Hydrocarbon Microseepage Survey

Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

FINAL REPORT

Prepared for
Canadian Natural Resources, Ltd.

March 2001

Geo-Microbial Technologies, Inc. (GMT)
East Main Street, Ochelata, OK 74051 USA
www.gmtgeochem.com

CANADIAN NATURAL RESOURCES LIMITED
2500, 855 - 2 Street S.W., Calgary, Alberta T2P 4J8 • Telephone (403) 517-6700 Fax (403) 517-7350

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NEB / ONE

January 7, 2002

National Energy Board
444 Seventh Avenue SW
Calgary, Alberta
T2P 0X8

Attention: Terry Baker

Re: Report on Geo-Microbial Sampling Survey
Exploration Licence 400 1253
NEB Authorization #9229-C144-1E
Colville Hills Area, NWT

Enclosed please find a report on the Geo-Microbial Sampling Survey that Canadian Natural Resources Limited conducted on EL 400 in the Colville Hills Area, NWT between January and March of 2001.

Should you have any questions or concerns, please contact the undersigned at 517-6822.

Yours very truly,
CANADIAN NATURAL RESOURCES LIMITED

Jim Mak
Area Landman

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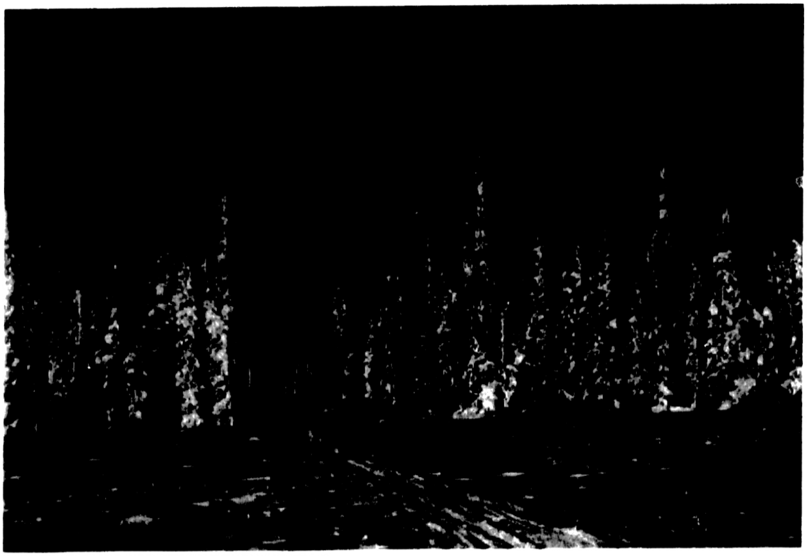

Geo-Microbial Technologies, Inc. (GMT)
East Main Street, Ochelata, OK 74051 USA
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Hydrocarbon Microseepage Survey
Microbial Oil Survey Technique (MOST)

Central Mackenzie Valley Prospect Block 4, EL 400, Northwest Territories, Canada

Prepared for
Canadian Natural Resources Energy, Ltd.
Calgary, Alberta

Submitted by
Geo-Microbial Technologies, Inc.
Ochelata, Oklahoma, USA

March 28, 2001

Executive Summary

Geo-Microbial Technologies, Inc., has completed analysis of 429 shallow soil samples collected for the Microbial Oil Survey Technique (MOST) to evaluate hydrocarbon microseepage in the Central Mackenzie Valley prospect area in the Northwest Territories, Canada. This reconnaissance survey covered an area of approximately 2600 sq. kilometers (1000 sq. miles). Samples were collected at 1000 meter intervals along 11 southeast-northwest geochemical traverses and 8 southwest-northeast traverses. The objectives of this geochemical survey are to assess the extent and magnitude of hydrocarbon microseepage (1) along selected seismic lines, (2) related to specific exploration leads and prospects, and (3) to identify areas that may warrant further geological, geophysical or geochemical evaluation.

The results of the microbial survey document the presence of strong hydrocarbon microseepage in parts of the survey area, and little or no microseepage over most of the area. Microbial anomalies range from small 2-3 sample groupings to areally extensive anomalies that extend for 5 to 10 kilometers along survey lines. The largest groupings of hydrocarbon microseepage anomalies occur in the southeastern and northwestern portions of the survey area. The principal anomalies are: (1) centered at the intersection of Lines 17 and 19, and extending both north and south along Line 17; (2) west of the intersection of Lines 24 and 26 and possibly extending as far as Line 3; (3) along Line 5/5A between Lines 3 and 4, and extending 5-8 km north; and (4) near the intersection of Line 1 with Lines 4 and 15. A number of small anomaly clusters occur in the northeaster part of the survey, along Lines 11, 12, and 1. The location of Well O-35 occurs within a small microbial anomaly near the intersection of Lines 24 and 26, however, a much larger microseepage anomaly begins 1-3 km west of O-35 and extends farther west to Line 17, and possibly as far as Line 3. No significant microseepage appears associated with the eastern portion of the survey as represented by Lines 2, 6, and 23; or in the southwest part of the survey area represented by Line 4.

These microseepage anomalies identify the general areas with higher petroleum potential, that is, those areas representing either migration pathways or leakage from accumulations. Equally important in this survey are the extensive portions of the survey area characterized by very low microbial values. Areas with little or no significant microseepage may indicate poor exploration potential unless (1) the reservoir is significantly underpressured, (2) contains heavy oil with little or no associated gas, (3) is highly compartmentalized, or (4) the geologic setting suggests presence of exceptional seals and/or preferential microseepage along faults, fractures, or inclined bedding surfaces.

All of these anomalies, both large and small, should be carefully correlated with available geological and geophysical data to fully evaluate the exploration significance of the hydrocarbon migration at these sites. Do not disregard the possibility of traps and reservoirs other than your principal objective.

Introduction

The successful application of surface and near-surface geochemical techniques in petroleum exploration requires careful acquisition, interpretation, and integration of surface and subsurface data (Klusman, 1993; Lopez et al., 1994; Schumacher and Abrams, 1996; Schumacher, 1999). Hydrocarbon microseepage data, such as the microbial data of this report, can provide the explorationist with the means to screen large areas -- or individual leads and prospects -- rapidly, economically, and qualitatively for their overall hydrocarbon potential. Microbial data can help establish favorable trends or fairways of production by delineating zones of active hydrocarbon migration associated with migration pathways and/or individual accumulations. Such data can facilitate high-grading of individual leads and prospects on the basis of their probable hydrocarbon charge. Surface exploration data cannot replace conventional exploration methods, but their hydrocarbon detection ability makes them a potentially powerful complement to them. **Geochemical and microbial data have found their greatest utility when used in conjunction with the available geological and geophysical information.** The need for such an integrated approach cannot be overemphasized. Properly applied, the combination of surface and subsurface data can reduce exploration risk by focusing on the areas with greatest petroleum potential.

Assumptions, Uncertainties, and Limitations

Assumptions: The underlying assumption of all near-surface geochemical exploration techniques is that hydrocarbons are generated and/or trapped at depth and leak in varying but detectable quantities to the surface. This has long been shown to be an established fact, and the close association of surface geochemical anomalies with faults and fractures is well known. It is further assumed, or at least implied, that the anomaly at the surface can be reliably related to a petroleum accumulation at depth. The success with which this can be done is greatest in areas of relatively simple geology and becomes increasingly difficult as the geology becomes more complex. **The geochemical anomaly at the surface represents the end of a petroleum migration pathway, a pathway that can range from short distance vertical migration at one end of the spectrum to long distance lateral migration at the other extreme** (Thrasher and others, 1996). Relationships between surface geochemical anomalies and subsurface accumulations can be complex; proper interpretation requires integration of seepage data with geological, geophysical, and hydrologic data. Understanding geology, and hence petroleum dynamics, of a basin is the key to using seepage data in exploration.

Macroseepage versus Microseepage: *Macroseeps* represent visible oil and gas seeps; very localized areas containing large concentrations of light hydrocarbons as well as, if available, high molecular weight hydrocarbons. Macroseeps are located at the termination of faults, fractures, and outcropping carrier beds.

Microseepage is defined as high concentrations of analytically detectable light hydrocarbons in soils, sediments or waters. These are invisible seeps recognized only by the presence of anomalous concentrations of light hydrocarbons, volatile heavier hydrocarbons or hydrocarbon-induced alteration products. Most surface geochemical methods, including the microbial method used in this survey, are designed to detect microseepage. Hydrocarbon migration in microseeps is a pressure-driven, or buoyancy-driven, process and is predominantly vertical (Klusman and Saeed, 1996), particularly in areas of simple, "layer-cake" geology. In geologically and structurally complex areas, microseeps and macroseeps will tend to follow the same migration pathways.

Seepage Activity: Seepage activity refers to the relative rate of hydrocarbon seepage. It may range from active seepage at one end of the spectrum, to passive seepage at the other (Abrams, 1992; Schumacher, 1999). The term *active seepage* refers to areas where subsurface hydrocarbons seep in large concentrations into shallow sediments and into the overlying water column. Such active seeps often display acoustic anomalies on conventional or high resolution seismic profiles and can be detected geochemically by most sampling methods. Areas where subsurface hydrocarbons are not actively seeping are referred to as characterized by *passive seepage*. Such seeps usually contain light hydrocarbons above background levels, but may only be detectable in deeper samples or near major leak points. For soil gas and microbial methods to be effective, light hydrocarbons must be seeping at a rate greater than the rate of destruction or dissipation. Reservoirs that are significantly underpressured, or contain heavy oil with little or no associated light hydrocarbons, may display little or no active hydrocarbon microseepage.

Anomaly Recognition: Hydrocarbon microseepage data, whether soil gas or microbial or other indirect measurements, is inherently noisy data and requires adequate sample density to distinguish between anomalous and background areas. Matthews (1996) has reviewed the importance of sampling design and sampling density in target recognition, and states that undersampling is probably the major cause of ambiguity and interpretation failures in surface geochemical studies.

To optimize the recognition of an anomaly, the sampling pattern and sample number must take into consideration the objective of the survey, the expected size and shape of the anomaly (or geologic target), the expected natural variation in surface measurements, and the probable signal-to-noise ratio (Matthews, 1996). Defining background values adequately is an essential part of anomaly recognition and delineation; Matthews suggests that as many as 80% of the samples be collected outside the immediate area of interest. We concur with these recommendations for reconnaissance and prospect evaluation surveys, however, for field development surveys optimum results are obtained when numerous samples are collected in a closely spaced grid pattern over the feature of interest. Sample spacing is routinely 100 meters or less in such detailed surveys.

Survey Method and Data Analysis

Microbial Oil Survey Technique (MOST): The microbial method was developed by Phillips Petroleum (Beghtel et al., 1987) more than 30 years ago and since 1985 has been available to industry from GMT. With MOST, microseeps are detected by observing the concentrations and distributions of hydrocarbon-oxidizing microbes in shallow soils. There is a direct, positive relationship between the hydrocarbon concentrations in soils and these microbial populations, a relationship that is easily measurable and reproducible. High microbial population distributions are therefore reliable indicators of light hydrocarbon migration pathways and/or leakage from individual petroleum accumulations. The specific suite of microorganisms measured are obtained from soil samples collected at a depth of about 20 centimeters and, after dehydration to stabilize the samples, shipped to our Oklahoma lab to be analyzed for the presence of these hydrocarbon-oxidizing microbes, chiefly butane-oxidizing microbes.

In processing the samples, twenty-five (25) grams of the collected soil were analyzed from each sample location. The 25 grams of soil were diluted and plated three times with agar gel and n-butanol. The butanol is the only utilizable organic carbon source for these microorganisms. Only those microorganisms already capable of light hydrocarbon metabolism survive in this selective growth medium. After one week of incubation, the microorganisms grow into colonies visible to the naked eye. These colonies were counted and the Microbial Value for each sample was calculated as the average of the three agar plates. These values are reported in Table 1.

Survey Objectives

The purpose of hydrocarbon microseepage surveys is to establish the presence and distribution of hydrocarbons in the area of exploration interest. Traps and structures located along the migration pathways represented by seepage anomalies should be considered significantly more prospective than those not associated with such hydrocarbon anomalies.

CNRL's area of exploration interest lies in Block 4, EL 400, Central Mackenzie Valley, Northwest Territories, Canada. The survey area encompasses about 2600 square kilometers (1000 square miles), and is located between 66°30' and 67°00' North Latitude and 126° and 127° West Longitude. The terrain consists primarily of forested rolling hills and muskeg (see photo pages).

The principal objectives of the Central Mackenzie Valley survey are to assess the extent and magnitude of hydrocarbon microseepage (1) along selected seismic lines, (2) related to specific exploration leads and prospects, and (3) to identify areas that may warrant further geological, geophysical or geochemical evaluation.

Survey Design and Sampling Methodology

The survey design and sampling pattern used for this survey was developed by Canadian Natural Resources personnel, with input from GMT and PK Services. Due to the large size of expected traps, samples were collected at approximately 1000 meter intervals (3280 feet) along both new and old seismic lines. Samples were collected along 11 southeast-northwest geochemical traverses and 8 southwest-northeast traverses as shown on Map 1. Samples were collected by PK Services of Calgary; the 3-man crew was assisted by native guides; sample locations were recorded with a Garmin 12XL GPS unit. Microbial samples were dehydrated after collection and shipped to GMT's lab in Oklahoma for processing, analysis and interpretation.

Results

The results of the Central Mackenzie Valley survey are summarized on the accompanying tables, figures, and maps.

Table1 list both the **Microbial and Smoothed Microbial Values** for each sample as well as its x-y sample location. The Smoothed Microbial Values are calculated using a 5-point weighted moving average function. This calculation averages the two sample points on each side of a particular data point and gives the most weight to the sample point in question, then more weight to the closest two samples, and finally the least weight to the outside two samples. This function effectively reduces noise in the data and helps delineate clusters of anomalously high and low values.

The **statistical characteristics of the microbial sample population** are summarized in Table 2. Measured microbial values in the surveyed area ranged from 1 to 500. The total sample population has a mean microbial value of 142 and a standard deviation of 140. The background microbial population has a mean of 55 and a standard deviation of 40.

Figure 1 displays the **frequency distribution histogram** of the Microbial Values for the survey area. This distribution indicates the magnitude and skewness of the data set present over the area of exploration interest. A histogram's skewness and mean can indicate the relative potential of the surveyed area. A non-productive survey area is usually represented by a histogram of normal frequency distribution, i.e., a normal bell-shaped curve. When the frequency distribution indicates dual populations, or more commonly is skewed to the right, then the histogram represents an area with an anomalous hydrocarbon microseepage population. A right-hand skewed histogram has higher Microbial Values and a higher Microbial Value mean than a non-productive, normal frequency distribution. **The microbial distribution of the Central Mackenzie Valley prospect data set is very strongly right-skewed and suggests the presence of anomalous hydrocarbon microseepage in the survey area.** Such highly skewed microbial distributions are characteristic of productive basins and plays.

Figure 1B illustrates the sample weight distribution for the CNRL samples. Approximately one half (48%) of the samples were of "normal" weight (20-25gm), however, almost one-third of samples were of very low weight (1-10gm) and consisted largely of organic matter. Most of these low weight samples represent muskeg environments. Despite the large variation in weight among these samples, there is no significant correlation between microbial values and sample weight (Figure 1B). This is not too surprising, however, since the abundance of butane-oxidizing microbes reflects the concentration of hydrocarbon gas in the soil, not the soil composition or mineralogy.

The **definition of microbial anomalies** and anomaly thresholds is based on the population statistics. For this survey samples with microbial **values of 235 and above (background mean plus 4.5 SD) should be considered anomalous**. Anomaly thresholds are based on these observations. Microbial values of 170-234 (background mean plus 3-4.5 S.D.) may be considered anomalous if associated with higher values. **More important than an individual microbial value is whether or not samples with higher microbial values group together over geologically significant features** such as seismic highs, stratigraphic pinch-outs, faults, etc. Single point highs may merely reflect "noise" in the data, especially when samples come from an extreme environment and/or the distance between samples is great. Single sample highs should be considered geologically significant only if their location coincides with the surface expression of a fault or other significant geological or structural feature.

ANOMALY THRESHOLDS

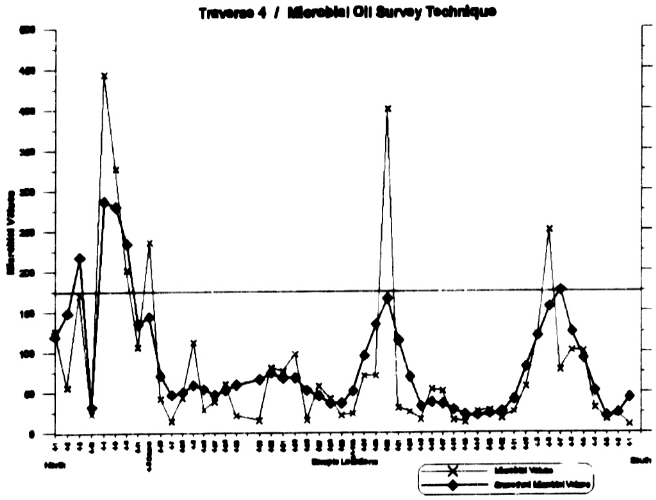
Mapping Color	Microbial Values	Statistical Values	% of Samples
RED	235-500	208-535	21.6
YELLOW	170-234	173-207	8.4
NO COLOR	1-169	1-172	70.0

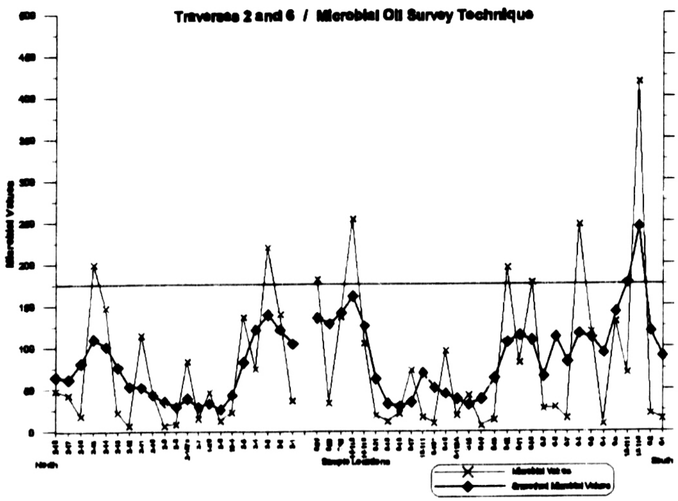
All maps are printed at a scale of 1:100,000 as well as at 1:250,000. Map 1 indicates the **sample locations** for each station. In the **Microbial Value Map** (Map 2) the anomalous samples have been highlighted using a bubble map format. Numbers next to each location represent the microbial count for that sample. The bubble maps use proportional and color coded symbols where the size and color of the circle is determined by the value of the sample at that location. The colors red (>4.5 SD above background mean) and yellow (3-4.5 SD above background mean) portray the anomalously high values and represent approximately the highest 30% of the data.

The data portrayed in the **Smoothed Microbial Value Map** (Map 3) represents the statistically smoothed microbial data. Each sample value represents a weighted average which considers the values at adjacent sites. This smoothing reduces data noise and tends to highlight more significant anomalies or anomaly clusters. Because smoothing (or averaging) of the data results in lower absolute values relative to the original microbial data, the individual anomaly thresholds on the smoothed microbial map are lower than those on the microbial value map, however, each threshold or mapping category represents exactly the same number (or percentage) of samples.

The microbial values and smoothed microbial values are plotted as **Microbial Lineplots** for survey lines 1, 2, 3, 4, 5, 5A, 6, 12, 15, 17, 19, 23, 24, and 26 (Figures 2-13). These lineplots effectively demonstrate the variation in microbial values displayed along survey lines. The smoothed data is shown as the heavier black line on the lineplots. **Profile peaks which contrast strongly from background values identify geochemical leads which may warrant further geologic or seismic evaluation.** Also, isolated very high or very low single points may represent random noise or possible fault indicators, but such single point highs can create sizable statistical anomalies if their value is extreme enough. The groupings of both high value and low value samples are displayed in profile and thus relative comparisons of values can be made. These interpretations can easily be compared to seismic profiles or geologic cross sections. Trends and groups of similar microbial values -- both high and low -- as well as sharp contrasts in microbial values (also good fault indicators) help direct explorationists toward geological and geophysical features which may be otherwise overlooked. The illustrations on the next two pages represents reduced version of the microbial lineplot from a number of survey lines and illustrates the microbial response of both a high microseepage areas and background, or non-anomalous areas.

