRAWDOWNS (MSL) IN PUMPING WELLS

	5.2 mgd		8.2 mgd	
Well Number	Head (ft below msl)	Drawdown (ft)	Head (ft below msl)	Drawdown (ft)
2B	-31.85	37.55	-59.75	65.45
3	-28.64	34.84	-54.88	61.08
4	-31.85	37.55	-59.75	65.45
5	-39.73	45.13	-69.94	75.34
6	-35.11	40.71	-63.39	68.99
7	-29.30	34.60	-54.80	60.10
8	-26.79	32.89	-51.90	58.00
9	-35.74	41.34	-63.20	68.80
10	-52.54	58.84	-81.82	88.12
11	-26.11	32.71	-47.82	54.42
12	-48.93	54.63	-75.31	81.01
13	-33.89	38.99	-58.80	63.90
14	-34.45	41.45	-63.45	70.45
15	-55.41	61.41	-87.84	93.84
16	-68.42	74.72	-103.10	109.40
17	-57.01	63.11	-77.69	83.79
18	-47.19	53.89	-74.70	81.40
19	-29.17	38.27	-45.60	54.70

Drawdown Analysis for 2.5 Million Gallons Per Day

Average monthly withdrawals from GDU between January 1983 and May 1984 (Table 5) indicate 2.5 mgd have been pumped from the well field. This rate is 30 percent of the well field maximum design capacity (8.2 mgd). Further analysis revealed that the zone of influence for the withdrawal of 2.5 mgd was 36 percent smaller than that resulting from the withdrawal of 8.2 mgd and 7 percent smaller than that resulting from a withdrawal of 5.2 mgd. Even at this rate (2.5 mgd) the zone of influence extends beyond Harris Corporation's northern boundary (Figure 4).

TABLE 5

AVERAGE MONTHLY PUMPAGE IN MGD
FROM JANUARY 1983 TO MAY 1984

1983	January	2.3
	February	2.3
	March	2.2
	April	2.2
	May	2.5
	June	2.3
	July	2.5
	August	2.4
	September	2.5
	October	2.4
	November	2.3
	December	No data
1984	January	2.4
	February	2.5
	March	No data
	April	3.2
	May	3.6

