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**<sup>210</sup>Pb DATING OF LACUSTRINE SEDIMENTS  
FROM ANTELOPE LAKE (CORE 063,  
STATION ALS1), SASKATCHEWAN**

**L.J. Turner**

**NWRI Contribution No. 94-142**

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## **MANAGEMENT PERSPECTIVE**

A lacustrine sediment core from Antelope Lake, Saskatchewan was dated using the  $^{210}\text{Pb}$  method. The  $^{210}\text{Pb}$  profile of the sediment core was used to determine the chronological age of the sediment as well as the sedimentation rate. The mean specific gravity was determined to be  $2.520 \text{ g}\cdot\text{cm}^{-3}$ . Data were analyzed using two models: the Constant Initial Concentration (CIC) model and the Constant Rate of Supply (CRS) model. The average mass sedimentation rate was determined to be  $0.15 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CIC1 model,  $0.15 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CIC2 model, and  $0.19 \pm 0.058 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CRS model.

## SOMMAIRE À L'INTENTION DE LA DIRECTION

On a daté un sédiment lacustre du lac Antelope, en Saskatchewan. On s'est servi du profil du  $^{210}\text{Pb}$  d'une carotte de ce sédiment pour en déterminer l'âge chronologique ainsi que son taux de sédimentation. La densité moyenne du sédiment était  $2,520 \text{ g} \cdot \text{cm}^{-3}$ . Les données ont été analysées à l'aide de deux modèles : le modèle de la concentration initiale constante (CIC) et celui du taux d'alimentation constant (CRS). Le modèle CIC1 et le modèle CIC2 ont donné un taux de sédimentation moyen de la masse de  $0,15 \text{ g} \cdot \text{cm}^{-2} \cdot \text{année}^{-1}$ , alors que le modèle CRS a donné un taux de  $0,19 \pm 0,058 \text{ g} \cdot \text{cm}^{-2} \cdot \text{année}^{-1}$ .

## ABSTRACT

A lacustrine sediment core was dated from Antelope Lake, Saskatchewan. The  $^{210}\text{Pb}$  profile of the sediment core was used to determine the chronological age of the sediment as well as the sedimentation rate. The mean specific gravity was determined to be  $2.520 \text{ g}\cdot\text{cm}^{-3}$ . The sedimentation rate was calculated to be  $0.79 \text{ cm}\cdot\text{yr}^{-1}$  for core 063 using a CIC model. The average mass sedimentation rate was determined to be  $0.15 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CIC1 model,  $0.15 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CIC2 model, and  $0.19 \pm 0.058 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  using the CRS model.

## RÉSUMÉ

On a daté un sédiment lacustre du lac Antelope, en Saskatchewan. On s'est servi du profil du  $^{210}\text{Pb}$  d'une carotte de ce sédiment pour en déterminer l'âge chronologique ainsi que son taux de sédimentation. La densité moyenne du sédiment était  $2,520 \text{ g} \cdot \text{cm}^{-3}$ . Pour la carotte 063, le modèle CIC a donné un taux de sédimentation de  $0,79 \text{ cm} \cdot \text{année}^{-1}$ . Le modèle CIC1 et le modèle CIC2 ont donné un taux de sédimentation moyen de la masse de  $0,15 \text{ g} \cdot \text{cm}^{-2} \cdot \text{année}^{-1}$ , alors que le modèle CRS a donné un taux de  $0,19 \pm 0,058 \text{ g} \cdot \text{cm}^{-2} \cdot \text{année}^{-1}$ .

