United States Department of Agriculture Northeast NTC
Soil Conservation Service Chester, PA 19013

Subject: Electromagnetic Induction (EM) survey of Animal Waste Storage Ponds, Arizona; 17 to 21 August 1992
Date: 9 September 1992

To: Donald W. Gohmert
State Conservationist
USDA-Soil Conservation Service
201 E. Indianola Ave.
Suite 200
Phoenix Arizona 85012

Purpose:
To provide electromagnetic induction (EM) training and technical assistance to SCS personnel on the use of this technique and to survey dairy lagoons for potential seepage.

Participants:
Karen Charlesworth, Soil Conservation Tech., SCS, Chandler, AZ
Blake Covey, Geologist, SCS, Phoenix, AZ
Dino Desimone, District Conservationist, SCS, Chandler, AZ
Jim Doolittle, Soil Specialist, SSQAS, SCS, Chester, PA
Kim Doolittle, Earth Team Volunteer, SCS, Chester, PA
Tim Grandy, Soil Conservation Tech., SCS, Buckeye, AZ
Jon Hall, District Conservationist, SCS, Phoenix, AZ
Steve Jones, WME, SCS, Phoenix, AZ
Lloyd Nelson, Soil Conservation Tech., SCS, Phoenix, AZ
Dave Richmond, State Soil Scientist, SCS, Phoenix, AZ
Aubrey Sanders, State Geologist, SCS, Phoenix, AZ
Steve Smarik, District Conservationist, SCS, Buckeye, AZ

Activities:
Participants followed the activities of outlined in Enclosure 1, with the exception that Lagoon #3 was not surveyed. Excessive temperatures (+110° F) necessitated frequent pauses and slowed field work.

Equipment:
The electromagnetic induction meters used were the EM31, EM38, and EM34-3 manufactured by GEONICS Limited.[1] Measurements of conductivity are expressed as milliSiemens per meter (mS/m). Two-dimensional contour plots of the survey areas were prepared using SURFER software developed by Golden Software, Inc.[1]

---

1. Use of trade names in this report is for identification purposes only and does not constitute endorsement.

The ground-penetrating radar unit used in the exploratory study at the Gatlin Archaeological Site near Gila Bend was the Subsurface Interface Radar (SIR) System-8 manufactured by Geophysical Survey Systems, Inc. [1]. Components of the SIR System-8 used in this study were the model 4800 control unit, ADTEK SR 8004H graphic recorder, power distribution unit, transmission cable (30 m), and the model 3110 (120 MHz) antenna. The system was powered by a 12-volt vehicular battery.

Results:

1. The cooperation of the landowners who participated in this study is appreciated. The location and identity of the surveyed sites have not been disclosed in this report.

2. Participants received field training on the operation of the EM31 and EM34-3 meters and data interpretation. Each participant was provided with opportunities to evaluate these meters and to appraise their suitability to soil and site assessment studies.

3. Electromagnetic induction techniques were successfully used in Arizona to help characterize and assess dairy lagoons. Each meter, coil orientation, and spacing provided interpretative data at each site. Selected sites presented complex subsurface environments. Cultural and geologic noise produced interference at some sites which complicated interpretations. Simulated contour plots of apparent conductivity provide a method for rapidly detecting the presence of contaminant zones and estimating patterns of contaminant movements in soils. Plume-like features emanating from lagoons, while restricted, were identified on contour plots from most study sites. However, the nature and composition of these features, unless supported by additional independent measurements, remain interpretive.

4. Results from these field studies do not replace the need for direct sampling, but rather guide in the placement of monitoring wells and provide supplemental information. Sampling is required to evaluate the type and concentration of contaminants.

5. Compared with studies conducted in moist areas of the country with shallower depths to ground water tables, lateral seepage from animal waste lagoons appears to be more restricted in arid areas.

6. Ground-penetrating radar appears to offer some potential for archaeological investigations at the Gila Bend Site. While depth of penetration was less then 3 feet, several anomalies and areas of disturbed soil conditions were identified on the radar profile. The EM38 meter, acquired by the Arizona State Office, can be used to systematically survey this site and may detect buried cultural anomalies. This brief study offered limited opportunity for publicity (coverage on Phoenix television station (Channel 10 News, August 17, 1992) and The Arizona Republic (Tuesday, August 18, 1992; page B1).

I feel that this field study was rewarding to all participants. It was my pleasure to work in your state and with members of your staff.

With kind regards.

James A. Doolittle
Soil Specialist

cc:
R. Crawford, State Resource Conservationist, SCS, Phoenix, AZ
J. Culver, National Leader, SSQA Staff, NSSC, SCS, Lincoln, NE
A. Dornbusch, Jr., Director, MWNTC, SCS, Lincoln, NE
A. Holland, Director, NENTC, SCS, Chester, PA
C. Holzhey, Assistant Director, Soil Survey Division, NSSC, SCS, Lincoln, NE
S. Jones, WME, SCS, Phoenix, AZ
D. Richmond, State Soil Scientist, SCS, Phoenix, AZ
A. Sanders, Geologist, SCS, Phoenix, AZ
D. Settler, Environmental Engineer, WNTC, SCS, Portland, OR
C. Sterns, Geologist, WNTC, Portland, OR

Discussion:

Gatlin Archaeological Site:

The Gatlin Archaeological Site is located in an area of map unit 267, Dateland-Denure fine sandy loams, saline-sodic, 0 to 3 percent slopes. Dateland and Denure soils are members of the coarse-loamy, mixed, hyperthermic Typic Camborthids family. These soils vary from slightly saline to moderately saline. The relatively high concentration of soluble salts and the preponderance of 2:1 expanding lattice clays in the soil profile restrict the profiling depth of the GPR. In these soils, the profiling depth of the 120 MHz antenna was restricted to depths of less than 2.5 to 3 feet.

Areas of cultural and natural disturbances were identified on radar profiles. These disturbed areas included an old road, leveled archaeological test areas, several old tree roots, and drainageways. Several point anomalies were identified on the radar profiles. Some of these anomalies undoubtedly represent natural features occurring in the soil such as large roots or rock fragments. Others may represent buried artifacts or burials. Verification of these radar interpretations is essential.

It was speculated that Hohokam period structural features would produce distinct graphic signatures on radar profiles. Based on work in other portions of the country, buried cultural layers can be distinguished on radar profiles. At the Gatlin Archaeological Site, an abandon road and several subsurface features believed to be cultural in origin were identified on radar profiles. However, as no ground-truth observations were conducted with the radar survey, these interpretations remain tentative.

Because of limited depth of penetration (< 3 feet) and poor resolution of subsurface features, the ground-penetrating radar does not appear to be an appropriate tool for characterizing and differentiating subsurface soil horizons and geologic strata on similar soils and sediments in Arizona.

Dairy Lagoons:

Studies by Brune and Doolittle (1990) and Huffman and Westerman (1991) have discussed unpredictable, localized seepage from swine and dairy lagoons and the need to monitor these structures. Electromagnetic induction (EM) techniques were used in these studies to detect the presence and extent of leachate plumes and to improve the placement of monitoring wells. In these studies, the presence of contaminants was inferred from the occurrence of plume-like features emanating from lagoons. Within these plume-like features, levels of apparent conductivity progressively diminished with increasing distances away from the contaminant sources.

As the EM data represents apparent, not true conductivities, results from surveys are interpreted qualitatively. The ability of EM techniques to detect seepage and map contaminant plumes requires a significant contrast in electrical conductivity between contaminated and uncontaminated areas. In addition, detection of contaminants depends upon local ground conditions, presence of interfering cultural features, and the sensitivity and penetration depths of a particular meter.

Buckeye, Arizona; Proposed site of Lagoon #1 - 17 August 1992
This is a proposed site for a dairy lagoon. This survey was conducted in order to obtain preliminary data on the site.

This site was located in areas of map units Ac (Antho sandy loam, saline alkali) and Ld (Laveen loam, saline alkali) adjacent to the Gila River. Antho and Laveen soils are deep, well drained, medium textured, and contain excessive amounts of soluble salts. Antho soils are members of the coarse-loamy, mixed (calcareous), hyperthermic Typic Torrifluvents family; Laveen soils are members of the coarse-loamy, mixed hyperthermic Typic Calciorthids family.

Figure 1 is a two-dimensional contour plot of the ground surface. The contour interval is 1 foot. In Figure 1, north is towards the upper margin. Highly variable and heterogeneous soil and terrain conditions characterize this site. The site has been disturbed by extensive land leveling operations and dissected by several gullies Gullies descend onto the flood plain of the Gila River. A holding areas for dairy cows adjoin the southern edge of the survey area.

The grid covered an irregularly shaped, 450 to 950 foot by 100 to 500 foot area. The grid interval was 50 feet. This provided 143 grid intersects or observation points. At each intersect, measurement were taken with the EM34-3 meter in both the horizontal (Figure 2) and vertical modes (Figure 3). A 10 meter intercoil spacings was used with the EM34. Table 1 (in the compendium to this report) lists the effective profiling depths of this meter with varied orientations and/or intercoil spacings.

Interpretation of the EM data are based on the identification of spatial patterns in the data set. The survey area was dissected by gullies, had been disturbed by land leveling operations, and contained heterogeneous soil materials. These factors complicated interpretations. Because of the complex soil and terrain conditions, problems of "equivalence" existed and complicated the detection of contaminant plumes at this site. In natural systems, problems of equivalence occur when changes in one parameter (i.e. contaminant levels) are offset or masked by changes in another parameter (i.e. clay, moisture, or presence of buried artifacts). At this site the complexity of soils, fill materials, and terrain may introduce errors into interpretations by masking the presence of contaminant plumes. It must be remembered that not all sites are equally suited to the use of EM techniques.

Several inferences can be made from figures 2 and 3. The patterns of apparent conductivity, evident in figures 2 and 3, characterize a highly disturbed site with variable soil conditions. The spacing and pattern of contour lines are highly variable and exceedingly complex.

Several point anomalies are evident in these figures. The presence of buried metallic artifacts may be responsible for these anomalies. One fairly large anomalous area is evident near coordinates 550X and 300Y. Generally, apparent conductivity appears to increase with soil depth. Assuming that the clay content and mineralogy remains essentially constant, increases in apparent electrical conductivity with soil depth are most likely related to increases in soluble salts or volumetric water content.

Buckeye, Arizona; Evaporation Ponds at Lagoon Site #2 - 18 August
The evaporation ponds support a dairy operation. The purpose of this investigation was to see whether seepage occurred and was detectable in areas surrounding the evaporation ponds. At the time of the survey, only the northern-most pond contained water. The two other evaporation ponds receive little and infrequent amounts of effluent.

This site was located in an areas of map unit Aba (Antho sandy loam, 0 to 1 percent slopes) and CO (Cherioni-Rock outcrop complex) adjacent to Waterman Wash. Antho soils are members of the coarse-loamy, mixed (calcareous), hyperthermic Typic Torrifluvents family. Cherioni are members of the loamy-skeletal, mixed, hyperthermic, shallow Typic Durorthids family. Some land leveling operations have been carried on at this site. The land surface slopes to the west towards Waterman Wash. A runoff reservoirs and a smaller, more frequently used evaporation pond is near the western edge of the survey area. Farm structures border the northern edge of the survey area.

Figure 4 is a two-dimensional contour plot of the ground surface. The contour interval is 1 foot. Waterman Wash is beyond the upper margin of this plot. In the northwest corner of the survey area, the land surface slopes towards the wash. Because of the presence of the evaporation ponds, the interior of the survey area was not surveyed.

The grid covered a 800 by 500 foot, L-shaped area (approximately 2.75 acres). The grid interval was 50 feet. This provided 84 grid intersects or observation points. At each intersect, measurement were taken with the EM31 (figure 5 and 6) and EM34-3 meters (figures 7 and 8) in both the horizontal and vertical modes. A 10 meter intercoil spacings was used with the EM34-3 meter.

Several inferences can be made from these figures. Apparent conductivity values appear to increase with soil depth. No extensive zone of seepage from the evaporation ponds are evident in these figures. However, a broad, plume-like zone of higher conductivities appears to extend 50 to 100 feet from the eastern edge and about 50 feet from the northern edge of the structure. Surprisingly, the plume-like zone is best expressed in the area that lies adjacent to the eastern boundary of the two southern most evaporation ponds; the ponds that are the least utilized. It was felt that the grid area was to small to adequately assess the plume-like area and its relationship with local soil and geologic patterns. Interference from farm buildings is suspected of producing "cultural noise" responsible for some of the higher conductivity values along the northern boundary of the survey area.

Because of accessibility, the survey area was located slightly upslope and along the most distal sides of the evaporation ponds from Waterman Wash. Later, during a reconnaissance survey with the EM31 meter, higher levels of apparent conductivity were observed surrounding the runoff reservoirs and a one acre evaporation pond adjacent to Waterman Wash.

Phoenix, Arizona; Waste Storage Area-Site #3 - 19 August

The waste storage area supports a dairy operation near Litchfield Park. This waste storage area has been in operation since 1959 and is located in an area of coarse-textured soils. The site is in an area of map unit TD (Torripsamments and Torrifluvents, Frequently Flooded) adjacent to the Agua Fria River. A levee to the west of the survey site separates the area from the Agua Fria River. The survey area contains former channel and bar deposits from the Agua Fria River. Slightly beyond the eastern margin of the study area, an embankment separates the study site from higher-lying animal holding areas. Based on data from a nearby observation well, the depth to the water table is estimated to be about 75 feet (22 meters).

Figure 9 is a two-dimensional contour plot of the ground surface. The contour interval is 0.5 foot. North is towards the lower margin of this figure. The Agua Fria River is to the west of this plot. A slightly elevated ridge of alluvial deposits extends from the northwest to near the southeast corner of the study site. Wastes are being discharged onto the surface of the study site from a pipe located in the embankment near coordinates 0X and 200Y. High-tension power lines, adjacent to the southwest corner of the study area, interfered with survey results. Most of the data collected from the area (interference often produced higher values of conductivity) of suspected interference were omitted from the survey results.

