File
Doolittle

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Northeast NTC
CHESTER, PA 19013

SUBJECT: Electromagnetic Induction (EM) survey of Milking Center Waste Filter Strips Chenango County, New York; May 5 to 7 1992

DATE: 11 May 1992

To: Paul A. Dodd
State Conservationist
Soil Conservation Service
Syracuse, NY

Purpose:
To use electromagnetic induction (EM) techniques to monitor selected milking-center waste filter strips in Chenango County, and to provide baseline conductivity data for a proposed animal waste holding facility in Cayuga County, New York.

Participants:
Dana Chapman, ASCE, SCS, Syracuse, NY
Jim Doolittle, Soil Specialist, SCS, Chester, PA
Rich Hamstra, District Manager, Norwich, NY
Frank Geter, Environmental Engineer, SCS, NENTC, Chester, PA
Nora Lawrence, CET, SCS, Seneca Falls, NY
Lance Lockwood, District Technician, Norwich, NY
Dave Sullivan, Geologist, SCS, Syracuse, NY

Activities:
Field surveys of three filter strips in Chenango County were completed on 5 and 6 May 1992. In addition, baseline apparent conductivity data were obtained at a proposed site of an animal waste holding facility in Cayuga County on 6 May 1992.]

Equipment:
The electromagnetic induction meter was the EM31-3 manufactured by GEONICS Limited. 1. Measurements of conductivity are expressed as milliSiemens per meter (ms/m). Two-dimensional contour plots and three-dimensional surface nets of the EM and elevation data were prepared using SURFER software developed by Golden Software, Inc.1.

Discussion:
Filter strip operators reported that their systems were operating well and only complained of occasional odors. Grids had been established at each site prior to the arrival of the EM equipment. Grids were established in a downslope direction of each filter strip. Survey flags were inserted in the ground at 25 foot intervals. At each of the grid intersects, relative measurements of surface elevations were obtained with a level and stadia rod. At each site, the height of the level was assumed, for convenience, to be at 100 feet. The contour interval is 1 foot. Figures 1, 2, and 3 are two-dimensional contour plots of

the surface topography at sites 1,2, and 3, respectively. In each of these figures, the location of the filter field has been identified.

At each site, apparent conductivity measurements were obtained at all grid intersects with the EM31 meter in both the horizontal and vertical dipole modes. Figures 4 through 9 are two-dimensional contour plots of apparent conductivity measurements within the grid sites. In each plot, the contour interval is 1 mS/m. Two contour plots of apparent conductivity have been prepared for each site. These computer simulations represent data obtained with the EM31 in the horizontal and vertical dipole modes. The EM31 meter scans depths of 0-2.75 meters in the horizontal (H) and 0-6.0 meters in the vertical (V) dipole mode. Data represent integrated values of apparent conductivity measured over the depth scanned.

Chenango County - Site 1

This filter strip was constructed in 1988 in an area of Howard gravelly loam. The Howard series is a member of the loamy-skeletal, mixed, mesic Glossoboric Hapludalfs family.

The filter field is about 50 foot wide by 60 foot long. Effluent is transferred from a 1000 gallon concrete settling tank through a 4 inch diameter, PVC pipe into a 2 by 2 by 50 foot wide trench filled with NYS DOT #2 crushed stone. Another 2 by 2 by 50 foot trench of stones parallels the first trench at a distance of 30 feet.

A 150 by 125 foot grid was established at this site. The grid provided 42 observation sites (grid intersects). The site was heavily disturbed with several large farm implements and wire fences present. These implements and the disturbed nature of the grid area interfered with EM measurements.

In Figures 4 and 5, isopleths pass through the filter field. Within the filter field, values of apparent conductivity are low. Isopleth patterns do not appear to have been modified by the filter field. Within the filter field and with a 25 foot grid interval, no significant source of possible contaminants were detected with the EM31 meter. The unusually high conductivity values in the lower right corner of Figure 4, reflect a standing area for dairy cows with high concentrations of excrement on the surface. Though the influence of these contaminants is less apparent when conductivity values are integrated over 6.0 meters (Figure 5), their presence is still detectable with EM techniques.

Chenango County - Site 2

This filter strip was constructed in 1990 in an area of Howard gravelly loam. This is a 50 foot wide by 55 foot long field. Effluent is transferred from a 1000 gallon concrete settling tank

through a 4 inch diameter, PVC pipe into a 2 by 2 by 80 foot wide trench filled with NYS DOT #2 crushed stone. Another 2 by 2 by 50 foot trench of stones parallels the first trench at a distance of 25 feet.

A 150 by 75 foot grid was established at this site. The grid provided 28 observation sites (grid intersects). In Figures 6 and 7, isopleths pass through the filter field. Within the filter field, values of apparent conductivity are low in the horizontal mode (possibly reflecting the crushed stones in the trenches) and slightly higher in the vertical mode (possibly reflecting soil conditions or low concentrations of contaminants). However, within the filter field, no noteworthy indications of potential contaminants were detected with the EM31 meter.

Chenango County - Site 3

This filter strip was constructed in 1990 in an area of Valois gravelly silt loam. The Valois series is a member of the coarse-loamy, mixed, mesic Typic Dystrochrepts family.

This is a 75 foot wide by 40 foot long field. Effluent is transferred from a 1000 gallon concrete settling tank through a 4 inch diameter, PVC pipe into a 2 by 2 by 10 foot wide trench filled with NYS DOT #2 crushed stone. Another 2 by 2 by 75 foot trench of stones parallels the first trench at a distance of 31 feet.

A 125 by 125 foot grid was established at this site. The grid provided 32 observation sites (grid intersects). The operators house was located in the lower right-hand corner of the grid (see figures 8 and 9). The house appeared to have influence (elevated) EM measurements taken within 25 feet of the structure. In addition, a buried utility or pipe line appears to have been located leading away from this structure along the right-hand margin of Figure 9. The septic system for the house may have produced the elevated conductivity values (>8 mS/m) to the immediate, lower-left of the house. As these features were not apparent when measurements were taken in the horizontal mode (Figure 8), they must be assumed to be fairly deeply buried (>2 m).

Within the filter field, some indication of contaminants is evident in both figures 8 and 9. Isopleth patterns appear to have been modified by the filter field. Values of apparent conductivity are high in near-the-surface in the upper right-hand corner of the filter field (Figure 8). Values of apparent conductivity are high and reflect possible deep seepage of contaminants in the upper left-hand corner of the filter field (Figure 9).

