EASTERN GEOSCIENCES, INC.
Hydrogeologic, Geothermal, & Geophysical Consulting

MEMO

To: Gregg Barkley, P.E.

From: Tom Dwyer

CC:

Date: November 16, 2009

Re: Plumsted Township, Lakewood Recharge Site

The following is a brief summary of the hydrogeologic evaluation of the Plumsted Township Lakewood recharge site as of this date.

Test Borings and Test Wells

Four Geoprobe test borings were drilled during the week of October 13th. Test boring locations are illustrated on Figure 1. At each location, continuous core tube samples were collected until the base of the more permeable sediments was identified. Two-inch-diameter test wells were subsequently constructed at each location, with screen intervals across the saturated portion of the more permeable sediments. Test boring and test well locations are provided in Figure 1, and information for each location is summarized in Table 1.

The test borings demonstrate that the site is underlain primarily by fine to medium sand which transitions sharply to a silty very fine sand at depths of: 32.5 feet at MW1; 30 feet at MW2; 20 feet at MW3; and 22.8 feet at MW4 (Table 1). At location MW1, the upper sand layer transitions to a coarse, gravelly sand and sandy gravel at a depth of approximately 22.5 feet. Based on the regional geologic mapping, we would expect that the more permeable sediments would become thicker and deeper to the southeast. However, based on estimated elevations for the interface with the silty sand, the regional dip of this unit cannot be quantified based on the onsite test wells alone. The shallower depth to this interface at MW3 and MW4 appears to be primarily a function of topographic elevation (Table 1) rather than regional dip of the geologic unit.

The upper ten feet of sediments generally contains ten percent or less silt and clay. However, shallow zones of silty/clayey sand were observed in the upper five feet of the soil profile at MW1 and MW4. These materials would likely need to be replaced during construction of a subsurface disposal system. Subsequent infiltration testing of these materials and the underlying sediments will be needed to determine the appropriate infiltration design.

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Ground-Water Levels and Flow Directions

During drilling of the test borings, saturated sediments were observed at depths of: 20 feet at MW1; 22.5 feet at MW2; 15 feet at MW3; and 13 feet at MW4. Water levels were subsequently measured at all four test wells, plus an existing monitoring well at the adjacent landfill site, on October 23rd (Table 2). Calculated ground-water elevations provided in Table 2 are based on an approximated grade elevation of 150 feet at the existing landfill monitoring well identified on Figure 1 as LF1. Accuracy of this assumed elevation will need to be verified as part of any subsequent work on this site. Depth to ground-water from grade, based on the October 23rd water levels, are: 21.6 ft at MW1; 22.5 feet at MW2; 16.1 feet at MW3; and 13.8 feet at MW4. Based on comparison to recorded water levels for long-term monitoring wells in the region, it is estimated that the water-level observations for October of 2009 are within two feet of historical seasonal-high water levels.

Calculated ground-water flow directions for the October 23rd water levels are shown on Figure 1 as hydraulic gradient vectors. The hydraulic gradient vectors indicate that streams located to the west and northwest of the site are primarily controlling the direction of ground-water flow.

Hydraulic Testing

Single-well, constant-rate pumping tests were conducted at all four test wells in order to determine transmissivity and hydraulic conductivity of the saturated zone. Results of these tests are summarized in Table 3. Calculated transmissivity values range from 55 to 1500 ft^2/d, with a median of 533 ft^2/d. Calculated hydraulic conductivity values range from 14 to 200 ft/d, with a median of 52 ft/d. Transmissivity is the product of hydraulic conductivity and thickness of the saturated zone. Therefore, it is not unexpected that the highest transmissivity values were calculated at MW1 and MW2. However, hydraulic conductivity is also greater at MW1 and MW2. This appears to indicate that the sediments tend to be more permeable to the south and southeast where they are also thicker. The sandy gravel and gravelly sand zones observed at MW1 support this interpretation.

Ground-Water Mounding Analysis

In order to arrive at a preliminary estimate of onsite wastewater discharge capacity, a numerical ground-water flow model was constructed and calibrated for the site. The model takes into account the hydraulic boundary conditions created by the surrounding network of streams, which are represented as head-dependent discharge boundaries. These streams cut across the interface between the Kirkwood Formation (which directly underlies the tested areas) and the deeper Vincentown Formation. Therefore, the model required representation of both formations. This was done as a combined, single layer for the purpose of the preliminary model.

During model calibration, it was determined that the transmissivity of the single model layer needs to be greater than the calculated transmissivity values from the pumping tests in order for the model to calibrate to observed water levels. Ultimately, the best model calibration was obtained with a transmissivity in the site vicinity of approximately 2100 ft^2/d, as compared to the highest tested transmissivity values of 1000 to 1500 ft^2/d (Table 3). It is postulated that the difference between tested and modeled transmissivity results from the deeper, finer-grained sediments providing additional transmissive capacity that could not be fully quantified by the shallow test wells. This will eventually need to be verified by additional, deeper test borings and larger-scale hydraulic testing if the site evaluation is to be expanded. Calibrated ground-water levels are illustrated on Figure 2.