Microseepage Patterns: Background Microseepage

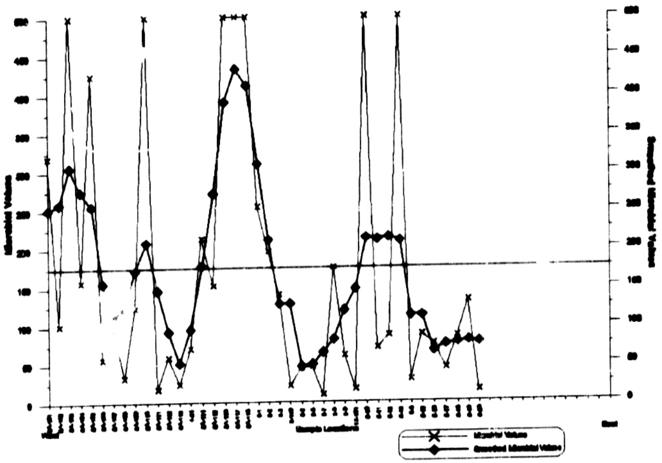




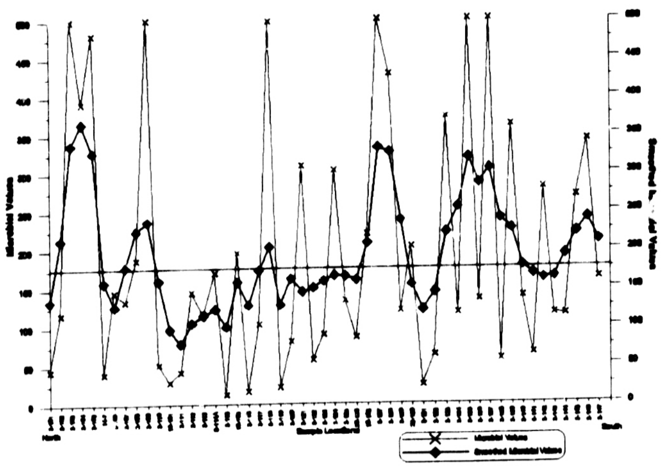
Microbial profiles along three seismic lines illustrating different levels of background microseepage. The threshold for anomalous microseepage is indicated by the red line (MV=175). Most of Line 4 is typical of areas where there has been little or no hydrocarbon generation. The lower profile, Lines 2 and 6, show regionally elevated and more variable background microbial values. This pattern is typical of areas where hydrocarbon generation and migration has occurred.

Microseepage Patterns: Anomalous Microseepage

Traverses 5A and 5 / Microbial Oil Survey Technique



Traverse 3 / Microbial Oil Survey Technique



Microbial profiles for seismic Line 3 and 5/5A illustrating examples of microbial anomalies found in the survey area. The central and western anomalies on Line 5/5A (upper figure) are well developed, defined by multiple anomalous microbial values, and contrast sharply from adjacent low values. Line 3 (lower figure) illustrates a microseepage pattern typical of extreme environments, high sample-to-sample variability. Microbial anomalies along Line 3 are less well defined due to the presence of low values adjacent to high values. In this setting, the smoothed microbial value (heavy line) helps identify potentially significant microseepage anomalies.

Interpretation and Discussion

Interpretation Guidelines: A microbial or soil gas anomaly at the surface represents the end of a petroleum migration pathway. The increased microseepage within these anomalies may reflect hydrocarbon leakage from an accumulation, or merely leakage from a carrier bed or other migration pathway. If the leakage is from an accumulation, that oil or gas pool may occur at any depth. The large clusters of samples of very high microbial populations (or very low) may indicate the location of discrete structural or stratigraphic targets within the survey area. **If this is a basin characterized by predominantly vertical microseepage, then the correlation of a strong microbial anomaly at the surface with a possible trap at depth suggests that the trap is charged with hydrocarbons**; conversely, if the trap is not associated with a positive microbial anomaly, the assumption is that the trap is not charged with hydrocarbons. If the structural or geologic setting of this basin suggests that microseepage may be predominantly lateral, such as along steeply dipping stratigraphic surfaces and unconformities, the interpretation will be more difficult since microbial anomalies may then not be located vertically above a trap. Which of these migration scenarios is more likely in the Central Mackenzie Valley survey area? What is the relationship of the anomalies to outcrop geology, mapped structural closures, stratigraphic pinch-outs, reefs, faults, basement highs, etc.?

General Observations: The microbial results for the 429 soil samples collected from the Central Mackenzie Valley prospect area document the presence of strong hydrocarbon microseepage in parts of the area and little or no microseepage over most of the survey area. As a generalization, **the most prospective areas based on anomalous microseepage are in the southeastern and west-central parts of the survey area (Maps 2, 3).** If one divides the surveyed area into quadrants using seismic lines 3 and 5/5A, **the largest cluster of anomalous microbial values occurs in the southeast quadrant, south of Line 5/5A between Lines 3 and 20.** Another potentially significant grouping of microbial anomalies occurs in the **northwest quadrant**, from near the middle of Line 5 extending north along portions of Lines 3 and 15. The **northeast quadrant**, north of Line 5/5A and east of Line 3, contains only four small anomaly clusters. The **southwest quadrant,** south of Line 5/5A and west of Line 3, includes **no significant microseepage** anomalies, however, it has only been sampled along a single traverse.

Principal Microseepage Anomalies: The principal microseepage anomalies are shown on Maps 2-3 and Figures 2-13 and include the following:

> **Line 1:** Three clusters of anomalous samples occur along this line: a) one small cluster occurs east of the *intersection of Lines 1 and 12*; b) a second small cluster occurs near the *middle of the line* southwest of its intersection with Line 10; c) the third group of anomalous samples occurs near the *west end of the line* between its intersection with Lines 4 and 15.
>
> **Line 2:** Mostly background values characterize this line; there are no significant single point anomalies or anomaly clusters.
>
> **Line 3:** *Four major clusters of anomalous samples* occur along this line, and three of them are in the southern half of the line: a) a small anomaly 3-4km long at the *south end of the line*; b) large anomaly located *7-14km north of the south end* of the line; if this anomaly links up with one at western end of Lines 24 and 26, it may represent a single feature 5x10km in size; c) a small anomaly located *3-4km south of Line 19*; d) a *7-8km long anomaly near north end of Line 3* and extending both north and south from intersection with Line 14.

Line 4: Mostly background samples except for a small cluster of anomalous samples near north end of the line at its intersection with Line 1. This anomaly may join up with the anomaly at north end of Line 15. South of the intersection of Line 4 with Line 5/5A, microbial values are uniformly low; the two isolated samples with higher values may merely represent background noise unless their location coincides with a fault or other significant geologic feature.

Lines 5 and 5A: *Three main groupings of anomalous samples* occur along Line 5/5A: a) *eastern third of the line* between Lines 6 and 17; since this is only anomalous on the smoothed microbial map, it might merely reflect the impact of the single point "500"high; b) *well developed 7-8km long anomaly between Lines 3 and 4*; might it extend north to Line 18 and beyond? c) *west end of line*, 4-5km long anomaly; cannot speculate about its possible significance or extent since no other samples collected nearby.

Line 6: Mostly background values although there are a few isolated single point highs.

Line 10: No significant anomalies along this line.

Line 11: Two small anomaly clusters of 3-5 samples each. The better developed anomaly occurs near *north end of line between Lines 12 and 14*; the second anomaly occurs at *south end of line*, south of its intersection with Line 16.

Line 12: A small anomaly in the south-central part of the line near its intersection with line 11.

Line 14: Mostly background microbial values; the few single-point highs appear unrelated to nearby microseepage anomalies.

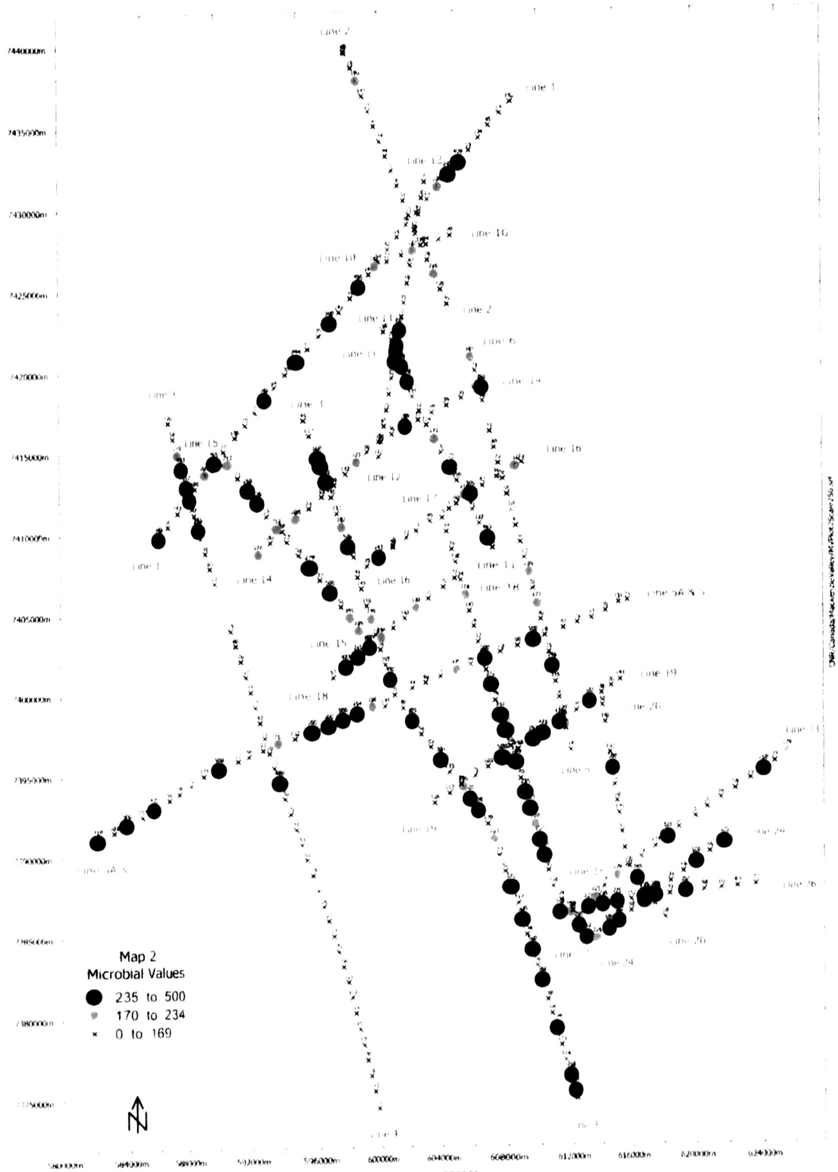
Line 15: Two principal microbial anomalies are present, one in the *northern third of the line* and the second in the *southern third of the line*. The northern anomaly appears to be part of a larger anomaly also seen on Lines 1 and 4. The southern anomaly apears to be linked with one at the west end of Line 18.

Line 16: Mostly background values except at intersection with Line 11.

Line 17: Samples from this line are *highly anomalous from its intersection with Line 5/5A to the south end of the line*. Two principal microseepage anomalies can be recognized: a) *a very large anomaly is centered on the intersection of Lines 17 and 19* and extends about 6km both north and south along Line 17 from that intersection; b) a smaller but potentially significant anomaly occurs near the *south end of the line, at its intersection with Lines 24 and 26*; this anomaly may extend east to the vicinity of the O-35 well, and west to Line 3.

Line 18: A small anomaly exists at the *west end of the line*, west of its intersection with Line 15; this microseepage anomaly appears to extend along Line 15, both north and south of the intersection with Line 18.

Line 19: The *middle third of Line 19 is highly anomalous and forms the heart of one of the larger seepage anomalies in the survey area*. The anomaly extends along Line 17 for about 6km both north and south of its intersection with Line 19.



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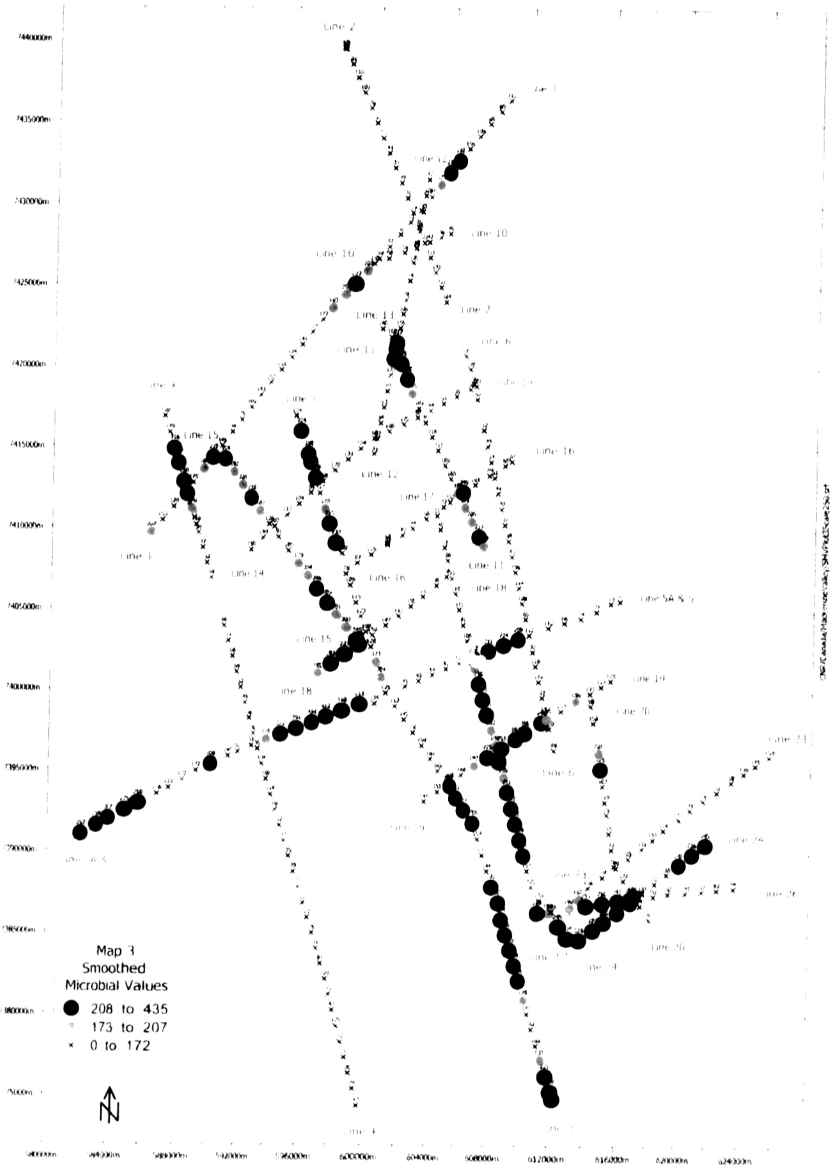
Zone 9W

0km 2km 4km 6km 8km 10km

CANADIAN NATURAL RESOURCES, LTD.
HYDROCARBON MICROSEEPAGE SURVEY
Map 2 Microbial Values
Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada



Scale 1 250000
Universal Transverse Mercator (UTM) System
Zone 9W

0km 2km 4km 6km 8km 10km

GMT
Geo-Microbial Technologies, Inc
East Main St. P.O. Box 132
Ochelata, OK 74051 USA
918 535 2281 Fax 918 535 2564
Web http://www.gmtgeochem.com

CANADIAN NATURAL RESOURCES, LTD.
HYDROCARBON MICROSEEPAGE SURVEY
Microbial Oil Survey Technique (MOST)
Map 3 Smoothed Microbial Values
Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

Line 20: Mostly background values *except at its intersection with Lines 24 and 26,* near the location of the O-35 well.

Line 23: Mostly background *except near its intersection with Line 26.*

Line 24: The principal microseepage anomaly occurs along the *western half* of this line, west of its intersection with Line 26. There may be *two separate anomalies: a small one near the location of the O-35 well, and a second and larger one that begins about 2km west of the first and extends west to Line 17* (and possibly farther west to Line 3).

Line 26: The western half of the line is highly anomalous. As with Line 24, there may be *two separate anomalies: a small one near the location of the O-35 well, and a second and larger one that begins about 2km west of the first and extends west to Line 17* (and possibly farther west to Line 3).

Do the patterns of high and low microseepage anomalies make geologic sense? How do they relate to the mapped or inferred distribution of traps, known reservoirs, reservoir thickness, wells with gas shows, etc.? How do the microbial anomalies observed near and west of the O-35 well correspond with the areal extent of traps and reservoirs in the vicinity of the well? The microseepage data suggests that a well location 2-4km west of O-35 might be a favorable site --- is that geologically reasonable? What about the location of some of the larger and more extensive microseepage anomalies? For example, is there geologic or seismic evidence for a trap in association with the geochemical anomalies near the intersection of Lines 17 and 19, or along Line 5 between Lines 3 and 4, or near the intersection of Lines 11 and 12? If there is good correlation between a microseepage anomaly at the surface and a trap at depth, it suggests that the trap is charged with hydrocarbons. Conversely, if the trap is not associated with a positive (and extensive) microbial anomaly, it suggests that the trap is not charged with hydrocarbons.

If the expected reservoir(s) are unlikely to be productive at the site of some of the microbial anomalies, what other reservoir intervals are present that could account for the elevated microseepage observed there? What is the possibility of an undiscovered or unexpected productive reservoir in the survey area? Do not disregard the possibility of traps and reservoirs other than your primary objective.

Sample Variability and Reproducibility: Surface geochemical data, whether soil gas or microbial or other indirect measurements, are inherently noisy data. Sample-to-sample variability among microbial samples results from the non-homogeneous distribution of hydrocarbon-oxidizing microbes in soil, the variable concentration of oxygen and light hydrocarbons in soil pore spaces, varying hydrocarbon flux, variable soil moisture or ice content, variable soil pH, etc. These variables tend to be most extreme in harsh climates and terrain. The uncertainties introduced by such high sample-to-sample variability can be minimized by close sample spacing (250 meters or less), since increased sample density will help distinguish between anomalous and background areas. Additionally, **one must focus on clusters of high (or low) samples rather than individual samples. For example, if an anomaly consists of a series of 3 or 4, or more, anomalous samples and if that anomaly is also represented on a comparable portion of an adjacent or intersecting geochemical traverse (or seismic line), it is far more likely to have exploration significance than if it involved fewer samples or occurs on a single line only.**

Hydrocarbon Composition: The microbial method employed for this survey represents a cost-effective way to identify areas of significant hydrocarbon microseepage, areas that may represent leakage from an accumulation or a migration pathway. The methodology does not, however, discriminate between oil and gas microseepage. By focusing on the presence of butane-oxidizing microbes, the MOST technique is effective in recognizing leakage from accumulations containing oil, oil and gas, gas condensate, and gas containing light hydrocarbons such as ethane, propane, and butane. The technique cannot, however, discriminate between such accumulations. One can infer the composition of migrating hydrocarbons through **sorbed soil gas analysis**, a method also available from GMT. The sorbed soil gas method (SSG) analyzes light hydrocarbons directly using acid extraction of shallow soils and sediments, shothole cuttings, and uphole cuttings. Not only is there often a direct relationship between the soil gas hydrocarbons and a subsurface accumulation, but the composition of the soil gas hydrocarbons reflects that of the reservoired hydrocarbons (Jones and Drozd, 1983). Furthermore, the sorbed soil gas concentrations record seepage over long periods of time rather than just the present-day seepage. SSG samples are generally collected at a minimum depth of one meter

Conclusions and Recommendations

The results of the microbial survey document the presence of strong hydrocarbon microseepage in parts of the survey area, and little or no microseepage over most of the area. Microbial anomalies range from small 2-3 sample groupings to areally extensive anomalies that extend for 5 to 10 kilometers along survey lines.

The largest groupings of hydrocarbon microseepage anomalies occur in the southeastern and northwestern portions of the survey area. The principal anomalies are: (1) centered at the intersection of Lines 17 and 19, and extending both north and south along Line 17; (2) west of the intersection of Lines 24 and 26 and possibly extending as far as Line 3; (3) along Line 5/5A between Lines 3 and 4, and extending 5-8 km north; and (4) near the intersection of Line 1 with Lines 4 and 15. A number of small anomaly clusters occur in the northeaster part of the survey, along Lines 11, 12, and 1. The location of Well O-35 occurs within a small microbial anomaly near the intersection of Lines 24 and 26, however, a much larger microseepage anomaly begins 1-3 km west of O-35 and extends farther west to Line 17, and possibly as far as Line 3. No significant microseepage appears associated with the eastern portion of the survey as represented by Lines 2, 6, and 23; or in the southwest part of the survey area represented by Line 4.