Cayuga County - Site 1

This survey was conducted in order to obtain baseline information concerning variations in apparent conductivity values across the site of a proposed animal waste holding facility. A grid was established at this site at the time of the EM survey. The grid was established in a downslope direction of the proposed animal waste holding facility. Eighty-three survey flags were inserted in the ground at 50 foot intervals.

As evident in Figures 10 and 11, variations in conductivity values exist at this site. The high values adjacent to the roadway (lower, right-hand margin) are believed to reflect concentrations of road salts and washed materials. The higher values along the lower portion of these figures (between the 100 and 400 foot intersects and below the benchmark (TBM2)) have been produced from seepage from an adjoining animal waste facility. Indications of seepage from this structure are noticeable at distances as great as 70 feet into the survey area.

In each computer simulation, two additional features have been identified: a wet spot, "w," and an anomaly, "A." Saturated soil conditions are reflected in the higher apparent conductivity values near "W." The anomaly may indicate soils having less clay or greater amounts of coarse fragments. Either condition would result in lower apparent conductivity values.

Results:

1. Variations in the meters response are produced by changes in the ionic concentration of earthen materials. These changes are produced by changes in sediment type, degree of saturation, nature of the ions in solution, and metallic objects. In the examined filter strips, no significant indications of higher concentrations of soluble salts were observed. As the filter strips were relatively new and viewed as operating well, the observed EM response was not surprising.