The calibrated model was subsequently used to evaluate two potential wastewater discharge scenarios. In the first scenario, wastewater loading is limited to the parcels located north and south of the Township parcels (Figure 3). Wastewater loading was adjusted until calculated depth to water was at least four feet beneath all discharge areas (providing a two-foot unsaturated zone with a two-foot allowance for seasonal-high water levels). Wastewater loading was assumed to be uniform across these areas. Hence, this represents a best-case simulation. Because of the lower grade elevation of Lot 34, this lot was eliminated from the analysis. For this scenario, the estimated maximum wastewater discharge capacity is 650,000 GPD, with depth to water calculated as shown on Figure 4. Depth to water for these calculations was determined using digitized topography from the USGS topographic maps, which have a contour interval of 10 feet. Detailed site topography will eventually be required for final determination of site discharge capacity.

In the second scenario, wastewater loading was simulated within the topographically higher lots within approximately the 150-foot elevation contour (Figure 5). Calculated water-table contours are illustrated in Figure 5, and calculated depth to water is illustrated in Figure 6. For this scenario, the estimated maximum wastewater discharge capacity is 760,000 GPD. Again, this is a best-case estimate and is subject to modification pending further site testing and detailed topographic mapping.

Again, it is emphasized that the wastewater discharge simulations represent best-case scenarios subject to the following limitations: 1) additional test borings and hydraulic testing will be required to confirm transmissivity of the ground-water flow system; 2) detailed site topography will be needed to determine optimum discharge configuration and the resulting depth to water; 3) wet season water levels will be required to confirm minimum depth to water. Given the regional, southeastward dip of the geologic units, it is unlikely that additional, favorable discharge areas will be found to the north and west of the parcels evaluated. More likely, the most favorable additional discharge areas will be located to the south and east.

