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L'ÉNERGIE ATOMIQUE
DU CANADA LIMITÉE

UNCERTAINTIES IN ESTIMATING WORKING LEVEL MONTHS

Incertitudes prévalant dans l'estimation des mois à niveau de travail

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Chalk River, Ontario

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Résumé

On présente une procédure statistique permettant d'estimer le nombre d'évaluations du niveau de travail (NT) requis pour calculer le NT moyen avec toute précision requise, à des niveaux de confiance donnés. Cette procédure part de l'hypothèse que les évaluations du NT ont une répartition normale. Les évaluations du NT des mines canadiennes d'uranium servent à illustrer une procédure assurant que les mois à NT estimés peuvent être calculés avec la précision requise. Un addenda donne les résultats d'essais de normalité des données NT, résultats obtenus par l'essai W et par l'essai de Kolmagornov-Smirnov.

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L'Energie Atomique du Canada, Limitée
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ABSTRACT

A statistical procedure is presented that can be used to estimate the number of Working Level (WL) measurements that are required to calculate the average WL to any required precision, at given confidence levels. The procedure assumes that the WL measurements have a normal distribution. WL measurement from Canadian Uranium mines are used to illustrate a procedure of insuring that estimated Working Level Months can be calculated to the required precision. An addendum reports the results of tests of normality of the WL data using the W-test and the Kolmagornov-Smirnov test.

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TABLE OF CONTENT

A. INTRODUCTION

The question "How often must radon daughter concentrations in a mining atmosphere be measured"? is often asked, and the standard reply is "That depends on what you want to know". This report assumes from the outset that we want to know a miner's radon daughter exposure in Working Level Months* (WLM) to within a given percentage (usually 50%) with a certain degree of confidence (usually 95%). Stated differently, we want to estimate a miner's WLM exposure accurately enough that, on the average, 95 out of 100 independent estimates of that miner's WLM exposure will be within 50% of our estimate. The question now is, "How often must radon daughter concentration be measured to achieve this precision in the estimated WLM exposure"? Following is a simple method of estimating the required measurement frequency from previous measurements. Because previous measurements are used, all uncertainties due to random fluctuations in the measured WL such as those caused by changes in the mine atmosphere and by the inherent randomness of nuclear decay are taken into account.

B. REQUIRED NUMBER OF MEASUREMENTS

The usual method[1] of calculating WLM's is to multiply the average WL in an area by the time a miner spends in that area. The

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* *A WLM is an exposure of 170 hours to an atmosphere containing one working level (WL) (1.3 x 10^5 MeV/ℓ potential α energy from the decay of the ^{222}Rn daughters ^{218}Po (RaA) through ^{214}Po (RaC')), or any combination of exposure time and radon daughters concentration that gives 2.21 x 10^7 MeV·h/ℓ exposure.*

relative uncertainty in WL is thus identical to the relative uncertainty in WLM, provided that the time spent in that area is known exactly.

The following assumptions are used.

1) The WL data for each location-period j have underlying normal probability distributions, each with mean μ_j, and standard deviation σ_j. This assumption was shown to be at least approximately true in two studies[2, 3].

2) The average value of individual WL measurements (x_{ij}) for each location-period j is given by

$$\bar{x}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} x_{ij} \tag{1}$$

where $\bar{x}_j$ is an estimate of the population mean value μ_j for that location-period.

3) The sample standard deviation $S(x_j)$ for each location-period is given by

$$S(x_j) = \left[\frac{1}{n_j - 1} \sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2 \right]^{\frac{1}{2}} \tag{2}$$

where $S(x_j)$ is an estimate of the population standard deviation σ_j for that location-period.

A location-period refers to all measurements made in a giver location within a few hours, a few days, a few months, etc.

With these assumptions, the minimum number of samples M_j, required to estimate the average WL, $\bar{\mu}_j$, for a given location-period to within

P percent of μ_j, the population mean, can be calculated (at the 95% confidence level) using relation (3).

$$\hat{\mu}_j = \mu_j \pm 1.96\ \sigma_j (M_j)^{-\frac{1}{2}} \quad (3)$$

where $\hat{\mu}_j$ is our estimate of μ_j after M_j measurements, and where

$$P = \frac{1.96\ \sigma_j (M_j)^{-\frac{1}{2}}}{\mu_j} \times 100 \quad (4)$$

from which

$$M_j > \left[\frac{2\ \sigma_j}{P\mu_j} \times 100\right]^2 \quad (5)$$

if $\hat{\mu}_j$ is to be within P percent of μ_j in 95% of the times that $\hat{\mu}_j$ is measured. Substituting $S(x_j)$ for σ_j and $\overline{x}_j$ for $\hat{\mu}_j$ into equation (5), we obtain an estimate m_j, of M_j.