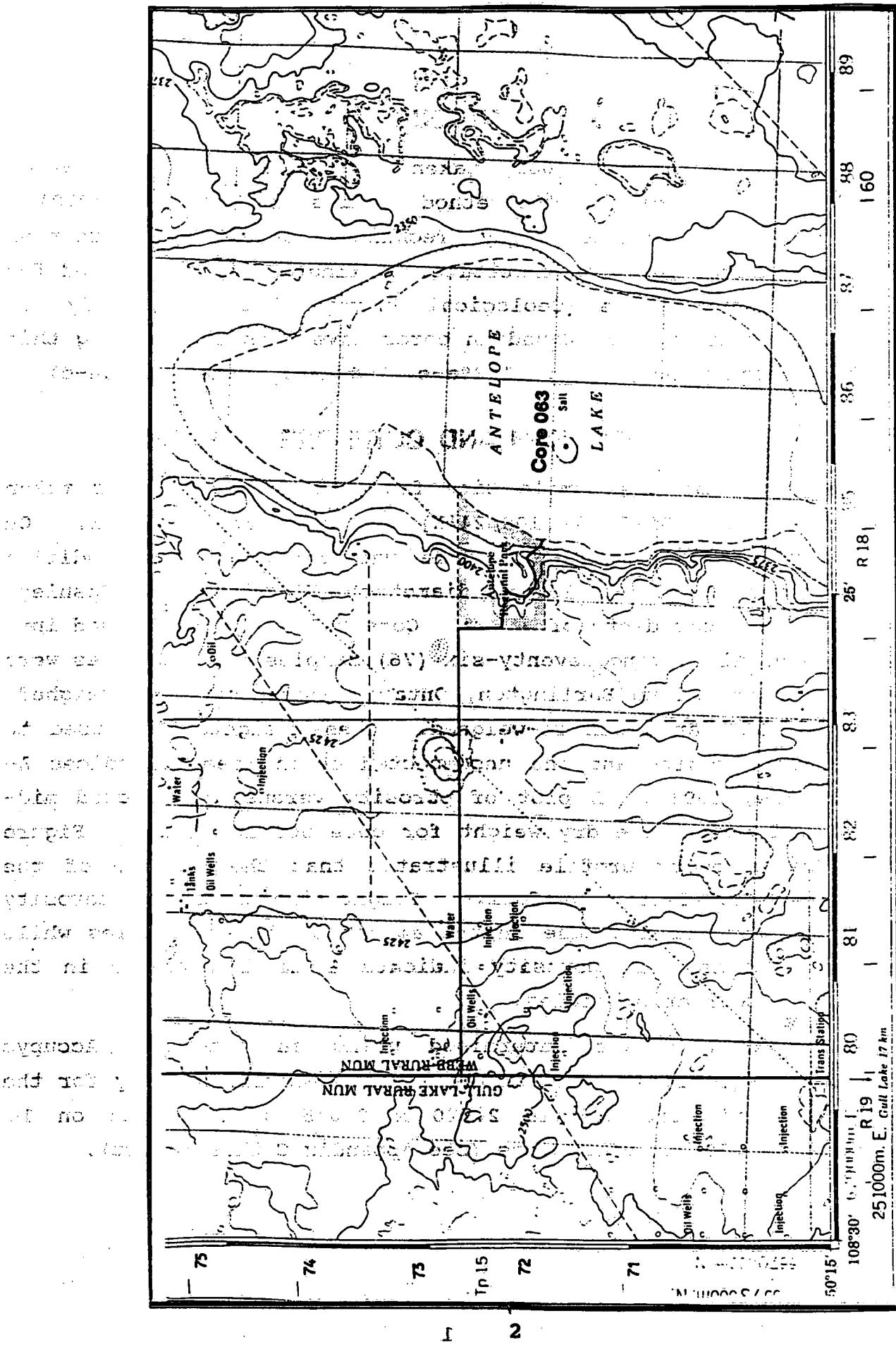
## INTRODUCTION

In this study, a core (063) taken from Antelope Lake (station ALS1) was dated using a  $^{210}\text{Pb}$  method (Eakins and Morrison, 1978). The core was collected by Technical Operations personnel (National Water Research Institute, Burlington) and submitted for analysis by B. Vance (Geological Survey of Canada, Study No. 910013). Other western Canadian cores have been dated using this method (Turner and Delorme, 1988a-e, 1989a-d; Turner, 1994a-c).