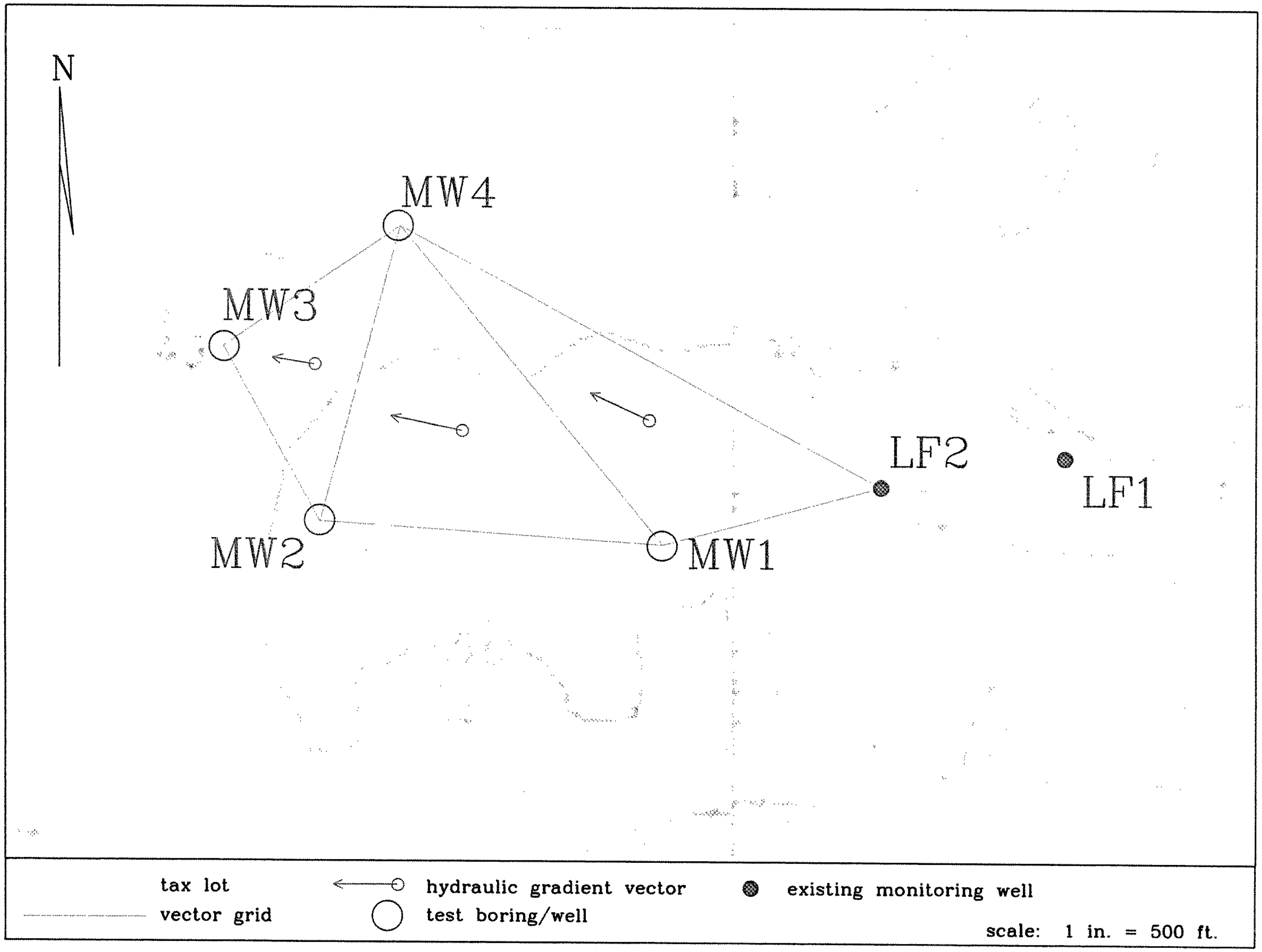

Figure 1: Test Boring/Well Locations and Hydraulic Gradient Vectors

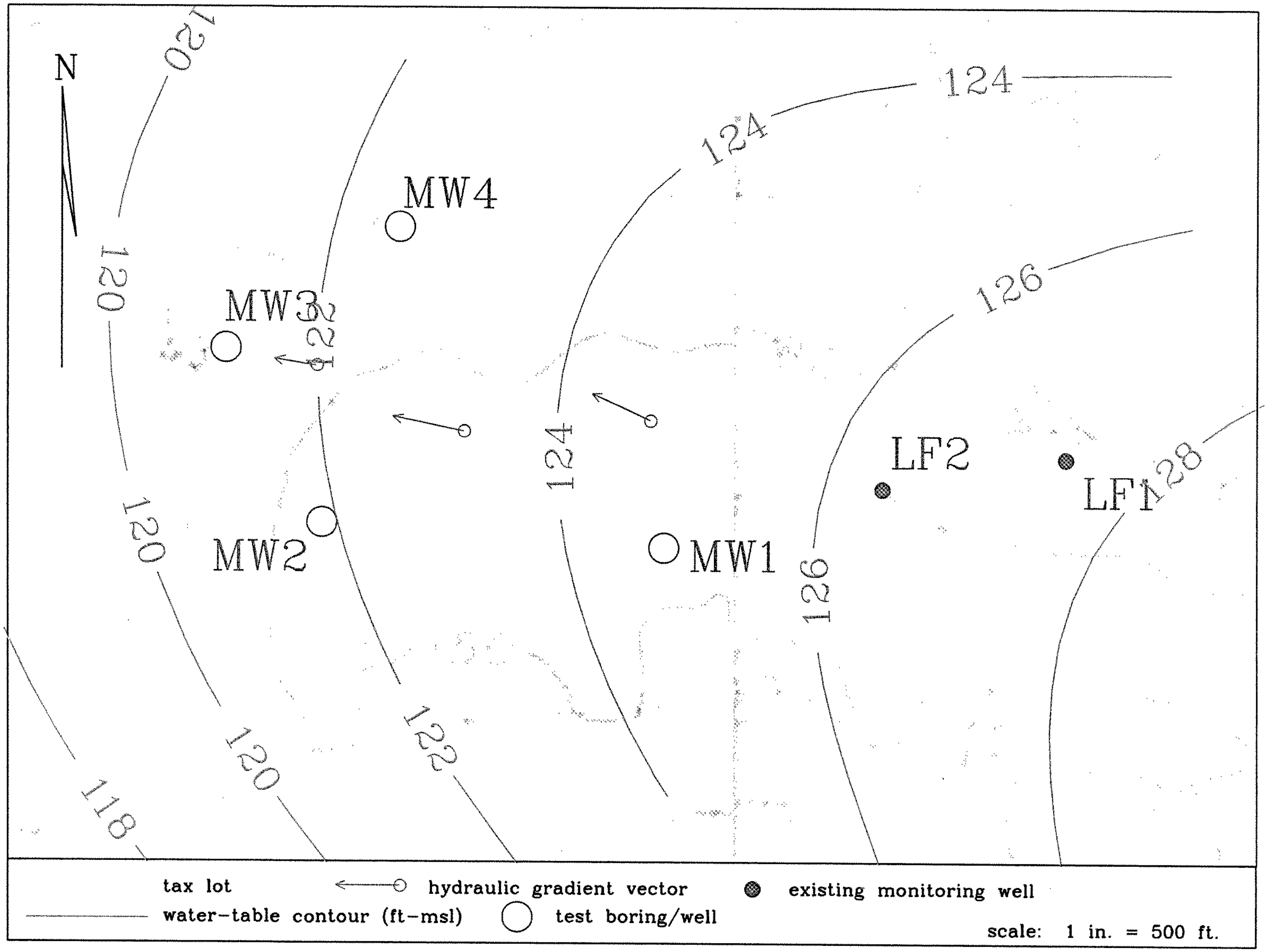

Figure 2: Simulated Water-Table Contours for Background Calibration

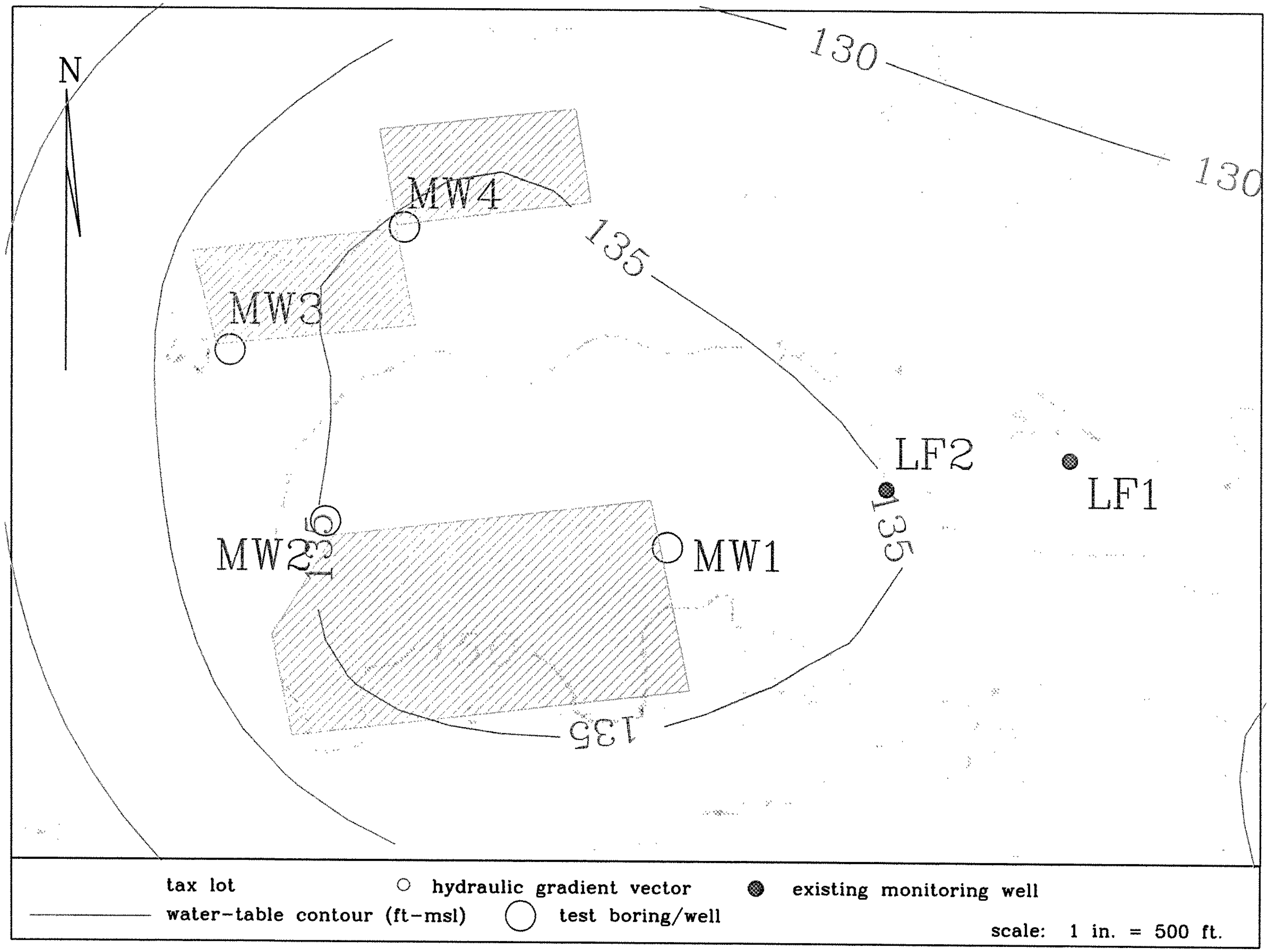

Figure 3: Simulated Water-Table Contours for 650,000 GPD Discharge

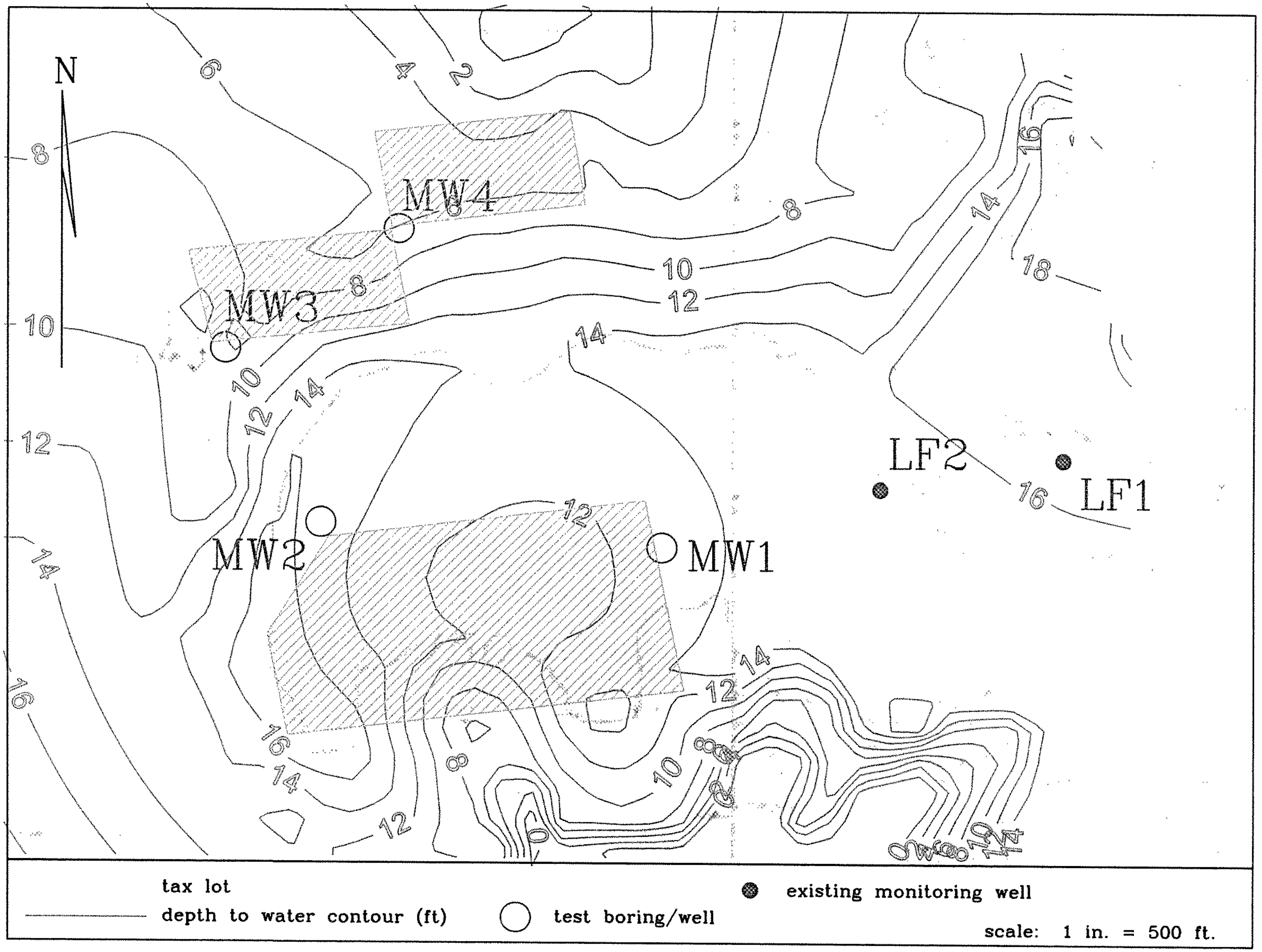

Figure 4: Simulated Depth to Water Contours for 650,000 GPD Discharge

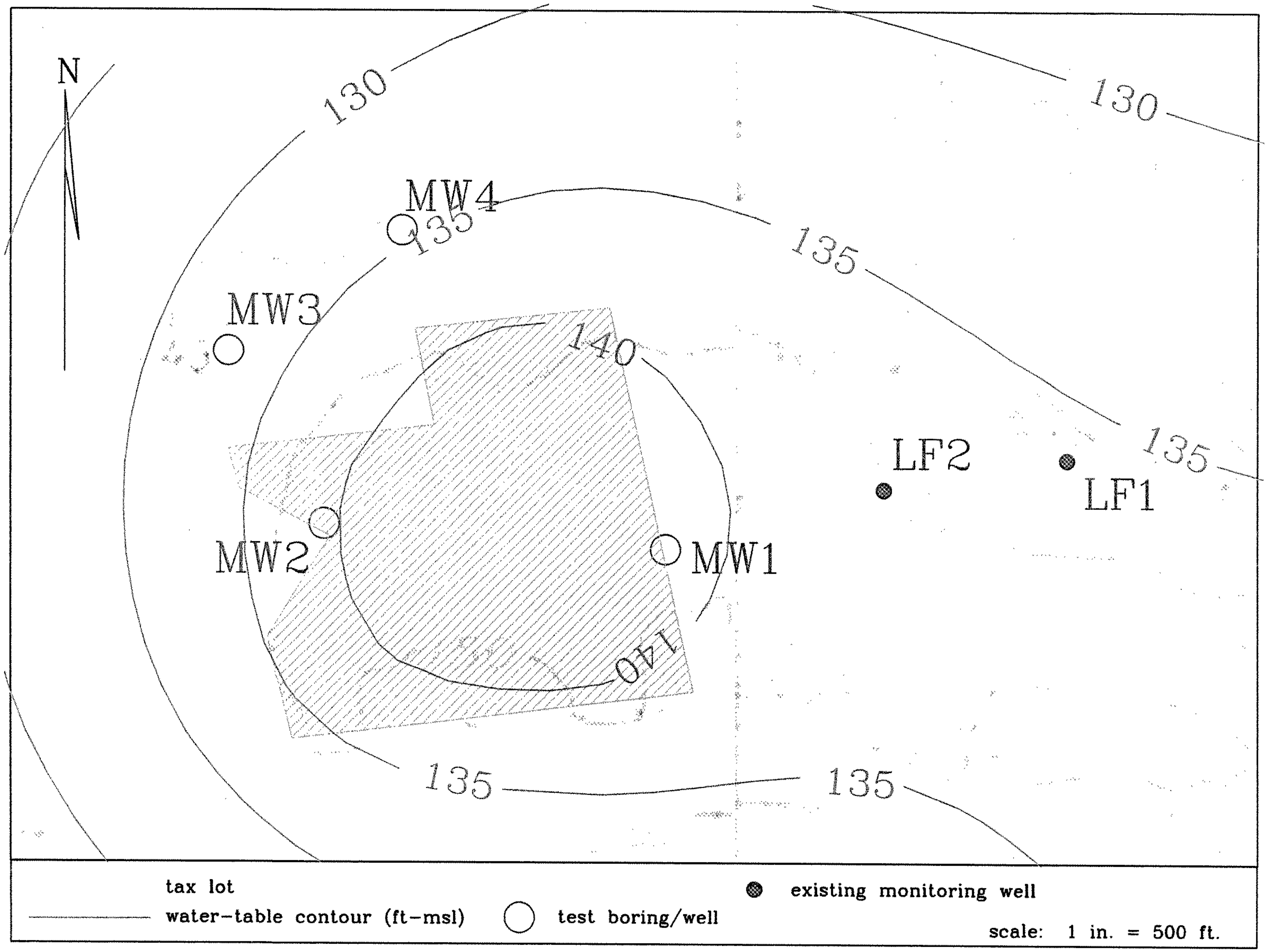