That is,

$$m_j > \left[\frac{2S(x_j)}{P\overline{x}_j} \times 100\right]^2 \quad (6)$$

Thus, if the coefficient of variation $C_j = S(x_j)/\overline{x}_j$ is greater than P/200, more than one sample will be required to estimate the mean WL to within P percent with 95% confidence for that location-period.

C. UNCERTAINTIES IN WL MEASUREMENTS

WL measurement results have been made available to the author and from these, 63 location-days involving 19 locations were judged suitable for an analysis as described in Section B.

Table 1 lists the average daily WL at each location at which 3 or more measurements were made during that day, along with the sample standard deviation and coefficient of variation for that day. Thirty-two of these 63 location-days would require more than one measurement per day if the daily average WL was to be estimated to within 50%, and 47 would require more than one measurement if the daily average was to be estimated within 25% of the population mean value, μ_j, at the 95% confidence level.

Table 2 lists the average WL measurements, $\bar{x}_j$, for each location over the given time period along with n_j, the number of samples at the j^{th} location, $S(x_j)$ and C_j. Also listed is m_j, the number of samples required to estimate $\hat{\mu}_j$ to within 50% of μ_j with 95% confidence. As can be seen, only three location-periods have a stable enough radon daughter concentration that the average WL can be estimated to within 50% of the true mean with only one measurement, and none could be measured to within 25% at the 95% confidence level with one measurement. This result indicates that the radon daughter concentrations are less stable from day to day than they are during individual days where 31 of 63 location-days the average WL could be estimated to be within 50% of the population value with one measurement (Table 1). Table 2 also indicates that the precision with which a WL is known on any one day does not permit us to assign a correspondingly precise value for any other day, unless measurements are made on that day also.

D. WORKING LEVEL MONTH CALCULATIONS FROM LOCATION D MEASUREMENTS

In Table 3 are the results of a more detailed analysis of the measurements at location D, the location for which the most data were available. Given are $\overline{x}_j$, $S(x_j)$, and $S(\overline{x}_j) = S(x_j)/\sqrt{n_j}$ for each day, $\overline{x}_p$, $S(x_p)$, $S(\overline{x}_p) = S(x_p)/\sqrt{n_p}$ for each period, and $\overline{x}_T$, $S(x_T)$, and $S(\overline{x}_T) = S(x_p)/\sqrt{n_T}$ for the total set of data. Using the model developed above, we may estimate the uncertainty in our estimation of WLM assigned to individual miners under the various conditions given below.

1) The average Working Level over the total period and the 95% confidence limits are calculated using relations (1) and (2) to be

$$\overline{WL} = 0.558 \pm 0.206 \quad (2\ \sigma)$$

Then if this average WL is multiplied by a miner's accumulated time at this location to estimate his WLM for this location during the 79 days that data are available, the estimated WLM will have an uncertainty of 37%. This result does not necessarily mean that a miner's WLM from this location is known to within 37%. It will be within 37% only if the available data are in fact representative of the average WL during the period (July 11 to September 23) for which data were not available.

2) A miner works in this location only during the two periods the WL measurements were actually taken. Assuming 8 hours exposure per day during both periods, we may write (see Table 2)

$$WLM_D = \frac{24}{170} \times 1.136 + \frac{32}{170} \times 0.286 = 0.214$$

with a standard deviation of

$$\Delta WLM_D = \frac{1}{170}[(0.192 \times 24)^2 + (0.035 \times 32)^2]^{\frac{1}{2}} = 0.028$$

or a 26% uncertainty at the 95% confidence level. Note that this uncertainty is the best that can be achieved with the data available (25 measurements in 7 days).

3) A miner worked in the location only during the period for which data were available each day (i.e. from the first to the last measurement, Δt_j of Table 3).

$$WLM_D = \frac{1}{170} \sum_{j=1}^{7} \overline{x}_j \cdot \Delta t_j = 0.081 \qquad (7)$$

Standard Deviation

$$\Delta WLM_D = \frac{1}{170} \left\{ \sum_{j=1}^{7} [S(\overline{x}_j) \cdot \Delta t_j]^2 \right\}^{\frac{1}{2}} = 0.0031 \qquad (8)$$

or a 7.7% uncertainty at the 95% confidence level.

4) Same as 3) except only one measurement is assumed to be made in each period, Δt_j

$$WLM_D = 0.081$$

Standard Deviation

$$\Delta WLM_D = \frac{1}{170}\left\{\sum_{j=1}^{7}[S(x_j) \cdot \Delta t_j]^2\right\}^{\frac{1}{2}} \tag{9}$$

$$= 0.0054$$

or a 13% uncertainty at 95% confidence.