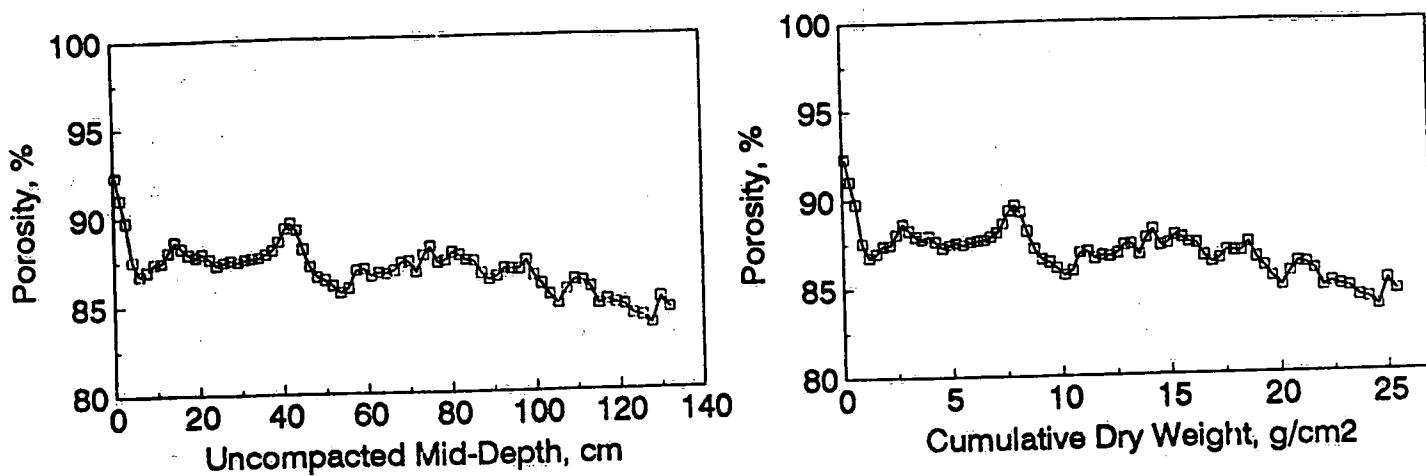
## LOCATION AND CORE PREPARATION

The location of the sample site from which the core was taken (Station 063;  $50^{\circ}15'4''\text{N}$   $108^{\circ}24'\text{W}$ ) is shown in Figure 1. On February 11, 1994, Antelope Lake was cored using a modified lightweight corer (10.16 cm diameter) (Williams and Pashley, 1978) at a water depth of 4.5 m. Core 063 was subsectioned into 1-cm intervals giving seventy-six (76) samples. The samples were then transported to Burlington, Ontario where they were weighed, freeze-dried, and then re-weighed. These weights were used to calculate porosity and the uncompacted depth (see Appendices A-B, Delorme, 1991). A plot of porosity versus uncompacted mid-depth and cumulative dry weight for core 063 is shown in Figure 2. The porosity profile illustrates that the texture of the sediments is fairly uniform. Slight increases in porosity indicate a small increase in the amount of fine particles while slight decreases in porosity indicate a small increase in the amount of coarser particles.

Specific Gravity was determined using an automated Accupyc pycnometer (Micromeritics, 1992). Mean specific gravity for the sediments of core 063 is  $2.520 \pm 0.045 \text{ g}\cdot\text{cm}^{-3}$  based on 10 samples and 50 determinations (see Appendix C this report).



**Figure 1.** Location map of the sampling site for core 063, Antelope Lake, Saskatchewan.



**Figure 2.** Distribution of porosity with uncompacted mid-depth or cumulative dry weight for core 063.

## METHOD

### *Laboratory Procedures*

Homogeneous portions of 23 samples (Table 1, including 2 sets of replicates) from core 063 were treated using a variation on the Eakins and Morrison (1978) polonium distillation procedure. Details of the laboratory procedure are found in a laboratory manual (Turner, 1990).