Figure 5: Simulated Water-Table Contours for 760,000 GPD Discharge

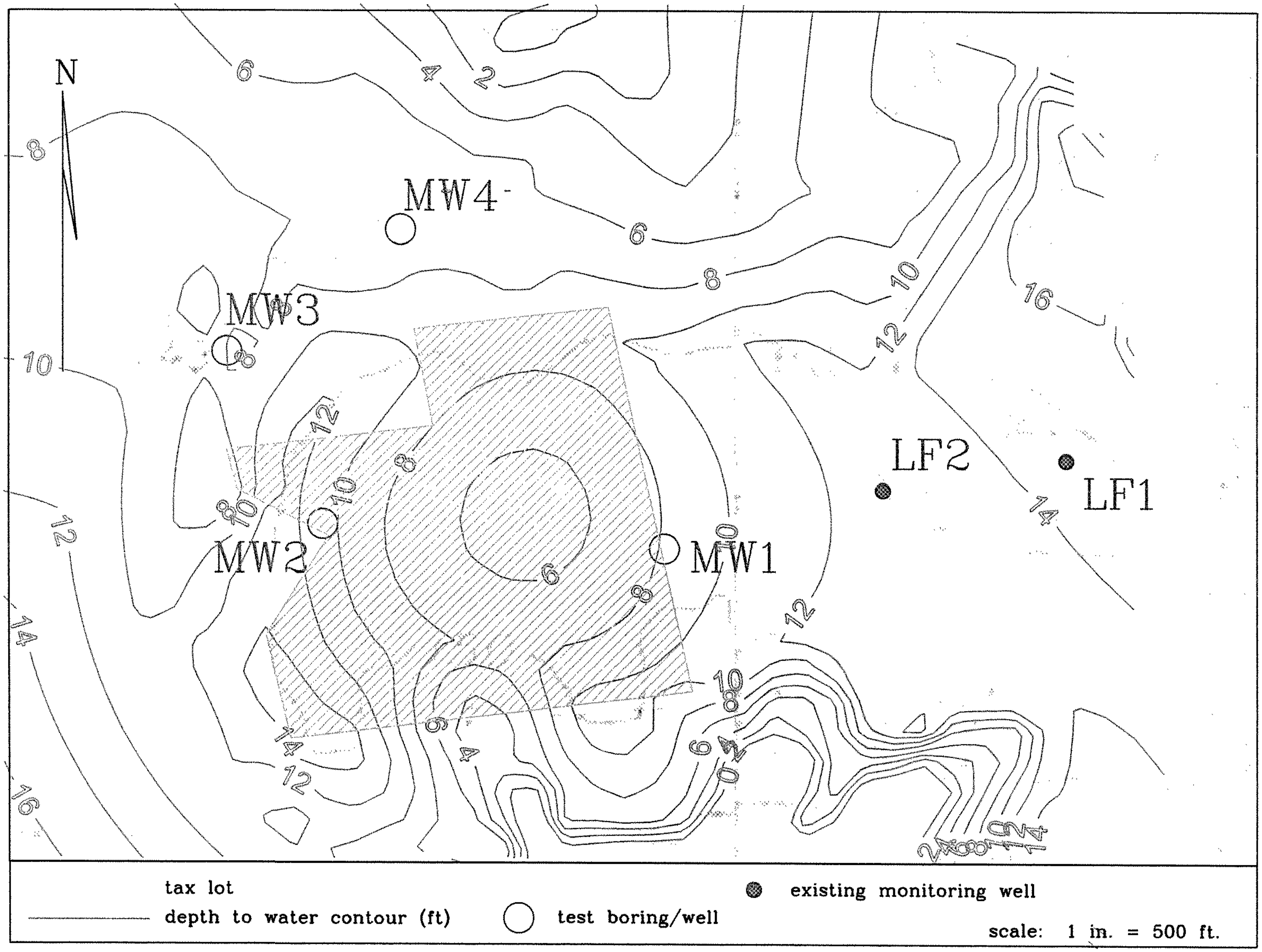

Figure 6: Simulated Depth to Water Contours for 760,000 GPD Discharge

Table 1: Test Boring and Well Information

	NAD83 State Plane Coord.							
Well	Easting (ft)	Northing (ft)	TOC Elev. (ft-msl)	Adj. TOC Elev. (ft-msl)	Stickup (ft)	Grade Elevation (ft-msl)	Depth to Silt (ft)	Top of Silty Sand Elev. (ft-msl)
LF2	492663	456405	510.08	152.00	2.0	150.0	#na	#na