Source: Compliance Data, SJRWMD

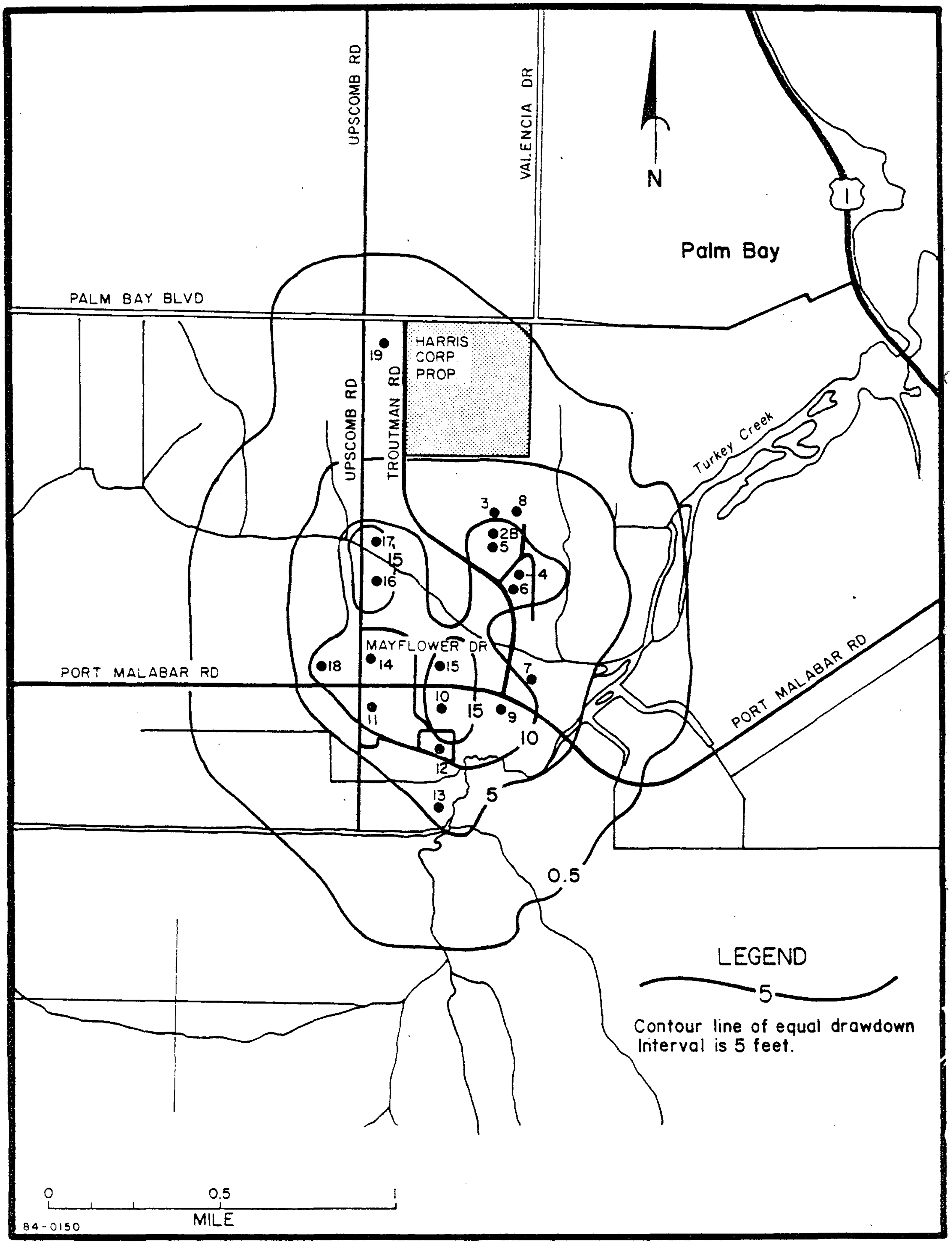

Figure 4. Drawdown Contours from Pumping 2.5 mgd in Shallow Rock Aquifer in Port Malabar Well Field

DISCUSSION AND CONCLUSION

Based on the results of the modeling, the zone of influence (0.5 feet) of the well field extends into the property at Harris Corporation whether pumping is at the well field's maximum design capacity (8.2 mgd), the design capacity of the wells (5.2 mgd), or at actual monthly averaged pumping rates. Withdrawing at maximum design capacity may lower the potentiometric surface as much as 20 feet along the southern property boundary of Harris Corporation.

To define a zone of influence for protection against ground water contamination from Harris Corporation would be futile since contamination of the supply wells has already occurred. However, to ensure greater protection for the well field from future contamination, and to use as a criteria for zoning classification, the extent of the zone of influence (0.5 foot contour) for well field design capacity (8.2 mgd) could be extended 600 feet beyond the 0.5 foot contour, thus providing maximum protection under worst case conditions.

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WELL FIELD SIMUNATION -DATA REPRESENTS ORIGINIONAL INPUT

```
     LEAK                SIP  CHEC            DK2  NUME HEAD
        26        24        18        50
CONT       1.0000    1.0000    600.00    1.0000    1.0000    FEET
         1          1.30000E-02.10000E-01.00000    .00000    .00000        10
     1.000     1.000     1.000
```