E. SUMMARY

If the statistics derived for location D using the total data are representative of other locations in the mine then the sample frequency required to estimate the WLM exposure for a quarter year from a given location (using $\sigma_j/\mu_j = 0.514/0.558 = 0.921$) to within an uncertainty P at the 95% confidence level may be calculated using equation (4). The results are shown in table 4, below.

TABLE 4

One Sample per	Number of Samples	P % Uncertainty at 2σ for WLM from Each Location
Quarter	1	184
Month	3	106
Two week	6.5	72
Week	13	51
Half week	26	36
Day	63	23

Individual locations in the mine may be more or less stable than the location for which the results of table 4 obtain. The only way to find out is to make enough measurements in each location that analyses similar to those of section B above can be done for each location of interest, and a sampling frequency then established for each location on the basis of these results.

If enough measurements at a location are available, and the individual times a miner spends in a location with respect to the times of the measurements are known, a smaller uncertainty in WLM will result if calculations similar to those done in Section D are used.

A miner's total WLM will be the sum of the WLM from each location and it will have an uncertainty that can be calculated from a formula similar to equation 9 by substituting the uncertainties in the WLM at each location for $S(x_j) \cdot \Delta t_j$.

F. ACKNOWLEDGMENTS

The author wishes to thank the Atomic Energy Control Board for making the working level data available, and Dr. S.D. Simpson for many helpful discussions during reviews of this paper.

G. REFERENCES

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TABLE 1

Average WL ($\overline{x}_j$), Sample Standard Deviation $S(x_j)$, and their Ratio, the Coefficient of Variation ($C_j = S(x_j)/\overline{x}_j$)

$\overline{x}_j$	$S(x_j)$	C_j	$\overline{x}_j$	$S(x_j)$	C_j	$\overline{x}_j$	$S(x_j)$	C_j
0.149	0.108	0.72	0.12	0.006	0.05	0.066	0.008	0.12
0.032	0.022	0.69	0.20	0.12	0.60	0.263	0.137	0.52
0.111	0.070	0.63	0.29	0.04	0.14	0.148	0.123	0.83
0.476	0.092	0.19	0.10	0.05	0.50	0.31	0.095	0.31
1.20	0.204	0.17	0.027	0.010	0.37	0.17	0.027	0.16
0.21	0.049	0.23	0.083	0.046	0.55	0.163	0.060	0.37
0.09	0.017	0.19	0.31	0.067	0.23	0.06	0.044	0.73
0.17	0.05	0.29	0.14	0.04	0.29	0.345	0.030	0.09
0.15	0.04	0.27	0.058	0.004	0.07	0.033	0.005	0.15
0.20	0.0	0.0	0.15	0.015	0.10	0.331	0.061	0.18
0.19	0.04	0.21	0.34	0.025	0.07	0.098	0.051	0.51
0.09	0.0	0.0	0.10	0.067	0.67	0.039	0.001	0.02
0.20	0.11	0.55	0.05	0.004	0.08	0.060	0.025	0.42
0.26	0.05	0.19	0.10	0.033	0.33	0.045	0.024	0.53
0.19	0.15	0.79	0.10	0.008	0.08	0.038	0.014	0.37
0.22	0.07	0.32	0.26	0.103	0.40	0.032	0.005	0.16
0.28	0.22	0.78	0.08	0.01	0.125	0.048	0.017	0.35
0.24	0.055	0.23	0.04	0.02	0.50	0.41	0.022	0.05
0.17	0.053	0.31	0.21	0.46	0.22	0.073	0.030	0.41
0.231	0.031	0.13	0.10	0.012	0.12	0.05	0.018	0.36
0.16	0.017	0.11	0.297	0.021	0.07	0.187	0.228	1.22

TABLE 2

Average WL ($\overline{x}_j$) of n_j measurements taken over p days in individual locations. The sample standard deviation ($S(x_j)$) is used to calculate the coefficient of variation (C_j) and the number of measurements (m_j) that would be required to measure the average WL to within 50% at the 95% confidence level.

Stope	n_j	p Days	$\overline{x}_j$	$S(x_j)$	C_j	m_j
A	8	3	0.086	0.080	0.93	14
B	7	3	0.110	0.058	0.53	6
C	8	3	0.665	0.216	0.32	2
D	8	3	1.136	0.543	0.48	4
D	17	4	0.286	0.145	0.51	5
D	25	79	0.558	0.514	0.92	14
E	15	5	0.226	0.042	0.19	1
F	14	5	0.168	0.052	0.31	2
G	15	5	0.154	0.060	0.39	3
H	14	5	0.206	0.117	0.57	6
H	14	40	0.211	0.110	0.52	5
I	9	3	0.318	0.048	0.15	1
J	9	3	0.045	0.015	0.33	2
K	9	3	0.114	0.043	0.38	3
L	9	3	0.139	0.058	0.42	3
M	9	3	0.276	0.063	0.23	1
N	9	3	0.040	0.014	0.35	2
O	11	4	0.234	0.106	0.45	4
P	11	4	0.121	0.077	0.64	7
Q	13	4	0.064	0.040	0.63	7
R	14	4	0.038	0.011	0.29	2
S	10	4	0.055	0.016	0.29	2
S	11	4	0.091	0.120	1.32	28