2. Using the EM 31 meter, a grid spacing of about 10 feet is recommended for filter strips. Filter strips are relatively small structures and more closely-spaced data are required to detect changes in conductivity. The 25 foot grid intervals used in this survey is considered too coarse for filter fields.

3. It is recommended that, with operators permission, additional survey be completed on the animal waste holding facility in Cayuga County to monitor potential growth of contaminant plumes.

I appreciated this opportunity to work in your state and to introduce members of your staff to electromagnetic induction methods.

With kind regards,

James A. Doolittle

James A. Doolittle
Soil Specialist

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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 milliSiemen 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).

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 required 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 meter. The actual depth of measurement

will depend on the conductivity of the earthen material(s) scanned.

TABLE 1

Depth of Measurement

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM31	3.7m	2.75m	6.0m

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.

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FIGURE 1

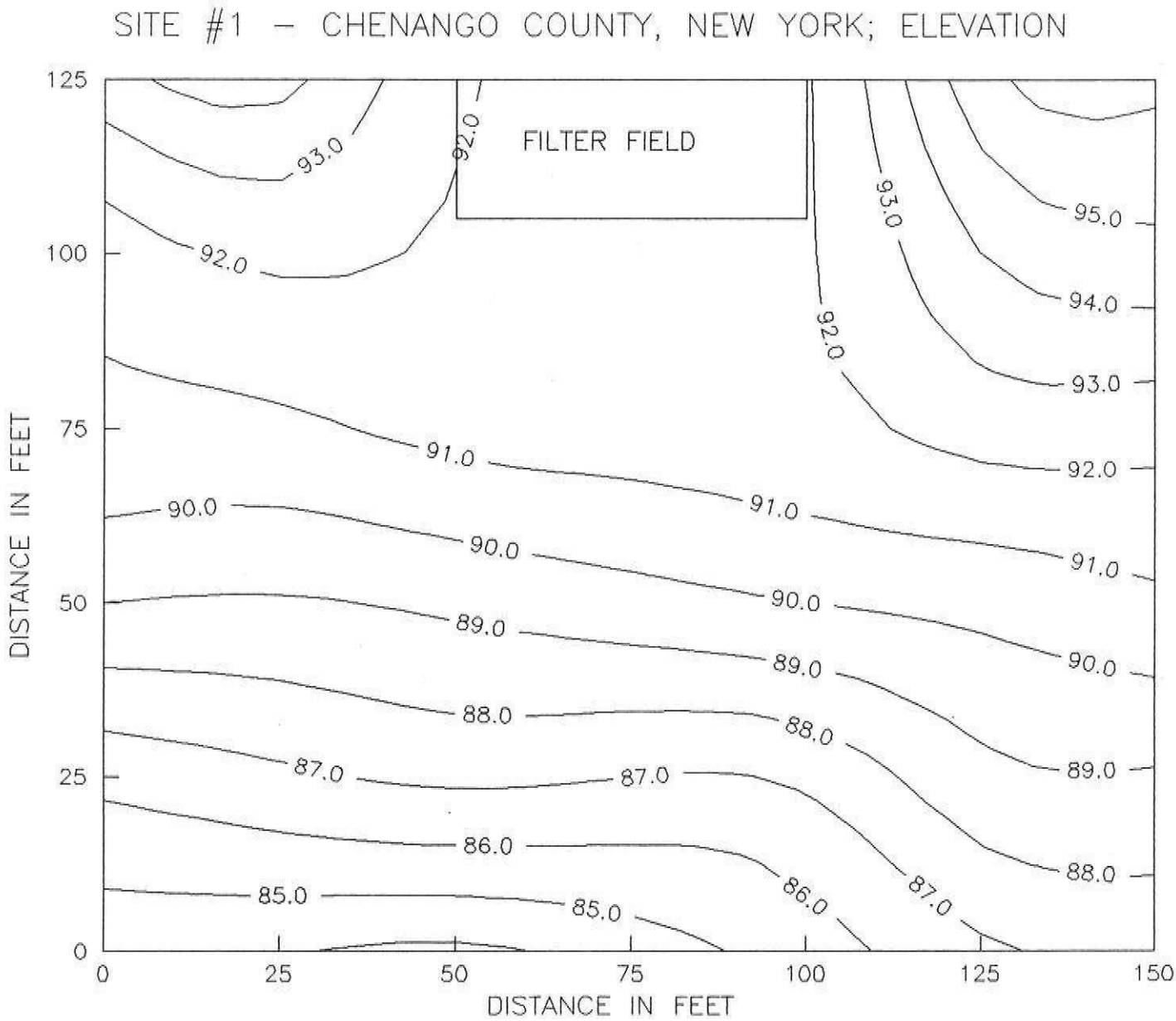
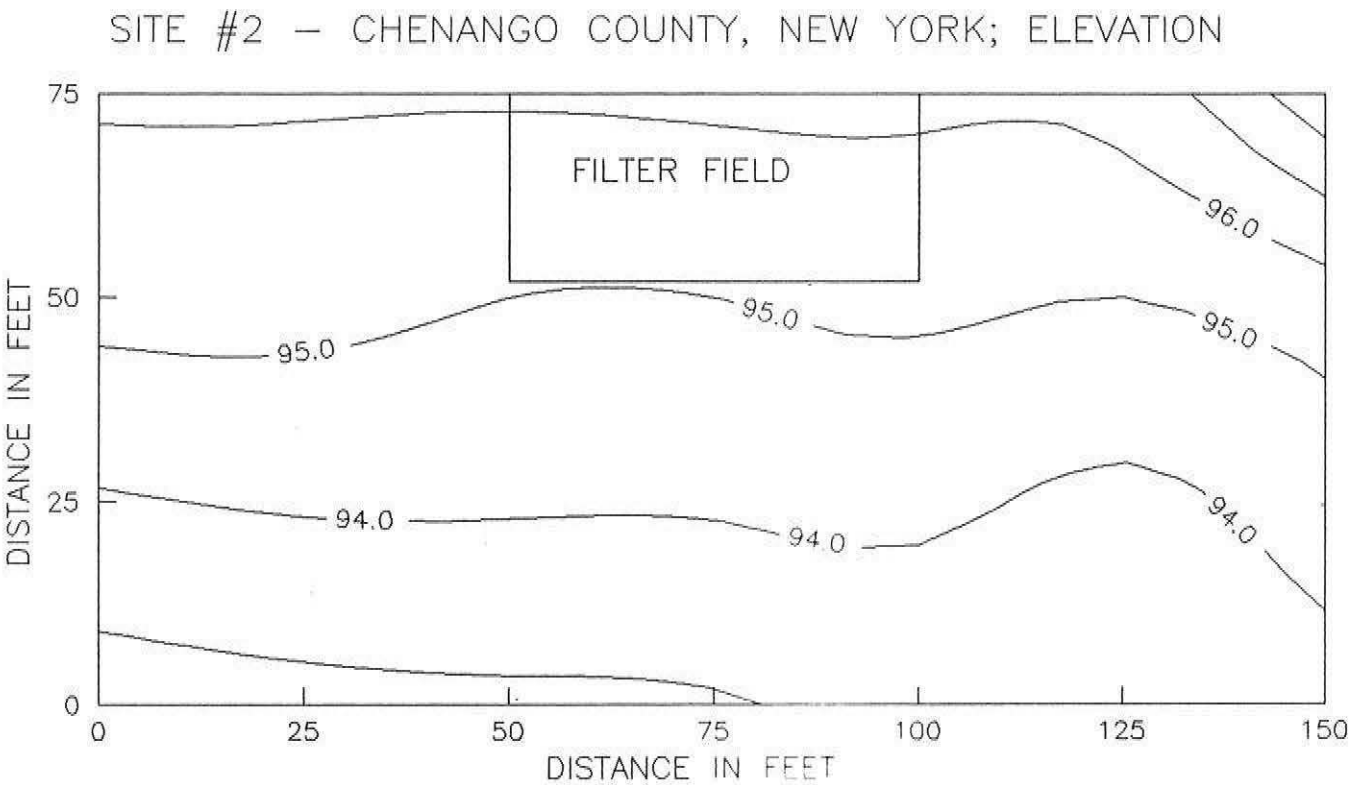