The grid interval was widen to 100 feet on this and all subsequent sites. This was done to provide greater areal coverage in the time allotted for each lagoon (one day). It was considered of greater importance that a more comprehensive rather than a more detailed coverage of each site be conducted. In addition, it was felt that any large area of contamination, if present, would be detected using a 100 foot interval.

The grid covered a rectangular area with dimensions of 800 feet by 300 feet (approximately 5.5 acres). This provided 32 grid intersects or observation points. At each intersect, measurement were taken with the EM31 (figures 10 and 11) and EM34-3 meters in both the horizontal and vertical modes. A 10 (figures 12 and 13) and a 20 (figures 14 and 15) meter intercoil spacings were used with the EM34-3 meter.

Several inferences can be made from these figures. Values of apparent conductivity are highest near the surface (figure 10 and 11) and in the area immediately adjacent to the outflow pipe (coordinates 0X and 200Y). A distinct zone of higher conductivity is observable within a triangular area in the eastern and northeastern portion of the study site (within coordinates 0X, 650Y; 0X, 0Y; 225X, 0Y). In this zone, values of apparent conductivity 3.0 to 3.75 and 2.0 to 2.5 times higher than the background value of 20 mS/m were observed within depths of 6 meters (see figures 11 and 12) and 15 meters (see figures 13 and 14), respectively. The zone of higher conductivities is in the area most suspected of being contaminated from the surface discharge of animal wastes.

Based on survey results, no evidence has been found to support lateral movement of contaminants into the Aqua Fria River. Within the upper 15 meters of the study site, values of apparent conductivity decrease with increasing soil depth profiled (figures 10, 11, 12, and 13). From 15 to 30 meters, values of apparent conductivity appear to increase slightly (except in zone of suspected contamination). This phenomenon may be caused by the presence of the water table between depths of 15 to 30 meters.

The high-tension power lines interfered with measurements made in the southwest corner of the study sites. The zone of interference from the high tension power lines grew and measurements made at more distant observation point were affected with each increase in intercoil spacing. In addition, with the EM34 meter, the area affected by interference was greater in the vertical dipole orientation.

<u>Chandler, Arizona; Lagoon-Site #4 - 20 August</u>
The lagoon storage area supports a dairy operation. This site was located in an area of map unit Es (Estrella loam). Estrella soils are members of the fine-loamy, mixed (calcareous), hyperthermic Typic Torrifluvents family. The lagoon is along the southern margin of the study site. A roadway, fence line, and drainage canal bisects the survey area. The presence of several large farm implements and a metal fence line produced noticeable signal interference along the southwest and eastern borders of the study site.

The grid covered a 1100 by 135 foot area (approximately 3.4 acres). The grid interval was 100 feet. This provided 47 grid intersects or observation points. At each intersect, measurement were taken with the EM31 (figures 16 and 17) and EM34-3 meters (figures 18 and 19) in both the horizontal and vertical modes. A 10 meter intercoil spacings was used with the EM34-3 meter.

Several inferences can be made from these figures. Patterns of apparent conductivity are exceedingly complex within the confined study area and are believed to reflect a history of varying land uses and management practices. Values of apparent conductivity are highest near the surface and decrease with increasing soil depth. In each plot, zones of higher apparent conductivities appear to emanate from the sides of the lagoon (immediately adjacent to the southern boundary of the study site) between X coordinates of 290 and 600, and 900 to 1050. These zones are detectable within the upper 6 to 7.5

meters of the soil profile (see figures 16, 17, and 18) at distances as great as 135 feet from the sides of the lagoon. When depths of 15 meters are scanned (see Figure 19), these zones become more restricted and are observable only within distances of less than 75 feet from the lagoon.

This site is difficult to characterize. The presence of cultural noise from farm implements and fences interfered with interpretations. The northern half of the study site was suspected of having a complex history of use. In many portions of the enclosed contour plots from this site, values of apparent conductivity increased away from the lagoon. The complexity of this site requires a greater knowledge of land use and additional independent measurements before adequate interpretations can be made. However, the contour plot do provide a starting point for these investigations and observations.

Chandler, Arizona; Waste Storage Area-Site #5 - 21 August

The waste storage area supports a dairy operation. This site was located in an area of map unit Gm (Gilman loam). Gilman soils are members of the coarse-loamy, mixed (calcareous), hyperthermic Typic Torrifluvents family.

The grid covered an irregularly-shaped rectangular area with dimensions of 100 to 900 feet by 300 to 400 feet (approximately 6.2 acres). The grid interval was 100 feet. This provided 42 grid intersects or observation points. At each intersect, measurement were taken with the EM31 (figures 20 and 21) and EM34-3 meters (figures 22 and 23) in both the horizontal and vertical modes. A 10 meter intercoil spacings were used with the EM34-3 meter.

Several inferences can be made from these figures. Values of apparent conductivity are highest nearest to the lagoon and appear to decrease away (both laterally and vertically) from the structure. Assuming that the broad, plume-like features apparent in these figures represent seepage, contaminated areas are detectable with EM meters at distance of less than 100 feet from the structure. Another inference is that these broad, plume-like areas represent soil materials with higher-conductivity which has been excavated from lower depths and spread onto the surface. Once again, some field observations and independent measurements are needed to confirm interpretations.

In each plot, a zones of higher-conductivity is evident along the upper margin of the plot. This zone represents contrasting soil materials or contaminants from a source other than the lagoon.

Review of Electromagnetic Induction Methods

Electromagnetic inductive (EM) is a surface-geophysical method in which electromagnetic energy is used to measure the terrain or apparent conductivity of earthen materials. This technique has been used extensively to monitor groundwater quality and potential seepage from waste sites (Brune and Doolittle, 1990; Byrnes and Stoner, 1988; De Rose, 1986; Greenhouse and Slaine, 1983; Greenhouse et al., 1987; and Siegrist and Hargett, 1989)

For surveying, the meter is placed on the ground surface or held above the surface at a specified distance. A power source within the meter generates an alternating current in the transmitter coil. The current flow produces a primary magnetic field and induces electrical currents in the soil. The induced current flow is proportional to the electrical conductivity of the intervening medium. The electrical currents create a secondary magnetic field in the soil. The secondary magnetic field is of the same frequency as the primary field but of different phase and direction. The primary and secondary fields are measured as a change in the potential induced in the receiver coil. At low transmission frequency, the ratio of the secondary to the primary magnetic field is directly proportional to the ground conductivity. Values of apparent conductivity are expressed in milliSiemens per meter (mS/m).

Electromagnetic methods measure the apparent conductivity of earthen materials. Apparent conductivity is the weighted average conductivity measurement for a column of earthen materials to a specified penetration depth (Greenhouse and Slaine; 1983). The averages are weighted according to the depth response function of the meter (Slavich and Petterson, 1990). As EM measurements represent weighted averages, they do not reflect the conductivity of any single layer.

Variations in the meters response are produced by changes in the ionic concentration of earthen materials which reflects changes in sediment type, degree of saturation, nature of the ions in solution, and metallic objects. Factors influencing the conductivity of earthen materials include: (i) the volumetric water content, (ii) the amount and type of ions in soil water, (iii) the amount and type of clays in the soil matrix, and (iv) the soil temperature. Williams and Baker (1982), and Williams (1983) observed that, in areas of salt affected soils, 65 to 70 percent of the variation in measurements could be explained by the concentration of soluble salts. However, as water provides the electrolytic solution through which the current must pass, a threshold level of moisture is believed to be required by some researchers in order to obtain meaningful results (Van der Lelij, 1983).

The depth of penetration is dependent upon the intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. Table 1 list the anticipated depths of measurements for the EM31, EM34-3, and EM38 meters. The actual depth of measurement will depend on the conductivity of the earthen material(s) scanned.

TABLE 1

Depth of Measurement
(all measurements are in meters)

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM31	3.7	2.75	6.0
EM34-3	10.0	7.5	15.0
	20.0	15.0	30.0
	40.0	30.0	60.0
EM38	1.0	0.75	1.5

The conductivity meters provide limited vertical resolution and depth information. However, as discussed by Benson and others (1984), the absolute EM values are not necessarily diagnostic in themselves, but lateral and vertical variations in these measurements are significant. The seasonal variation in soil conductivity (produced by variations in soil moisture and temperature) can be added to the statement by Benson. Interpretations of the EM data are based on the identification of spatial patterns in the data set appearing on two-dimensional contour plots.

References

Benson, R. C., R. A. Glaccum, and M. R. Noel. 1984. Geophysical techniques for sensing buried wastes and waste migration: an application review. IN: D. M. Nielsen and M. Curls (eds.) Surface and Borehole Geophysical Methods in Ground Water Investigations. NWWA/EPA Conference, San Antonio, Texas. p. 533-566.

Brune, D. E. and J. Doolittle. 1990. Locating lagoon seepage with radar and electromagnetic survey. Environ. Geol. Water Science 16(3):195-207.

Byrnes, T. R. and D. W. Stoner. 1988. Groundwater monitoring in karstic terrain; A case study of a landfill in northern New York. IN Proceeding of the FOCUS Conference on Eastern Regional Ground Water Issues. September 27-29 1988. Stamford, Connecticut. National Water Wells Assoc. Dublin, Ohio p. 53-76.

De Rose, N. 1986. Applications of surface geophysical methods to ground water pollution investigations. IN: Evaluation of Pesticides in Ground Water. American Chemical Society, Washington, D.C. p. 118-140.

Greenhouse, J. P., and D. D. Slaine. 1983. The use of reconnaissance electromagnetic methods to map contaminant migration. Ground Water Monitoring Review 3(2):47-59.

Greenhouse, J. P., M. E. Monier-Williams, N. Ellert, and D. D. Slaine. 1987. Geophysical methods in groundwater contamination studies. In Exploration "87 Proceedings. Application of Geophysics and Geochemistry. p. 666-677.

Huffman, R. L., and P. W. Westerman. 1991. Seepage and electromagnetic terrain conductivity around new swine lagoons. American Society of Agricultural Engineers. St. Joseph, MO. Paper No. 914016. pp. 15.

Siegrist, R. L. and D. L. Hargett. 1989. Application of surface geophysics for location of buried hazardous wastes. Waste Management & Research 7:325-335.

Slavich, P. G. and G. H. Petterson. 1990. Estimating average rootzone salinity from electromagnetic induction (EM-38) measurements. Aust. J. Soil Res. 28:453-463.

Van der Lelij. A. 1983. Use of electromagnetic induction instrument (Type EM-38) for mapping soil salinity. Water Resource Commission, Murrumbidgee Div., N.S.W. Australia. pp. 14.

Williams, B. G. 1983. Electromagnetic induction as an aid to salinity investigations in northeast Thailand. CSIRO Inst. Biological Resources, Div. Water and Land Res. Canberra, Australia. Tech. Memo 83/27. pp. 7.

Williams, B. G. and G. C. Baker. 1982. An electromagnetic induction technique for reconnaissance surveys of soil salinity hazards. Australian J. Soil Res. 20(2):107-118.

Encl. 1

<u>AGENDA</u>

ELECTROMAGNETIC INTRODUCTION (EM)
SURVEY OF ANIMAL WASTE
PONDS AND LAGOONS

AUGUST 17-21, 1992

<u>MONDAY</u> - BUCKEYE, ARIZONA

8:00	Entrance Conference	Gross/Sanders Harrington/Jones
8:30	Travel to Buckeye F.O.	
9:30	Buckeye F.O.	Smarik
10:00-3:30	Survey Lagoon #1	
3:30	Travel to Phoenix	
4:30	Phoenix State Office	

* Gila Bend - Ground Penetrating Radar, Arch Site (Covey, Smarik)

<u>TUESDAY</u> - BUCKEYE, ARIZONA

8:30-3:30	Survey Lagoon #2 and #3	Grandy

<u>WEDNESDAY</u> - PHOENIX, ARIZONA

7:30	Leave Phoenix S.O	
8:00	Arrive Phoenix F.O.	Hall
8:30-3:30	Survey Lagoon #4	
4:30	Arrive Phoenix S.O.	

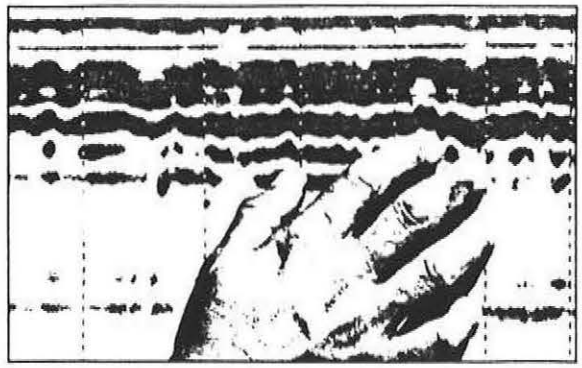
<u>THURSDAY</u> - CHANDLER, ARIZONA

7:30	Leave Phoenix S.O.	
8:30	Arrive Chandler F.O.	Desimone
9:00-3:30	Survey Lagoon #5	
4:30	Arrive Phoenix S.O.	

<u>FRIDAY</u> - CHANDLER, ARIZONA

8:30	Chandler F.O.	Desimone
8:30-1:00	Survey Lagoon #6	
2:00-3:30	Phoenix S.O. Seepage Study Conference	Harrington/Weaver Sanders/Pachek Richmond/Jones Covey/Smarik/Hall Desimone

Radar fails to 'see' much at Hohokam site



Experts use device in hunt for artifacts

By Gail Tabor
The Arizona Republic

James Doolittle (left) and Aubrey Sanders of the Soil Conservation Service prepare to use a ground-penetration radar. The radar was used at the Gatlin Site to help locate artifacts, but it could read to a depth of only 2 feet. A printout (top) shows the results.

Photos by Michael Meister/The Arizona Republic

GILA BEND — A Hohokam settlement from long ago may bring new life to this economically depressed town, known as a fan-belt and water-pump pit stop for people heading to California or Mexico.

However, a machine that can see through the ground and which was expected to help speed along the tourist attraction failed to see far enough Monday to help much.

Known as the Gatlin Site, after a rancher who owned the land, the ceremonial platform and village are made up of a four-story mound, ball courts, trash mounds, pit houses, burial grounds and an irrigation system. The site, believed to be at least nine centuries old, is a national landmark and a state historic site. It is on land now owned by the U.S. government.

