ACTION ON WASTE PROGRAM

GROUND CONDUCTIVITY AND TOTAL MAGNETIC FIELD SURVEYS OF THE PEEL RIVER WASTE SITE, NORTHEAST YUKON TERRITORY

M.A. Power M.Sc. P. Geo.

Location: 66° 30' 59" N 134° 04' 16" W
NTS: 106 L 8
Regional Management District: Dawson
Date: March, 14, 1995

SUMMARY

Ground conductivity and total magnetic field surveys were conducted at the Peel River Site (Action on Waste Site DA #243) to investigate the nature and extent of contamination. The total magnetic field survey detected 6 anomalies which appear to be caused by ferromagnetic debris. Most of these anomalies are near an old sump exposed in section in the riverbank. The ground conductivity survey outlined an area of low resistivity covering approximately 500 m^3 roughly coincident with the location of metallic debris and with the known location of the old sump exposed in the river bank. The geophysical surveys appear to have defined the limits of the remaining portion of the old site.

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INTRODUCTION

Total magnetic field and shallow ground conductivity surveys were conducted at a former Shell Canada oilfield staging area on the Peel River in the northern Yukon to determine the location of buried waste at the site. This report describes the surveys and their results.

LOCATION AND ACCESS

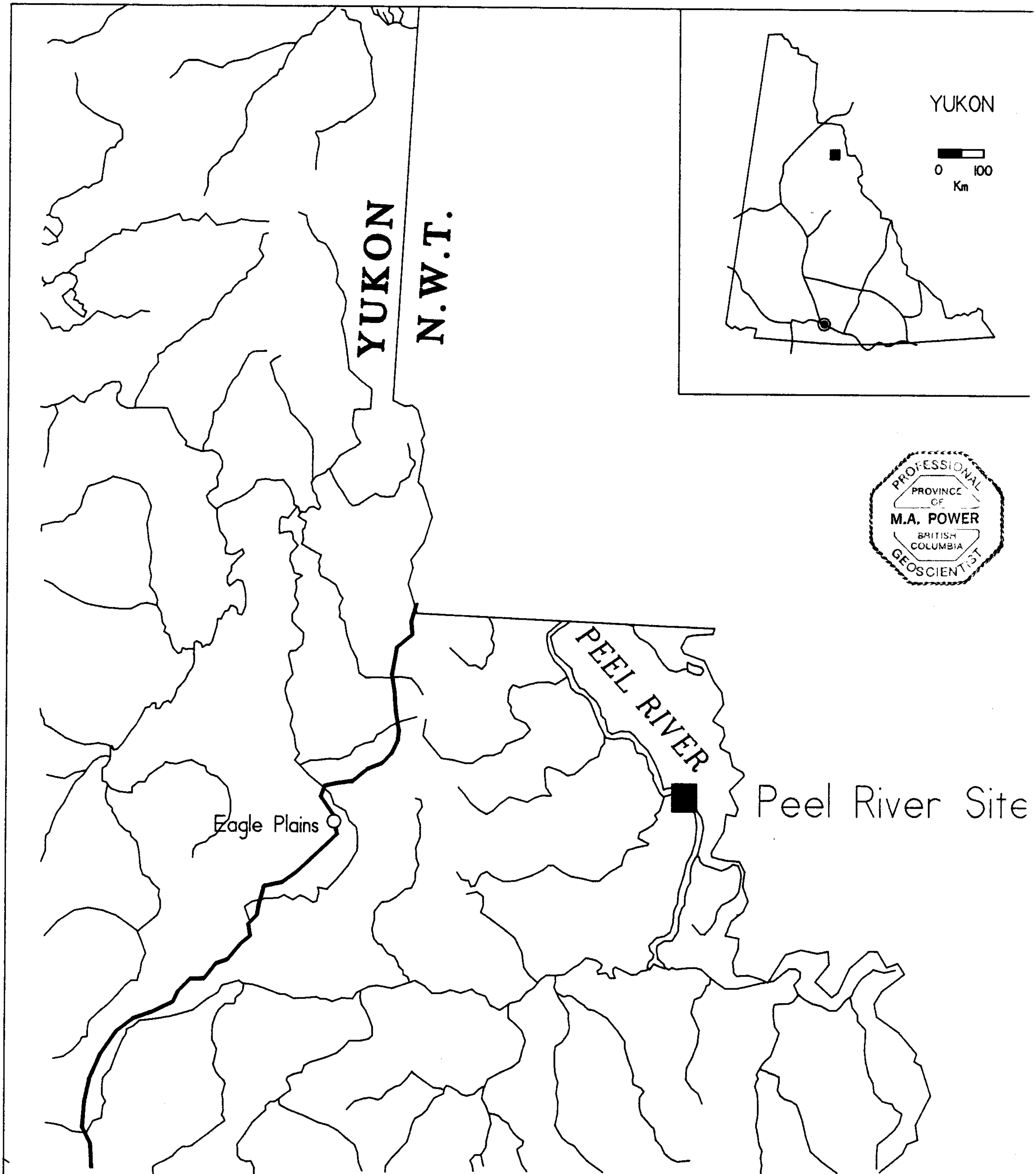
Shell Canada's Peel River Site is designated as Site DA # 243 by the Action on Waste Program of the Arctic Environmental Strategy. It is located at 66° 30' 59" N 134° 04' 16" W on the north side of the Peel River, approximately 4 km upstream of the confluence of the Caribou and Peel Rivers (Figures 1 and 2). The Peel River Site is approximately 120 km east of Eagle Plains, Y.T. and 110 km south of Fort McPherson, N.W.T. It is accessible by helicopter from these locations or by boat from Fort McPherson.

