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NIROP FRIDLEY
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GEOPHYSICAL INVESTIGATION

OF THE

NORTH 40 SITE AT THE

NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT

(NIROP)

Fridley, Minnesota

for

Morrison Knudsen Corporation

July 1995

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Brooklyn Park, Minnesota

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GEOSPHERE MIDWEST INC

Brooklyn Park, Minnesota

27 July 1995

John McCumbers
Ulrich Cordon
Morrison Knudsen Corporation
2420 Mall Drive
Corporate Square 1, Suite 211
North Charleston, SC 29406

Re: Geophysical Investigation at NIROP, Fridley, MN: Report Transmittal
Contract N62467-93-D-1106: RFP 4324-027

Dear John and Ulrich:

We have completed our geophysical survey and report at the NIROP Facility in Fridley (Minneapolis), Minnesota. Detailed EM31 and EM61 color contour maps have identified numerous buried utilities and unknown metallic anomaly zones. Our final composite figure (Figure 4.4) locates nine primary zones which likely contain high concentrations of metallic objects; Figure 4.4 also identifies 41 secondary metallic targets.

We recommend that the nine primary areas be investigated further, using drilling and trenching methods for confirmation of our results. The 41 secondary target areas may require investigation in the future if the original nine areas yield undesirable materials.

If we may assist you or your staff further, please call.

Sincerely,

Robert A. Glaccum
President

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Morrison Knudsen N62467-93-D-1106
Geosphere Midwest 95-591

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EXECUTIVE SUMMARY

The Naval Industrial Reserve Ordnance Plant (NIROP), located south of Interstate 694 and east of the Mississippi River in the northern Minneapolis suburb of Fridley, has been producing naval guns, missile launchers, torpedo tubes and associated control systems since 1941. It is believed that during this time, debris and materials have been stored and disposed of in the North 40 portion of the site property (Figure 1.1). Some of the past disposal may have occurred in trenches or pits cut into sandy/silty terrace soils, situated some 50 feet above the Mississippi River level.

Survey: The North 40 area was surveyed for detection and delineation of buried materials including metallic materials. Three geophysical instruments were employed for this purpose: 1) EM31 to map buried metal and conductive wastes/soils, 2) EM34 to locate any deeper (greater than 20 feet) conductive plumes, and 3) EM61 to identify zones of metallic burials. The site was gridded with wooden stakes on 50x50 foot centers, followed by a finer grid along 10 foot parallel lines. The survey was conducted in a north-south direction along the 10 foot parallel grid lines with measurements taken every 5 feet (every 0.6 feet for the EM61 survey). The EM34 survey was limited to 8 profile lines due to the presence of many cultural interferences. The EM31 and EM61 data were processed and contoured as color maps over a base map of the site.

Results: The conductivity and inphase EM31 contour maps (Figures 4.1 and 4.2) clearly show buried metallic utilities (pipelines and cables) as well as surface railroad tracks and steel reinforced concrete pavement. In addition, other (smaller) features are identified which are anomalous and cannot be correlated to known or suspected utility structures. Such anomalies may represent groups of large buried metal objects. The EM61 contour map also shows surface features (railroad tracks, concrete rebar) and many zones of shallower metallic anomalies (Figure 4.3). A composite anomaly map (Figure 4.4) identifies nine primary zones using both EM31 and EM61 results; 41 secondary (smaller) targets are also located. The EM34 profiles revealed minor conductivity changes in the 20-50 foot depth regime, suggesting little or no probability of a deeper conductive plume.

1 INTRODUCTION

1.1 LOCATION AND DESCRIPTION

The Naval Industrial Reserve Ordnance Plant (NIROP) is situated in the city of Fridley, a northern suburb of the Minneapolis/St Paul metropolitan area. The plant occupies property jointly owned by the Navy and FMC in an area approximately 1000 feet east of the Mississippi River (along East River Drive) and one mile south of Interstate 694.

NIROP has produced naval guns, missile launchers, torpedo tubes and associated control systems since 1941. It is believed that debris and materials were stored and disposed of in the northern portion of the site property; this acreage is called the North 40 area (Figure 1.1). Much of the past disposal may have taken place in trenches or pits cut into sandy/silty terrace soils, situated some 50 feet above the Mississippi River.

The North 40 area encompasses approximately 11 acres and consists of several buildings, railroad spurs and switching tracks, and concrete roadways and aprons (Figure 1.2). Building 50 is a long warehouse structure situated along the northwest section of the site; Building 37 bounds the site on the southeast. Concrete roadways are reinforced by steel bars/mesh and are oriented north-south in the central and east-central portions of the survey area. Several railroad spurs dominate the east-west central portion of the area.

Large propane tanks and piping are present along the north-central and east-central boundaries of the site. Chain link fences run along the perimeter of the site on all sides except along Building 37. Four metal light poles connected by buried wire conduit run east-west across the north-central portion the site. A storm sewer system also runs east-west across the southern half of the survey area.

In the early 1980's, remediation work included the survey and detection of a limited amount of buried materials. Some of these materials were identified and excavated for proper disposal; however, due to the coarseness of the original geophysical survey, steel drums and waste products may have remained undetected.

1.2 PURPOSE

Geosphere Midwest was contracted to conduct a detailed geophysical survey of the North 40 site; this survey included coverage using EM31, EM34 and EM61 methods. The needed information included location and delineation of buried metallic materials (such as drums), conductive zones and general fill areas. Good signal levels (providing geophysical contrast) were expected between the dry sandy/silty soil and buried waste materials. Detection and mapping of conductive soils and ground-water plumes might also be expected in the EM31 and EM34 results.

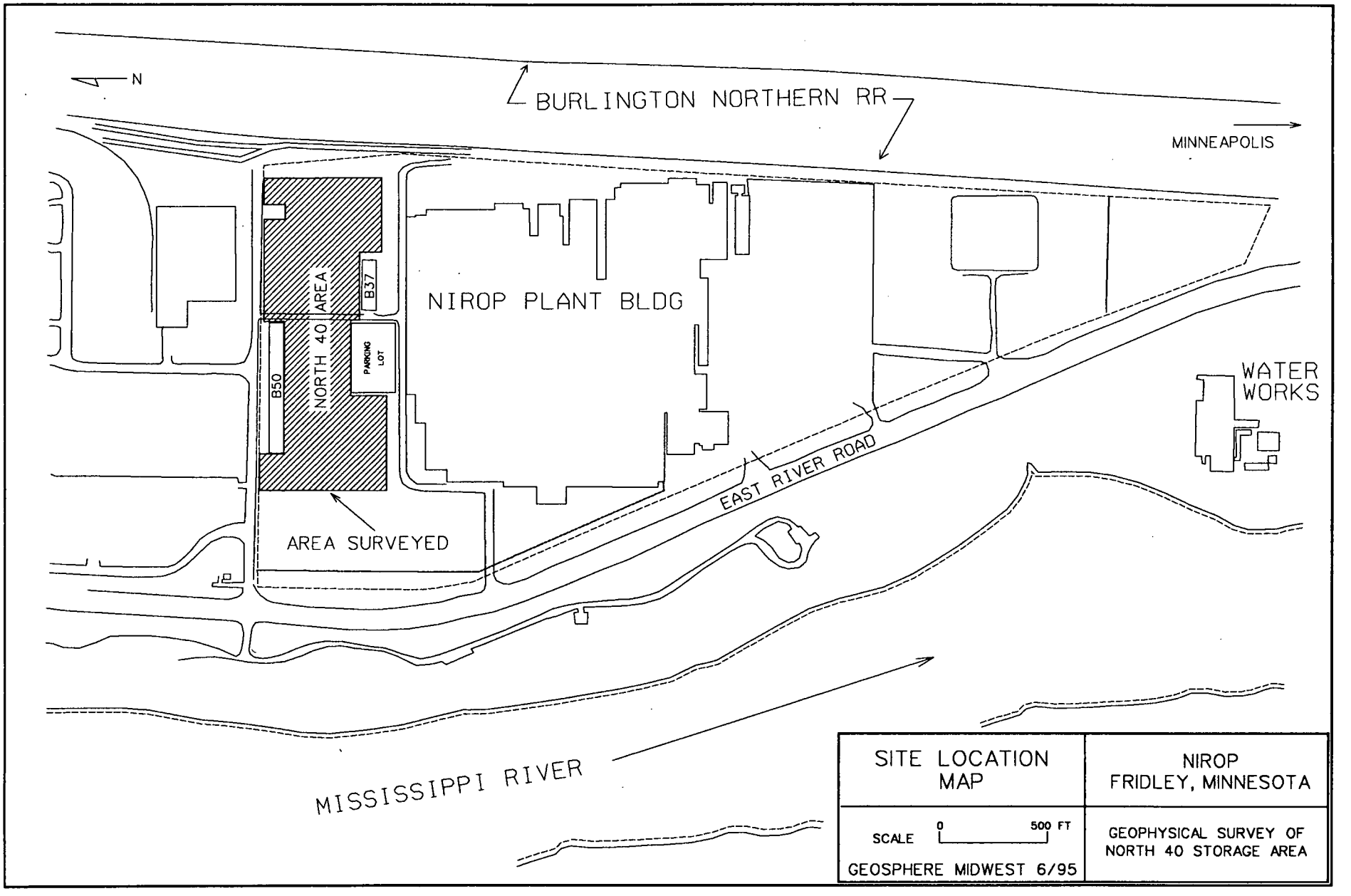

N
BURLINGTON NORTHERN RR
MINNEAPOLIS
NIROP PLANT BLDG
NORTH 40 AREA
B37
B50
PARKING LOT
AREA SURVEYED
EAST RIVER ROAD
WATER WORKS
MISSISSIPPI RIVER
SITE LOCATION MAP
NIROP
FRIDLEY, MINNESOTA
SCALE 0 500 FT
GEOSPHERE MIDWEST 6/95
GEOPHYSICAL SURVEY OF NORTH 40 STORAGE AREA

FIGURE 1.1

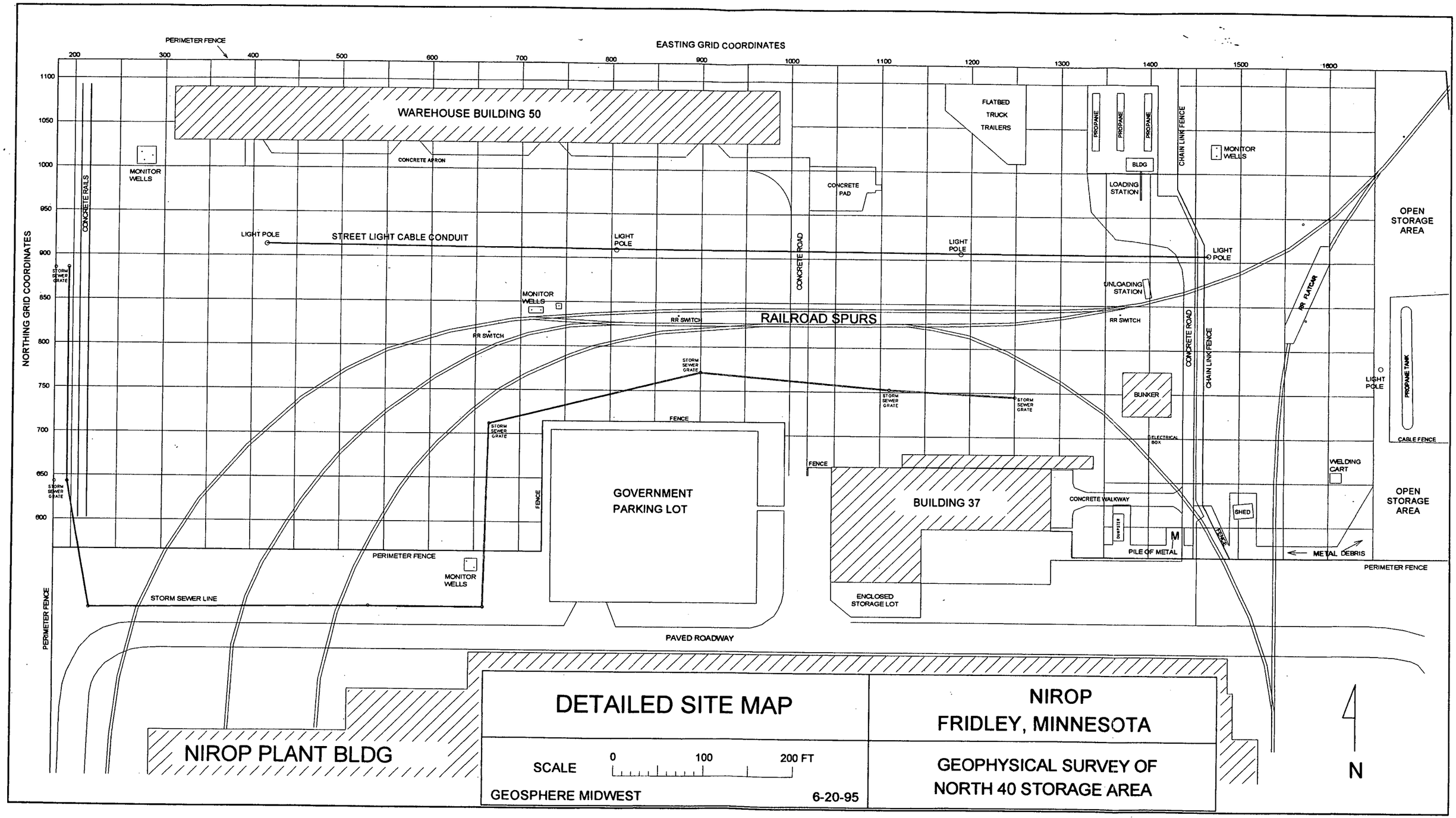

EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
CONCRETE APRON
MONITOR WELLS
CONCRETE RAILS
STORM SEWER GRATE
LIGHT POLE
STREET LIGHT CABLE CONDUIT
CONCRETE PAD
CONCRETE ROAD
FLATBED TRUCK TRAILERS
PROPANE
BLDG
LOADING STATION
CHAIN LINK FENCE
UNLOADING STATION
RR SWITCH
RAILROAD SPURS
RR FLATCAR
BUNKER
ELECTRICAL BOX
OPEN STORAGE AREA
PROPANE TANK
CABLE FENCE
WELDING CART
FENCE
GOVERNMENT PARKING LOT
BUILDING 37
CONCRETE WALKWAY
DUMPSTER
SHED
PILE OF METAL
METAL DEBRIS
ENCLOSED STORAGE LOT
PAVED ROADWAY
STORM SEWER LINE
NIROP PLANT BLDG
DETAILED SITE MAP
SCALE
0
100
200 FT
GEOSPHERE MIDWEST
6-20-95
NIROP
FRIDLEY, MINNESOTA
GEOPHYSICAL SURVEY OF
NORTH 40 STORAGE AREA
N

FIGURE 1.2

2 GEOPHYSICAL METHODS

2.1 GENERAL DESCRIPTION

Three electromagnetics methods were used at the NIROP Site in Fridley, Minnesota:

1) EM31
2) EM61
3) EM34.

2.1.1 BASIC EM PRINCIPLES

The EM induction method determines electrical properties of earth materials by inducing electromagnetic currents in the ground and measuring the secondary magnetic field produced by these currents. An alternating current is generated in a wire loop or coil above the ground's surface; both the primary magnetic field (produced by the transmitter coil in the instrument) and the secondary field (produced by currents in the earth) induce a corresponding alternating current in the receiver coil of the instrument. The coils are kept at a fixed distance and orientation to simplify handling of the data.

After compensating for the primary field (which can be computed from the relative orientations of both coils), both the magnitude and relative phase of the secondary field are measured. These measurements are then converted to components of inphase and 90 degrees (quadrature-phase) with the transmitted field. The quadrature-phase component, using certain simplifying assumptions, is converted to a measure of apparent ground conductivity. This apparent conductivity conversion assumes a homogeneous, isotropic earth. In practice, this value is an estimate of the average conductivity of the ground in the proximity of the instrument, to a depth of investigation (approximately 20 feet for the EM31 and 50 feet for the EM34) which is dependent on the instrument's coil spacing (3.66 meters for the EM31 and 10 meters for the EM34), operating frequency and the conductivity distribution of the earth. The inphase component provides a semi-quantitative measure of nearby metallic anomalies.

Data quality of the conductivity (quadrature) signal may be degraded by the presence of cultural interference such as that caused by utility lines, steel fences and large metallic objects whose high conductivity values may overwhelm the conductivity of the ground itself. Often, very high metallic responses will cause negative values in both the quadrature and inphase signals. The EM31 system produces a linear signal up to the 600 millimhos/meter level; the EM34 system produces a linear signal up to 65 millimhos/meter, higher conductivities may yield higher or lower readings.

2.2 EM31 AND EM34 ELECTROMAGNETICS

The EM31 instrument was employed to locate areas of shallow (0-20 feet) fill materials, contaminated soil and buried debris which have conductivity and inphase signals very different from natural soils. The EM34 was used to locate possible deeper conductive anomalies such as conductive plumes. The presence of increased EM values divulge the location of concentrated amounts of electrolytes which are likely associated with bulk waste materials. EM signals also indicate metallic anomalies which may be in response to buried metallic objects such as drums, tanks and pipes which have high conductivity relative to typical soil conditions. The Geonics EM31 instrument was used as the primary tool for the following reasons:

1) provides conductivity information to 20 feet depth
2) is capable of resolving relatively small lateral features such as pipes and tanks
3) can be easily transferred to a digital recorder for near-continuous profile data.

2.2.1 EQUIPMENT

Electromagnetics measurements were taken with Geonics EM31 and EM34 systems used in the vertical dipole orientation mode at coil spacings of 3.66 and 10 meters respectively at operating frequencies fixed by the manufacturer. The instrument was connected to a digital data logger (OmniData Polycorder) to obtain and store data from multiple profile lines over the site. Readings were made at 5 foot intervals along these lines in units of millimhos/meter (mmhos/m). The maximum investigative depth of the EM31 instrument for single drum-sized targets is 5 to 10 feet (as stated by Geonics); quadrature sensitivity is reduced in areas which have conductive clayey soils. The EM34 data were taken along specific profiles at intervals of 5 feet using a special rigid boom system to permit rapid near-continuous data acquisition; depth of penetration is approximately 50 feet.

2.3 EM61 ELECTROMAGNETICS

The Geonics EM61 instrument was used to detect and map zones exhibiting metallic anomalies. The EM61 operates in a somewhat different manner than the EM31 and EM34 systems. The transmitter generates a pulsed primary magnetic field that induces eddy currents in the ground as well as in nearby metallic objects. The eddy currents produce a secondary field that decays with time after the termination of each primary field pulse. The receiver measures the strength of the secondary field produced by the eddy currents at a sufficiently long time after the start of the decay that the current induced in the ground has fully dissipated and only the eddy currents in nearby metal is measured. The system is sensitive to both ferrous and non-ferrous metal.

The Geonics literature states that the EM61 can detect a single 55-gallon drum to a maximum depth slightly greater than 10 feet. The response is a single sharp peak, providing high resolution data that can be used to accurately locate relatively small metal objects. Larger quantities of drums (and other metal) can be detected at greater depths. The EM61 is relatively insensitive to nearby cultural features such as buildings, fences and power lines.

2.3.1 EQUIPMENT

The Geonics EM61 was employed over the entire site at a higher density of readings along each profile line to provide a detailed map of buried metallic items. The instrument was pulled around as a trailer with an odometer mounted to the axle to trigger the data logger. Operated in this manner, measurements were made every 0.6 feet along each line. Survey lines were 10 feet apart. Data were displayed and recorded digitally on an OmniData recorder to facilitate computer processing.

3 DATA ACQUISITION

3.1 SURVEY LINES AND COVERAGE

A coarse 50x50 foot grid was positioned over the much of the North 40 site using wooden stakes and surveyor tape. An east-west base line was established along the southern edge of the concrete apron south of Building 50; the north-south base line (grid line 1000N) was set along the western edge of the concrete road passing through the center of the survey area (grid line 1000E). An effective grid of 10x5 feet was employed using movable polypropylene rope containing marked 10 foot intervals. The site was clear of brush and trees; allowances were made for interior fences, buildings and above-ground propane tanks. Data were not collected in narrow spaces between fences, buildings and propane tanks due to metallic interfence, buried pipes and safety concerns. The area extended approximately 1500 feet in the east-west direction and 350-550 feet in the north-south direction as depicted by the survey/grid lines shown in Figure 1.2. Field work was conducted over the period 12-16 June 1995.

3.2 EM31

Using the Geonics EM31 instrument, a series of parallel EM lines was made over the North 40 site in a north-south direction at a line spacing of 10 feet (Figure 3.1); readings were taken every 5 feet along each line. One hundred forty-six lines of EM data were acquired at the 10 foot spacing. (Line density was increased in the south-central quadrant to 5 feet, due to identification of a drum in this area; see pattern change in Figure 3.1.) Both the quadrature (conductivity) and inphase signals of the instrument were simultaneously recorded on a digital (Omnidata Polycorder) data logger. Finally, the data were dumped to a field computer, assigned grid coordinates, processed, and plotted as quadrature conductivity and inphase (metal) contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM31 profile (cross-section) lines are given in Appendix B.

3.3 EM34

Following a preliminary review of EM31 contour maps, it became apparent that many areas of the site were subject to interference from buried utility lines, railroads tracks, buildings, and steel reinforced concrete roadways which would seriously impair any large scale coverage by the EM34 system. Therefore, certain areas of the site were selected for limited followup profiles with the truck-boom EM34 system. These included the north-central, south-central and western portions of the site. Four parallel lines were made in an east-west direction with approximate line spacings of 20 feet; four parallel lines were also run in the north-south direction in the western end of the site (see Figure 3.1). Readings were taken every 5 feet along each line. Output from the EM34 was recorded on a digital (Omnidata Polycorder) data logger. The data were dumped to a field computer, assigned grid coordinates, processed, and plotted as a series of profile lines. Individual EM34 profile lines are given in Appendix B.

3.4 EM61

Using the Geonics EM61, parallel lines were run across the site in a north-south direction at a line spacing of 10 feet (Figure 3.2); readings were taken every 0.6 feet along each line, using a counter keyed to the EM61's wheel. (Line density was increased in the north-central quadrant to 5 feet, due to many metallic targets visible at the surface and preliminary EM31 data; note pattern change in Figure 3.2.) Data were recorded on a digital (Omnidata Polycorder) data logger. Finally, the data were periodically dumped to a field computer, assigned grid coordinates, processed, and plotted as EM61 metal response contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM61 profile (cross-section) lines are given in Appendix C.

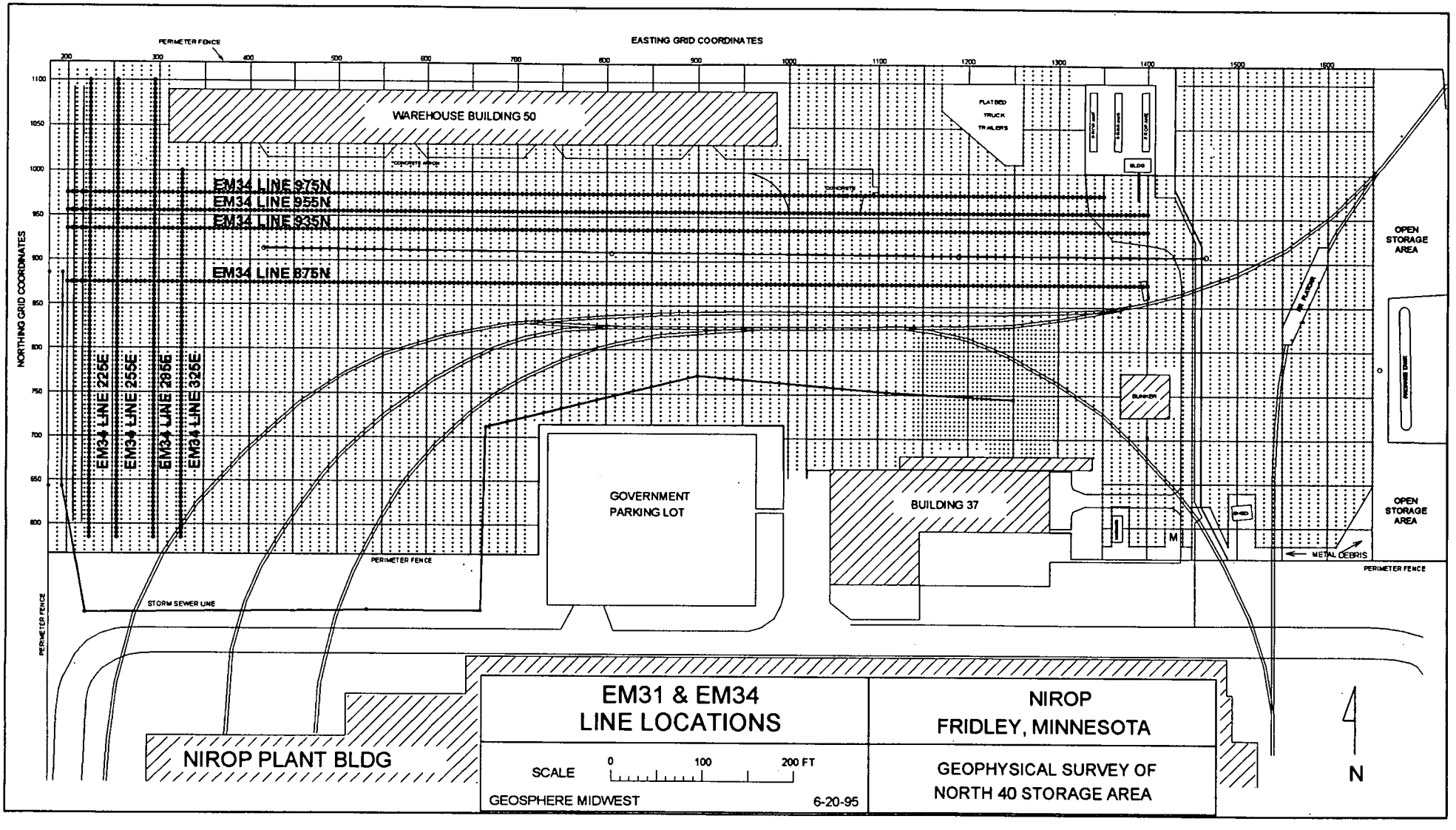
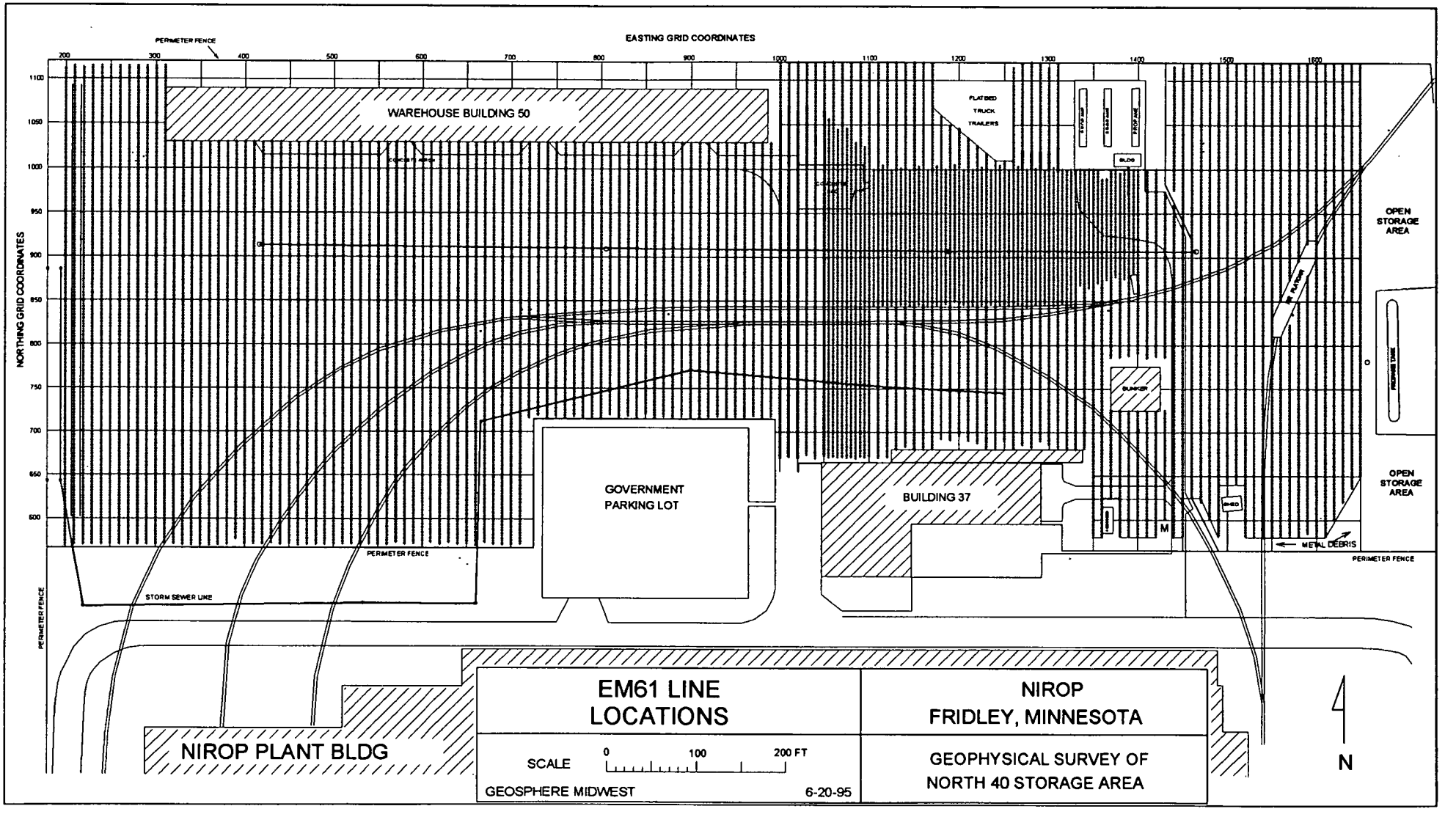

EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
FLATBED TRUCK TRAILERS
EM34 LINE 975N
EM34 LINE 955N
EM34 LINE 935N
EM34 LINE 875N
EM34 LINE 225E
EM34 LINE 255E
EM34 LINE 285E
EM34 LINE 325E
GOVERNMENT PARKING LOT
BUILDING 37
BUNKER
OPEN STORAGE AREA
OPEN STORAGE AREA
METAL DEBRIS
STORM SEWER LINE
NIROP PLANT BLDG
EM31 & EM34 LINE LOCATIONS
NIROP FRIDLEY, MINNESOTA
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 6-20-95
GEOPHYSICAL SURVEY OF NORTH 40 STORAGE AREA
N

FIGURE 3.1


EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
FLATBED TRUCK TRAILERS
GOVERNMENT PARKING LOT
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STORM SEWER LINE
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EM61 LINE LOCATIONS
NIROP
FRIDLEY, MINNESOTA
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 6-20-95
GEOPHYSICAL SURVEY OF NORTH 40 STORAGE AREA
N

FIGURE 3.2

4 SURVEY RESULTS AND CONCLUSIONS

4.1 EM31 RESULTS

The processed EM31 data are presented as conductivity and inphase contour maps shown in Figures 4.1 and 4.2. These contours have been plotted in color over a detailed base map of the site along with the geophysical grid system to assist in identifying anomalous conditions. Typically, in landfilled areas, EM conductivity contours represent a large deviation from background conditions, ranging from high values over conductive fill to negative values over buried metal and reinforced concrete. The range of inphase contours represents zones of surface and buried metallic objects/utilities, which may have either high positive or negative values.

4.1.1 UTILITY CORRELATION

Analysis of Figures 4.1 and 4.2 reveal the presence of several characteristic EM features:

a) surface railroad tracks
b) reinforced concrete roads/pads
c) perimeter fences and buildings
d) singular objects such as light poles and iron manhole covers.
e) buried utility lines
f) unknown anomalies caused by buried materials.

The dominant EM contour features are strong responses caused by railroad spurs, reinforced concrete roads/aprons, perimeter fences, metal light poles, and storm sewer grates/manhole covers (Figure 4.1 and 4.2). These EM responses are easily correlated to the known features identified in the field and on the site base map. Other linear anomaly features may be likewise interpreted as representations of buried utilities, some of which are known from site utility maps and still others which are surmised from noted sources such as surface (propane) tanks and loading/dispensing stations (see Figures 4.1 & 4.2). Irregular EM conductivity and inphase anomalies which do not appear to be associated with known or interpreted utility lines are potential zones of buried metal materials.

As observed in Figures 4.1 and 4.2, north of the main railroad spur, a prominent linear zone of anomalies passes west to east through the central portion of the site, from grid station 425E/910N to 1470E/910N. This strong series of anomalies is interpreted as the buried cable/conduit for four street lights located along this line. A similar, but weaker linear anomaly located at an offset of 50 feet to the south is also interpreted as an electrical cable conduit, probably as an older, unrecorded system (NIROP utility maps did not show any structure in this location). Another linear trend of strong negative conductivity contours (Figure 4.1) which are oriented north-south along the western boundary correlate to two parallel concrete "rails" approximately 10 feet apart. Small singular anomalies occur along manholes situated along the storm sewer line passing east-west through the southern portion of the site (see Figure 4.2).

Four other buried utility features are found in the eastern portion of the survey area. Three appear to be associated with the large propane tank on the eastern periphery. Two are oriented towards the northwest (in the direction of the three smaller propane tanks) and one towards the west. A long corridor of interpreted utilities runs north-south from the three small propane tanks, passes under the bunker and heads towards the main NIROP plant building to the south (along grid line 1390E).

4.1.2 POSSIBLE BURIED MATERIAL

No large EM anomalies were detected which might indicate massive burial trenches or pits; however, several irregular (unlike linear patterns from utilities) EM anomalies were found in various areas of the site.

1) Of particular concern is a series of anomalies particularly visible in the inphase data given in Figure 4.2 centered between coordinates 1150E/790N and 1240E/775N. At the eastern most coordinate, a buried drum was observed in an erosional gully on the side of a slight rise in the ground surface.

2) Also of interest is a distinctive inphase (and lesser conductivity) anomaly along the northern perimeter of the survey area at grid line 1300E. This anomaly is at least 50 feet long and appears to extend in an east-west direction.

3) Two other sizeable anomalies are found to the west of the concrete road, along grid line 775N at 840E and 950E. These features lie just north of the storm sewer (plotted on the base map) and could be associated with the storm sewer.

4) Two other zones of unexplained EM anomalies lie north of the railroad tracks, near coordinates 875E/990N and 775E/925N (Figure 4.2). The size and shape of these anomalies suggest two pits of buried metallic materials.

5) Farther west, two more anomalies are centered at coordinates 440E/875N and 490E/960N. The 440E/875N anomaly appears to extend over a 70 foot area from 430E to 500E. It appears to lie between the street light cable conduit and the unknown utility to the south.

6) Another significant EM metallic anomaly is situated between the railroad spurs at coordinates 530E/630N in the southwest section of the survey area.

7) Weaker inphase anomalies (Figure 4.2) are visible surrounding coordinates 1200E/950N. During the field survey, numerous small pieces of metal plates, nuts, bolts, and scrap metal were found and moved from the ground surface. The EM responses from this area are consistent with such scattered metal in the subsurface.

8) Other anomalous EM zones are interpreted to be related to different fill conditions as observed around the western railroad spurs where low EM values occur over large areas. Similarly, high conductivity values (Figure 4.1) are observed just west of the large propane tank

(coordinates 1620E/825N). As they are not accompanied by metallic responses in the inphase data (Figure 4.2), the anomaly may represent a thicker or more conductive fill material.

4.2 EM34 RESULTS

The EM34 results are presented in profile form in Figures B-33 through B-35 in Appendix B. Figures B-33 and B-34 present the long east-west profile lines (875N, 935N, 955N, and 975N) and Figure B-35 presents the four north-south lines (225E, 255E, 295E, and 325E). Both EM conductivity and inphase measurements are presented together with the conductivity scale on the left side and the inphase scale (in ppt) on the right side of the plot.

The strong metallic features recorded in the data in Figures B-33 and B-34 are caused by the effect of the central concrete road (1000E to 1050E), the buried utility corridor (see EM31 discussion above) at the eastern end (1300E to 1350E) and the concrete "rails" at the western end of these four lines. The central portion of each profile does not appear to be affected by metal except for Profile 875N. Here, the data is very irregular due to the presence of a suspected cable conduit south of the street light conduit (see EM31 discussion above and Figure 4.1).

The remaining EM34 data show slight variations in values along the line; conductivities appear to have a slight rise in the central portion of the lines with slight decreases to both the west and east. Due to the presence of so many interfering cultural features, we cannot attach much significance to this small effect. The four north-south profiles (Figure B-35) also show minor variations in conductivity values; however, no significant local highs or general trends are observable. Consequently, no evidence exists for a deeper conductive anomaly (plume) in the 20-50 foot soil/ground water system.

4.3 EM61 RESULTS

4.3.1 CORRELATION TO KNOWN OBJECTS

The processed EM61 data are presented in Figure 4.3. Higher value contours generally represent higher concentrations of buried metal or shallower metal objects. Most metal responses are recorded from depths in the range of 0 to 10 feet. Responses recorded by the EM61 are typically very "tight", ie, high values only occur over and immediately adjacent to the suspected target (whereas EM31 readings may be influenced up to 15-20 feet from the utility or surface metal). Buried utility lines are not usually detected by the EM61 instrument due to the utility's small size and depth of burial. (In comparison, the EM31 instrument has a greater depth of penetration and is particularly sensitive to linear conductive features, ie, buried pipes and cable conduits.)

Analysis of the metal response contours in Figure 4.3 shows a correlation with features observed in the EM conductivity and inphase maps (Figures 4.1 & 4.2):

1) surface railroad tracks

2) reinforced concrete roads/pads
3) perimeter fences and buildings (to a limited degree).
4) singular objects such as light poles and iron manhole covers.

In Figure 4.3, note the break in continuity of the north-south roadway anomaly. This occurs precisely where the storm sewer line crosses below the roadway, suggesting that the original reinforced concrete road was ripped up for the sewer and then replaced with normal concrete. The remaining, unidentified anomalies are probably caused by fill or buried metallic materials.

4.3.2 FILL AND BURIED MATERIALS

A detailed inspection of Figure 4.3 reveals a considerable number of low amplitude contours and a moderate number of stronger (higher) readings. As seen in Figure 4.3, the blue/green contours represent instrument readings from 50 up to 200 millivolts. These contour levels cover a significant portion of the site. For this reason, we interpret that these values are probably related to soil/fill types which may have appreciable iron content. Conversely, contour levels over 200 millivolts (yellow and warmer colors) locate much more localized targets, caused by larger buried metallic objects.

In an attempt to identify the more significant areas, the EM61 data was compared to the two EM31 data sets (Figures 4.1 and 4.2). Those EM61 areas which have EM31 counterparts are listed below and are located as primary targets (A1 through A9) in the composite anomaly map given in Figure 4.4:

Anomaly 1:	1200E/ 770N	Anomaly 5:	875E/980N
Anomaly 2:	1280E/1085N	Anomaly 6:	775E/920N
Anomaly 3:	950E/ 775N	Anomaly 7:	480E/970N
Anomaly 4:	840E/ 775N	Anomaly 8:	470E/880N
		Anomaly 9:	530E/630N

These anomalies identify nine zones within the North 40 area which have the highest probability of containing drum-sized metallic materials. Possible target depths likely vary from 1 foot to approximately 7 feet. The crosses located within each outlined zone define the precise location of the metal target which provided the strongest response in the EM61 instrument. Future excavation should start at these mapped positions.

Figure 4.4 also identifies 41 secondary metal targets obtained from the EM61 contour map. Most of these secondary zones are estimated to be caused by responses from one to two significant objects. Shallow targets will be found where strong gradients are observed in the EM61 anomaly; strong but lower gradients suggest a deeper metallic source target. If drums are identified in several of the nine primary zones, the secondary target zones (Figure 4.4) should also be investigated. Also shown in Figure 4.4 is our recommended location for an exploratory trenching of the concrete rail anomaly found along the western edge of the site (Zone C1 in Figure 4.4).