Archaeologists believe it might have been a regional ceremonial center for the estimated 1,500 Hohokam living in the area now called Gila Bend.

A lot of digging must be done; the challenge is homing in on artifacts without wasting time and effort.

This is where ground-penetration radar comes in. James Doolittle, an agent with the Soil Conservation Service of the U.S. Department of Agriculture, brought the machine from Pennsylvania for a test. Could it see through the tightly packed desert floor to what lies 2 feet or more beneath the surface?

Doolittle said he has used the machine successfully in other areas of the country.

"We've gone to 126-feet depth (in sandy soils), but in this area, soil is the limiting factor," he said.

A truck dragged a big box around the field, and a printout showed the results. The radar could read to a depth of only 2 feet. Some points that may be artifacts also may be large rocks or mesquite roots.

"An archaeologist is the key," Doolittle said. "He will be able to read this and tell a lot more than anybody else. And the only way to verify the interpretation is to dig."

A daylong meeting Wednesday by several agencies involved in the project will feature brainstorming sessions on how to raise more funds and which agency is responsible for what job. The park is envisioned as a series of archaeological displays connected by landscaped walkways.

John Laird, nephew of the rancher, Cole Gatlin, and curator of the Gila Bend Museum by virtue of owning all the artifacts in it, said University of Arizona archaeologists excavated the area in 1958 and 1959, but ran out of money in 1960. The mound was covered with plastic and dirt for protection and preservation.

"It was rich," Laird said, telling of pots and copper bells found in burial sites.

"The pyramid is the only four-story one of its type, that we know of."

Land at the site's far end already is being cleared for a recreational-vehicle park, Laird said, but he knows people want to see their past.

"The main thing is to get that mound uncovered so people can see it," he said. "We can put catwalks around it and let people watch the excavation as it goes on inside the mound.

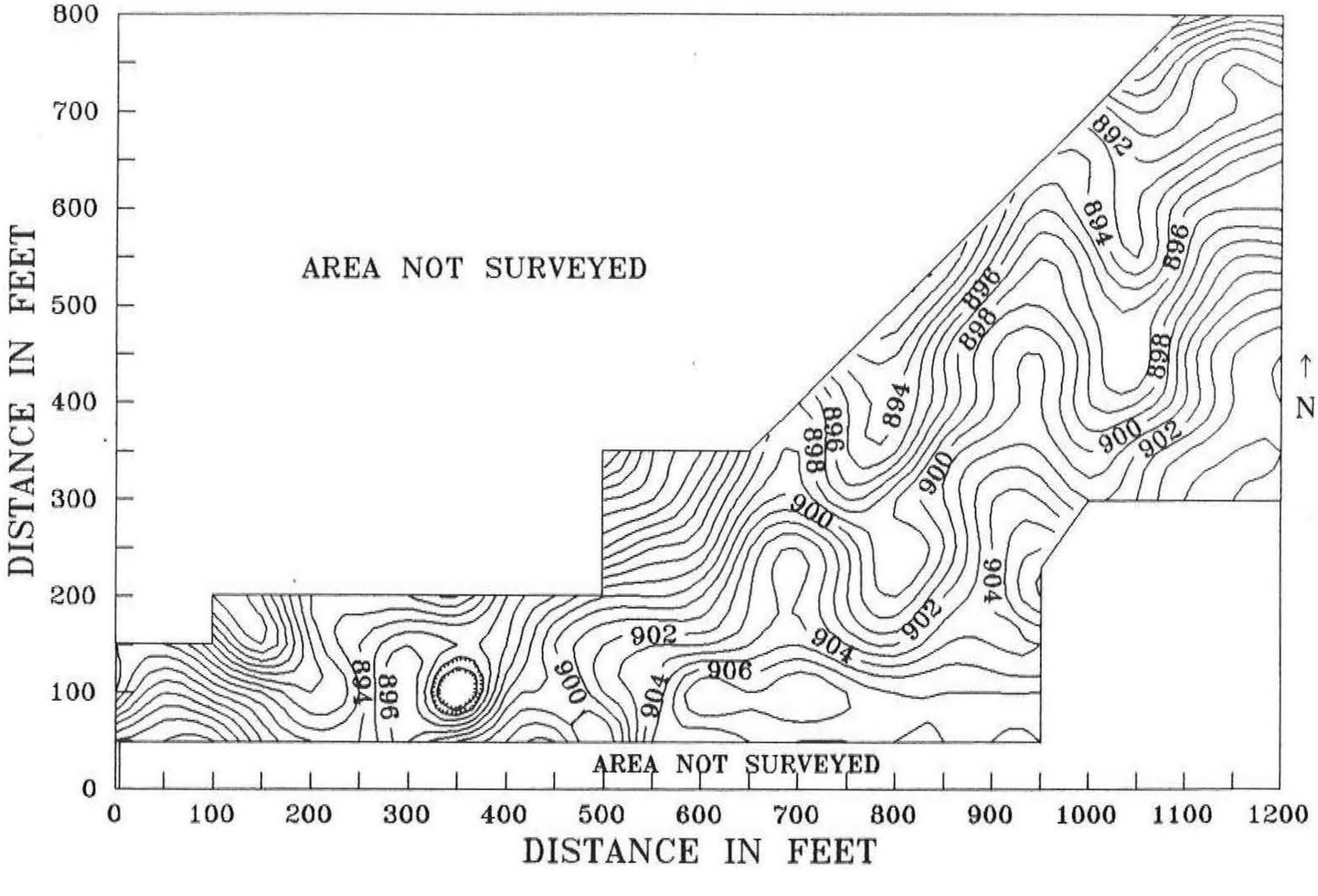
"Until then, we're just spinning our wheels."

The Arizona Republic

FIGURE 1

ARIZONA LAGOON STUDY

DAIRY LAGOON - 1
RELATIVE TOPOGRAPHY
CONTOUR INTERVAL = 1.0 FT



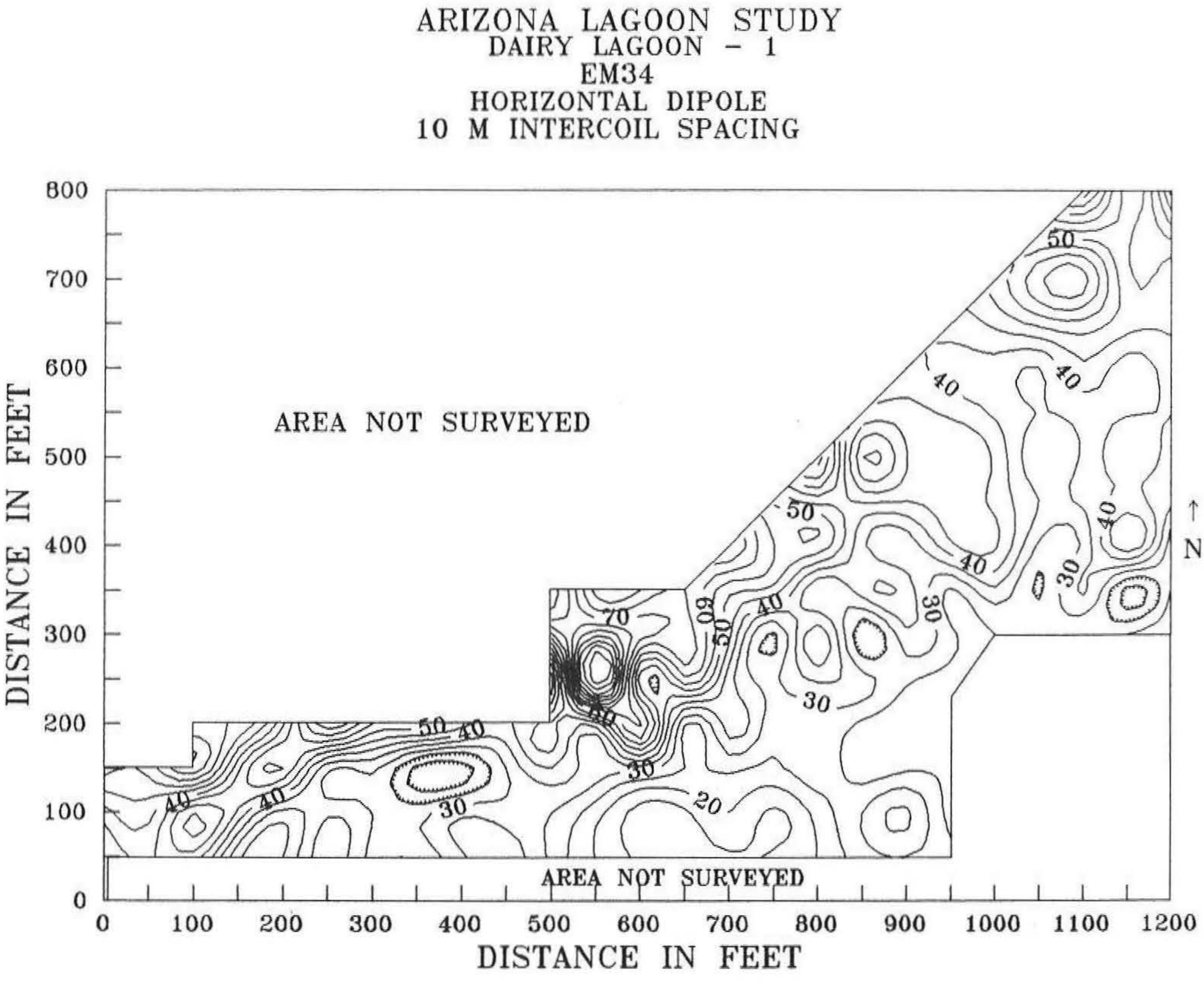
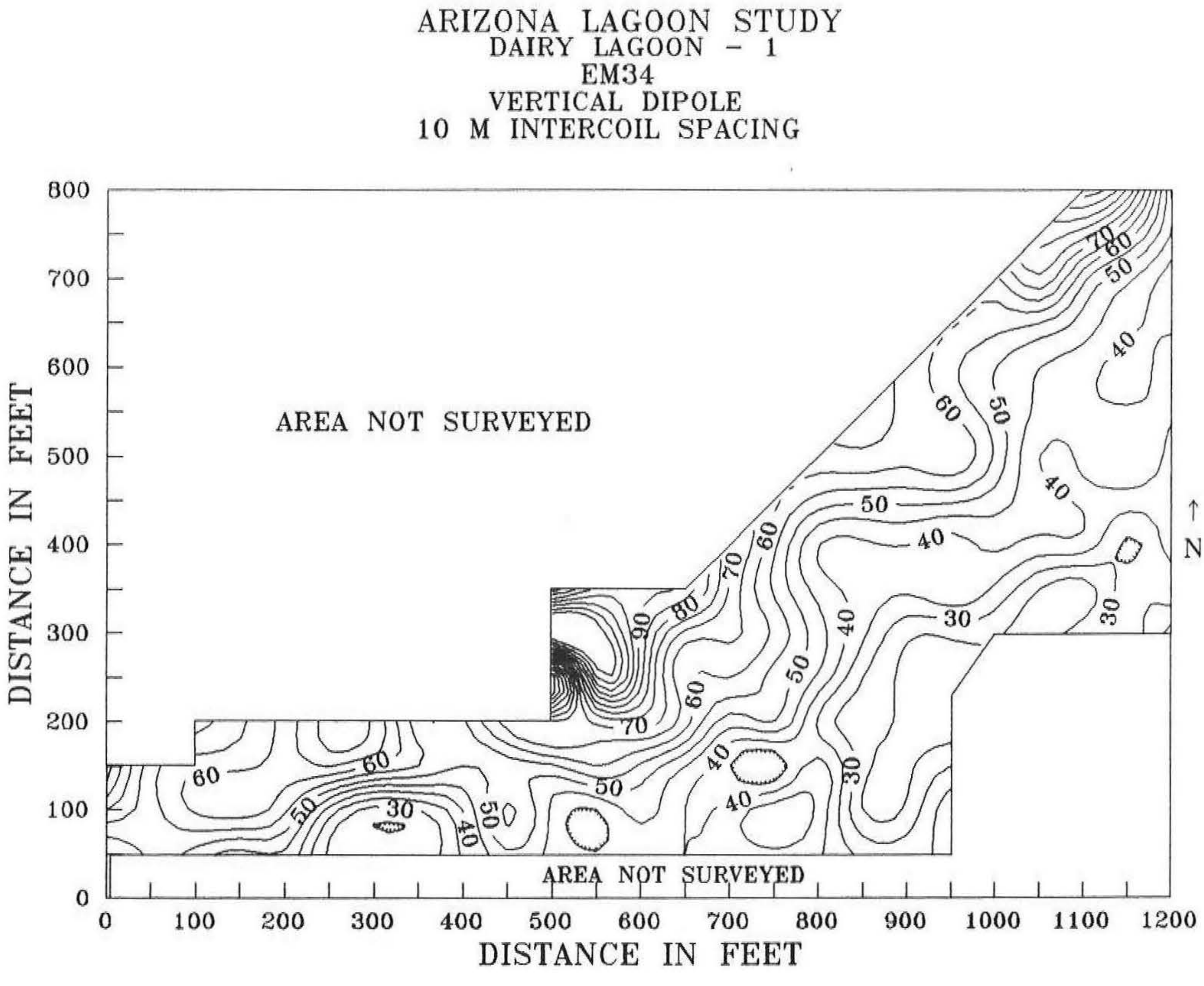
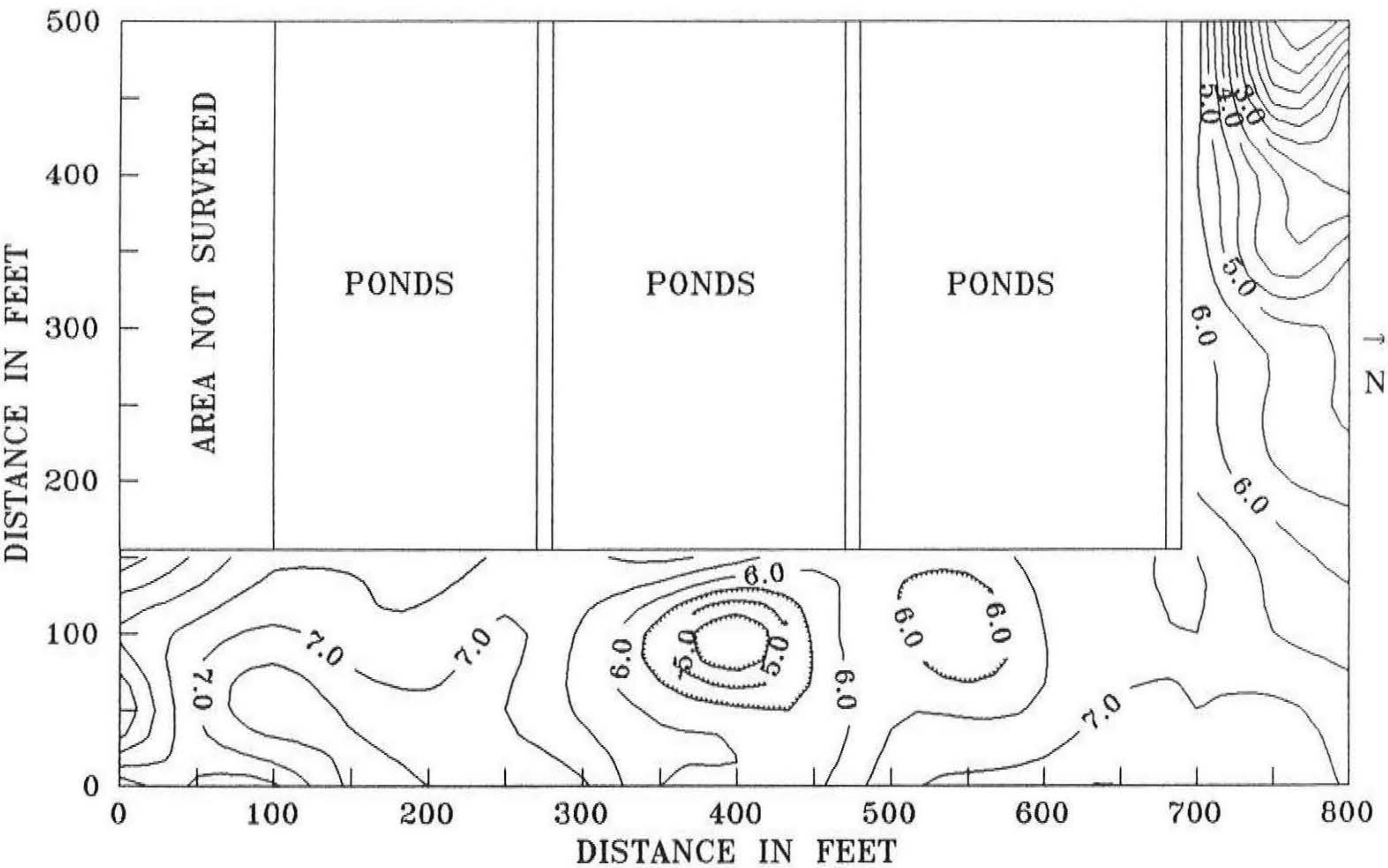
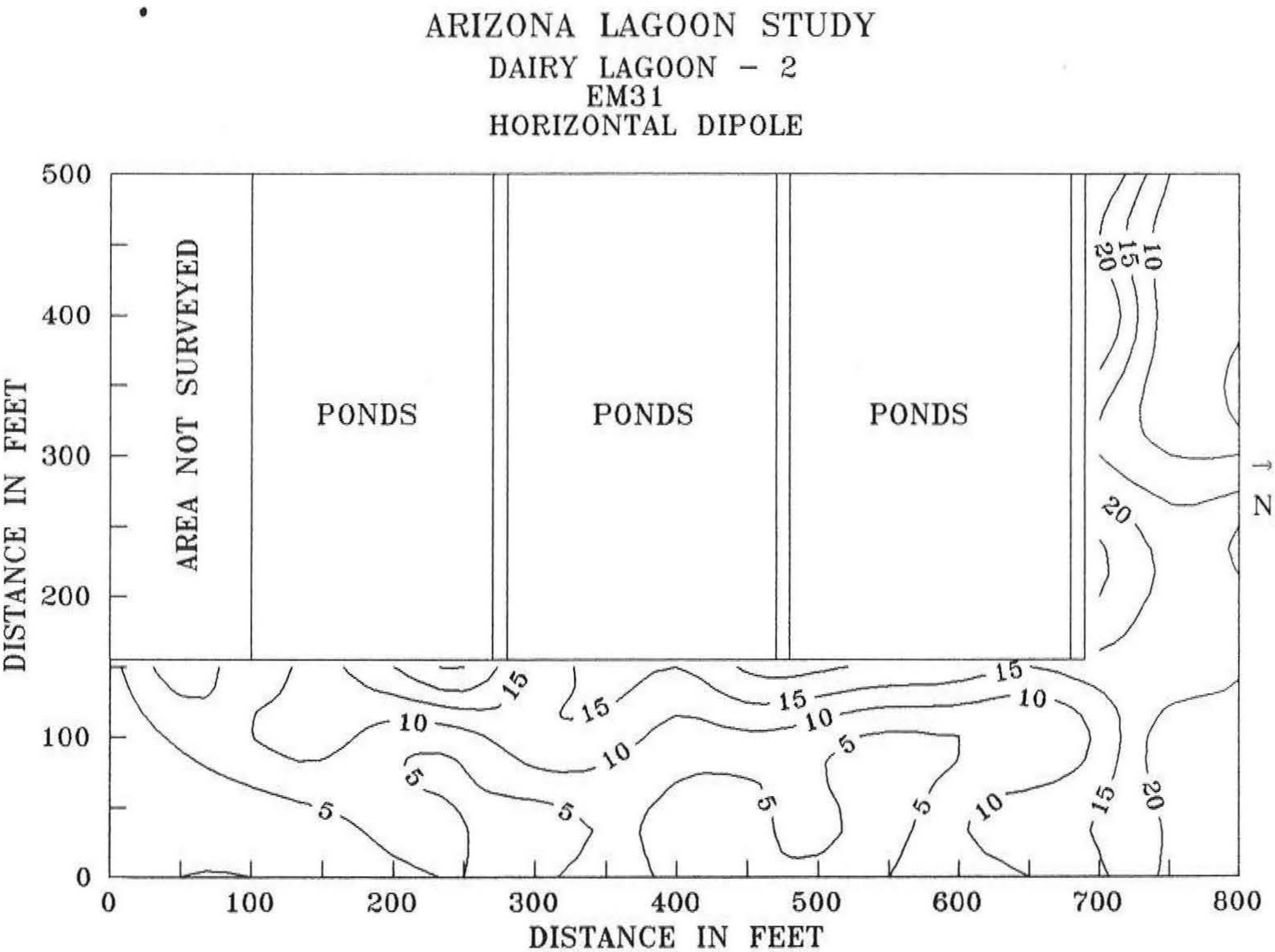