SITE #1 – CHENANGO COUNTY, NEW YORK; ELEVATION
FILTER FIELD
93.0
92.0
92.0
93.0
95.0
94.0
93.0
92.0
91.0
91.0
91.0
90.0
90.0
90.0
90.0
89.0
89.0
89.0
88.0
88.0
88.0
87.0
87.0
87.0
86.0
86.0
85.0
85.0
DISTANCE IN FEET
DISTANCE IN FEET
0
25
50
75
100
125
150

FIGURE 2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FILTER FIELD
96.0
95.0
95.0
95.0
94.0
94.0
94.0
DISTANCE IN FEET
DISTANCE IN FEET
0
25
50
75
100
125
150
0
25
50
75

FIGURE 3

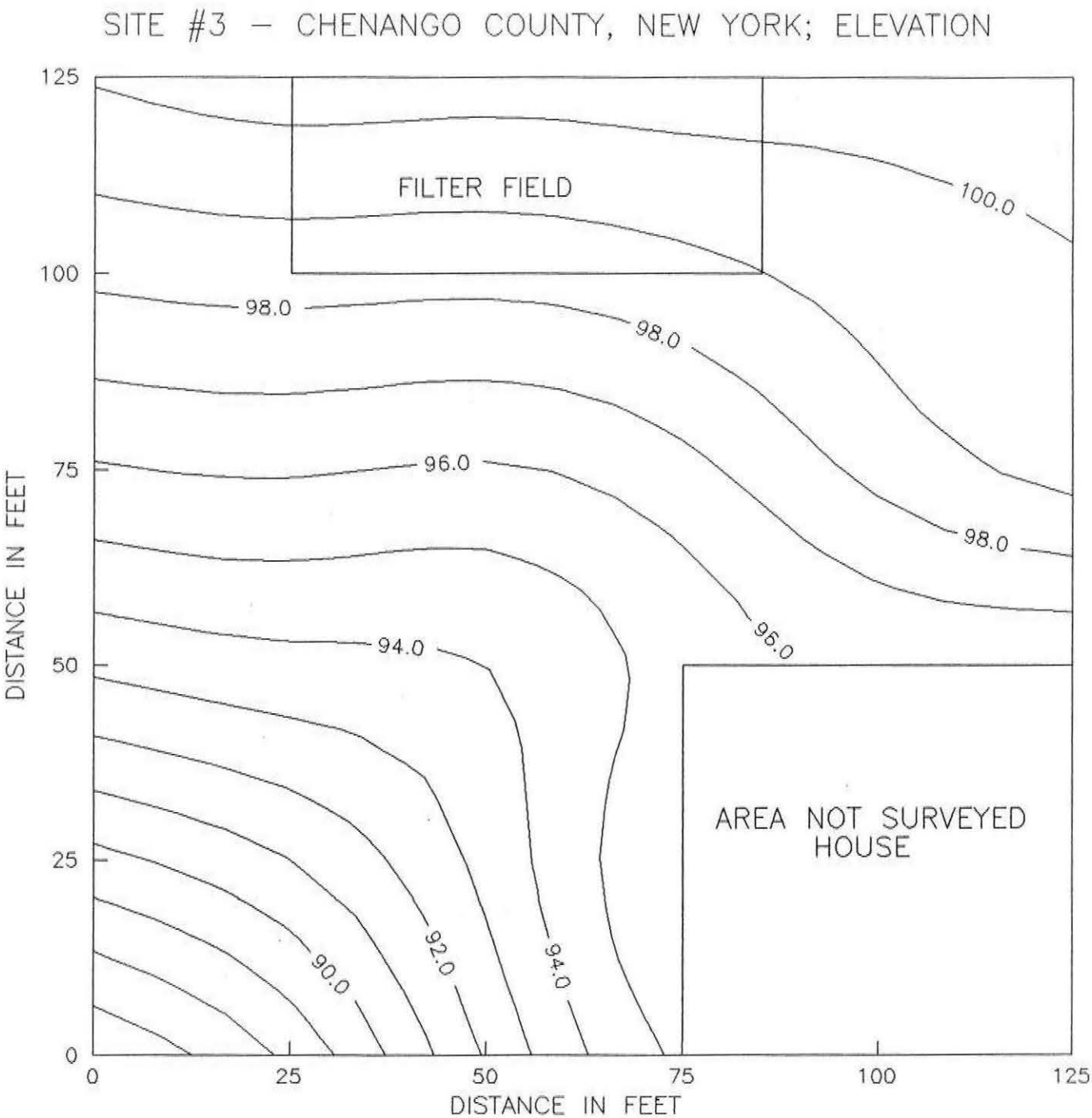
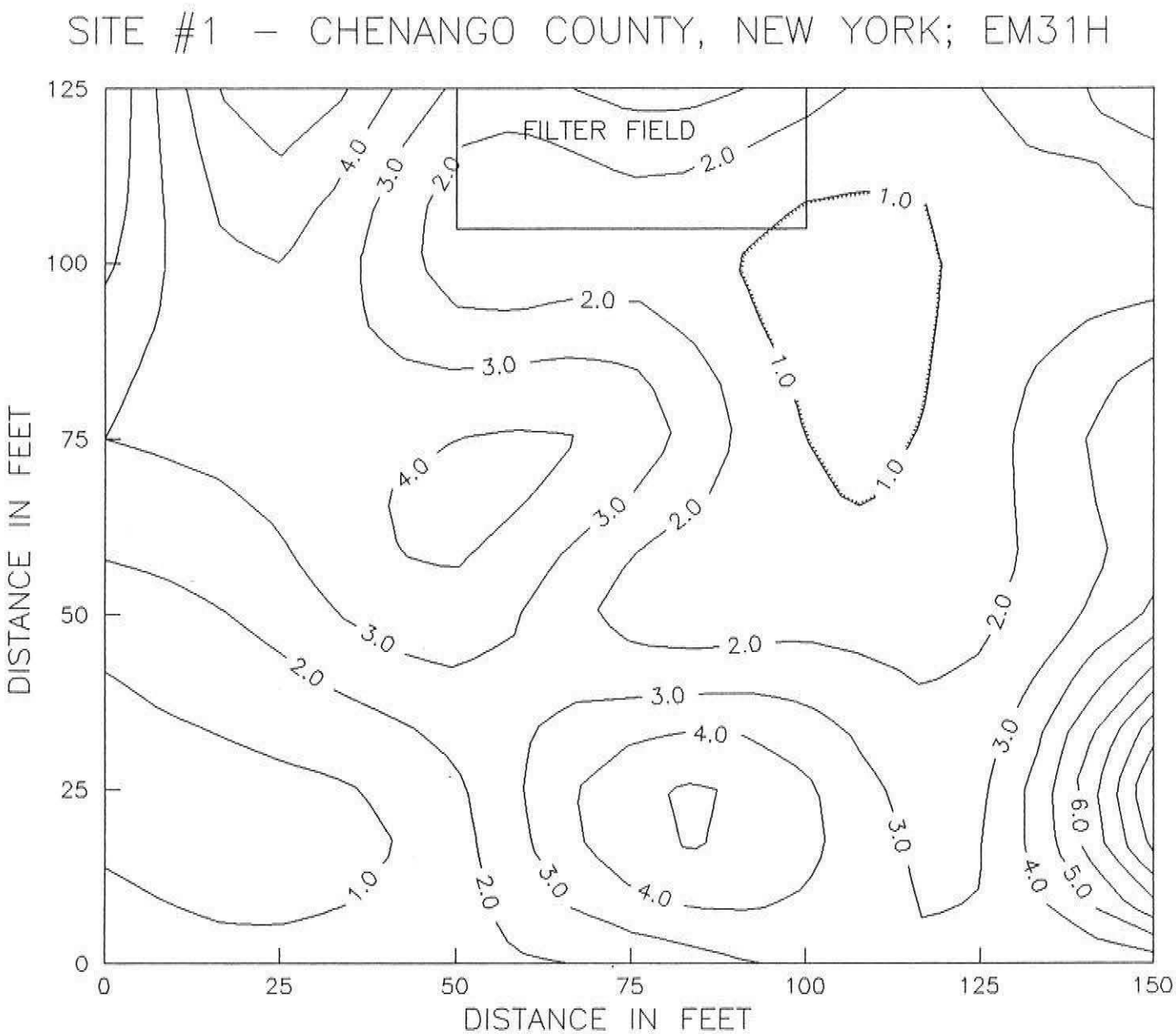

SITE #3 – CHENANGO COUNTY, NEW YORK; ELEVATION
FILTER FIELD
AREA NOT SURVEYED
HOUSE
100.0
98.0
98.0
98.0
96.0
96.0
94.0
94.0
92.0
90.0
DISTANCE IN FEET
DISTANCE IN FEET
0
25
50
75
100
125