SITE DESCRIPTION

The site is in the active flood plain of the Peel River at a site of erosion in the outside bend of a meander loop (Figure 3). The active river channel is approximately 3 m below the level of an older elevated flood plain and has undercut the bank bounding the site. The portion of the site on the older flood plain is flat and covered with willows and alders up to 12 cm in diameter. A 3 m thick section of the sediments underlying the old flood plain is exposed in the river bank. These consist of approximately 1 m of overbank silt and clay overlying poorly sorted fluvial sand and gravel. From approximately 20 m E to 50 m E along the river bank, a waste pit is exposed in cross-section. In this area, the overbank silt and clay beds have been removed and a 3 m section of gravel with minor scrap iron and concrete is visible in the bank.

SURVEY DESCRIPTION

The geophysical surveys were performed on March 9, 1995 by a crew consisting of M. Power (crew chief), G. Davidson and J.W.R. Smith. A survey grid consisting of a baseline and tieline parallel to the north bank of the river (azimuth 110°) and survey lines extending 40 to 50 m inland was cut and picketed. The limits of the grid are coincident with the limits of the site as indicated by DIAND personnel. All lines were picketed at 10 m intervals with half-lengths of survey lathe. Both the magnetic field and ground conductivity surveys were conducted using a 2 m station spacing.



ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 24	
SITE LOCATION	RMO DISTRICT: Dawson	
	NTS: 106 L 8	Scale: 2,170,000(
	Drawn by: M.A.P.	
AMEROK GEOPHYSICS	DATE: 14 MAR 95	Figure: 1