ARIZONA LAGOON STUDY
DAIRY LAGOON - 1
EM34
HORIZONTAL DIPOLE
10 M INTERCOIL SPACING
AREA NOT SURVEYED
AREA NOT SURVEYED
DISTANCE IN FEET
DISTANCE IN FEET
N
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
20
30
40
50
60
70

Figure 3


ARIZONA LAGOON STUDY
DAIRY LAGOON - 1
EM34
VERTICAL DIPOLE
10 M INTERCOIL SPACING
AREA NOT SURVEYED
AREA NOT SURVEYED
DISTANCE IN FEET
DISTANCE IN FEET
N
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

ARIZONA LAGOON STUDY
DAIRY LAGOON - 2
RELATIVE TOPOGRAPHY
CONTOUR INTERVAL = 0.5 FT




ARIZONA LAGOON STUDY
DAIRY LAGOON - 2
EM31
HORIZONTAL DIPOLE
AREA NOT SURVEYED
PONDS
PONDS
PONDS
DISTANCE IN FEET
DISTANCE IN FEET
N
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
5
10
15
20

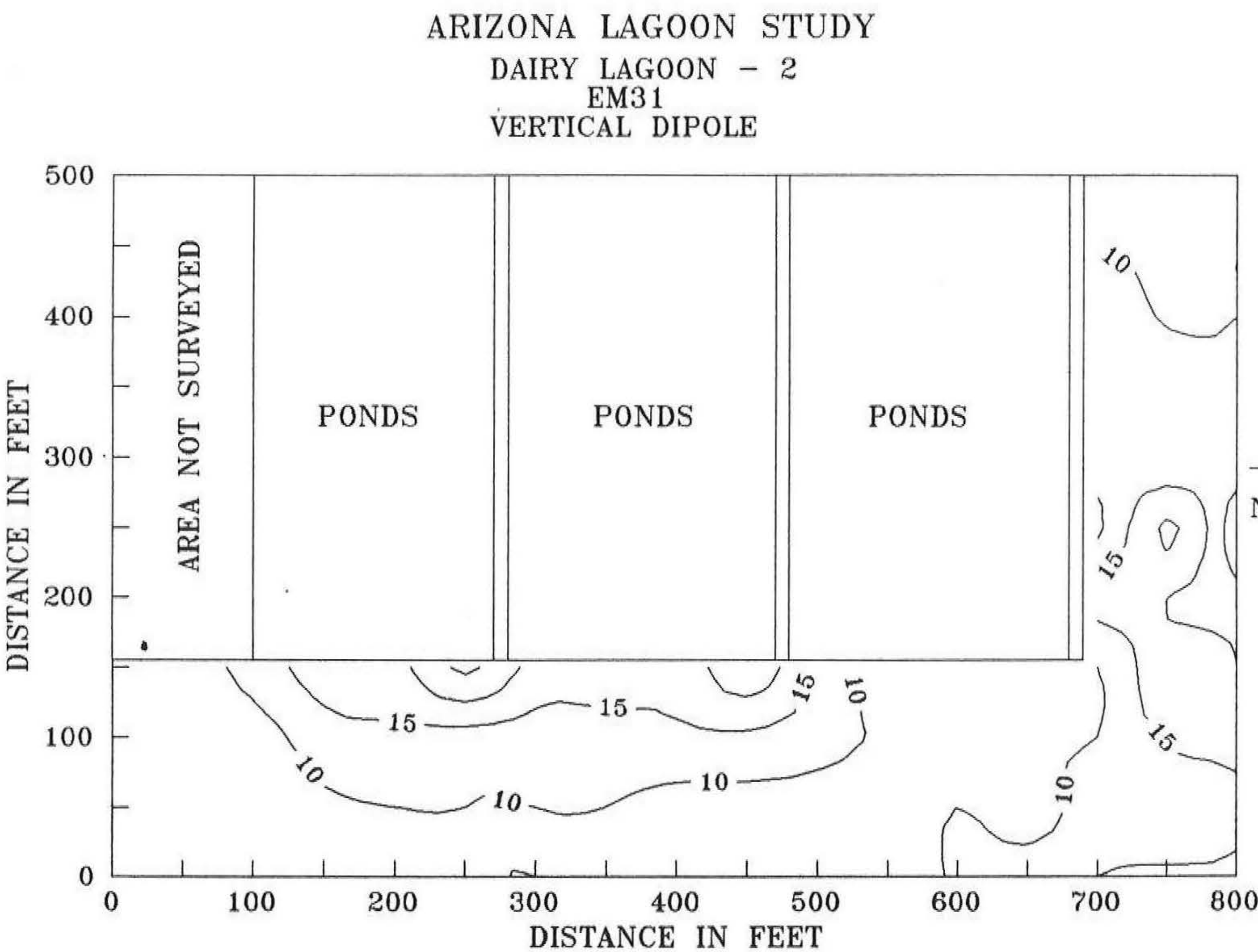

ARIZONA LAGOON STUDY
DAIRY LAGOON - 2
EM31
VERTICAL DIPOLE
AREA NOT SURVEYED
PONDS
PONDS
PONDS
10
15
15
15
15
10
10
10
10
10
15
10
15
N
DISTANCE IN FEET
DISTANCE IN FEET
0
100
200
300
400
500
600
700
800
0
100
200
300
400
500