FIGURE 4


SITE #1 – CHENANGO COUNTY, NEW YORK; EM31H
FILTER FIELD
DISTANCE IN FEET
DISTANCE IN FEET
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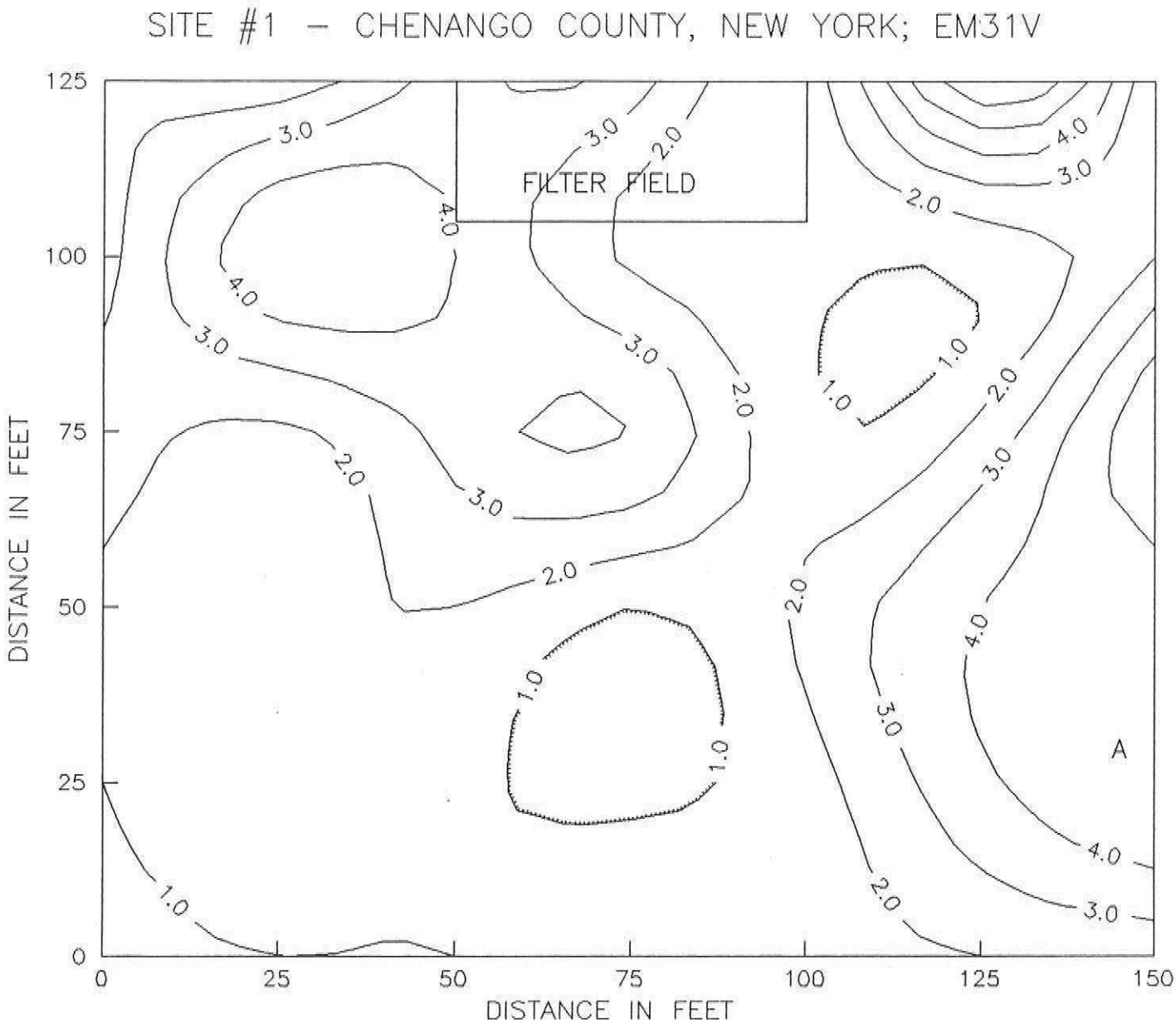
50
75
100
125
150
1.0
2.0
3.0
4.0
5.0
6.0

FIGURE 5


SITE #1 – CHENANGO COUNTY, NEW YORK; EM31V
FILTER FIELD
A
DISTANCE IN FEET
DISTANCE IN FEET
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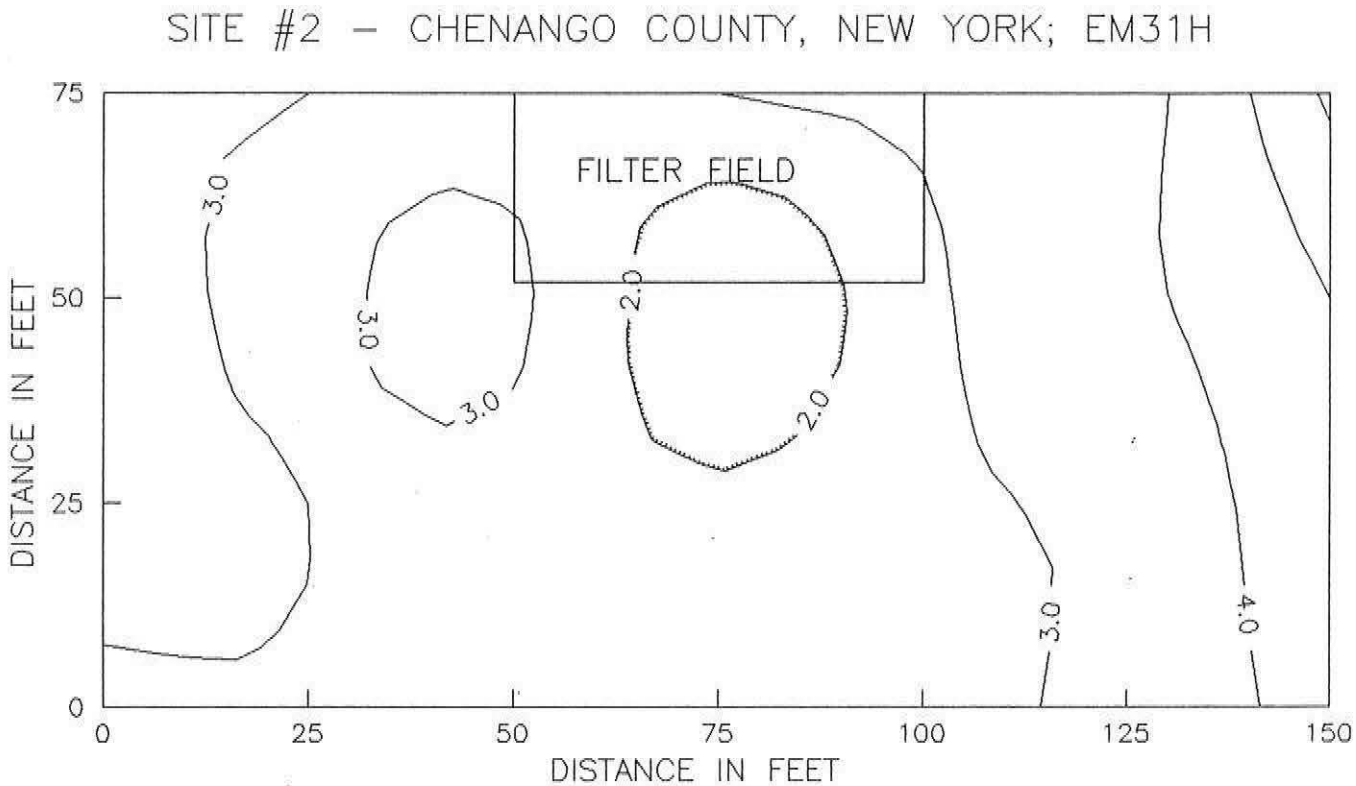
50
75
100
125
150
1.0
2.0
3.0
4.0