All of these anomalies, both large and small, should be carefully correlated with available geological and geophysical data to fully evaluate the exploration significance of the hydrocarbon migration at these sites. Do not disregard the potential of deep traps and reservoirs.

* * * * * *

Although the discovery of a surface geochemical anomaly does not guarantee the discovery of commercially significant hydrocarbons, it establishes the presence of hydrocarbons in the area of interest and possibly in the exploration target. Hydrocarbon seeps at the surface represent one end of the migration pathway. Traps and structures along such pathways should be considered significantly more prospective than those not associated with hydrocarbon anomalies. If the areal extent of the microseepage anomaly at the surface approximates the extent of the reservoir or closure in the subsurface, it may indicate that the reservoir and trap is fully charged.

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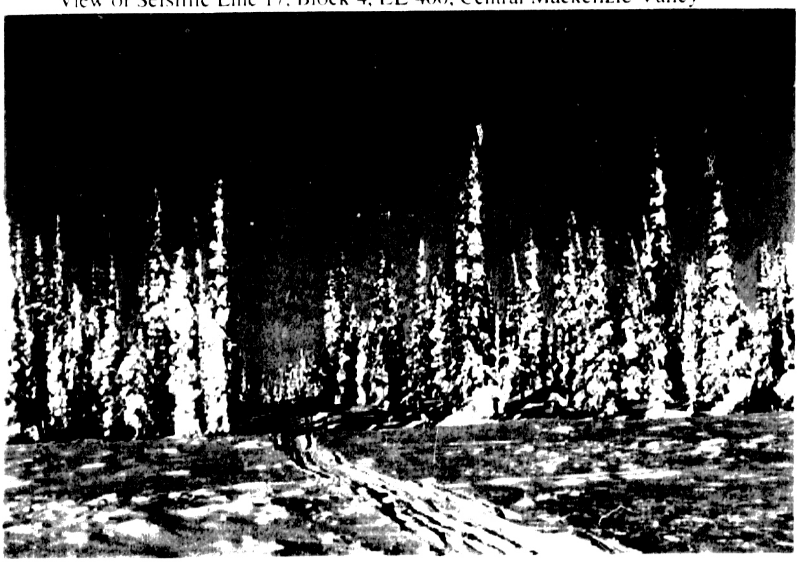
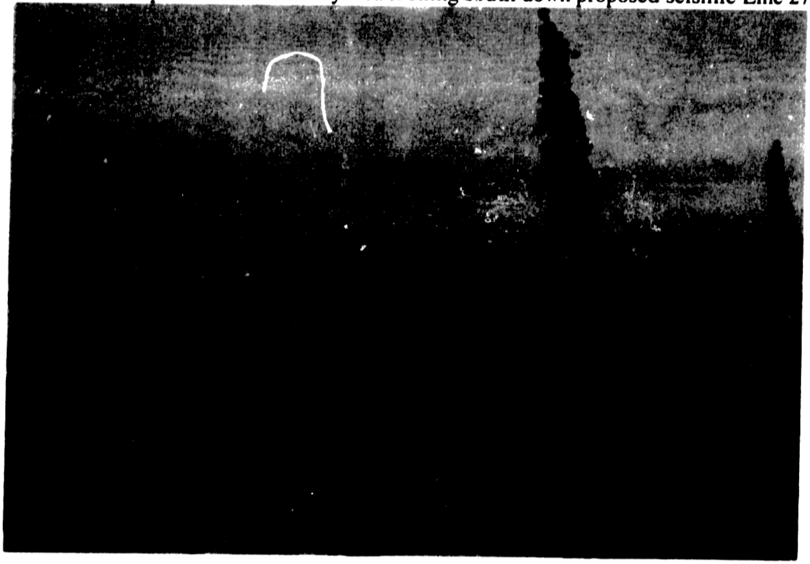
General View of the Central Mackenzie Valley Survey Area

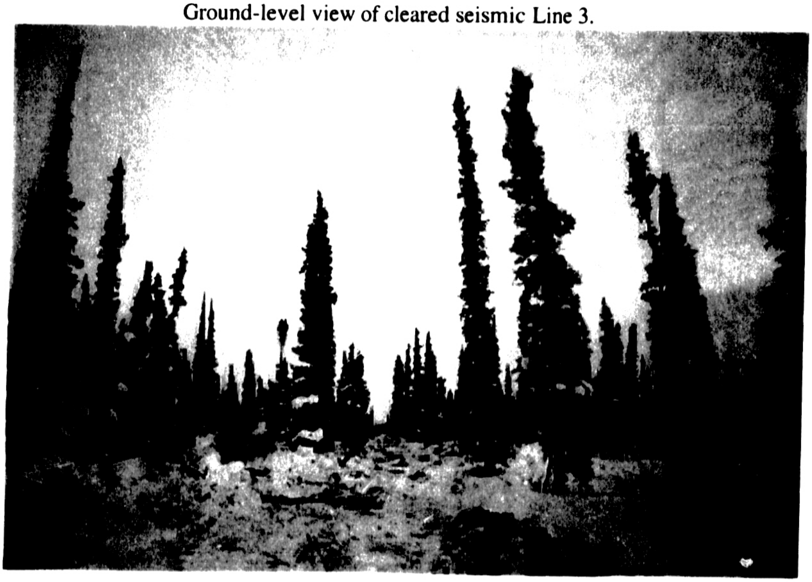
View of Seismic Line 17, Block 4, EL 400, Central Mackenzie Valley



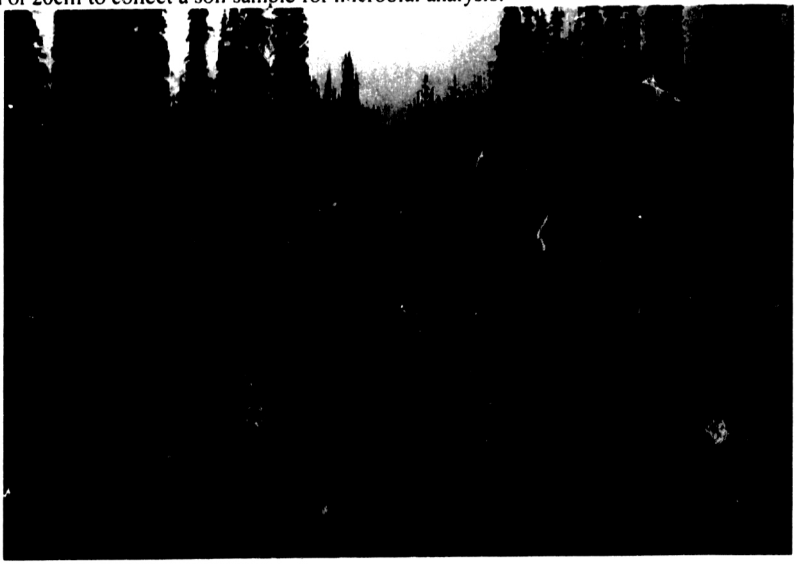
View of the eastern portion of the survey area looking south down proposed seismic Line 27



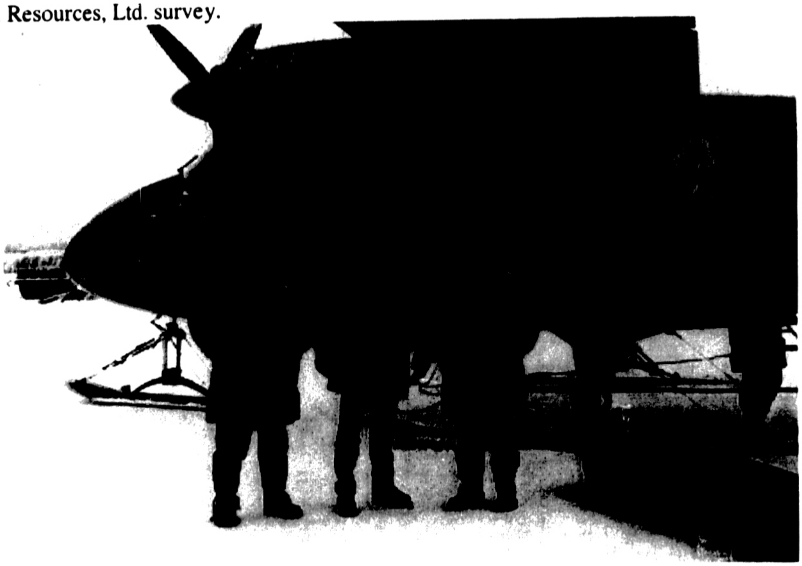
Ground-level view of cleared seismic Line 3.



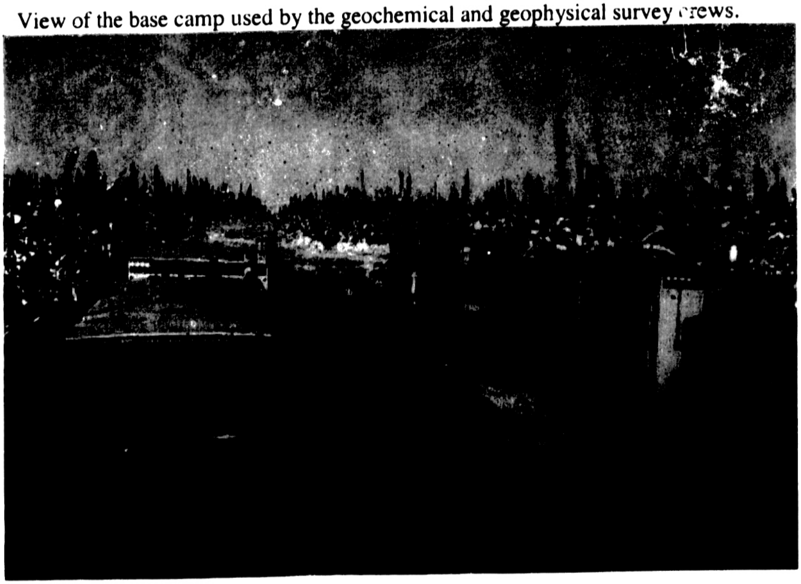
A typical day in the field. Bottom photo illustrates the use of an electric-powered auger to drill to a depth of 20cm to collect a soil sample for microbial analysis.



Members of the geochemical field crew arriving in the Northwest Territories for the Canadian Natural Resources, Ltd. survey.



View of the base camp used by the geochemical and geophysical survey crews.



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Hydrocarbon Microseepage Survey

Canadian Natural Resources, Ltd.

Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

March 2001

429 Samples Processed
419 Samples Mapped (See Notes on Table 1a)

Survey Microbial Average = 146
Survey Standard Deviation = 155

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
1	101	1-1	348	207	586046.99	7409665.68	-127.04286	66.79478
1	2	1-2	8	155	586686.83	7410454.39	-127.02775	66.80167
1	103	1-3	162	129	587370.48	7411278.12	-127.01161	66.80886
1	104	1-4	107	121	588009.23	7412035.9	-126.99653	66.81547
1	105	1-5	100	170	588594.74	7412770.92	-126.98267	66.82189
1	106	1-6	209	188	589266.12	7413598.12	-126.96678	66.82911
1	107	1-7	365	222	589852.77	7414317.86	-126.95289	66.83539
1	108	1-8	27	145	590445.17	7415040.16	-126.93886	66.84169
1	109	1-9	136	94	591139.98	7415894.3	-126.92239	66.84914
1	110	1-10	10	75	591755.95	7416652.28	-126.90778	66.85575
1	111	1-11	1	100	592394.16	7417430.13	-126.89264	66.86253
1	112	1-12	340	143	593008.22	7418185.01	-126.87806	66.86911
1	113	1-13	64	152	593647.12	7418959.86	-126.86289	66.87586
1	114	1-14	126	151	594279.41	7419738	-126.84786	66.88264
1	115	1-15	244	124	594900.38	7420515.9	-126.83308	66.88942
1	116	1-16	25	124	596188.6	7422095	-126.80242	66.90317
1	116	1-16	17	141	595543.31	7421307	-126.81778	66.89631
1	118	1-18	390	172	596829.57	7422858.47	-126.78717	66.90981
1	119	1-19	143	193	597431.18	7423561.58	-126.77286	66.91592
1	120	1-20	36	200	598143.99	7424401.6	-126.75589	66.92322
1	121	1-21	436	222	598700.02	7425063.21	-126.74264	66.92897
1	122	1-22	147	201	599374.48	7425865.38	-126.72656	66.93594
1	123	1-23	98	99	600040.64	7426656.27	-126.71067	66.94281
1	124	1-24	62	47	600669.31	7427397.98	-126.69567	66.94925
1	125	1-25	24	36	601313.95	7428159.41	-126.68028	66.95586
1	126	1-26	46	33	601960.83	7428921.1	-126.66483	66.96247
1	127	1-27	7	17	602661.87	7429639.25	-126.64817	66.96867
1	128	1-28	19	87	603380.7	7430465.4	-126.631	66.97583
1	129	1-29	206	175	604003.76	7431180.97	-126.61611	66.98203
1	130	1-30	242	226	604672.99	7431947.58	-126.60011	66.98867
1	131	1-31	409	238	605306.99	7432678.41	-126.58494	66.995
1	132	1-32	59	166	605951.93	7433422.1	-126.5695	67.00144
1	133	1-33	104	105	606604.69	7434179.67	-126.55386	67.008
1	134	1-34	46	66	607223.02	7434938.27	-126.539	67.01458
1	135	1-35	14	80	607888.24	7435693.33	-126.52306	67.02111
1	136	1-36	162	113	608482.37	7436374.3	-126.50881	67.027
2	101	2-1	36	104	604546.93	7423986.14	-126.61	66.91736
2	102	2-2	139	121	604151.87	7424903.77	-126.61822	66.92572
2	103	2-3	219	139	603748.3	7425821.13	-126.62664	66.93408

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
2	104	2-4	74	121	603345.07	7426736.31	-126.63506	66.94242
2	105	2-5	136	82	602939.94	7427650.36	-126.64353	66.95075
2	106	2-6	12	26	602512.53	7428617.18	-126.65247	66.95956
2	107	2-7	15	29	602135.83	7429497.81	-126.66033	66.96758
2	108	2-8	8	29	601337.15	7431308.83	-126.67706	66.98408
2	109	2-9	6	35	600928.34	7432226.34	-126.68564	66.99244
2	110	2-10	44	43	600532.9	7433119.84	-126.69394	67.00058
2	111	2-11	114	52	600145.81	7434041.6	-126.70203	67.00897
2	112	2-12	6	53	599755.8	7434966.64	-126.71019	67.01739
2	113	2-13	22	76	599379.59	7435866.57	-126.71806	67.02558
2	114	2-14	147	101	598968.82	7436812.14	-126.72669	67.03419
2	115	2-15	199	110	598577.92	7437733.93	-126.73489	67.04258
2	116	2-16	18	81	598236.1	7438545.99	-126.74206	67.04997
2	117	2-17	43	62	597833.29	7439448.48	-126.75056	67.05819
2	118	2-18	48	65	597796.97	7439549.81	-126.75131	67.05911
2	107a	2-107a	83	39	601738.98	7430397.81	-126.66864	66.97578
3	101	3-101	44	134	595264.44	7416915.19	-126.82764	66.85703
3	102	3-102	117	214	595575.5	7415965.53	-126.82131	66.84842
3	103	3-103	500	338	596059.23	7414532.22	-126.81144	66.83542
3	104	3-104	392	366	596216.41	7414048	-126.80825	66.83103
3	105	3-105	481	328	596542.21	7413083.33	-126.80161	66.8222[illegible]
3	106	3-106	145	127	596851.1	7412154.91	-126.79533	66.81386
3	107	3-107	133	178	597192.77	7411126.15	-126.78839	66.80453
3	108	3-108	187	225	597477.86	7410259.42	-126.78261	66.79667
3	109	3-109	500	237	597878.36	7409074.41	-126.77447	66.78592
3	110	3-110	51	160	598254.72	7408436.35	-126.76644	66.78008
3	111	3-111	41	78	598505.86	7407193.63	-126.76175	66.76886
3	112	3-112	145	105	598741.9	7406485.89	-126.75697	66.76244
3	113	3-113	116	115	599097.29	7405417.65	-126.74978	66.75275
3	114A	3-114A	170	123	599381.67	7404563.32	-126.74403	66.745
3	115	3-115	12	100	599705.82	7403602.23	-126.73747	66.73628
* 3	**116**	**3-116**	**16**	**128**	**600012.41**	**7402680.7**	**-126.73128**	**66.72792**
3	117	3-117	103	173	600330.57	7401725.03	-126.72486	66.71925
3	118	3-118	498	204	600646.04	7400775.99	-126.7185	66.71064
3	119	3-119	21	128	600957.98	7399832.42	-126.71222	66.70208
3	120	3-120	80	162	601533.04	7399007.91	-126.69989	66.6945
3	121	3-121	309	145	602148.72	7398193.94	-126.68664	66.687
3	122	3-122	56	150	602743.53	7397391.58	-126.67386	66.67961
3	123	3-123	89	159	603346.21	7396577.36	-126.66092	66.67211
3	124	3-124	303	166	603949.66	7395763.28	-126.64797	66.66461
3	125	3-125	133	165	604488.13	7395014.92	-126.63644	66.65772
3	127	3-127	500	333	605756.93	7393340.61	-126.60922	66.64228
3	128	3-128	428	327	606305.84	7392598.55	-126.59747	66.63544
3	129	3-129	120	238	606918.05	7391785.38	-126.58436	66.62794
3	131	3-131	23	121	607587.67	7389825.35	-126.57097	66.61014
3	132	3-132	62	144	607884.7	7388838.33	-126.56514	66.60119
3	133	3-133	372	222	608195.87	7387846.31	-126.559	66.59219
3	134	3-134	117	255	608637.28	7386866.11	-126.54992	66.58325
3	135	3-135	500	319	608829.27	7385810.33	-126.54653	66.57372
3	136	3-136	134	286	609109.56	7384895.27	-126.54103	66.56542
3	137	3-137	500	305	609410.28	7383939.76	-126.53511	66.55675
3	138	3-138	56	240	609707.19	7382984.12	-126.52928	66.54808
3	139	3-139	361	226	609992.38	7382059.28	-126.52369	66.53969
3	140	3-140	138	178	610357.92	7380874.33	-126.51653	66.52894
3	141	3-141	64	167	610625.27	7380026.94	-126.51128	66.52125
3	142	3-142	279	161	610906.98	7379102.03	-126.50578	66.51286
3	143	3-143	115	163	611226.88	7378094.99	-126.4995	66.50372
3	144	3-144	114	192	611473.49	7377187.69	-126.49478	66.4955