<u>TABLE 3</u>

ANALYSIS OF DATA FROM LOCATION D

Time	Date	WL	Δt_j	$\bar{x}_j$	$S(x_j)$	$S(\bar{x}_j)$	
0952	9-7-75	1.42	3.13	1.603	0.168	0.097	$\bar{x}_p = 1.136$
1145	"	1.75					$S(x_j) = 0.543$
1300	"	1.64					$S(\bar{x}_p) = 0.192$
0930	10-7-75	1.43	3.33	1.197	0.204	0.118	
1035	"	1.05					
1250	"	1.11					
0940	11-7-75	0.29	1.03	0.345	0.078	0.055	
1042	"	0.40					
0932	23-9-75	0.363	4.42	0.345	0.030	0.014	$\bar{x}_p = 0.286$
1037	"	0.314					$S(x_j) = 0.145$
1152	"	0.316					$S(\bar{x}_p) = 0.035$
1300	"	0.346					
1357	"	0.384					
0942	24-9-75	0.336	3.83	0.331	0.061	0.031	
1035	"	0.380					
1153	"	0.365					
1332	"	0.243					
0915	25-9-75	0.052	4.32	0.045	0.024	0.012	
1019	"	0.028					
1140	"	0.024					
1334		0.075					
0910	26-9-75	0.41	3.42	0.410	0.022	0.011	
1008	"	0.38					
1132	"	0.43					
1235	"	0.42					
							$\bar{x}_T = 0.558$
							$S(x_j) = 0.514$
							$S(\bar{x}_T) = 0.103$

APPENDIX

Mean working level values ($\bar{x}_j$), sample standard deviations ($S(x_j)$), coefficients of variation (C_j) and the number of measurements required to estimate each working level to within 50% at the 95% confidence level (m_j) were calculated for 59 location-days and 13 location-periods from data recently made available to the author. Thirty-three of the 59 location-days (see Table A-1) were stable enough that, during that day, a single measurement would have been sufficient to estimate the working level to within 50% at the 95% confidence level. When the data were grouped, only 3 of the 13 location-periods (see table A-2) were stable enough that one measurement would estimate the working level for that location-period to within 50% at the 95% confidence level. Table A-3 lists the required number of measurements to achieve the stated precision for various confidence levels.

Figures A-1 and A-2 are scatter plots of C_j against $\bar{x}_j$ for the location-days and location-periods respectively. As can be seen, there is little if any evidence for the coefficient of variation (C_j) varying with average working level ($\bar{x}_j$).

The number of measurements required to achieve better than 50% uncertainty at the 95% confidence level given in Table A-2 for each location-period should not be interpreted as the number required for that location for any period of the same duration. It is likely that this number of measurements at that location would suffice for a longer period; how much longer can only be ascertained by measurements covering longer periods of time. This statement is supported by the fact that the "cumulative" coefficients of variation (see Table A-4) tended to increase rapidly when the second day's measurements were added to the first day's, less rapidly when the third day's measurements were added to the previous day's, etc. These cumulative coefficients are displayed in Figures A-3(a) and A-3(b).

TABLE A-1

Location-Day	n_j	$\overline{x}_j$	$S(x_j)$	C_j	m_j
A-1	15	0.076	0.016	0.211	1
A-2	15	0.124	0.094	0.758	9
A-3	16	0.053	0.011	0.208	1
A-4	12	0.057	0.010	0.175	1
B-1	16	0.349	0.074	0.212	1
B-2	18	0.261	0.097	0.372	3
B-3	17	0.271	0.080	0.295	2
B-4	21	0.329	0.049	0.149	1
B-5	12	0.347	0.050	0.144	1
C-1	5	0.700	0.201	0.287	2
C-2	4	0.618	0.080	0.129	1
C-3	5	0.446	0.042	0.094	1
C-4	9	0.701	0.124	0.177	1
D-1	23	0.220	0.036	0.164	1
D-2	19	0.258	0.062	0.240	1
D-3	25	0.252	0.051	0.202	1
D-4	22	0.188	0.042	0.223	1
D-5	20	0.265	0.056	0.211	1
E-1	14	0.074	0.011	0.146	1
E-2	16	0.132	0.102	0.775	10
E-3	13	0.099	0.026	0.262	2
E-4	16	0.121	0.024	0.202	1
E-5	14	0.103	0.067	0.648	7
F-1	12	1.19	0.184	0.154	1
F-2	17	0.899	0.116	0.129	1
F-3	12	0.865	0.331	0.382	3
F-4	9	0.563	0.158	0.280	2
G-1	3	0.380	0.052	0.137	1
G-2	13	0.398	0.077	0.194	1
G-3	11	0.447	0.122	0.273	2
G-4	16	0.357	0.075	0.210	1
G-5	7	0.364	0.045	0.124	1

Table A-1 Continued...