FIGURE 6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FILTER FIELD
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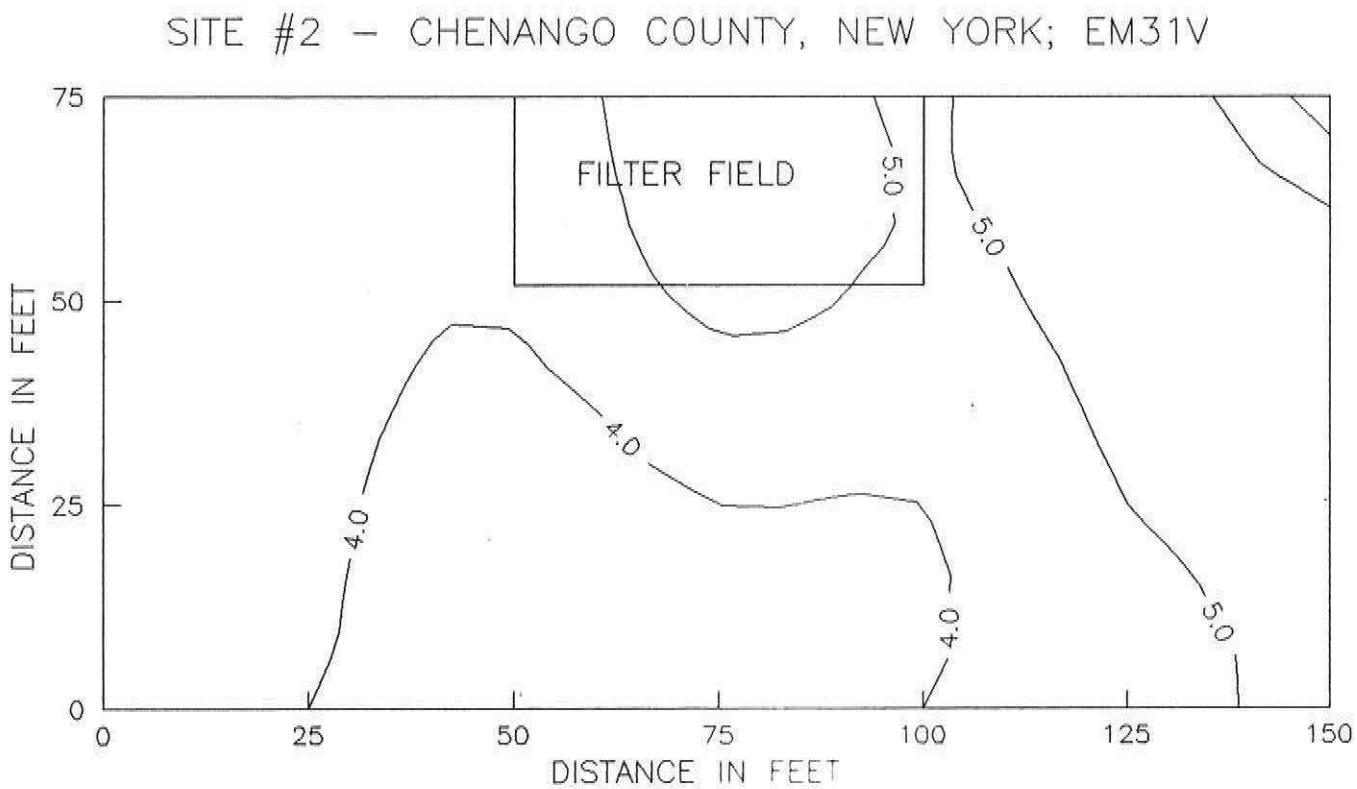
3.0
3.0
2.0
2.0
3.0
4.0
DISTANCE IN FEET
DISTANCE IN FEET
0
25
50
75
0
25
50
75
100
125
150