MW1	491917	456202	506.74	148.66	2.6	146.1	32.5	113.6
MW2	490792	456290	504.90	146.82	2.5	144.3	30.0	114.3
MW3	490473	456876	498.02	139.94	2.6	137.3	20.0	117.3
MW4	491053	457273	496.07	137.99	2.2	135.8	22.8	113.0

TOC Elev. = relative elevations provided by Van Cleef Engineering
Adj. TOC Elev. = top of casing elevation adjusted to 150-ft contour at LF2 plus two-foot stickup
DTW = depth to water
GW Elev. = ground water elevation

Table 2: Ground-Water Model Calibration

Well	NAD83 State Plane Coord.		TOC Elev.	Adj. TOC Elev.	DTW 10/23/09	GW Elev.	Simulated GW	Error
	Easting (ft)	Northing (ft)	(ft-msl)	(ft-msl)	(ft)	(ft-msl)	Elev. (ft-msl)	(ft)
LF2	492663	456405	510.08	152.00	26.20	125.80	126.4	0.60
MW1	491917	456202	506.74	148.66	24.11	124.55	124.83	0.28
MW2	490792	456290	504.90	146.82	24.99	121.83	121.87	0.04
MW3	490473	456876	498.02	139.94	18.69	121.25	121.17	-0.08
MW4	491053	457273	496.07	137.99	16.02	121.97	122.54	0.57
							Mean Error (ft):	0.28
							RMS Error (ft):	0.39