Location-Day	n_j	$\overline{x}_j$	$S(x_j)$	C_j	m_j
H-1	23	0.905	0.136	0.151	1
H-2	2	0.121	0.031	0.258	2
H-3	21	0.730	0.188	0.258	2
H-4	21	0.161	0.026	0.161	1
H-5	3	0.433	0.021	0.048	1
I-1	5	0.488	0.066	0.135	1
I-2	22	0.649	0.342	0.527	5
I-3	26	0.613	0.251	0.409	3
I-4	25	0.630	0.112	0.178	1
I-5	25	0.368	0.096	0.262	2
J-1	16	0.493	0.055	0.111	1
J-2	3	0.640	0.212	0.331	2
J-3	18	0.584	0.174	0.296	2
J-4	14	0.456	0.052	0.114	1
J-5	23	0.439	0.116	0.264	2
K-1	20	0.406	0.045	0.111	1
K-2	4	0.335	0.054	0.163	1
K-3	11	0.327	0.112	0.342	2
L-1	4	0.198	0.056	0.283	2
L-2	24	0.215	0.061	0.283	2
L-3	21	0.283	0.060	0.212	1
L-4	20	0.185	0.060	0.325	2
M-1	21	0.297	0.127	0.426	3
M-2	23	0.321	0.096	0.300	2
M-3	23	0.163	0.055	0.335	2
M-4	9	0.150	0.050	0.337	2

TABLE A-2

Location-Period	Period(days)	n_j	$\overline{x}_j$	Sx_j	C_j	m_j
A	4	58	0.072	0.030	0.415	3
B	5	83	0.310	0.081	0.261	2
C	4	23	0.631	0.158	0.251	2
D	5	109	0.236	0.057	0.242	1
E	5	73	0.107	0.060	0.565	6
F	4	49	0.901	0.284	0.315	2
G	5	49	0.391	0.089	0.227	1
H	5	88	0.491	0.362	0.738	9
I	5	103	0.559	0.240	0.430	3
J	5	74	0.497	0.132	0.266	2
K	4	37	0.374	0.080	0.214	1
L	4	69	0.226	0.071	0.315	2
M	4	76	0.246	0.117	0.477	4

TABLE A-3

Required Number of Measurements for each Location-period to Estimate the WL to with the Stated Limits at the σ, 2σ and 3σ Confidence Levels.

Location-Period	25%			50%		
	σ	2σ	3σ	σ	2σ	3σ
A	3	13	25	1	3	7
B	2	5	10	1	2	3
C	2	5	9	1	3	2
D	1	4	9	1	1	3
E	6	21	46	2	6	12
F	2	7	15	1	2	4
G	1	4	8	1	1	2
H	9	35	75	2	9	20
I	3	12	27	1	3	7
J	2	5	11	1	2	3
K	1	3	7	1	1	2
L	2	7	15	1	2	4
M	4	15	33	1	4	9

TABLE A-4

The "cumulative" coefficients of variation for each location calculated from all the measurements (numbers in brackets) taken to the end of each day, including those from previous days.

LOCATION	DAYS				
	1	2	3	4	5
A	0.21(15)	0.45(30)	0.49(46)	0.42(58)	
B	0.21(16)	0.31(33)	0.31(50)	0.27(71)	0.26(83)
C	0.29(5)	0.27(9)	0.29(67)	0.25(23)	
D	0.16(23)	0.31(42)	0.29(67)	0.28(89)	0.24(109)
E	0.15(14)	0.76(30)	0.66(43)	0.55(59)	0.57(73)
F	0.15(12)	0.20(29)	0.26(40)	0.32(49)	
G	0.14(3)	0.18(16)	0.23(27)	0.24(42)	0.23(49)
H	0.15(23)	0.75(43)	0.60(64)	0.74(85)	0.74(88)
I	0.14(5)	0.51(27)	0.46(53)	0.38(78)	0.43(103)
J	0.11(16)	0.20(19)	0.26)37)	0.26(52)	0.27(74)
K	0.11(3)	0.13(21)	0.22(35)	0.21(37)	
L	0.20(4)	0.28(28)	0.28(49)	0.32(69)	
M	0.30(21)	0.36(44)	0.45(69)	0.48(76)	
Average	0.18	0.34	0.37	0.36	