FIGURE 7


SITE #2 – CHENANGO COUNTY, NEW YORK; EM31V
FILTER FIELD
5.0
5.0
4.0
4.0
4.0
5.0
DISTANCE IN FEET
DISTANCE IN FEET
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25
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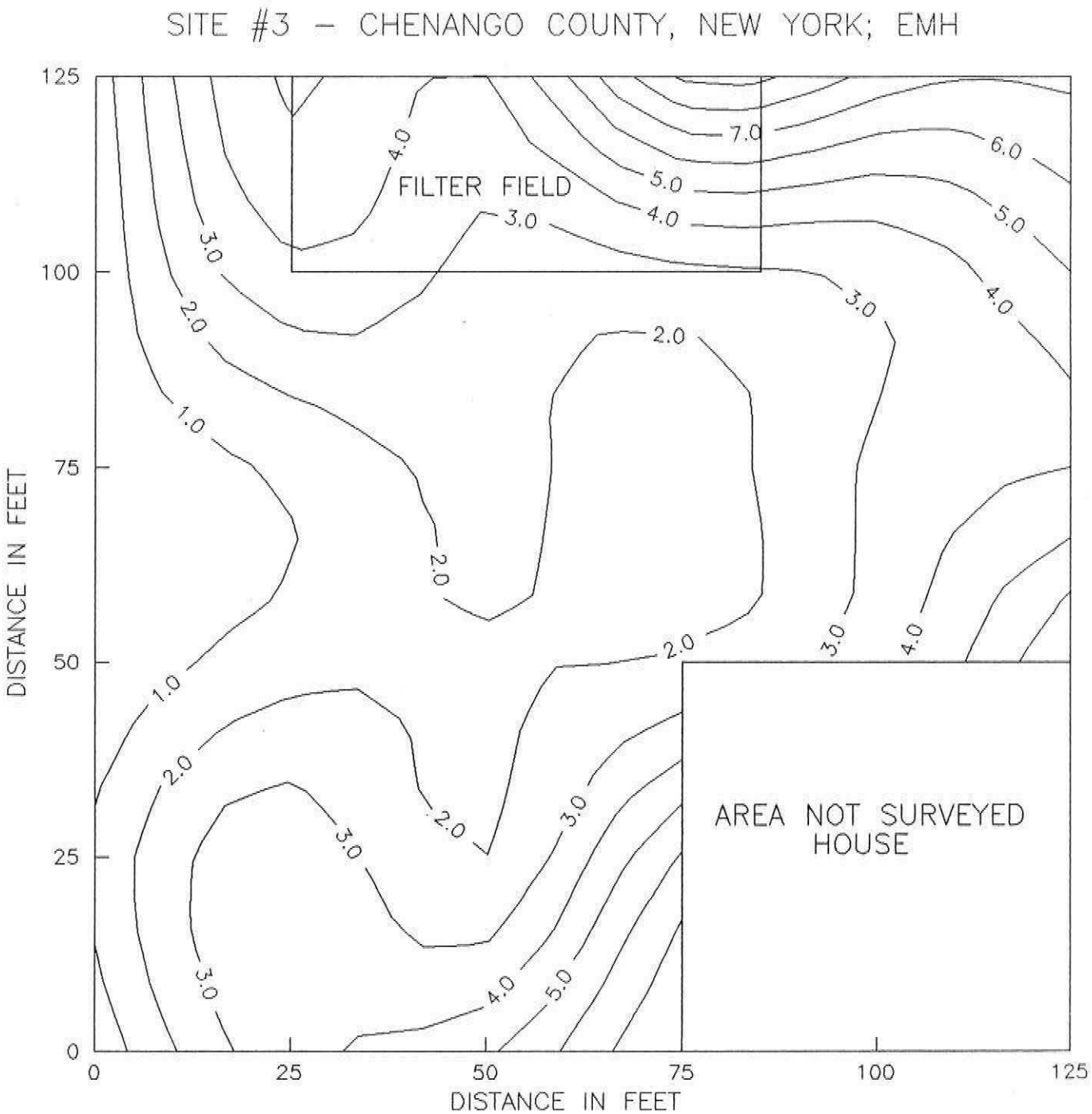
75
0
25
50
75
100
125
150

FIGURE 8


SITE #3 – CHENANGO COUNTY, NEW YORK; EMH
FILTER FIELD
AREA NOT SURVEYED
HOUSE
DISTANCE IN FEET
DISTANCE IN FEET
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75
100
125
1.0
2.0
3.0
4.0
5.0
6.0
7.0

FIGURE 9

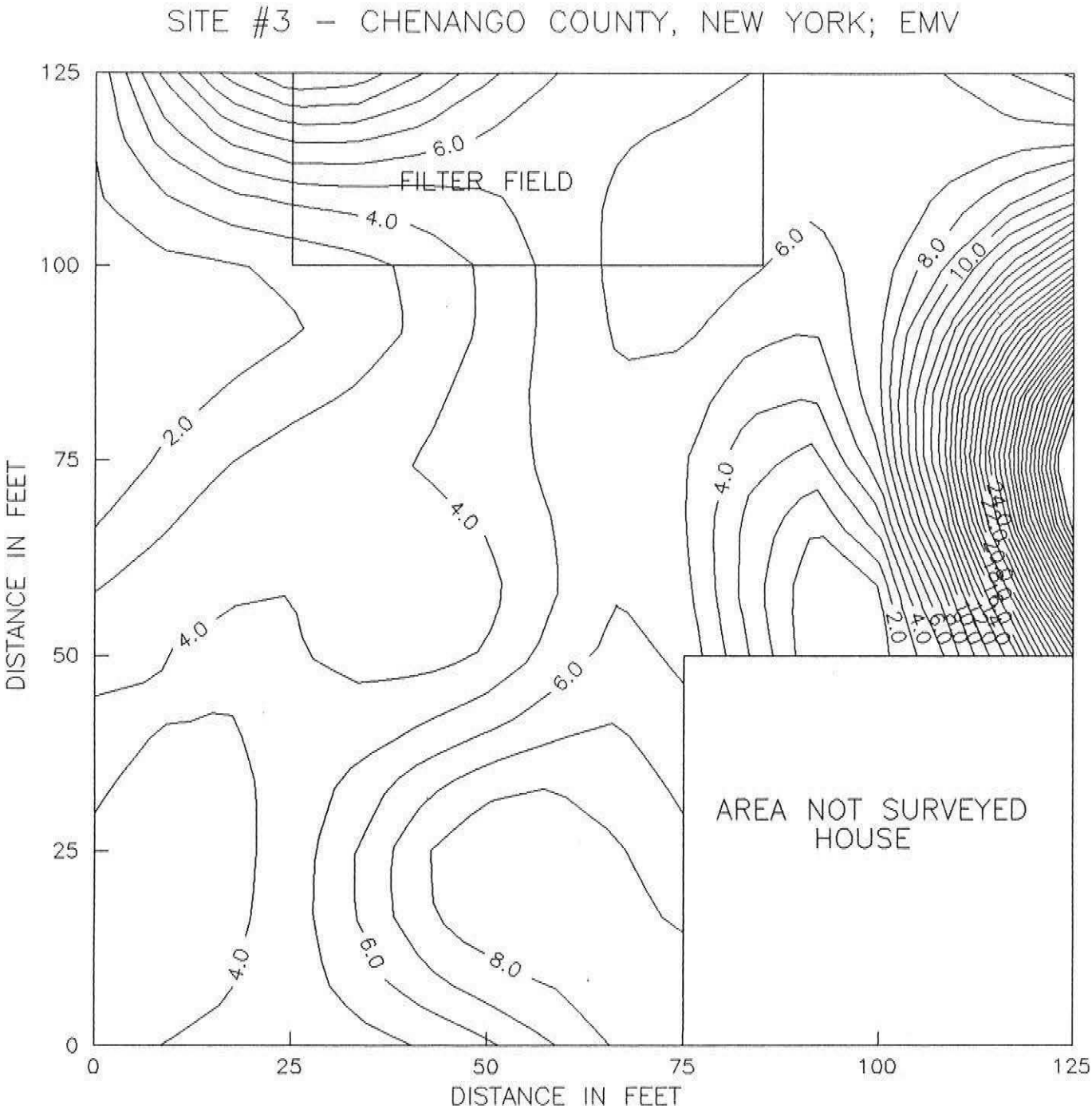

SITE #3 - CHENANGO COUNTY, NEW YORK; EMV
FILTER FIELD
AREA NOT SURVEYED
HOUSE
DISTANCE IN FEET
DISTANCE IN FEET
0
25
50
75
100
125
2.0
4.0
6.0
8.0
10.0