Following grinding and homogenizing, 0.5 g (upper core) to 2 g (lower core) of sediment were treated with concentrated HCl to remove carbonate materials, then mixed with approximately 10 dpm  $\text{ml}^{-1}$  of  $^{209}\text{Po}$  spike in a test tube. The  $^{209}\text{Po}$  spike was prepared on September 6, 1991 at 6.07 dpm/ml activity. The test tube and contents were then placed in an oven at 110°C until dry.

After cooling, glass wool plugs (one to hold the sediment at the bottom of the tube, one dampened to catch polonium at the opening of the tube) were inserted, then the tubes were placed into a

tube furnace and heated to 700°C for  $\frac{1}{2}$  hr to distill the polonium from the sediments. At this temperature, polonium passes easily from the sediment, through the dry wool plug and does not condense until reaching the wet wool plug outside the furnace.

After cooling, the tube was cut, and the upper part containing the damp glass wool (condenser) was digested in concentrated HNO<sub>3</sub> under reflux (to destroy organic material). The residue was then filtered and the filtrate boiled down and digested with two HCl treatments to remove any remaining traces of HNO<sub>3</sub>.

The polonium was then plated from the remaining solution onto a finely polished silver disk. The disk was counted in an alpha spectrometer. <sup>209</sup>Po was identified by its 4.88 MeV alpha particle, and <sup>210</sup>Po by its 5.305 MeV alpha particle. The <sup>210</sup>Po counts obtained from the spectrometer were compared to the <sup>209</sup>Po counts (of known activity) to determine the activity of <sup>210</sup>Po in the sediment sample.

#### *Sediment Dating Theory*

#### *CONTINUOUS*

Dating of lacustrine sediments has been actively pursued for several decades (Robbins and Edgington, 1975; Matsumoto, 1975; Appleby and Oldfield, 1978; and Farmer, 1978). Sedimentation rates are derived using either the CIC (constant initial concentration of unsupported <sup>210</sup>Pb; Robbins and Edgington, 1975; Matsumoto, 1975) or the CRS (constant rate of supply; Appleby and Oldfield, 1978) model. The CIC model assumes a constant sedimentation rate over the time period in which unsupported <sup>210</sup>Pb is measured. The CRS model assumes a variable sedimentation rate. Both models assume a constant flux of unsupported <sup>210</sup>Pb to the sediment/water interface. Depth can be corrected for sediment compaction in the CIC model using sediment porosity measurements; otherwise cumulative dry weight is used. Sediment compaction is accounted for in the CRS model by dealing with cumulative dry weight instead of sediment depth.

The profile of  $^{210}\text{Pb}$  in a sediment core can be described as follows:

$$A_{Tx} = (A_{U_0})e^{-\lambda t} + A' \quad (\text{li})$$

where  $A_{Tx}$  is the total activity of  $^{210}\text{Pb}$  in the sample in  $\text{pCi}\cdot\text{g}^{-1}$  dry wt at depth  $x$ , and of age  $t$ .

$A'$  is the activity of  $^{210}\text{Pb}$  supported by  $^{226}\text{Ra}$  in  $\text{pCi}\cdot\text{g}^{-1}$  dry wt (represented by constant  $^{210}\text{Po}$  activities attained at depth),

$A_{U_0}$  is the unsupported activity of  $^{210}\text{Pb}$  at the sediment/water interface in  $\text{pCi}\cdot\text{g}^{-1}$  dry wt,

$\lambda$  is the radioactive decay constant for  $^{210}\text{Pb}$  ( $0.693/22.26 \text{ yr}^{-1} = 0.0311 \text{ yr}^{-1}$ ),

And since  $A_{Ux} = A_{Tx} - A'$  then  $A_{Ux} = (A_{U_0})e^{-\lambda t}$  (lii)

where  $A_{Ux}$  is the unsupported activity of  $^{210}\text{Pb}$  in the sample in  $\text{pCi}\cdot\text{g}^{-1}$  dry wt at depth  $x$ ,

#### The Constant Initial Concentration (CIC) Model:

In the following derivations, equations which refer to the usage of cumulative dry weight instead of uncompacted depth in the CIC model are designated with an 'a'.