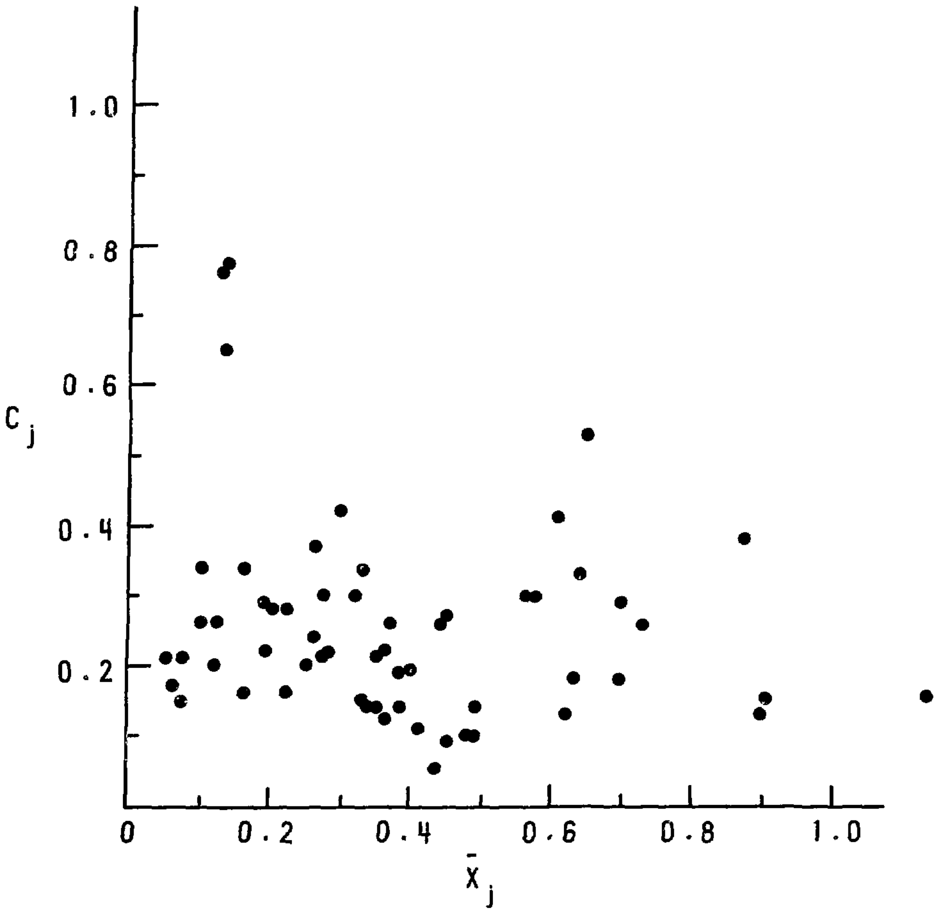

FIGURE A-1 - Scatter plot of C_j and $\bar{X}_j$ for location-days. C_j is the coefficient of variation and $\bar{X}_j$ is the average working level at location j.