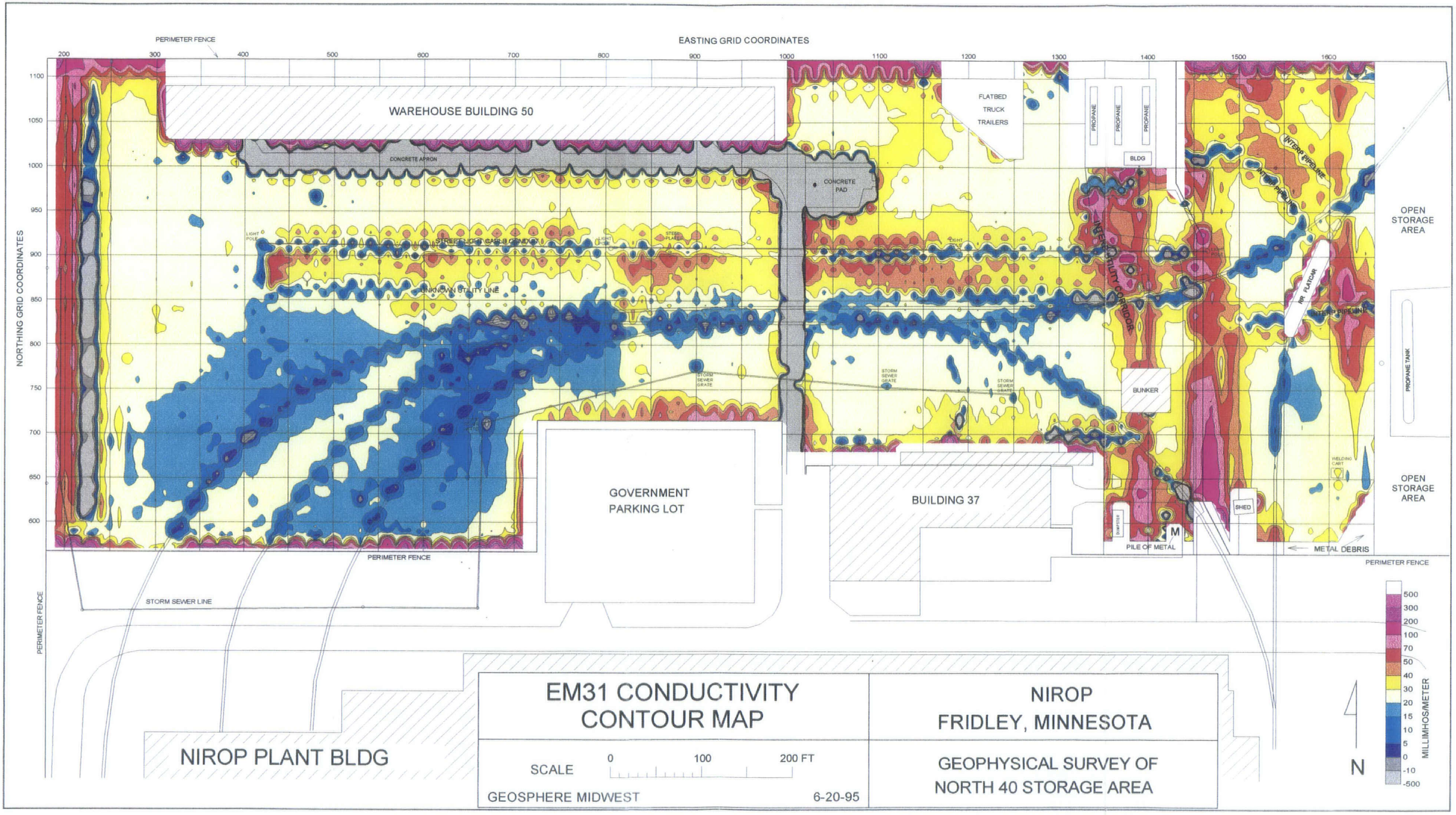

EM31 CONDUCTIVITY CONTOUR MAP
NIROP
FRIDLEY, MINNESOTA
GEOPHYSICAL SURVEY OF NORTH 40 STORAGE AREA
SCALE 0 100 200 FT
GEOSPHERE MIDWEST
6-20-95
EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
CONCRETE APRON
CONCRETE PAD
FLATBED TRUCK TRAILERS
PROPANE
BLDG
INTERR PIPELINE
OPEN STORAGE AREA
PROPANE TANK
STREET LIGHT CABLE CONDUIT
UNKNOWN UTILITY LINE
UTILITY CORRIDOR
RR FLATCAR
STORM SEWER GRATE
BUNKER
GOVERNMENT PARKING LOT
BUILDING 37
SHED
PILE OF METAL
METAL DEBRIS
STORM SEWER LINE
NIROP PLANT BLDG
MILLIMHOS/METER
500
300
200
100
70
50
40
30
20
15
10
5
0
-10
-500
N

FIGURE 4.1

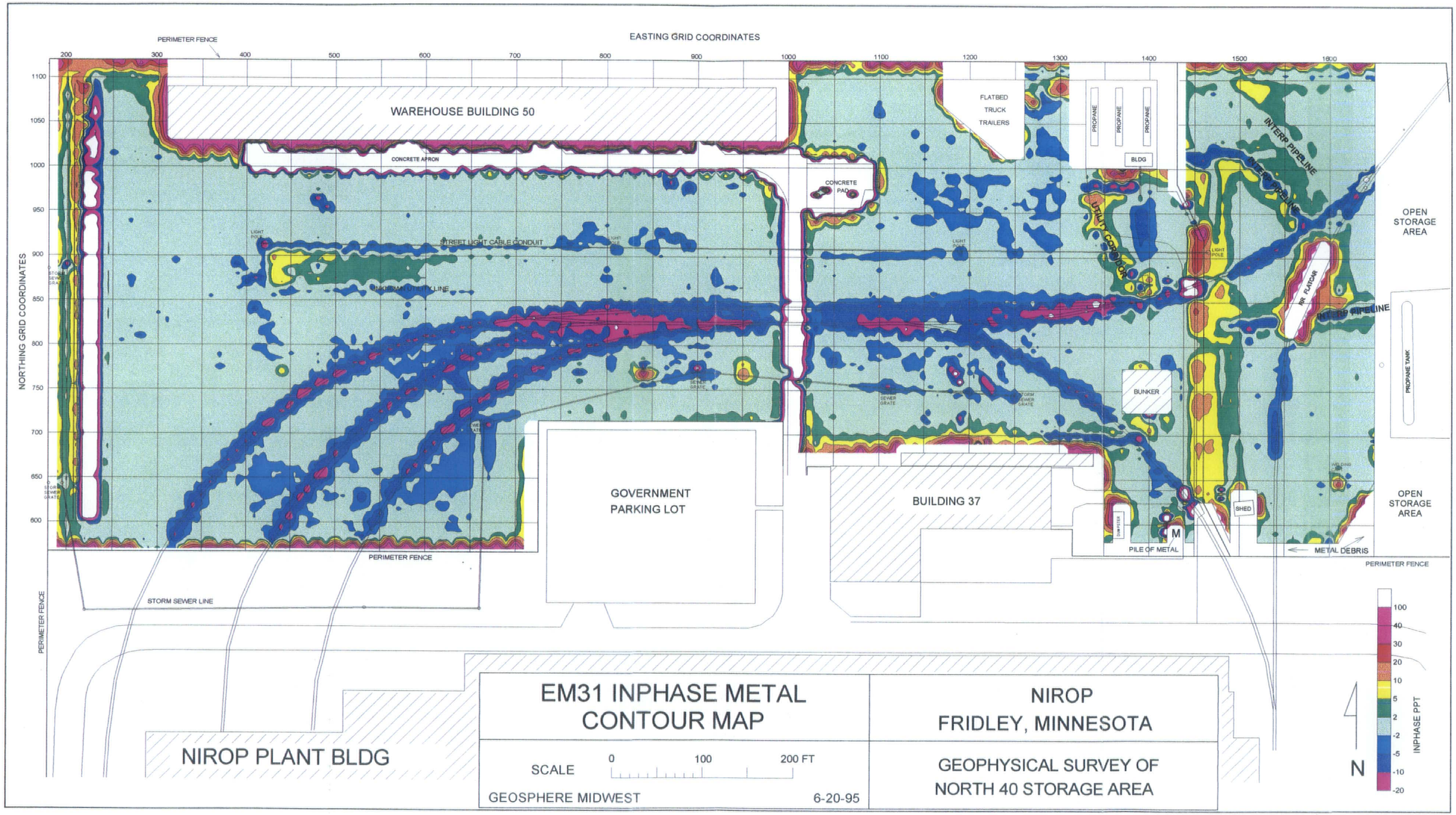

EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
CONCRETE APRON
CONCRETE PAD
FLATBED TRUCK TRAILERS
PROPANE
PROPANE
PROPANE
BLDG
INTERP PIPELINE
INTERP PIPELINE
UTILITY CORRIDOR
OPEN STORAGE AREA
STREET LIGHT CABLE CONDUIT
SIDEWALK
NR PLATCAR
INTERP PIPELINE
PROPANE TANK
BUNKER
GOVERNMENT PARKING LOT
BUILDING 37
SHED
PILE OF METAL
METAL DEBRIS
OPEN STORAGE AREA
PERIMETER FENCE
PERIMETER FENCE
STORM SEWER LINE
PERIMETER FENCE
NIROP PLANT BLDG
EM31 INPHASE METAL CONTOUR MAP
NIROP
FRIDLEY, MINNESOTA
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 6-20-95
GEOPHYSICAL SURVEY OF NORTH 40 STORAGE AREA
N
INPHASE PPT
100
40
30
20
10
5
2
-2
-5
-10
-20

FIGURE 4.2

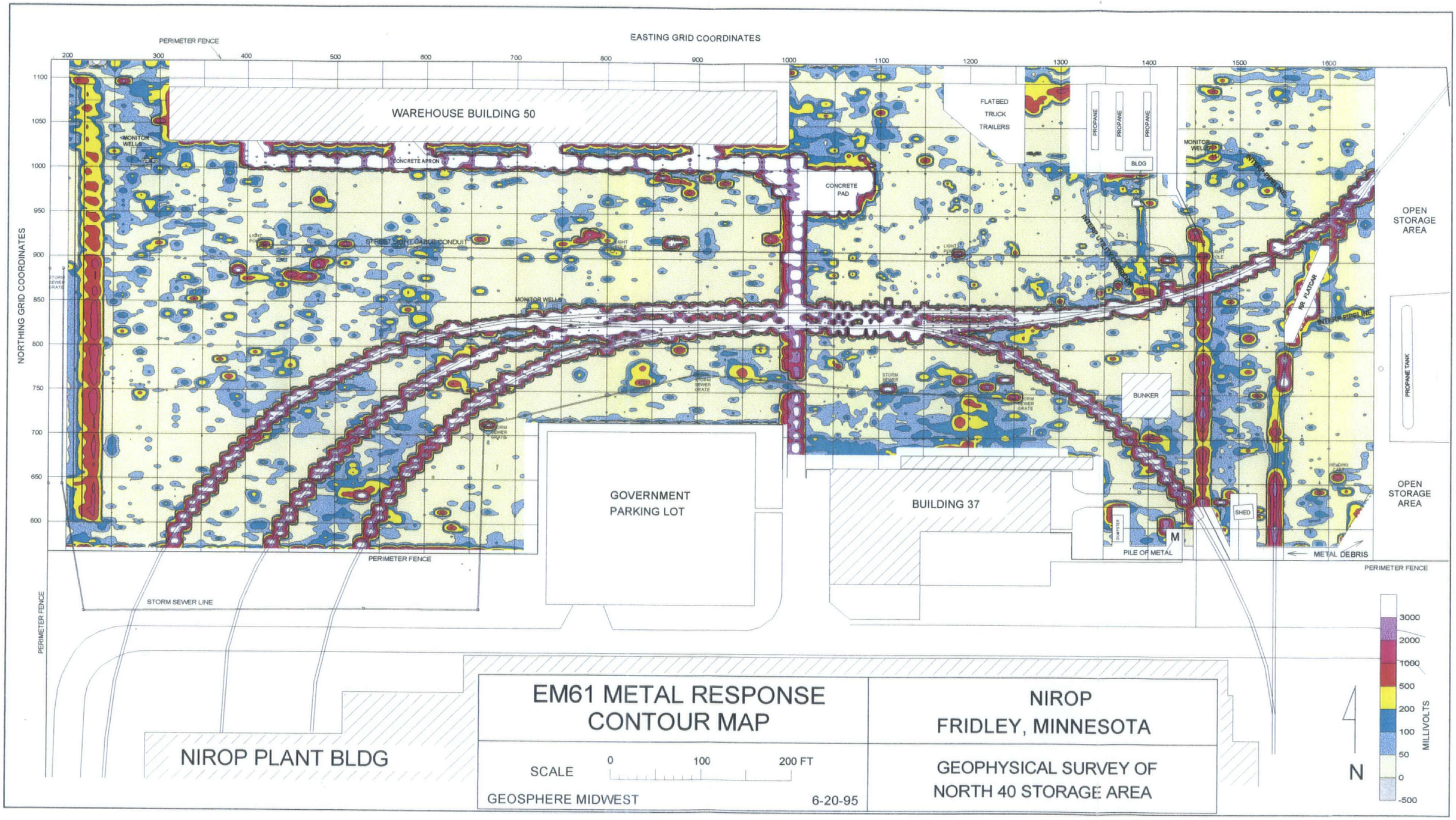

EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
CONCRETE APRON
MONITOR WELLS
STREET LIGHT CABLE CONDUIT
CONCRETE PAD
FLATBED TRUCK TRAILERS
PROPANE
BLDG
INTERPIPELINE
RR FLATCAR
OPEN STORAGE AREA
PROPANE TANK
BUNKER
GOVERNMENT PARKING LOT
BUILDING 37
SHED
DUMPSTER
PILE OF METAL
METAL DEBRIS
STORM SEWER GRATE
STORM SEWER LINE
NIROP PLANT BLDG
EM61 METAL RESPONSE CONTOUR MAP
NIROP
FRIDLEY, MINNESOTA
SCALE
0
100
200 FT
GEOSPHERE MIDWEST
6-20-95
GEOPHYSICAL SURVEY OF
NORTH 40 STORAGE AREA
N
MILLIVOLTS
3000
2000
1000
500
200
100
50
0
-500

FIGURE 4.3

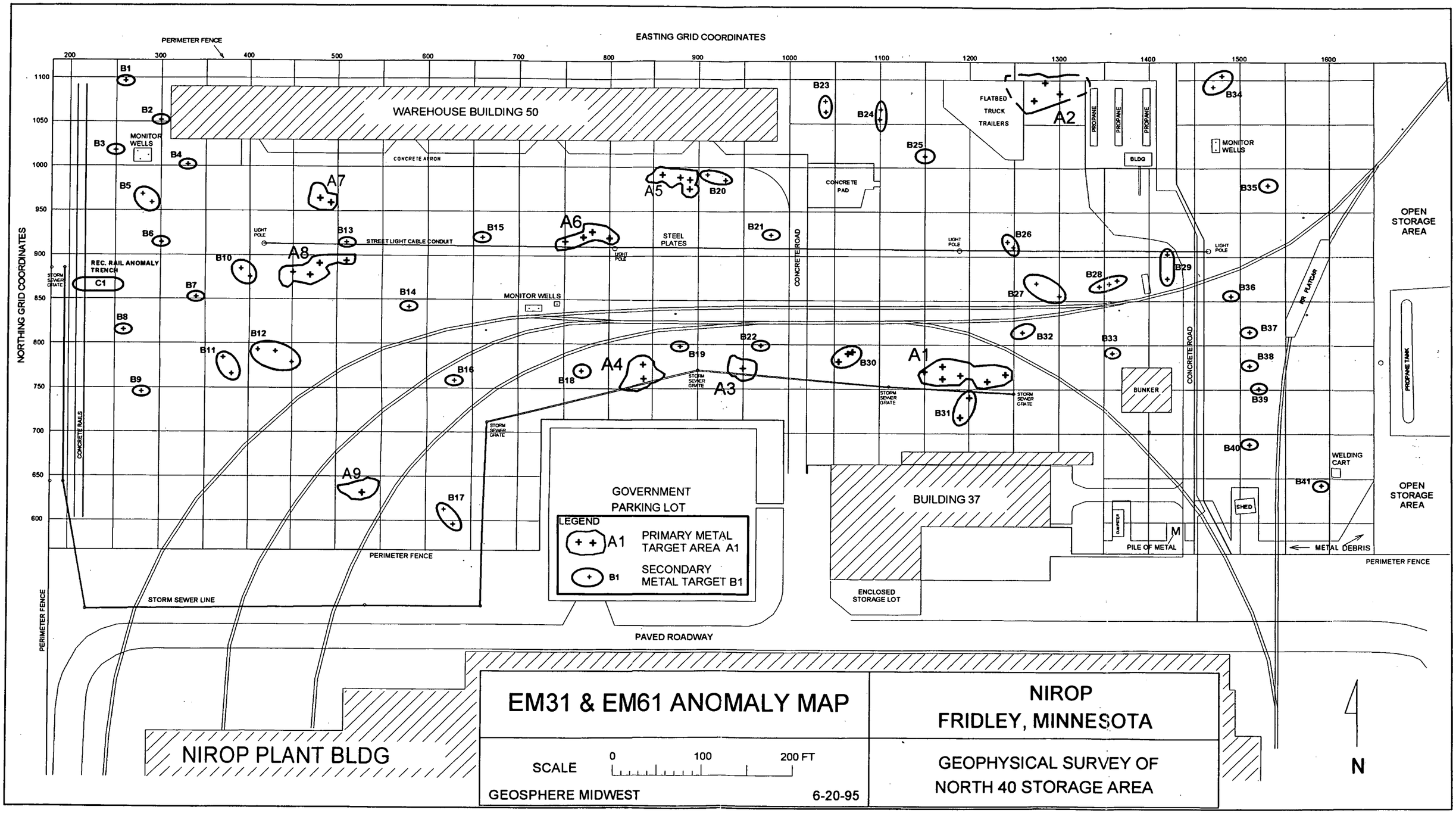

EASTING GRID COORDINATES
NORTHING GRID COORDINATES
PERIMETER FENCE
WAREHOUSE BUILDING 50
CONCRETE APRON
MONITOR WELLS
FLATBED TRUCK TRAILERS
PROPANE
BLDG
CONCRETE PAD
STEEL PLATES
STREET LIGHT CABLE CONDUIT
LIGHT POLE
REC. RAIL ANOMALY TRENCH
C1
STORM SEWER GRATE
CONCRETE ROAD
CONCRETE RAILS
OPEN STORAGE AREA
PROPANE TANK
BUNKER
WELDING CART
BUILDING 37
SHED
COMPUTER
PILE OF METAL
METAL DEBRIS
ENCLOSED STORAGE LOT
GOVERNMENT PARKING LOT
PAVED ROADWAY
STORM SEWER LINE
NIROP PLANT BLDG
LEGEND
A1 PRIMARY METAL TARGET AREA A1
B1 SECONDARY METAL TARGET B1
EM31 & EM61 ANOMALY MAP
NIROP
FRIDLEY, MINNESOTA
SCALE 0 100 200 FT
GEOPHYSICAL SURVEY OF
NORTH 40 STORAGE AREA
GEOSPHERE MIDWEST
6-20-95
N

FIGURE 4.4

APPENDICES

APPENDIX A

DESCRIPTION OF GEOPHYSICAL METHODS A-1

APPENDIX B

EM31 AND EM34 PROFILE DATA B-1

APPENDIX C

EM61 PROFILE DATA C-1

APPENDIX D

FIELD INFORMATION D-1

APPENDIX A

DESCRIPTION OF GEOPHYSICAL METHODS

Electrical Methods

Electrical properties are among the most useful geophysical parameters in characterizing earth materials. Variations in electrical conductivity (or its inverse, resistivity) typically correlate with variations in water saturation, fluid conductivity, porosity, permeability, and the presence of metal. Depending on the particular site, these variations may be used to locate contaminant plumes, salt water intrusion, stratigraphic units, sinkholes, fractures, buried drums and tanks, and any other feature whose electrical properties contrast with the surrounding earth.

Ground conductivity can be measured either directly, using the galvanic resistivity method, or inductively, using electromagnetic induction (EM). Because EM requires no direct contact with the ground surface, data can be acquired more quickly than with resistivity. Resistivity, however, can provide better vertical resolution and is generally less sensitive to cultural noise such as fences, buildings and overhead powerlines.

Applications of Electrical Methods

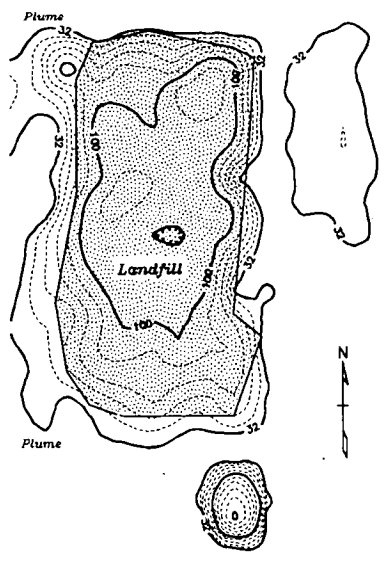
EM and resistivity can be applied to a wide variety of problems encountered in environmental, ground water, geotechnical, and archaeological work, including:

- **Location of buried drums, tanks, trenches, and utilities**
- **Location of landfills and bulk buried materials**
- **Delineation of contaminant plumes**
- **Depth of water table and aquifer identification and mapping**
- **Continuity of stratigraphic interfaces such as clay layers**
- **Mapping of faults and fractures**
- **Location of karst features**

Electromagnetic Induction

The EM technique measures the electrical properties of materials contained in the subsurface including soil, rock, ground water, and any buried objects. An alternating current in the EM transmitter coil creates a magnetic field which induces electrical current loops within the ground; the current loops, in turn, create a secondary magnetic field. Both the primary magnetic field (produced by the transmitter coil) and the secondary field induce a corresponding alternating current in the EM receiver coil. After compensating for the primary field (which can be computed from the relative positions and orientations of the coils), both the magnitude and relative phase of the secondary field can be measured. These can be converted to components in-phase and 90° out of phase with the transmitted field. The out of phase (or quadrature-phase) component, using certain simplifying assumptions, can be converted to a measure of apparent ground conductivity. The in-phase component, while generally not responsive to changes in bulk conductivity, is especially responsive to discrete, highly-conductive bodies such as metal objects. The apparent conductivity measurement is the average conductivity of one or more layers in the ground in the proximity of the instrument, to a depth of investigation dependent on the coil spacing, orientation, operating frequency of the instrument, and the individual conductivity of each ground layer.

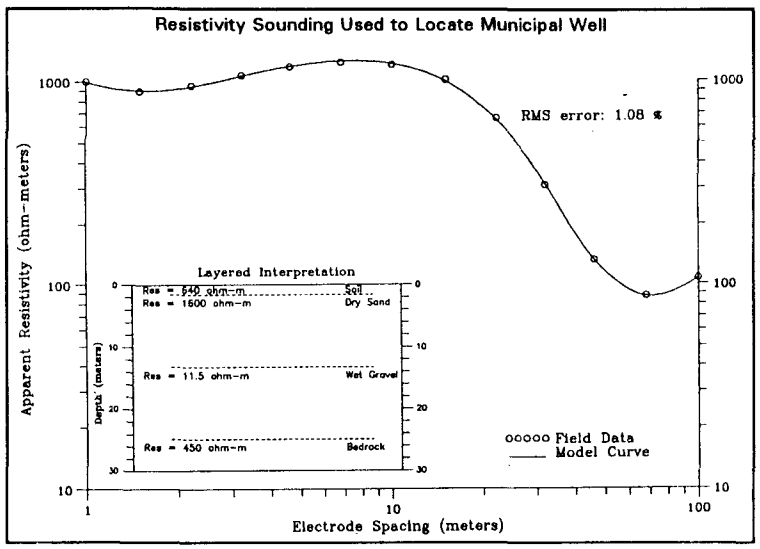
EM-34 Results Showing
Buried Materials and Plumes



Galvanic Resistivity

Using an older technique called resistivity, electrical conductivity (resistivity) can also be measured by applying a current directly into the ground through a pair of electrodes. A voltage difference measured across a second electrode pair provides the necessary information to calculate the apparent earth resistivity (the inverse of apparent conductivity). The depth of investigation depends on the electrode separation and geometry, with greater electrode separations yielding bulk resistivity measurements to greater depths.

The EM and resistivity methods are used in two different modes: **profiling** and **sounding**. Profiling is used to detect lateral variations across a site by taking a series of readings along a line using a fixed configuration of coils or electrodes. (EM is typically used in the profile mode). Soundings are used to estimate vertical variations in electrical conductivity or resistivity. A resistivity sounding is made by taking many readings with increasing electrode separations at a single location. An EM sounding is obtained by taking readings at a single location with several coil spacings and coil orientations. The data are then inverted to produce a model of conductivity (resistivity) variations with depth. Due to the greater number of readings possible, resisitivity soundings provide better vertical resolution than EM soundings. Profiles and soundings may be obtained simultaneously to yield a 3-dimensional model.



While both EM and resistivity measure apparent ground conductivity, their response to certain kinds of anomalies differs markedly. EM is very sensitive to highly conductive media, so a thin, high conductivity layer may dominate over much thicker, low conductivity layers. Also, if conductivities are very high, the measurements become non-linear and eventually turn negative. The resistivity method is less sensitive to thin, high conductivity layers and can measure even the lowest and highest apparent conductivities.

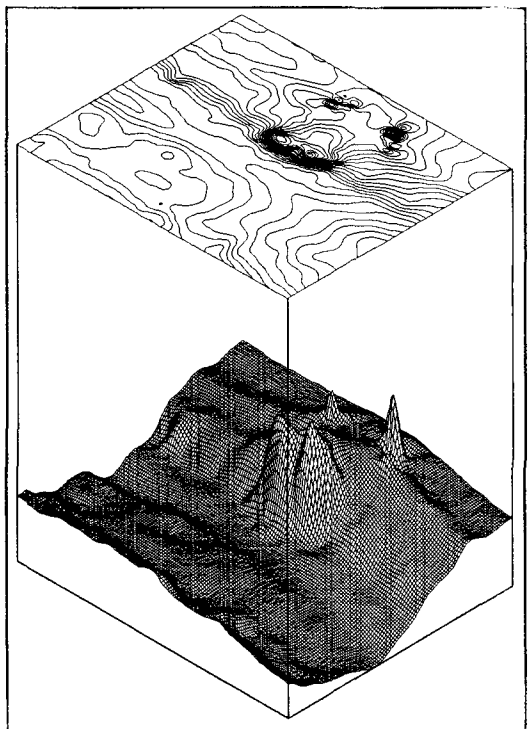
Field Procedures

For EM work, Geosphere uses the Geonics EM-31DL, EM-34XL, and EM-38 instruments. All instruments read apparent conductivity directly in units of millimhos/meter. The one-man portable EM-31 has a fixed coil separation with an investigative depth of 20 feet. The EM-34 requires a crew of two and has three coil separations, with investigative depths from 25 to 200 feet. Geosphere has rigged a 4x4 truck to acquire continuous data over large areas using the 10 meter configuration; this method has proved valuable in locating and mapping deep karst features, faults, and buried sand channels. The EM-38 measures shallow soil conductivities to depths of 3 to 6 feet. With all three instruments, data are acquired either on analog strip charts or digitally which are downloaded to a field computer. The in-phase component of these EM systems also provide valuable data concerning the location of buried metal objects and pipes. Other EM systems available include the EM-39 borehole induction logger.

Resistivity surveys usually employ a Wenner electrode array (four co-linear, equally-spaced electrodes) and an ABEM Terrameter earth resistivity meter. The instrument reading in ohms (applied current divided into the measured voltage difference) is converted to apparent resistivity (in ohm-meters) by means of a geometric factor determined for the electrode array. For soundings, the inter-electrode spacings are varied approximately logarithmically (six readings per decade) over a range determined for the particular site.

Data Processing

Conductivity profile data are often computer gridded, producing a data set which can be contoured or displayed as a 3-dimensional surface. Resistivity sounding data are inverted, using in-house computer software, producing a model of discrete layers, each of constant resistivity (or conductivity). The inversion routine computes theoretical curves based on a trial model and adjusts the model parameters iteratively until it achieves a satisfactory match with the field data. Geologic interpretation of electrical conductivity data involves matching observed anomalies with characteristic responses to known features. Constraining information, such as well data, outcrops, or other geophysical data, is very useful in producing a comprehensive, coordinated interpretation.



EM-31 Data Showing 3D Surface Display

Summary

Electrical geophysical techniques are extremely useful in a wide variety of situations. For example, the EM method can quickly provide very high density information which cannot otherwise be obtained in critical areas. Geosphere is among the leaders nationwide in applying electrical methods to environmental investigations, hazardous waste sites, ground water exploration, karst features, archaeology, and other disciplines.

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8616 Xylon Ave N Ste G • Brooklyn Park, MN 55445 Phone (612) 493-3596 • Fax (612) 493-3597

APPENDIX B

EM31 AND EM34 PROFILE DATA

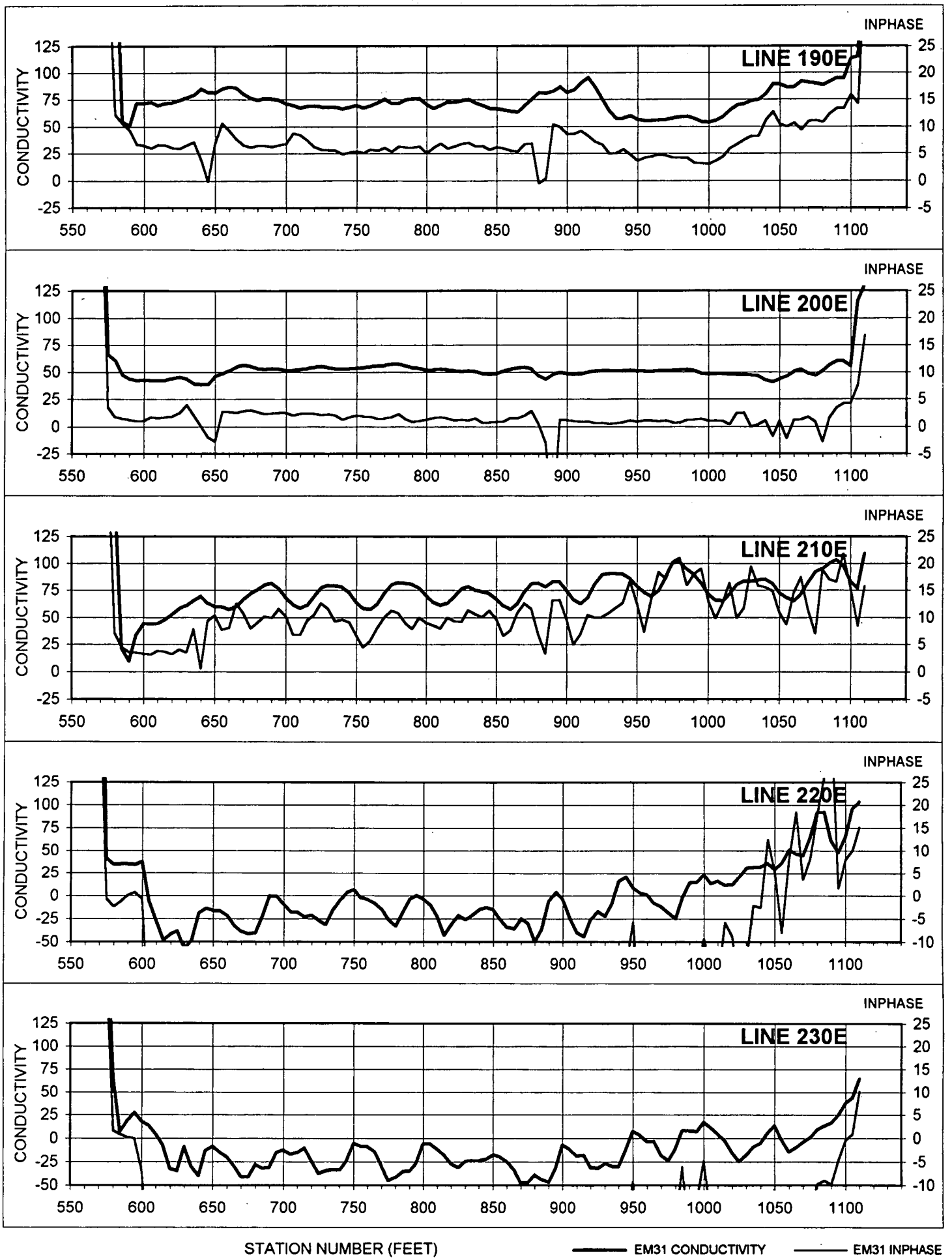
This appendix is a compilation of all EM31 and EM34 profile data obtained at the subject site. Locations of these EM lines are given in Figure 3.1. The following profiles include conductivity and inphase (vertical) scales and station location labels. Conductivity values are given in millimhos/meter (mmhos/m) and inphase values are given in parts per thousand (ppt) units.

B1. EM31 SURVEY: PROFILES FROM NORTH 40 SITE

Figures B-1 to B-32.

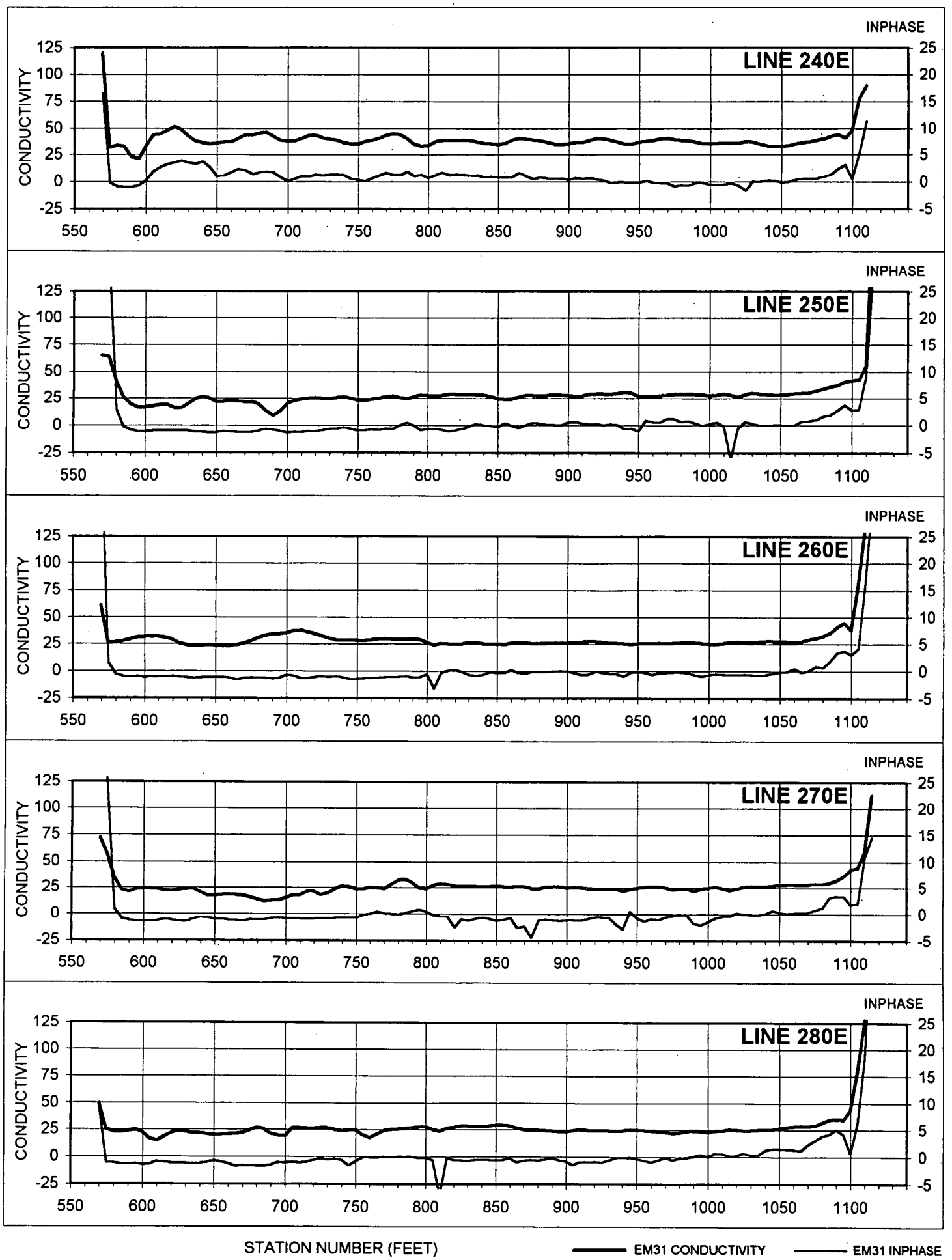
B2. EM34 SURVEY: PROFILES FROM NORTH 40 SITE

Figures B-33 to B-35.