FIGURE 10

SITE #1, CAYUGA COUNTY, NY; EM31H

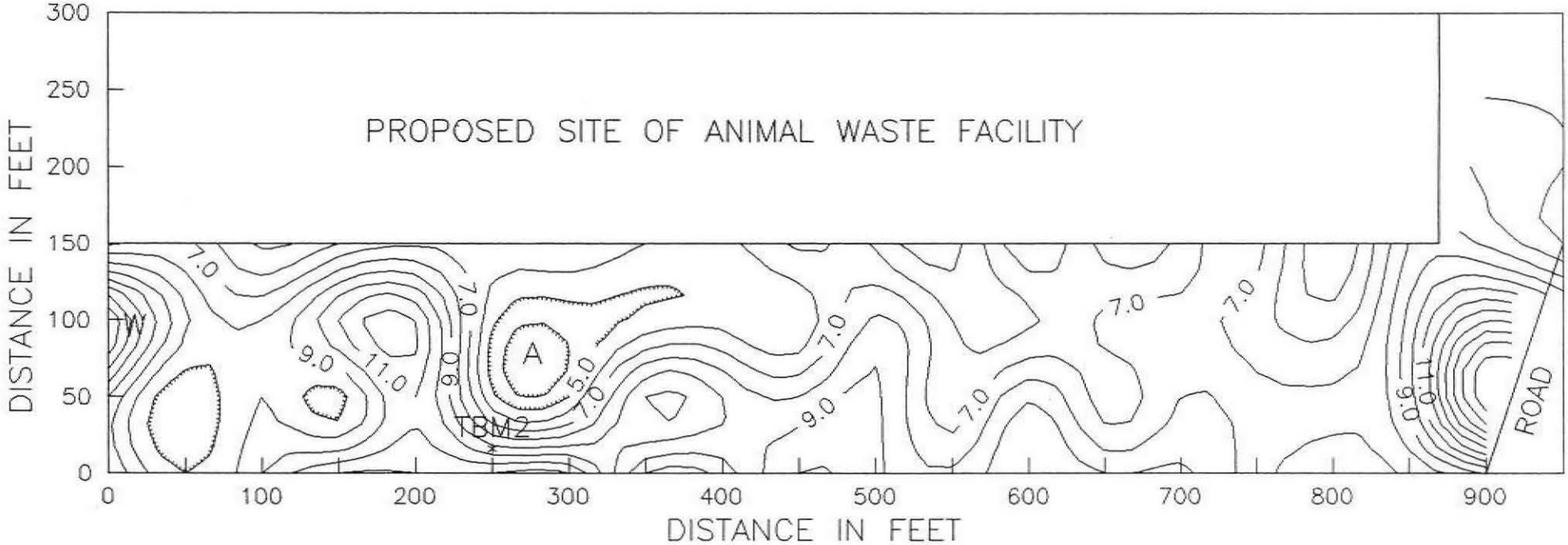
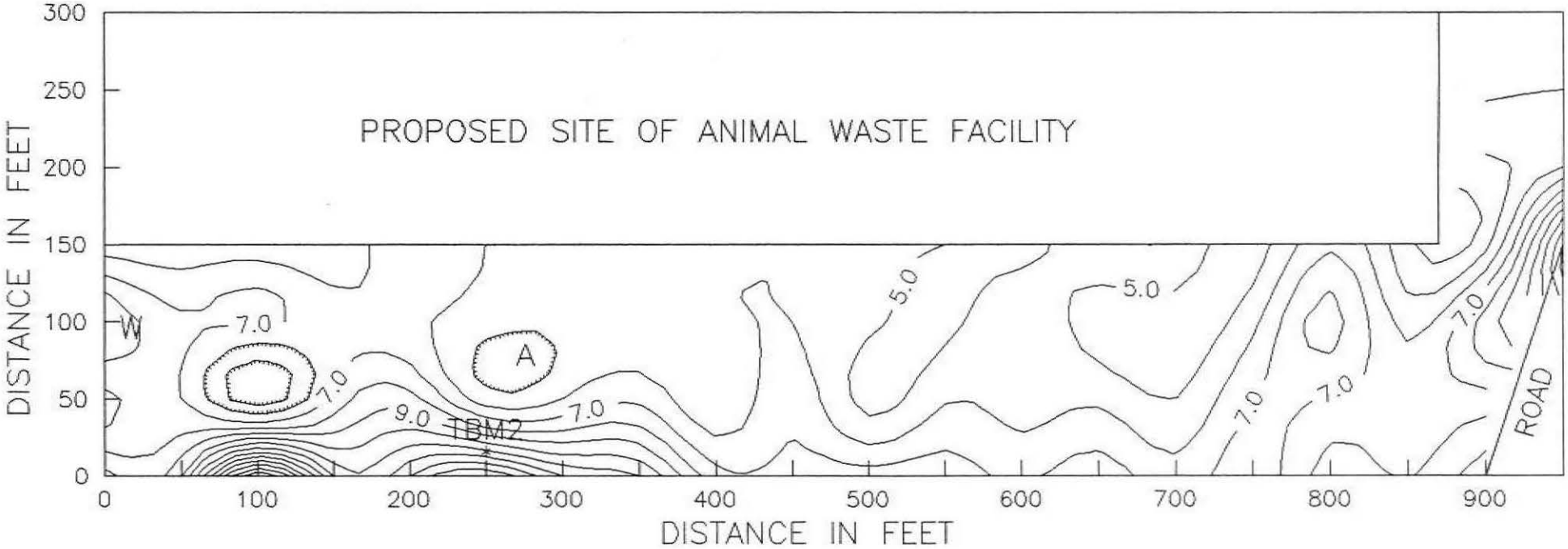


FIGURE 11

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