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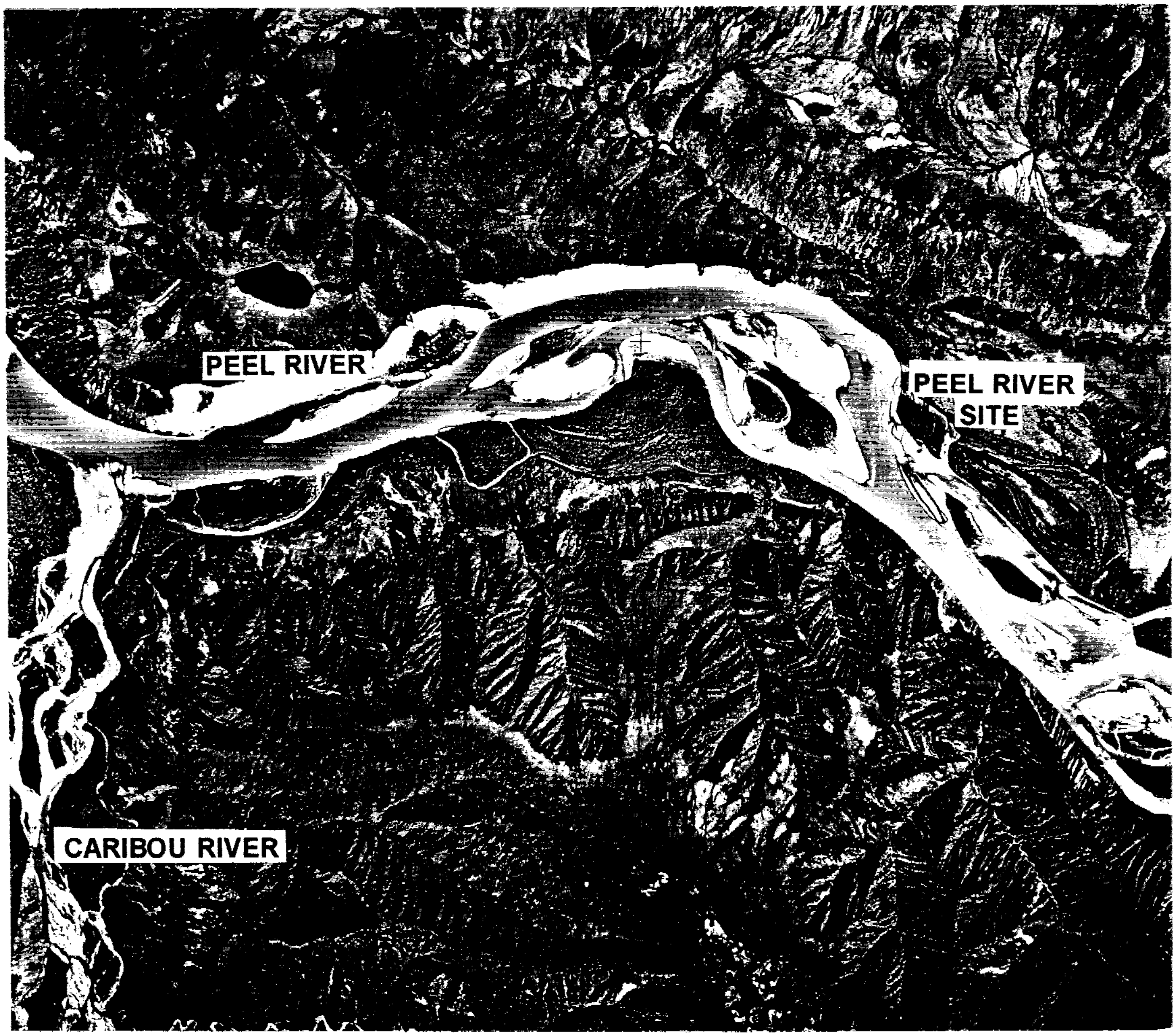
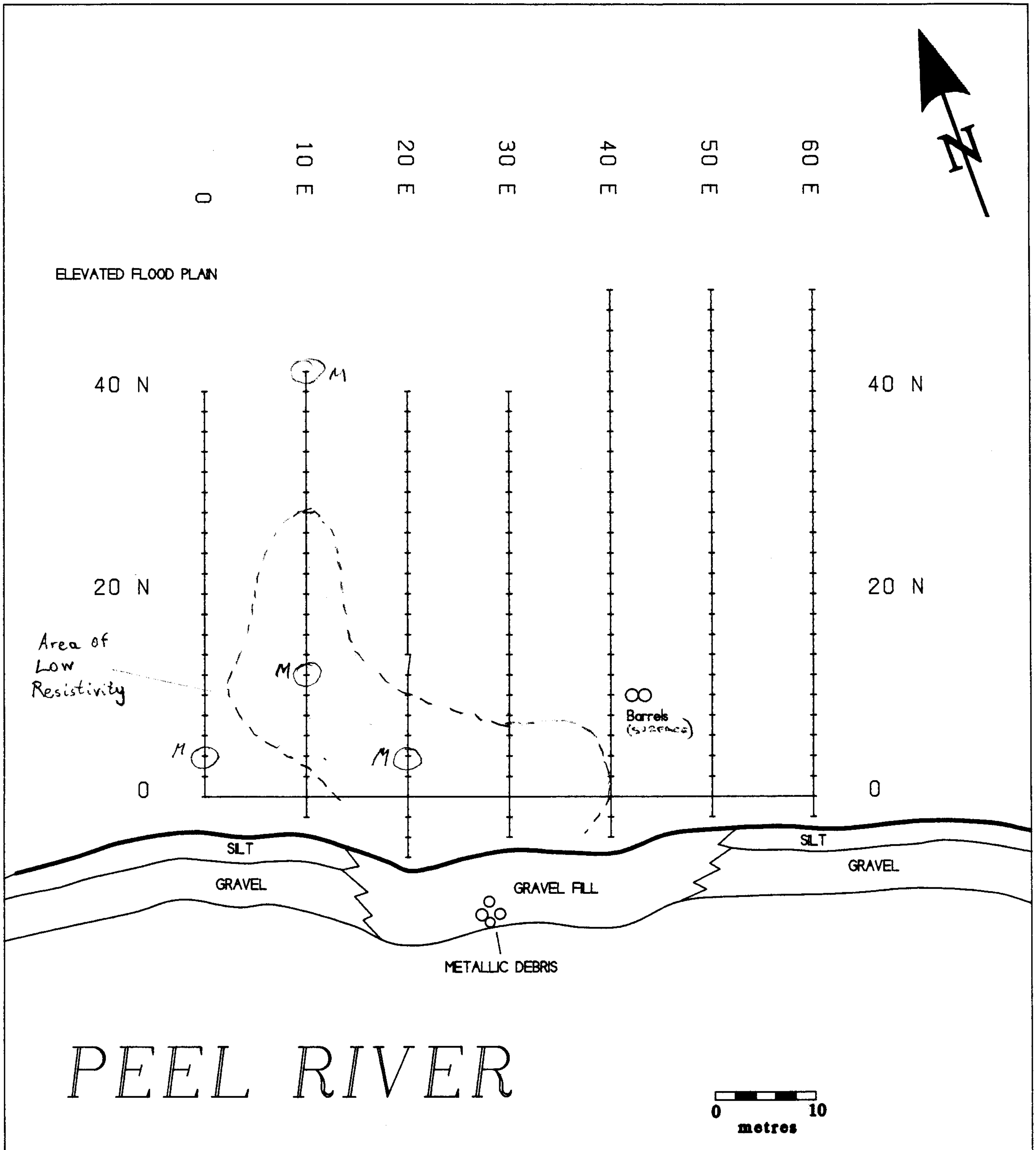