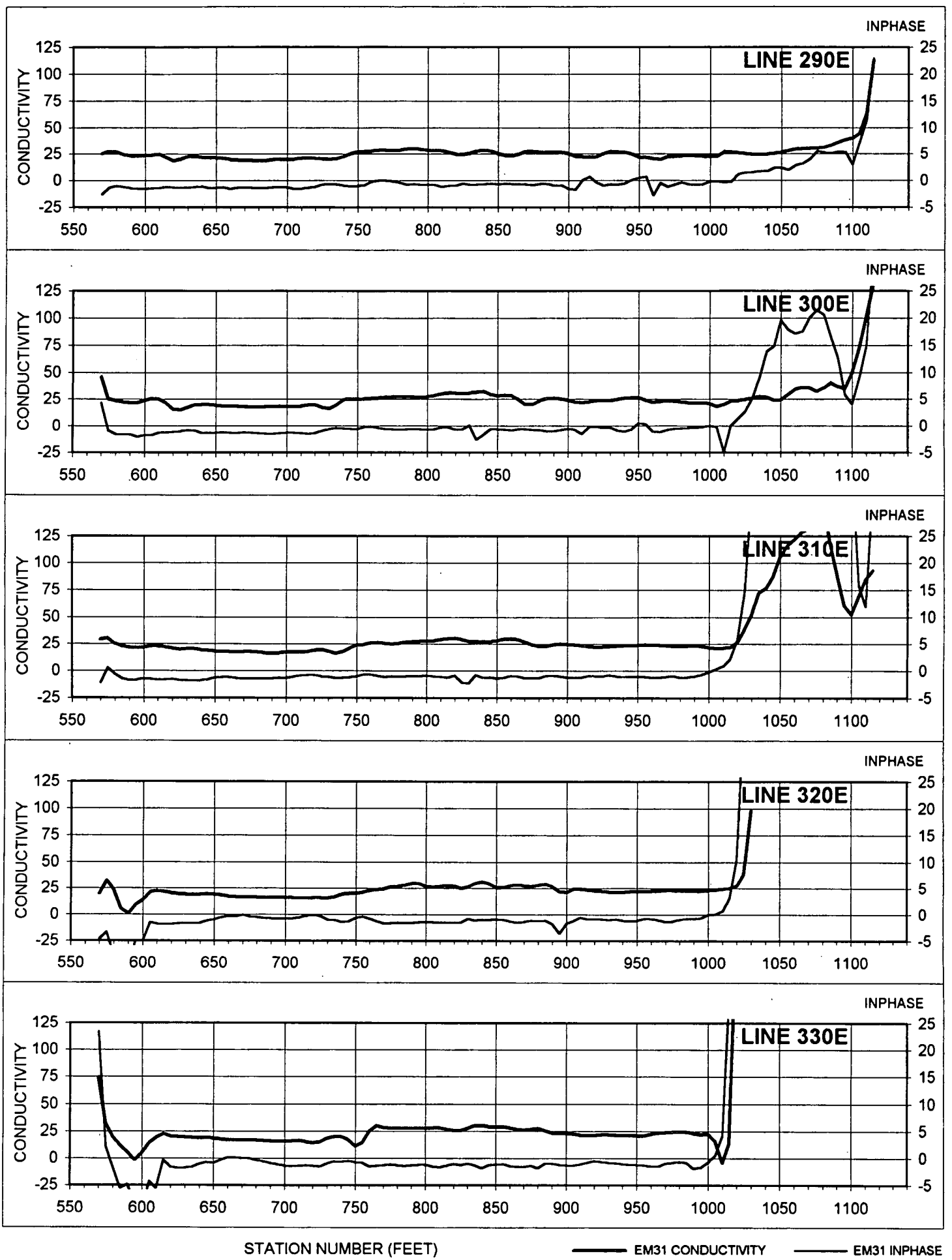
GEOSPHERE MIDWEST

FIGURE B-1



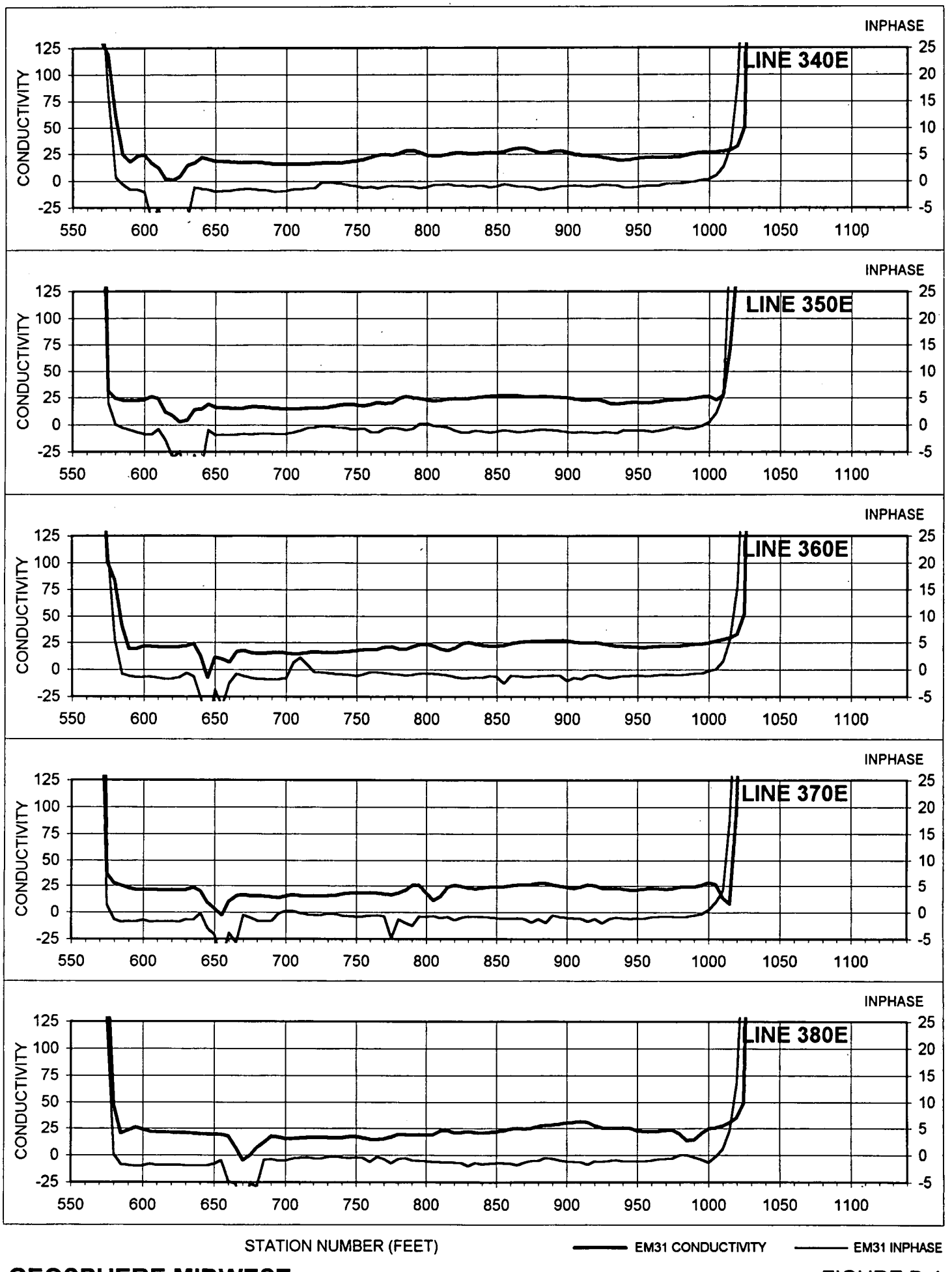
GEOSPHERE MIDWEST

FIGURE B-2



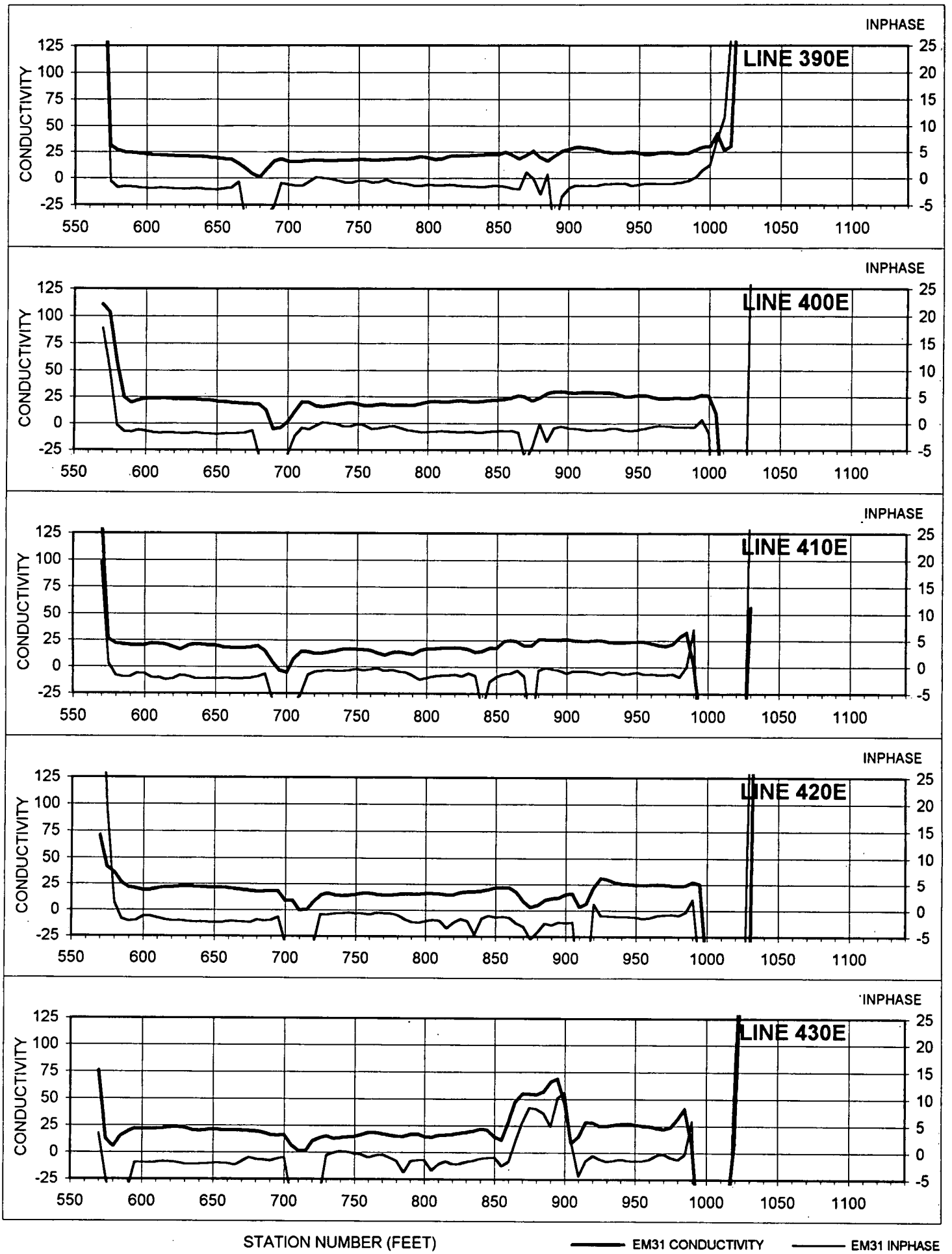
GEOSPHERE MIDWEST

FIGURE B-3



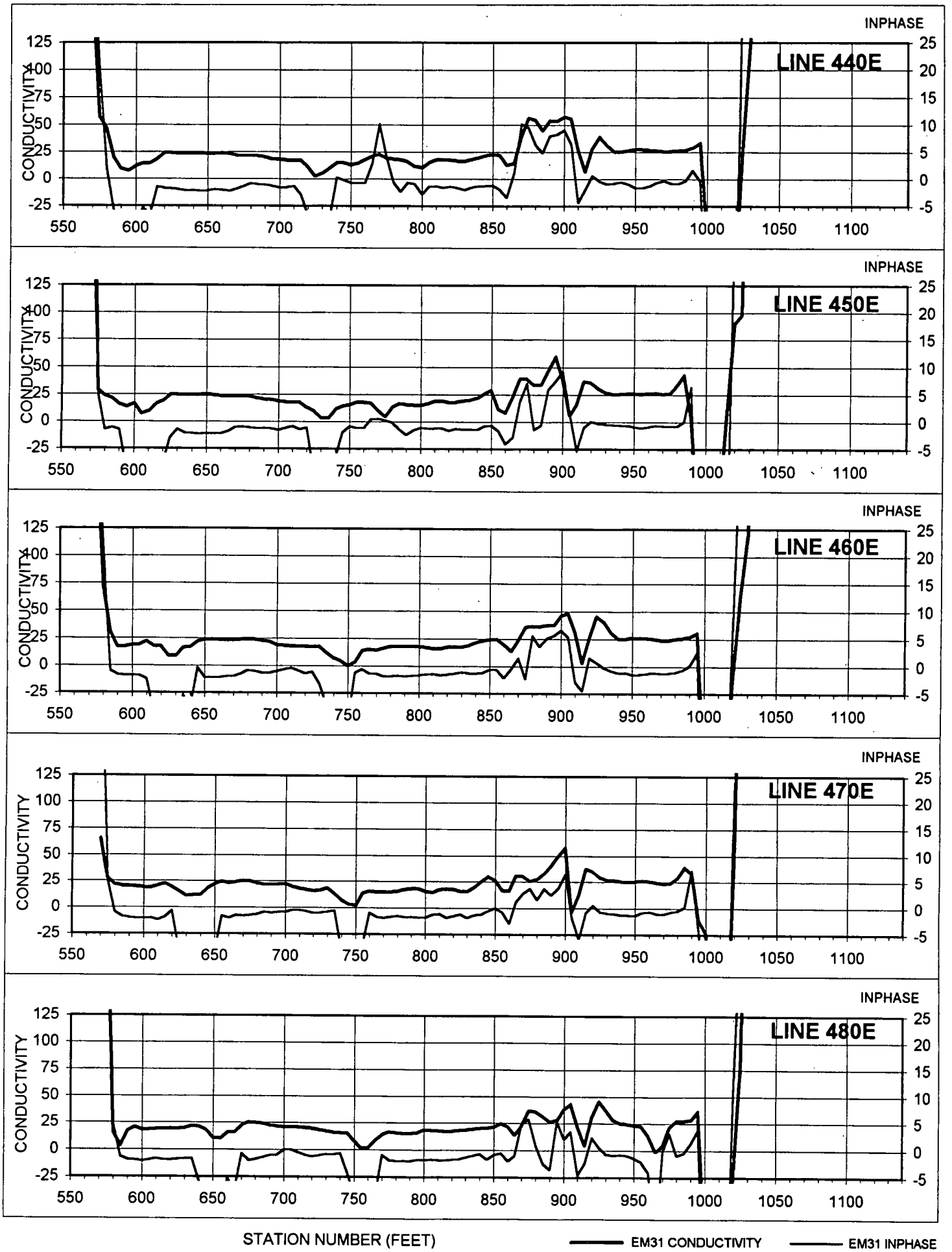
GEOSPHERE MIDWEST

FIGURE B-4



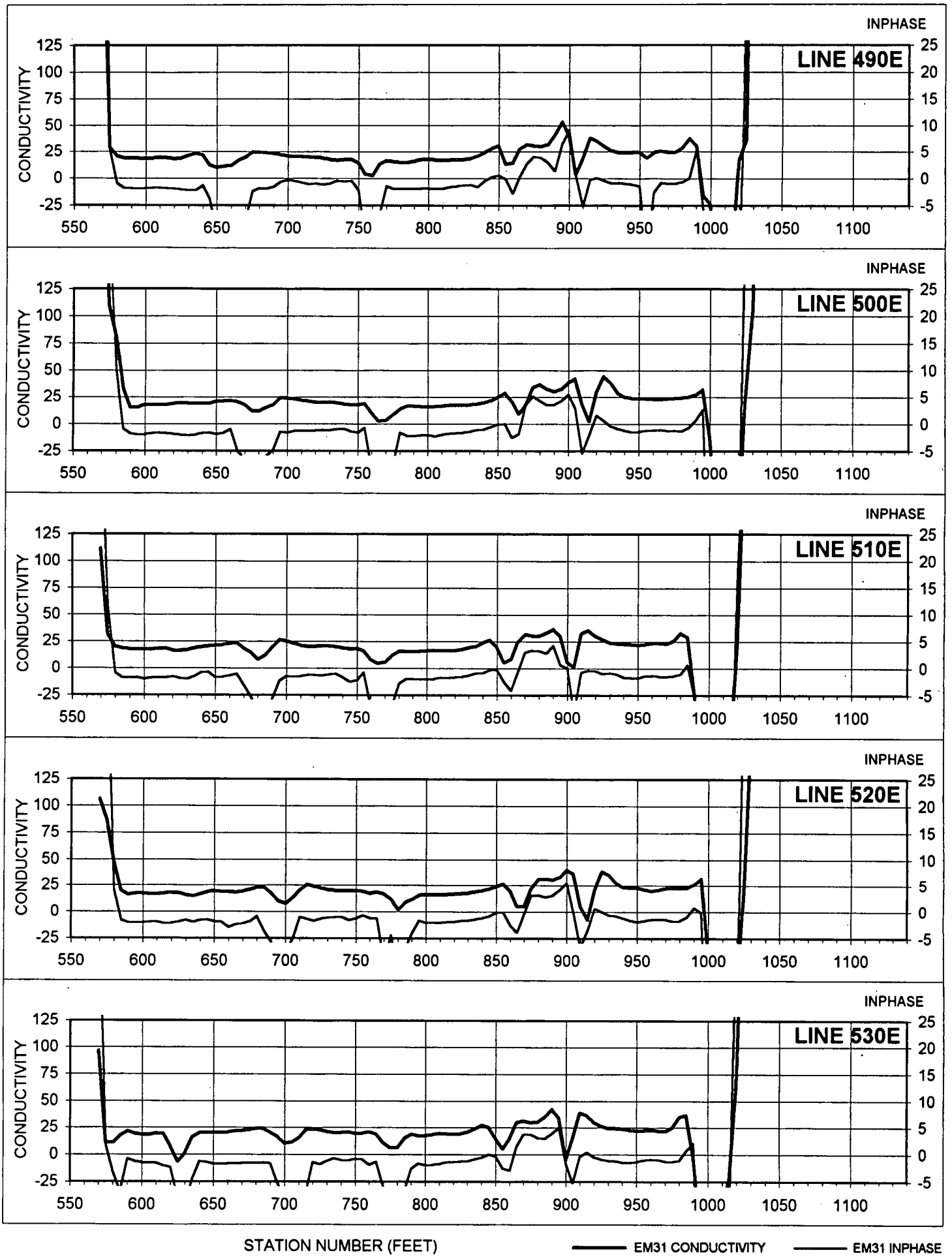
GEOSPHERE MIDWEST

FIGURE B-5



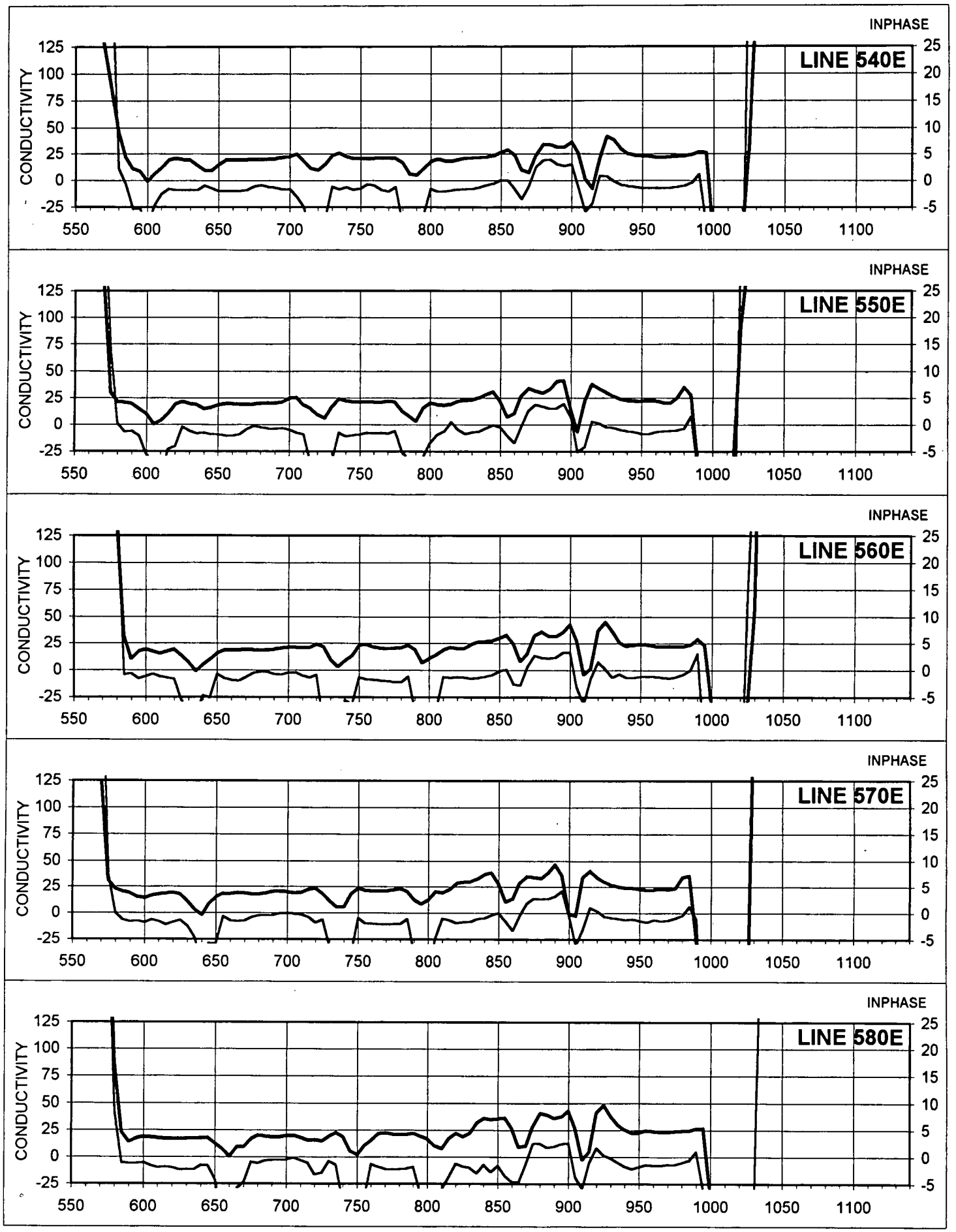
GEOSPHERE MIDWEST

FIGURE B-6



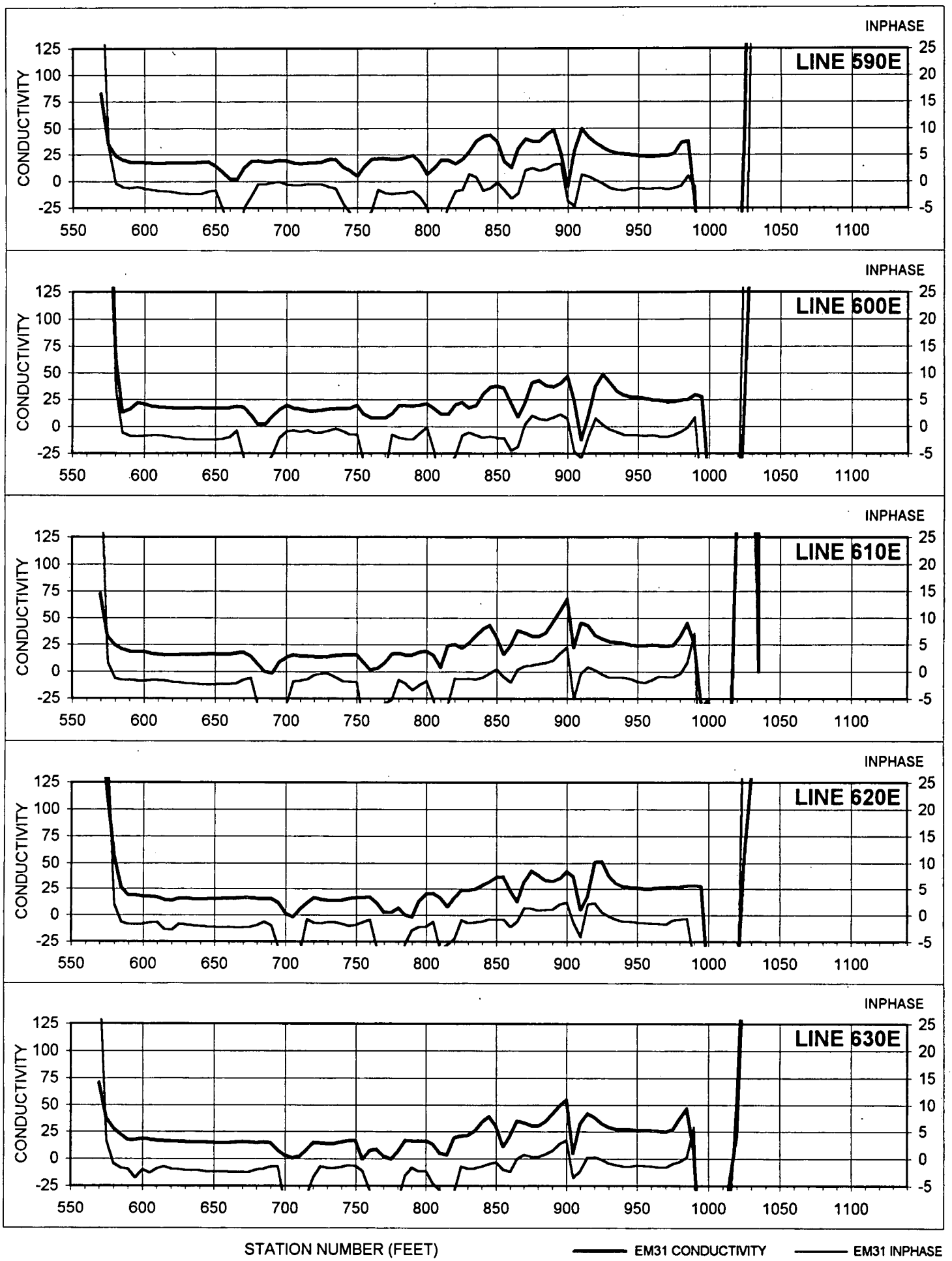
GEOSPHERE MIDWEST

FIGURE B-7



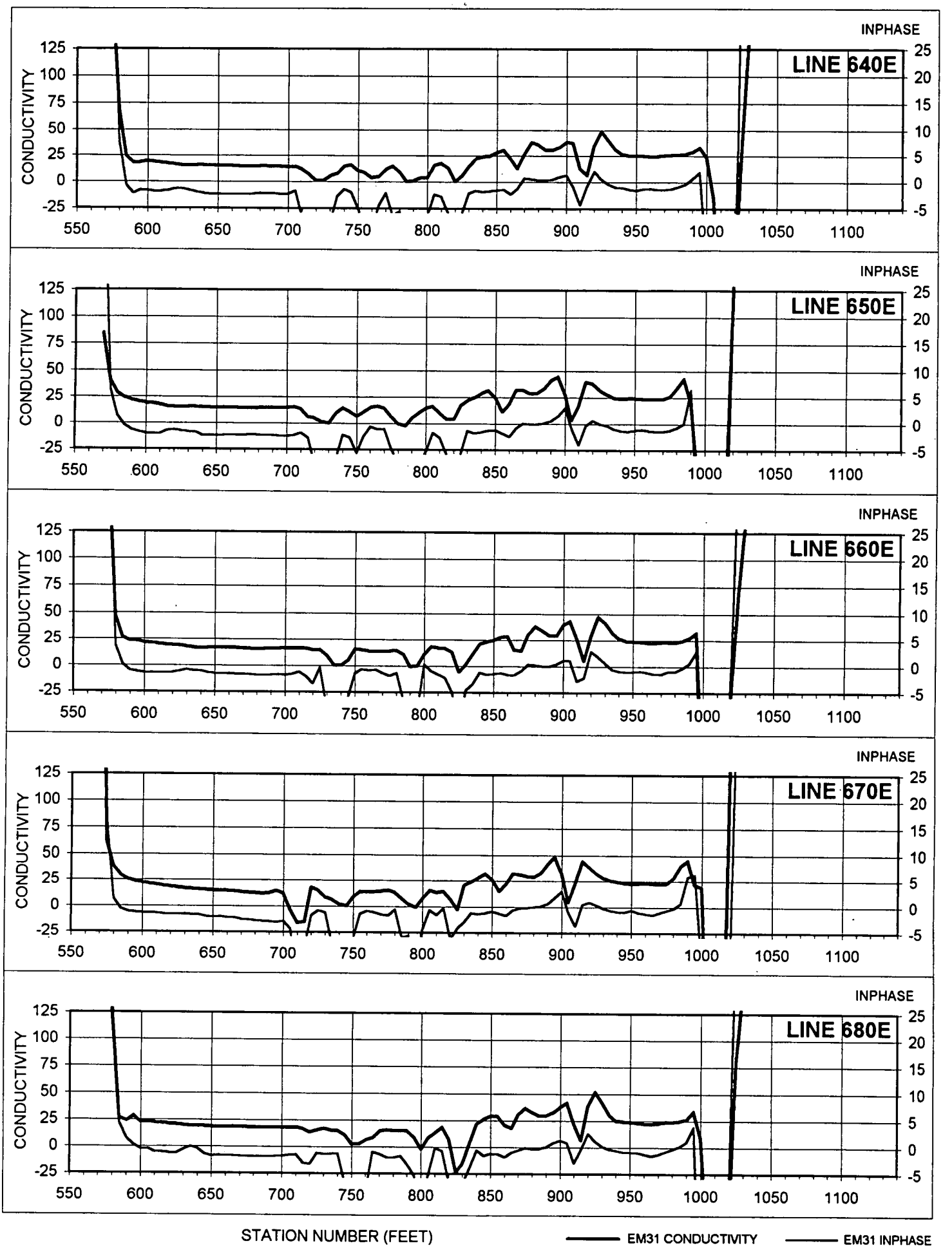
GEOSPHERE MIDWEST

FIGURE B-8



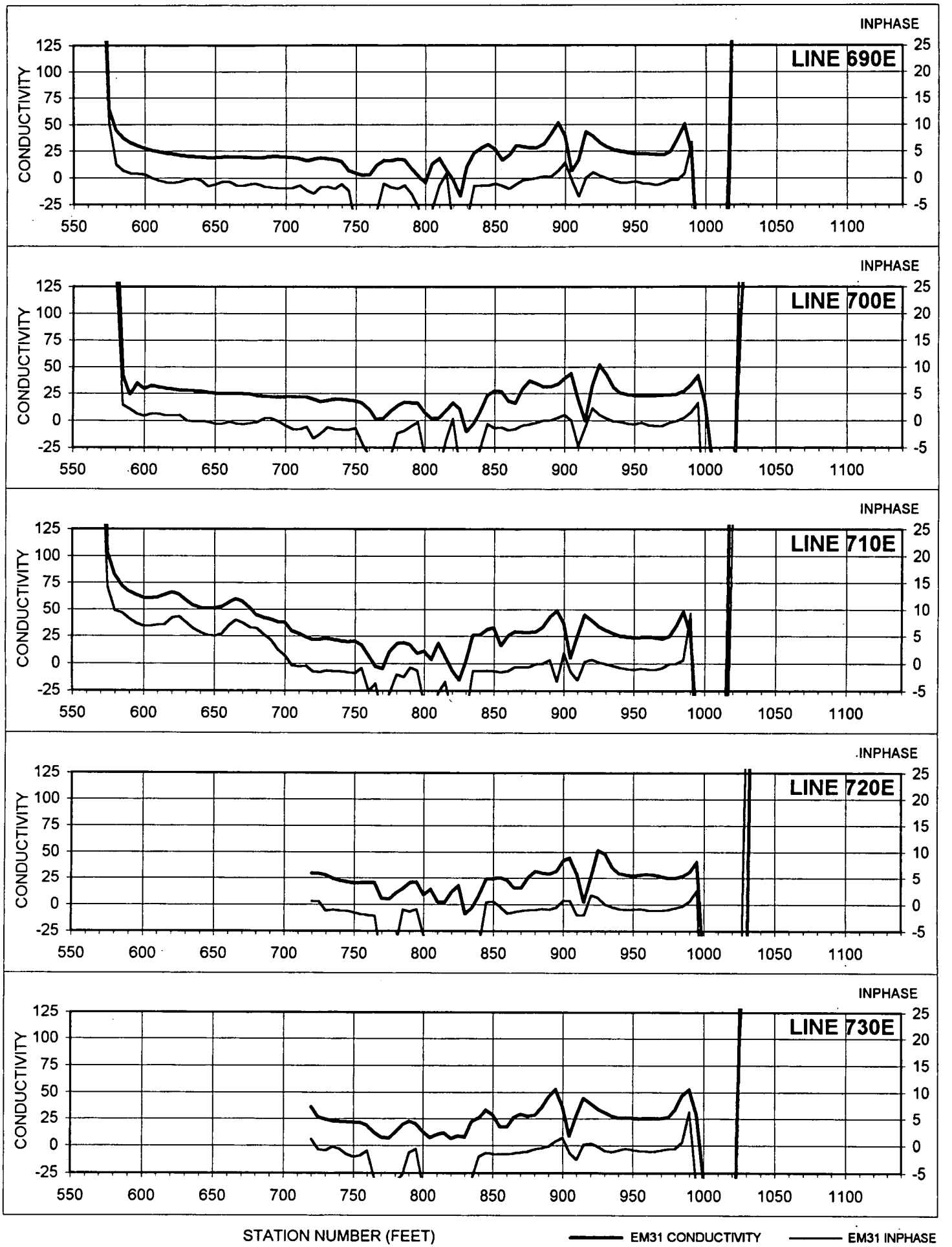
GEOSPHERE MIDWEST

FIGURE B-9



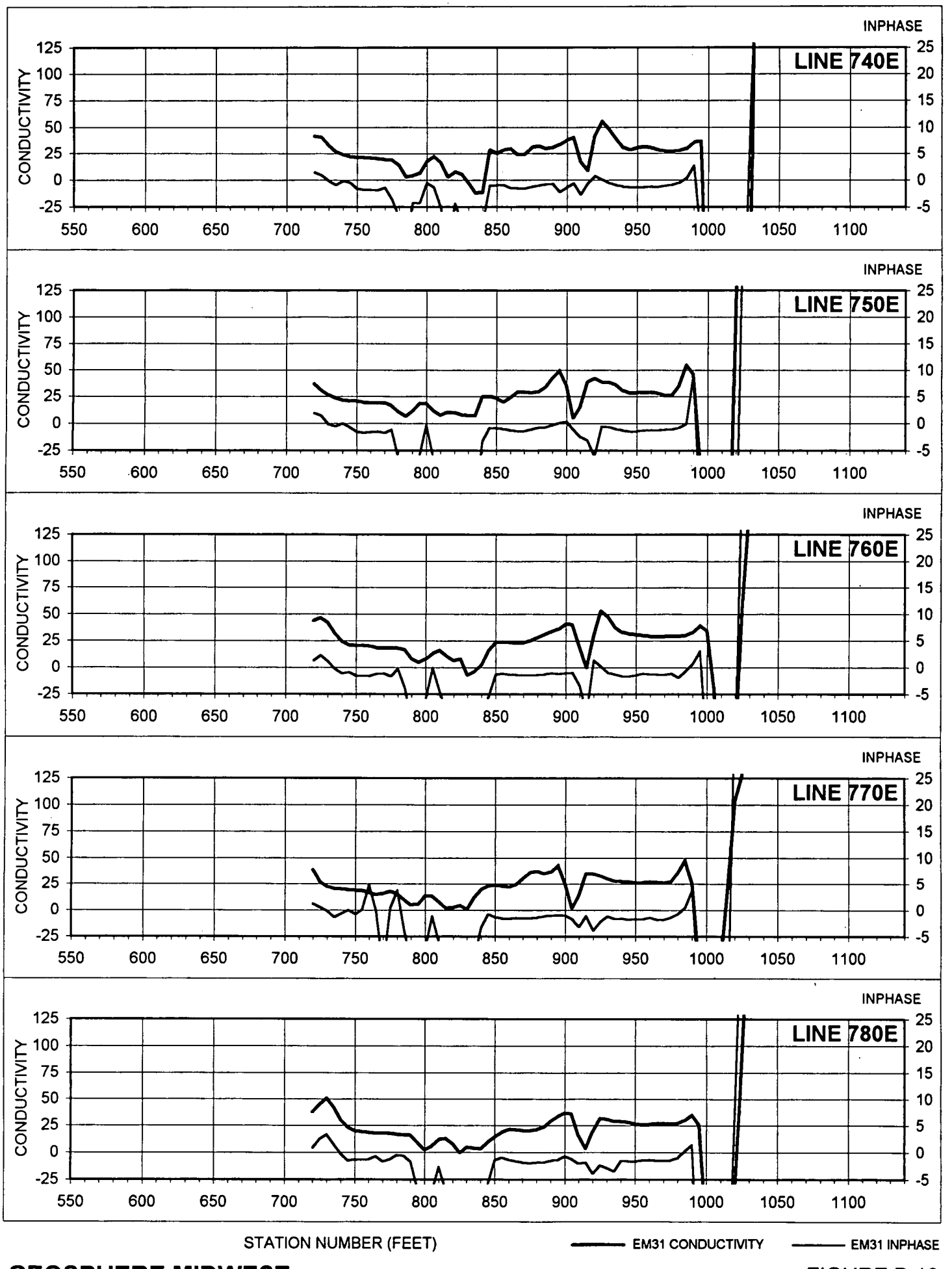
GEOSPHERE MIDWEST

FIGURE B-10



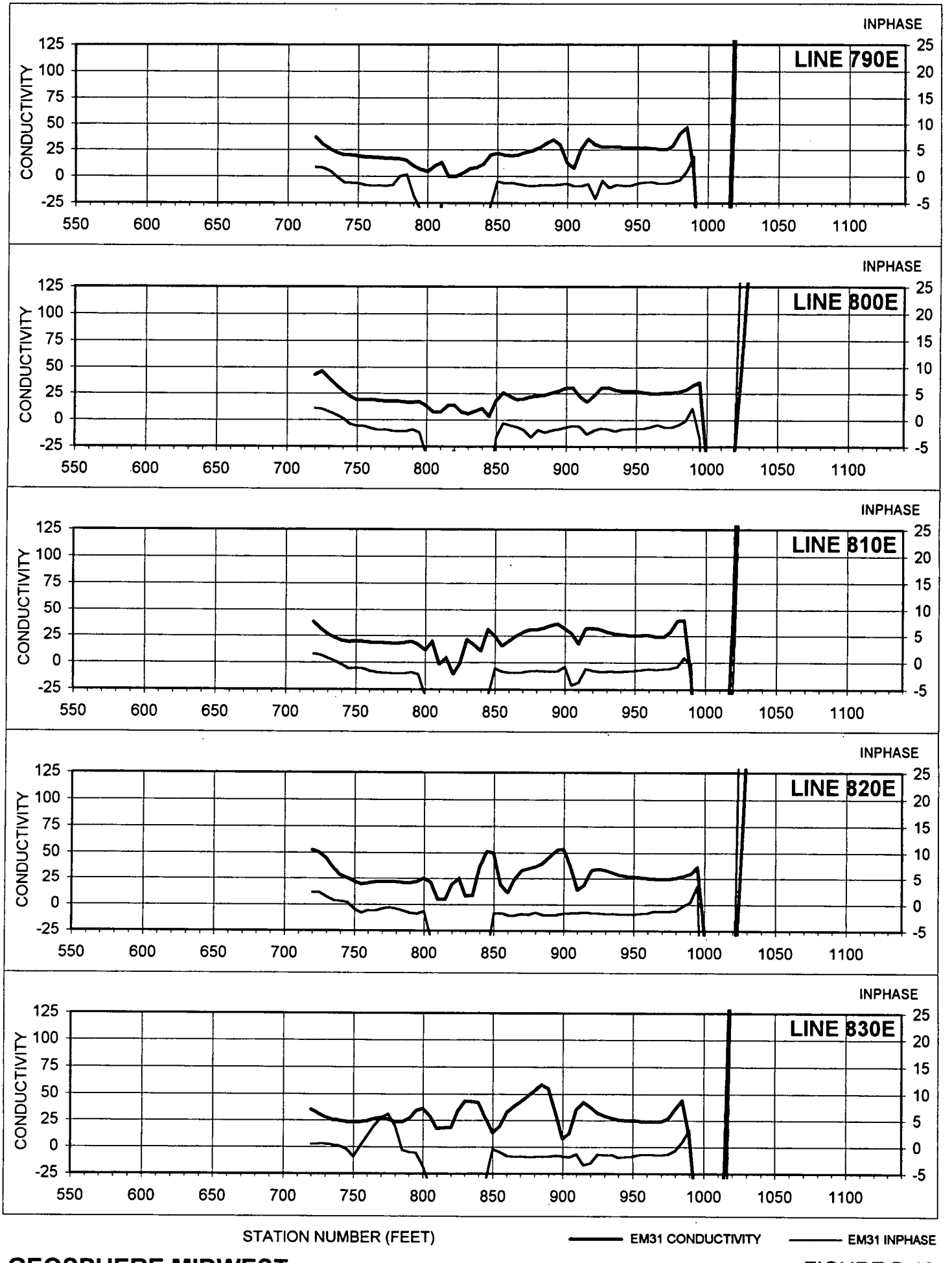
GEOSPHERE MIDWEST

FIGURE B-11



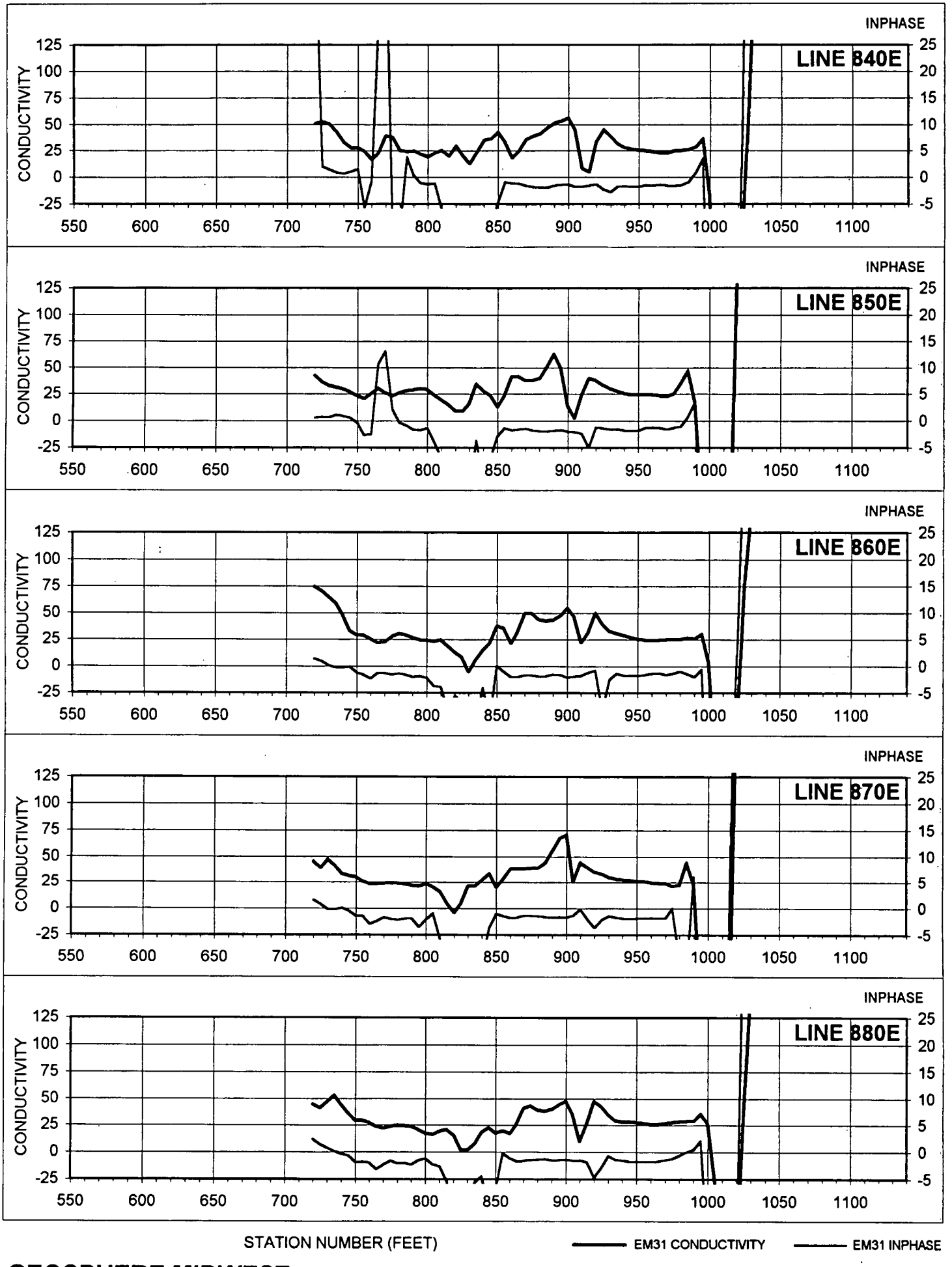
GEOSPHERE MIDWEST

FIGURE B-12



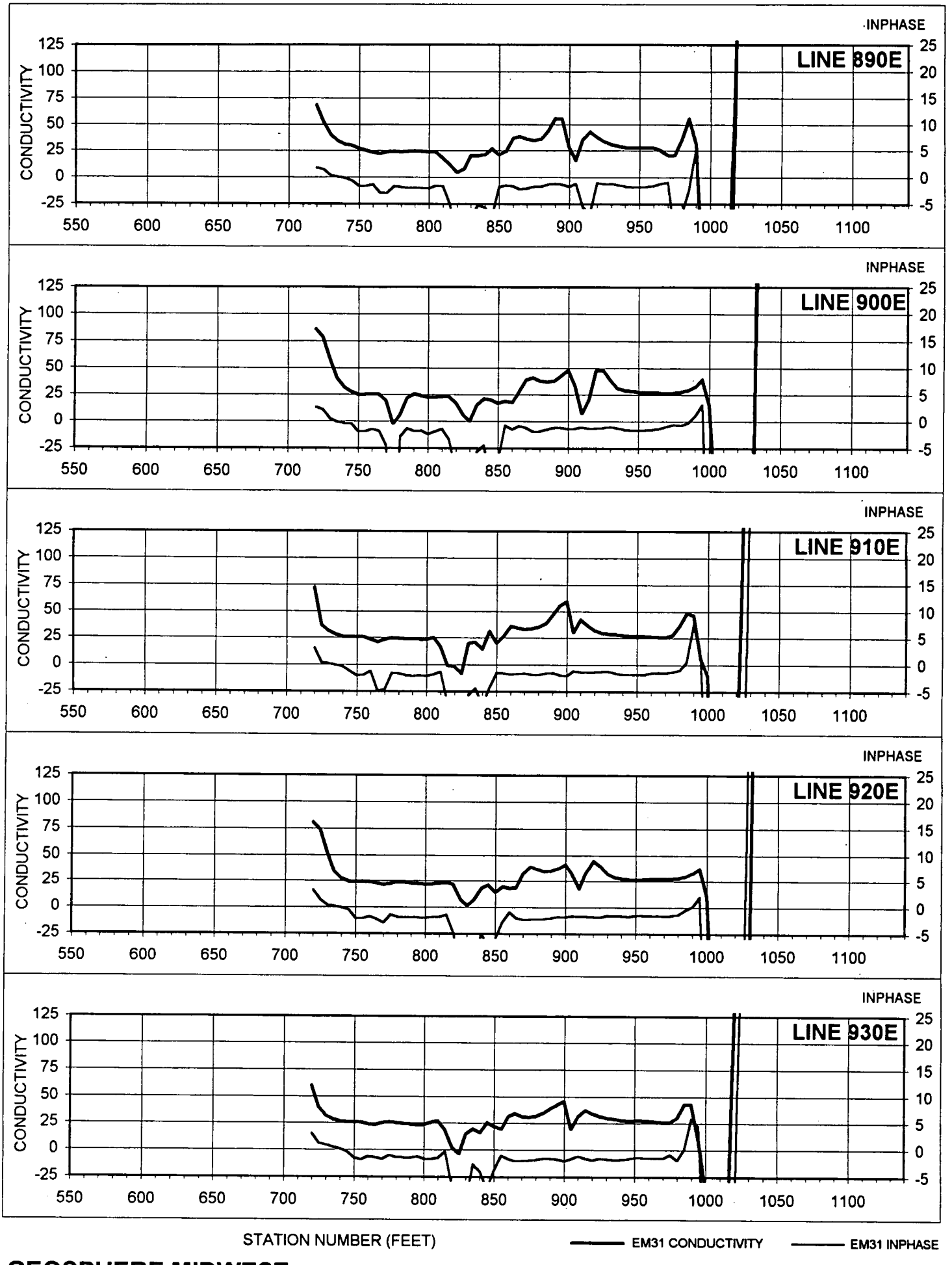
GEOSPHERE MIDWEST

FIGURE B-13



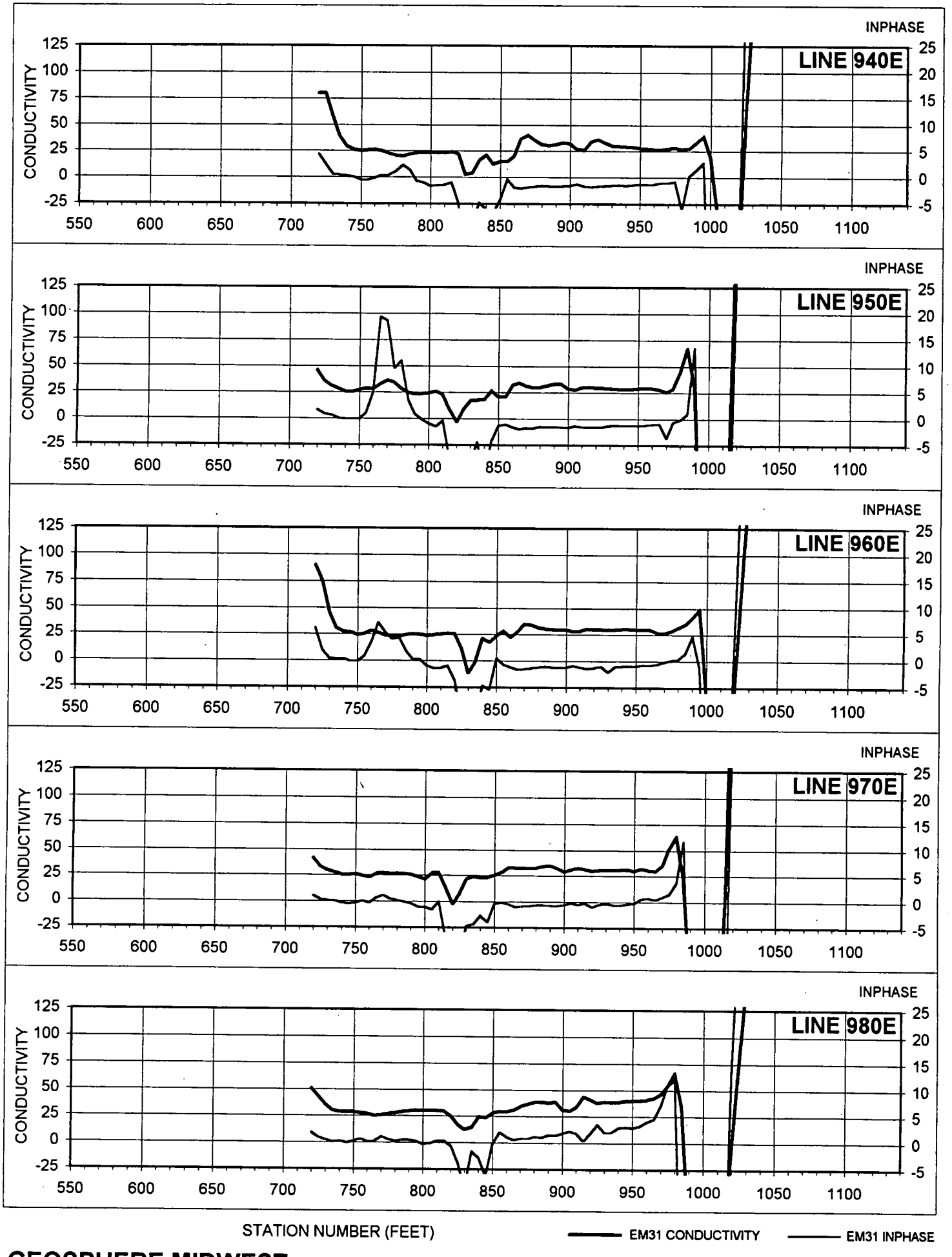
GEOSPHERE MIDWEST