TOC Elev. = relative elevations provided by Van Cleef Engineering
Adj. TOC Elev. = top of casing elevation adjusted to 150-ft contour at LF2 plus two-foot stickup
DTW = depth to water
GW Elev. = ground water elevation

Table 3: Calculated Aquifer Hydraulic Properties

Well	Pumping Rate (GPM)	Saturated Thickness (ft)	Test Phase	Analysis Method	Transmissivity (ft2/d)	Hydraulic Conductivity (ft/d)
MW1	4.6	11.0	Drawdown	Cooper-Jacob (1946)	738	67
			Recovery	Jacob (1963)	1000	91
MW2	3.9	7.5	Drawdown	Cooper-Jacob (1946)	860	115
			Recovery	Jacob (1963)	1500	200
MW3	0.5	3.9	Drawdown	Cooper-Jacob (1946)	104	27
			Recovery	Jacob (1963)	55	14
MW4	1.3	9.0	Drawdown	Cooper-Jacob (1946)	148	16
			Recovery	Jacob (1963)	328	36
				Minimum:	**55**	**14**
				Maximum:	**1500**	**200**
				Median:	**533**	**52**
				Mean:	**592**	**71**

Subj: **FW: Plumsted**
Date: 11/17/2009 3:30:34 P.M. Eastern Standard Time
From: gbarkley@vcea.org
To: PETERYLVISAKER@aol.com

I received the attached from Tom.

Basically the range of recharge flows is not greatly different for the Lot 34 & 108 alternative (Figure 8). By including recharge on Lot 45 (Figure 10) some benefit is gained since it is at a higher topographic elevation.

In general, by spreading the recharge area out, a greater discharge flow will be possible.

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From: Thomas Dwyer [mailto:tdwyer@easterngeo.com]
Sent: Tuesday, November 17, 2009 2:54 PM
To: gbarkley@vcea.org
Subject: Plumsted

Gregg,

As requested, I ran through some additional simulations of the ground-water model to evaluate the following scenarios: 1) including lots 34 and 108 in the simulation of wastewater discharge on the parcels outside of the green acres areas; and 2) including a portion of Lot 45 in the simulation of wastewater discharge on the topographically high area within the 150 ft-msl contour.

The first scenario, depicted in the attached Figure 8, results in an estimated increase in discharge capacity from 650,000 GPD to 760,000 GPD. Again, it should be emphasized that the subsurface conditions are expected to be worse to the north and west, so the feasibility of using these lots is not al all certain without first doing the subsurface investigations.

The second scenario, depicted in the attached Figure 10, results in an estimated increase in discharge capacity from 760,000 GPD to 890,000 GPD. Previously, we avoided simulating discharge on Lot 45, because it was understood that some distance should be maintained from the existing landfill. Nevertheless, we would expect subsurface conditions to be favorable on the southern half of Lot 45.

Let me know if you have any questions.

Tom Dwyer
Eastern Geosciences, Inc.