Figure 7

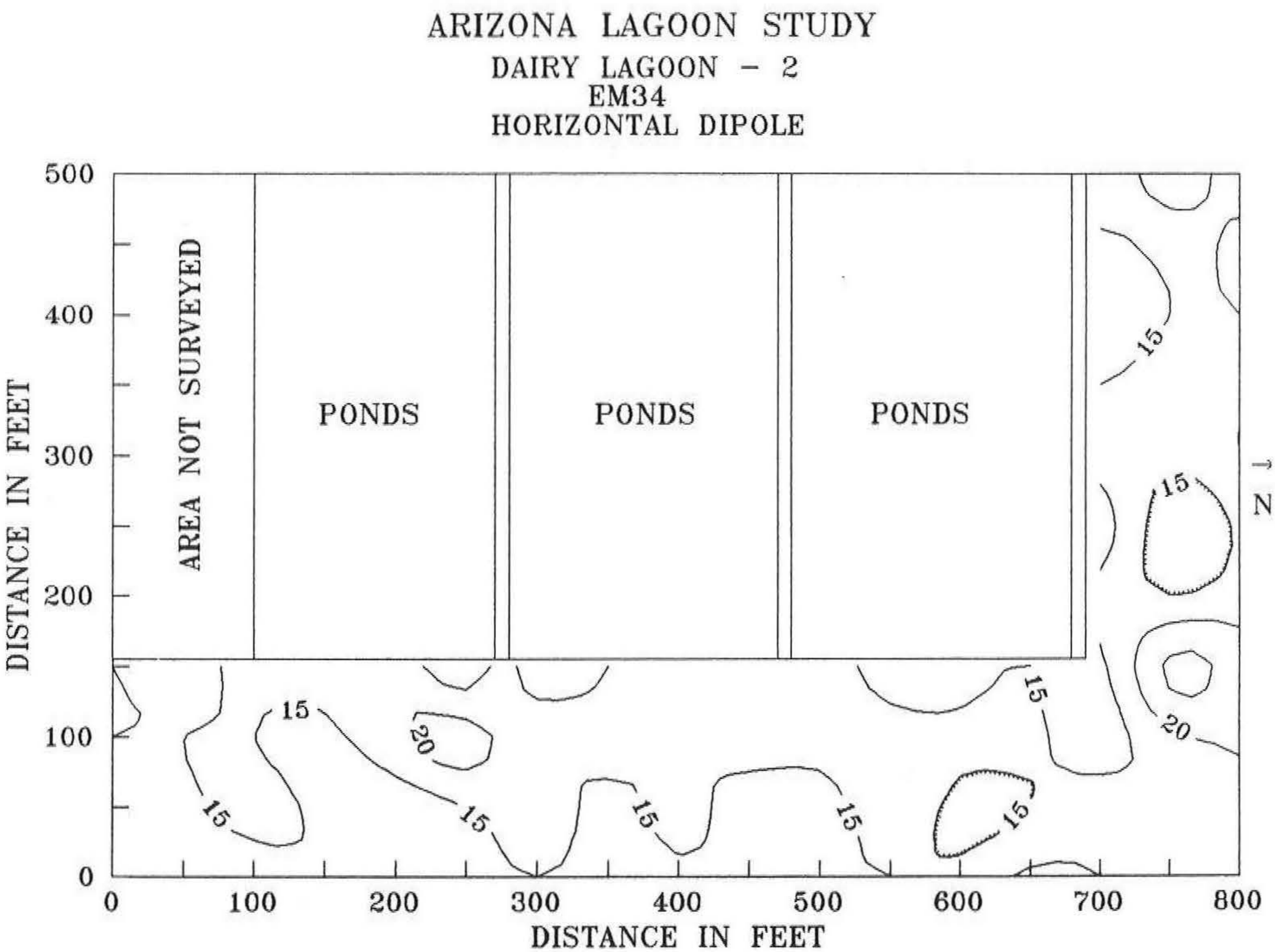
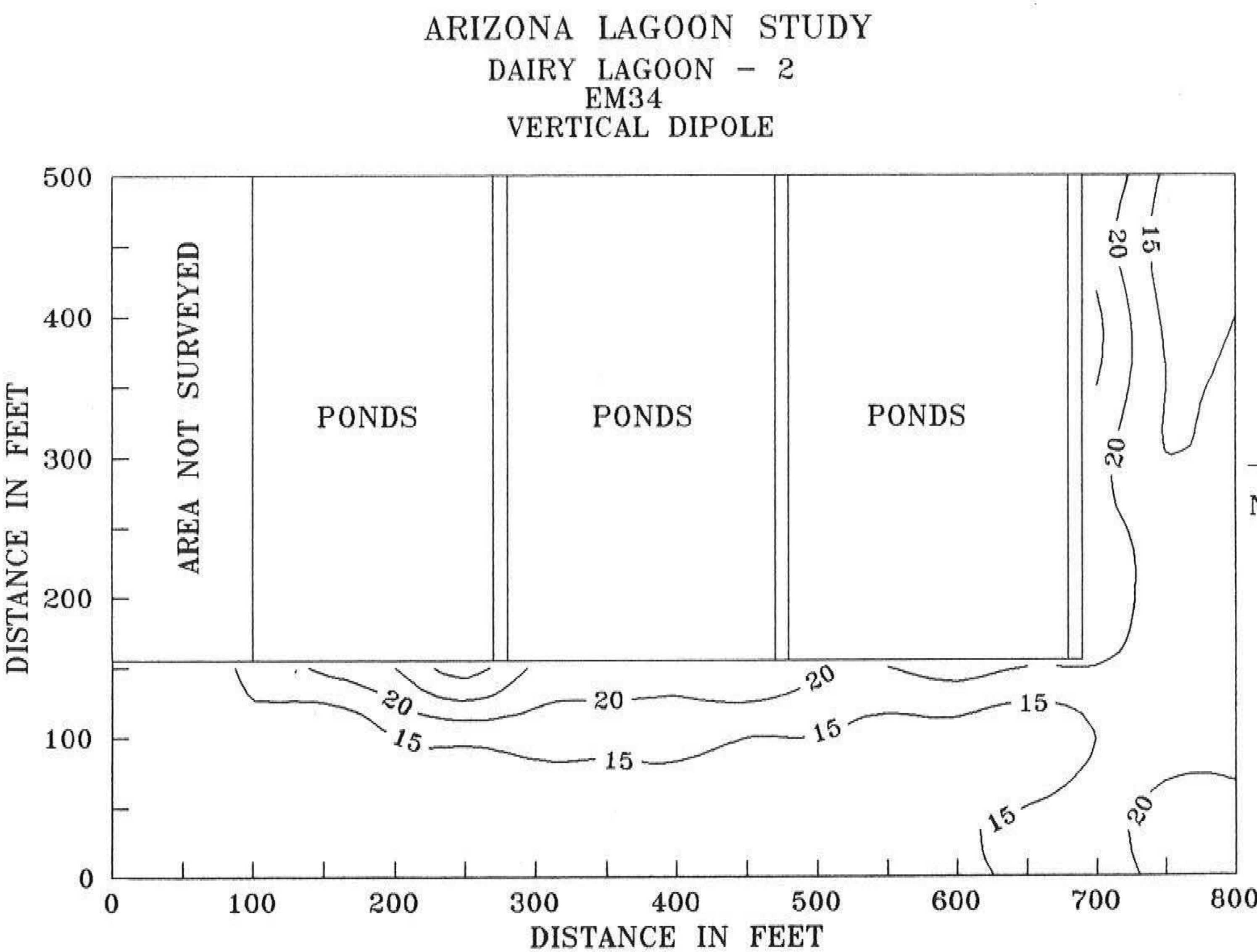
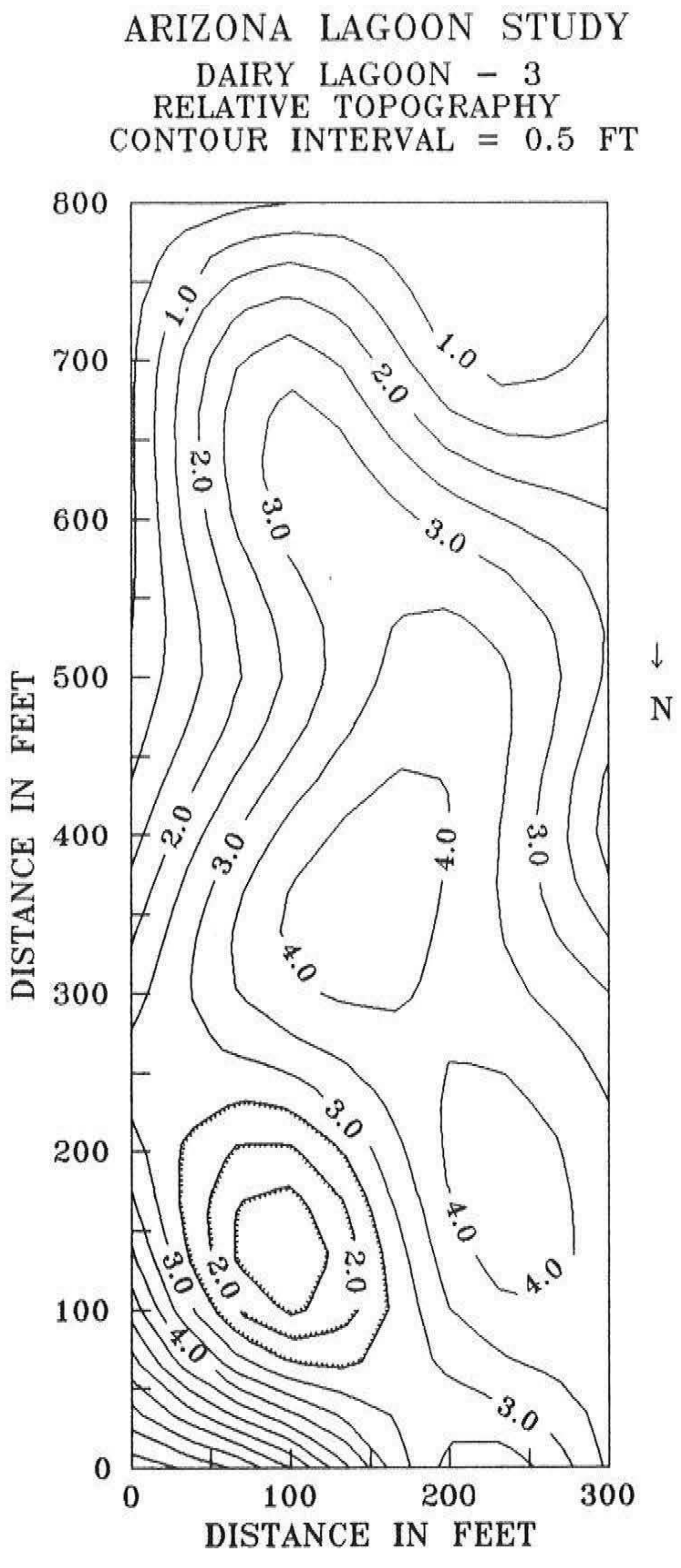

ARIZONA LAGOON STUDY
DAIRY LAGOON - 2
EM34
HORIZONTAL DIPOLE
DISTANCE IN FEET
DISTANCE IN FEET
AREA NOT SURVEYED
PONDS
PONDS
PONDS
N
15
20
0
100
200
300
400
500
600
700
800