FIGURE B-14



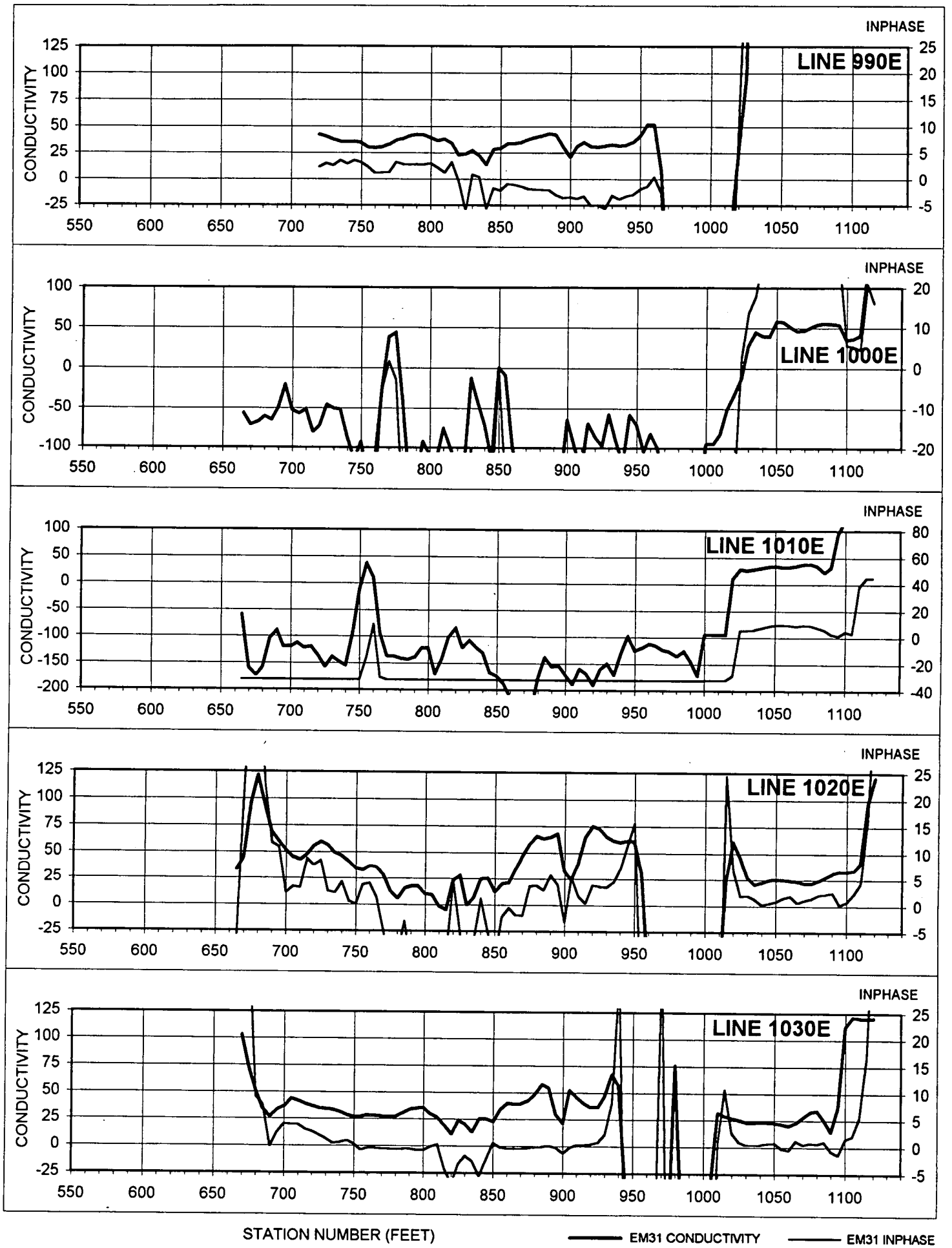
GEOSPHERE MIDWEST

FIGURE B-15



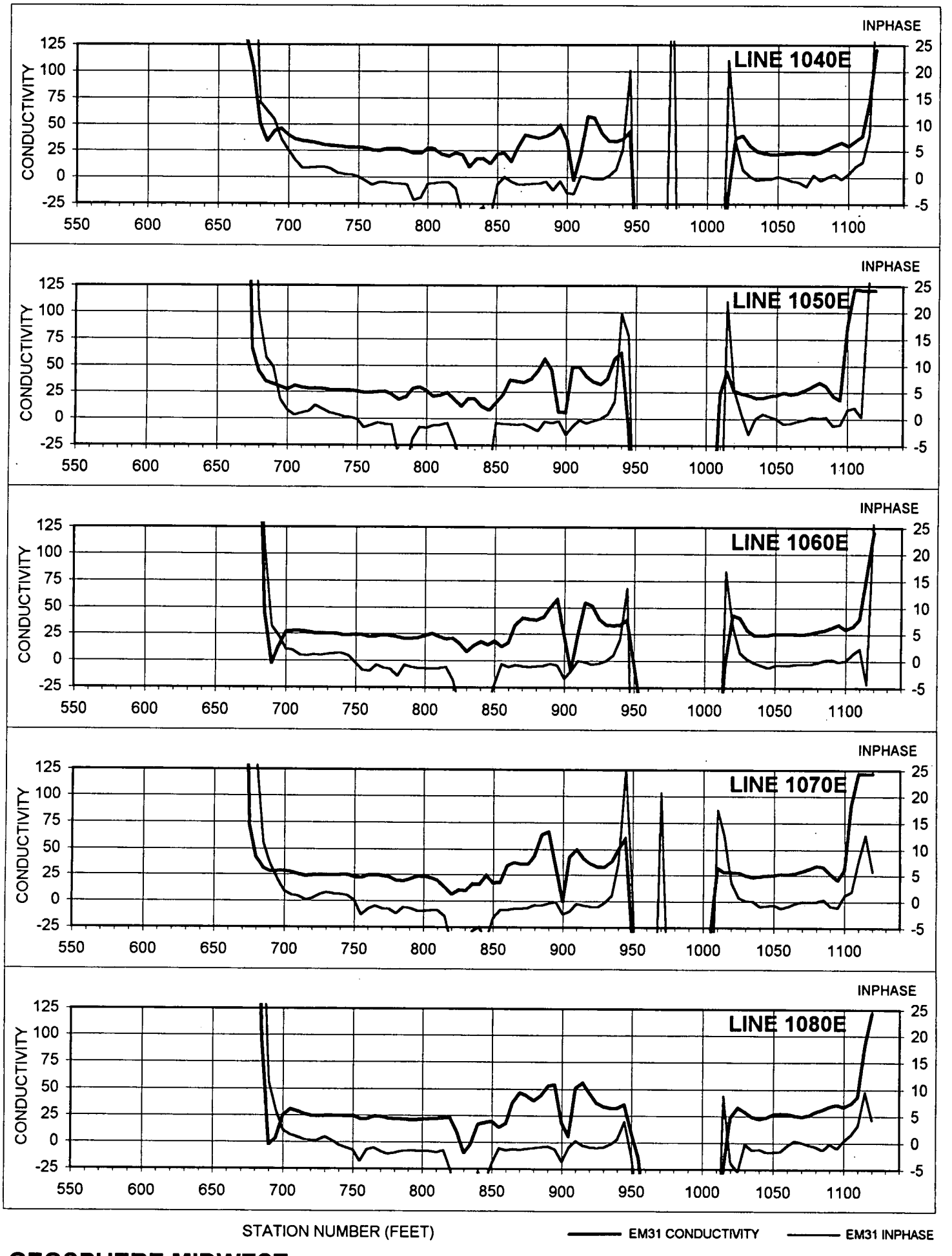
GEOSPHERE MIDWEST

FIGURE B-15a



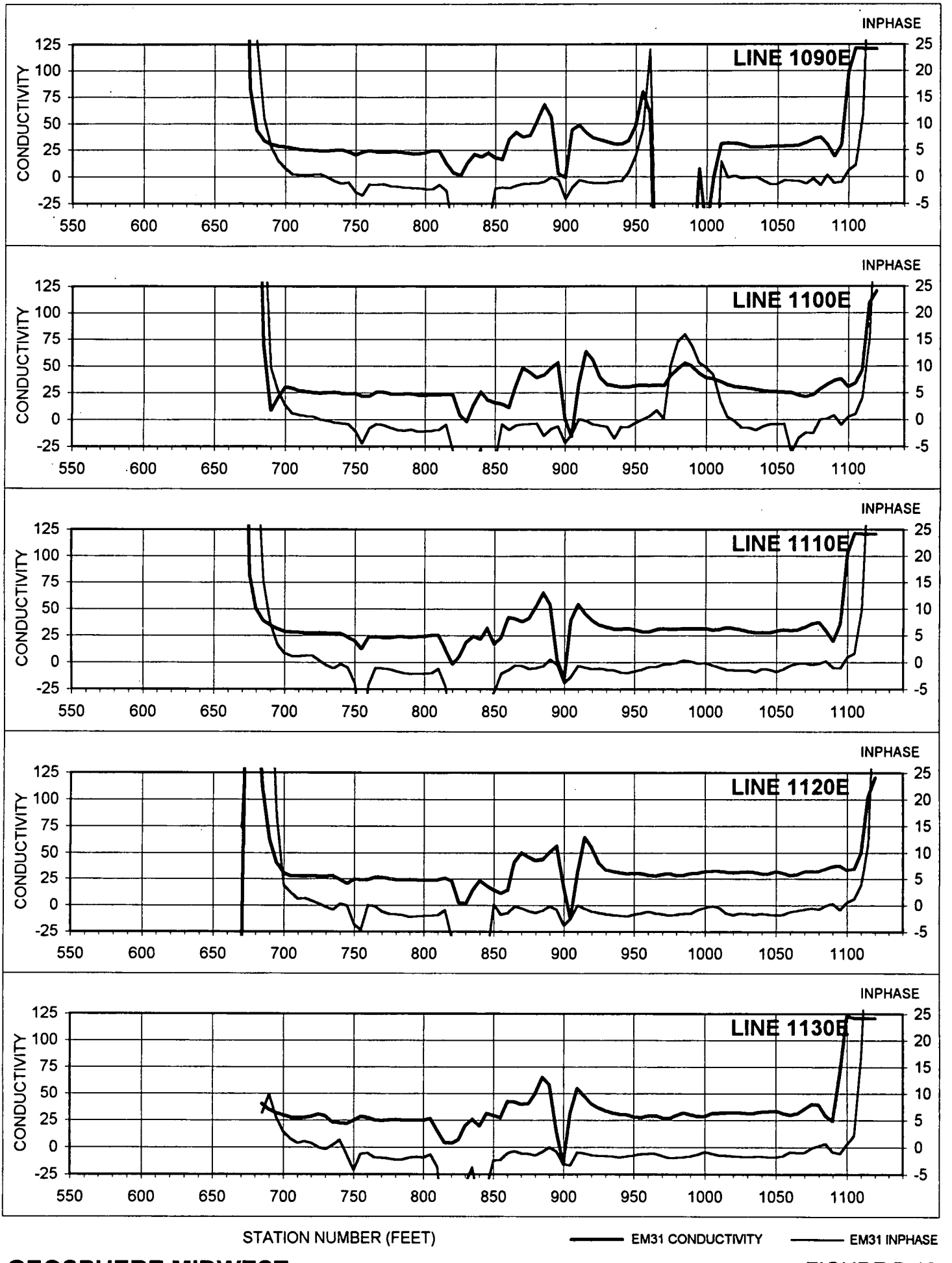
GEOSPHERE MIDWEST

FIGURE B-16



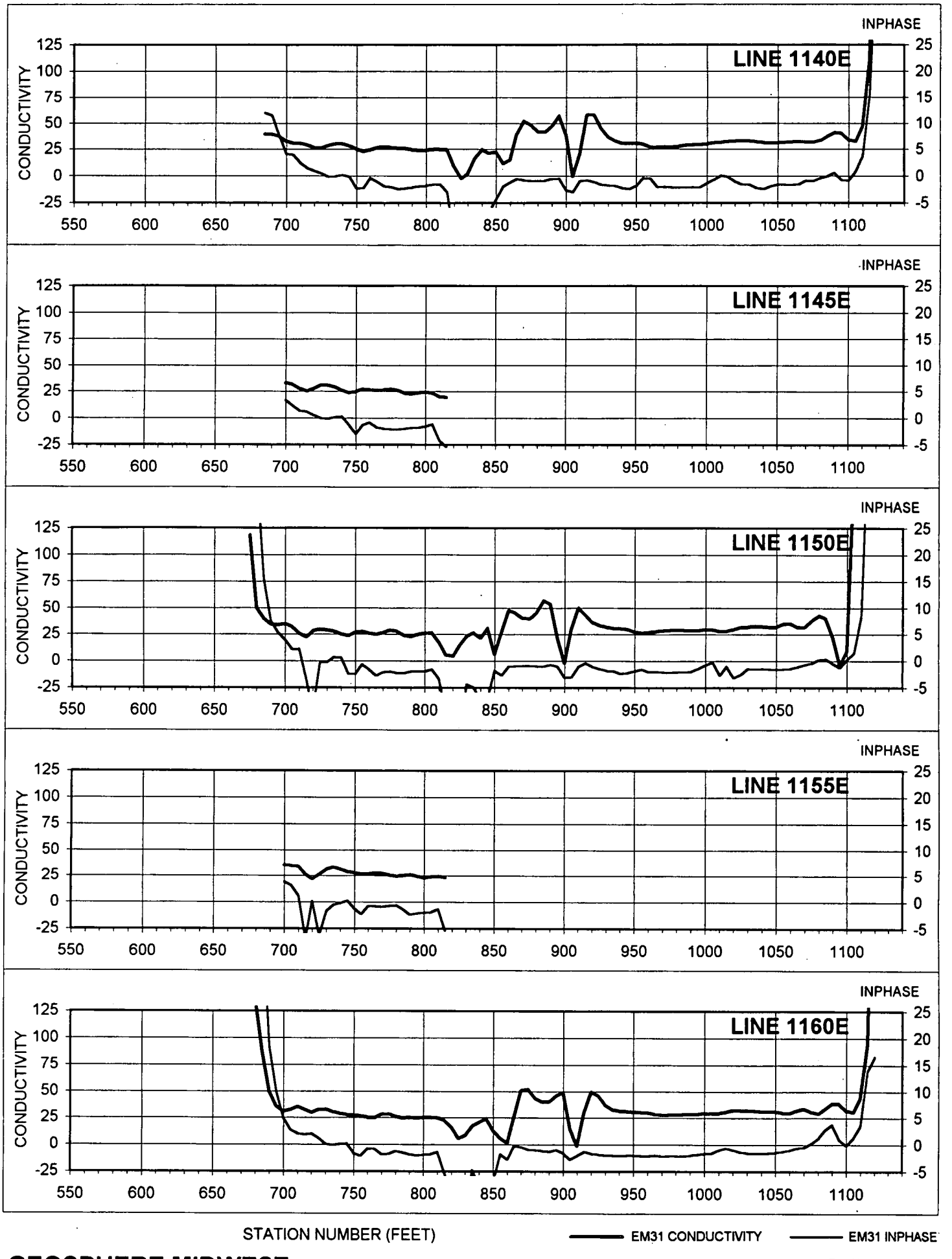
GEOSPHERE MIDWEST

FIGURE B-17



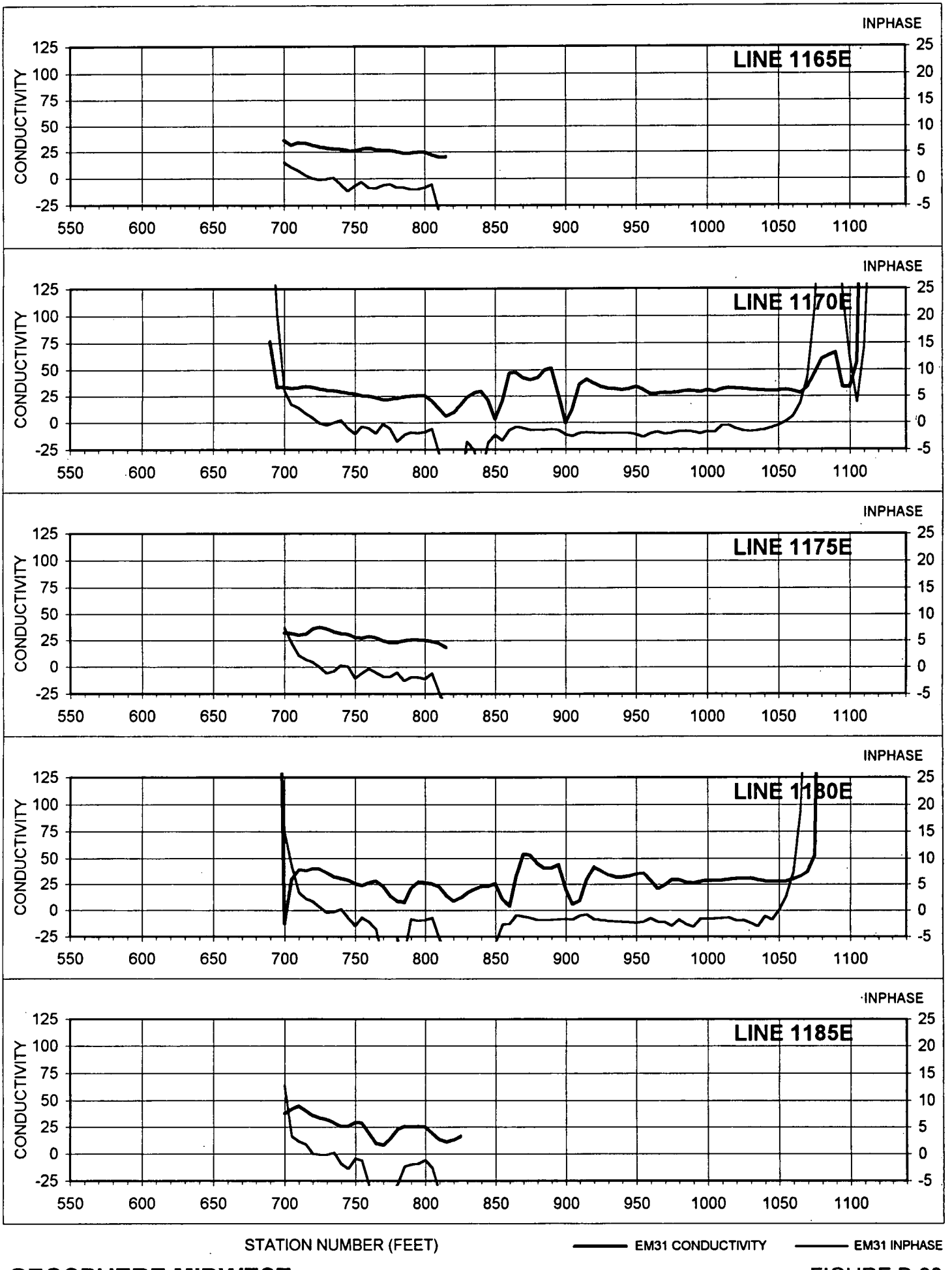
GEOSPHERE MIDWEST

FIGURE B-18



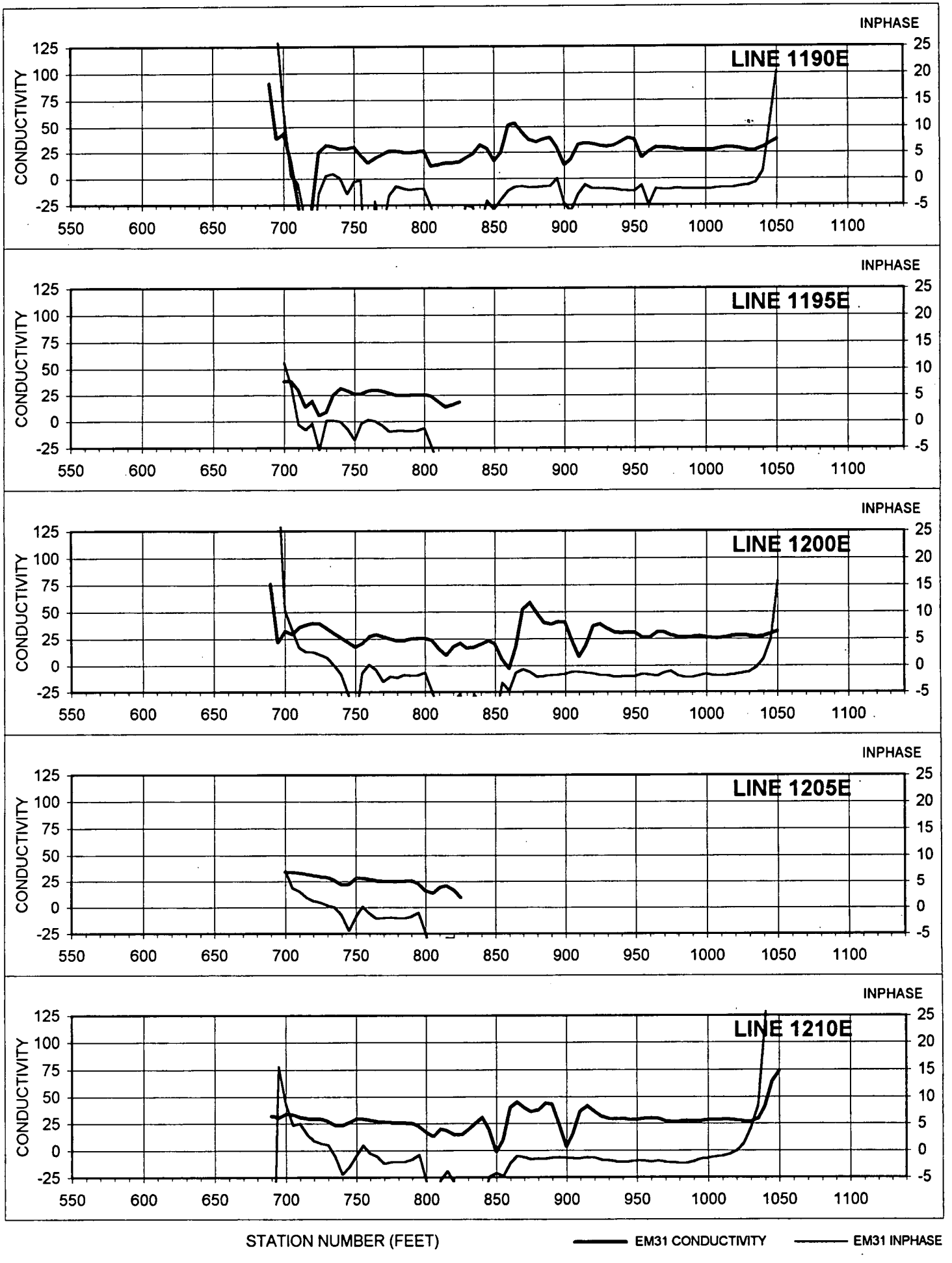
GEOSPHERE MIDWEST

FIGURE B-19



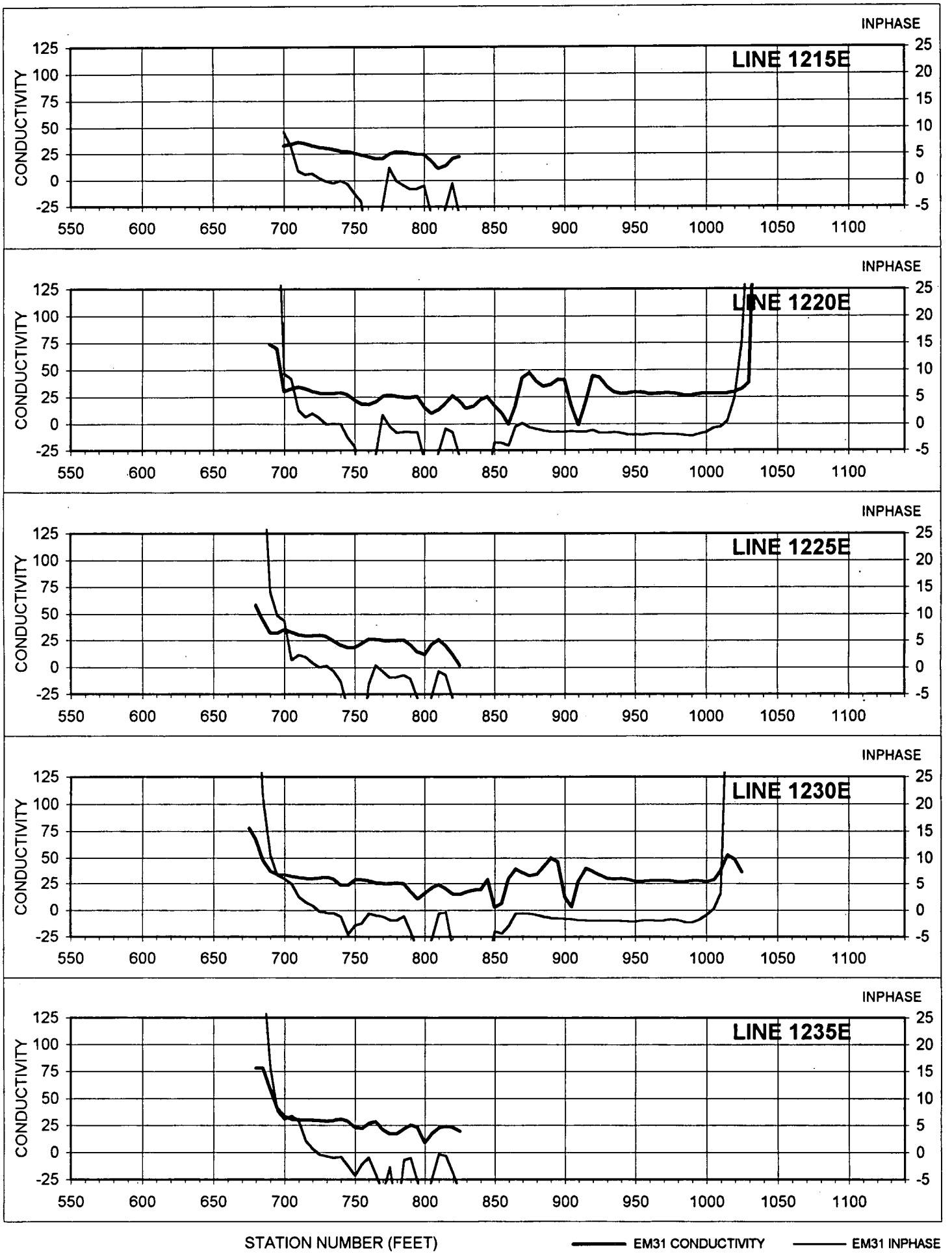
GEOSPHERE MIDWEST

FIGURE B-20



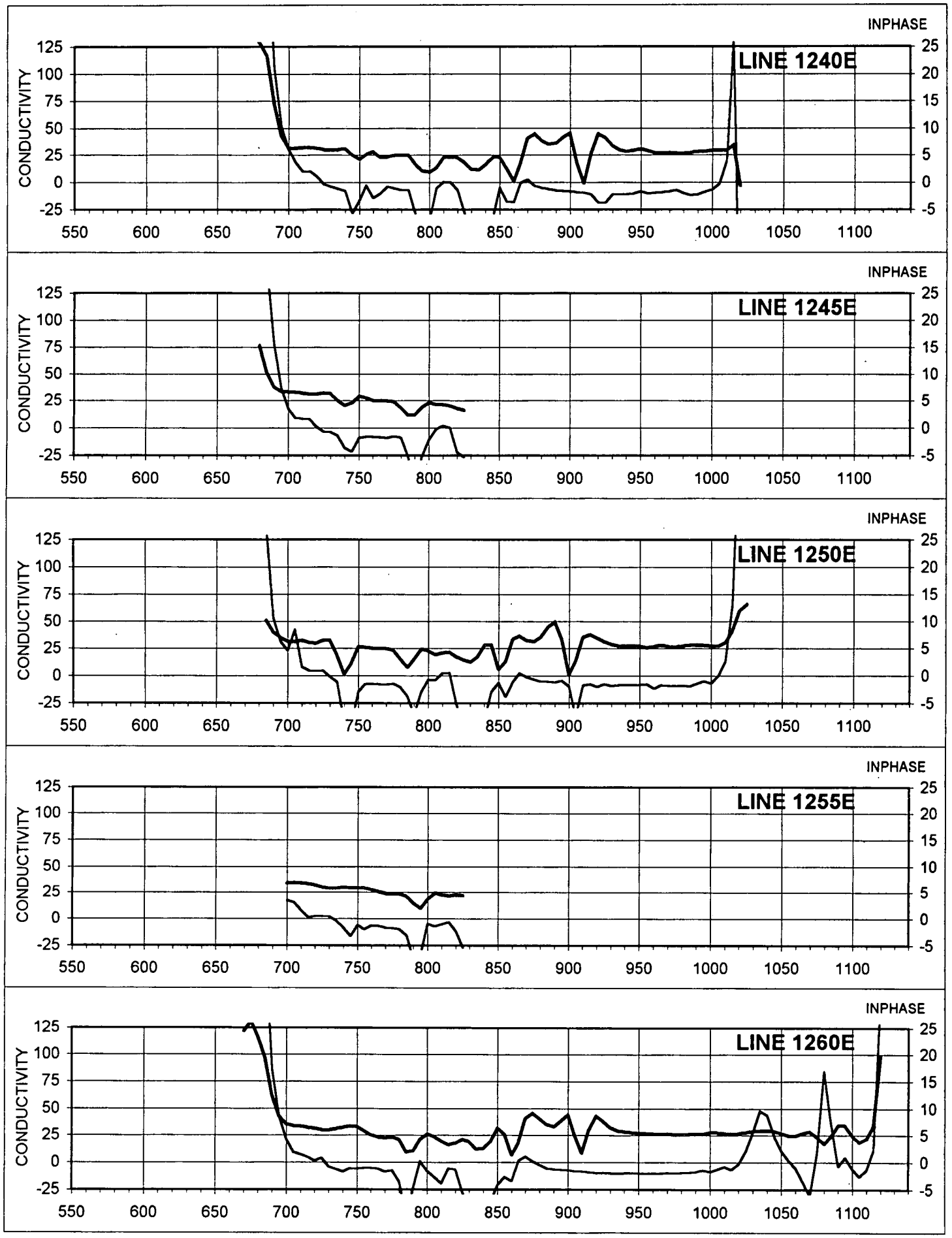
GEOSPHERE MIDWEST

FIGURE B-21



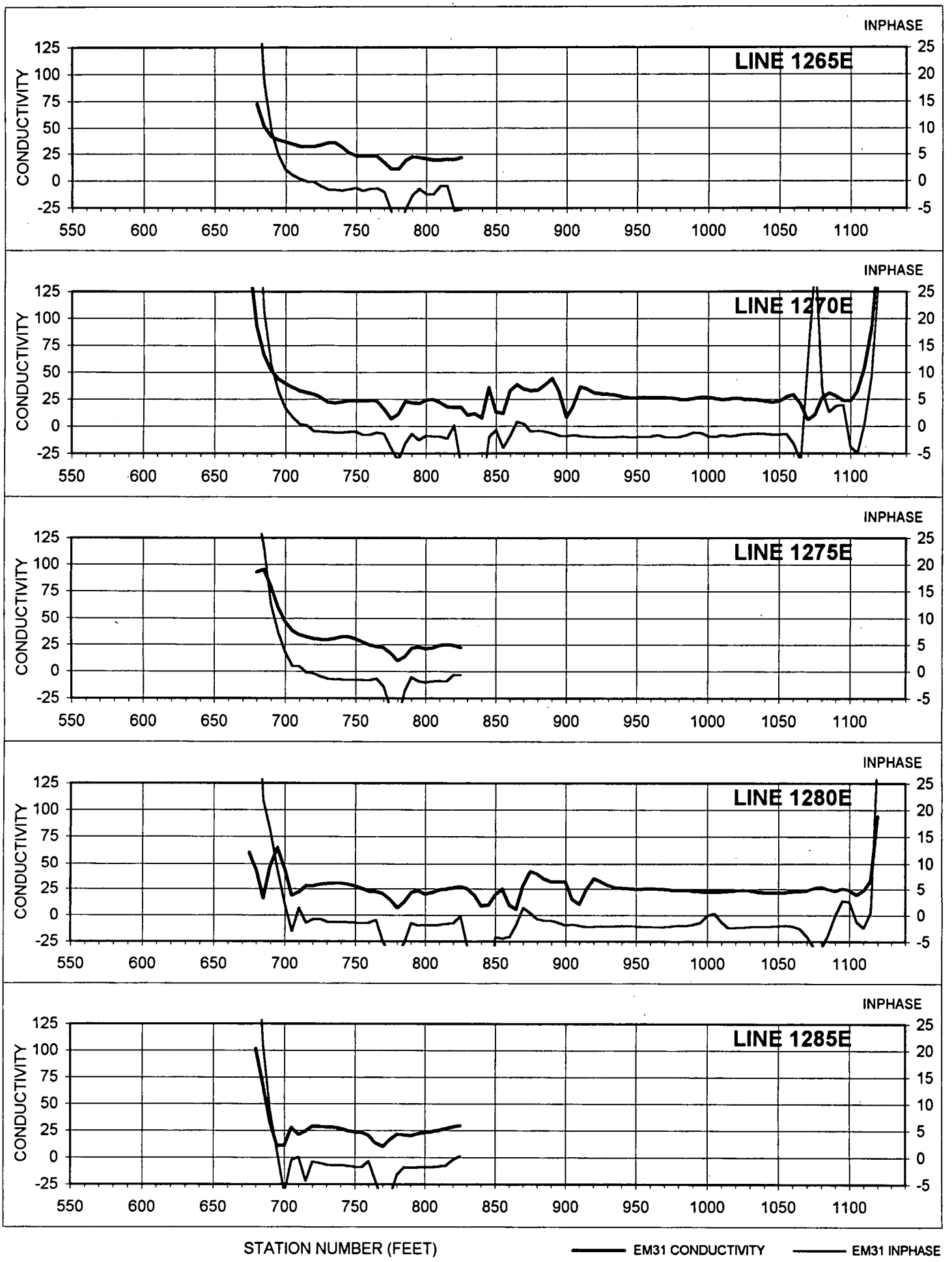
GEOSPHERE MIDWEST

FIGURE B-22



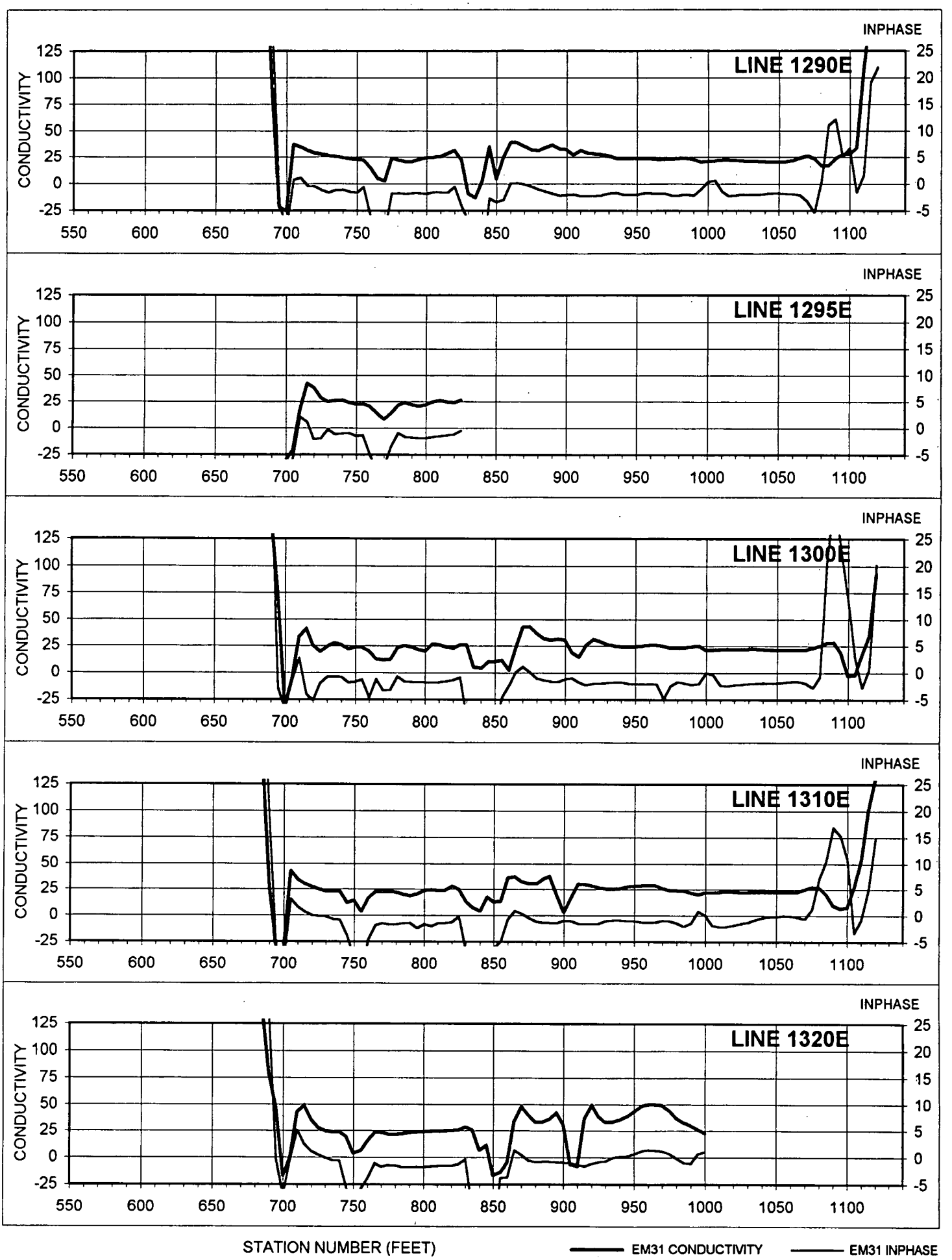
GEOSPHERE MIDWEST

FIGURE B-23



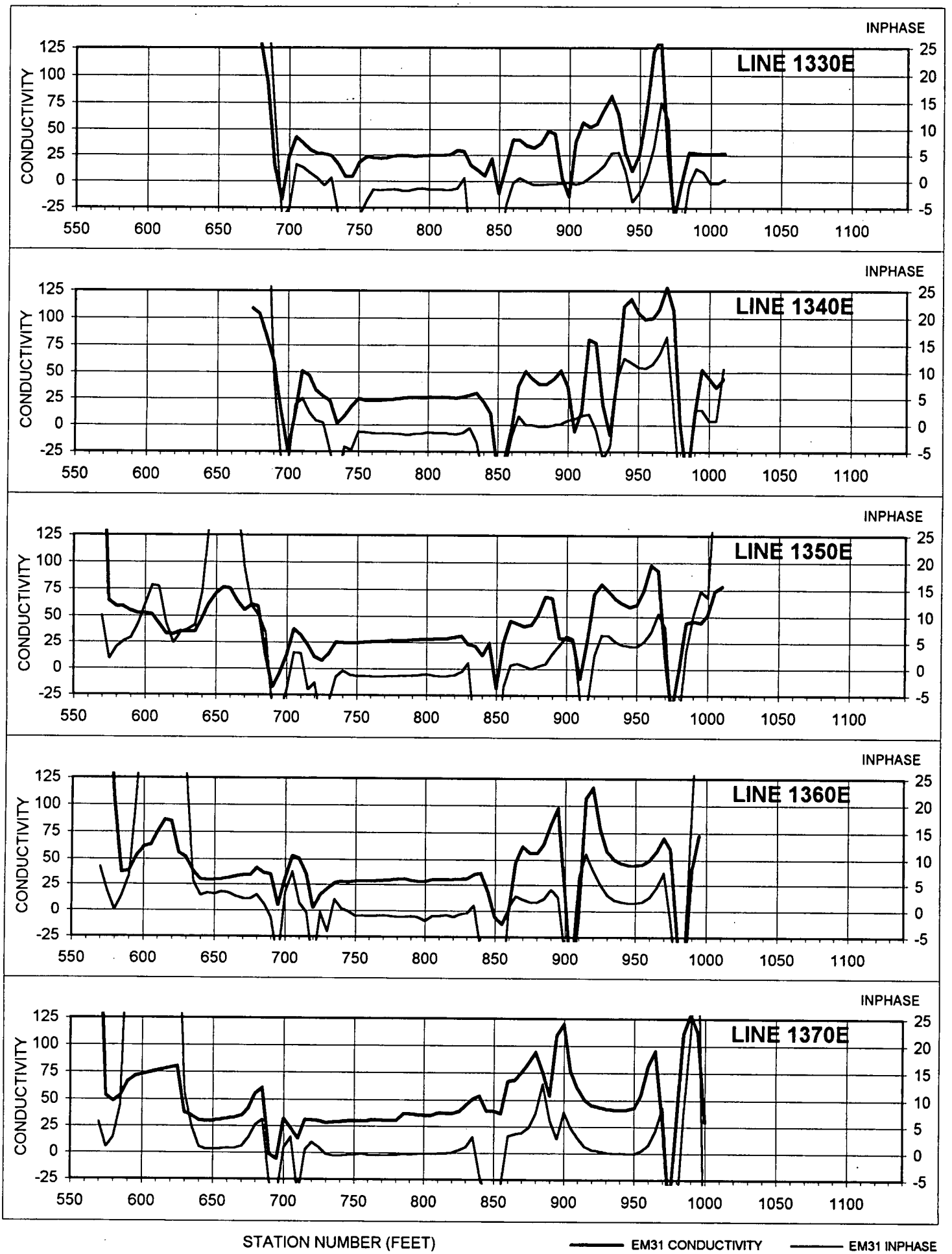
GEOSPHERE MIDWEST

FIGURE B-24



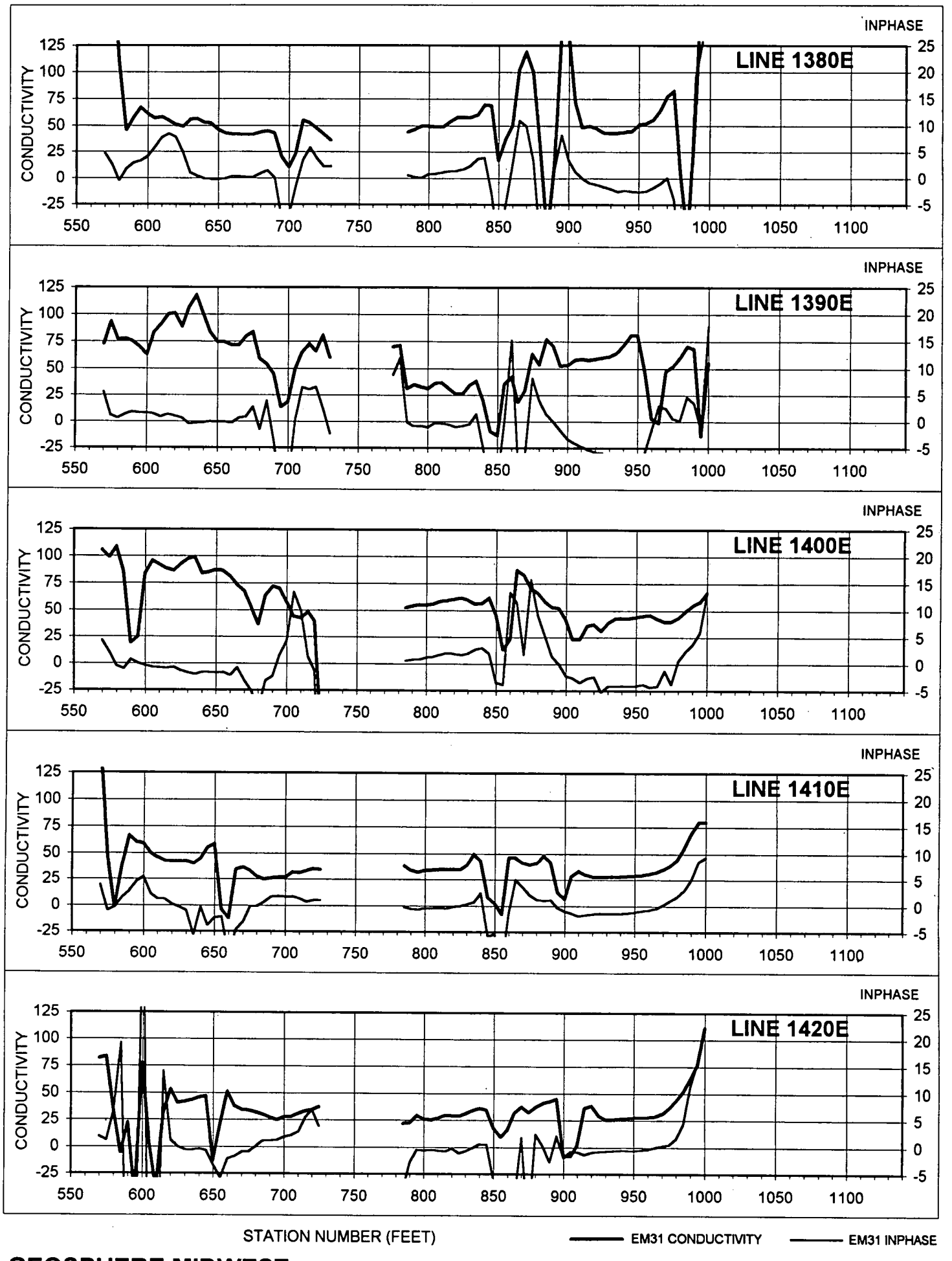
GEOSPHERE MIDWEST

FIGURE B-25



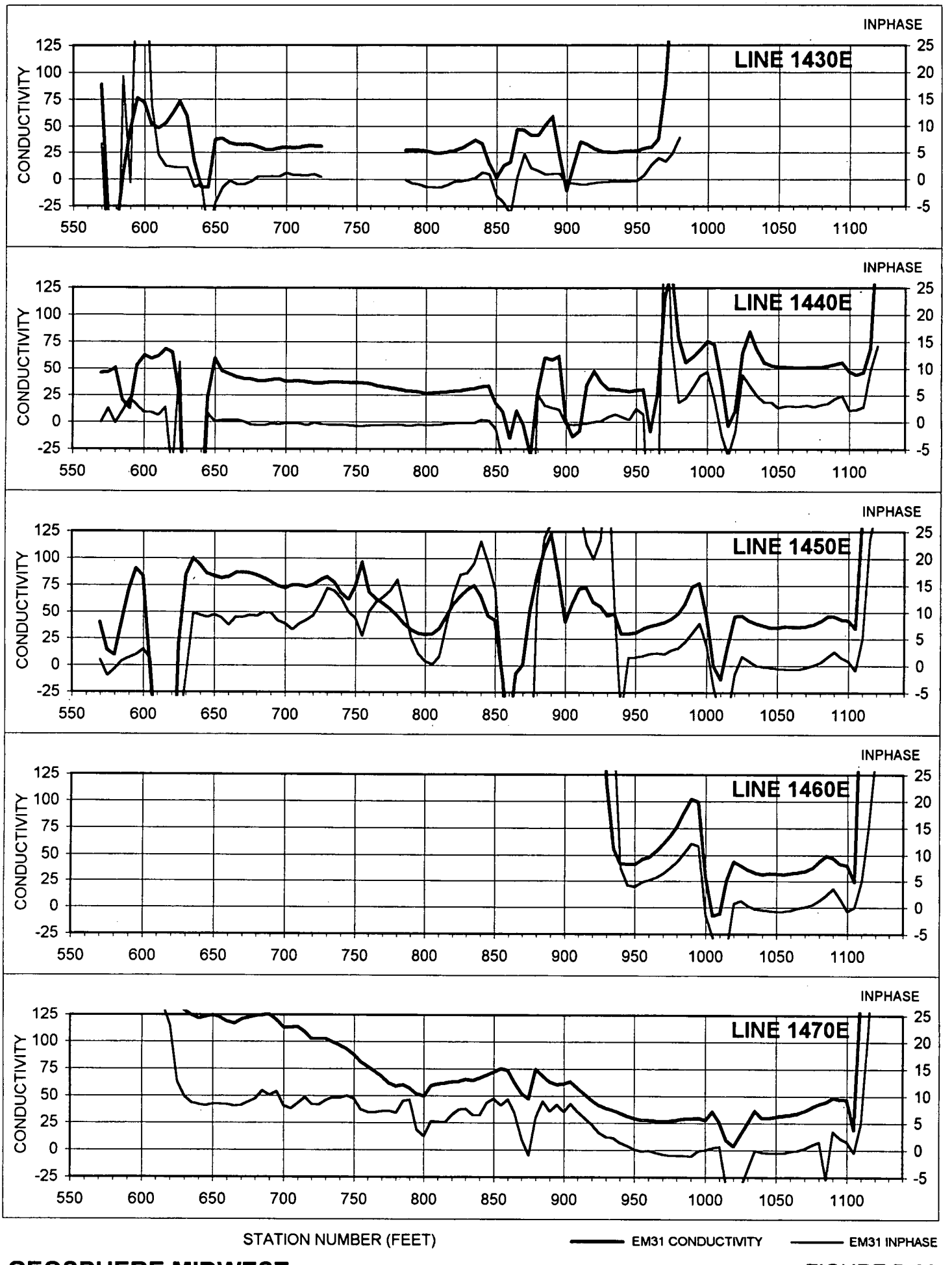
GEOSPHERE MIDWEST

FIGURE B-26