0 1000
metres

ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 243
DETAIL - AIR PHOTOGRAPH A12723 - 292	RMO DISTRICT: Dawson
	NTS: 106 L 8 | Scale: 1:50,000
	Drawn by: M.A.P.
AMEROK GEOPHYSICS	DATE: 14 MAR 95 | Figure: 2



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ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 243
GRID LOCATION	RMO DISTRICT: Dawson
	NTS: 106 L 8 / Scale: 1:500
	Drawn by: M.A.P.
AMEROK GEOPHYSICS	DATE: 14 MAR 95 / Figure: 3

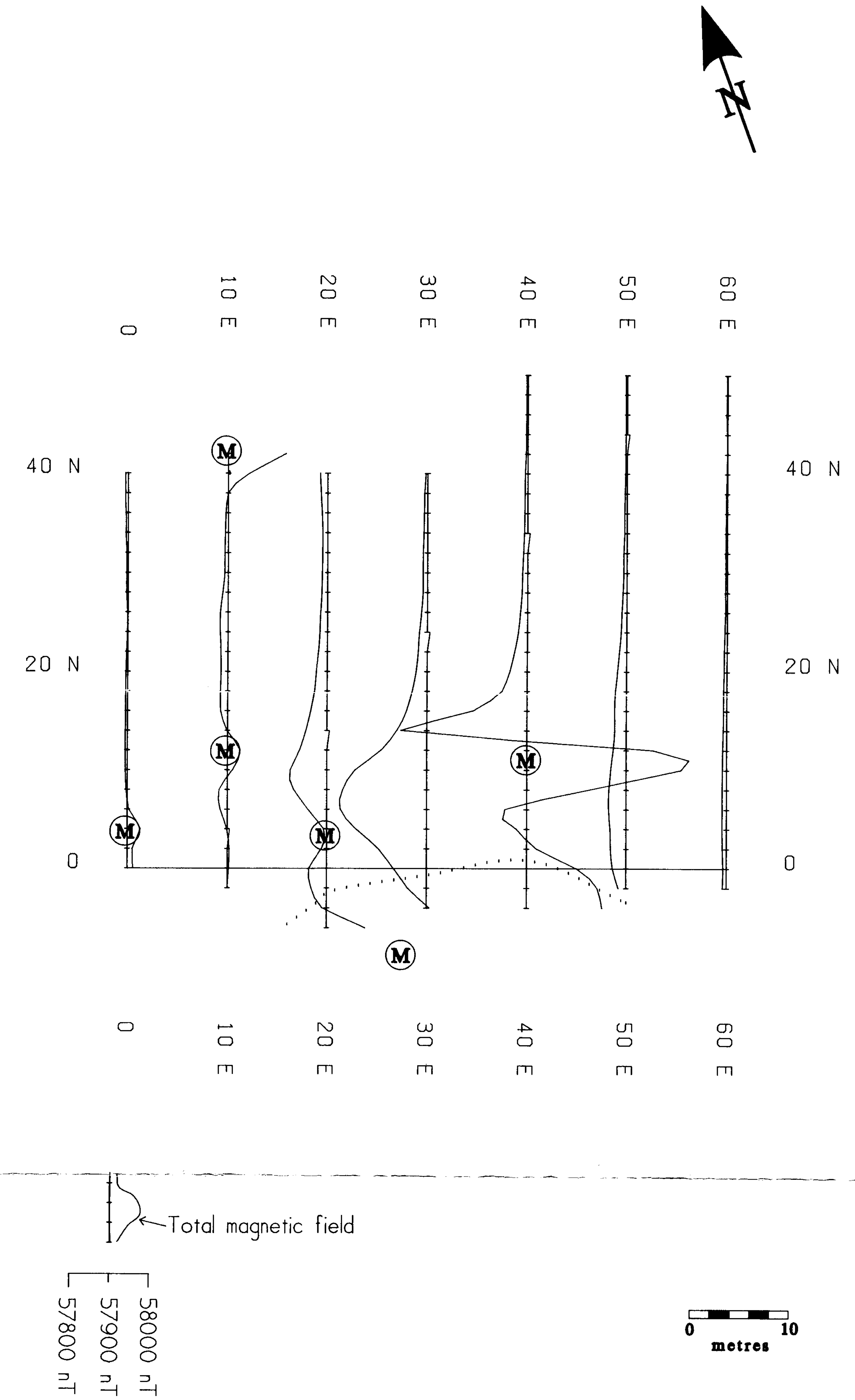
The total magnetic field survey was performed with a pair of Omni Plus proton precession magnetometers. These instruments record the strength of the local total magnetic field (ie. earth's field plus locally induced fields) to within ± 1 nanoTeslas (nT). The base station was synchronized with the field unit, installed 75 m west of the grid origin and cycled at an interval of 10 s throughout the magnetic field survey. This permits the removal of temporal variations in the geomagnetic field caused by solar and ionospheric activity. The geomagnetic field was unsettled throughout the field survey with variations of up to 3 nT recorded over 10 s intervals.

The ground conductivity survey was conducted with a Geonics EM-31 shallow electromagnetic system. This system consists of a pair of horizontal coils separated by 3.66 m in a rigid boom and connected to a central console. The instrument measures ground conductivity using the quadrature or out-of-phase component of the secondary electromagnetic field induced in the earth by the transmitting coil. Quadrature and ground conductivity have a linear relationship at low induction numbers (ie. at low conductivities and short intercoil spacings) and the instrument capitalizes on this phenomenon to measure ground conductivity. The EM-31 records the apparent half-space ground conductivity in milliSiemens per m (mS/m) and the in-phase component in ppt. The reported conductivity can be considered to be an average conductivity of the material beneath the instrument at the survey station to a depth of 6 m.

Both the magnetometers and the EM-31 have on-board digital RAM and record all data internally. Following the surveys, the data was dumped from the instruments to a laptop computer for subsequent data processing, plotting and interpretation. Corrections for temporal variations in the geomagnetic field (diurnal corrections) were performed using on-board software during the dumping process.

RESULTS

The results of the total magnetic field survey are shown in Figures 4 and 5. Figure 4 is a stacked profile map showing the survey grid with the total magnetic field profiles superimposed on the survey lines. The base level of the magnetic field in the survey area was 57900 nT; this corresponds to the level at the survey lines. Positive readings are to the right and negative readings to the left at a scale of 1 cm = 100 nT. The apparent locations of ferromagnetic debris (ie. iron or steel) are indicated by symbols on the plot at their grid locations. The strong response at 40E, 10N is caused by several stacked barrels at surface. The magnetic field low on lines 20E through 40E near the base line is probably caused by metallic debris exposed in the bank to the south. Other isolated anomalies probably caused by metallic debris are indicated on the diagram. Figure 5 displays the same data in contour map format.