In the CIC model, uncompacted mid-depth,  $z$ , can be used instead of natural depth,  $x$ , to compensate for sediment compaction. Otherwise cumulative dry weight is used. The uncompacted mid-depth is calculated from uncompacted thickness (Delorme 1991).

$$t_{ui} = \{(\phi_o - \phi_i)/(1 - \phi_o)\} + (TV_i * V_q) \quad (2)$$

where  $t_{ui}$  is the uncompacted thickness of the  $i^{\text{th}}$  sample,

$\phi_i$  is the porosity of the  $i^{\text{th}}$  sample expressed as a percentage,

$\phi_o$  is the porosity at the sediment-water interface calculated by regressing the top four sample porosities ( $\phi_i$ ) against natural mid-depth, and  $\phi_o = y$  intercept,

$TV_i$  is the total volume of the  $i^{\text{th}}$  sample,

$V_q$  is the volume of a cylinder 1 cm high and surface area equal to either the inside of the core tube or the stainless steel extrusion ring, whichever is appropriate.

The CIC model assumes a constant sedimentation rate (or mass sedimentation rate) over the time period in which unsupported  $^{210}\text{Pb}$  is measured, thus

$$t = z/S_o \quad (3)$$

$$t = c/w \quad (3a)$$

where  $S_o$  is the sedimentation rate in  $\text{cm} \cdot \text{yr}^{-1}$  at the sediment/water interface,

$z$  is uncompacted mid-depth,

$c$  in cumulative dry weight in  $\text{g} \cdot \text{cm}^{-2}$ ,

$w$  is the mass sedimentation rate in  $\text{g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$ .

The total  $^{210}\text{Pb}$  activity at the sediment water interface is:

$$A_{T0} = (P/w) \quad (4)$$

where  $P$  is the flux of  $^{210}\text{Pb}$  at the sediment water interface in  $\text{pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$ , (assumed constant).

Substituting equations (3) [and (3a)] and (4) into equation (1a) gives:

$$A_{Tz} = (P/w)e^{-z\lambda/S_o} + A' \quad (5)$$

$$\text{or} \quad A_{Tx} = (P/w)e^{-c\lambda/w} + A' \quad (5a)$$

Equation (5) or [5(a)] can be simplified using natural logarithms:

$$\ln(A_{Tz} - A') = \ln(P/w) - (\lambda/S_o)z \quad (6)$$

$$\ln(A_{Tx} - A') = \ln(P/w) - (\lambda/w)c \quad (6a)$$

The form of the equation is  $y = b + (m)x$

A graphical solution for  $P/w$  (the y-intercept) and  $\lambda/S_o$  [or  $(\lambda/w)$ ] (the slope of the line) is possible from a plot of  $x$  and  $y$  ( $z$  vs  $\ln(A_{Tz} - A')$ ) [or  $c$  vs  $\ln(A_{Tx} - A')$ ] (see Figure 4). As  $\lambda$  is known, then  $S_o$  [or  $w$ ] can be calculated.

$$S_o = \lambda/\text{slope} = \lambda/(m) \quad (7)$$

$$\omega = \lambda/\text{slope} = \lambda/(m) \quad (7a)$$

When using uncompacted depth, the mass sedimentation rate  $\omega$  ( $\text{g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ ) is represented by:

$$\omega = S_o (1 - \phi_o) \rho_s = S_i (1 - \phi_i) \rho_s \quad (8)$$

where  $\rho_s$  is the density of the solid phase of the sample (assumed constant),

$S_i$  is the sedimentation rate ( $\text{cm}\cdot\text{yr}^{-1}$ ) at a given uncompacted mid-depth  $z$ .