Table 1

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
3	145	3-145	268	221	611809.72	7376215.94	-126.48811	66.48667
3	146	3-146	341	239	612101.33	7375272.56	-126.48242	66.47811
3	147	3-147	161	210	612244.61	7374826.43	-126.47961	66.47406
4	1	4-1	9	43	599766.47	7374356.89	-126.7598981	66.474114
4	2	4-2	23	24	599502.46	7375382.7	-126.7649969	66.483394
4	3	4-3	16	20	599257.97	7376327.78	-126.7697261	66.491944
4	4	4-4	30	51	599003.99	7377306	-126.774645	66.500794
4	5	4-5	100	92	598766.38	7378229.05	-126.7792439	66.509144
4	6	4-6	101	125	598513.74	7379215.05	-126.7841331	66.518063
4	6	4-7	14	47	598254.24	7380198.71	-126.7891819	66.526963
4	8	4-8	112	59	598004.88	7381163.78	-126.7940211	66.535693
4	9	4-9	121	120	597755.46	7382109.9	-126.79888	66.544253
4	10	4-10	56	81	597451.07	7383056.33	-126.8049789	66.552833
4	11	4-11	25	41	597150.37	7384004.04	-126.8109981	66.561423
4	12	4-12	17	26	596843.13	7384953.66	-126.8171669	66.570032
4	13	4-13	27	23	596539.36	7385897.97	-126.8232661	66.578592
4	14	4-14	26	21	596251.67	7386808.27	-126.8290339	66.586842
4	15	4-15	12	22	595931.88	7387790	-126.8354731	66.595742
4	16	4-16	15	28	595620.14	7388737.45	-126.8417619	66.604332
4	17	4-17	51	35	595320.06	7389686.34	-126.8477911	66.612931
4	18	4-18	53	37	595014.45	7390634.06	-126.85395	66.621521
4	19	4-19	16	32	594707.97	7391573.97	-126.8601389	66.630041
4	20	4-20	25	69	594409.94	7392530.92	-126.8661281	66.638711
4	21	4-21	30	114	594105.3	7393479.87	-126.8722769	66.647311
4	22	4-22	400	166	593796.79	7394443.21	-126.8785061	66.656041
4	23	4-23	70	134	593491.12	7395394.3	-126.884685	66.66466
4	24	4-24	70	95	593193.64	7396319.03	-126.8907031	66.67304
4	25	4-25	21	36	592892.28	7397271.54	-126.8967919	66.68167
4	26	4-26	42	36	592590.28	7398221.82	-126.9029011	66.69028
4	27	4-27	57	45	592288.59	7399168.8	-126.90901	66.69886
4	28	4-28	15	52	591992.22	7400120.33	-126.9149989	66.707479
4	30	4-30	97	68	591689.49	7401069.55	-126.9211381	66.716079
4	31	4-31	76	68	591384.16	7402049.95	-126.9273169	66.724959
4	32	4-32	80	74	591079.89	7403003.63	-126.9334961	66.733599
4	33	4-33	15	66	590782.54	7403940.84	-126.939535	66.742089
4	35	4-35	21	59	589849.82	7406898.43	-126.9584911	66.768878
4	36	4-36	60	52	589552.96	7407820.47	-126.96432	66.777228
4	37	4-37	38	47	589266.83	7408762.32	-126.9703489	66.785758
4	38	4-38	28	54	588970.61	7409685.22	-126.9763981	66.794118
4	39	4-39	43	50	588681.72	7410604.93	-126.9822869	66.802447
4	40	4-40	42	71	588389.96	7411550.33	-126.9882261	66.811007
4	41	4-41	106	135	588097.68	7412476.7[illegible]	-126.994195	66.819397
4	42	4-42	23	32	587532.2	7414299.14	-127.0057331	66.835897
4	101	4-1	126	120	586735.88	7416875.33	-127.022	66.85922
4	102	4-2	56	149	587041.82	7415881.15	-127.01575	66.85022
4	103	4-3	170	218	587353.35	7414869.33	-127.00939	66.84106
4	104	4-4	443	287	587630.98	7413975.81	-127.00372	66.83297
4	105	4-5	327	280	587982.32	7412831.47	-126.99656	66.82261
4	106	4-6	201	234	588223.26	7412065.1	-126.99164	66.81567
4	106-2	4-6 Control	236	144	588223.26	7412065.1	-126.99164	66.81567
4	107	4-7	77	176	588518.62	7411128.72	-126.98561	66.80719
4	108	4-8	250	156	588812.99	7410187.87	-126.97961	66.79867
* 5	101	5-1	254	310	598415.93	7398696.11	-126.77069	66.69272
* 5	102	5-2	196	211	599406.39	7399106.55	-126.74794	66.69608
* 5	103	5-3	140	128	600293.8	7399161.06	-126.72781	66.69628
5	104	5-4	25	63	600891.48	7409140.17	-126.70597	66.78553
5	105	5-5	44	46	602181.22	7400234.59	-126.68419	66.70528

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
5	106	5-6	46	49	603062.43	7400586.55	-126.66394	66.70814
5	107	5-7	9	64	603991.92	7400952.9	-126.64258	66.71111
5	108	5-8	175	81	604951	7401336.33	-126.62053	66.71422
5	109	5-9	60	119	605858.3	7401693.56	-126.59967	66.71711
5	110	5-10	500	213	606782.51	7402030.56	-126.57844	66.71981
5	111	5-11	70	211	607719.44	7402431.97	-126.55686	66.72308
5	112	5-12	86	214	608665.98	7402807.32	-126.53508	66.72611
5	113	5-13	500	209	609567.38	7403168.93	-126.51433	66.72903
* 5	114	5-14	195	202	598569.4	7403852.39	-126.76303	66.73889
5	115	5-15	87	112	611453.31	7403904.26	-126.47092	66.73494
5	116	5-16	75	66	612376.12	7404211.9	-126.44972	66.73736
5	117	5-17	43	74	613337.58	7404465.67	-126.42769	66.73928
5	118	5-18	85	77	614268.35	7404912.66	-126.40617	66.74294
5	119	5-19	131	79	615159.69	7405430.87	-126.38547	66.74725
5	120	5-20	14	77	615756.38	7405546.36	-126.37183	66.74806
5A	101	5A-101	319	252	582086.45	7391001.4	-127.1455	66.62853
5A	102	5A-102	101	259	583069.43	7391541.63	-127.12294	66.63311
5A	103	5A-103	500	307	583847.93	7391980.07	-127.10506	66.63683
5A	104	5A-104	157	275	584835.92	7392494.33	-127.08239	66.64117
5A	105	5A-105	425	256	585612.88	7392936.59	-127.06453	66.64492
5A	106	5A-106	56	156	586669.58	7393511.67	-127.04025	66.64978
5A	107	5A-107	99	113	587368.27	7393892.87	-127.02419	66.653
5A	108	5A-108	32	122	588208.86	7394397.03	-127.00483	66.65728
5A	109	5A-109	123	172	589072.91	7394960.22	-126.98489	66.66208
5A	110	5A-110	500	208	590031.34	7395344.95	-126.96294	66.66525
5A	111	5A-111	17	146	591177.81	7395853.36	-126.93664	66.66947
5A	112	5A-112	58	92	591846.67	7396126.56	-126.92131	66.67172
5A	113	5A-113	23	51	592779.72	7396508.08	-126.89992	66.67486
5A	114	5A-114	213	178	593737.77	7396875.17	-126.87797	66.67786
5A	115	5A-115	152	272	594661.66	7397213.53	-126.85681	66.68061
5A	116	5A-116	500	391	595617.02	7397568.93	-126.83492	66.6835
5A	117	5A-117	500	434	596581.42	7397937.25	-126.81281	66.6865
5A	118	5A-118	500	412	597485.23	7398312.7	-126.79206	66.68958
6	101	6-1	14	89	611900.54	7396304.49	-126.46778	66.66667
6	102	6-2	20	119	611591.54	7397652.18	-126.47353	66.67686
6	103	6-3	130	142	611381.62	7398588.8	-126.47742	66.6[illegible]733
6	104	6-4	8	93	611154.97	7399581.66	-126.48164	66.69631
6	105	6-5	118	112	610936.26	7400567.05	-126.48569	66.70522
6	106	6-6	246	116	610719.41	7401531.32	-126.48972	66.71394
6	107	6-7	15	82	610522.13	7402407.12	-126.49339	66.72186
6	108	6-8	28	112	610290.26	7403454.5	-126.49769	66.73133
6	109	6-9	26	65	610044.34	7404448.88	-126.50236	66.74033
6	110	6-10	177	108	609797.96	7405425.41	-126.50706	66.74917
6	111	6-11	81	114	609567.84	7406373.59	-126.51142	66.75775
6	112	6-12	195	106	609328.47	7407347.08	-126.51597	66.76656
6	113	6-13	13	63	609097.44	7408291.91	-126.52036	66.77511
6	114	6-14	6	38	608869.3	7409255.83	-126.52467	66.78383
6	115	6-15	42	31	608625.41	7410253.73	-126.52931	66.79286
6	116	6-16	95	44	608147.89	7412190.84	-126.53842	66.81039
6	116	6-16 *	9	51	607916.12	7413149.1	-126.54283	66.81906
6	117	6-17	72	34	607678.52	7414124.99	-126.54736	66.82789
6	118	6-18	20	29	607445.17	7415085.44	-126.55181	66.83658
6	119	6-19	11	32	607205.48	7416099.22	-126.55636	66.84575
6	121	6-21	18	62	606749.08	7417999.39	-126.56506	66.86294
6	122	6-22	136	141	606525.97	7418970.34	-126.56928	66.87172
6	123	6-23	33	128	606261.61	7419843.74	-126.57453	66.87964
6	124	6-24	181	135	605961.22	7420677.82	-126.58064	66.88722
6	115A	6-115A	18	38	608389.28	7411215.13	-126.53381	66.80156

Table 1

	Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
	10	101	10-1	181	152	599772.66	7426341.84	-126.71706	66.94008
	10	102	10-2	22	68	600632.03	7426668.05	-126.69714	66.94272
	10	103	10-3	5	56	601619.3	7427042.82	-126.67425	66.94575
	10	104	10-4	4	69	602400.13	7427342.12	-126.65614	66.94817
	10	105	10-5	24	42	603298.42	7427676.23	-126.63531	66.95086
	10	106	10-6	7	36	604081.64	7427972.78	-126.61714	66.95325
	10	107	10-7	20	46	604741.51	7428221.28	-126.60183	66.95525
*	11	101	11-101	296	236	601195.34	7421085.88	-126.689	66.8925
	11	102	11-102	268	285	601566.01	7420160.24	-126.68133	66.88408
	11	103	11-103	426	260	601948.87	7419196.05	-126.67342	66.87531
	11	104	11-104	139	175	602304.29	7418303.39	-126.66608	66.86719
	11	105	11-105	12	100	602762.5	7417425.8	-126.65639	66.85917
	11	106	11-106	124	85	603231.24	7416544.2	-126.64647	66.85111
	11	107	11-107	171	118	603702.54	7415660.54	-126.6365	66.84303
	11	108	11-108	8	132	604143.09	7414830.45	-126.62719	66.83544
	11	109	11-109	272	169	604648.88	7413886.87	-126.6165	66.82681
	11	110	11-110	150	168	605079.27	7413072.14	-126.60742	66.81936
	11	111	11-111	216	189	605549.27	7412194.27	-126.5975	66.81133
	11	112	11-112	81	173	606045.48	7411271.75	-126.58703	66.80289
	11	114	11-114	465	227	606997.2	7409501.2	-126.56697	66.78669
	11	115	11-115	93	192	607313.08	7408899.88	-126.56033	66.78119
	12	1	12-1	7	42	603184.58	7431533.53	-126.63456	66.98547
	12	102	12-2	26	32	602989.27	7430546.48	-126.63989	66.97669
	12	3	12-3	22	18	602803.48	7429557.58	-126.645	66.96789
	12	4	12-4	22	43	602576.93	7428358.52	-126.65122	66.95722
	12	5	12-5	172	89	602379.93	7427297.84	-126.65664	66.94778
	12	6	12-6	167	100	602210.57	7426404.47	-126.66128	66.93983
	12	7	12-7	19	74	602004.36	7425299.97	-126.66694	66.93
	12	8	12-8	15	78	601778.89	7424107.75	-126.67311	66.91939
	12	8a	12-8a	235	239	601082.17	7420461.35	-126.69211	66.88694
	12	9	12-9	77	100	601616.41	7423240.36	-126.67756	66.91167
	12	9a	12-9a	83	127	600890.76	7419472.46	-126.69731	66.87814
	12	11	12-10	95	63	600517.06	7417483.91	-126.7075	66.86044
	12	12	12-12	65	56	600340.6	7416516.82	-126.71233	66.85183
	12	13	12-13	112	93	599979.83	7414604.73	-126.72214	66.83481
	12	13a	12-13a	29	72	600152.48	7415528.13	-126.71744	66.84303
	12	110	12-110	297	155	601446.72	7422374.94	-126.68217	66.90397
	12	110a	12-110a	17	79	600704.69	7418477.09	-126.70239	66.86928
	12	111	12-111	279	217	601270.01	7421435.64	-126.687	66.89561
	12	113	12-113	132	200	606500.35	7410424.68	-126.57744	66.79514
	13	1	13-1	158	140	600343.51	7422328.51	-126.70739	66.90392
	13	2	13-2	29	168	600907.61	7421824.96	-126.69494	66.89922
*	13	3	13-3	296	236	601194.64	7421104.82	-126.689	66.89267
	14	101	14-1	177	150	592532.89	7408631.02	-126.89625	66.78361
	14	102	14-2	161	140	593323.01	7409382.91	-126.87772	66.79011
	14	103	14-3	28	102	594060.54	7410077.46	-126.86042	66.79611
	14	104	14-4	206	117	594804.06	7410779.13	-126.84297	66.80217
	14	105	14-5	81	104	595538.75	7411470.67	-126.82572	66.80814
	14	106	14-6	55	96	596284.94	7412175.09	-126.80819	66.81422
	14	107	14-7	39	158	597031.69	7412877.52	-126.79064	66.82028
	14	8	14-8	132	128	597758.22	7413557.14	-126.77356	66.82614
	14	9	14-9	223	131	598497.43	7414253.04	-126.75617	66.83214
	14	10	14-10	86	104	599192.41	7414910.74	-126.73981	66.83781
	14	111	14-111	35	65	599977.64	7415565.24	-126.72139	66.84342
	14	112	14-112	96	106	600879.04	7416001.12	-126.7005	66.84703
	14	113	14-113	280	125	601797.13	7416441.29	-126.67922	66.85067
	14	114	14-114	17	80	602683.43	7416867.19	-126.65867	66.85419

Table 1

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
14	115	14-115	29	64	603573.24	7417297.99	-126.63803	66.85775
14	116	14-116	39	54	604479.78	7417731.97	-126.617	66.86133
14	117	14-117	96	95	605384.61	7418169.53	-126.596	66.86494
14	118	14-118	104	125	606290.55	7418605.23	-126.57497	66.86853
14	119	14-119	253	161	606688.93	7418797.07	-126.56572	66.87011
15	101	15-101 Control	213	214	590681.26	7414211.35	-126.93411	66.83419
* 15	102	15-102 Control	21	192	591290.24	7413405.02	-126.92086	66.82678
* 15	103	15-103 Control	260	201	591897.99	7412606.57	-126.90764	66.81944
* 15	104	15-104	356	218	592497.59	7411812.44	-126.89461	66.81214
15	105	15-105	59	182	593104.78	7411011.98	-126.88142	66.80478
15	106	15-106	232	139	593707.73	7410217.09	-126.86833	66.79747
15	107	15-107	22	91	594307.82	7409425.55	-126.85531	66.79019
15	108	15-108	93	105	594952.92	7408589.96	-126.84131	66.7825
15	109	15-109	279	179	595556.9	7407795.47	-126.82822	66.77519
15	110	15-110	32	204	596140.4	7407029.38	-126.81558	66.76814
15	111	15-111	500	246	596750.84	7406233.11	-126.80236	66.76081
15	112	15-112	91	209	597423.3	7405351.03	-126.78781	66.75269
15	113	15-113	191	201	597980.83	7404624.53	-126.77575	66.746
15	115	15-115	167	246	599168.98	7403065.15	-126.75008	66.73164
16	101	16-101	28	97	599128.54	7407869.83	-126.74706	66.77472
16	102	16-102	243	115	599923.86	7408379.54	-126.72858	66.77903
16	103	16-103	94	95	600917.07	7409007.23	-126.7055	66.78433
16	104	16-104	13	40	601840.31	7409599.23	-126.68403	66.78933
16	105	16-105	39	44	602497.46	7410012	-126.66875	66.79281
16	106	16-106	99	50	603403.26	7410593.86	-126.64767	66.79772
16	107	16-107	1	62	604593.22	7411352	-126.61997	66.80411
16	108	16-108	90	137	605041.27	7411644.75	-126.60953	66.80658
16	109	16-109	500	240	605958.27	7412229.05	-126.58817	66.8115
16	110	16-110	63	161	606727.23	7412720.86	-126.57025	66.81564
16	111	16-111	16	69	607606.5	7413285.3	-126.54975	66.82039
16	112	16-112	216	88	608574.49	7413909.36	-126.52717	66.82564
16	13	16-113	13	87	608984.34	7414170.03	-126.51761	66.82783
17	101	17-101	16	147	606640.39	7402121	-126.58158	66.72067
17	102	17-102	82	106	606370.31	7403076.78	-126.58686	66.72933
17	103	17-103	16	81	606086.19	7404057.7	-126.59244	66.73822
17	104	17-104	142	112	605812.43	7405014.49	-126.59781	66.74689
17	105	17-105	218	118	605533.37	7405998.99	-126.60328	66.75581
17	106	17-106	34	79	605263.67	7406939.25	-126.60858	66.76433
17	107	17-107	130	66	604951.8	7408053.08	-126.61469	66.77442
17	108	17-108	35	53	604716.99	7408849.66	-126.61933	66.78164
17	109	17-109	24	46	604403.71	7409941.17	-126.6255	66.79153
17	110	17-110	29	51	604158.71	7410793.19	-126.63033	66.79925
17	112	17-112	9	207	606866.79	7401338.71	-126.57714	66.71358
17	113	17-113	372	236	607136.21	7400407.49	-126.57186	66.70514
17	114	17-114	78	212	607414.45	7399435.35	-126.56642	66.69633
17	115	17-115	331	235	607685.98	7398491.97	-126.56111	66.68778
17	116	17-116	262	203	607961.95	7397529.82	-126.55572	66.67906
17	117	17-117	68	197	608233.01	7396573.08	-126.55044	66.67039
17	118	17-118	386	210	608513.86	7395585.5	-126.54497	66.66144
17	119	17-119	48	199	608798.98	7394583.6	-126.53942	66.65236
17	120	17-120	235	211	609047.99	7393704.16	-126.53458	66.64439
17	121	17-121	243	218	609334.77	7392702.37	-126.529	66.63531
17	122	17-122	228	253	609609.21	7391736.93	-126.52367	66.62656
17	123	17-123	257	248	609892.08	7390752.88	-126.51817	66.61764
17	124	17-124	354	227	610163.09	7389792.93	-126.51292	66.60894
17	125	17-125	50	157	610427.95	7388868.46	-126.50778	66.60056
17	126	17-126	138	125	610709.38	7387877.72	-126.50233	66.59158

Table 1

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
17	127	17-127	24	123	611232.07	7387040.62	-126.49131	66.58389
17	128	17-128	209	199	611788.6	7386241.81	-126.4795	66.57653
17	129	17-129	290	245	612356.09	7385421.22	-126.46747	66.56897
17	130	17-130	332	304	612874.9	7384680.2	-126.45647	66.56214
18	101	18-101	53	185	596895.37	7400981.55	-126.80328	66.71369
18	102	18-102	423	281	597710.48	7401587.15	-126.78433	66.71886
18	103	18-103	315	321	598500.79	7402185.43	-126.76594	66.72397
18	104	18-104	425	292	599286.67	7402787.14	-126.74764	66.72911
18	105	18-105	196	158	600093.03	7403398.76	-126.72886	66.73433
18	106	18-106	8	147	600892.74	7404013.74	-126.71022	66.73958
18	107	18-107	148	117	601685.06	7404616.41	-126.69175	66.74472
18	108	18-108	182	105	602461.39	7405213.16	-126.67364	66.74981
18	109	18-109	35	78	603267.78	7405822.43	-126.65483	66.755
18	110	18-110	25	48	604181.62	7406517.48	-126.6335	66.76092
18	111	18-111	37	58	604883.62	7407048.54	-126.61711	66.76544
19	101	19-101	108	141	603589.07	7393124.49	-126.65836	66.64108
19	102	19-102	163	151	604487.84	7393714	-126.63756	66.64606
19	103	19-103	220	208	605324.8	7394092.82	-126.61833	66.64917
19	104	19-104	75	148	606121.14	7394773.81	-126.59975	66.655
19	105	19-105	109	192	606953.63	7395311.41	-126.58047	66.65953
19	106	19-106	500	275	607780.42	7395851.29	-126.56131	66.66408
19	107	19-107	166	251	608662.62	7396391.38	-126.54089	66.66861
19	108	19-108	353	362	609526.64	7396980.14	-126.52083	66.67358
19	109	19-109	473	355	610118.39	7397357.44	-126.50711	66.67675
19	110	19-110	417	244	611143.36	7398019.02	-126.48333	66.68231
19	111	19-111	69	177	611463.9	7398227.25	-126.47589	66.68406
19	112	19-112	76	157	612287.6	7398747.23	-126.45678	66.68842
19	113	19-113	382	180	613131.3	7399289.5	-126.43719	66.69297
19	114	19-114	88	121	613971.68	7399829.68	-126.417[illegible]	66.6975
19	115	19-115	20	117	614627.81	7400256.43	-126.40242	66.70108
19	116	19-116	143	110	615235.09	7400642.24	-126.38831	66.70431
20	101	20-101	68	91	618058.1	7385860.49	-126.33869	66.57078
20	102	20-102	117	74	617438.98	7386716.86	-126.35181	66.57869
20	103	20-103	32	76	617124.1	7387168.85	-126.35847	66.58286
20	103A	20-103A	21	74	617197.89	7387051.46	-126.35692	66.58178
20	104	20-104	75	114	616898.94	7387475.14	-126.36325	66.58569
20	105	20-105	248	122	616303.26	7388297.01	-126.37589	66.59328
20	106	20-106	22	56	615676.41	7389172.37	-126.38919	66.60136
20	107	20-107	10	42	615502.83	7390193.98	-126.39214	66.61058
20	108	20-108	61	65	615332.6	7391201.22	-126.39503	66.61967
20	109	20-109	149	79	615143.16	7392352.74	-126.39822	66.63006
20	110	20-110	60	119	615008.62	7393124.91	-126.40053	66.63703
20	111	20-111	14	162	614844.35	7394112.34	-126.40331	66.64594
20	112	20-112	500	226	614674.51	7395150.87	-126.40617	66.65531
20	113	20-113	150	201	614523.16	7396129.92	-126.40867	66.66414
20	115	20-115	146	158	614197.63	7398025.71	-126.41425	66.68125
20	116	20-116	50	98	614022	7399062.91	-126.41725	66.69061
20	126	20-126	85	160	605223.02	7394277.49	-126.62047	66.65086
23	101	23-101	154	166	612940.87	7386297.52	-126.4535	66.57661
23	102	23-102	223	187	613498.29	7387117.04	-126.44019	66.58375
23	104	23-104	78	156	614095.28	7387851.3	-126.42606	66.59011
23	105	23-105	229	128	614975.42	7388480.28	-126.40564	66.59542
23	106	23-106	30	79	615803.74	7389066.11	-126.38642	66.60036
23	107	23-107	29	83	616606.65	7389636.62	-126.36778	66.60517
23	108	23-108	131	130	617493.37	7390262.28	-126.34719	66.61044
23	109	23-109	328	153	618232.74	7390830.6	-126.32997	66.61525
23	110	23-110	37	114	618953.63	7391419.54	-126.31314	66.62025
23	111	23-111	32	72	619998.2	7392090.81	-126.28892	66.62586