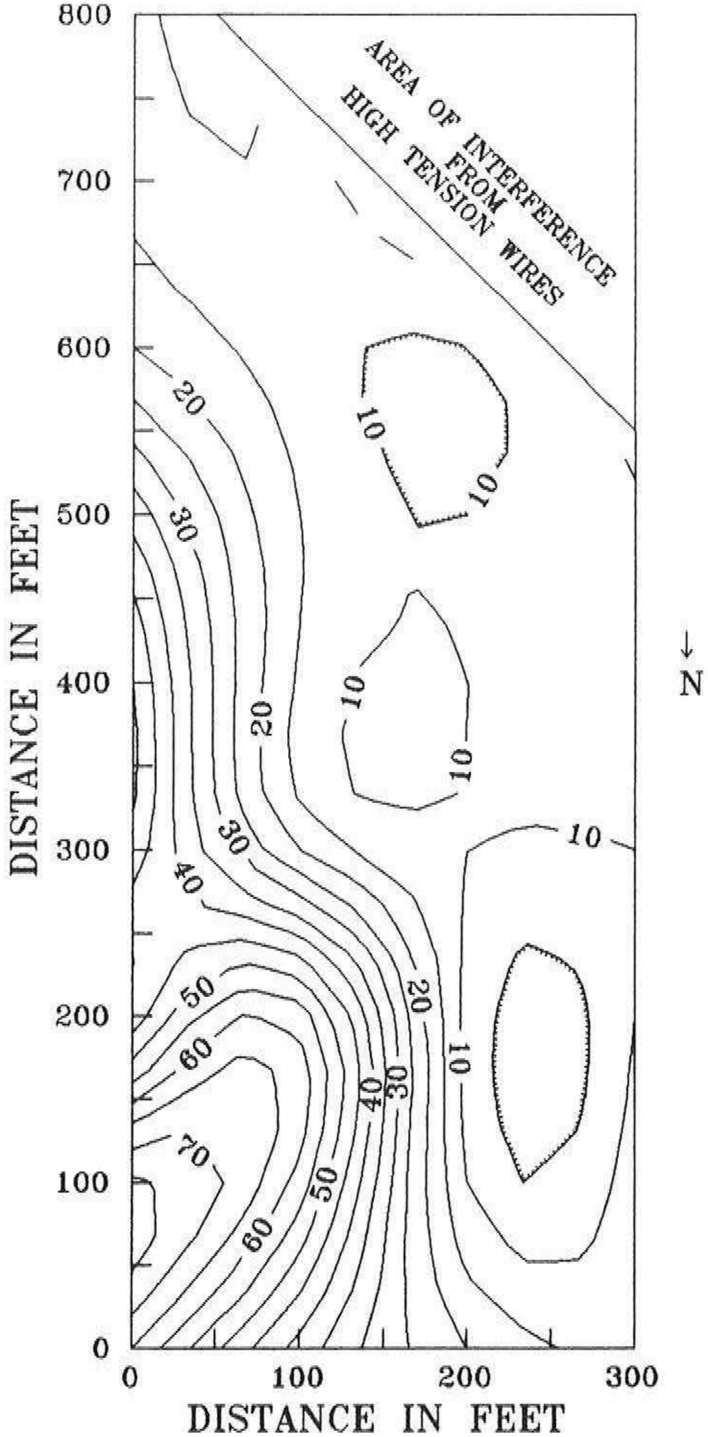
Figure 8

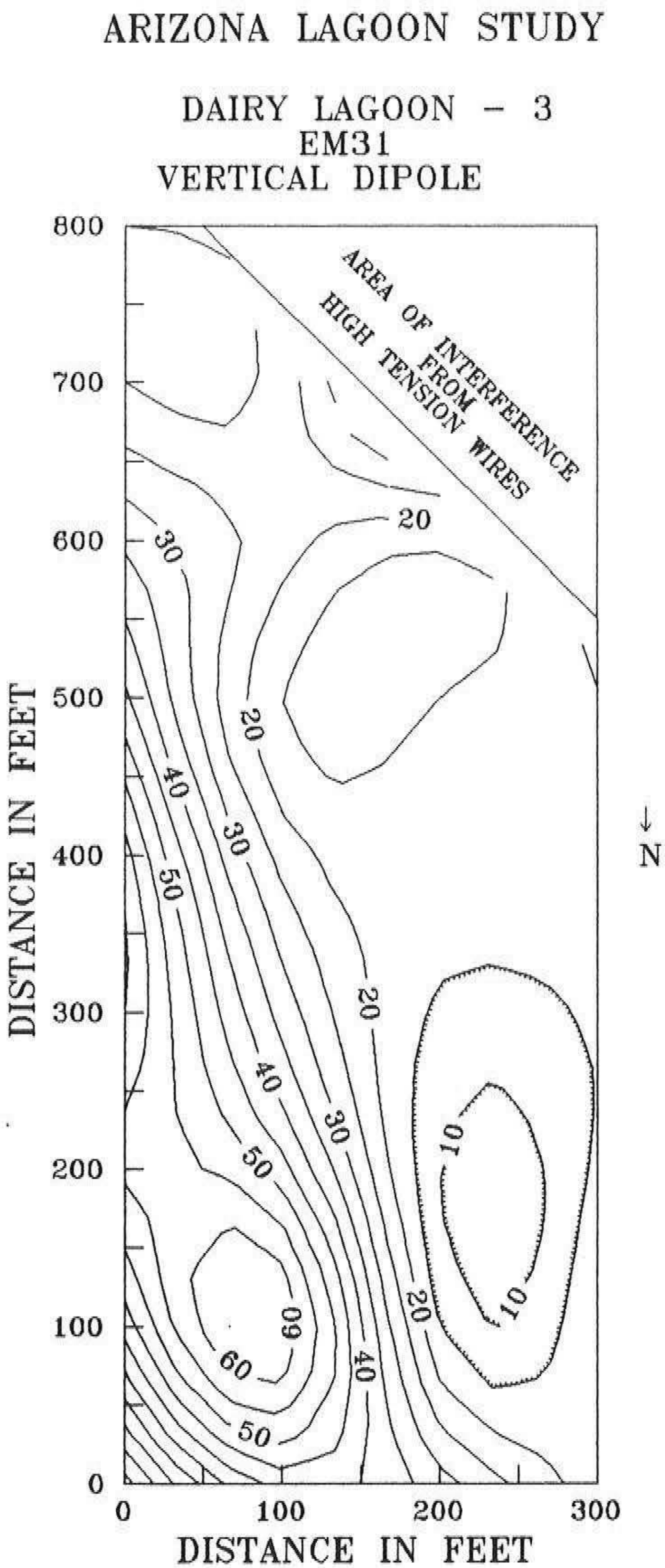

ARIZONA LAGOON STUDY
DAIRY LAGOON - 2
EM34
VERTICAL DIPOLE
AREA NOT SURVEYED
PONDS
PONDS
PONDS
20
15
N
DISTANCE IN FEET
DISTANCE IN FEET
0
100
200
300
400
500
600
700
800

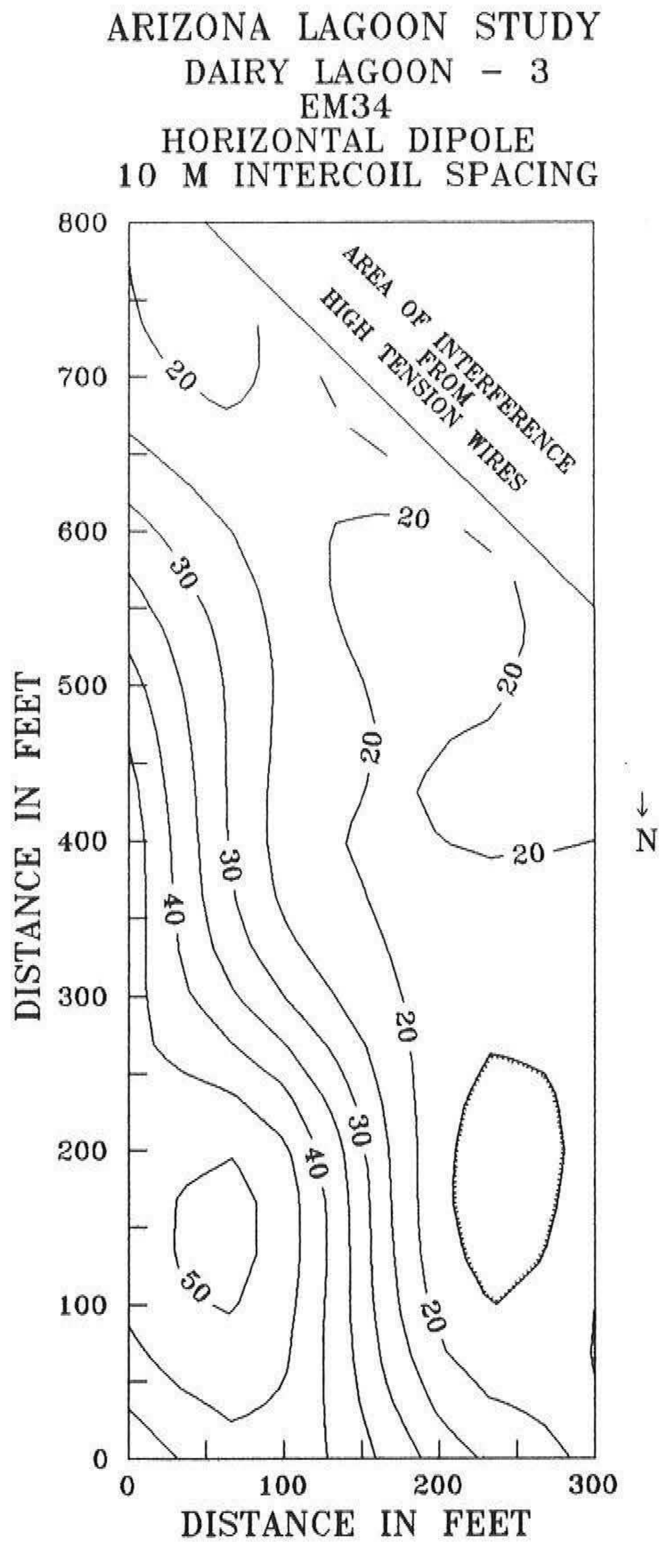

ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
RELATIVE TOPOGRAPHY
CONTOUR INTERVAL = 0.5 FT
DISTANCE IN FEET
DISTANCE IN FEET
N
1.0
2.0
3.0
4.0
0
100
200
300
400
500
600
700
800

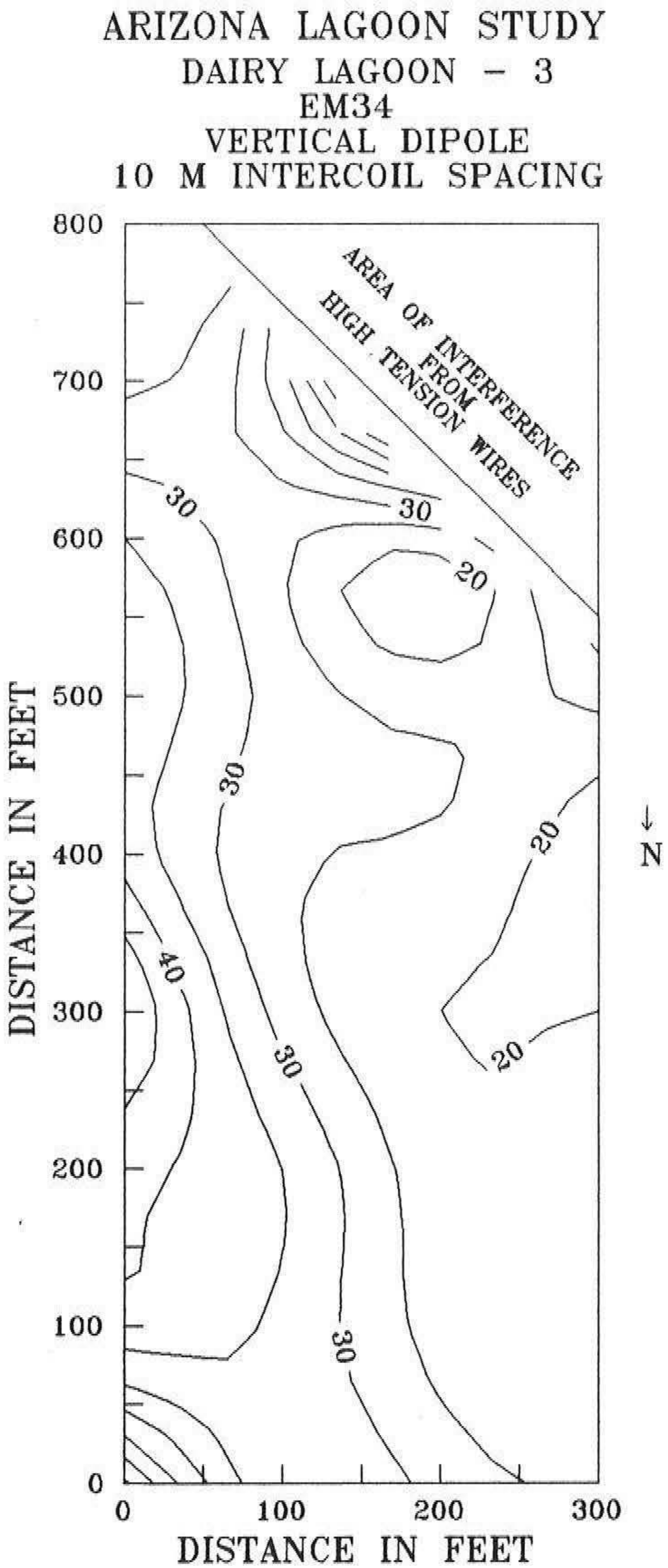
ARIZONA LAGOON STUDY

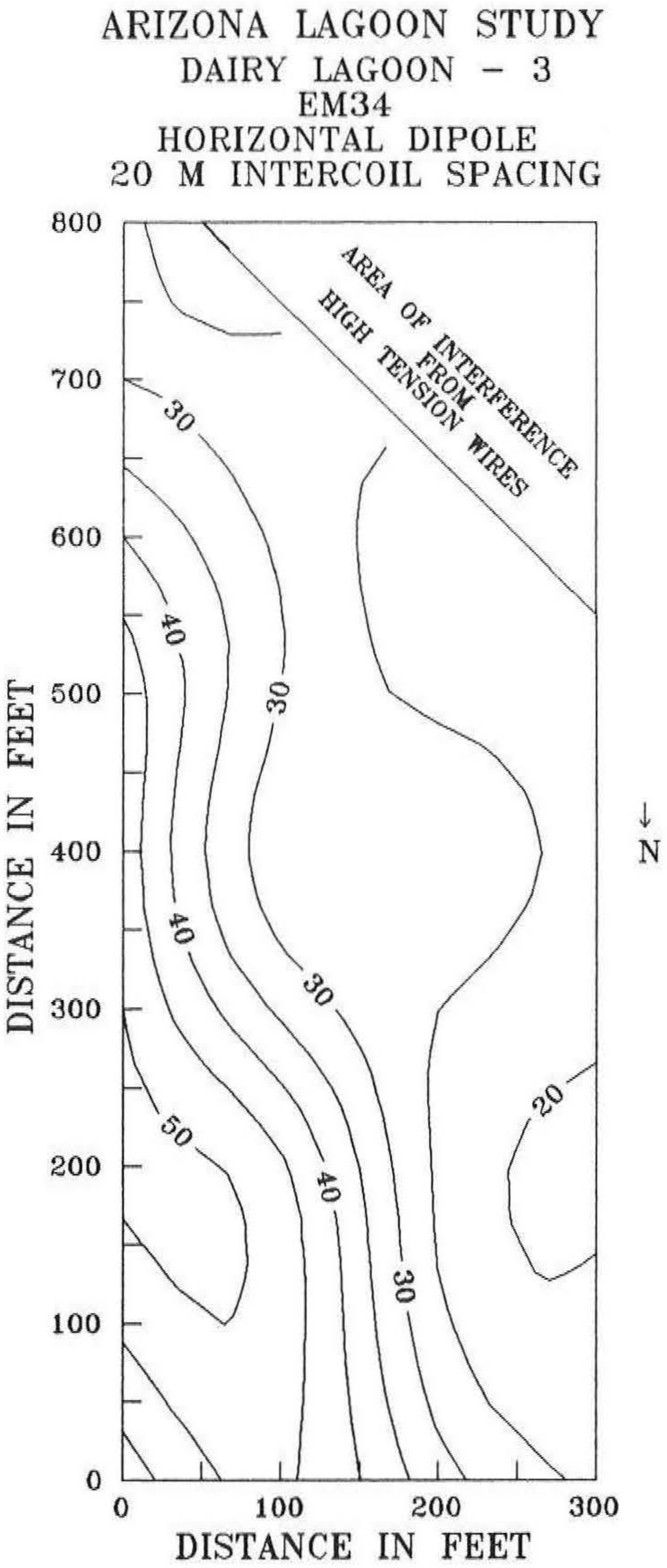
DAIRY LAGOON - 3
EM31
HORIZONTAL DIPOLE

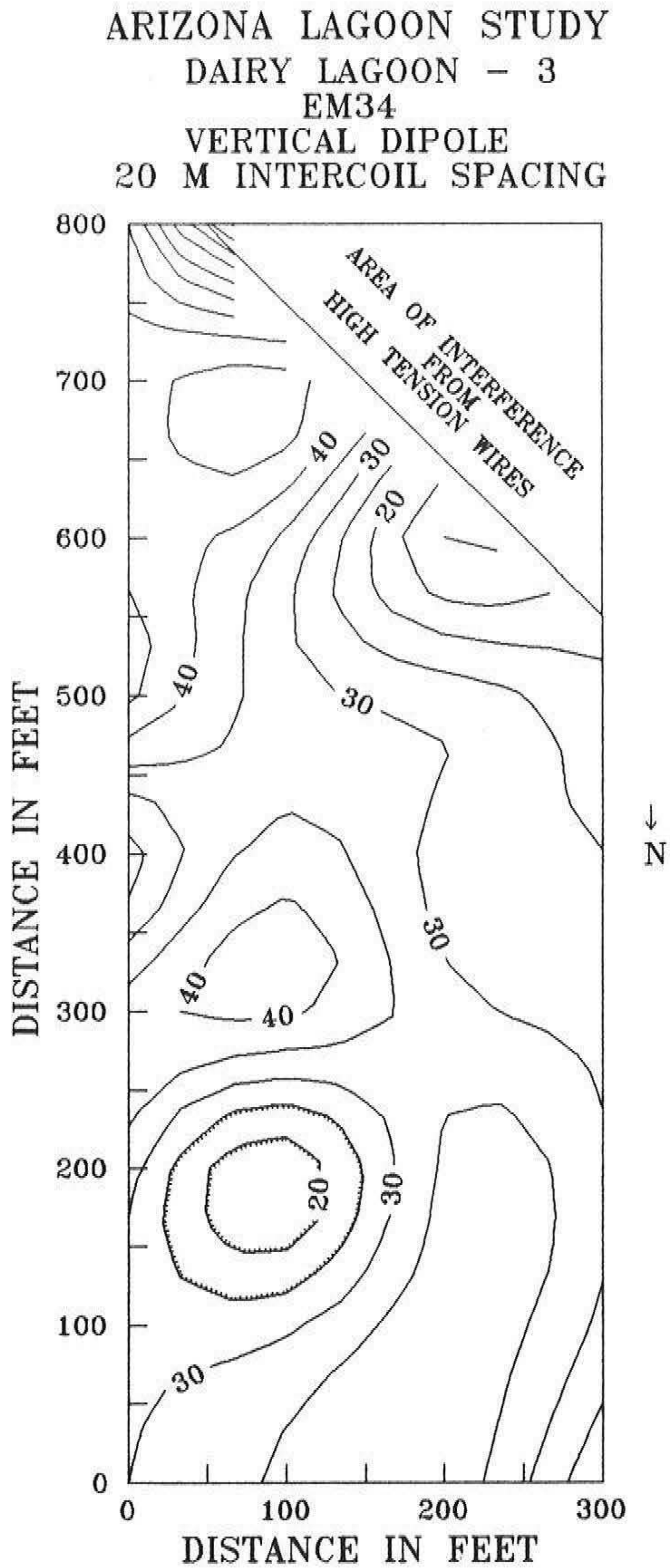



ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
EM31
VERTICAL DIPOLE
AREA OF INTERFERENCE FROM HIGH TENSION WIRES
DISTANCE IN FEET
DISTANCE IN FEET
N
0
100
200
300
400
500
600
700
800
10
20
30
40
50
60


ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
EM34
HORIZONTAL DIPOLE
10 M INTERCOIL SPACING
AREA OF INTERFERENCE FROM HIGH TENSION WIRES
20
30
40
50
0
100
200
300
400
500
600
700
800
DISTANCE IN FEET
DISTANCE IN FEET
N


ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
EM34
VERTICAL DIPOLE
10 M INTERCOIL SPACING
AREA OF INTERFERENCE FROM HIGH TENSION WIRES
30
30
20
30
20
40
30
20
30
DISTANCE IN FEET
DISTANCE IN FEET
N
0
100
200
300
400
500
600
700
800
0
100
200
300


ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
EM34
HORIZONTAL DIPOLE
20 M INTERCOIL SPACING
AREA OF INTERFERENCE FROM HIGH TENSION WIRES
30
40
50
20
DISTANCE IN FEET
DISTANCE IN FEET
0
100
200
300
400
500
600
700
800
N


ARIZONA LAGOON STUDY
DAIRY LAGOON - 3
EM34
VERTICAL DIPOLE
20 M INTERCOIL SPACING
AREA OF INTERFERENCE FROM HIGH TENSION WIRES
DISTANCE IN FEET
DISTANCE IN FEET
N
0
100
200
300
400
500
600
700
800
0
100
200
300
20
30
40

ARIZONA LAGOON STUDY

DAIRY LAGOON - 4
EM31
HORIZONTAL DIPOLE

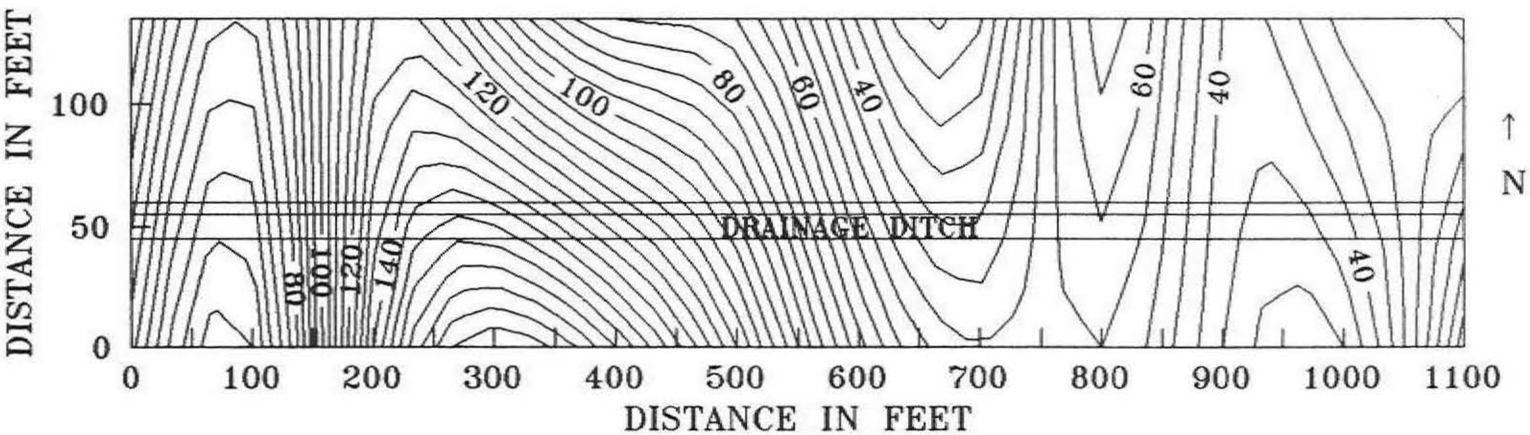


Figure 16

ARIZONA LAGOON STUDY

DAIRY LAGOON - 4
EM31
VERTICAL DIPOLE

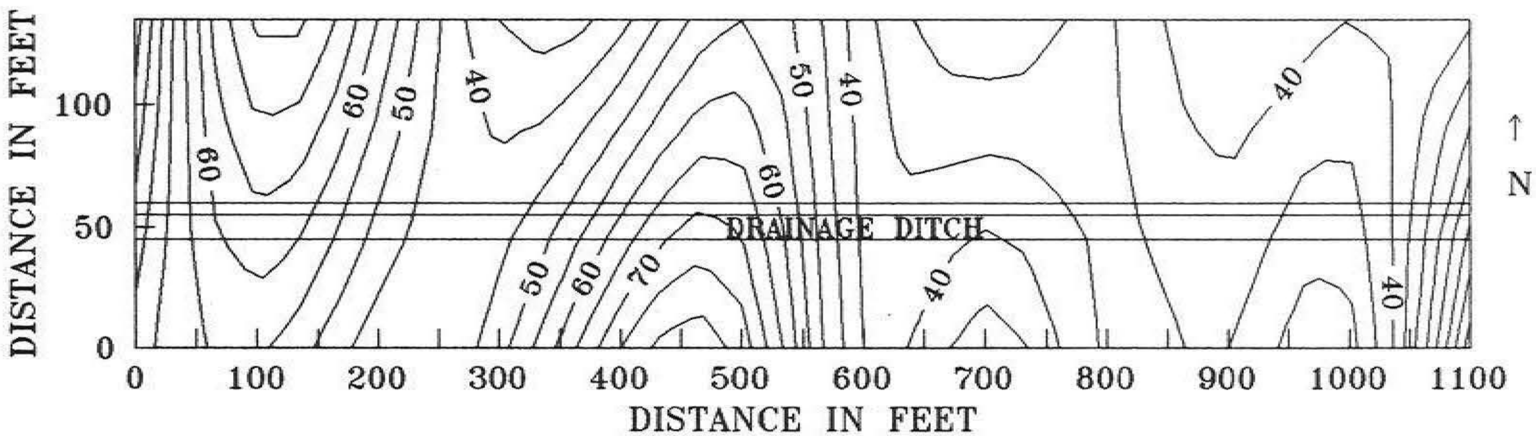


Figure 17

ARIZONA LAGOON STUDY

DAIRY LAGOON - 4
EM34
HORIZONTAL DIPOLE
10 M INTERCOIL SPACING

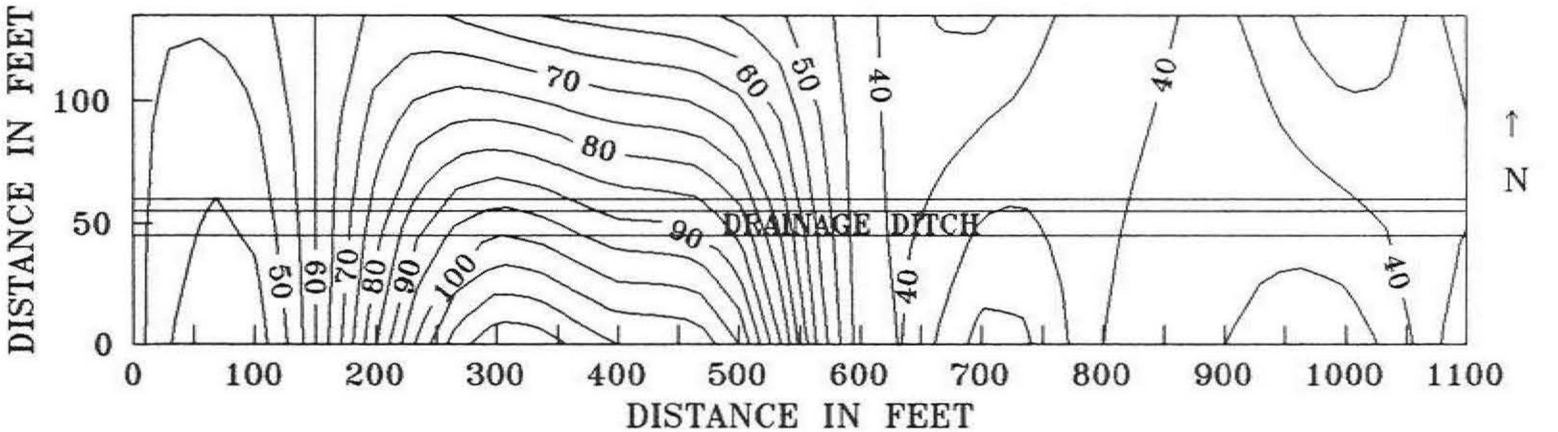


Figure 18

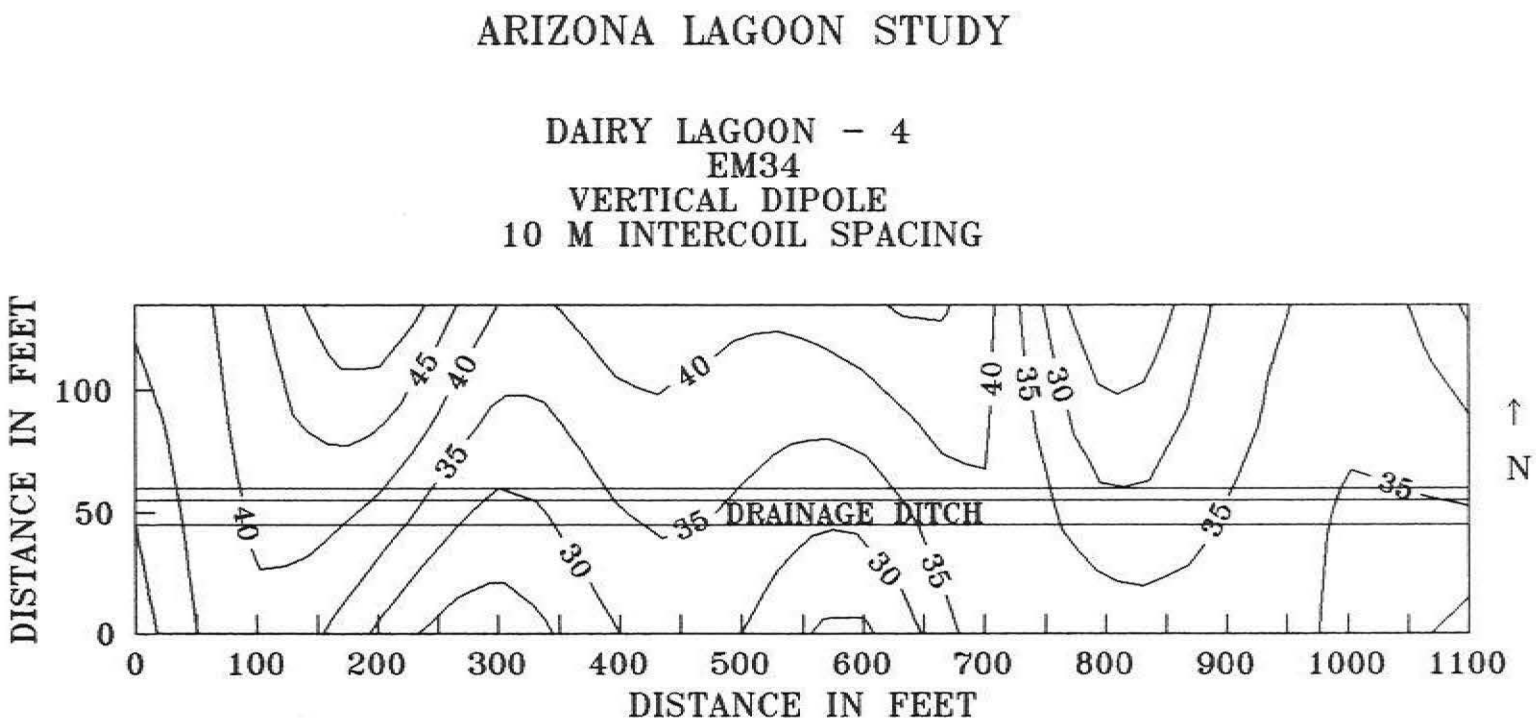

ARIZONA LAGOON STUDY
DAIRY LAGOON - 4
EM34
VERTICAL DIPOLE
10 M INTERCOIL SPACING
DISTANCE IN FEET
0
50
100
DRAINAGE DITCH
45
40
35
30
N
0
100
200
300
400
500
600
700
800
900
1000
1100
DISTANCE IN FEET