The flux at the sediment/water interface  $P$  ( $\text{pCi}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ ) can be calculated from the y-intercept and mass sedimentation rate.

$$P = \omega (e^b) \quad (9)$$

Using equation (6) [or (6a)] the time 't' in years since the sample was deposited is given by:

$$t = \frac{\ln(A_{Tz} - A') - \ln(P/\omega)}{(-\lambda)} = \frac{z}{S_o} \quad (10)$$

or

$$t = \frac{\ln(A_{Tx} - A') - \ln(P/\omega)}{(-\lambda)} = \frac{c}{\omega} \quad (10ai)$$

which can be written as:

$$t = -\frac{1}{\lambda} \ln \frac{(A_{Tz} - A')}{A_{To}} = \frac{z}{S_o} \quad \text{or} = \frac{c}{\omega} \quad (10aii)$$

The uncompacted mid-depth (cm) divided by the sedimentation rate ( $\text{cm}\cdot\text{yr}^{-1}$ ) [or cumulative dry weight, ( $\text{g}\cdot\text{cm}^{-2}$ ) divided by mass sedimentation rate ( $\text{g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ )] gives  $t$ .

#### The Constant Rate of Supply (CRS) Model:

Since the CRS model assumes a constant rate of supply, then

$$P = A_{Ui} * \omega_t \quad (11)$$

where  $P$  is the flux of  $^{210}\text{Pb}$  at the sediment water interface

in  $\text{pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$ , (assumed constant)

$A_{U_i}$  is the initial activity of unsupported  $^{210}\text{Pb}$  in sediment of age  $t$

$\omega_t$  is the dry Mass Sedimentation Rate ( $\text{g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$ ) at time  $t$ .

Sediment laid down during time period  $\delta t$  occupies a layer of thickness ( $\delta x$ ):

$$\delta x = \frac{\omega_t}{\rho_x} \delta t \quad (12)$$

where  $\rho_x$  is the dry mass/unit wet volume of the sample ( $\text{g} \cdot \text{cm}^{-3}$ ) at depth  $x$ .

$$\rho_x = \frac{d\omega}{dx} \quad (13)$$

The rate of change of depth is

$$\dot{x} = \frac{\omega}{\rho_x} \quad (14)$$

where ' $\dot{\cdot}$ ' denotes differentiation with regards to  $t$ .

$$\text{and } \dot{x} \rho_x = \omega = \dot{x}_o \rho_o \quad (15)$$

Equation (15) combines with (1b) to give

$$\dot{x} \rho_x A_{UX} = \dot{x}_o \rho_o (A_{Uo}) e^{-\lambda t} \quad (16)$$

Let  $B(x) = \int_x^{\infty} \rho_x * A_{UX} dx = \int_x^{\infty} A_{UX} dw$  (17)

represent the total residual or cumulative unsupported  $^{210}\text{Pb}$  beneath sediments of depth  $x$ ,

and  $B(0) = \int_0^{\infty} \rho_o * A_{Uo} dx = \int_0^{\infty} A_{Uo} dw$  (18)

represent the total residual unsupported  $^{210}\text{Pb}$  in the sediment column, then:

$$B(x) = B(0) e^{-\lambda t} \quad (19)$$

The age of layer at depth  $x$  is thus:

$$t = - \frac{1}{\lambda} \ln \frac{B(x)}{B(0)} \quad (20)$$

where  $B(x)$  and  $B(0)$  are calculated by direct numerical integration of the  $^{210}\text{Pb}$  profile (the plot of unsupported activity versus cumulative dry weight).

The mass sedimentation rate is calculated by dividing the change in the mid-sample cumulative dry weight by the difference of time in years for the sample analyzed.