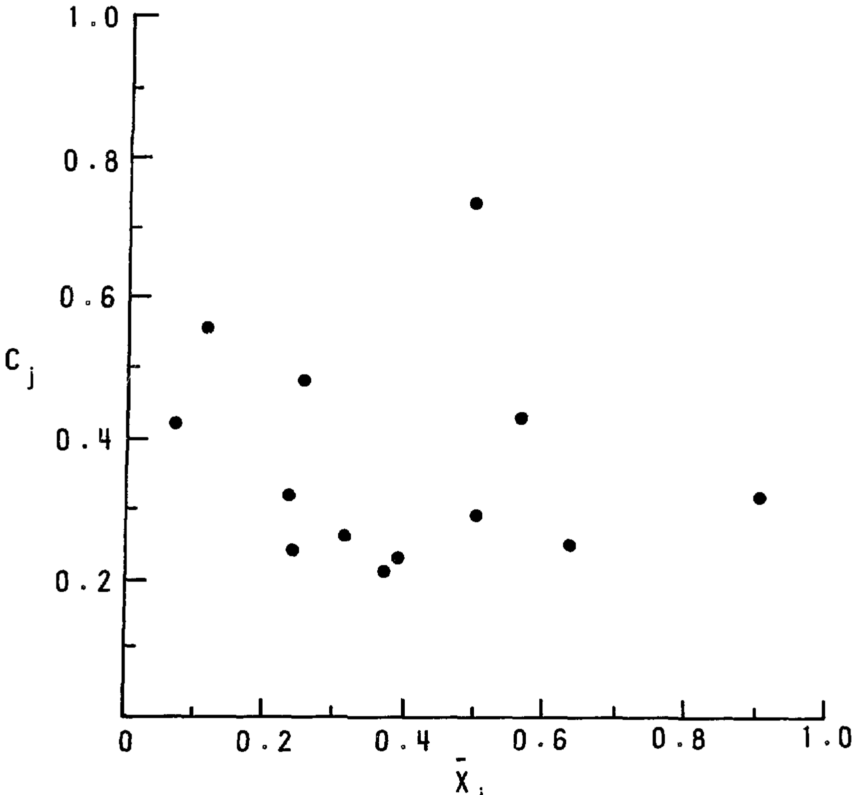

Figure A-2 - Scatter plot of C_j and $\overline{X}_j$ for location-periods. C_j is the coefficient of variation and $\overline{X}_j$ is the average working level at location j.

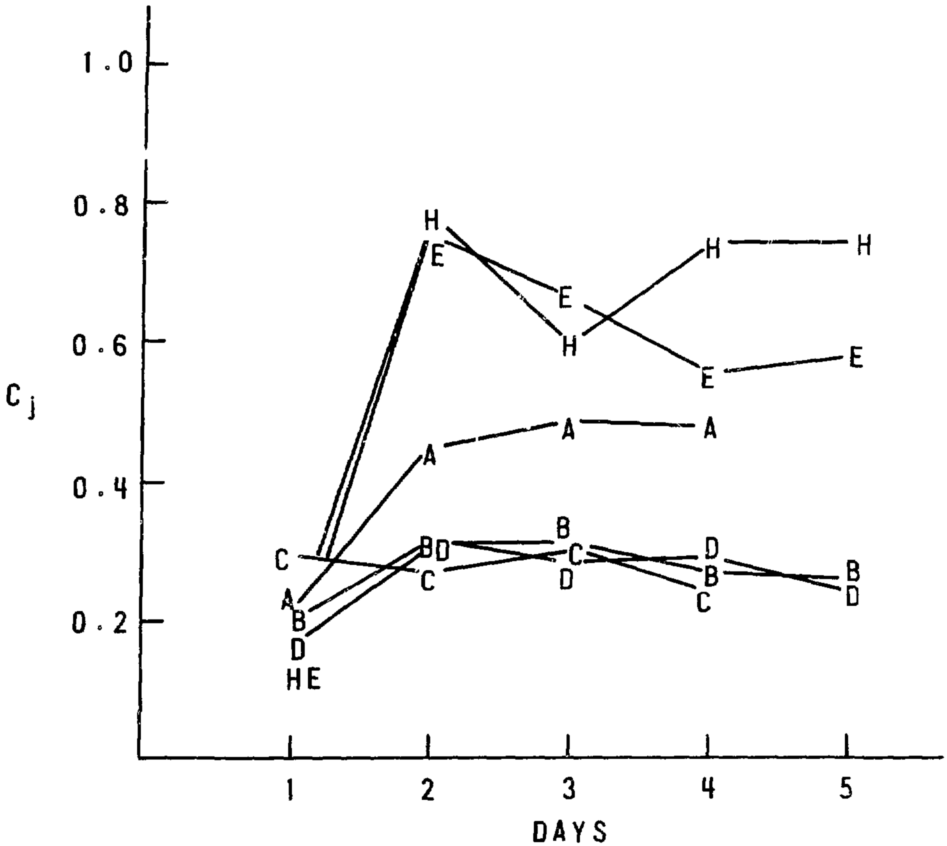

FIGURE A-3(a) - Plot of the cumulative coefficient of variation (C_j) as a function of the number of consecutive days measurements were made at each location. Letters refer to the location code.