Figure 19

ARIZONA LAGOON STUDY

DAIRY LAGOON - 5
EM31
HORIZONTAL DIPOLE

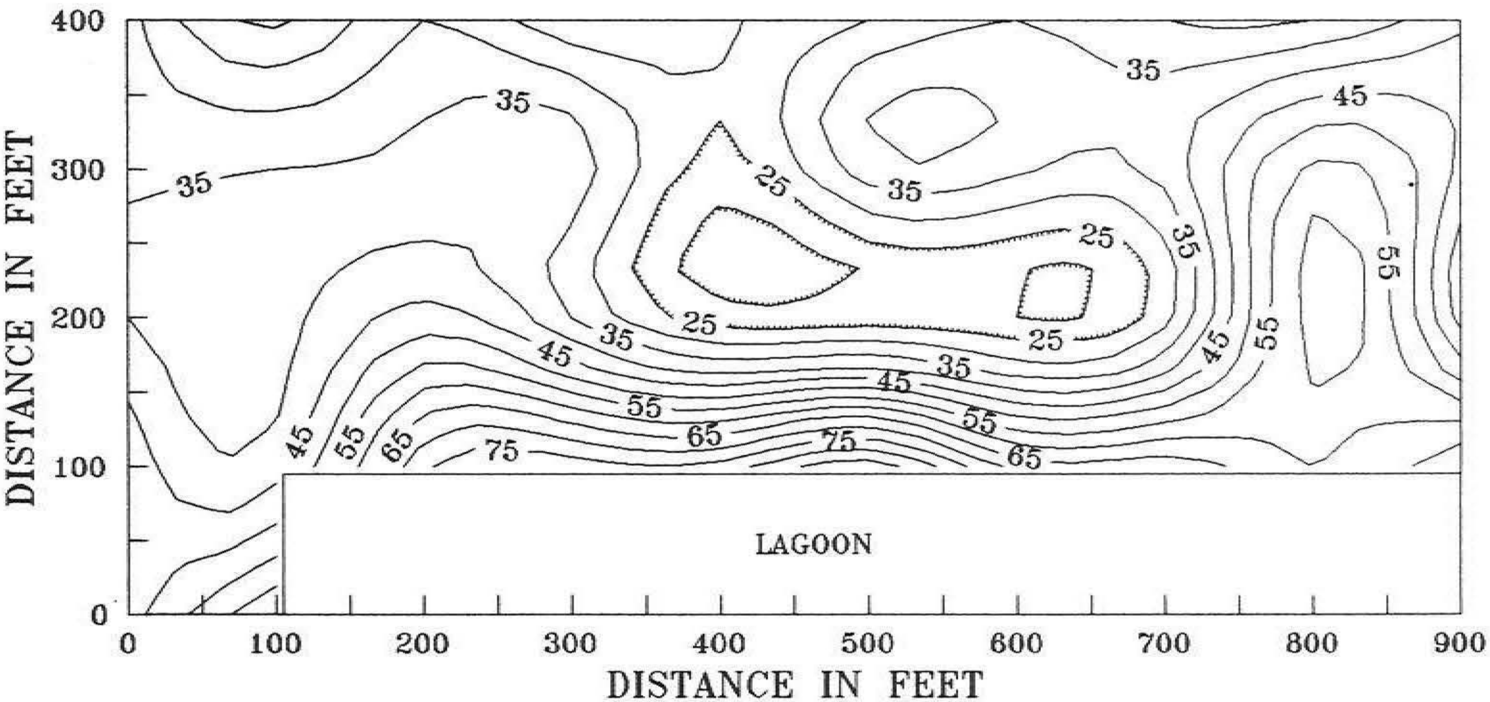


Figure 20

ARIZONA LAGOON STUDY

DAIRY LAGOON - 5
EM31
VERTICAL DIPOLE

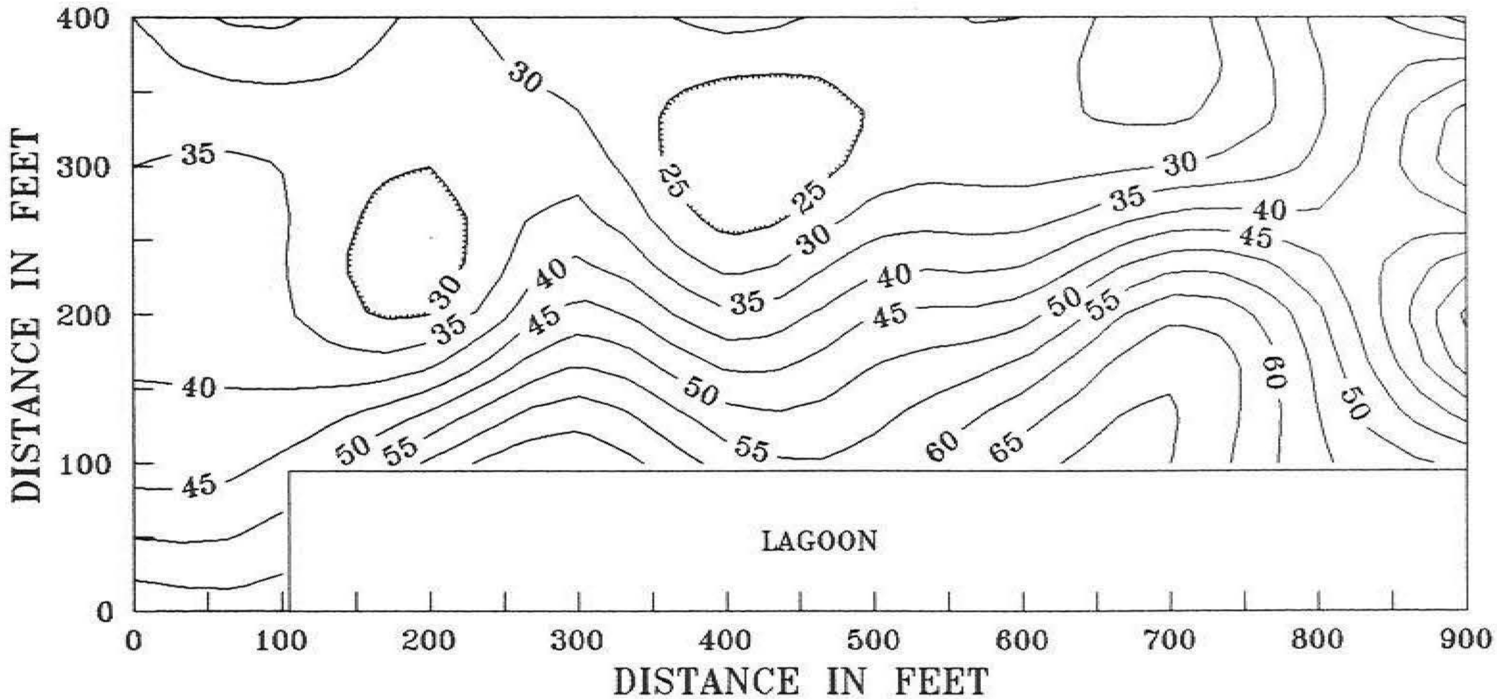


Figure 21

ARIZONA LAGOON STUDY

DAIRY LAGOON – 5
EM34
HORIZONTAL DIPOLE
10 M INTERCOIL SPACING

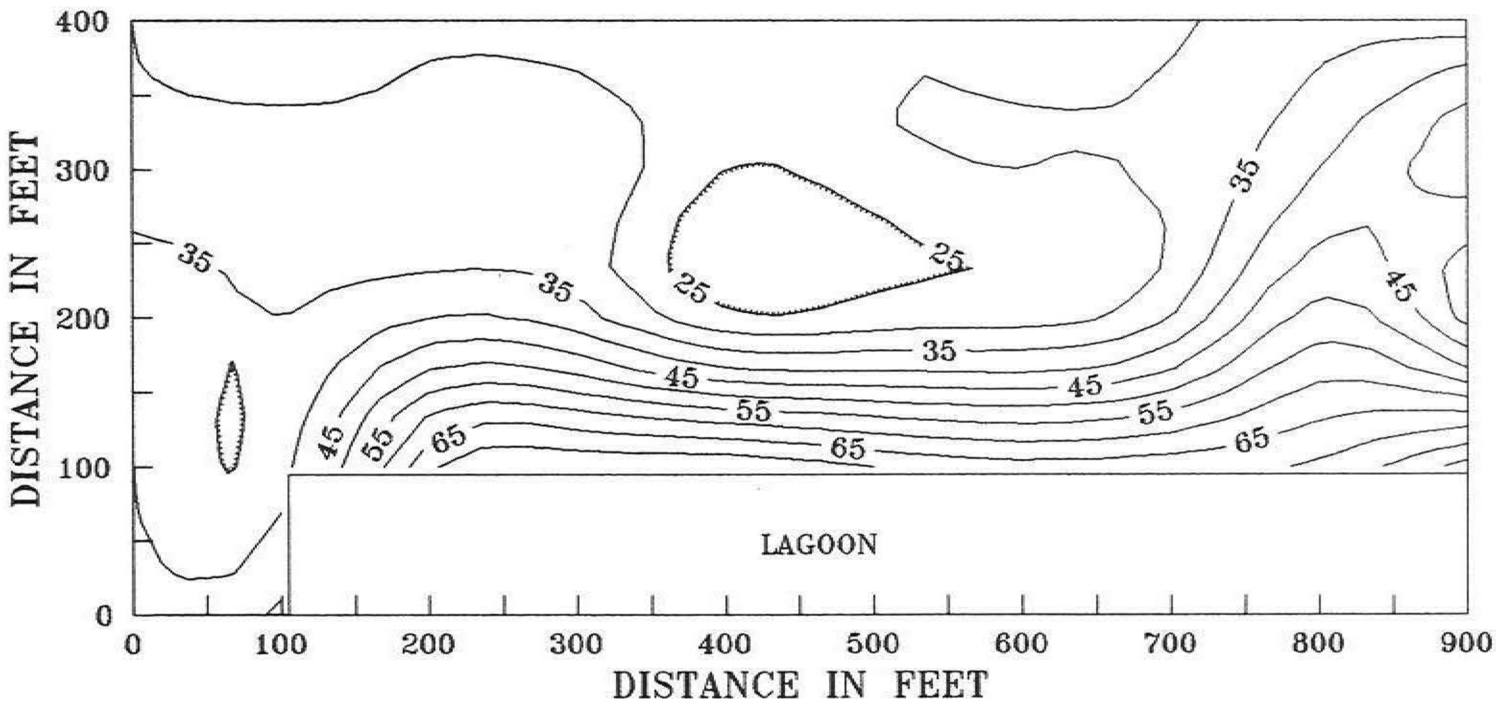


Figure 22

ARIZONA LAGOON STUDY

DAIRY LAGOON – 5
EM34
VERTICAL DIPOLE
10 M INTERCOIL SPACING

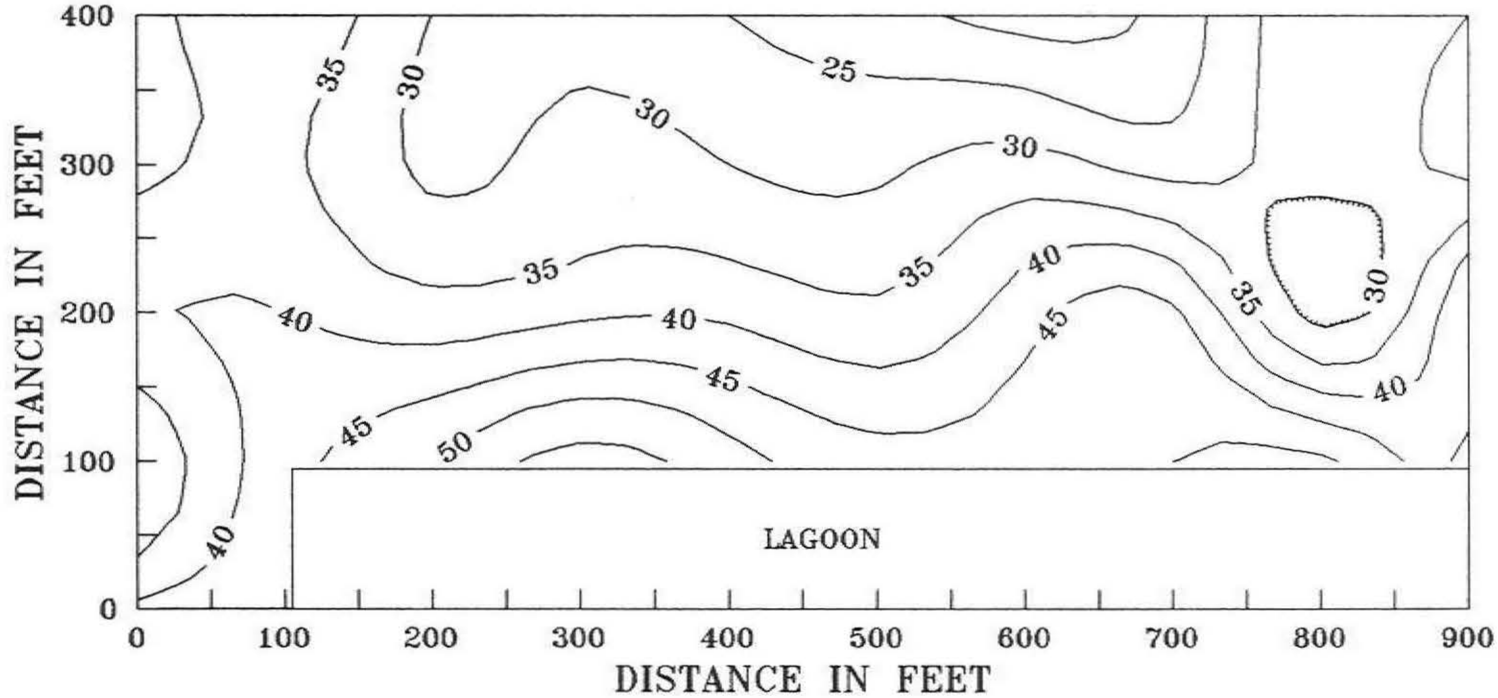


Figure 23