(M) - Ferromagnetic object

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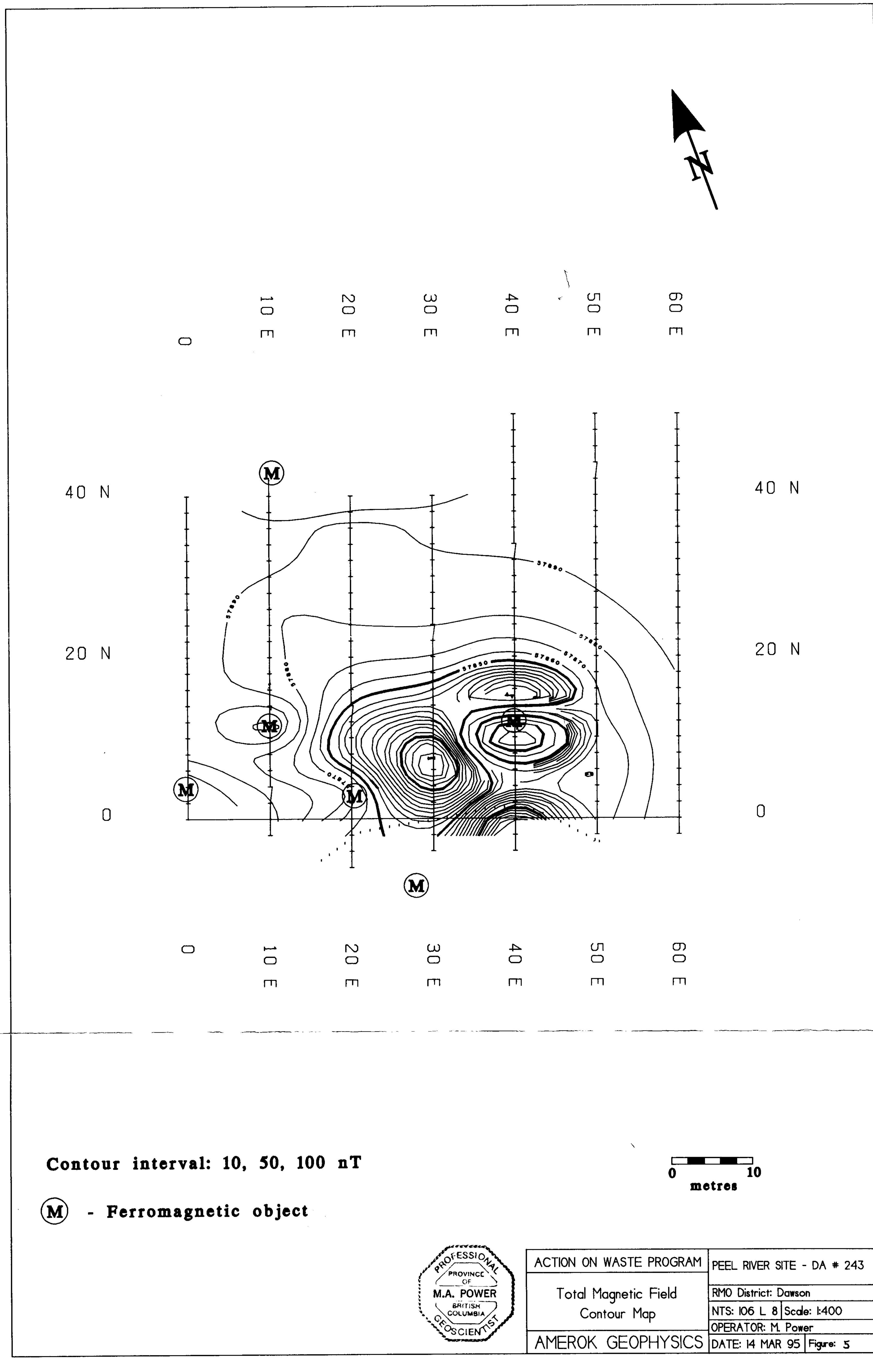
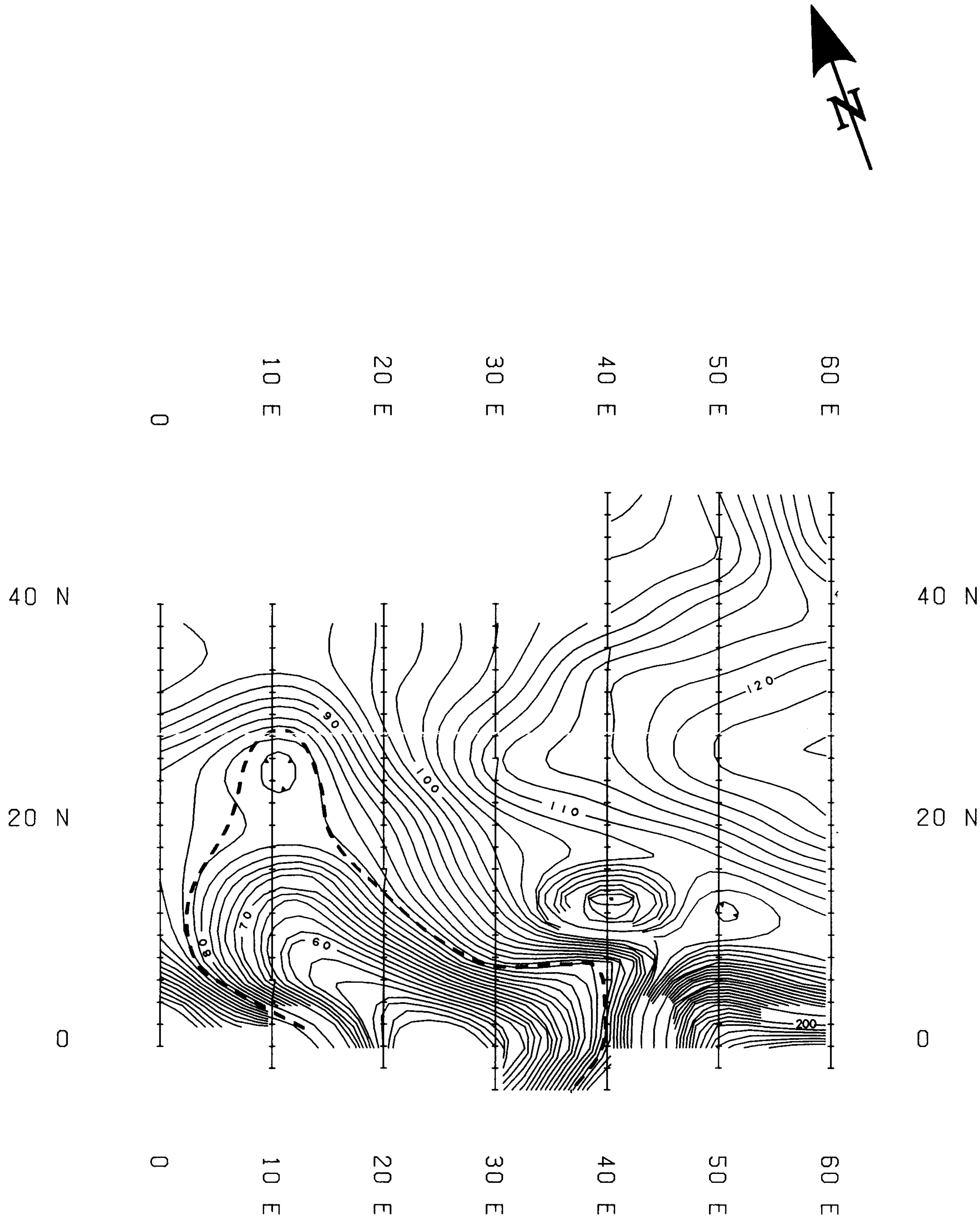
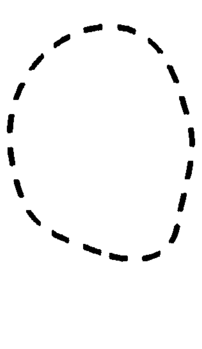
ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 243
Total Magnetic Field Stacked Profiles	RMO District: Dawson
	NTS: 106 L 8 | Scale: 1:400
	OPERATOR: M. Power
AMEROK GEOPHYSICS	DATE: 14 MAR 95 | Figure: 4



ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 243
Total Magnetic Field Contour Map	RMO District: Dawson
	NTS: 106 L 8 | Scale: 1:400
	OPERATOR: M. Power
AMEROK GEOPHYSICS	DATE: 14 MAR 95 | Figure: 5





0 10
metres

Contour interval: 2 ohm-m

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ACTION ON WASTE PROGRAM	PEEL RIVER SITE - DA # 243	
Geonics EM-31 Survey Apparent Resistivity	RMO District: Dawson	
	NTS: 106 L 8	Scale: 1:400
	OPERATOR: M. Power	
AMEROK GEOPHYSICS	DATE: 14 MAR 95	Figure: 6

In the Peel River area,the local strength, declination and inclination of the earth's magnetic field is 59,000 nT, 36° E and 80° N (Newitt and Haines, 1990a,b). Anomalies caused by ferromagnetic objects in this field consist of a strong positive peak centred just to the magnetic south of the object and much weaker negative trough on the magnetic north side of the object. Depending upon the depth to the object, the object location is beneath the positive peak or beneath the inflection point between the peak and trough. A good example of the anomaly produced by a magnetic object is the response at 40E, 10N. The maximum strength of the anomaly due to a compact mass of iron or steel in a steeply dipping local field is given by the expression for the maximum strength of a magnetic dipole:

$$T=\frac{2M}{r^3}$$

where **T** is the total field strength in nanoTeslas (nT), **M** is the dipole moment (approximately 500,000 cgs units per tonne of iron or steel) and **r** is the distance to the object in cm. Representative maximum anomaly strengths for different concentrations of iron or steel in a compact mass are summarized below:

Depth (m)	Barrel (40 lb)	500 lb	1000 lb	2000 lb
Surface	200 nT	925 nT	1850 nT	3700 nT
1.0	31 nT	390 nT	780 nT	1560 nT
3.0	6 nT	73 nT	146 nT	300 nT
5.0	3 nT	34 nT	69 nT	137 nT

The detection limit for a single barrel is approximately 2 m under normal operating conditions while larger masses of iron or steel can be located at greater depths. Given that the depth of burial at the Peel River Site is known to be approximately 3 m, the recorded maximum anomaly strengths suggest that the objects indicated on Figures 4 and 5 have masses less than approximately 450 kg. The exception to this would be the mass of steel and iron exposed in the river bank; no rough estimate of this mass can be made because the grid did not extend over the object.

The results of the ground conductivity survey are shown in Figure 6. In this diagram, conductivity has been converted to the more generally used electrical resistivity and contoured at a 2 ohm-m interval. The average resistivity of the overbank deposits and gravel is approximately 110 to 200 ohm-m as indicated by the resistivity in the northeast portion of the map. Resistivities below 80 ohm-m are anomalous in this setting and an area of anomalously low resistivity is enclosed within a dashed line on the figure. Higher apparent resistivities are recorded near the edge of the river bank on both sides of the resistivity low; these might be caused by lower overburden temperatures leading to lower liquid water concentrations in overburden near the edge of the bank.

Data provided to Amerok Geophysics by DIAND indicates that drilling fluid products likely to be encountered at the site include calcium chloride, bentonite, lime, caustic soda (sodium bicarbonate, sodium hydroxide), calcium oxide, sodium carbonate, barite, diesel oil, walnut shells, saw dust and lignite. Sodium bearing compounds dissociate readily in water and tend to depress the freezing points of the electrolytes they create. Consequently, an area contaminated by drilling mud would likely have a lower resistivity than the surrounding region and the area of low resistivity outlined in Figure 6 *may* be contaminated with some drilling mud. The apparent resistivity of this area is only slightly lower than the surroundings, suggesting that the contamination may not be extensive or of a high concentration. In addition, the presence of iron and steel debris will lower the overall resistivity of the sediments and may contribute to the lower apparent resistivity in this area. It should also be noted that thawed overbank clay deposits rich in organic debris also have a low electrical resistivity and could be confused with an area contaminated by drilling fluids. This seems unlikely at the Peel River Site since organic-rich clay is not exposed in the river bank near the resistivity low.

CONCLUSIONS

The results of this survey suggest the following conclusions:

a. Magnetic anomalies apparently caused by metallic objects were detected at six locations on the survey grid. The locations shown are considered accurate to $\pm$ 2 m. With the exception of the concentration of metallic debris exposed in the river bank, the anomalies are probably caused by concentrations of iron or steel with masses less than about 450 kg, provided that the depth of burial does not exceed 3 m. No reliable estimate of the mass of the metallic debris exposed in the river bank can be made.

b. An area of low near-surface apparent resistivity covering approximately 500 m^3 is present on the survey grid. The low overburden resistivity in this area might be caused by contamination from sodium-bearing drilling mud components. The presence of metallic debris in the area may also be contributing to the low apparent resistivity.

c. The survey grid seems to enclose and therefore define the limits of the zone of low apparent resistivity.

RECOMMENDATIONS

The geophysical surveys appear to have located and defined the areas affected by the Shell Canada operation and no further geophysical work is required to determine the limits of the site. If test pitting and sampling to determine the extent of drilling mud contamination is warranted, at least one pit at 20E 4N should be excavated to the base of fill or the water table.

Respectfully Submitted
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March 14, 1995

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