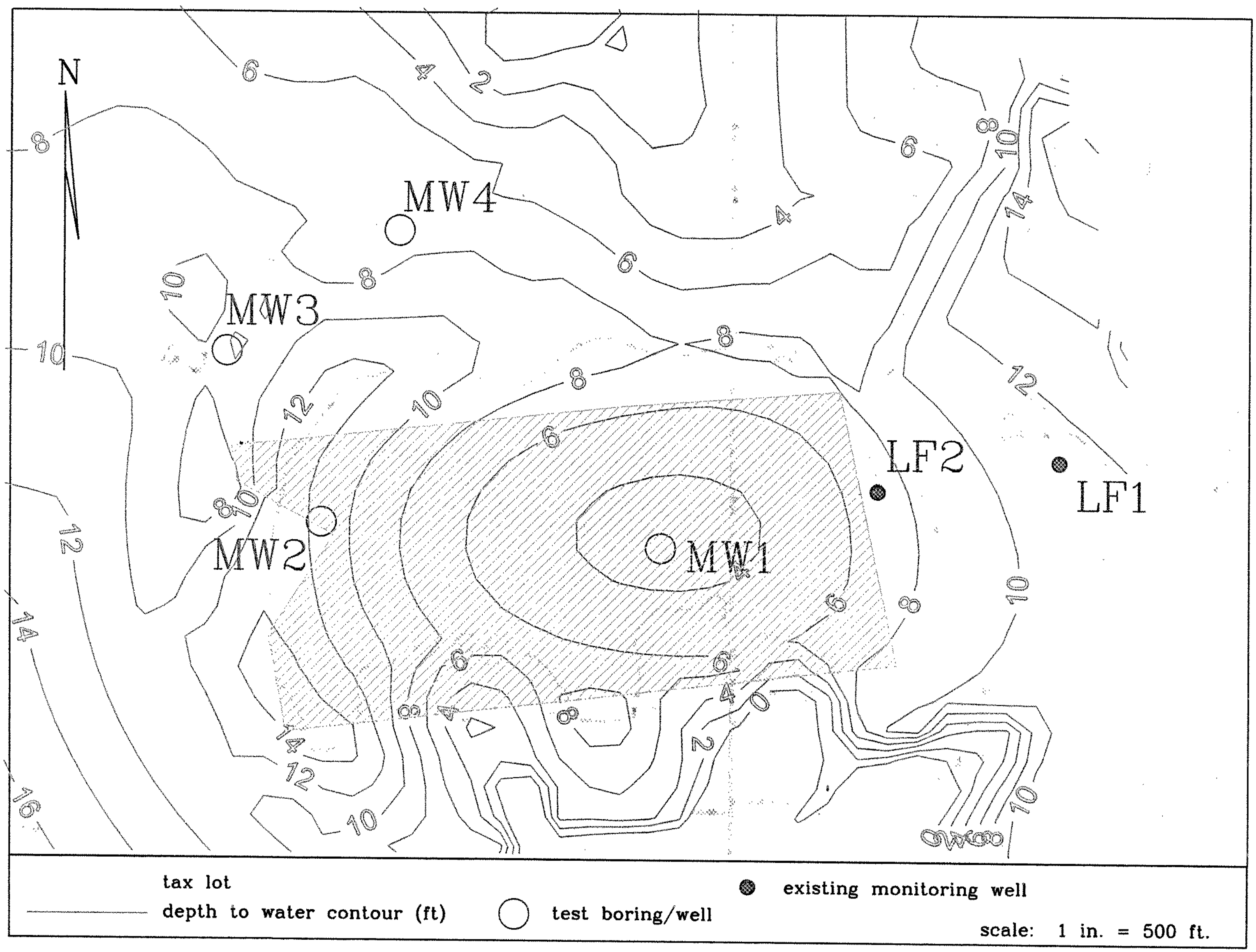

Figure 10: Simulated Depth to Water Contours for 890,000 GPD Discharge

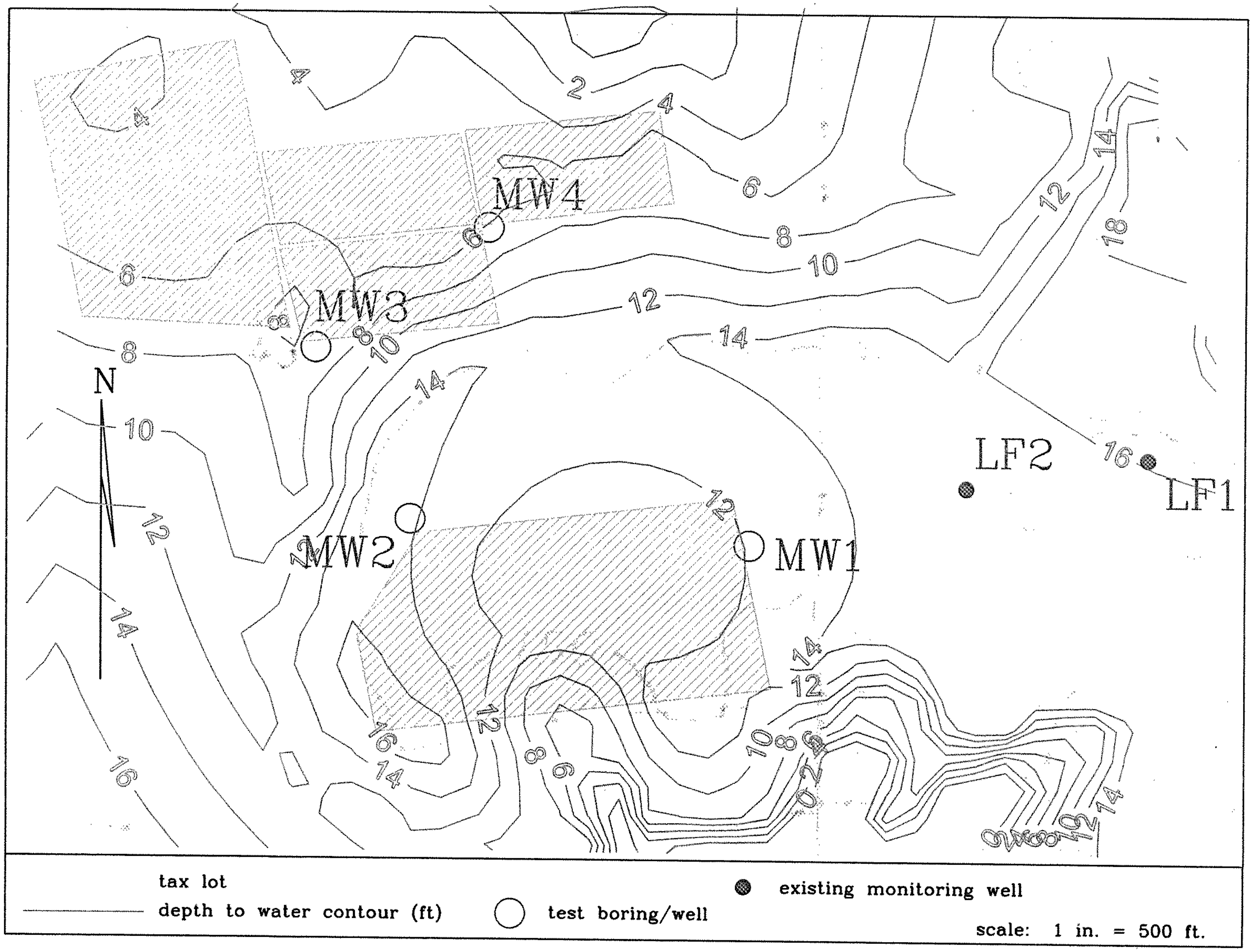

Figure 8: Simulated Depth to Water Contours for 760,000 GPD Discharge