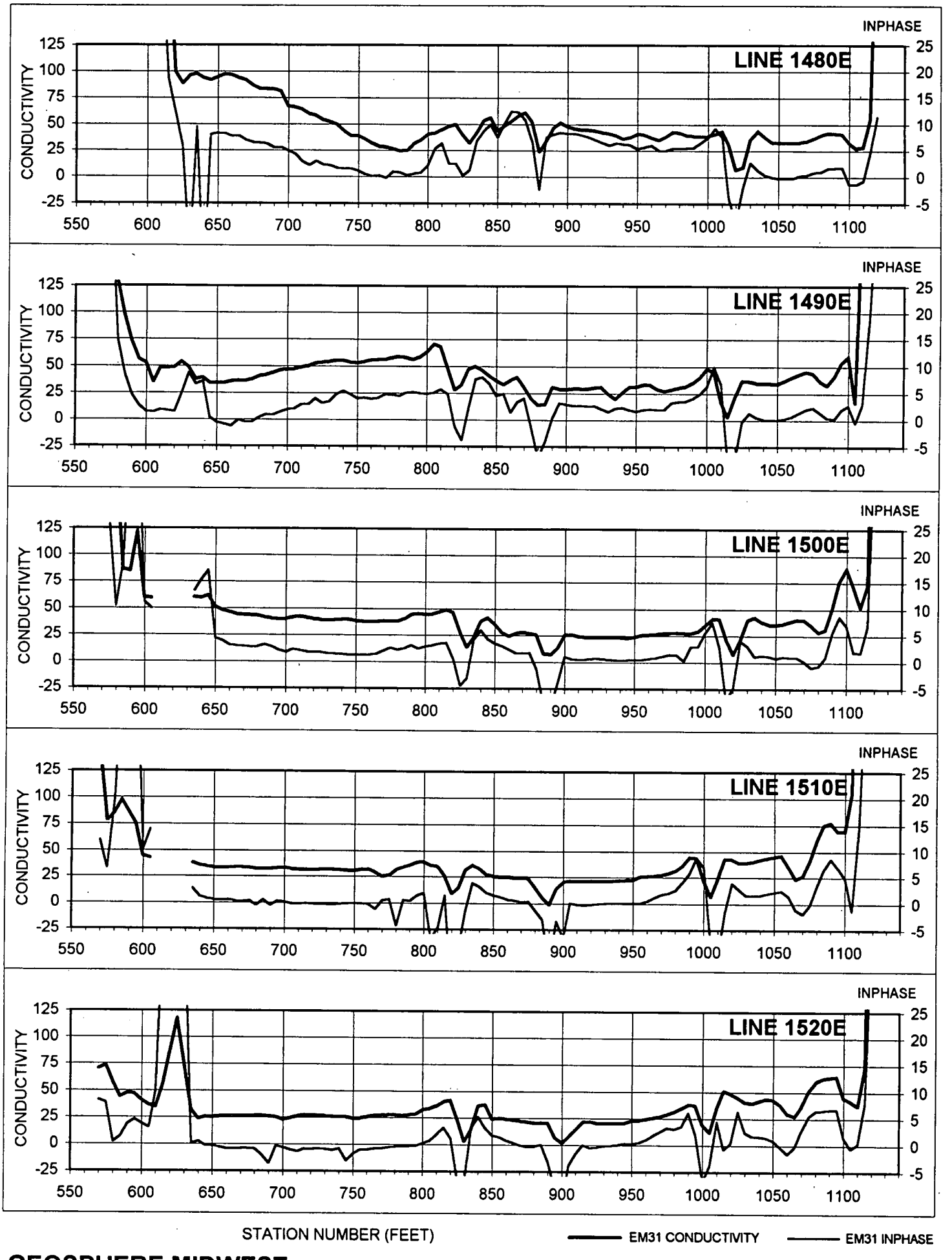
GEOSPHERE MIDWEST

FIGURE B-27



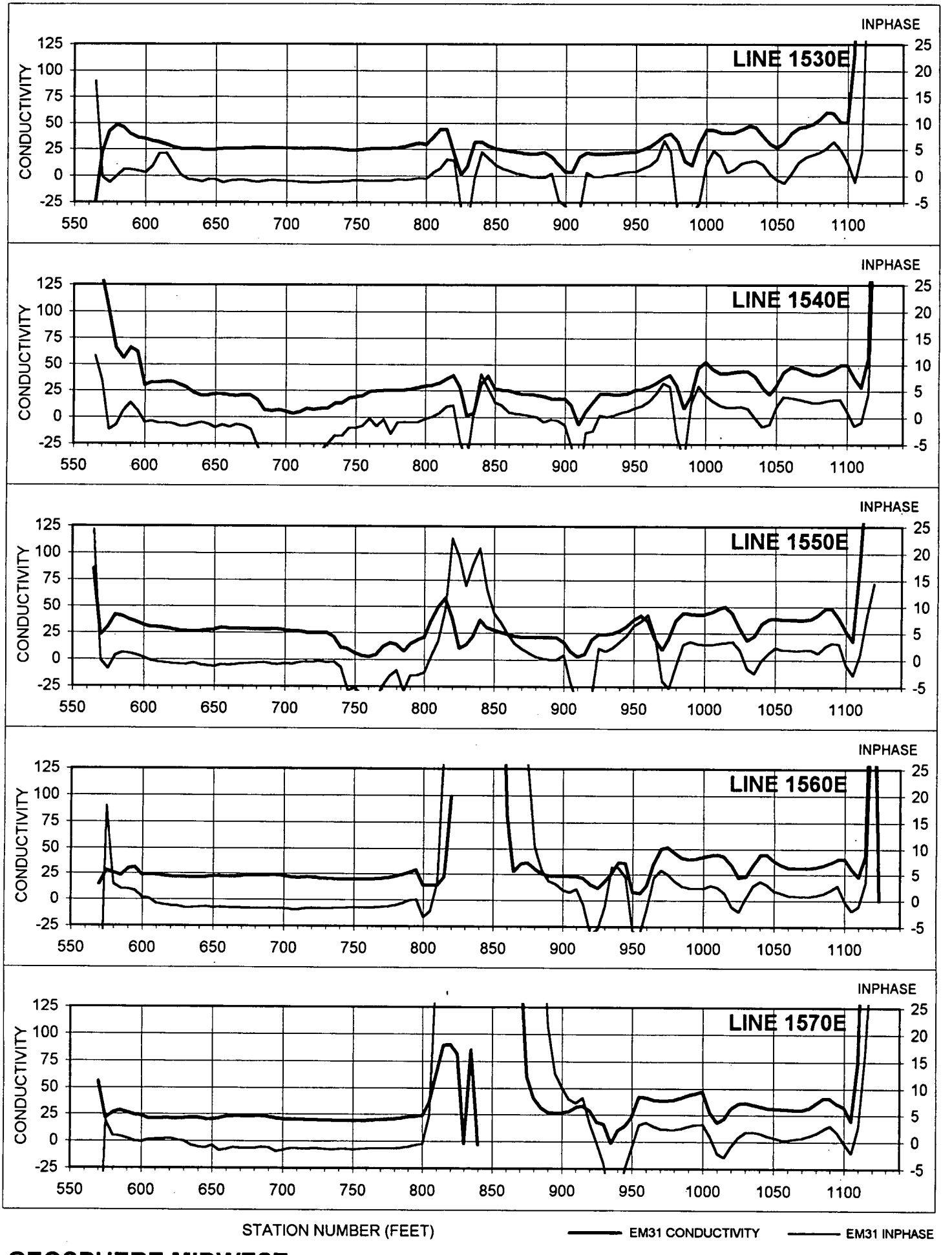
GEOSPHERE MIDWEST

FIGURE B-28



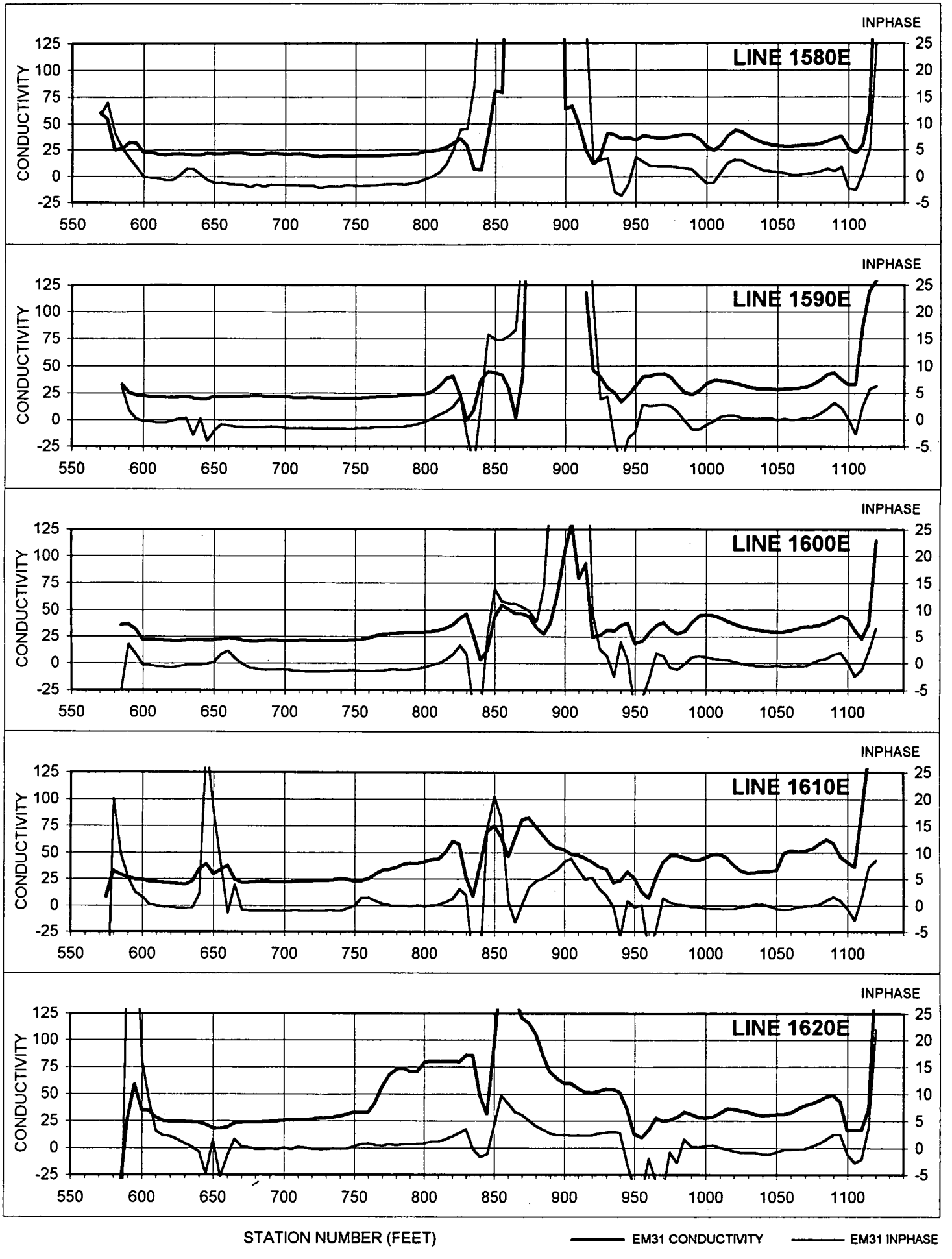
GEOSPHERE MIDWEST

FIGURE B-29



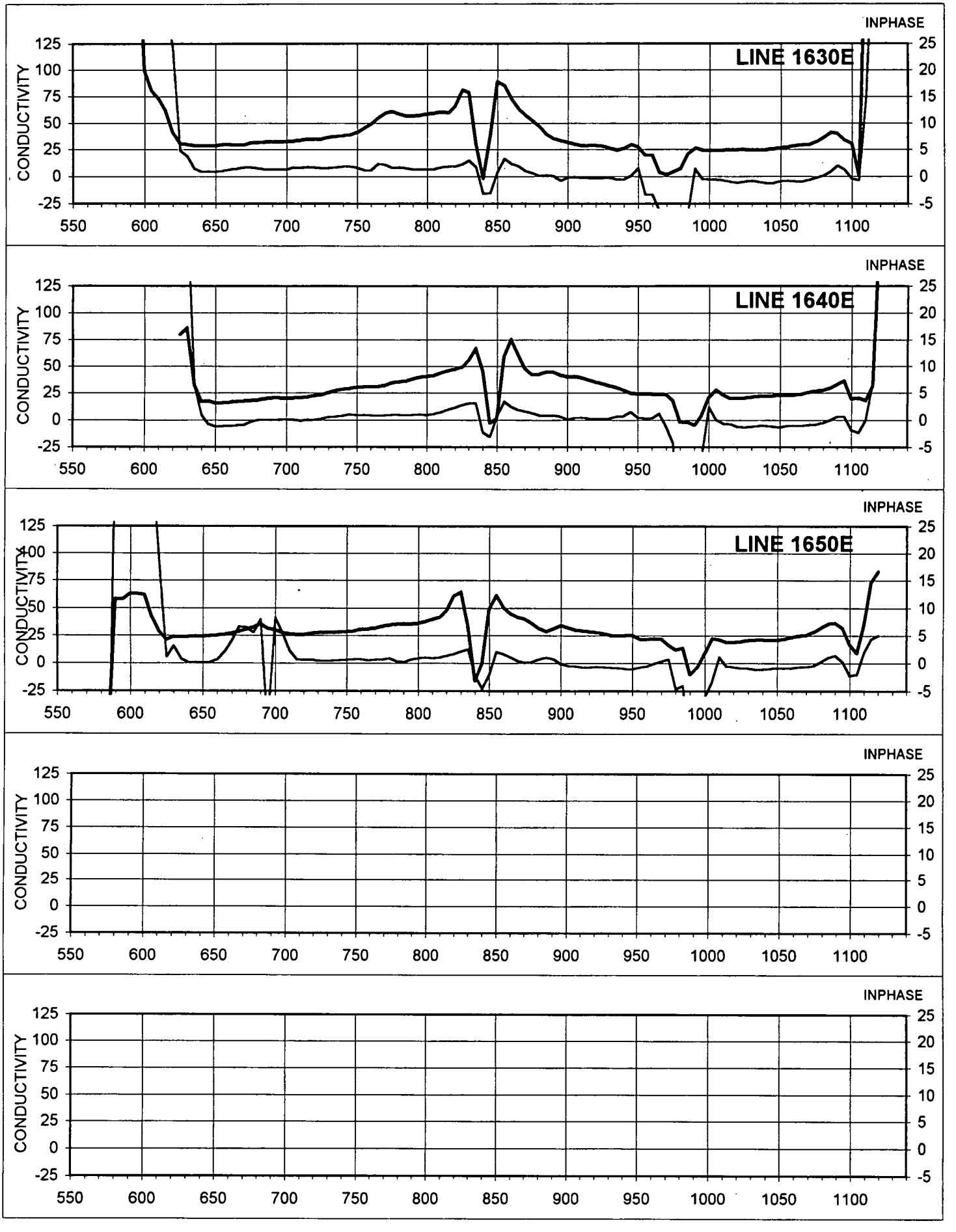
GEOSPHERE MIDWEST

FIGURE B-30



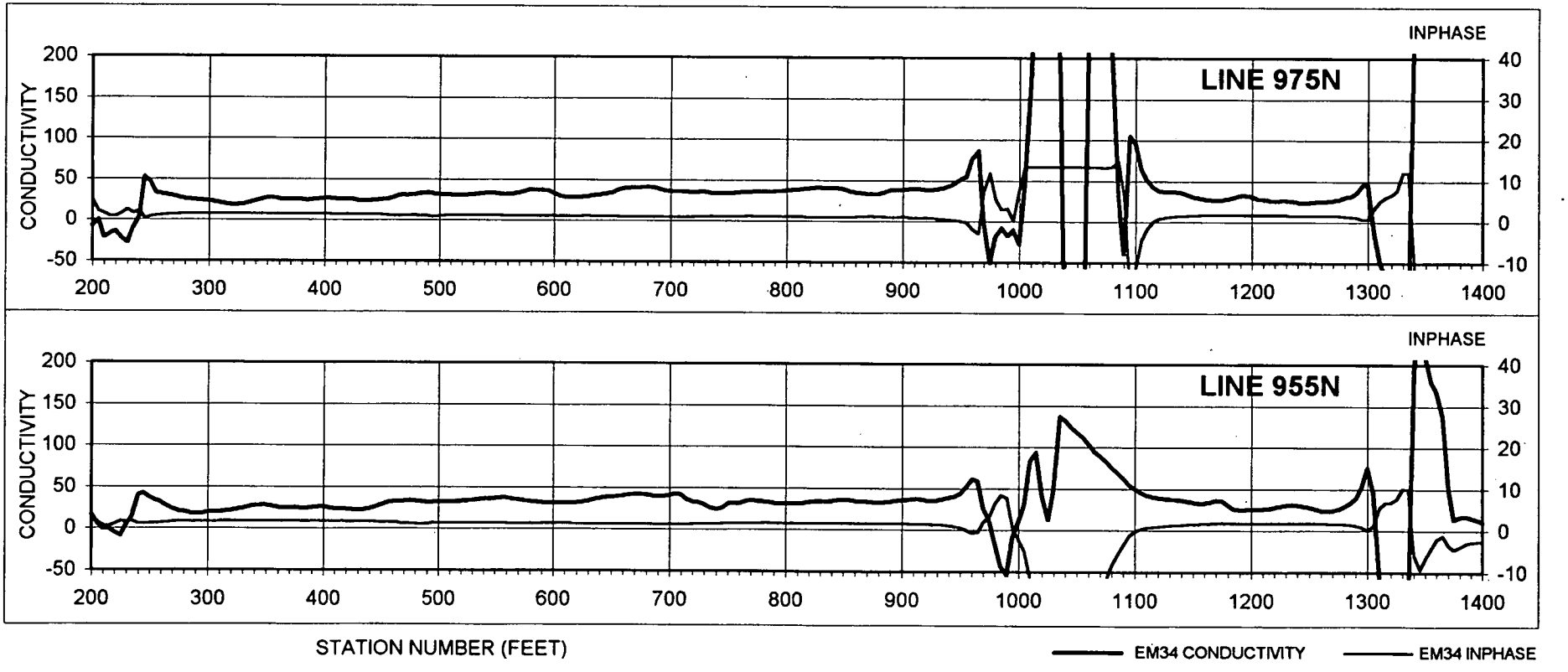
GEOSPHERE MIDWEST

FIGURE B-31



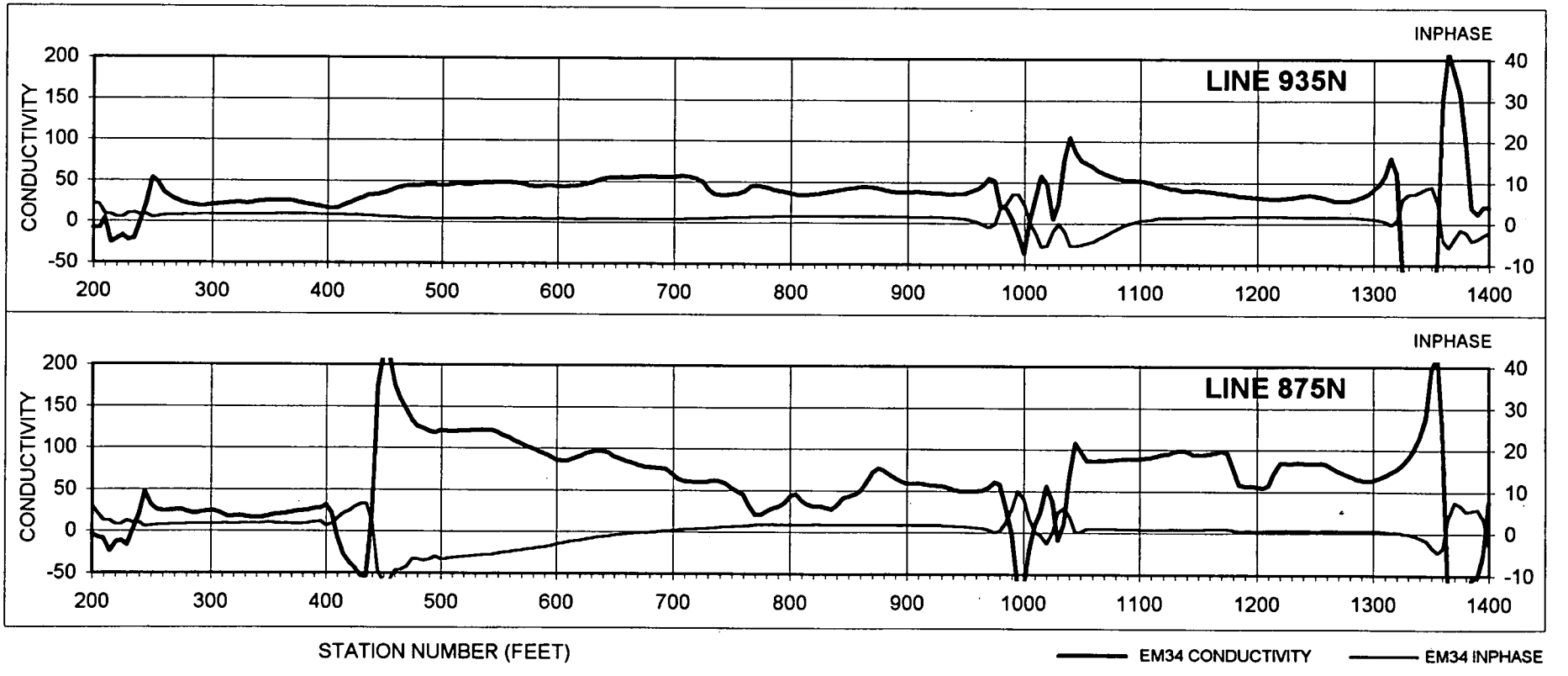
GEOSPHERE MIDWEST

FIGURE B-32



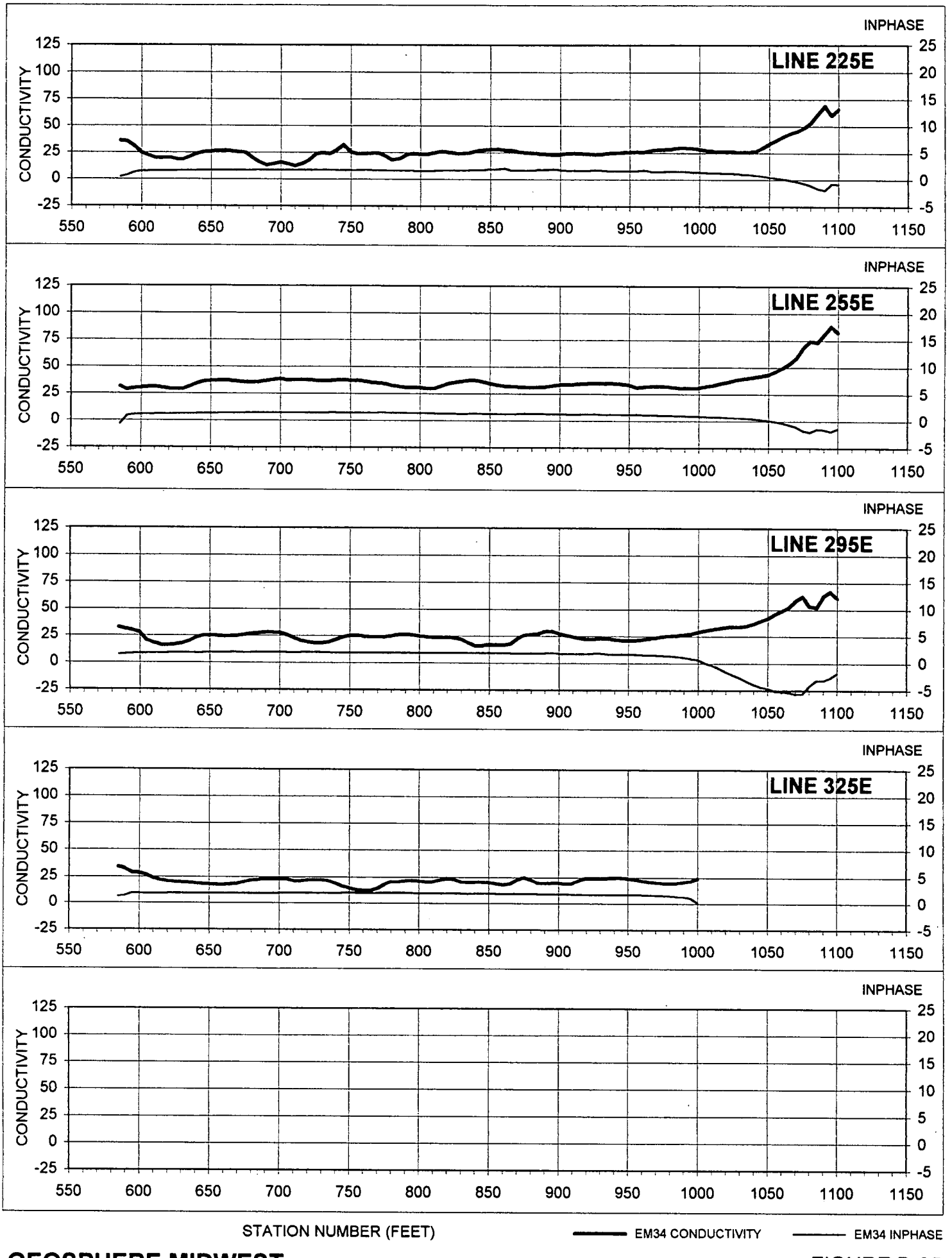
GEOSPHERE MIDWEST

FIGURE B-33



GEOSPHERE MIDWEST

FIGURE B-34



GEOSPHERE MIDWEST

FIGURE B-35

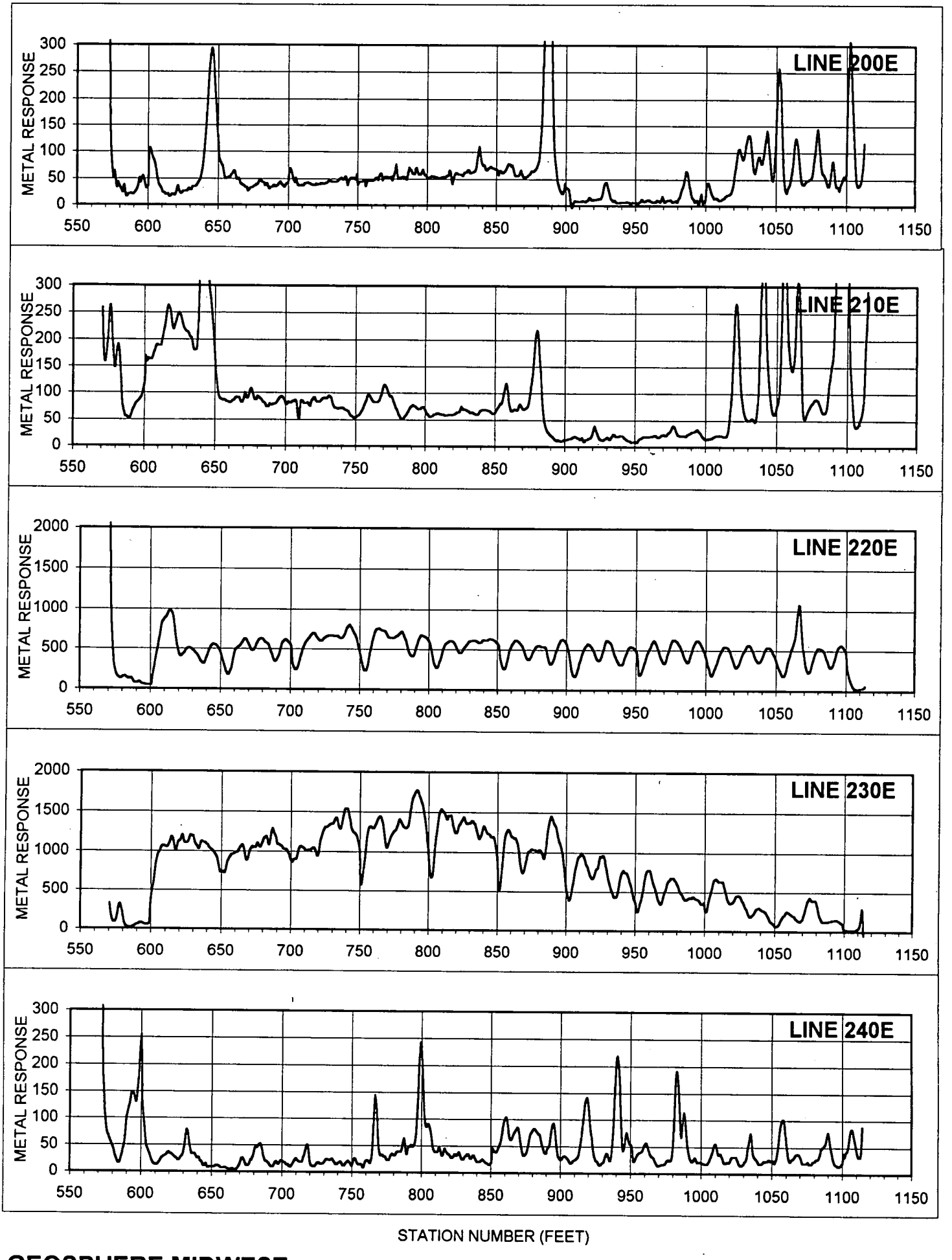
APPENDIX C

EM61 PROFILE DATA

This appendix is a compilation of all EM61 profile data obtained at the subject site. Locations of EM61 lines are given in Figure 3.2. The following profiles include relative metal response (vertical) scales in millivolts and station location labels in feet.

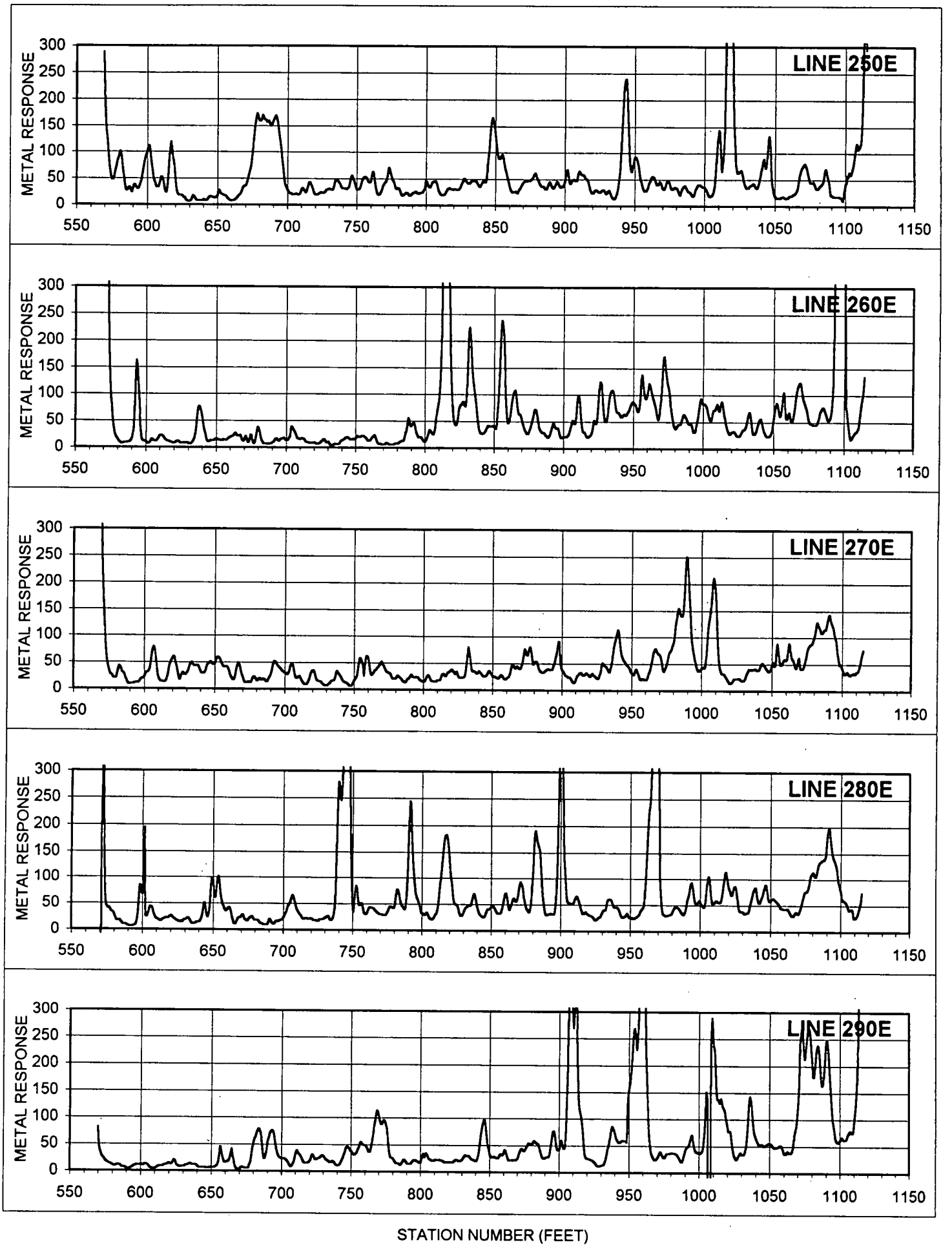
C1. EM61 SURVEY: PROFILES FROM NORTH 40 SITE

Figures C-1 to C-36.