Table 1

Traverse	Sample	ID	Microbial Values	Smoothed Microbial Values	X Westing	Y Northing	X Longitude	Y Latitude
23	112	23-112	65	43	620708.46	7392664.16	-126.27233	66.63072
23	113	23-113	16	38	621515.6	7393224.12	-126.25356	66.63542
23	114	23-114	58	63	622338.44	7393792.83	-126.23442	66.64019
23	115	23-115	15	88	623233.79	7394416.39	-126.21358	66.64542
23	116	23-116	269	136	624015.29	7394953.66	-126.19539	66.64992
23	117	23-117	77	145	624732.22	7395453.65	-126.17869	66.65411
23	118	23-118	179	159	625520.09	7396003.95	-126.16033	66.65872
23	130	23-130	203	154	607279.1	7390817.53	-126.57706	66.61914
24	101	24-101	325	245	621668.97	7390496.59	-126.25281	66.61092
24	102	24-102	55	236	620849.03	7389895.89	-126.27189	66.60586
24	103	24-103	500	241	620001.32	7389273.05	-126.29161	66.60061
24	104	24-104	69	165	619210.26	7388696.46	-126.31	66.59575
24	105	24-105	93	152	618409.51	7388110.76	-126.32861	66.59081
24	106	24-106	33	143	617593.64	7387517.98	-126.34756	66.58581
24	107	24-107	500	314	616762.57	7386909.19	-126.36686	66.58067
24	107A	24-107A	59	300	615913.91	7386287.65	-126.38656	66.57542
24	108	24-108	302	306	615074.71	7385675.72	-126.40603	66.57025
24	109	24-109	500	327	614401.95	7385176.93	-126.42164	66.56603
24	110	24-110	226	326	613575.02	7384574.92	-126.44081	66.56094
26	101	26-101	87	94	623511.02	7387852.89	-126.21394	66.5865
* **26**	**102**	**26-102**	**63**	**82**	**622447.73**	**7387743.11**	**-126.238**	**66.58594**
26	103	26-103	80	111	621506.03	7387643.55	-126.25931	66.58542
26	104	26-104	98	140	620489.59	7387536.59	-126.28231	66.58486
26	105	26-105	350	160	619318.2	7387480.23	-126.30875	66.58481
26	106	26-106	39	151	618331.21	7387316.19	-126.33114	66.58372
26	107	26-107	381	162	617423.76	7387221.73	-126.35167	66.58322
26	107A	26-107A	78	129	617290.16	7387210.48	-126.35469	66.58317
26	108	26-108	121	107	617101.14	7387186.85	-126.35897	66.58303
26	109	26-109	66	182	616928.22	7387160.57	-126.36289	66.58286
26	110	26-110	419	259	616733.37	7387127.79	-126.36731	66.58264
26	111	26-111	152	241	615928.42	7387001.32	-126.38556	66.58181
26	112	26-112	276	256	614948.24	7386848.84	-126.40778	66.58081
26	113	26-113	256	233	613971.65	7386693.5	-126.42992	66.57978
26	114	26-114	237	192	612978.4	7386531.15	-126.45244	66.57869
26	115	26-115	[illegible]	163	611980.57	7386370.06	-126.47506	66.57761
26	116	26-116	348	239	611119.08	7386239.39	-126.49458	66.57675

* Locations hi-lighted represent duplicate sample sites that must be averaged for mapping and smoothing calculations. See Table 1a

Table 1a

CONTROL SITES and DUPLICATE SAMPLE LOCATIONS

Microbial Values were averaged for mapping and smoothing purposes only.

Traverse	Sample	ID	ACTUAL Microbial Values	Smoothed Microbial Values	Westing	Northing	Longitude	Latitude
3	116	3-116	2		600012.41	7402680.7	-126.73128	66.72792
3	116-2	3-116-2	29		600012.41	7402680.7	-126.73128	66.72792
		Averaged	16	128				
5	101	5-1	8		598415.93	7398696.11	-126.77069	66.69272
5	101 Control	5-101 Control	500		598417.7	7398708.45	-126.77064	66.69283
		Averaged	254	310				
5	102	5-2	16		599406.39	7399106.55	-126.74794	66.69608
5	102 Control	5A-102 Control	376		599424.24	7399113.89	-126.74753	66.69614
		Averaged	196	211				
5	103	5-3	139		600293.8	7399161.06	-126.72781	66.69628
5	103 Control	5A-103 Control	140		600296.11	7399473.52	-126.7275	66.69908
		Averaged	140	128				
5	114	5-14	383		598569.4	7403852.39	-126.76303	66.73889
5	114	5-14	6		598569.4	7403852.39	-126.76303	66.73889
		Averaged	195	202				
11	101	11-101	343		601195.34	7421085.88	-126.689	66.8925
13	3	13-3	248		601194.64	7421104.82	-126.689	66.89267
		Averaged	296	236				
15	102	15-102 Control	41		591290.24	7413405.02	-126.92086	66.82678
15	102.2	15-102 Control	1		591290.24	7413405.02	-126.92086	66.82678
		Averaged	21	192				
15	103	15-103 Control	19		591897.99	7412606.57	-126.90764	66.81944
15	103-2	15-103 Control	500		591897.99	7412606.57	-126.90764	66.81944
		Averaged	260	201				
15	104	15-104	231		592497.59	7411812.44	-126.89461	66.81214
15	104-2	15-104 Control	480		592497.59	7411812.44	-126.89461	66.81214
		Averaged	356	218				
26	102	26-102	106		622447.73	7387743.11	-126.238	66.58594
26	102	26-102	20		622447.73	7387743.11	-126.238	66.58594
		Averaged	63	82				

Table 2

Data Analysis

Canadian Natural Resources, Ltd.

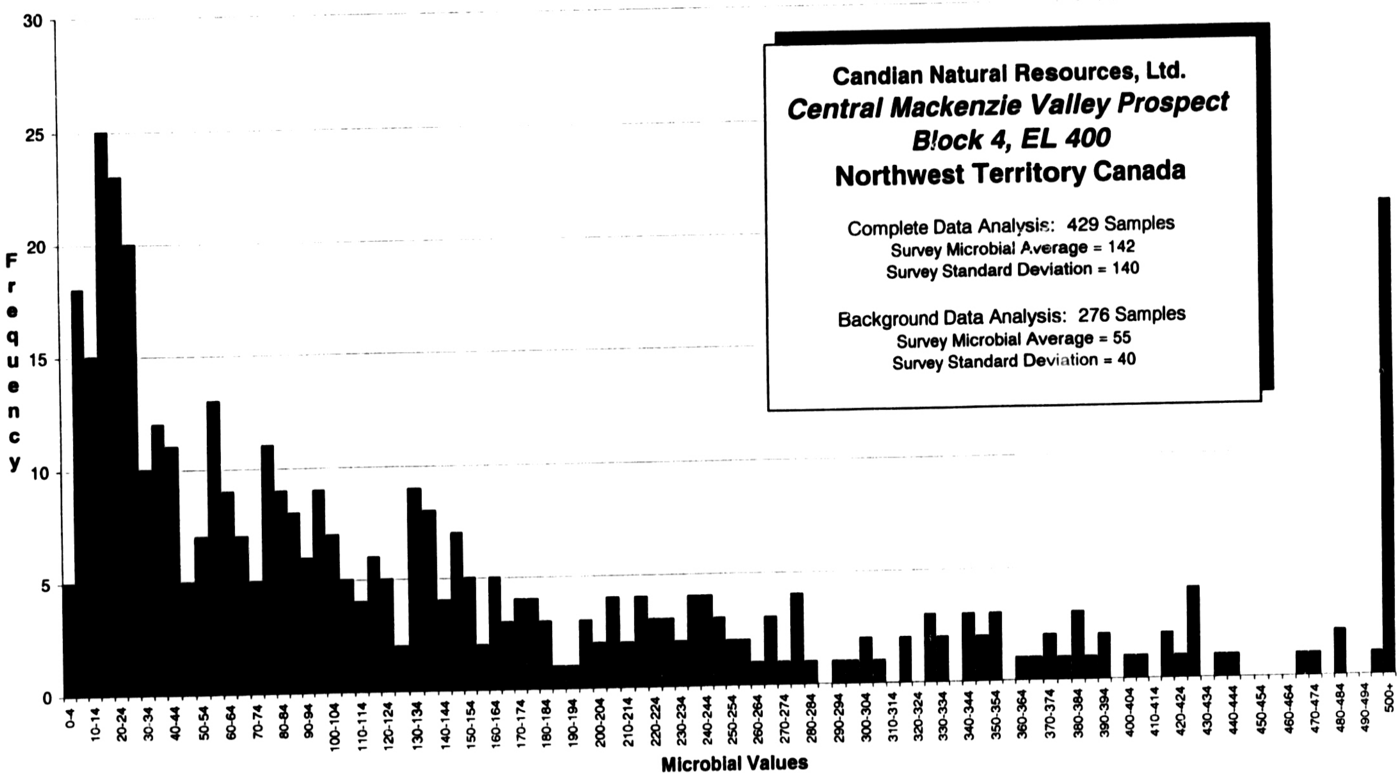
Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory Canada

Complete Data Analysis	
Mean	142
Standard Error	7
Median	91
Mode	500
Standard Deviation	140
Sample Variance	19701
Kurtosis	1
Skewness	1
Range	499
Minimum	1
Maximum	500
Sum	60870
Count	429

Background Data Analysis	
Mean	55
Standard Error	2
Median	44
Mode	15
Standard Deviation	40
Sample Variance	1592
Kurtosis	-1
Skewness	1
Range	141
Minimum	1
Maximum	142
Sum	15263
Count	276

Figure 1

Frequency Distribution Histogram



Geo-Microbial Technologies, Inc.

Figure 1a

Canadian Natural Resources, Ltd.
Sample Weight Distribution Histogram
Central Mackenzie Valley Prospect / Block 4, EL 400 / Northwest Territory, Canada

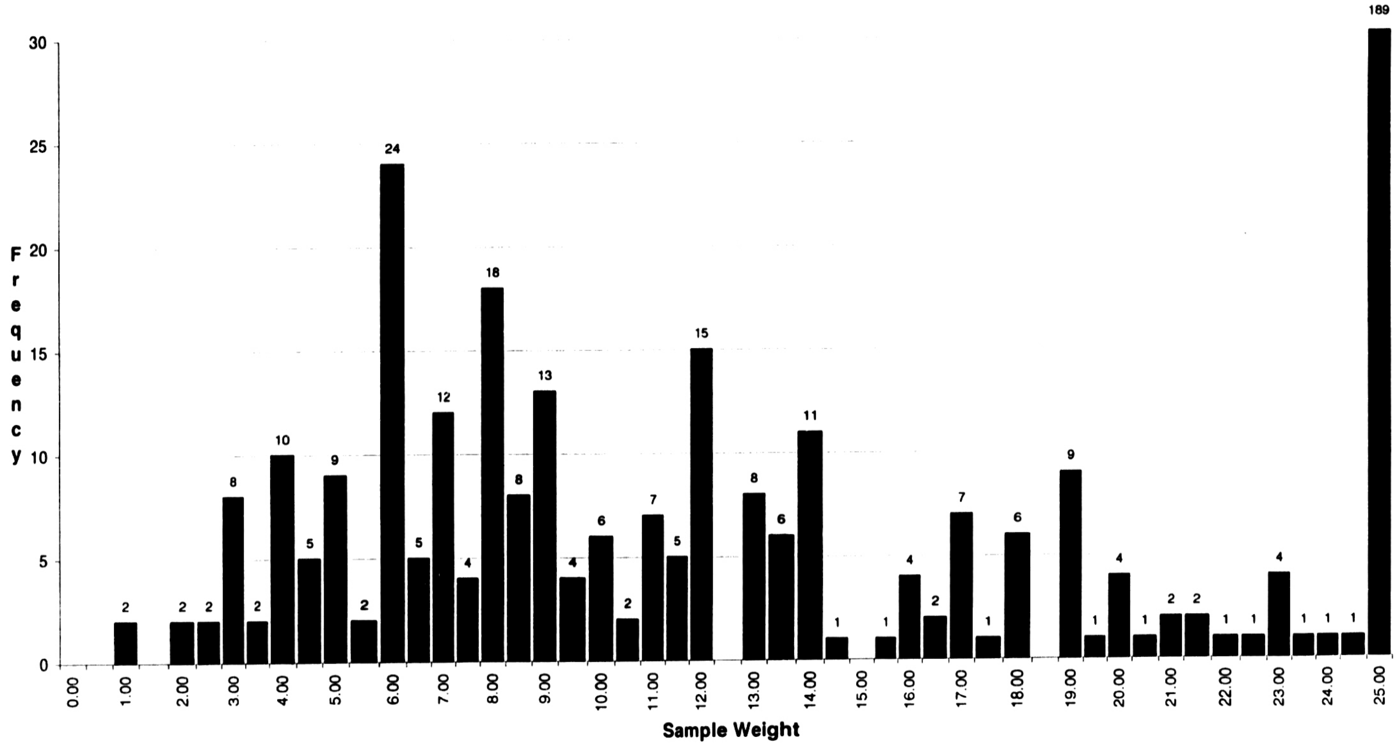


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Figure 1b

Canadian Natural Resources, Ltd.
Sample Weight vs. Microbial Value Cross Plot
Central Mackenzie Valley Prospect / Block 4, EL 400 / Northwest Territory, Canada