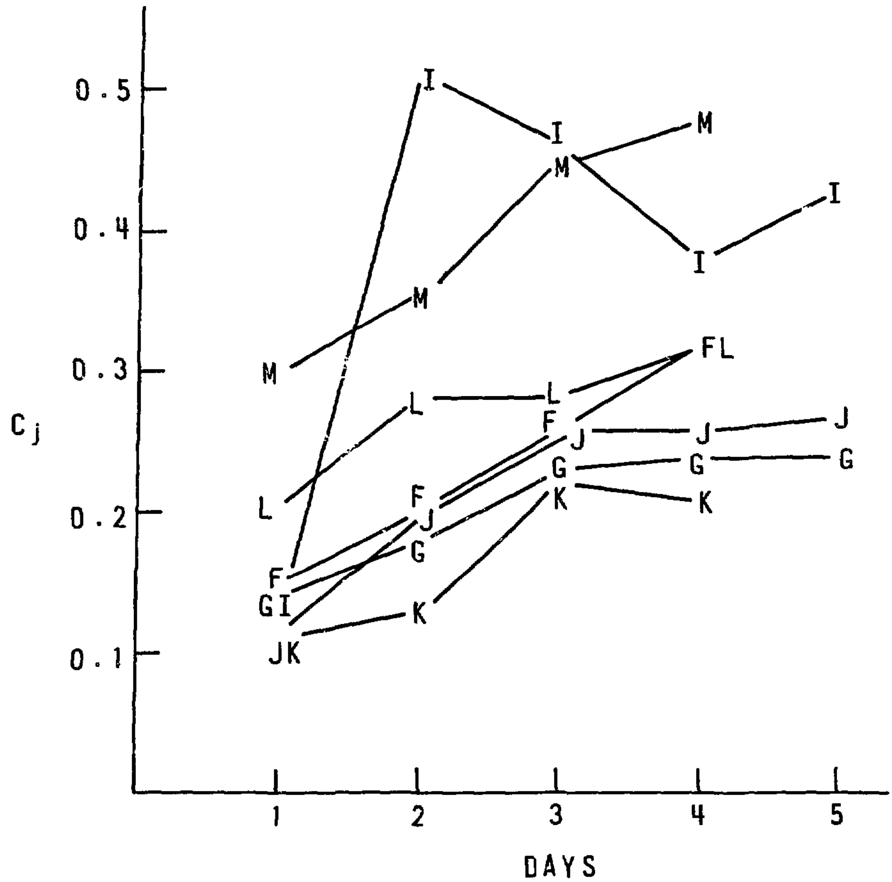

Figure A-3(b) - Plot of the cumulative coefficient of variation (C_j) as a function of the number of consecutive days measurements were made at each location. Letters refer to the location code.

ADDENDUM TO MR-76-1/D

This table gives the results of testing the data used in the appendix of MR-76-1/D for normality and log-normality using the W and Kolmogornov-Smirnov (KS) tests. The numbers given are the percent probability of obtaining the appropriate (W or Ks) statistic given that the data are random samples from a normal, or a log-normal, distribution. These tests have been evaluated using data with a known normal distribution with the result that the KS and W tests gave average results of 80 and 55% respectively. The underlined location-day results are the ones that could be considered as normal or log-normal on the basis of both of these tests.

DATA SET	SAMPLE SIZE	NORMAL		LOG-NORMAL	
		W(%)	KS(%)	W(%)	KS(%)
A-1	15	1	52	1	46
A-2	15	2	27	14	43
A-3	16	11	32	6	24
A-4	12	5	38	6	46
B-1	16	25	72	5	46
B-2	18	4	27	7	35
B-3	17	27	63	20	44
B-4	21	100	99	80	92
B-5	12	14	72	9	61
C-1	5	30	83	40	85
C-2	4	10	59	7	35
C-3	5	76	97	86	97
C-4	9	56	76	37	67
D-1	23	5	83	0	53
D-2	19	2	37	12	40
D-3	25	1	76	0	21
D-4	22	73	86	56	92
D-5	20	12	75	11	73
E-1	14	4	53	8	65
E-2	16	0	6	1	19
E-3	13	11	33	22	35
E-4	16	7	41	6	37
E-5	14	0	3	0	11
F-1	12	85	90	84	89
F-2	17	35	80	71	82
F-3	12	87	92	74	86

ADDENDUM TO MR-76-1/D (Continued)

DATA SET	SAMPLE SIZE	NORMAL W(%)	NORMAL KS(%)	LOG-NORMAL W(%)	LOG-NORMAL KS(%)
F-4	9	11	49	2	26
G-1	3	1	67	0	67
G-2	13	58	70	32	51
G-3	11	33	52	10	29
G-4	16	7	74	39	95
G-5	7	20	56	26	57
H-1	23	39	80	12	75
H-2	21	28	60	59	75
H-3	21	5	60	2	30
H-4	21	12	72	11	67
H-5	3	38	81	36	80
I-1	5	99	97	98	97
I-2	22	1	59	15	74
I-3	26	0	54	32	96
I-4	25	3	34	1	27
I-5	25	17	97	6	83
J-1	16	49	80	55	70
J-2	3	30	79	38	81
J-3	18	1	52	6	76
J-4	14	36	64	46	76
J-5	23	0	7	0	31
K-1	20	15	46	4	33
K-2	4	7	91	7	91
K-3	11	4	23	22	45
L-1	4	23	94	20	93
L-2	24	17	66	45	74
L-3	21	1	13	9	24
L-4	20	47	78	0	40
M-1	21	0	2	0	15
M-2	23	15	72	15	68
M-3	23	30	75	91	79
M-4	9	50	84	15	81

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