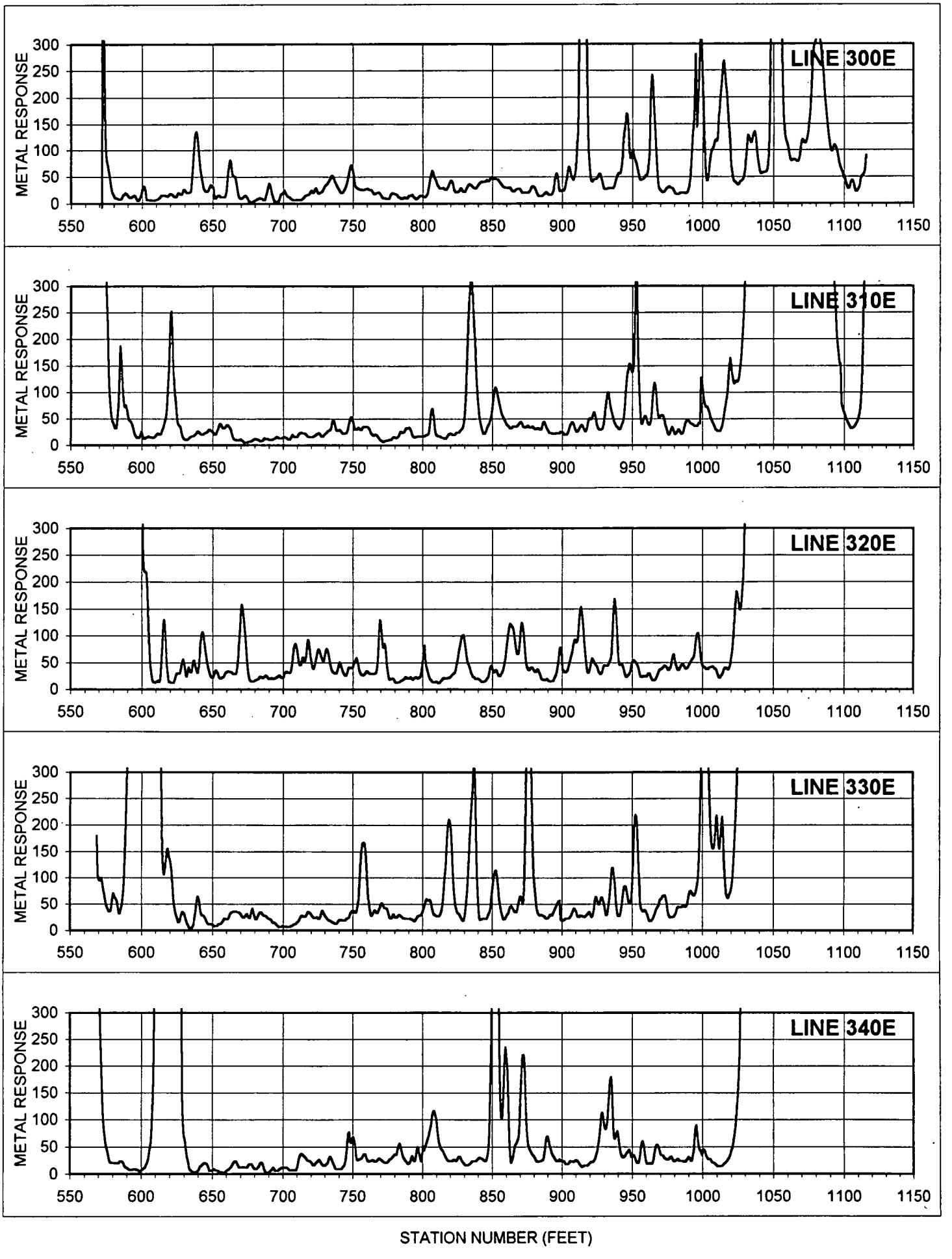
GEOSPHERE MIDWEST

FIGURE C-1



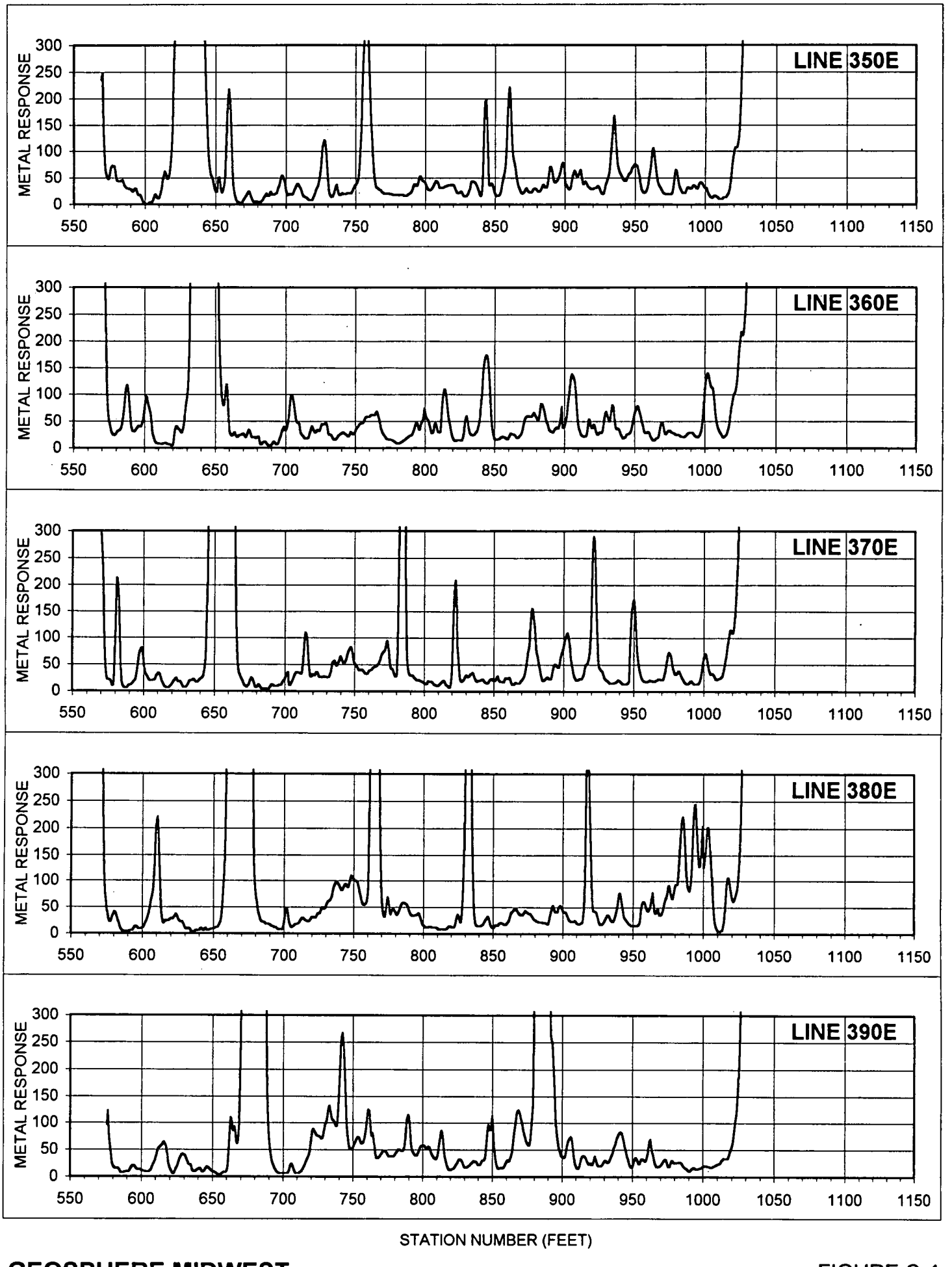
GEOSPHERE MIDWEST

FIGURE C-2



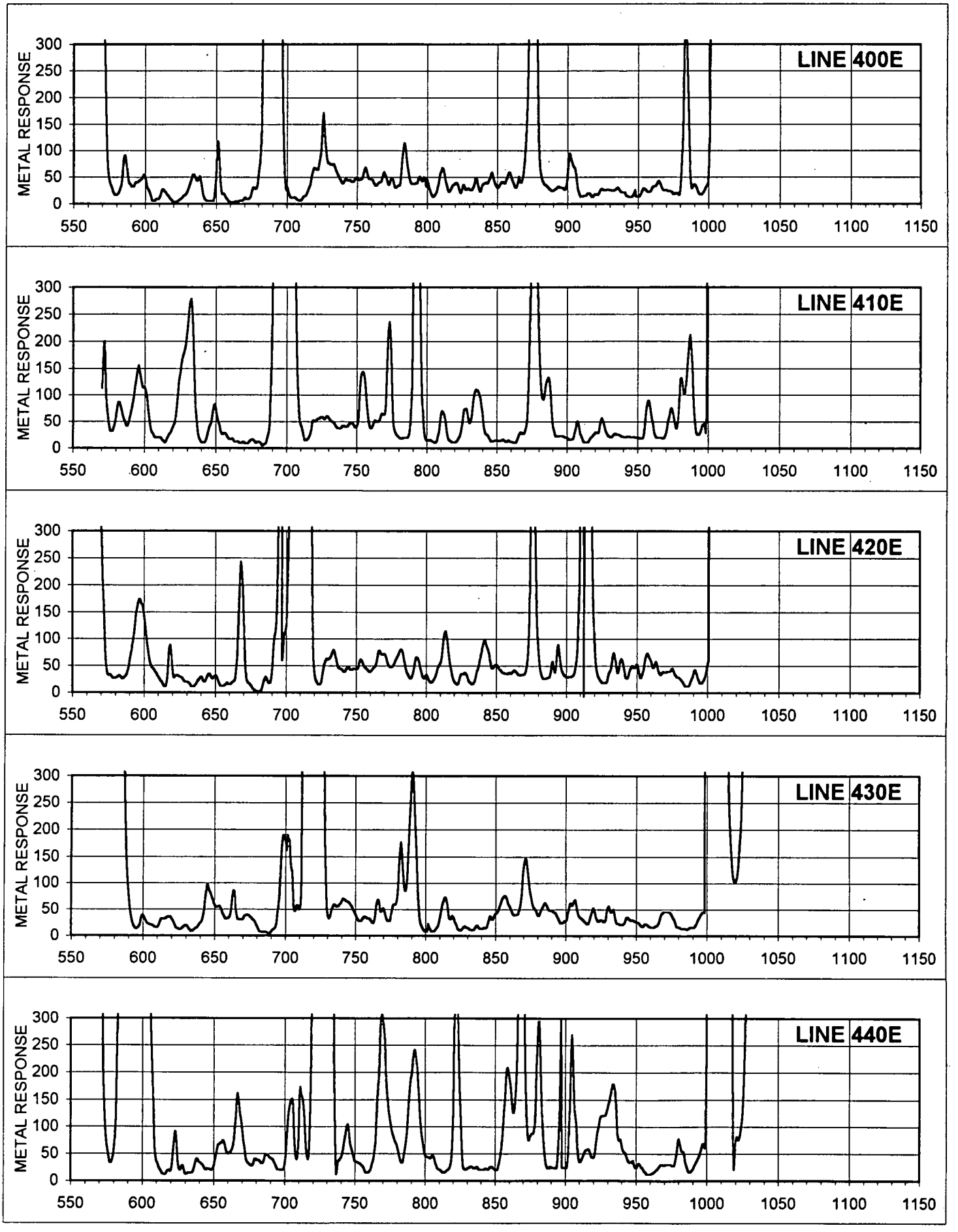
GEOSPHERE MIDWEST

FIGURE C-3



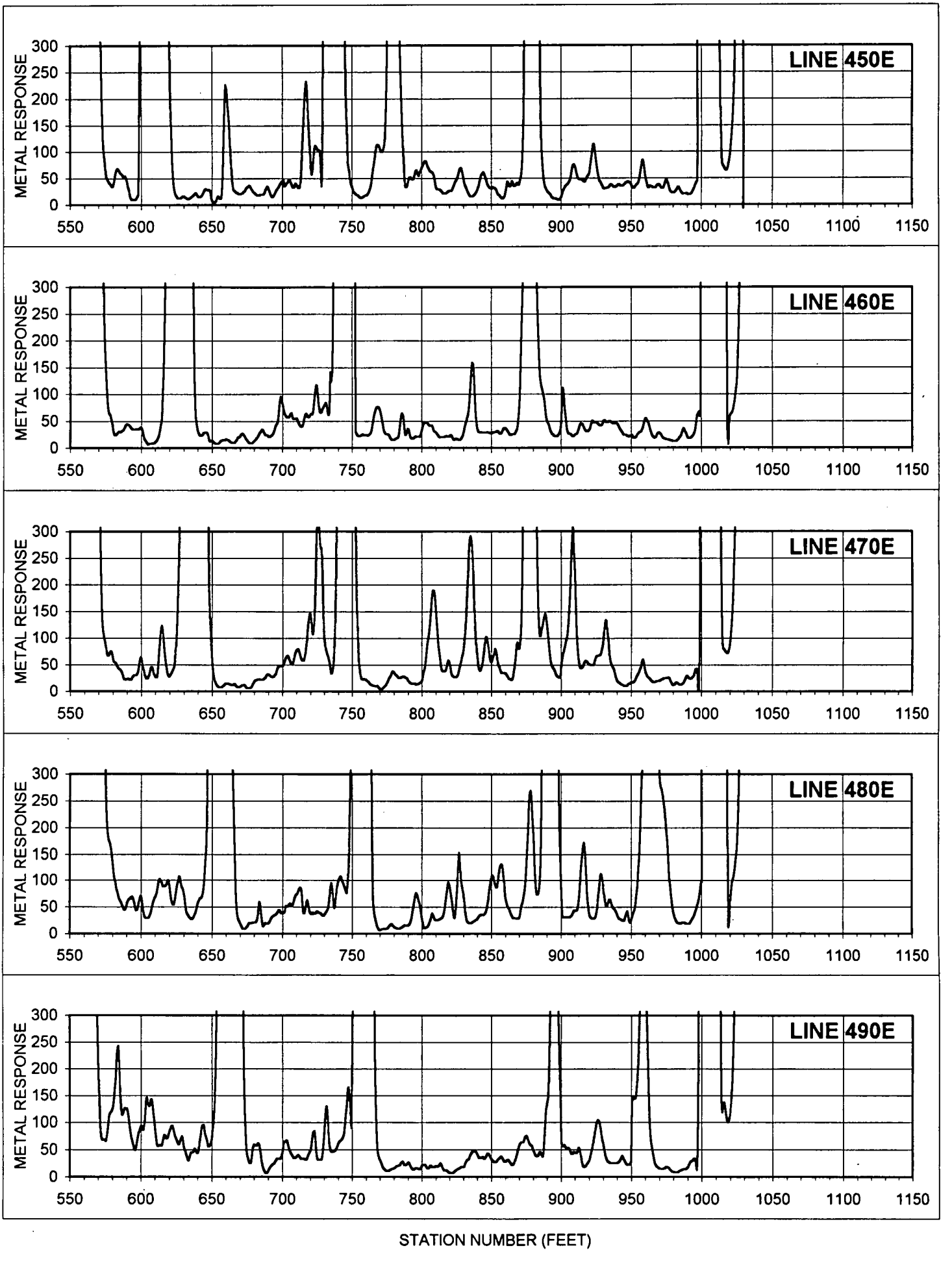
GEOSPHERE MIDWEST

FIGURE C-4



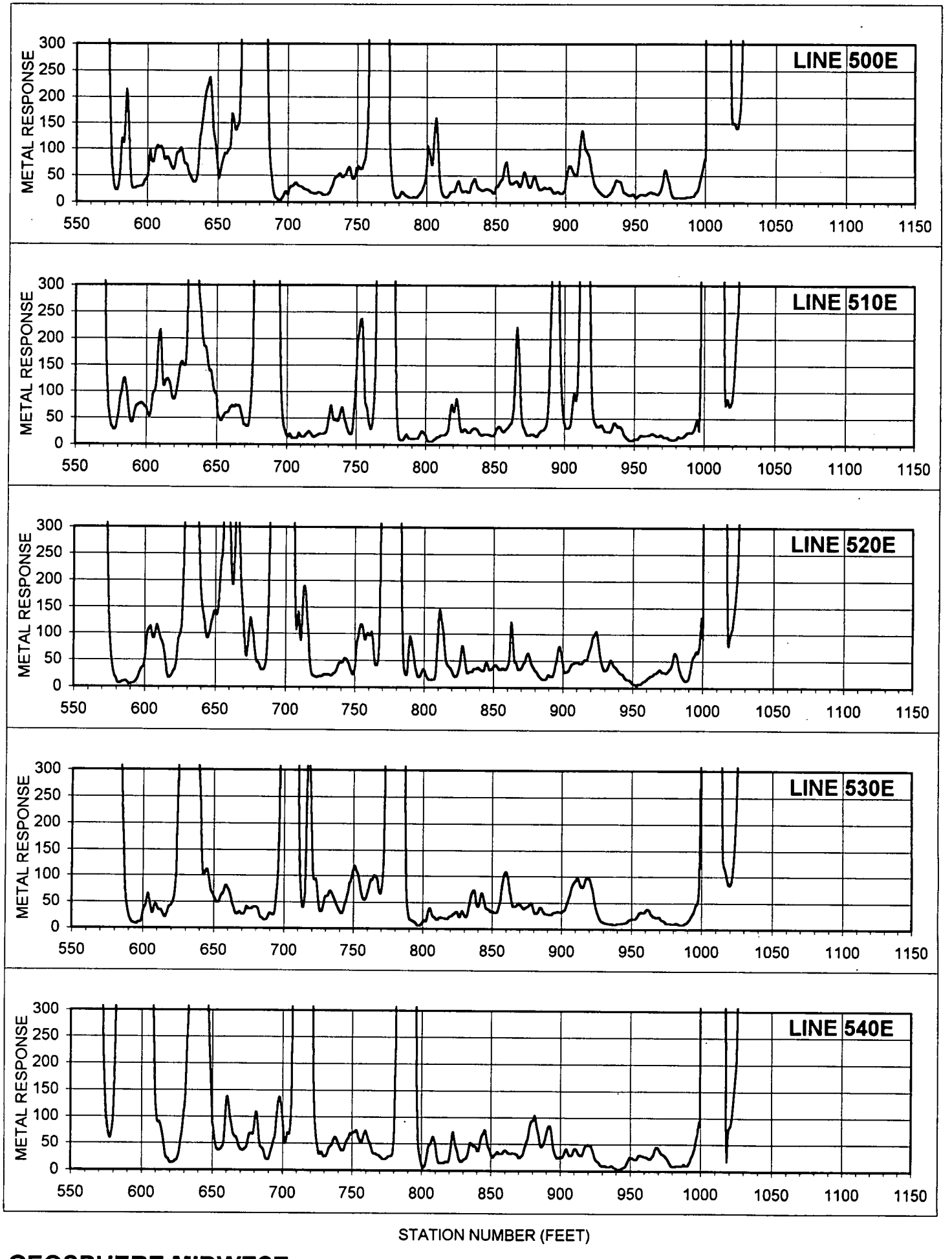
GEOSPHERE MIDWEST

FIGURE C-5



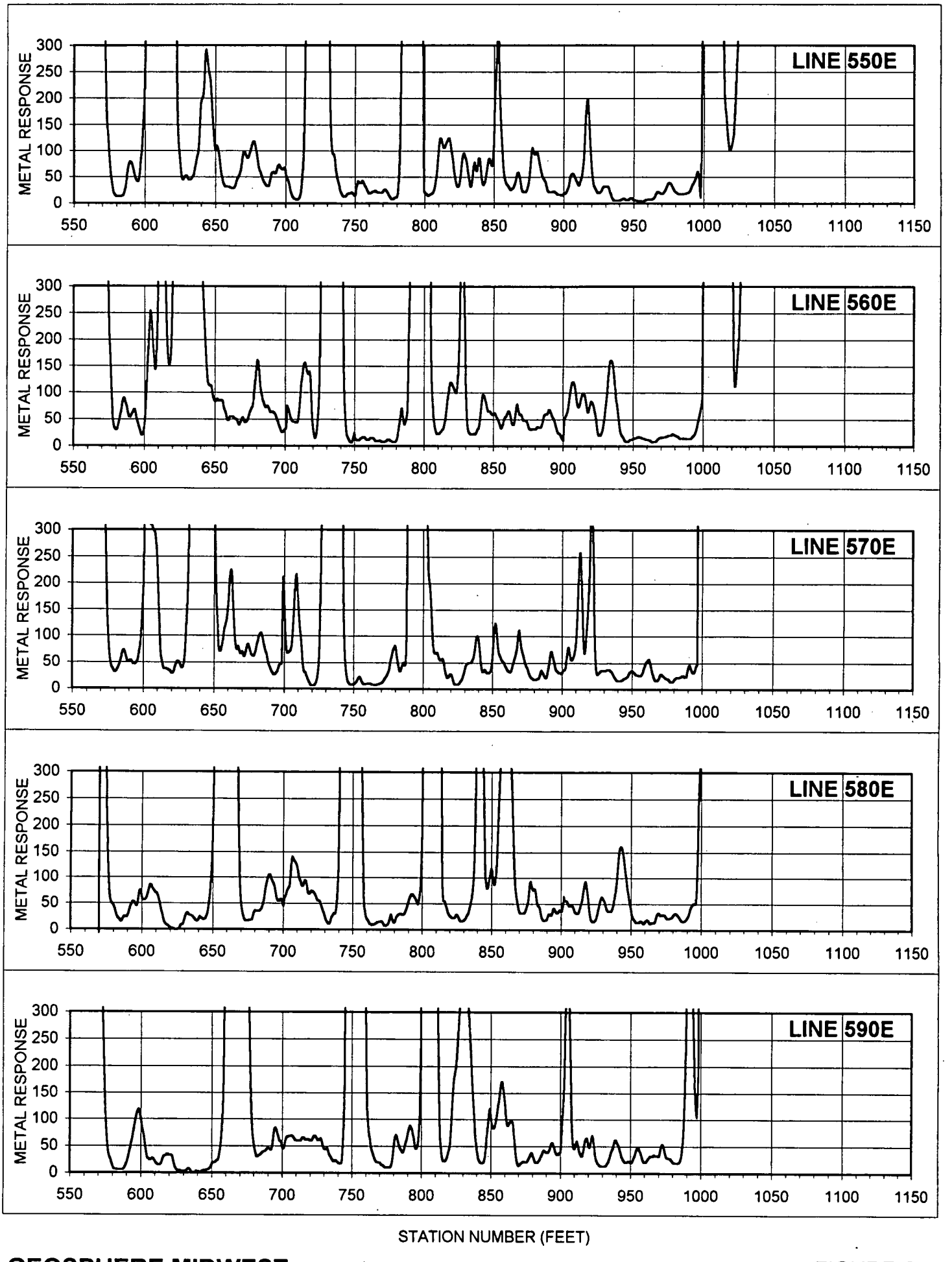
GEOSPHERE MIDWEST

FIGURE C-6



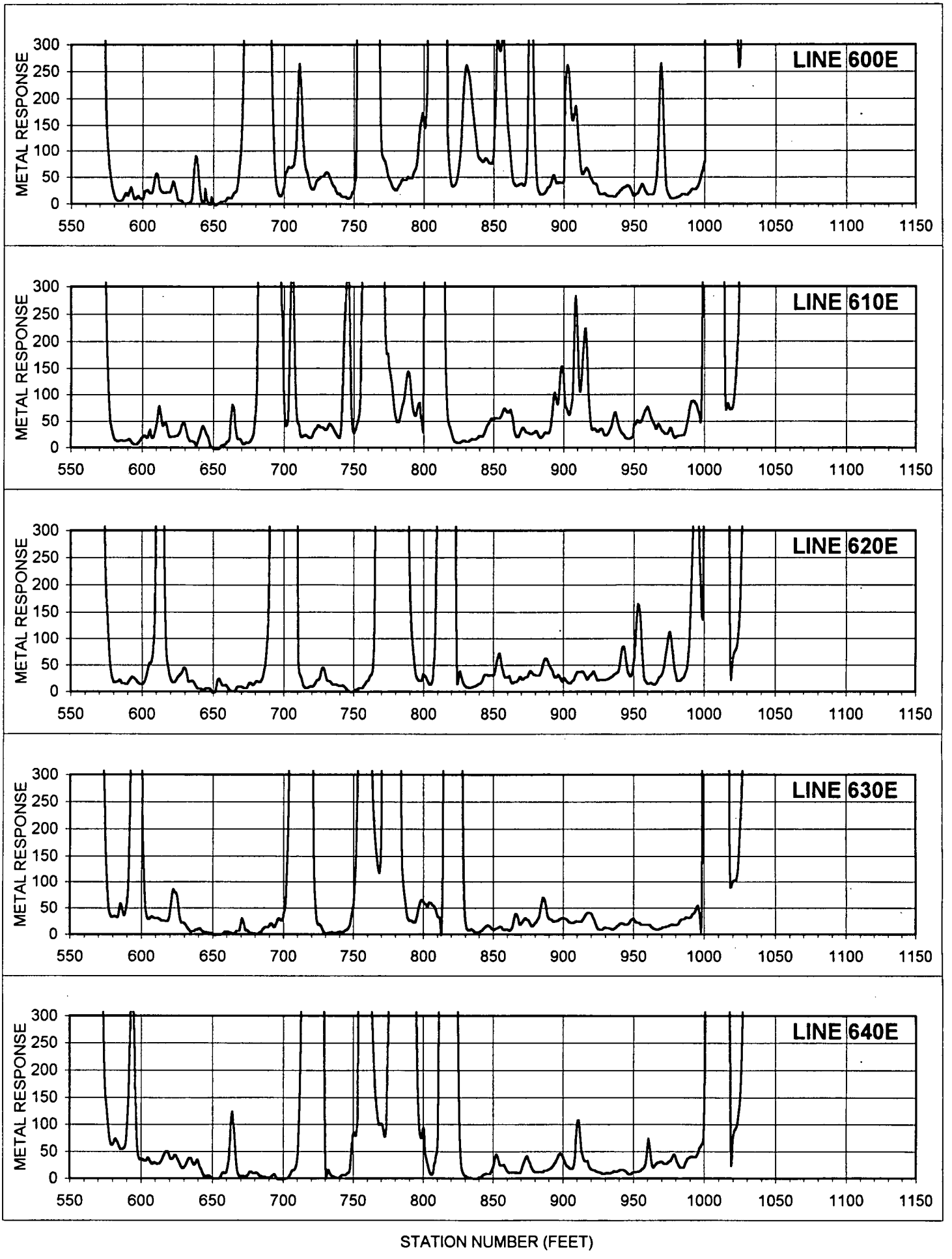
GEOSPHERE MIDWEST

FIGURE C-7



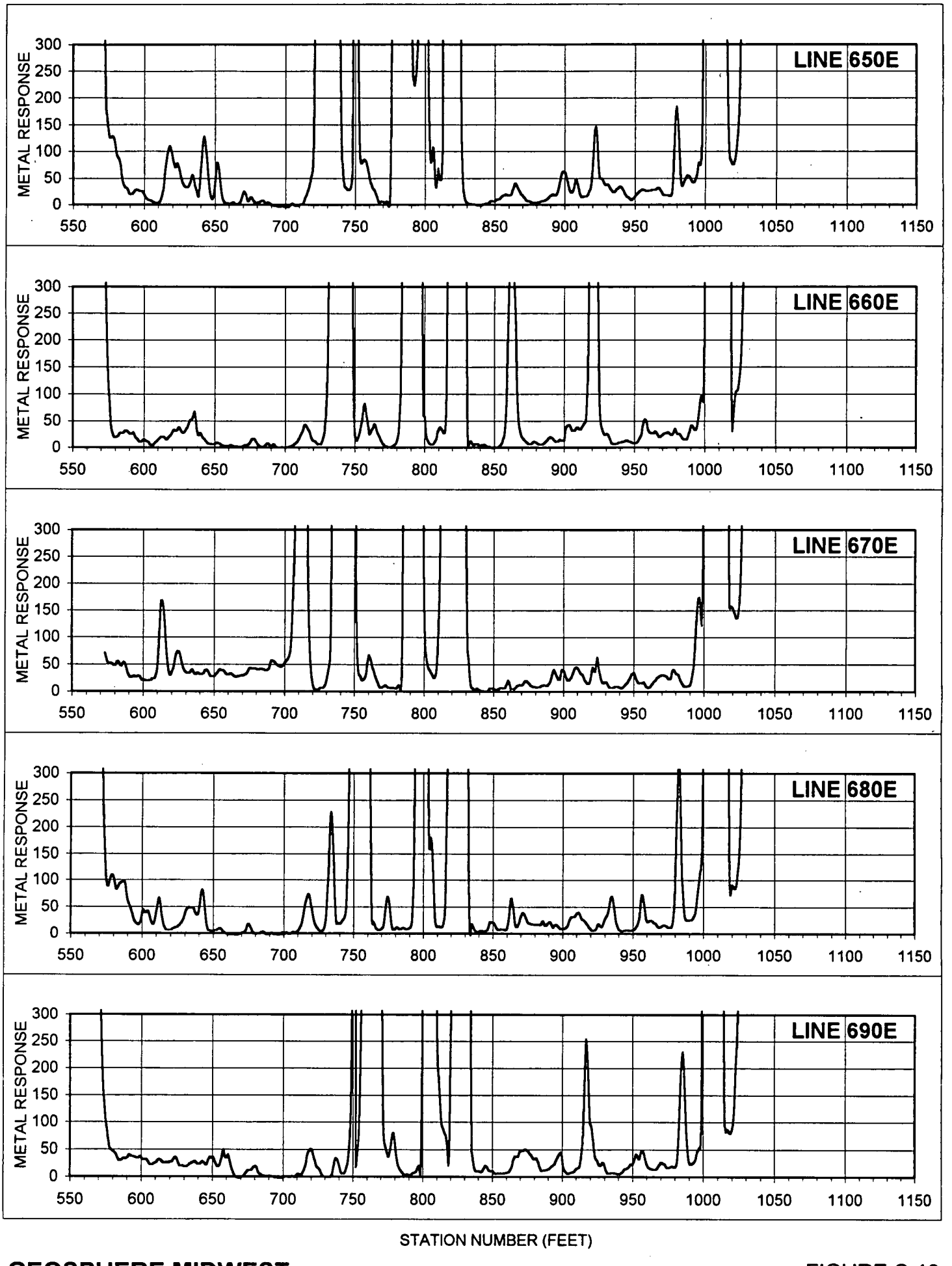
GEOSPHERE MIDWEST

FIGURE C-8



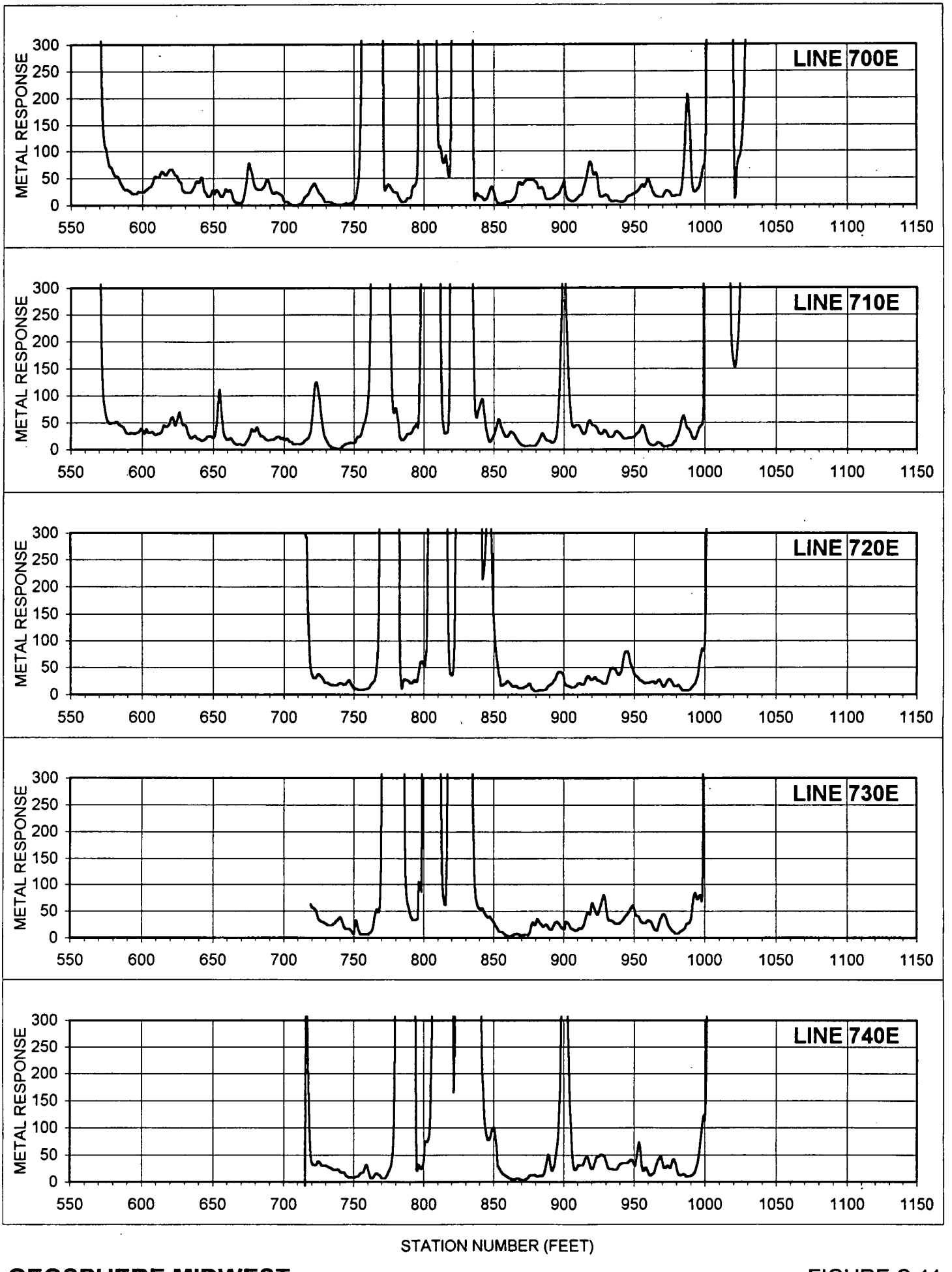
GEOSPHERE MIDWEST

FIGURE C-9



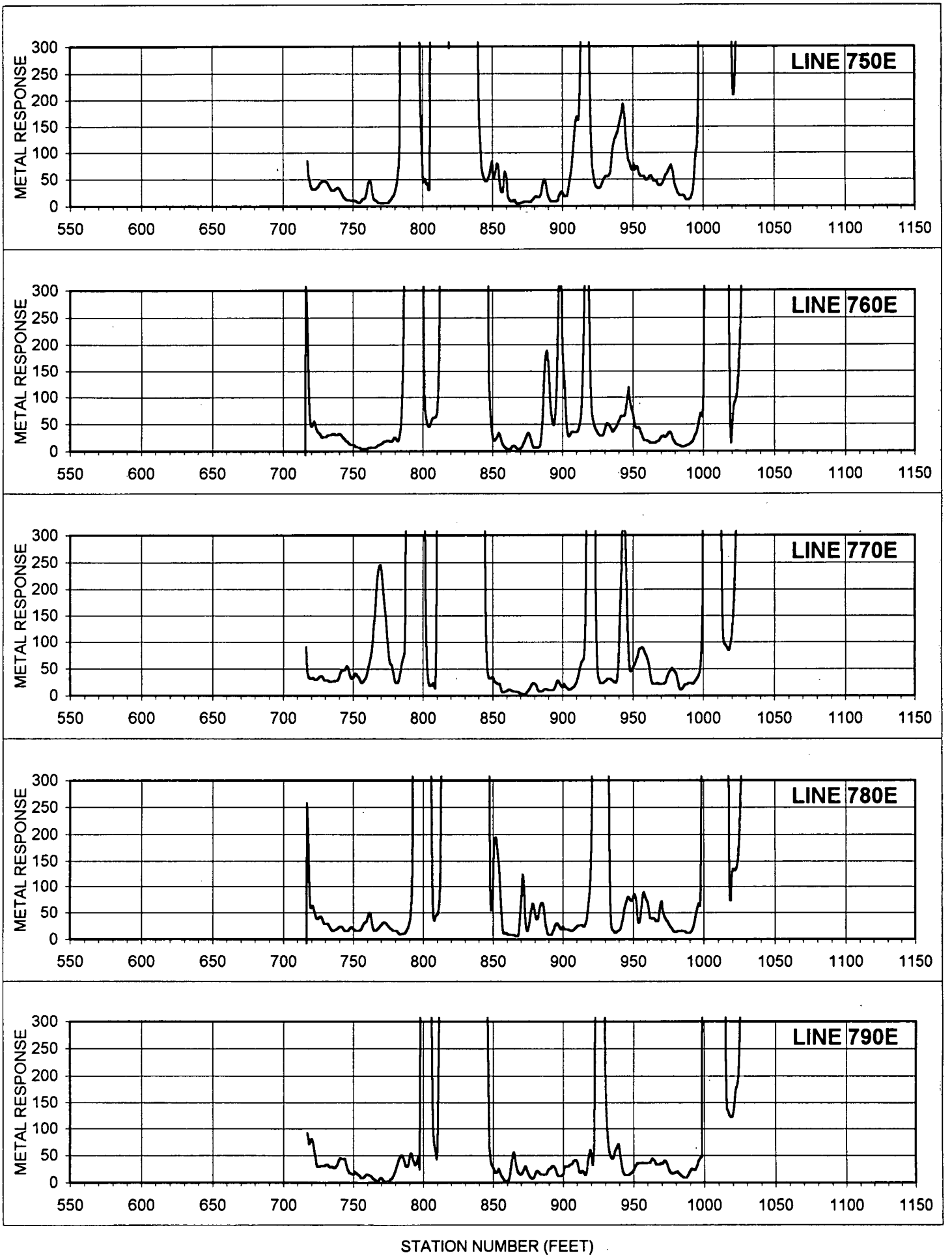
GEOSPHERE MIDWEST

FIGURE C-10



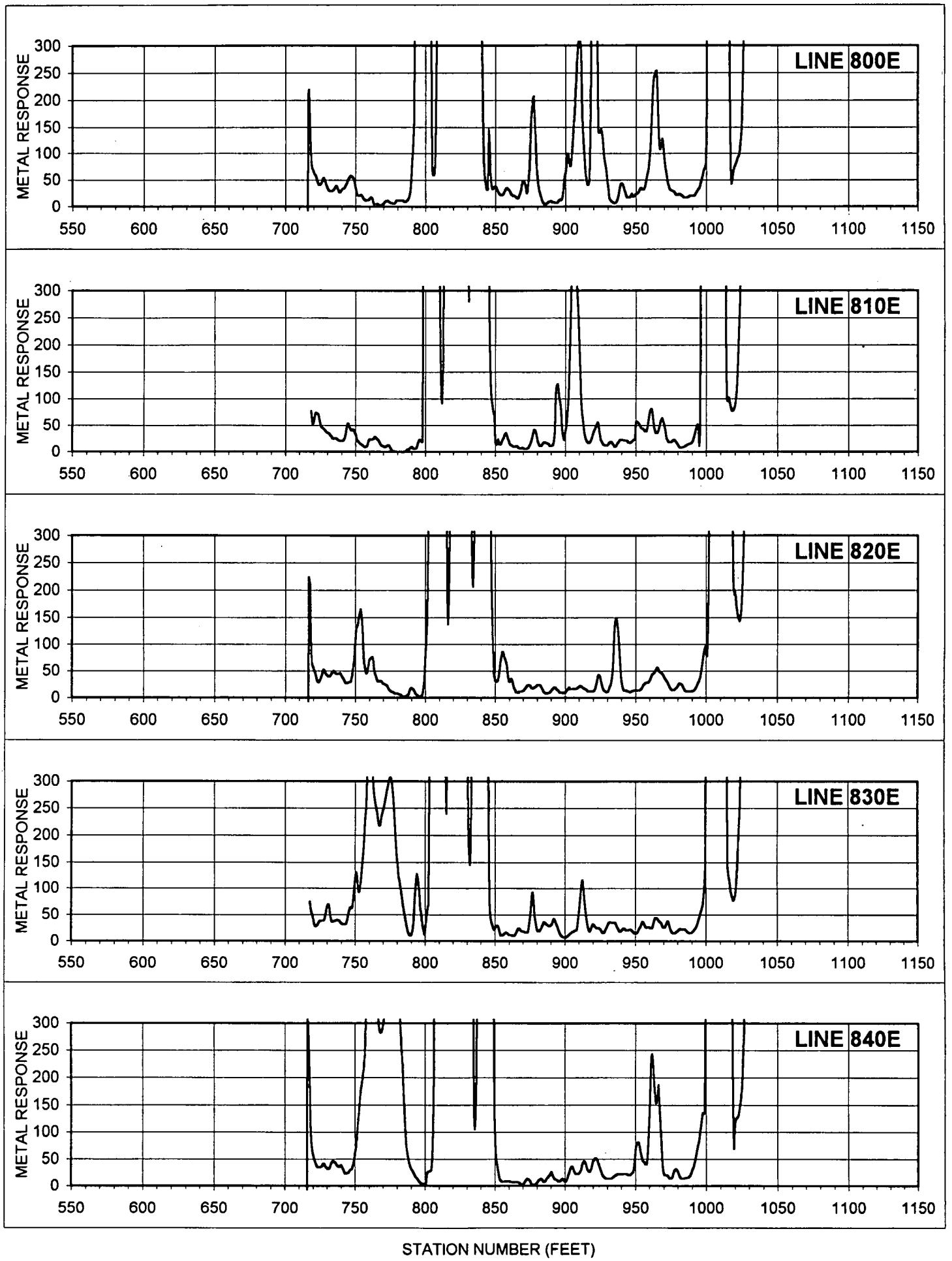
GEOSPHERE MIDWEST

FIGURE C-11



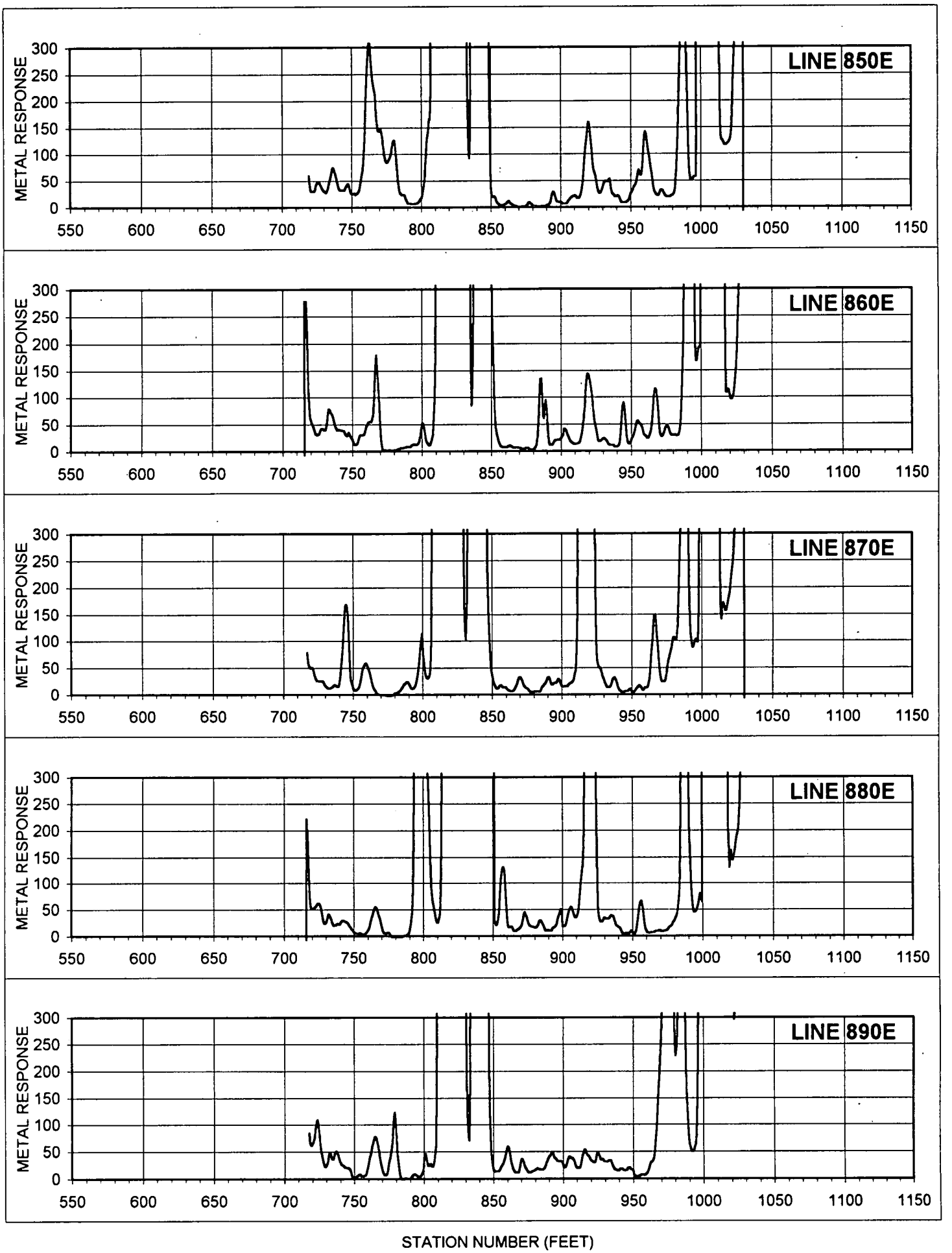
GEOSPHERE MIDWEST

FIGURE C-12



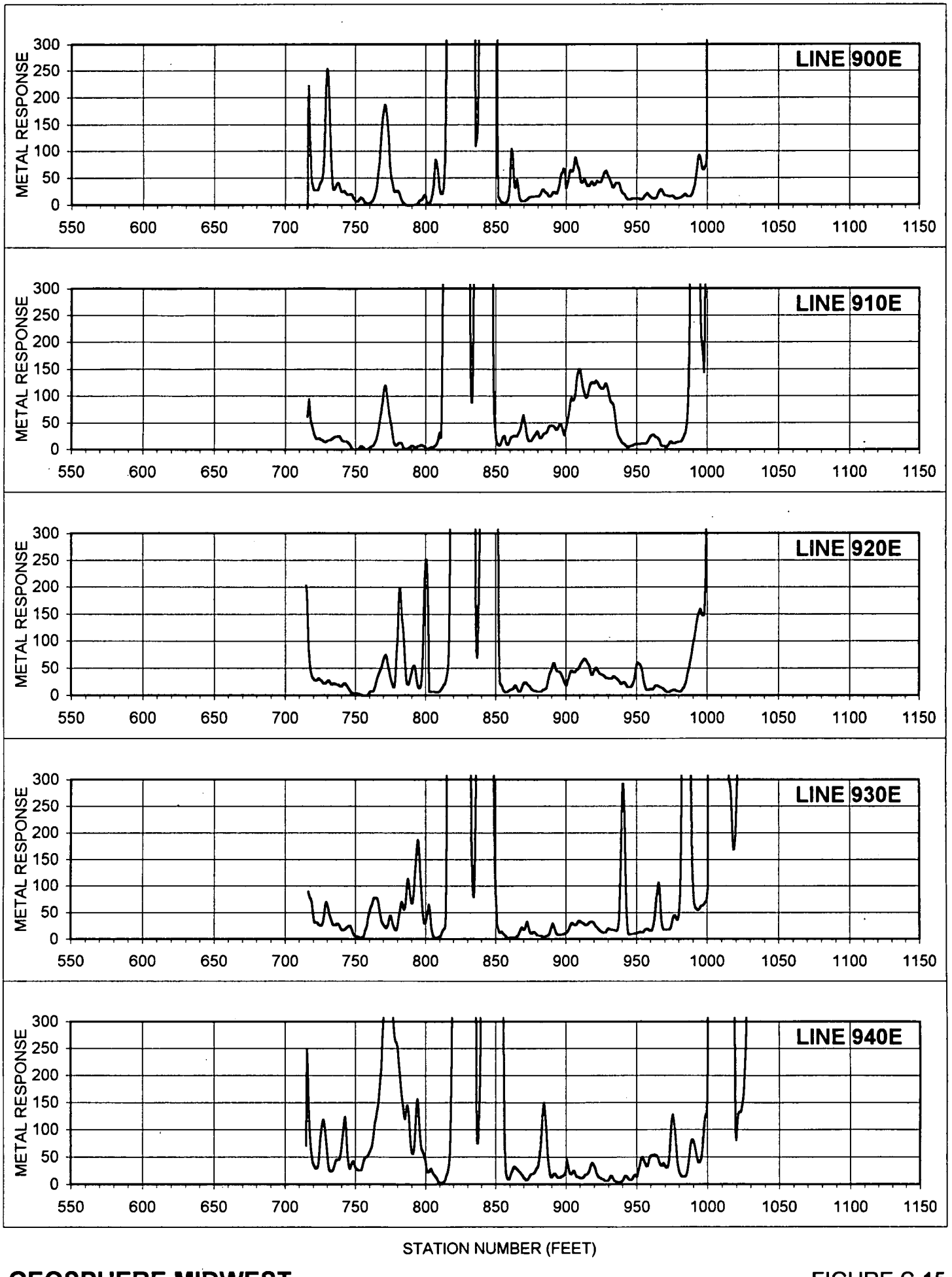
GEOSPHERE MIDWEST

FIGURE C-13



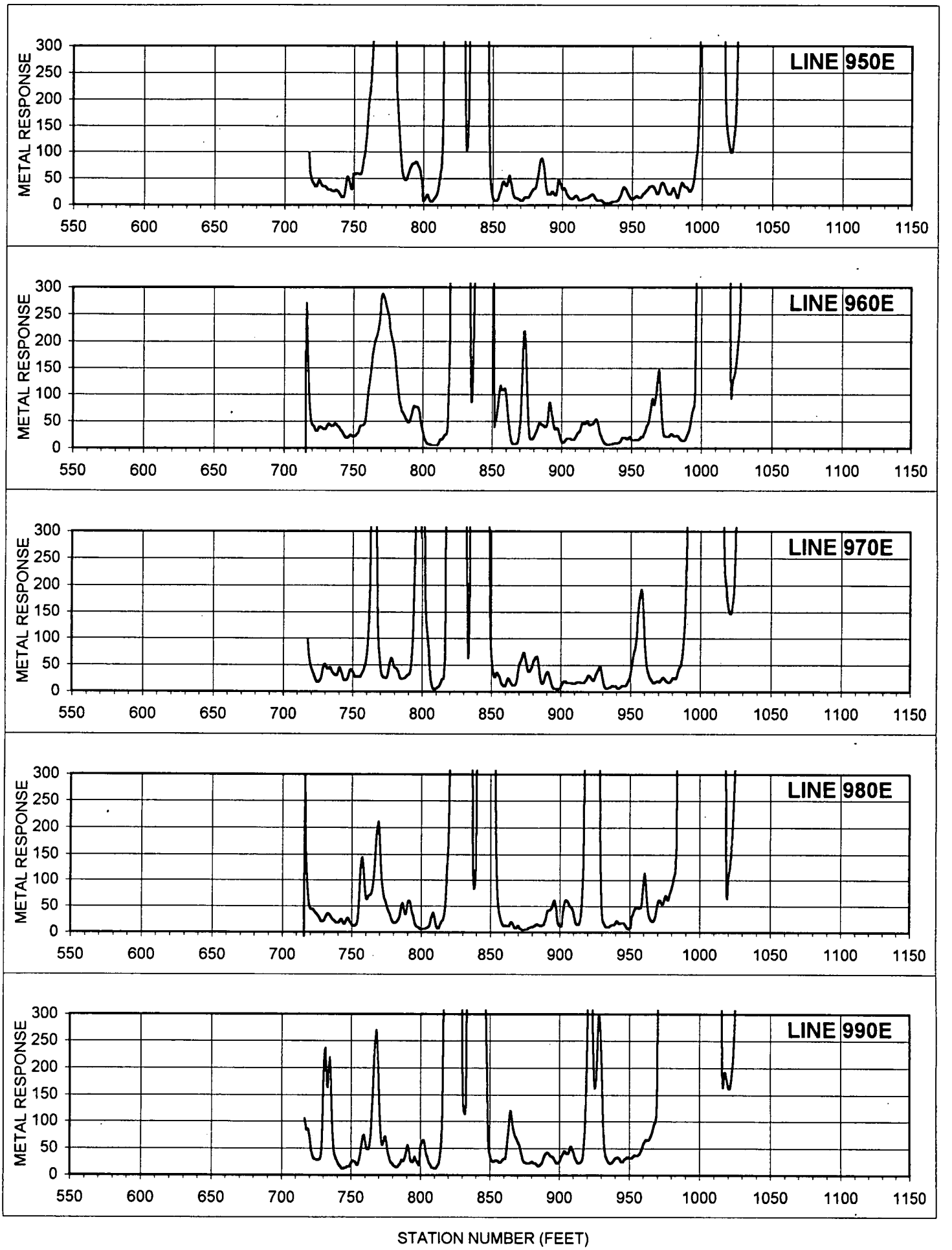
GEOSPHERE MIDWEST

FIGURE C-14



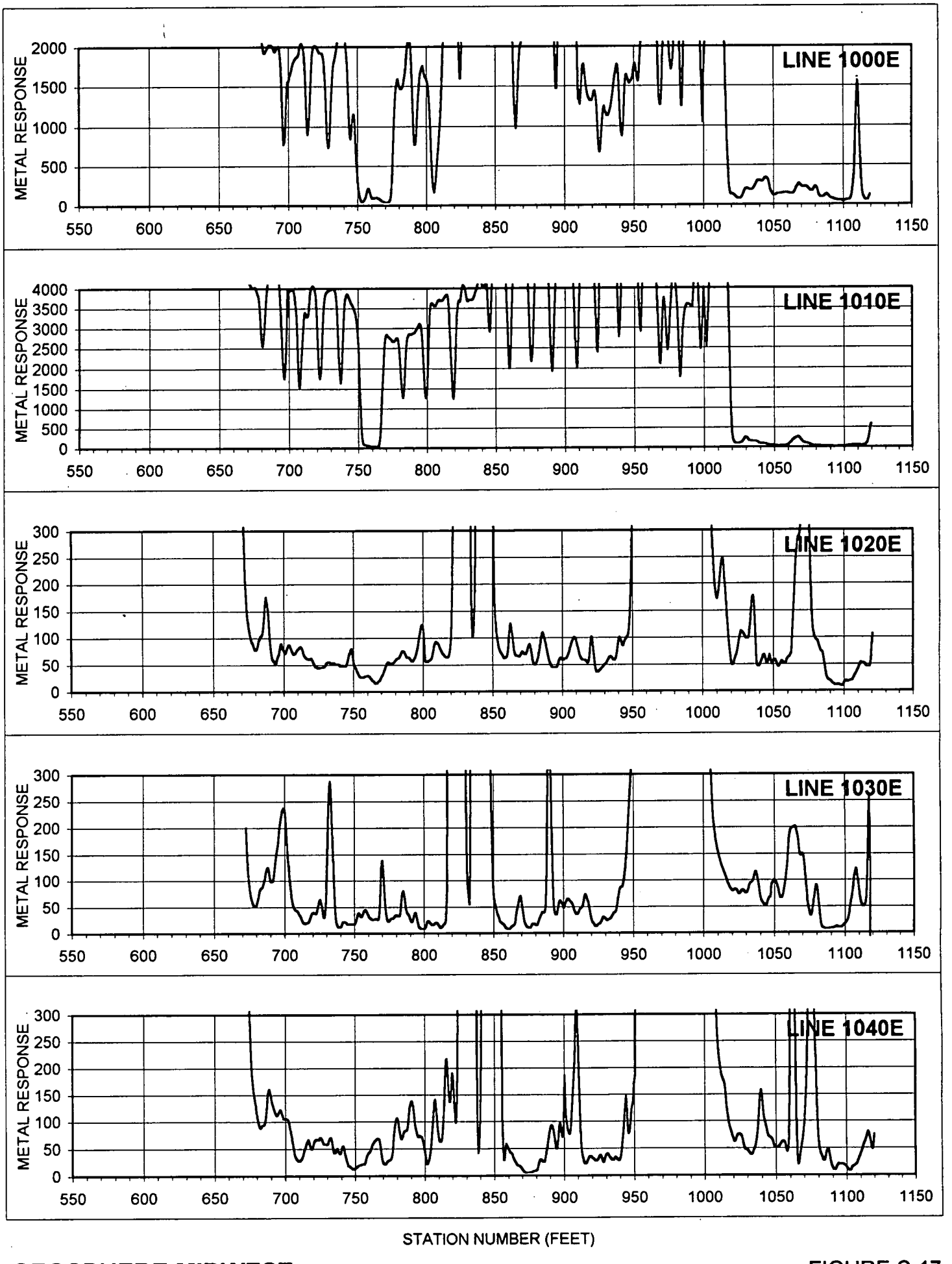
GEOSPHERE MIDWEST

FIGURE C-15



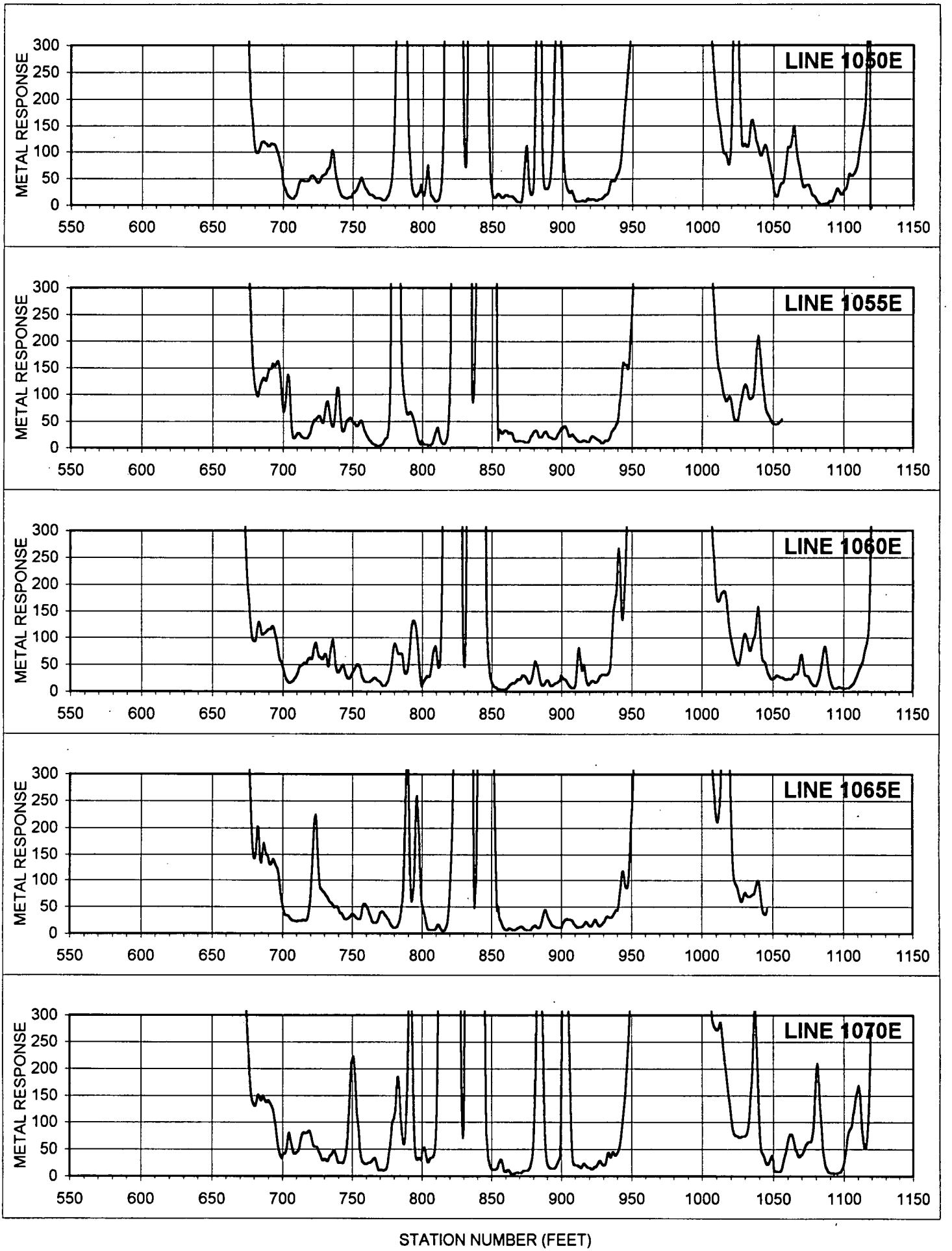
GEOSPHERE MIDWEST

FIGURE C-16



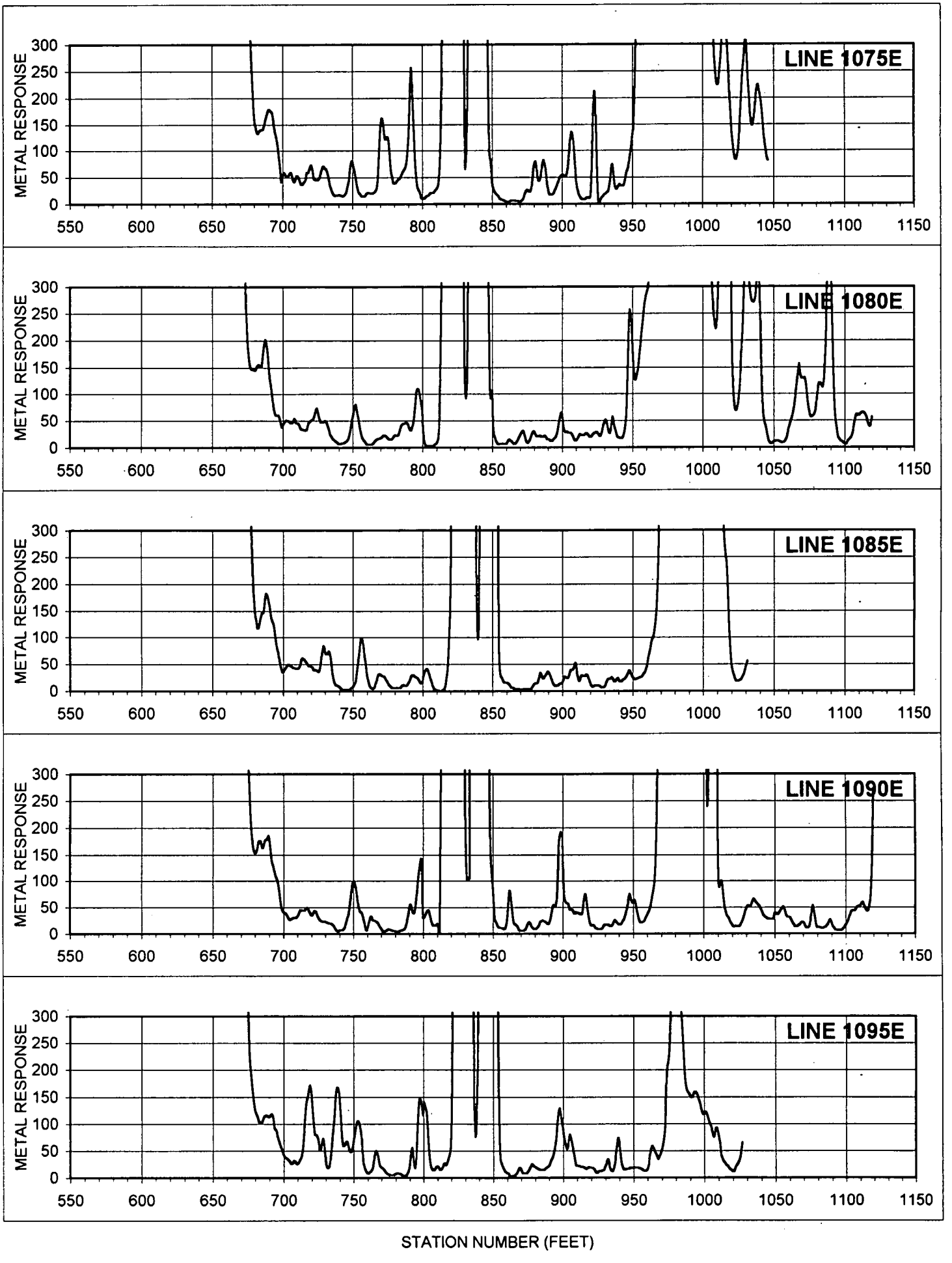
GEOSPHERE MIDWEST

FIGURE C-17



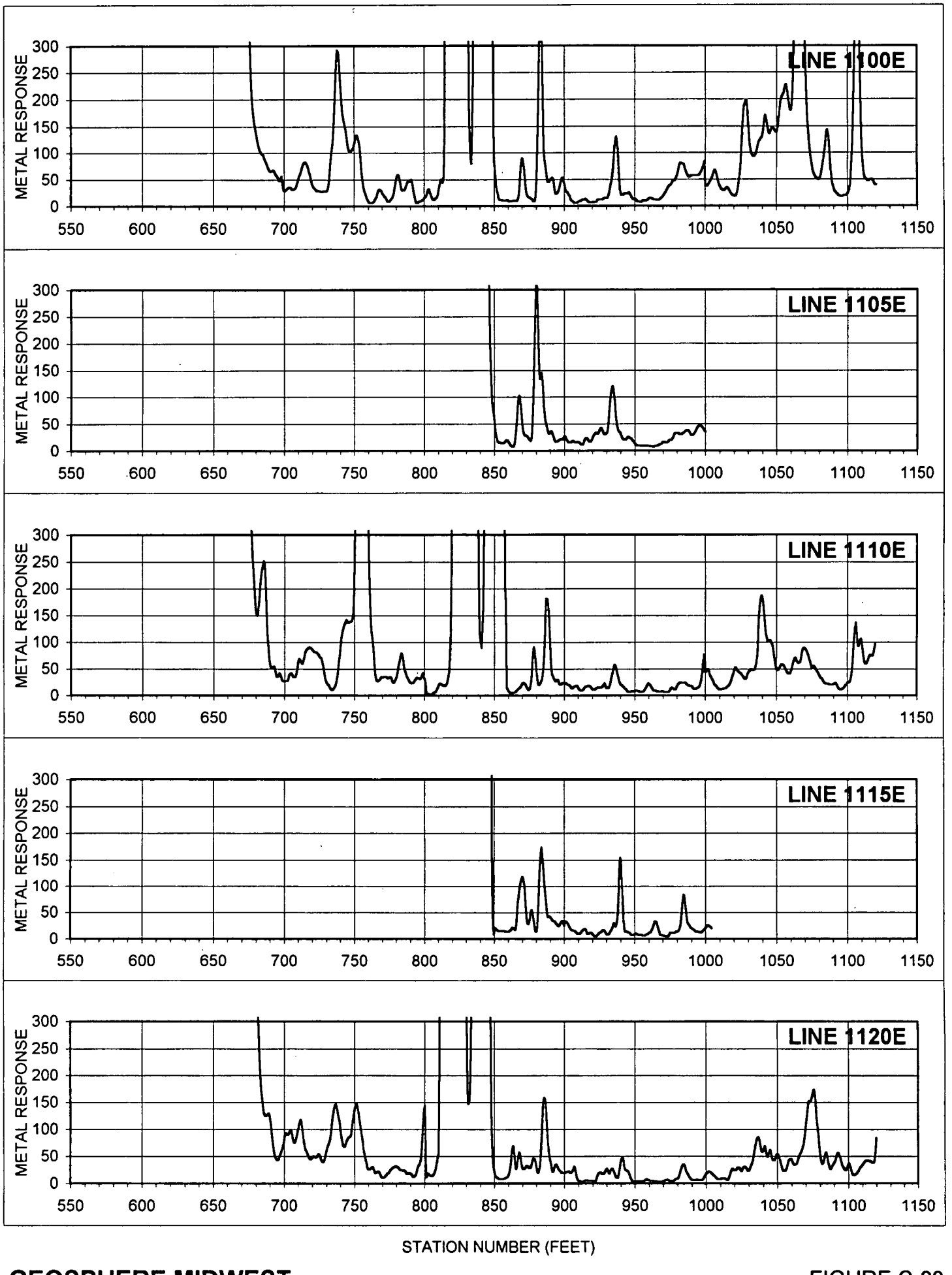
GEOSPHERE MIDWEST

FIGURE C-18



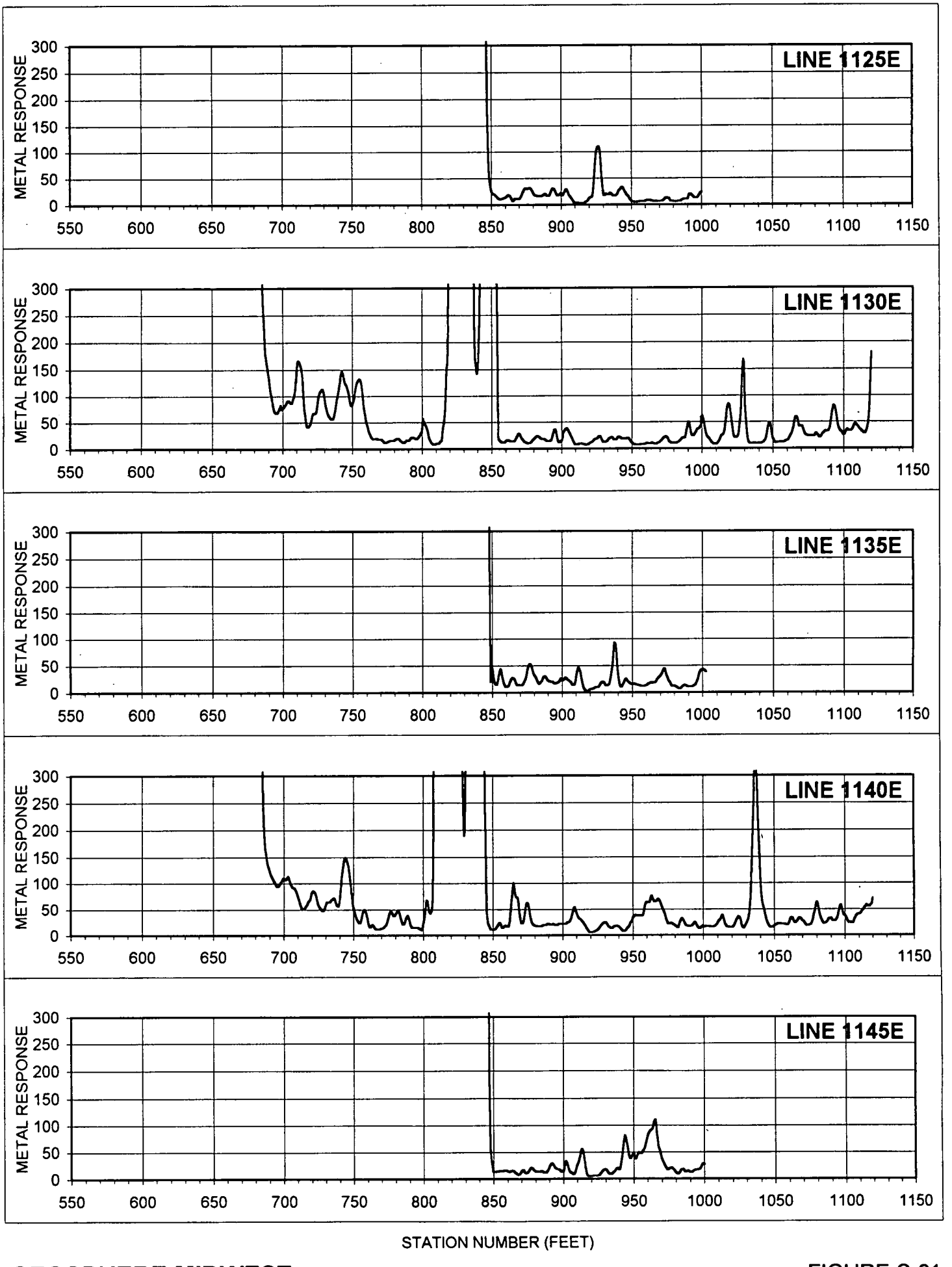
GEOSPHERE MIDWEST

FIGURE C-19



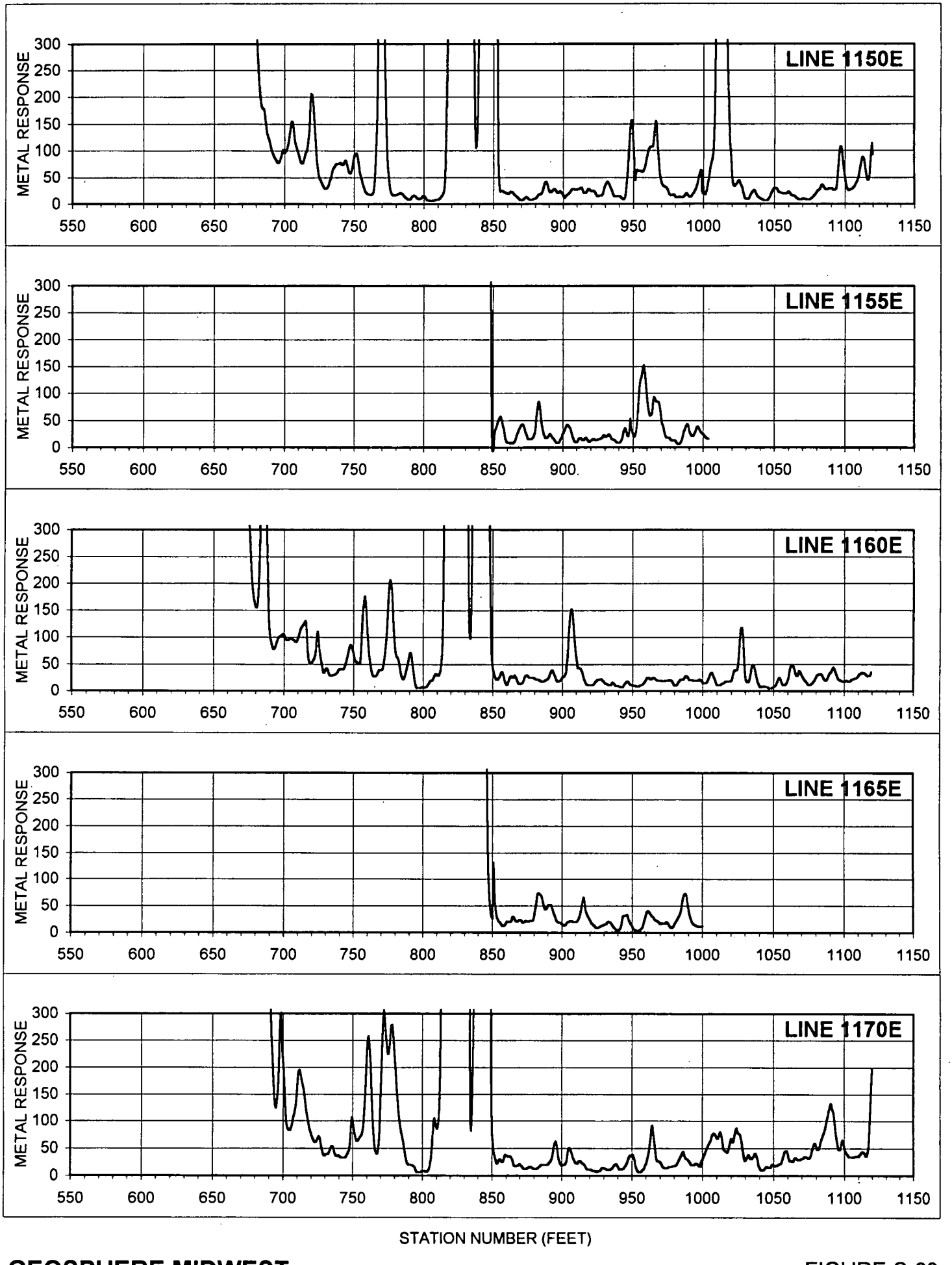
GEOSPHERE MIDWEST

FIGURE C-20



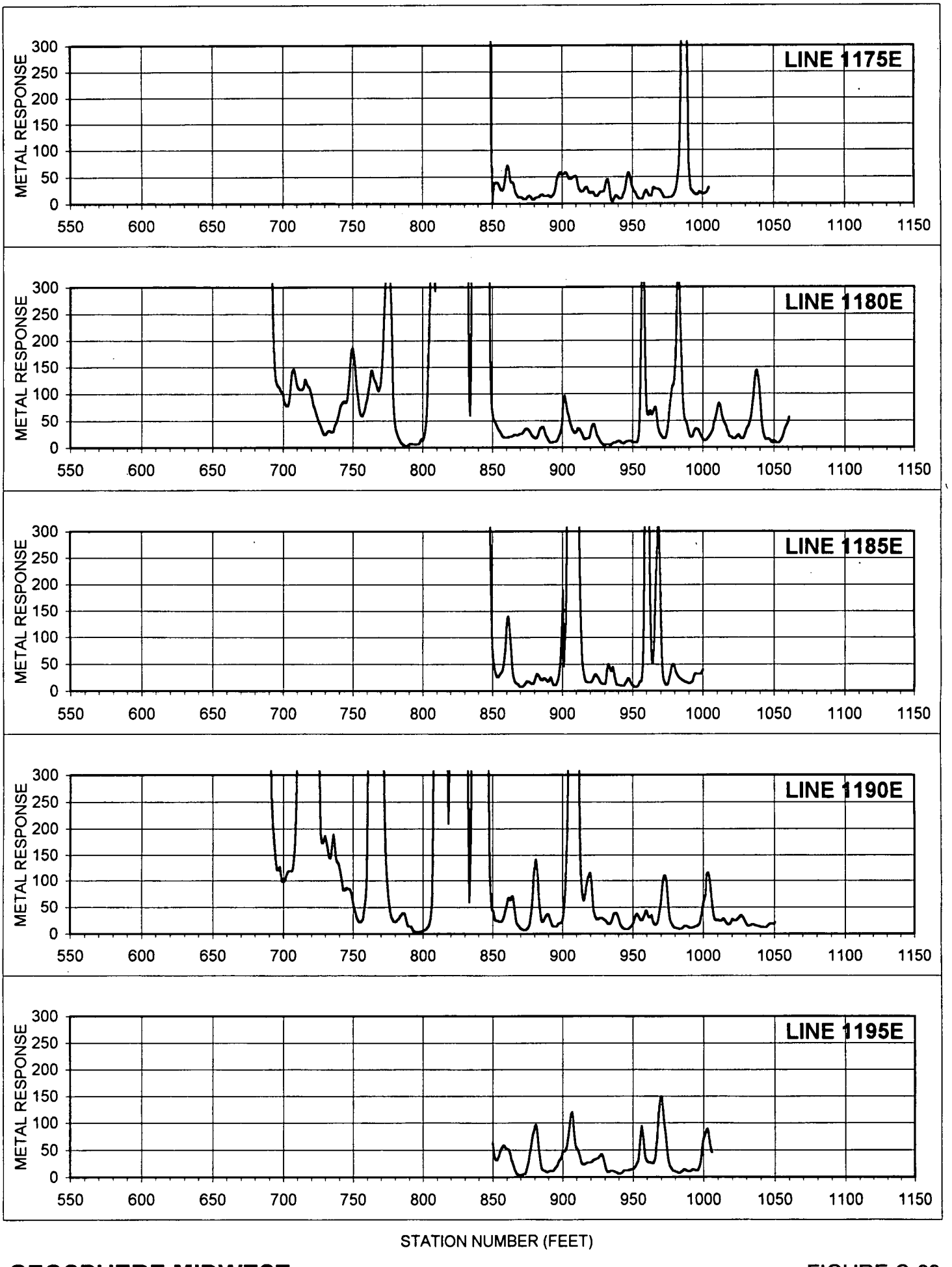
GEOSPHERE MIDWEST

FIGURE C-21



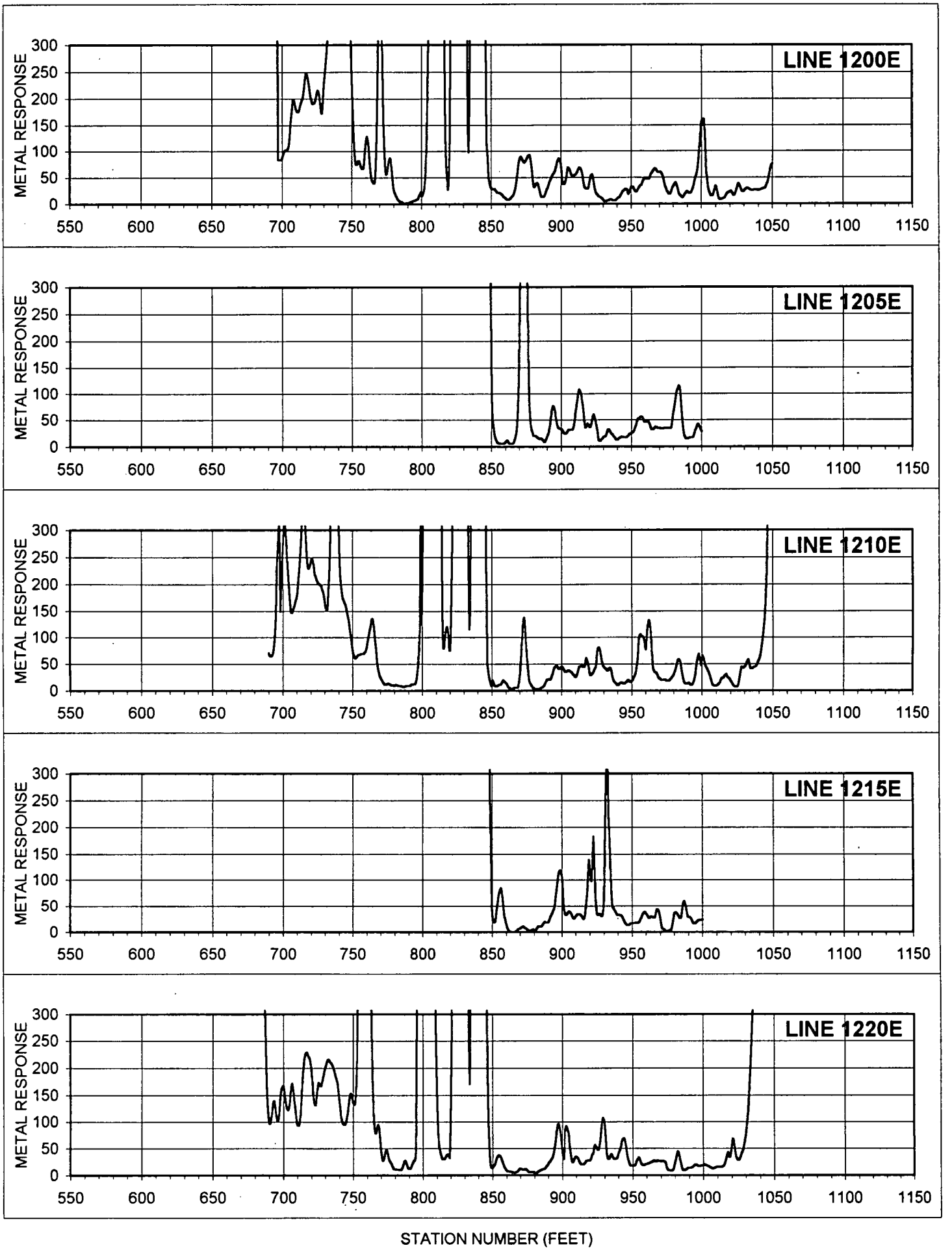
GEOSPHERE MIDWEST

FIGURE C-22



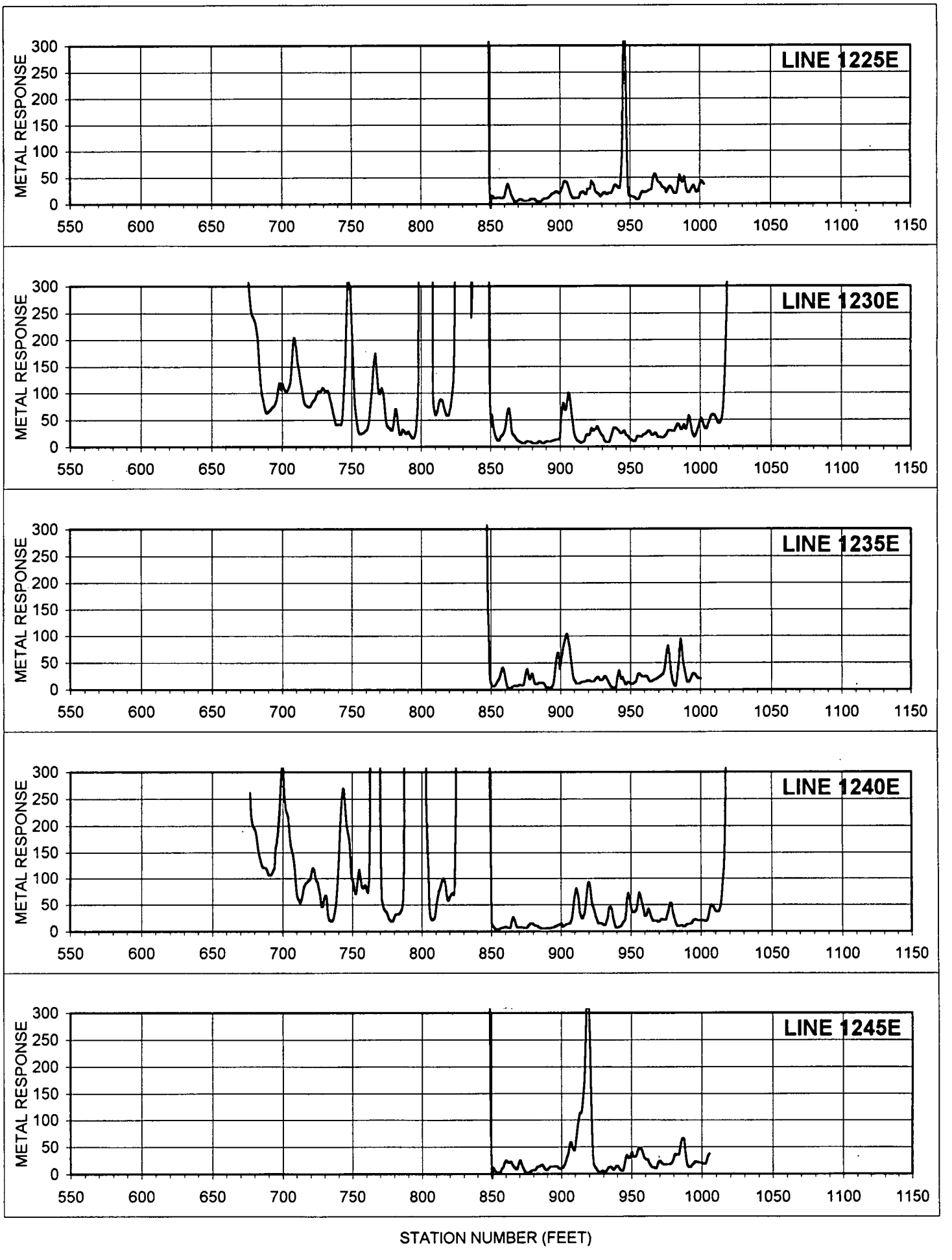
GEOSPHERE MIDWEST

FIGURE C-23



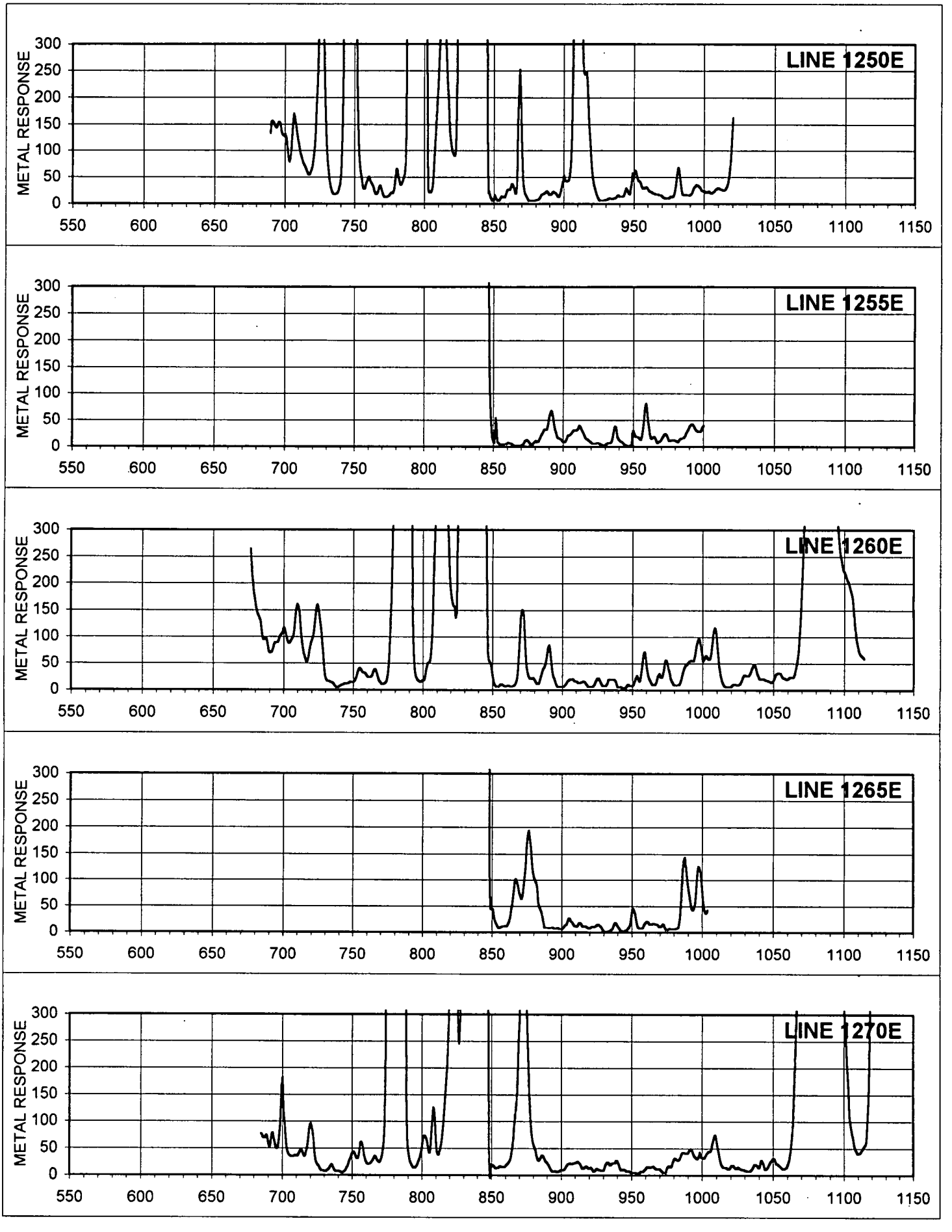
GEOSPHERE MIDWEST

FIGURE C-24



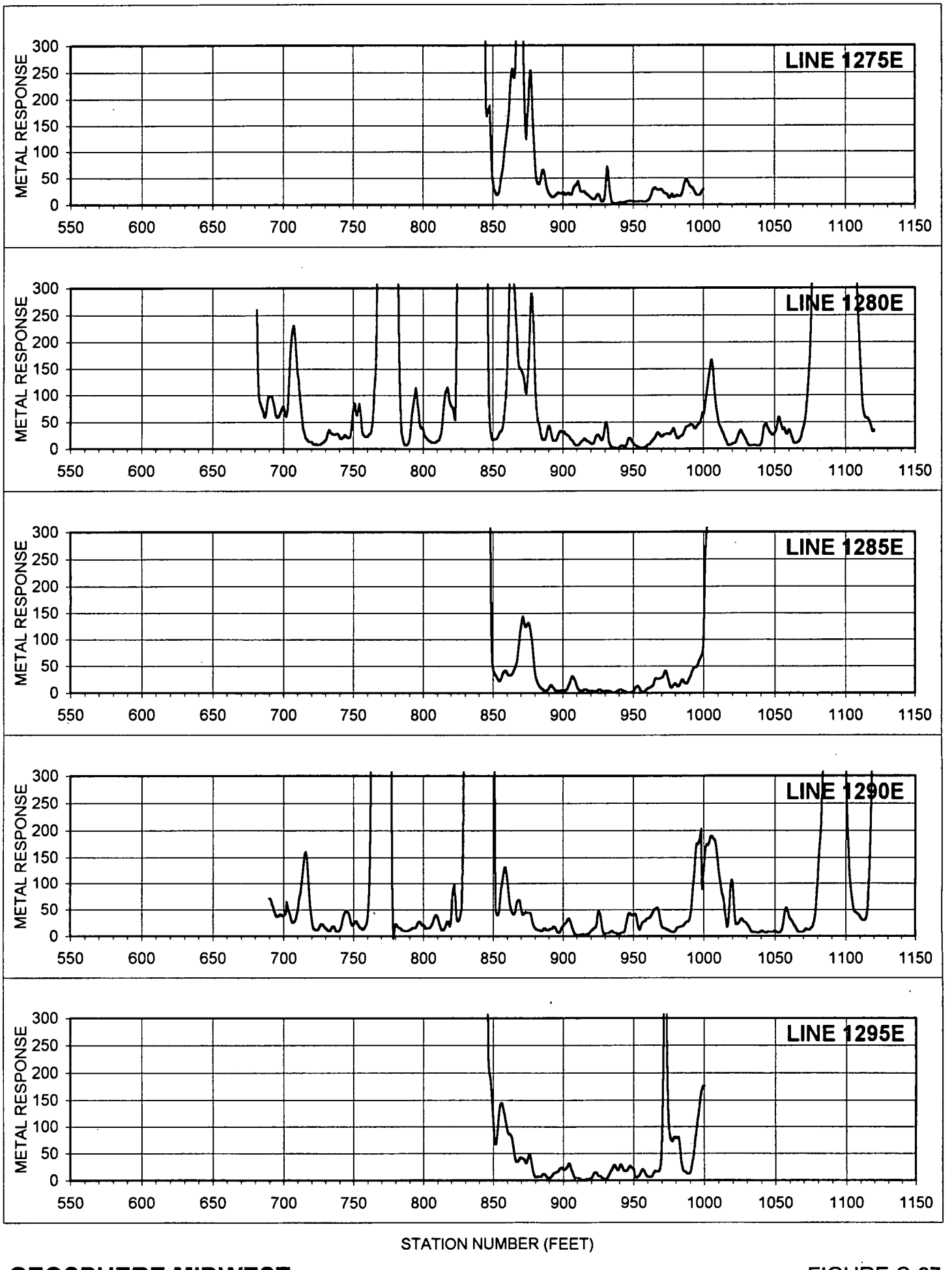
GEOSPHERE MIDWEST

FIGURE C-25



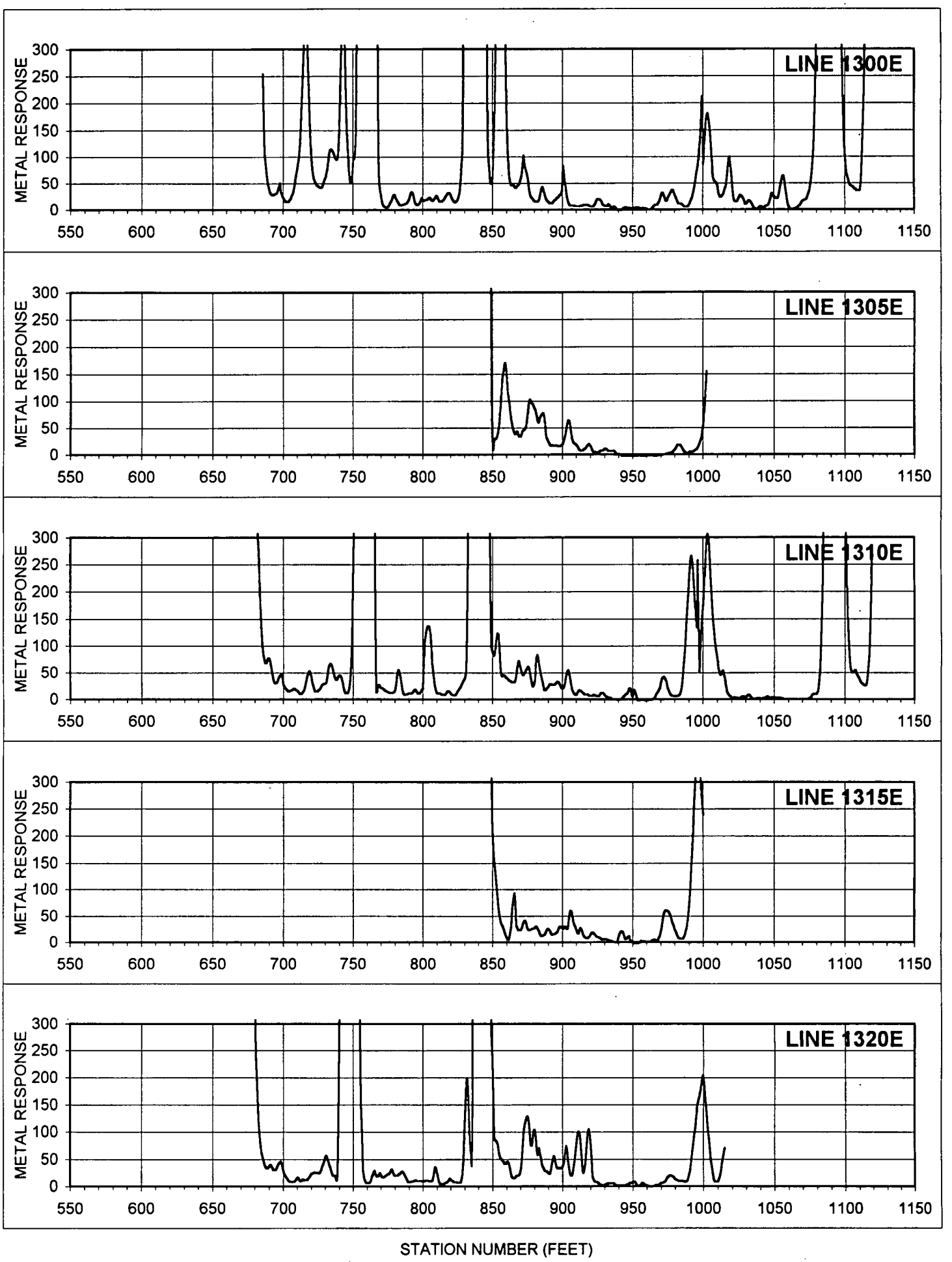
GEOSPHERE MIDWEST

FIGURE C-26



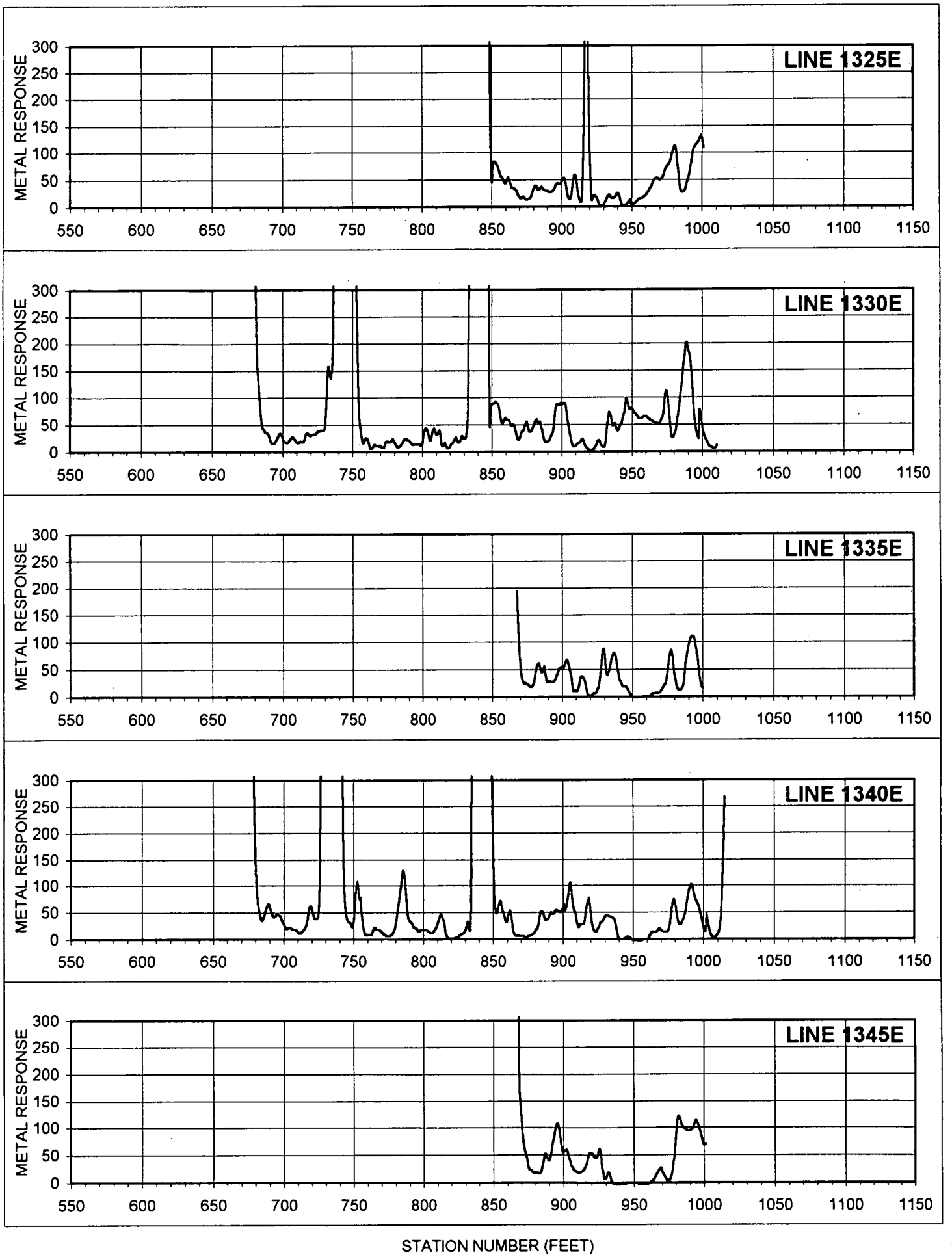
GEOSPHERE MIDWEST

FIGURE C-27



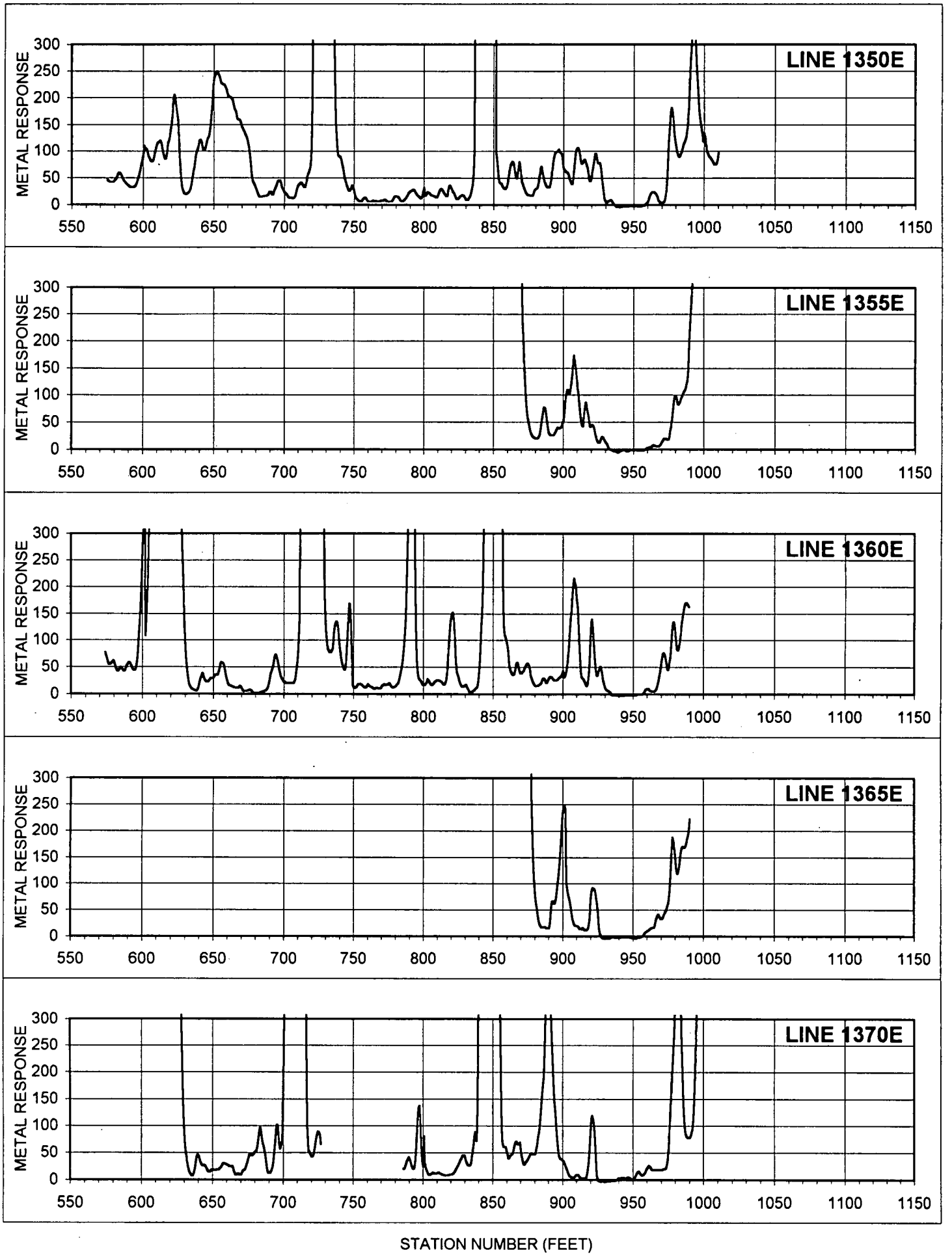
GEOSPHERE MIDWEST

FIGURE C-28



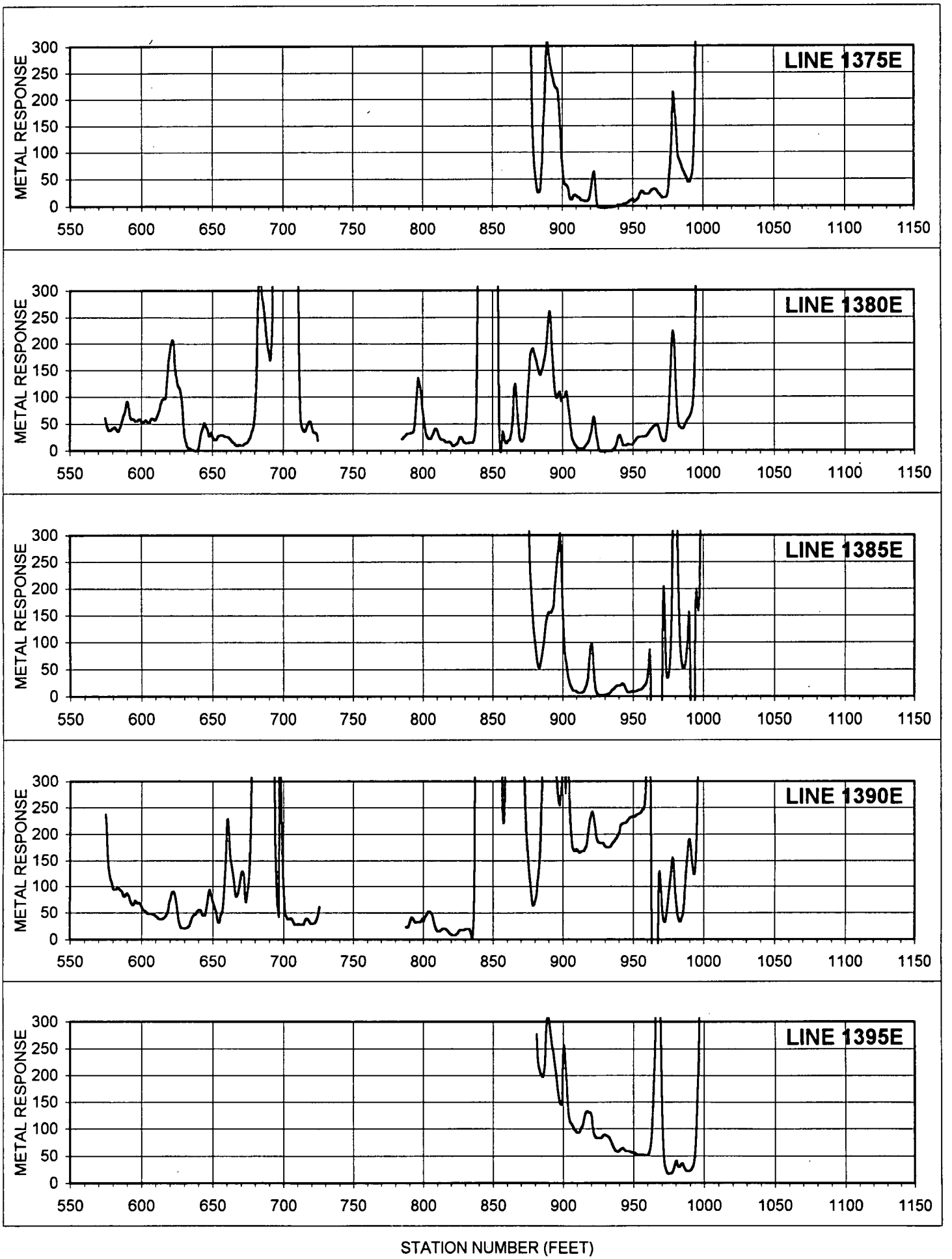
GEOSPHERE MIDWEST

FIGURE C-29



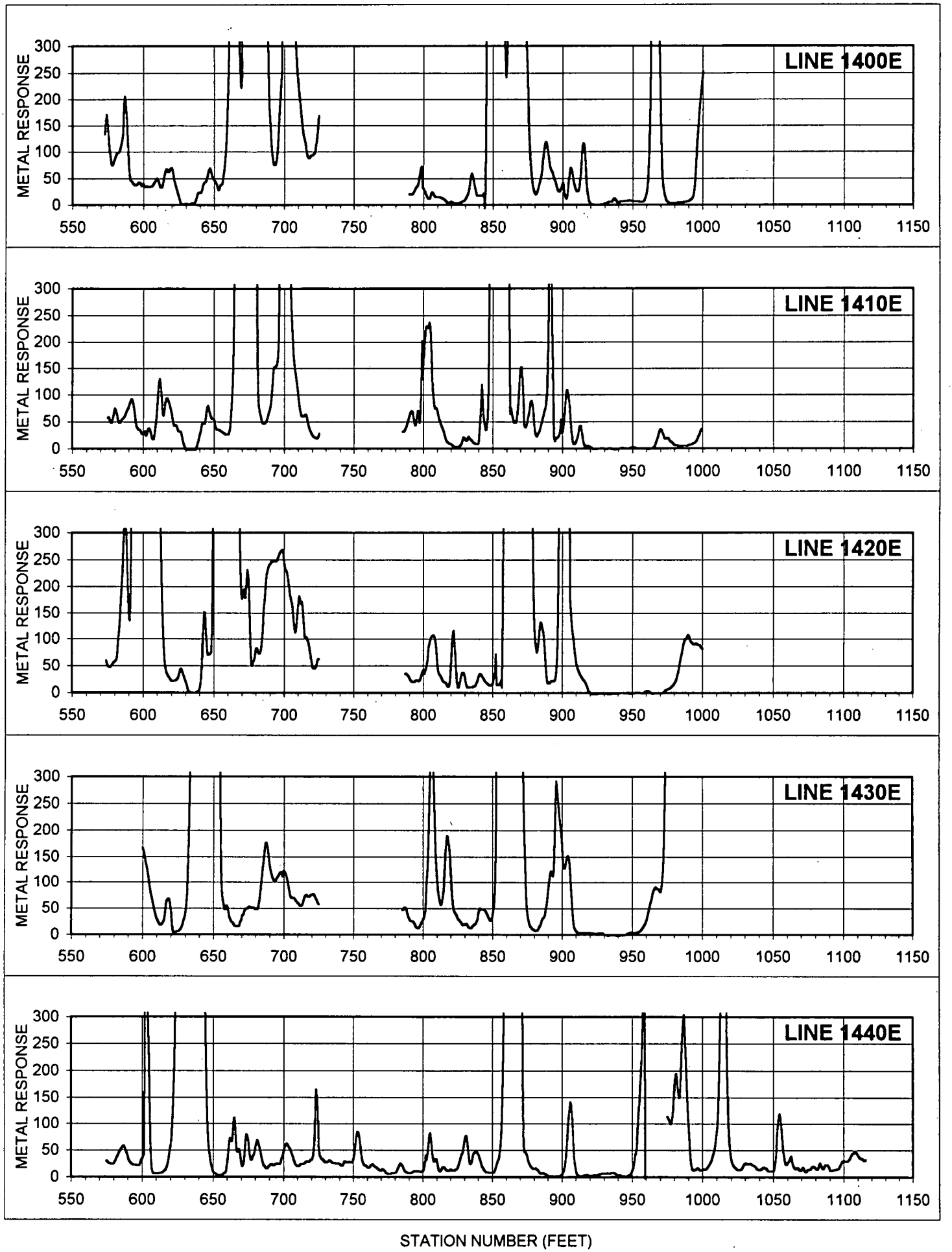
GEOSPHERE MIDWEST

FIGURE C-30



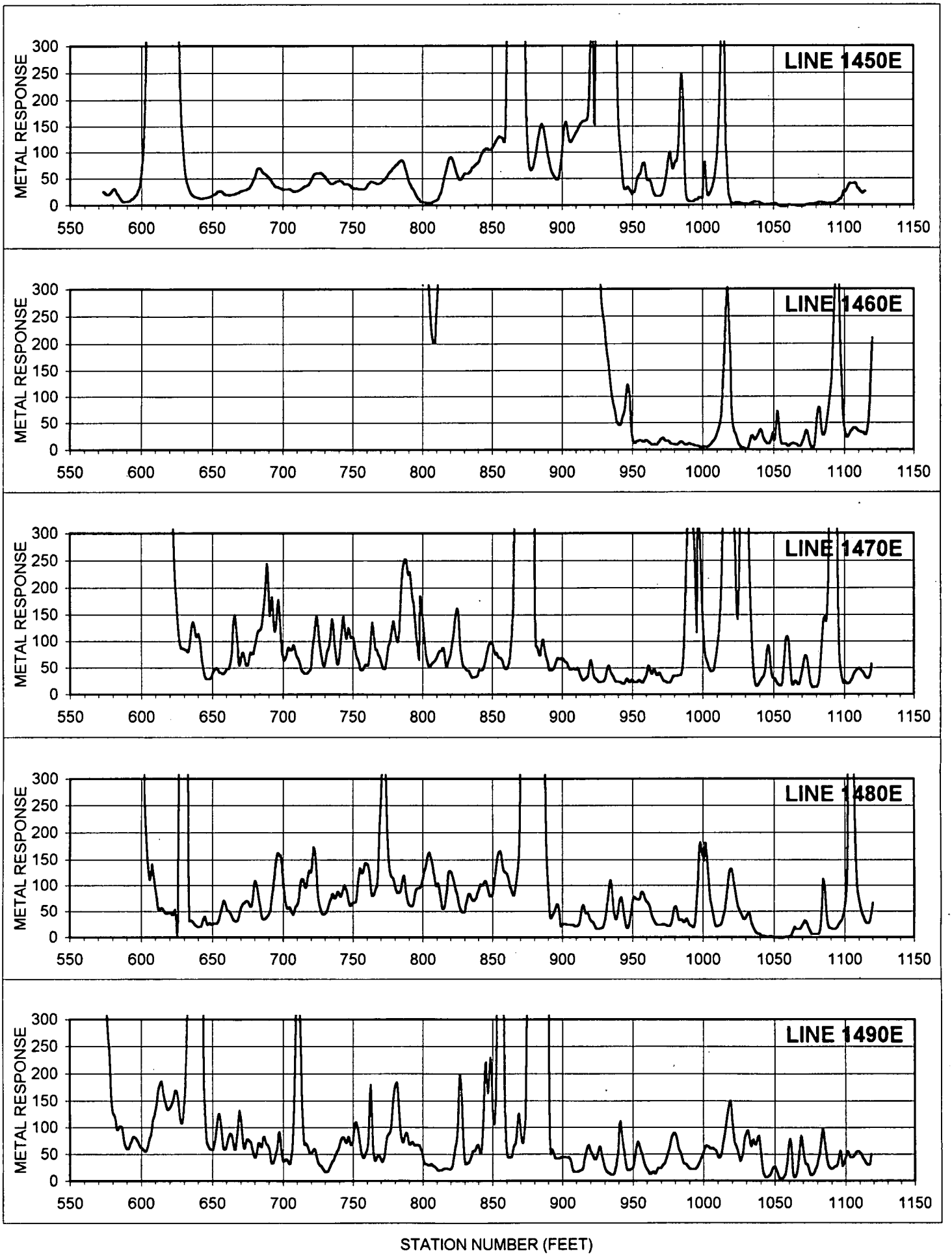
GEOSPHERE MIDWEST

FIGURE C-31



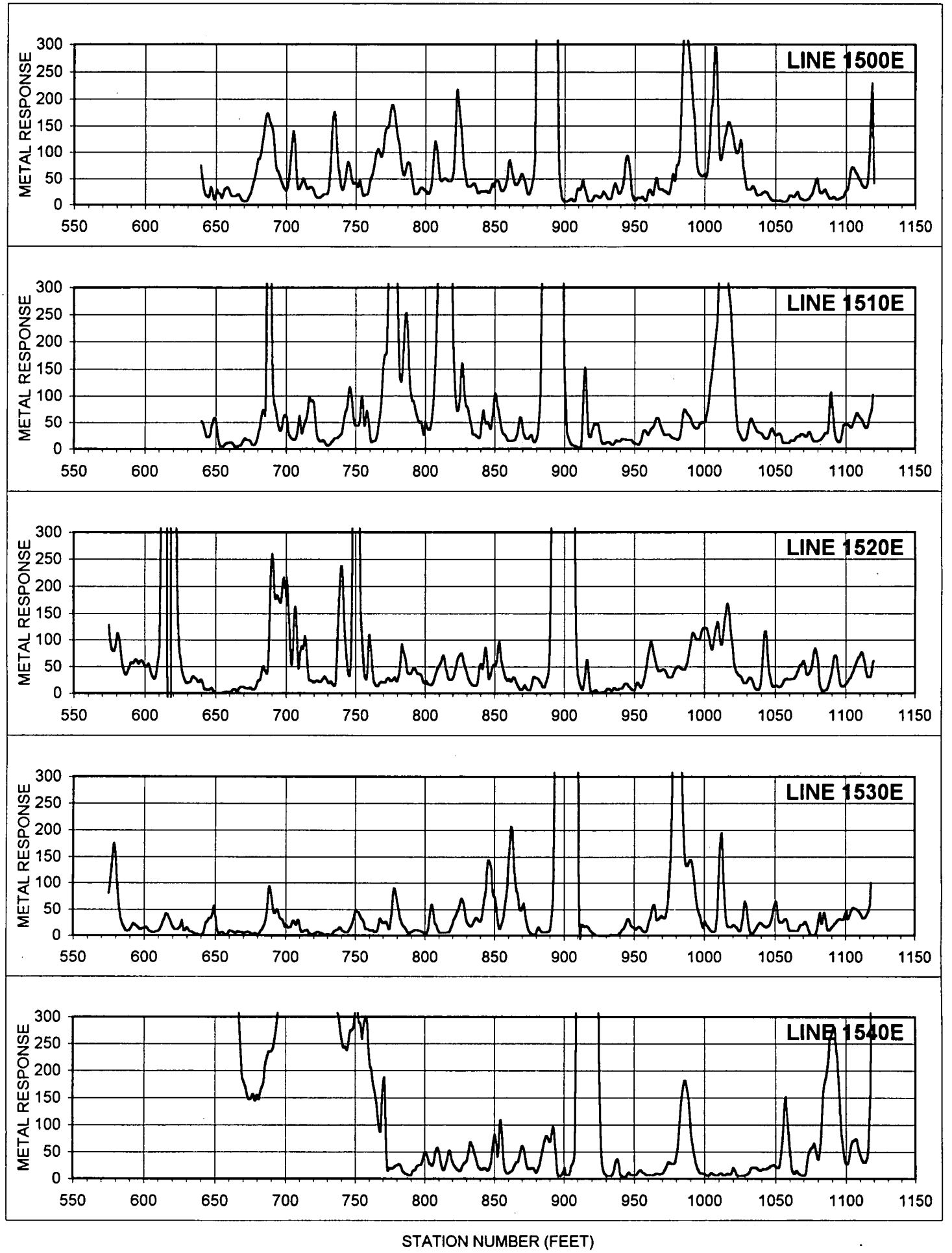
GEOSPHERE MIDWEST

FIGURE C-32



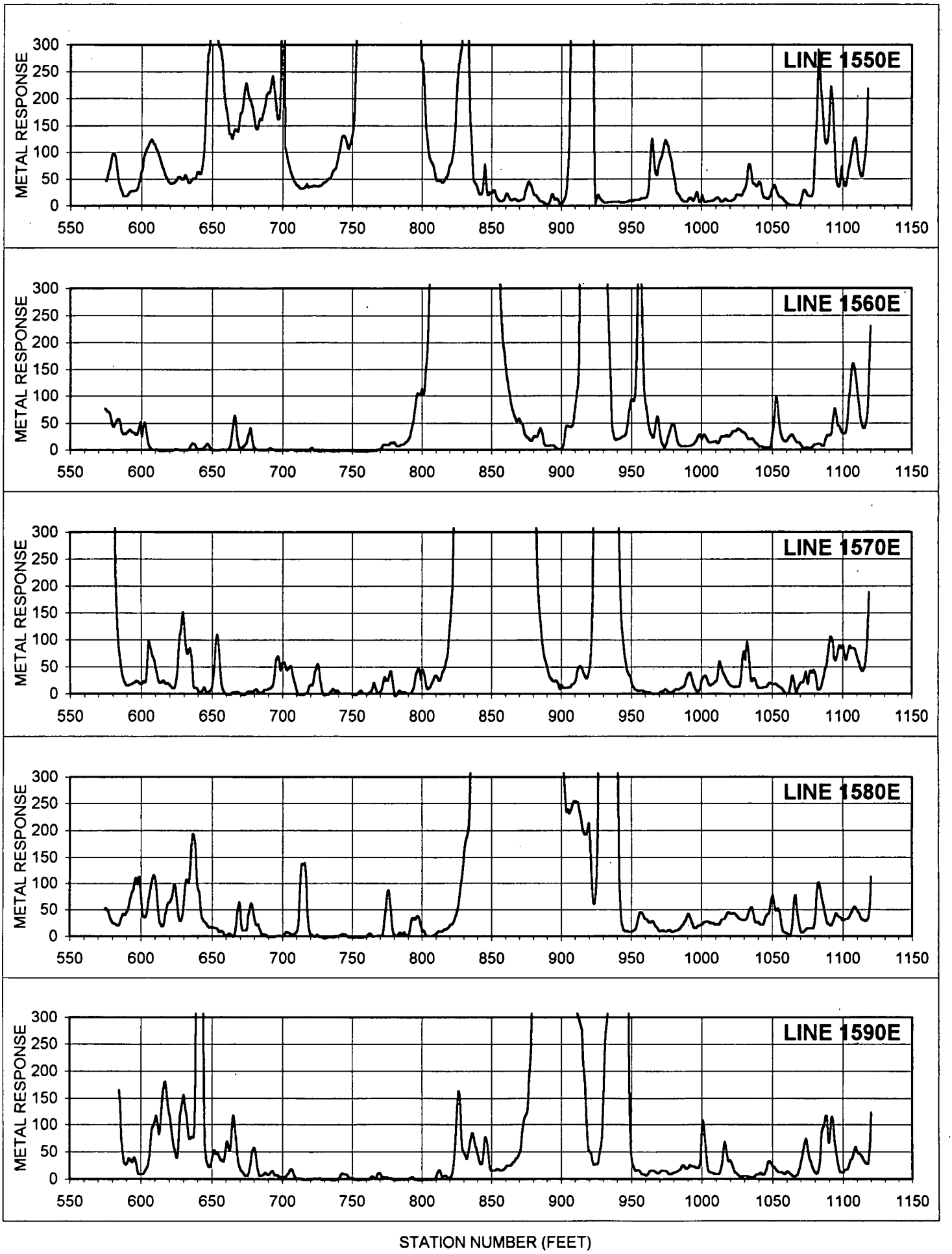
GEOSPHERE MIDWEST

FIGURE C-33



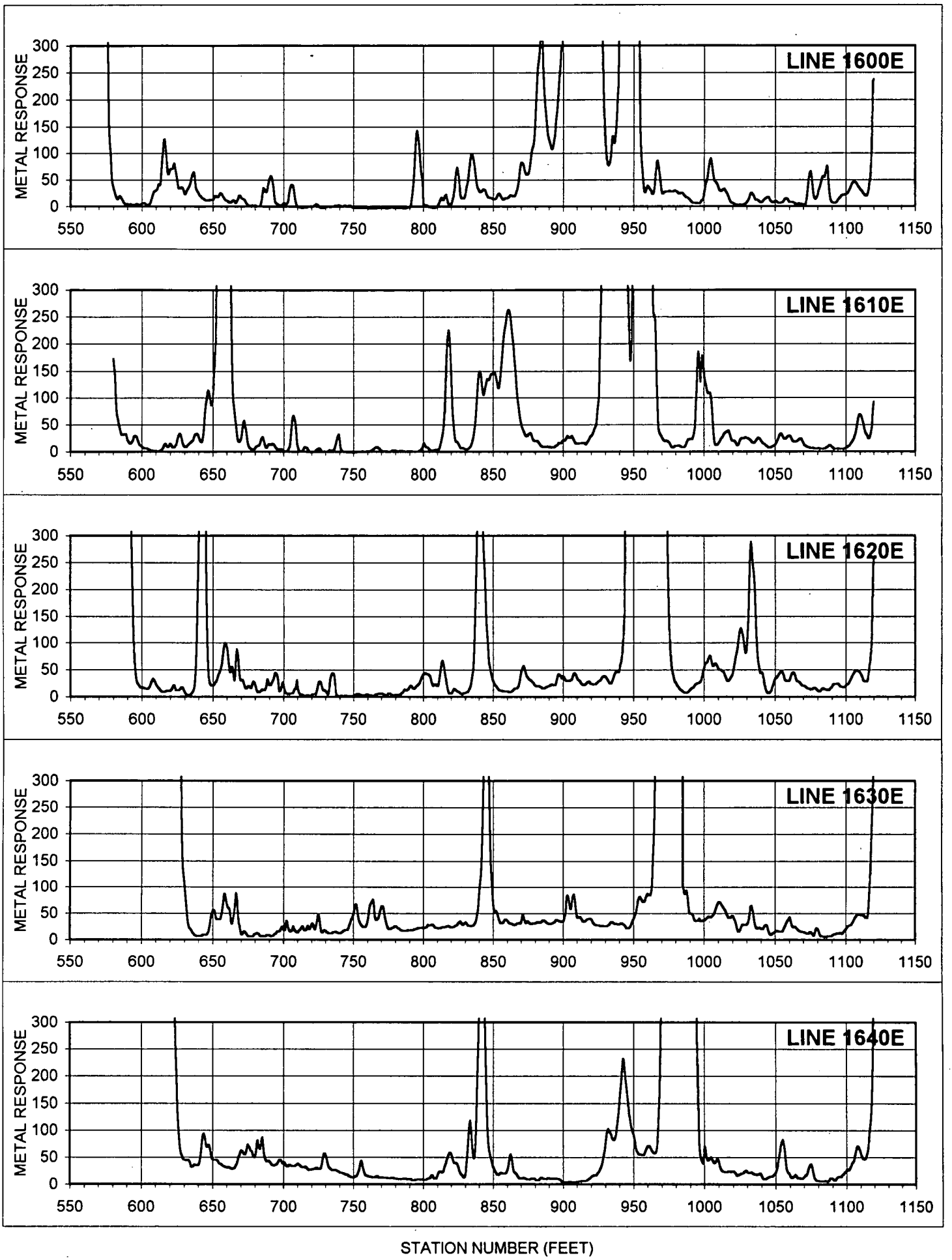
GEOSPHERE MIDWEST

FIGURE C-34



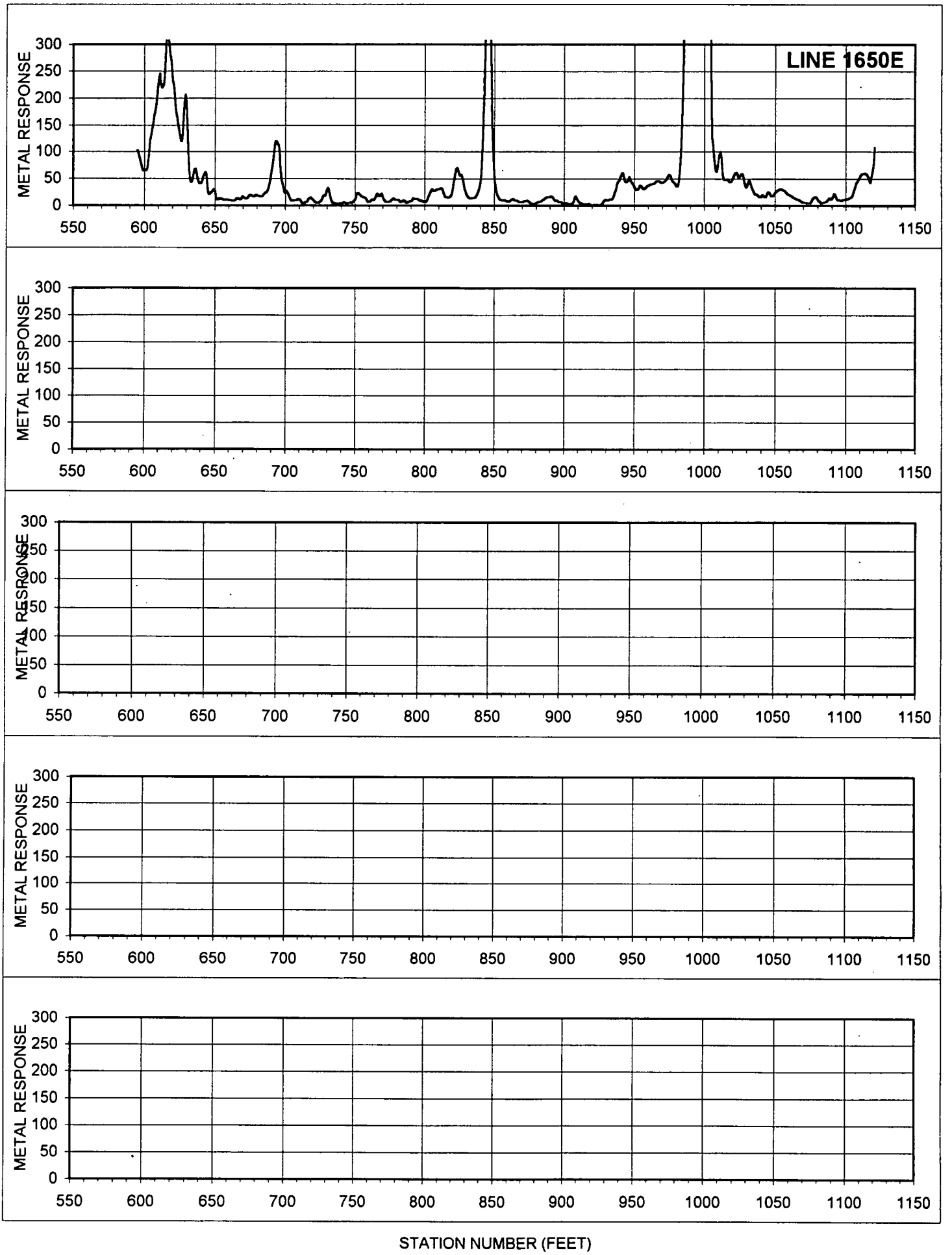
GEOSPHERE MIDWEST

FIGURE C-35



GEOSPHERE MIDWEST

FIGURE C-36



GEOSPHERE MIDWEST

FIGURE C-37

APPENDIX D

FIELD INFORMATION

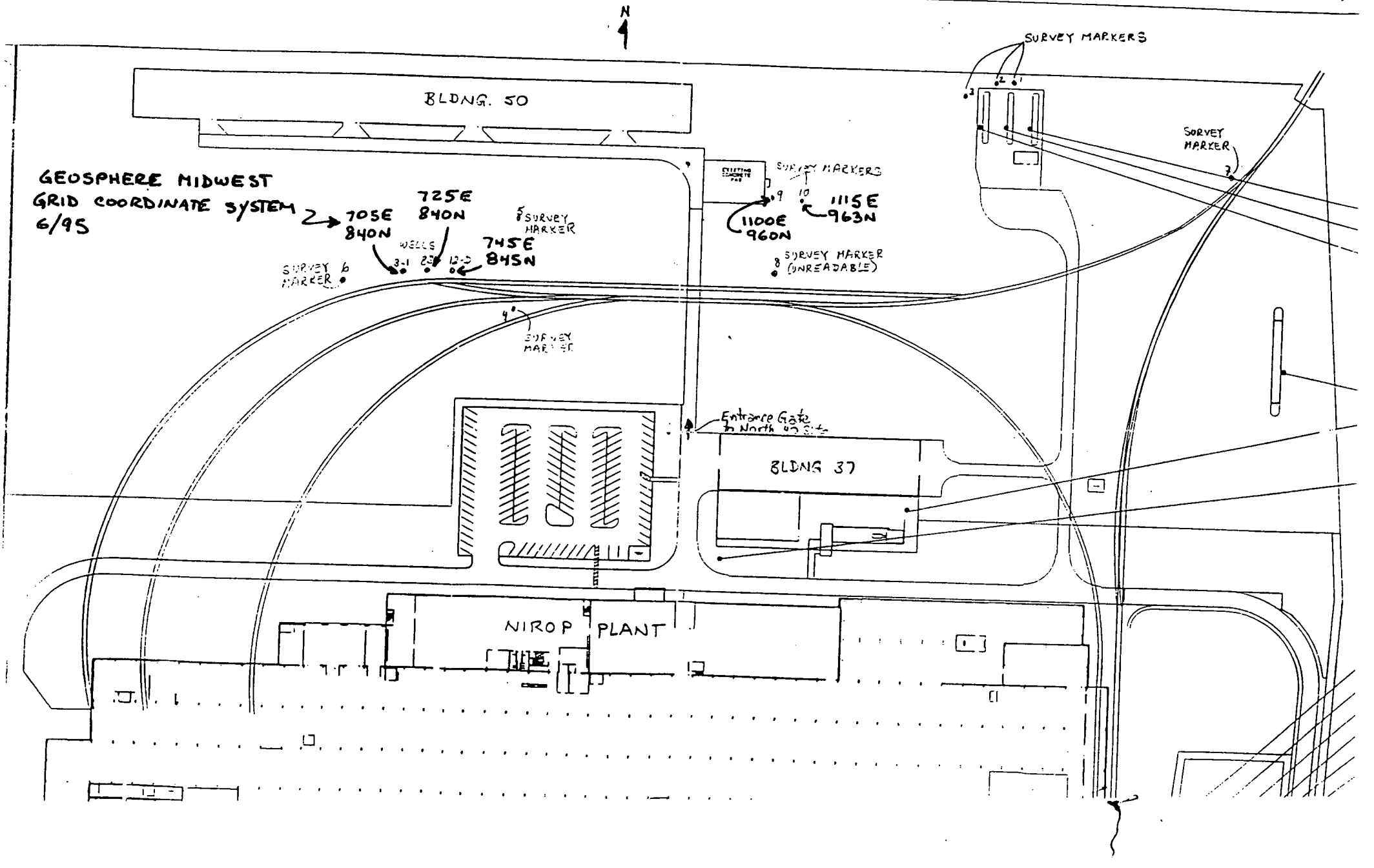
This appendix includes miscellaneous information relating Geosphere Midwest's geophysical grid system (used in this report) to RMT's coordinate system. Also included are the geophysical field activity sheets.

D1. SURVEY LOCATION INFORMATION

Figure/table relating Geosphere Midwest grid to RMT coordinates

D2. FIELD ACTIVITY SHEETS

NIROP - North 40 Site



Map Marker #	I.D.	
1	AB 232	behind propane tanks
2	AB 234	behind propane tanks
3	AT 08	behind propane tanks
4	AB 224	in central part of site
5	NB 19	in central part of site
6	AB 219	in central part of site
7	BB206	- in E site
8	unreadable	
9	AB043	← 1100E/960N (GSM) 5805.944E/7340.66[illegible]N (RMT) in N central area, by concrete pad
10	AB044	← 1115E/963N (GSM) 5824.164E/7341.656N (RMT)

Wells - in W central area of site, N of RR tracks

3-1 — U.S. Army Corps of Engineers, Omaha District (3-1) 837.38, vertical
705E/840N

8 S — vertical
725E/840N

12-D — ∡15°, 837.79
745E/845N

Figure 4 Meeting Signature Sheet

Type of Meeting: Geophysical Investigations at NIROP-North 40 Site

Topic: Kick-off meeting / Plan / Site Safety & Health Plan / Concerns / NIROP Plant Regulations

The following personnel were present for meeting conducted at (NIROP Plant) 0815 (time) on 6/12/95 (date) at NIROP Plant, Fridley, MN. (location).

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
ROBERT A GLACCUM	Robert A. Glaccum	GEOSPHERE MIDWEST
Donald W. Johnson	Donald W. Johnson	GEOSPHERE MIDWEST
Jim H. Treen	Jim H. Treen	Geosphere Midwest
PAT MOSITES	P Mosites	REICC / USNAVY

ULRICH J. CORDON — Ulrich J. Cordon — 6-12-95

Printed Name of Meeting Chairman — Signature — Date

- Discussed Site Safety & Health Plan / evacuation & assembly points / hospital route / site specific concerns (ballistic tests in Bldng 37 relate to "noise hazard" but seldom performed)
- Reviewed plan of activities for today: grid the area & if time permits commence geophysics w/ EM31.
- Toured plant, site, Bldng 37, facilities.

Figure 5 Pre-Entry Briefing Signature Sheet

Work area(s) to be entered NIROP - North 40 site, Fridley, MN.

The following personnel have had a pre-site entry briefing conducted at 0815 (time) on 06/12/95 (date) at NIROP Plant (location), and are familiar with this plan's provisions, and are willing to meet the requirements of this plan.