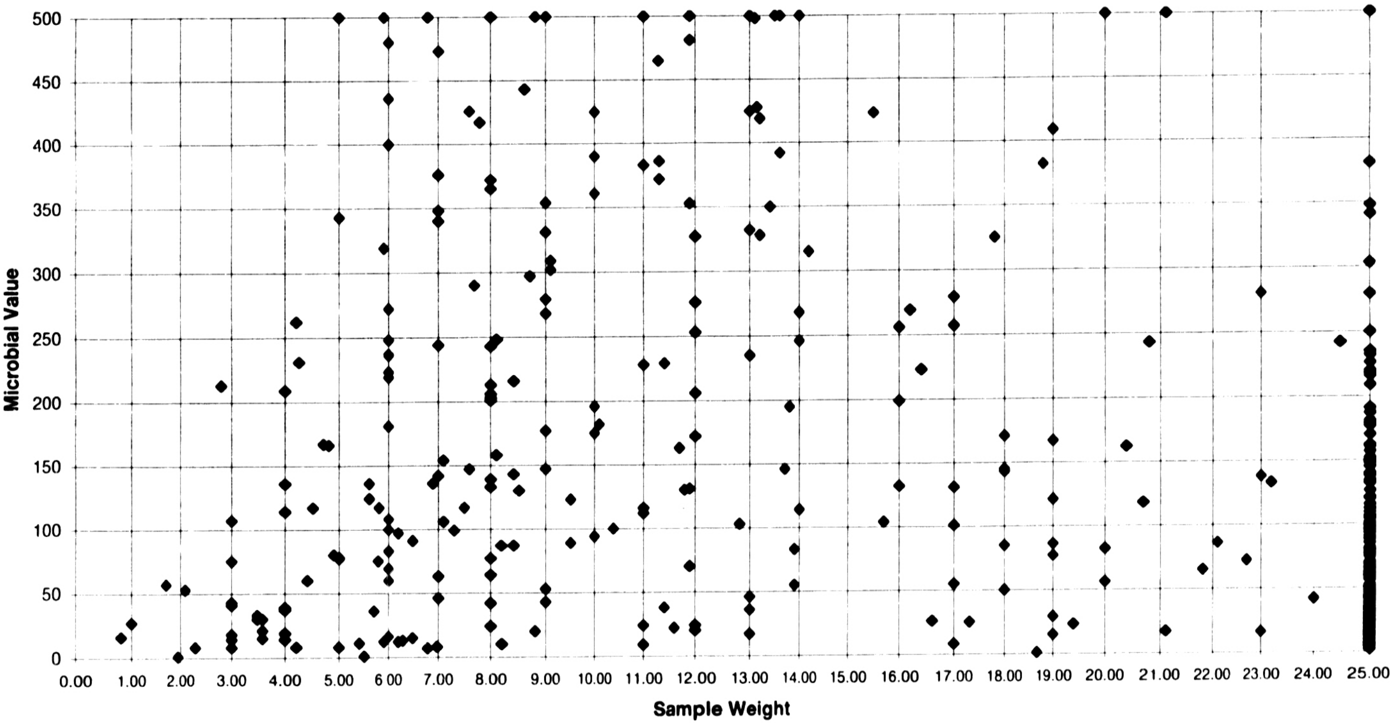

Figure 2

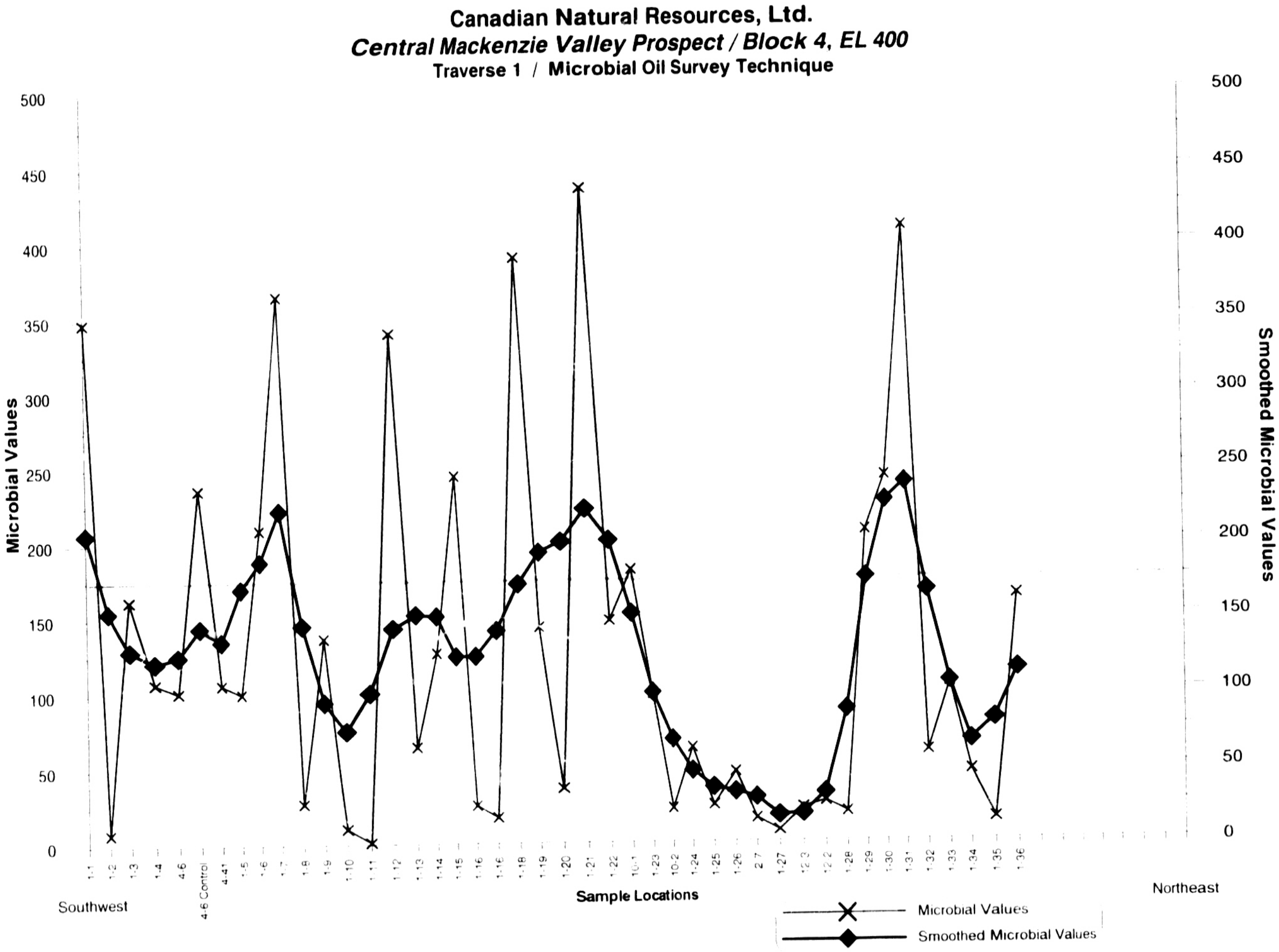

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Figure 3

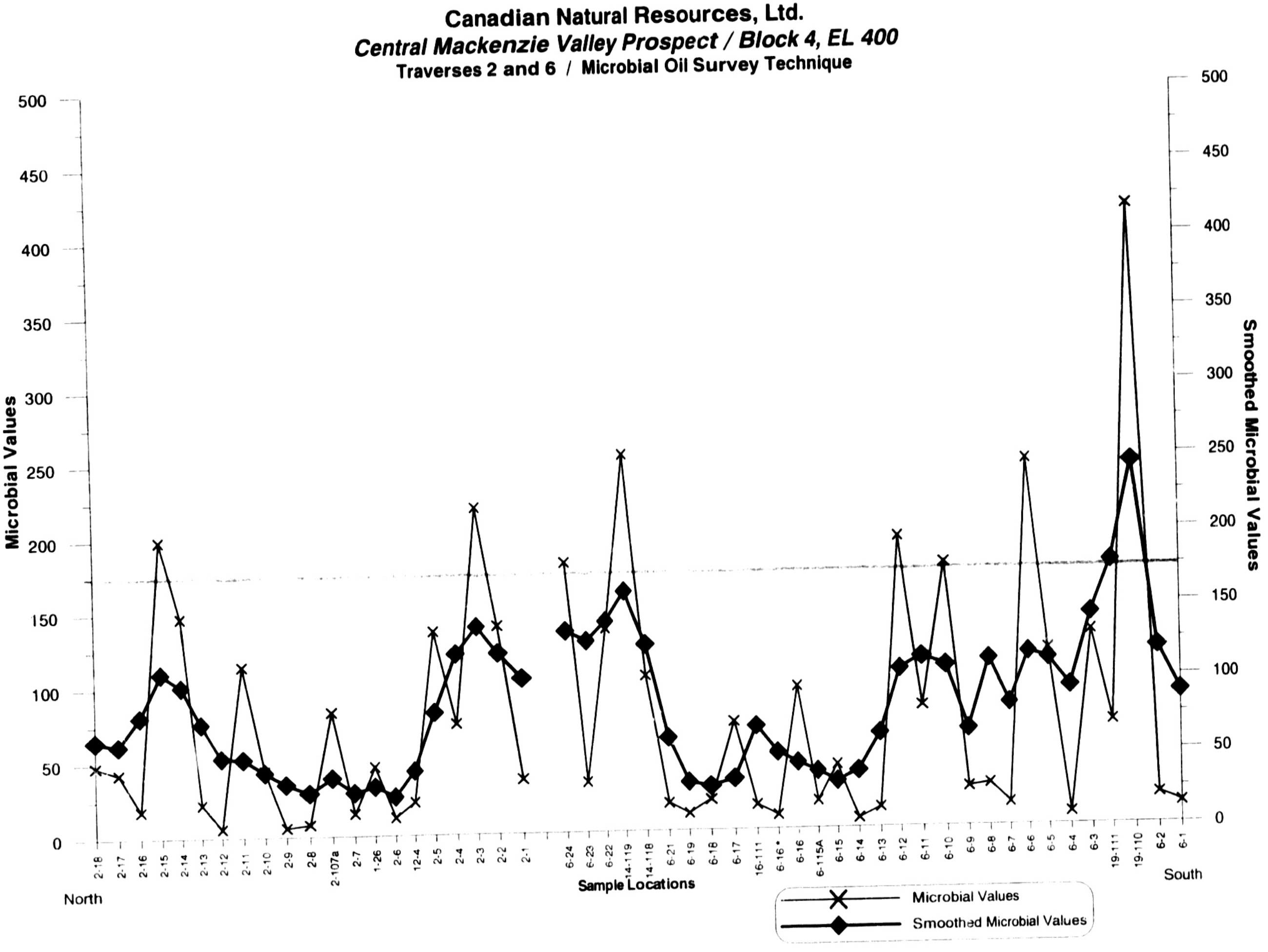

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Figure 4

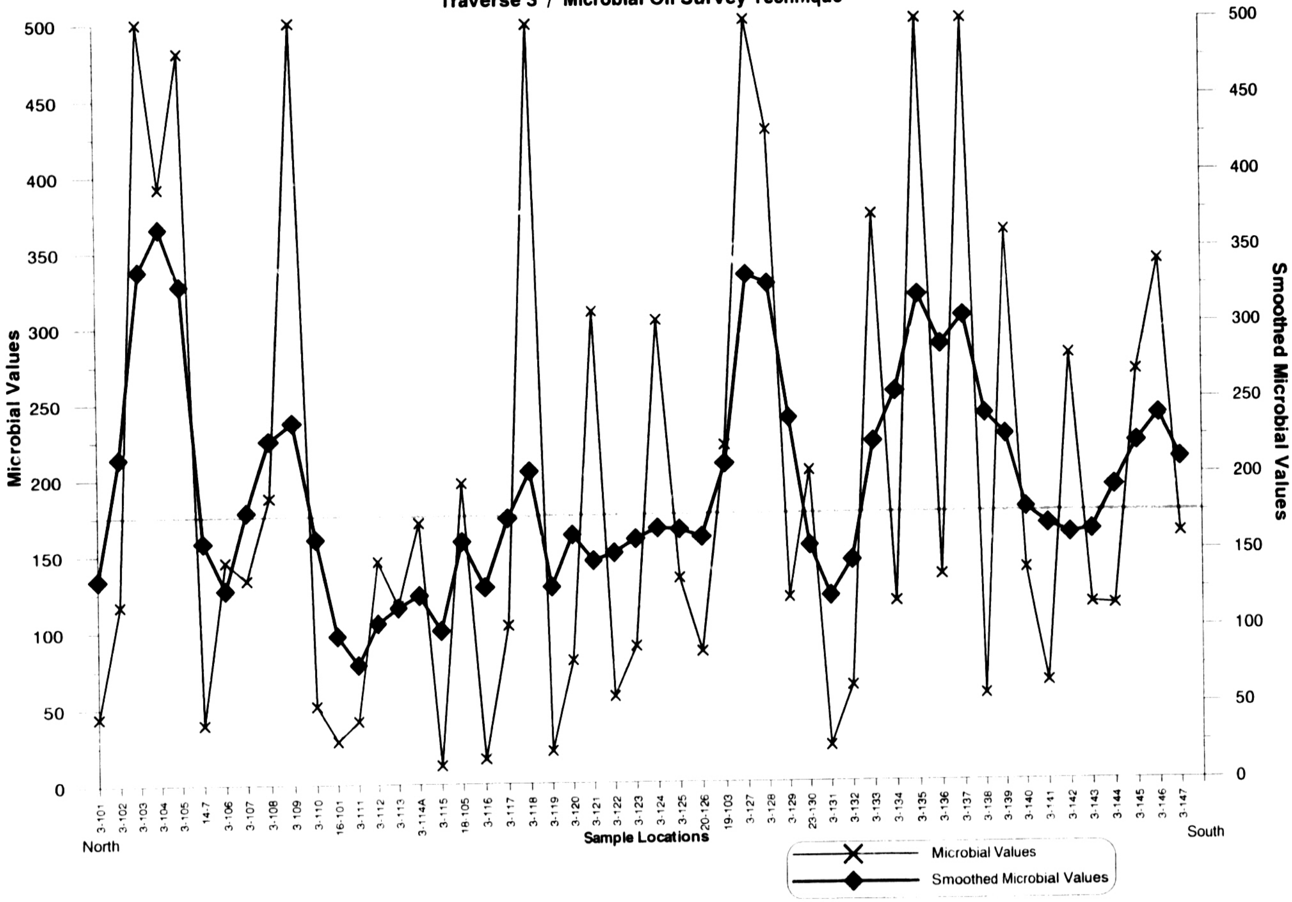

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Figure 5

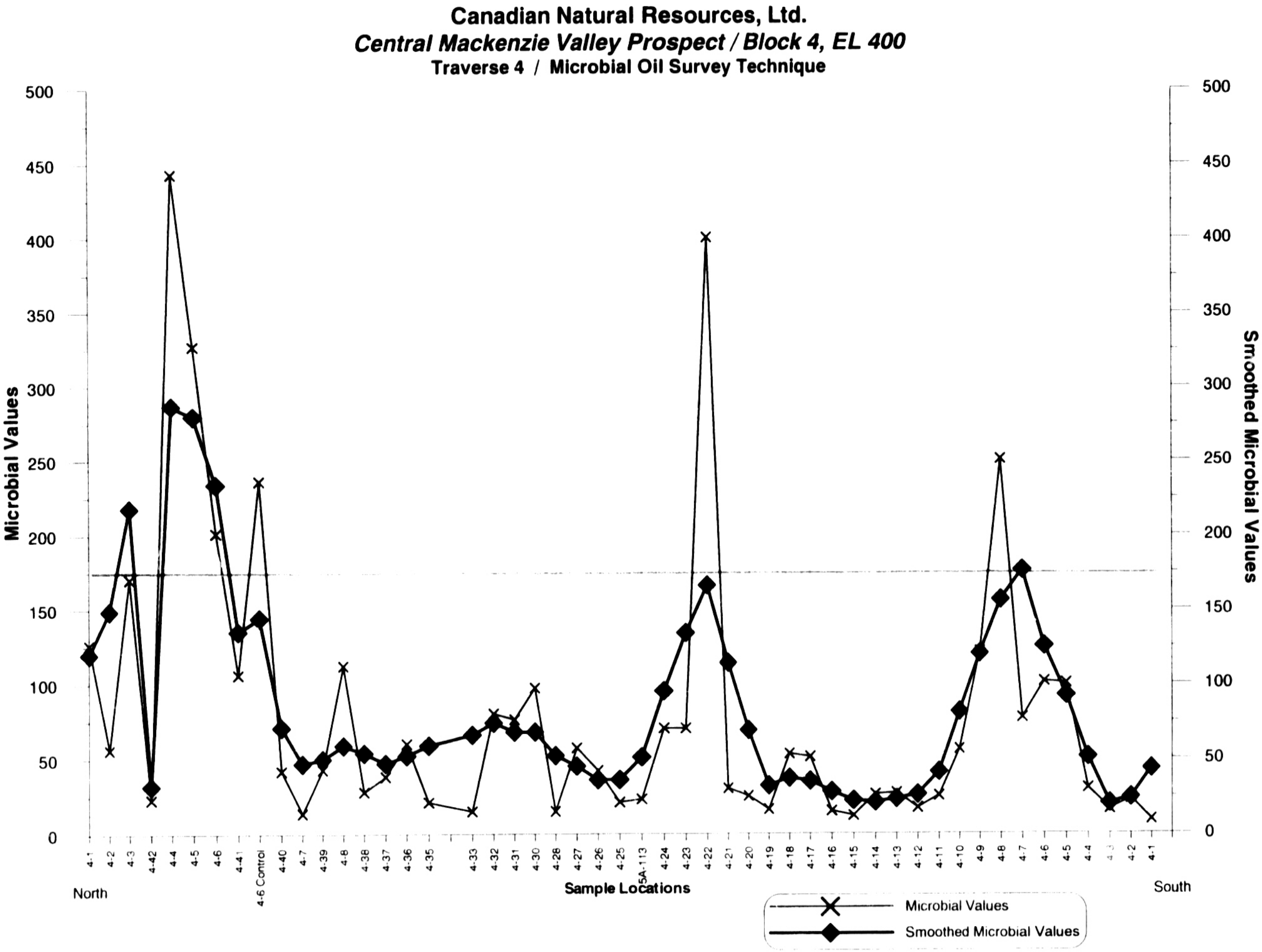

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Figure 6

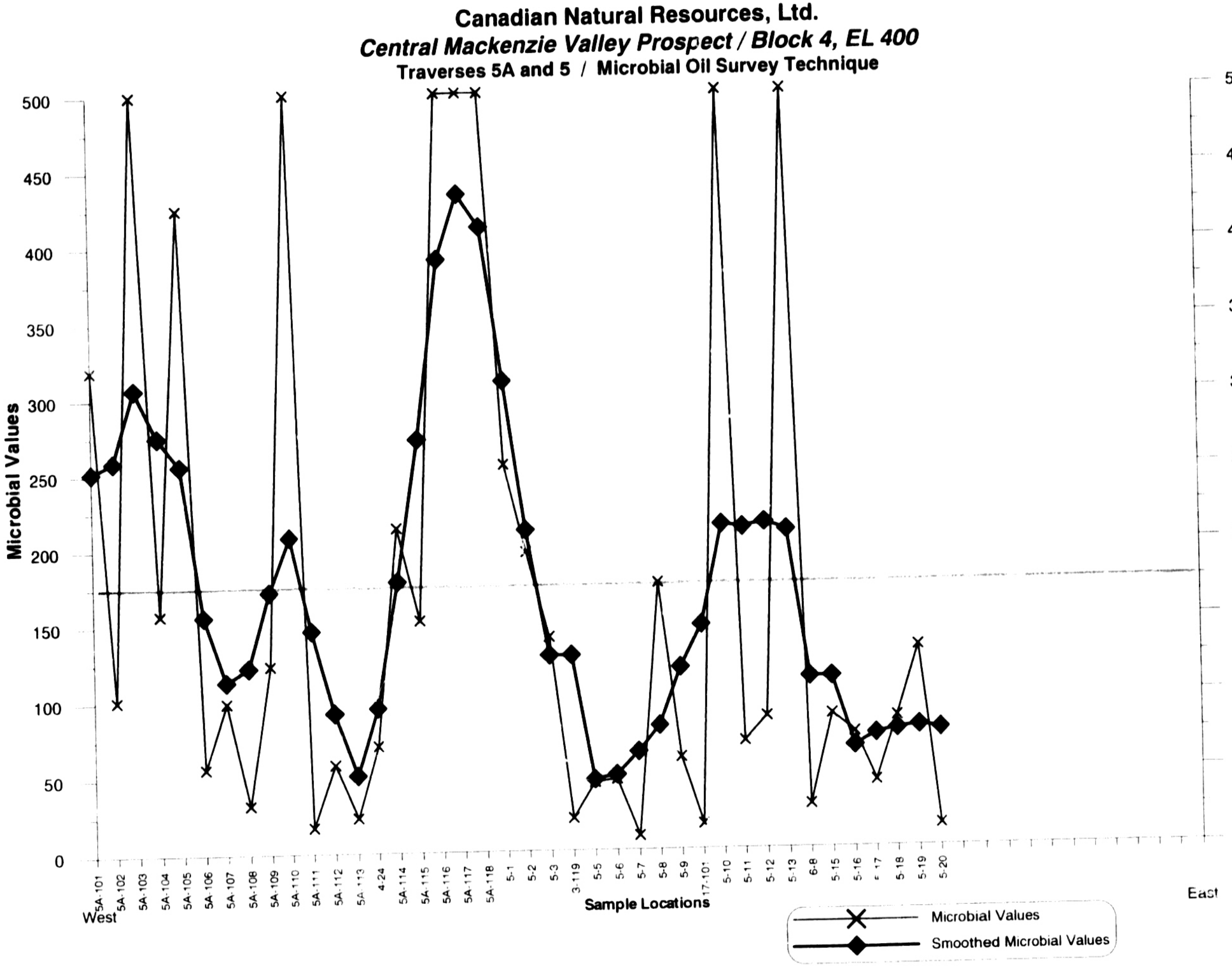

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Figure 7

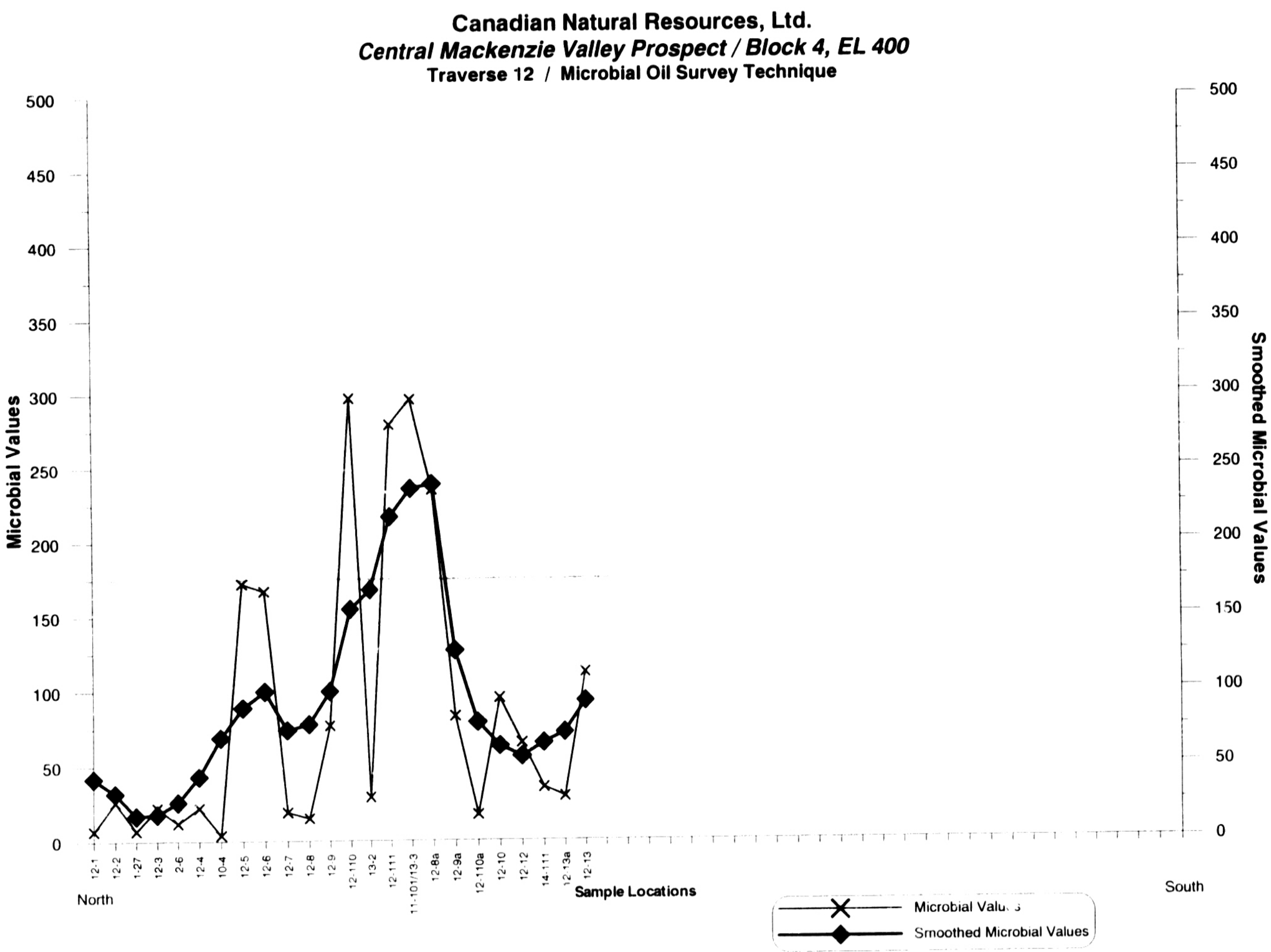

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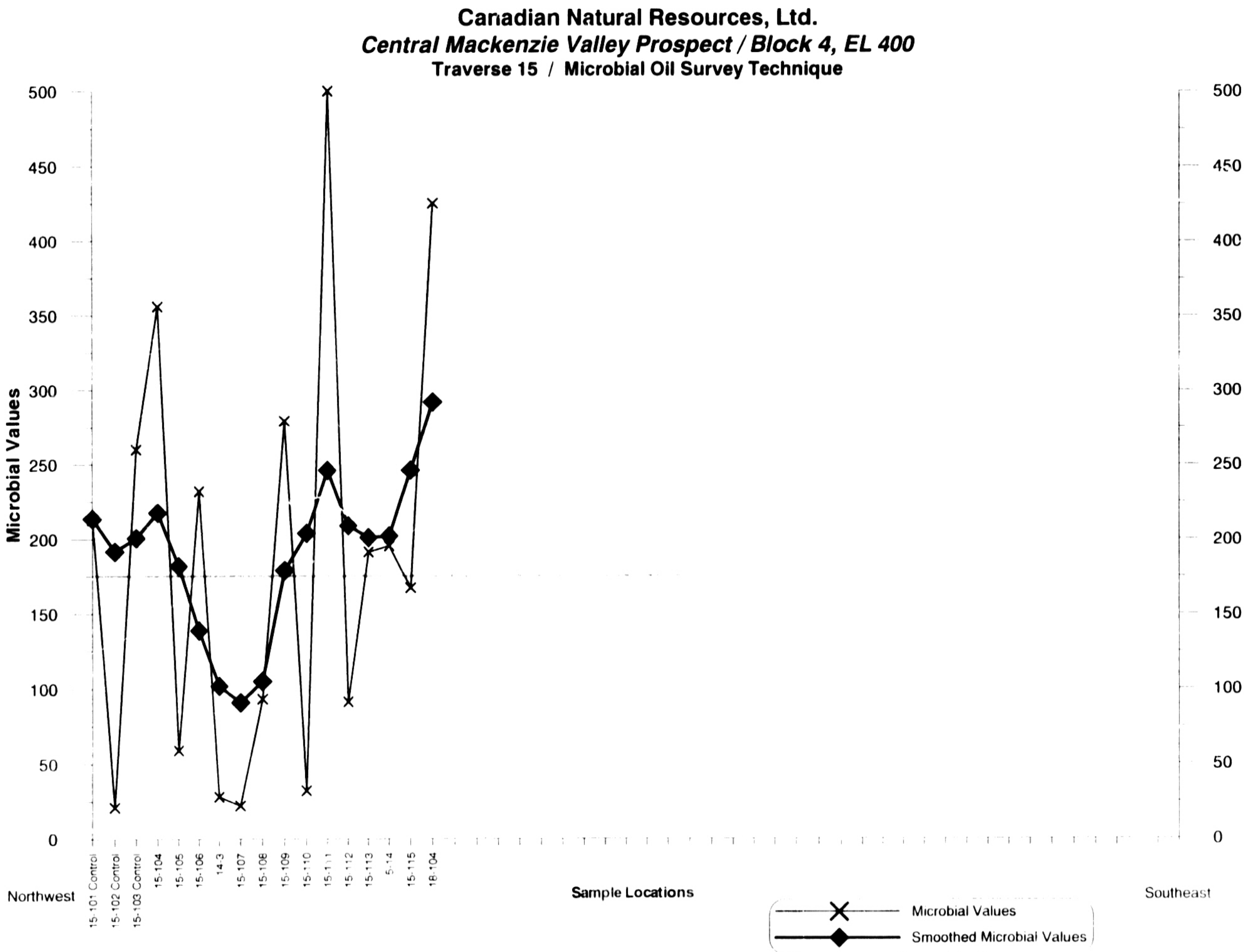