1.0000	1							
	15.10	15.10	15.10	15.10	15.10	15.10	15.10	15.10
	15.10	15.10	15.10	14.10	13.10	12.10	11.10	10.10
	9.10	8.10	7.00	6.00	6.00	6.00	6.00	6.00
	15.10	15.10	11.40	10.50	10.30	10.10	10.10	10.00
	10.00	10.00	10.00	9.90	9.90	9.80	9.70	9.40
	9.00	8.20	6.80	6.00	5.60	5.30	5.10	6.00
	14.00	14.00	11.20	10.50	10.20	10.10	10.10	10.00
	10.00	10.00	10.00	9.90	9.90	9.80	9.60	9.40
	8.90	8.20	6.80	6.00	5.60	5.30	5.10	6.00
	14.00	14.00	11.20	10.40	10.20	10.10	10.00	10.00
	10.00	9.90	9.90	9.90	9.80	9.80	9.60	9.40
	8.90	8.10	6.80	6.00	5.60	5.30	5.10	6.00
	14.00	14.00	11.10	10.40	10.10	10.00	10.00	9.90
	9.90	9.90	9.90	9.80	9.80	9.70	9.60	9.30
	8.90	8.10	6.70	6.00	5.60	5.30	5.10	6.00
	14.00	14.00	11.10	10.30	10.10	9.90	9.90	9.80
	9.60	9.80	9.80	9.80	9.70	9.60	9.50	9.20
	8.80	8.00	6.70	5.90	5.50	5.30	5.10	6.00
	14.00	14.00	11.00	10.20	9.90	9.80	9.70	9.70
	9.70	9.70	9.70	9.70	9.60	9.50	9.30	9.00
	8.60	7.30	6.50	5.80	5.50	5.20	5.10	6.00
	14.00	14.00	10.80	10.00	9.70	9.60	9.50	9.40
	9.40	9.50	9.50	9.50	9.40	9.30	9.10	8.70
	8.20	7.50	6.30	5.70	5.40	5.20	5.10	6.00
	14.00	14.00	10.50	9.50	9.30	9.10	9.00	8.90
	9.00	9.10	9.10	9.10	9.10	9.00	8.60	8.20
	7.60	6.80	6.00	5.60	5.30	5.20	5.10	6.00
	14.10	14.10	9.90	8.80	6.50	8.30	8.20	7.80
	8.30	7.60	8.50	8.60	8.60	8.50	8.00	7.10
	6.50	6.00	5.70	5.40	5.20	5.10	5.10	6.00
	14.10	14.10	8.70	7.50	7.10	7.00	6.90	6.90
	7.20	7.70	7.40	7.50	7.90	7.80	7.00	6.40
	6.00	5.70	5.40	5.30	5.20	5.10	5.00	6.00
	14.10	15.10	7.90	6.70	6.40	6.30	6.30	6.30
	6.50	7.00	6.70	6.70	7.20	7.10	6.30	5.90
	5.60	5.40	5.30	5.20	5.10	5.10	5.00	6.00
	10.10	10.10	6.90	6.10	5.90	5.90	5.90	6.00
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	8.00	8.50	6.20	5.70	5.60	5.60	5.80	6.00
	6.10	6.10	5.90	5.80	5.70	5.60	5.50	5.40
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	6.70	6.30	6.00	5.70	5.60	5.40	5.30	5.20

5.20	5.10	5.10	5.10	5.00	5.00	5.00	3.00
4.10	4.10	5.10	5.20	5.30	5.40	5.70	6.10
6.90	6.50	6.20	5.80	5.50	5.40	5.20	5.20
5.10	5.10	5.10	5.00	5.00	5.00	5.00	3.00
2.10	2.10	4.70	5.10	5.20	5.30	5.50	5.90
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3.00	3.00	4.70	5.00	5.10	5.20	5.40	5.60
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5.10	5.00	5.00	5.00	5.00	5.00	5.00	2.00
4.00	4.00	4.90	5.00	5.10	5.20	5.30	5.40
5.60	5.80	5.80	5.70	5.40	5.20	5.10	5.10
5.00	5.00	5.00	5.00	5.00	5.00	5.00	2.00
6.00	6.00	5.10	5.10	5.10	5.10	5.20	5.20
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5.10	5.10	5.10	5.10	5.10	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00
6.00	6.00	5.30	5.10	5.10	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00
6.00	6.00	5.20	5.10	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00
4.00	4.00	4.80	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00
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4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

A-2

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1.0        1
1350       900       900       600       300       300       600       600
600        600       600       600       600       600       600       600
600        600       600       300       300       600       600       900
900        1350
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          14         13 -0.22     0.170000
          13         13 -0.33     0.170000
          14         13 -0.33     0.170000
          15         14 -0.39     0.170000
          15         13 -0.36     0.170000
          17         14 -0.33     0.170000
          13         14 -0.33     0.170000
          18         13 -0.36     0.170000
          18         12 -0.56     0.170000
          13         10 -0.36     0.170000
          19         12 -0.57     0.170000
          22         12 -0.49     0.170000
          17         10 -0.33     0.170000
          17         12 -0.51     0.170000
          15         10 -0.55     0.170000
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14	10	-0.89	0.170000
17	9	-0.53	0.170000
9	10	-0.61	0.170000