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
ROBERT A. GLACCUM	Robert A. Glaccum	GEOSPHERE MIDWEST
Donald W. Johnson	Donald W. Johnson	GEOSPHERE MIDWEST
John H. Tigan	John H. Tigan	Geosphere Midwest
PAT MOSITES	P. Mosites	REICC / US NAVY

ULRICH J. CORDON — Ulrich J. Cordon — 6-12-95

Printed Name of Supervisor — Signature — Date

Figure 6. SSHO DAILY LOGBOOK REPORT

Date June 12, 1995 Report Number 001

Location(s) Work Activity and # Employees: NIROP - North 40 site, Fridley, MN.
Geophysical investigations (EM31, EM34-3, EM61) to locate buried debris.
{MK - U. Cordon
{Geosphere Midwest - R. Glaccum, D. Johnson, J. Traen} personnel at site

Weather: Wind speed <3 mph Wind direction Northerly
Temp & Pressure 60°-70° Precipitation ∅
Amount sun v. sunny; clear skies

Monitoring conducted:

Location	Sampled for	Instrument used	Results	Sampled By/Time
	N/A			

Levels of Protection: Level D (Hard hat, safety glasses, steel toe boots)
- Have First Aid Kit & other supplies in trunk of car
- Posted Work Zone Layout, Hospital Rte, + Important Phone #s on car dashboard
- All personnel informed of above, SSHP, safety concerns listed below.

Problems or Unusual Situations: none

Correspondence: —
- Maintained contact w/ NIROP site liaison (Pat Mosites)

Other Comments: Safety concerns: physical (tripping, falling, ...)
fork lifts and trucks may enter site on central & eastern rds.
Locomotive may cross site using existing RR tracks
possible noise within Bldng. 37 (warning given); (shell explosion tests)

SSHO Printed Name: ULRICH J. CORDON Signature Ulrich J. Cordon Date 6-12-95

Figure 4 Meeting Signature Sheet

Type of Meeting: Geophysical Investigations at NIROP-North 40 Site.

Topic: Plan-of-the-day / reviewed yesterday's results.

The following personnel were present for meeting conducted at 0800 (time) on 6/13/95 (date) at NIROP parking lot (location).

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
ROBERT A. GLACCUM	Robert A. Glaccum	GEOSPHERE MIDWEST
JIM H. TIGEN	Jim H. Tigen	Geosphere Midwest
DONALD W. JOHNSON	Donald W. John	Geosphere Midwest
TOM BENSON	Tom Benson	MK

ULRICH J. CORDON — Ulrich J. Cordon — 6-13-95

Printed Name of Meeting Chairman — Signature — Date

- Discussed plan for today: - complete grid on eastern side of area
  - resume EM31 measurements
- Reviewed yesterday's results: - GSM provided B&W contour maps of EM31 measurements identified areas w/ possible buried debris.
  - reviewed EM61 data from another similar project; EM61 detects any near-surface metal (bolts, wire, washings...) which may lead to many anomalies at NIROP — the site has lots of metallic debris scattered on & near surface.

Figure 5 Pre-Entry Briefing Signature Sheet

Work area(s) to be entered NIROP - North 4D Site, Fridley, MN.

The following personnel have had a pre-site entry briefing conducted at 0800 (time) on 6/13/95 (date) at _____ (location), and are familiar with this plan's provisions, and are willing to meet the requirements of this plan.

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
ROBERT A GLACCUM	Robert A Glaccum	GEOSPHERE MIDWEST
DONALD W. JOHNSON	Donald W. Johnson	GEOSPHERE MIDWEST
JOHN H. TIKEN	John H. Tiken	Geosphere Midwest
TOM BENSON	Tom Benson	MK

ULRICH J. CORDON — Ulrich J. Cordon — 6-13-95

Printed Name of Supervisor — Signature — Date

Figure 6. SSHO DAILY LOGBOOK REPORT

Date 6-13-95 Report Number 002

Location(s), Work Activity, and # Employees: NIROP - North 40 Site, Fridley, MN.
Geophysical Investigations to Locate buried metallic debris
V. CORDON ; T. BENSON — MK
B. GLACCUM, D. JOHNSON, J. TRAEN — Geosphere Midwest

Weather: Wind speed <1 mph. Wind direction NE
Temp & Pressure 80° Precipitation Ø
Amount sun v sunny ; clear skies

Monitoring conducted:

Location	Sampled for	Instrument used	Results	Sampled By/Time
	N/A			

Levels of Protection: D (Hard hat, safety glasses, steel toe boots)
• First Aid Kit ; Work Zone Layout + Maps ; other supplies — in car in muster area (parking lot).

Problems or Unusual Situations: none

Correspondence: Site visit by Messrs. D. Cabiness (U.S.Navy-Charleston); P. Mosites (REICC-U.S.Navy-NIROP); M. Finton (MK-PM-Cleveland).

Other Comments: Ø

SSHO Printed Name: ULRICH J. CORDON Signature Ulrich J. Cordon Date 6-13-95

Figure 4 Meeting Signature Sheet

Type of Meeting: Geophysical Investigations at NIROP-North 40 site

Topic: Plan-of-the-day

The following personnel were present for meeting conducted at 0845 (time) on 6-14-95 (date) at NIROP-North 40 parking lot (location).

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
Thomas A. Benson	Thomas A. Benson	MK
Jim H. Treen	Jim H. Treen	Geosphere Midwest
Donald W. Johnson	Donald W. Johnson	Geosphere Midwest
Roberta Glaeman	Roberta Glaeman	Geosphere Midwest

ULRICH J. CORDON — Ulrich J. Cordon — 6-14-95

Printed Name of Meeting Chairman — Signature — Date

- Discussed plan for the day – resume EM31 measurements (currently 75% complete)