Figure 8



Geo Microbial Technologies, Inc

Figure 9

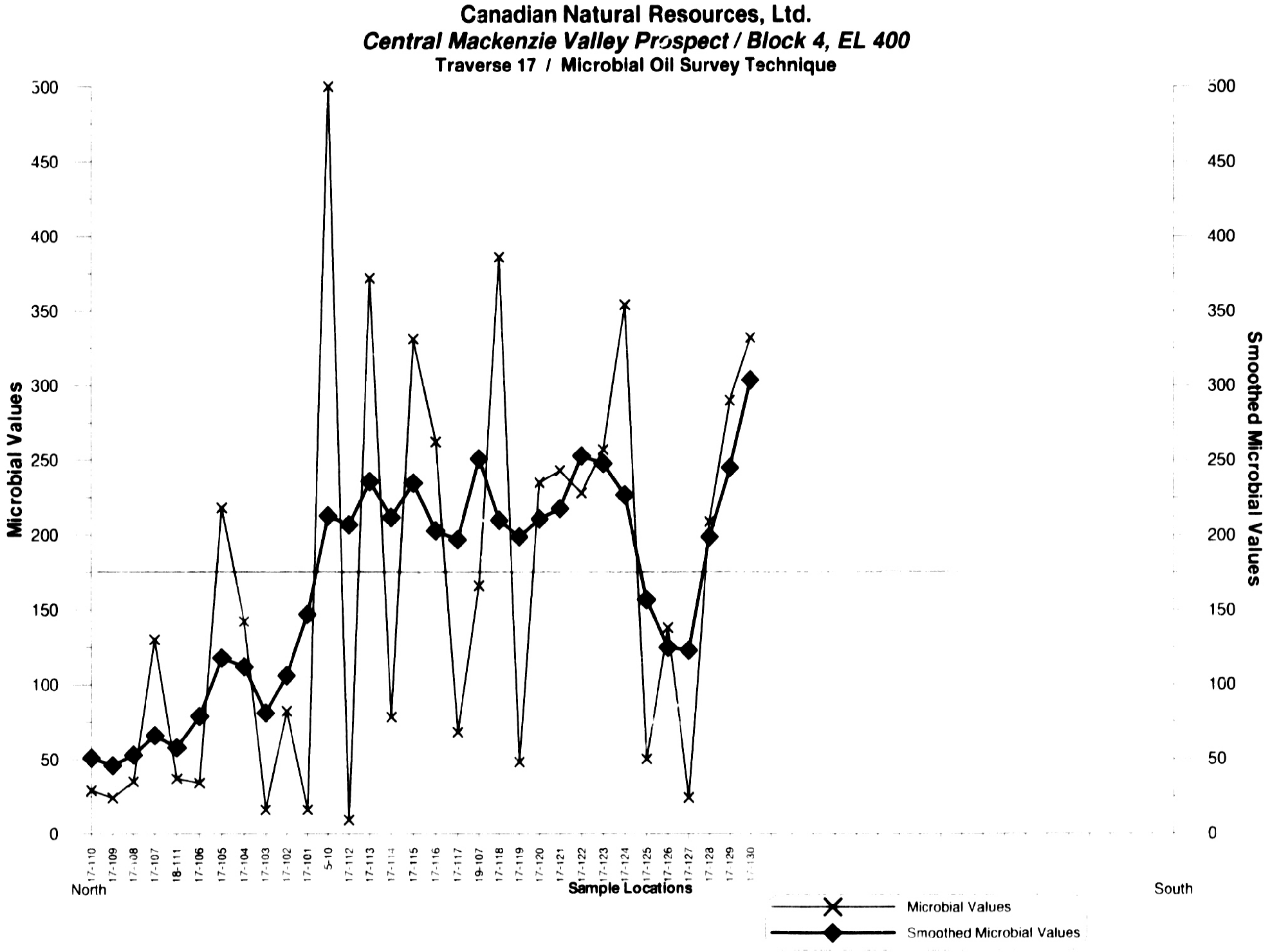


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Figure 10

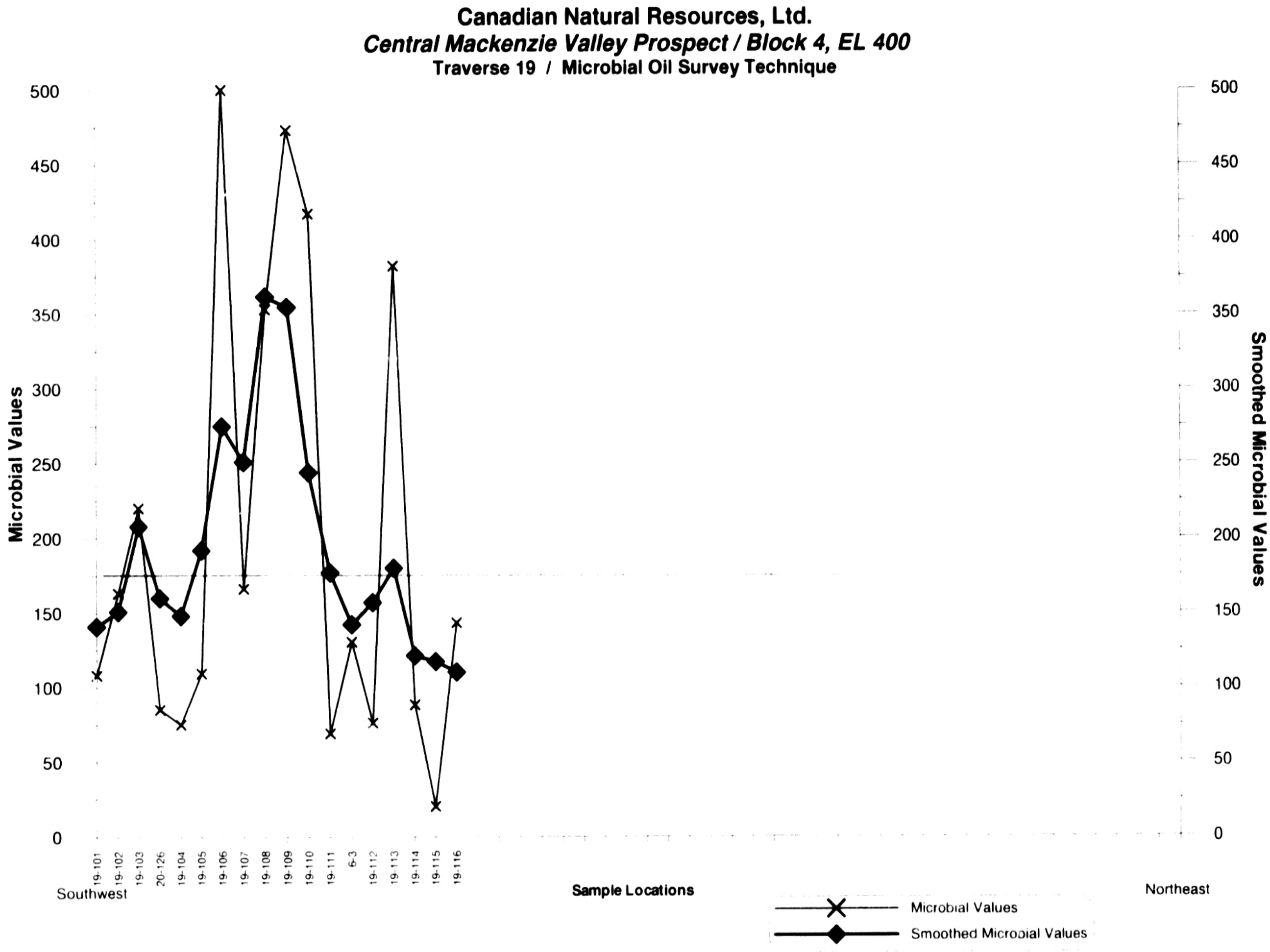

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Figure 11

Canadian Natural Resources, Ltd.

Central Mackenzie Valley Prospect / Block 4, EL 400

Traverse 23 / Microbial Oil Survey Technique

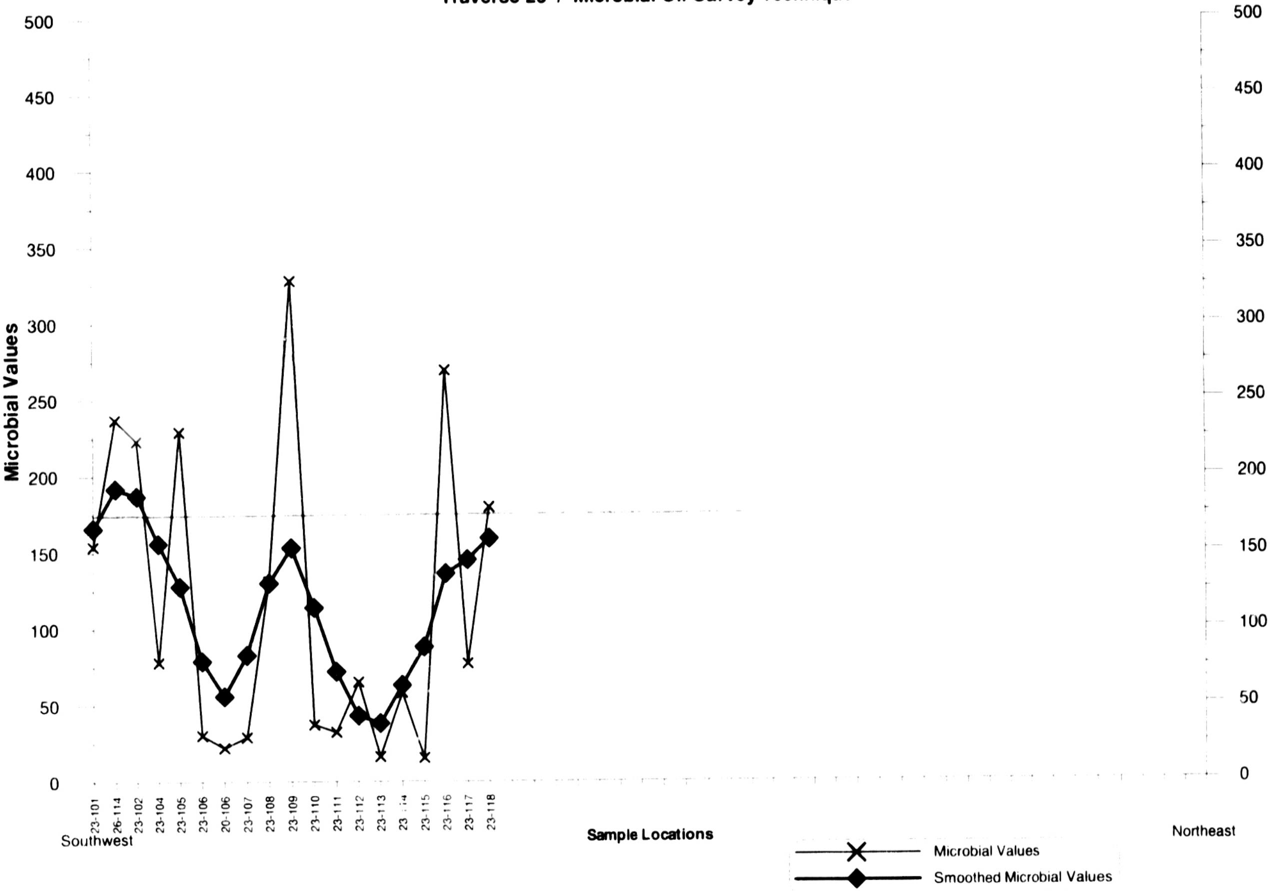

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Figure 12

Canadian Natural Resources, Ltd.
Central Mackenzie Valley Prospect / Block 4, EL 400
Traverse 24 / Microbial Oil Survey Technique