  - resume EM61 measurements (currently 10% complete)
  - P.M.-possibly start EM34-3 measurements (when finish w/ the EM31)
- Site has been gridded & marked.

Figure 5 Pre-Entry Briefing Signature Sheet

Work area(s) to be entered NIROP - North 40 site, Fridley, MN.

The following personnel have had a pre-site entry briefing conducted at 0845 (time) on 6-14-95 (date) at NIROP - North 40 site parking lot (location), and are familiar with this plan's provisions, and are willing to meet the requirements of this plan.

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
Thomas A Benson	Thomas A. Benson	MK
Jim H. Treen	Jim H. Treen	Geosphere Midwest
Donald W. Johnson	Donald W. Johnson	Geosphere Midwest
ROBERT A. GLAUCUM	Robert A. Glaucum	Geosphere Midwest

ULRICH J. CORDON — Ulrich J. Cordon — 6-14-95

Printed Name of Supervisor — Signature — Date

Figure 6. SSHO DAILY LOGBOOK REPORT

Date 06-14-95 Report Number 003

Location(s) Work Activity and # Employees: NIROP - North 40 side, Fridley, MN.
Geophysical Investigations to locate buried metal debris
U. CORDON, T. BENSON — MK
B. GLACCUM, D. JOHNSON, J. TRAEN — GSM

Weather: Wind speed < 5 mph. Wind direction NW
Temp & Pressure 85°-90° Precipitation ϕ
Amount sun v. sunny; clear skies

Monitoring conducted:

Location	Sampled for	Instrument used	Results	Sampled By/Time
	N/A			

Levels of Protection: D (Hard hat, safety glasses, steel toe boots)

Problems or Unusual Situations: ~~None~~ - NIROP personnel resumed spraying herbicide - the fumes & herbicide interferes w/ geophysical work as it sticks to the wheels of the EM61; requested they move to W end of site (away from geophysicists) & then postpone work in other areas of site. All OK.

Correspondence: site visit by EPA, MPCA, Navy ... persons; gave brief presentation of work, progress, results to-date.

Other Comments: ϕ

SSHO Printed Name: ULRICH J. CORDON Signature Ulrich J. Cordon Date 6-14-95

Figure 4 Meeting Signature Sheet

Type of Meeting: Geophysical Investigations at NIROP-North 40 site

Topic: Plan-of-the-day.

The following personnel were present for meeting conducted at 0800 (time) on 6-15-95 (date) at NIROP-North 40 parking lot (location).

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
Thomas A. Benson	Thomas A. Benson	MK
Jim H. Tracy	Jim H. Tracy	Geosphere Midwest
Donald W. Johnson	Donald W. Johnson	Geosphere Midwest
ROBERT A. GLASCOW	Robert A. Glascow	Geosphere Midwest

ULRICH J. CORDON — Ulrich J. Cordon — 6-15-95

Printed Name of Meeting Chairman — Signature — Date

- Resume measurements w/ EM61 and EM34.
- Results of EM34 do not show any additional info. from that of the EM31 & 61; (basically nothing appears to be buried at depths >20', nor any contaminant plumes outlined); decreased emphasis on EM34 — will not run lines on S part of site (also, RR tracks + fence too close & will interfere w/ EM34)
- Good results w/ EM31 & EM61; few sporadic anomalies & only one considerable anomaly just N of Bldng. 37 (buried debris in trench?).

Figure 5 Pre-Entry Briefing Signature Sheet

Work area(s) to be entered NIROP - North 40 site, Fridley, MN

The following personnel have had a pre-site entry briefing conducted at 0800 (time) on 6-15-95 (date) at NIROP - North 40 parking lot (location), and are familiar with this plan's provisions, and are willing to meet the requirements of this plan.

NAME	SIGNATURE	ORGANIZATION
ULRICH J. CORDON	Ulrich J. Cordon	MK
Thomas A. Benson	Thomas A. Benson	MK
Jim H. Tigan	Jim H. Tigan	Geosphere Midwest
Donald W. Johnson	Donald W. Johnson	Geosphere Midwest
ROBERT A. GLACCUM	Robert A. Glaccum	Geosphere Midwest

ULRICH J. CORDON — Ulrich J. Cordon — 6-15-95

Printed Name of Supervisor — Signature — Date

Figure 6. SSHO DAILY LOGBOOK REPORT

Date 06-15-95 Report Number 004

Location(s) Work Activity and # Employees: NIROP-North 40 site Fridley, MN.
Geophysical Investigations to locate buried metal debris
V. CORDON, T. BENSON — MK
B. GLACCUM, D. JOHNSON, J. TRAEN - GSM

Weather: Wind speed <5 mph. Wind direction NW
Temp & Pressure 90° Precipitation ∅
Amount sun v. sunny, clear skies

Monitoring conducted:

Location	Sampled for	Instrument used	Results	Sampled By/Time
	N/A			

Levels of Protection: Level D (hard hat, safety glasses, steel toe boots)

Problems or Unusual Situations: none

Correspondence: Met various times w/ P. Mosites

Other Comments: ∅

SSHO Printed Name: V. J. CORDON Signature [signature] Date 6-15-95

Figure 4 Meeting Signature Sheet

Type of ~~Meeting~~ Activity: Geophysical investigations at NIROP-North 40 site

~~Topic:~~ Fridley, MN.

The following personnel were present for meeting conducted at ——— (time) on 6/16/95 (date) at ——— (location).

NAME	SIGNATURE	ORGANIZATION

Printed Name of Meeting Chairman Signature Date

- GSM completed geophysical survey in western & northern areas of site. (Northern area was surveyed after NIROP removed truck trailers from this area yesterday p.m. — EM31 had to be brought back to site).