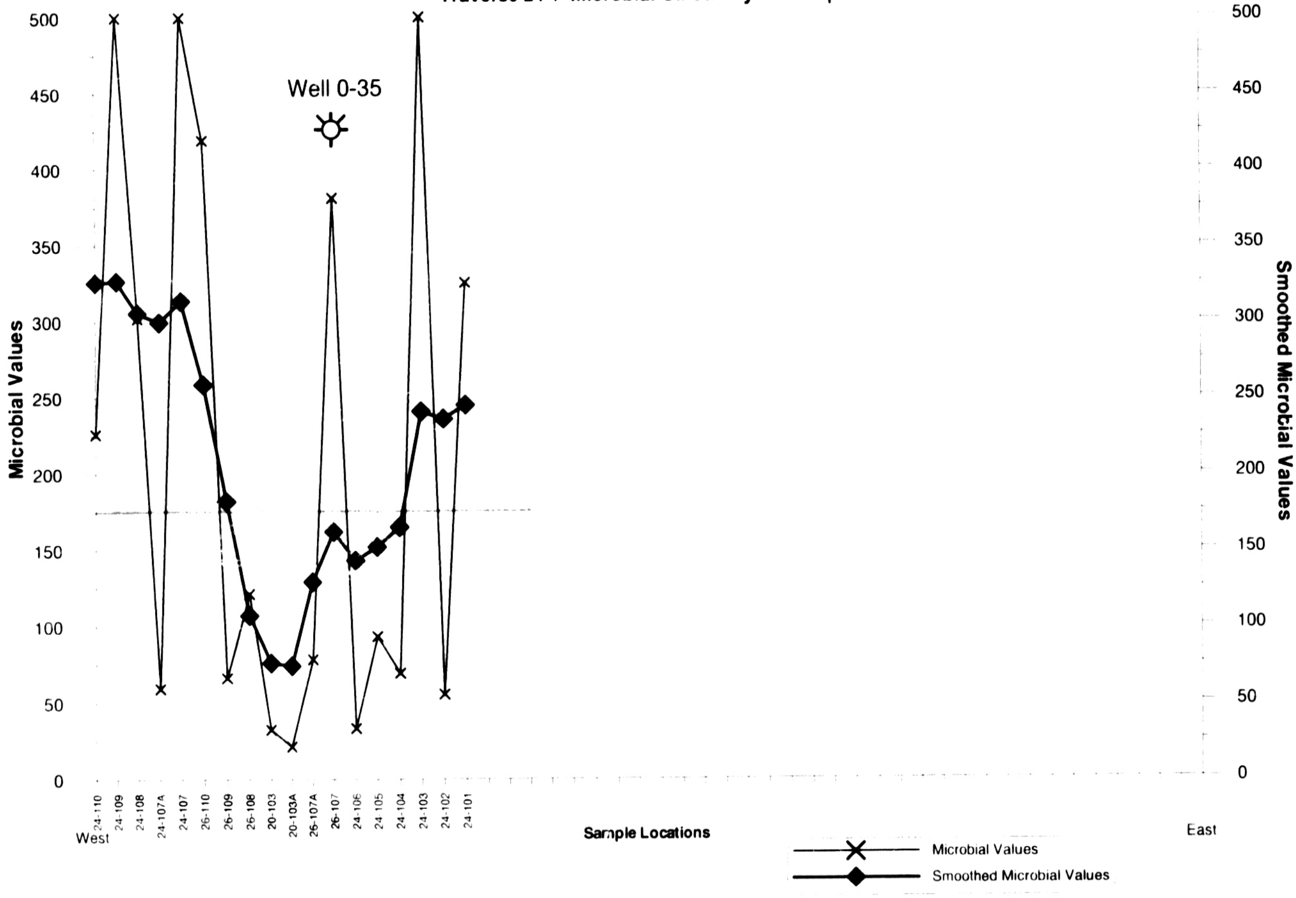

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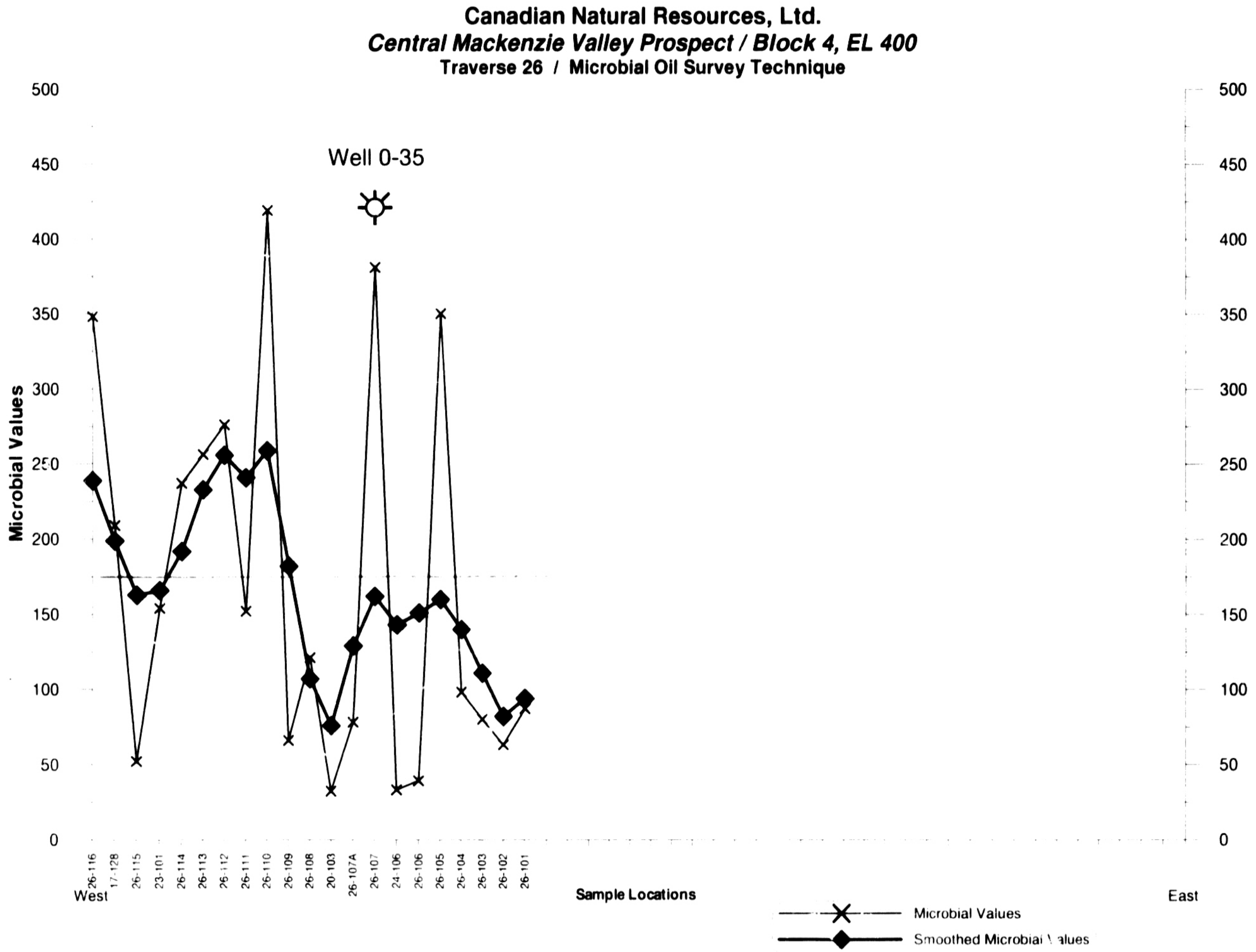
Figure 13



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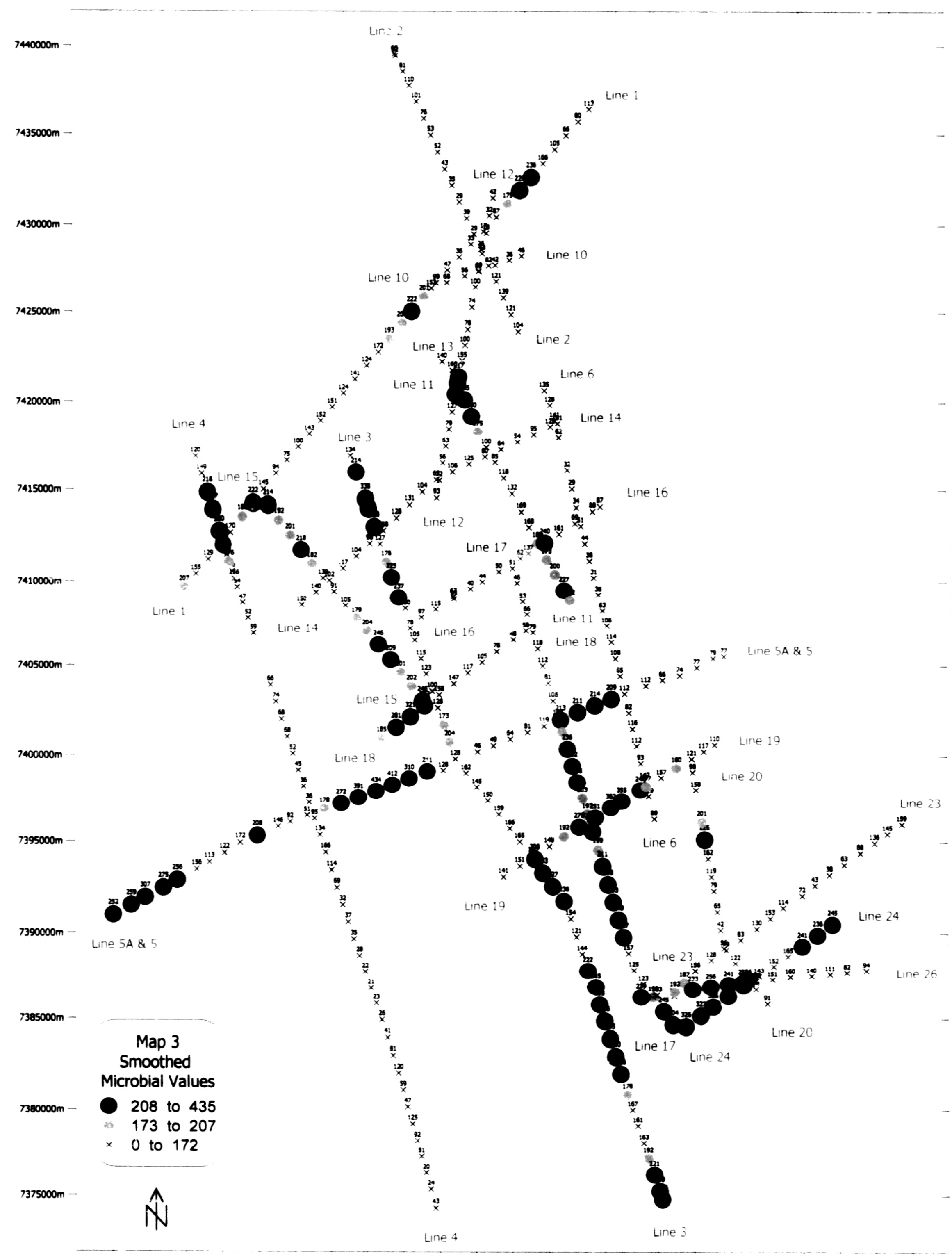
MAPS



Scale 1:250000
Universal Transverse Mercator (UTM) System
Zone 9W

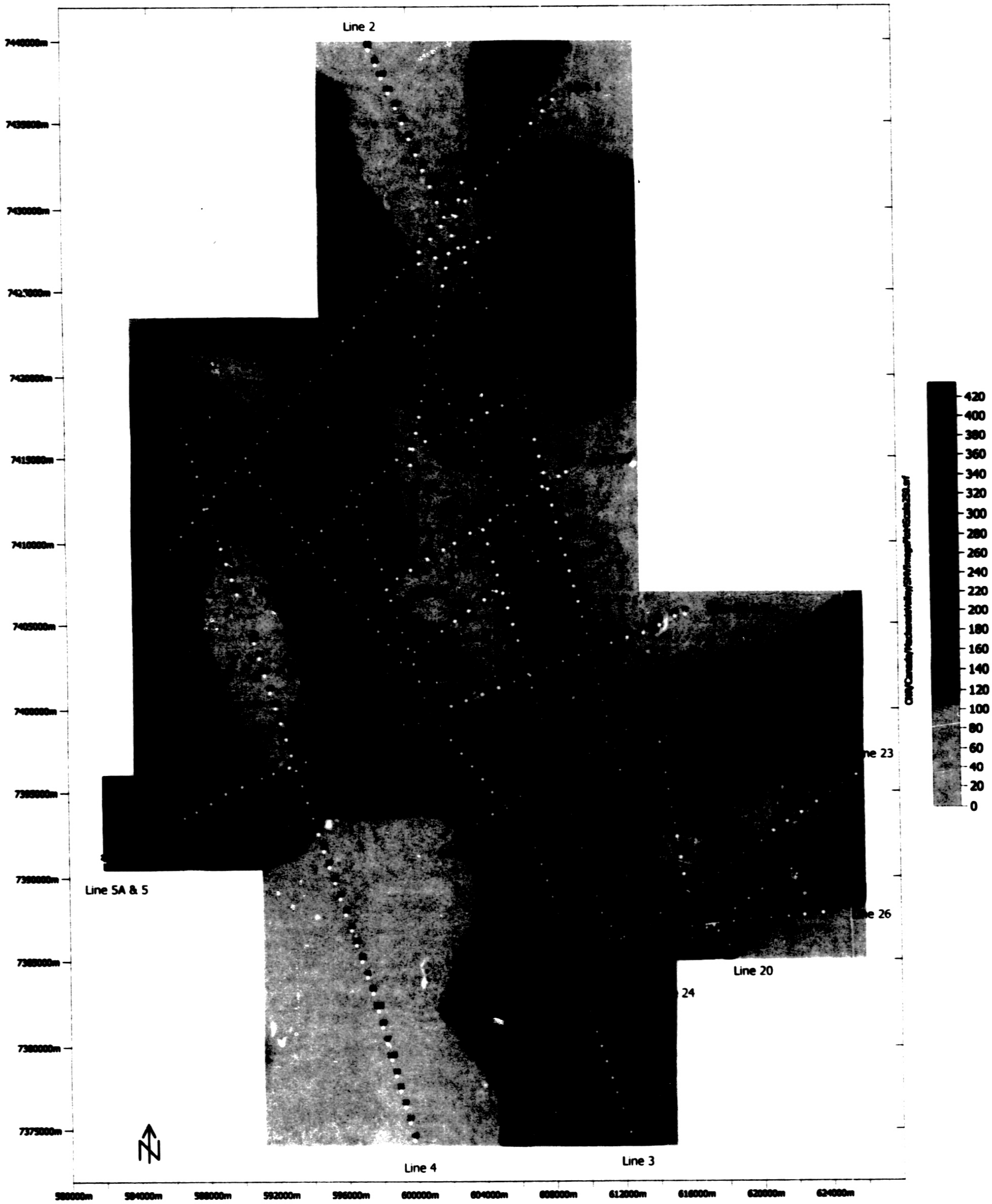
0km 2km 4km 6km 8km 10km

Geo-Microbial Technologies, Inc
East Main St., P.O. Box 132
Ochelata, OK 74051 USA
918.535.2281 Fax: 918.535.2564
Web: http://www.gmtgeochem.com

9233-2144-1E

CANADIAN NATURAL RESOURCES, LTD.
HYDROCARBON MICROSEEPAGE SURVEY
Microbial Survey Technique "MOST"
Map 3 - Smoothed Microbial Values
Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

Date: March 2001



Scale 1:250000
Universal Transverse Mercator (UTM) System
Zone 9W

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CANADIAN NATURAL RESOURCES, LTD.

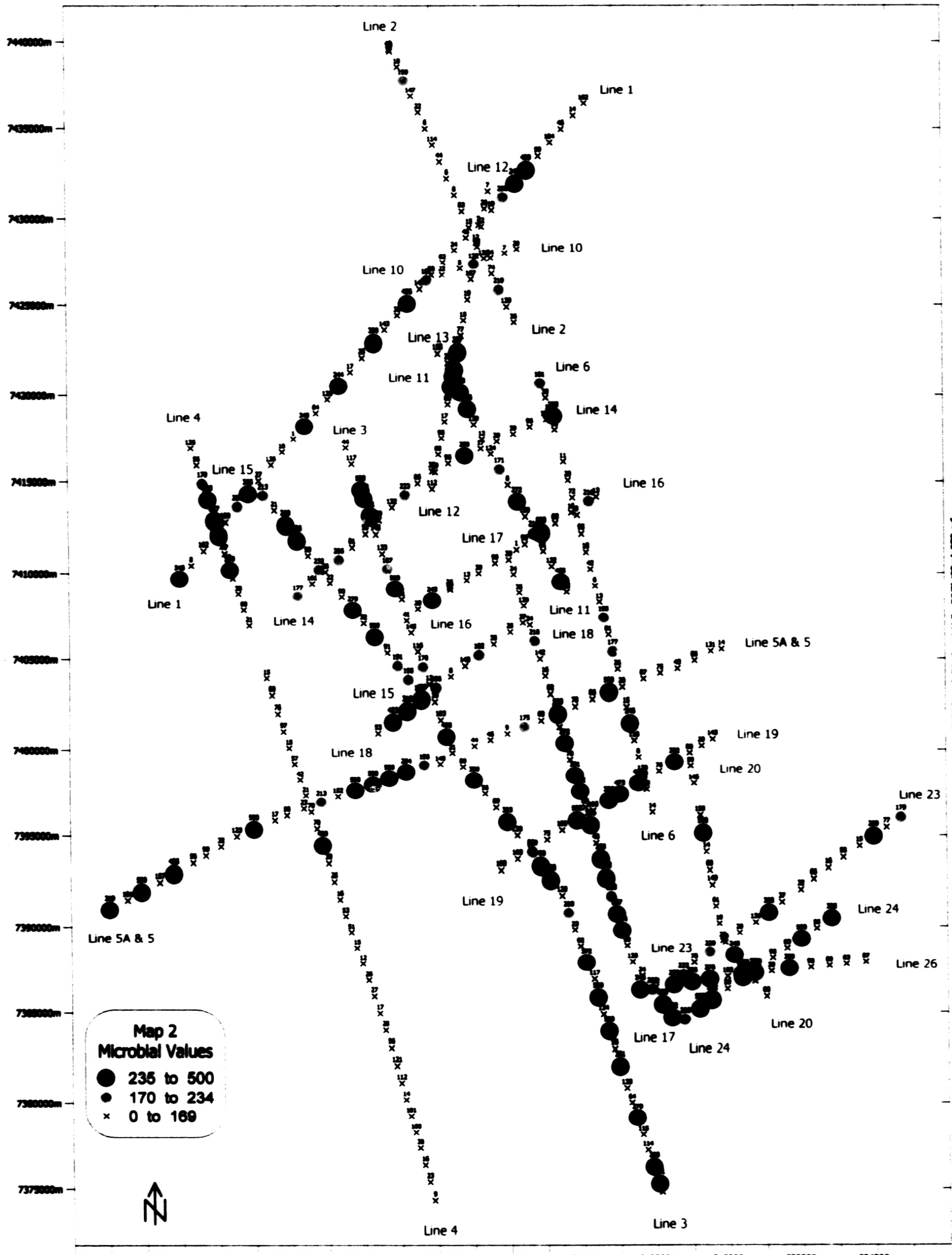
HYDROCARBON MICROSEEPAGE SURVEY

Microbial Oil Survey Technique "MOST"

Map 4 - Image Map
Smoothed Microbial Values

Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

Date: March 2001



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Universal Transverse Mercator (UTM) System
Zone 9W

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East Main St., P.O. Box 132
Ochelata, OK 74051 USA
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CANADIAN NATURAL RESOURCES, LTD.

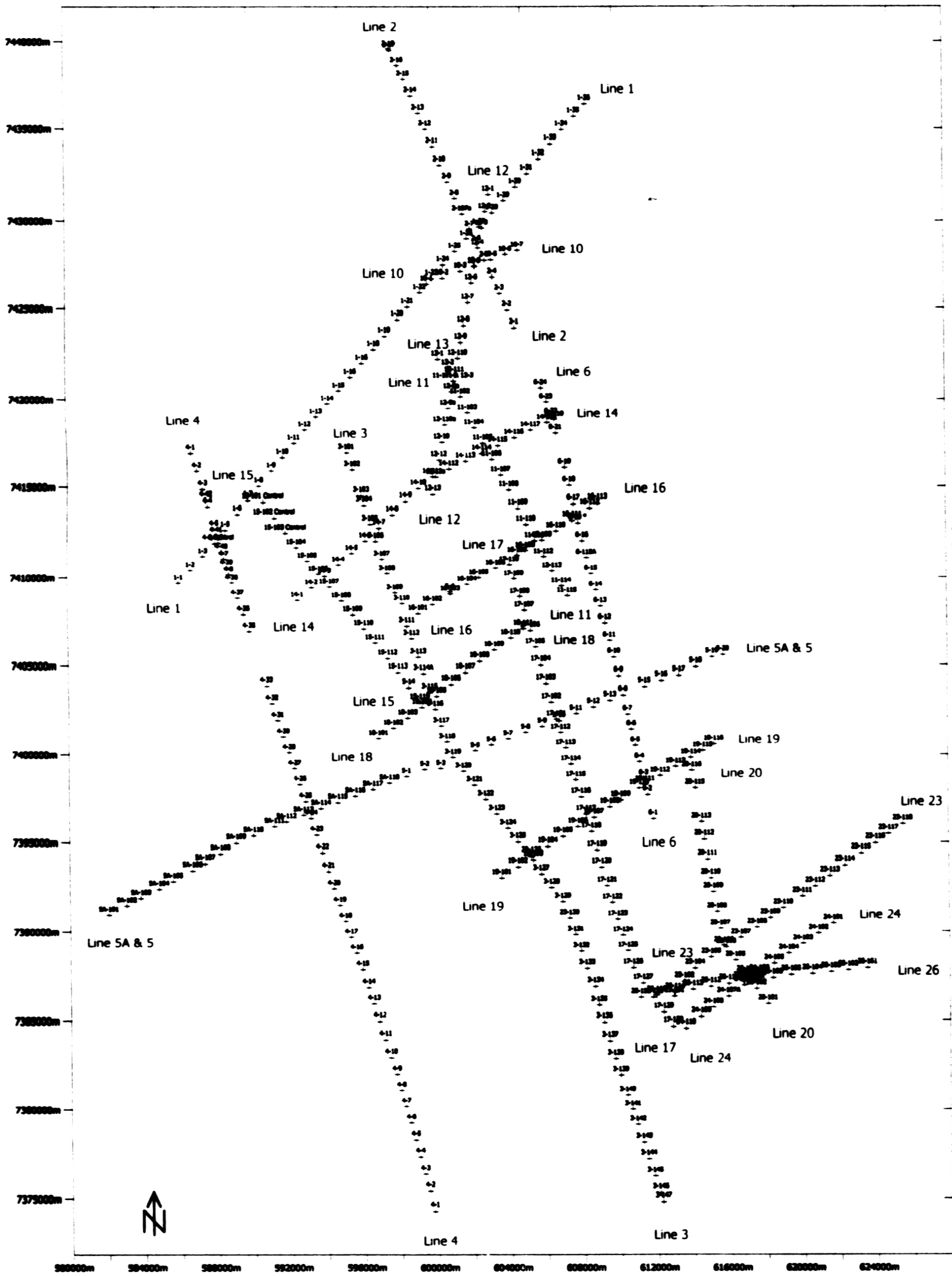
HYDROCARBON MICROSEEPAGE SURVEY

Microbial Oil Survey Technique "MOST"

Map 2 - Microbial Values

Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

Date: March 2001



Scale 1:250000
Universal Transverse Mercator (UTM) System
Zone 9W

0km 2km 4km 6km 8km 10km

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Web: http://www.gmtgeochem.com

CANADIAN NATURAL RESOURCES, LTD.

HYDROCARBON MICROSEEPAGE SURVEY

Microbial Oil Survey Technique "MOST"

Map 1 - Sample Locations

Central Mackenzie Valley Prospect
Block 4, EL 400
Northwest Territory, Canada

Date: March 2001

9233-C144-1E.