The mean  $^{210}\text{Pb}$  supply rate (flux) is calculated from

$$P = \lambda B(0) \quad (21)$$

## Quality Assurance/Quality Control

### *Quality Assurance: Collection and Preparation of Core Samples*

The samples for core 063 was collected using a modified lightweight corer. When the core was extruded, the outer smeared portion was removed using a stainless steel ring to prevent contamination of sediments from above (following the procedure outlined by Delorme, 1991).

The samples were freeze-dried using a standard procedure. Minimum loss of water from each sample was achieved by keeping tight lids on the vials before weighing and freeze drying. There was no transfer of sediments from the vials until freeze-drying was complete and the dry weights obtained.

Test runs for quality control on the alpha spectrometry equipment were last done in November, 1994.

### *Quality Control: Contamination and Method Checks*

Blanks (no sample, no spike), were run through the same analytical procedures as samples, to determine if there was contamination from analytical reagents. Blanks, prepared at the

same time as the sediment samples, exhibited a background activity of 0.03 dpm when run in all detectors, an activity comparable to empty sample holders.

Yield tracer solutions (no sediment sample) were also run through the analytical procedure. No counts above background were detectable in the  $^{210}\text{Po}$  region of the spectra for disks prepared using only the spike (no sample), indicating no polonium ( $^{210}\text{Po}$ ) contamination in the analyses from spike solutions.

#### **Quality Assurance: System Checks**

The alpha spectrometer has been monitored since May of 1988. Sample chambers are examined on a monthly basis for contamination. Empty sample holders give a background count rate of 0.01 dpm which equals the equipment specifications.

## **RESULTS**

Table 1 lists the  $^{210}\text{Po}$  activities for the 23 samples prepared for core 063. Figure 3 depicts the  $^{210}\text{Po}$  activity profile with depth and cumulative dry weight. The symbols used in figure 3 indicate which detector was used during sample analysis. Circles represent detector 3, triangles represent detector 2, and squares represent detector 1. The appearance of the activity profile may indicate a varying sedimentation rate. The profile may be defined by more than one slope, and the decay is not as expedient as expected.

#### **Reproducibility of Results**

Two slices from core 063 were chosen to have the analysis for  $^{210}\text{Po}$  repeated. These are listed in Table 2. The  $^{210}\text{Po}$  activities are given in Table 1.

**Table 2 Reproducibility of Antelope Lake analyses.**

<u>Core</u>	<u>Sample</u>	<u>Uncompacted Mid Depth</u>	<u><math>^{210}\text{Po}</math> activity</u>
		<u>Mean <math>\pm</math> Std Deviation</u>	
063	10	14.4	8.3 $\pm$ 0.3
	30	46.4	4.6 $\pm$ 0.1

Table 1. Activity of  $^{210}\text{Po}$  in Core 063 Sediment.

Sample	Cum. Dry Wt. g/cm <sup>2</sup>	Uncomp. Mid Depth cm	<sup>210</sup> Po dpm/g	DET No.
1	0.17	0.47	6.8	3
2	0.40	1.56	6.7	1
5	1.26	6.02	7.2	2
7	1.90	9.49	6.9	2
9	2.52	12.83	7.5	1
10	2.82	14.43	8.3 ± 0.2	1/2/3
10R	2.82	14.43	8.4 ± 0.2	1/2/3
10R2	2.82	14.43	8.4 ± 0.3	1/2/3
11	3.10	15.99	7.4	1
13	3.70	19.19	6.3	1
15	4.33	22.46	5.8	3
17	4.97	25.83	6.1	2
20	5.93	30.90	5.9	2
25	7.41	38.96	5.7	1
30	8.82	46.36	4.5 ± 0.1	1/2/3
30R	8.82	46.36	4.6 ± 0.1	1/2/3
30R2	8.82	46.36	4.7 ± 0.1	1/2/3
35	10.58	55.57	3.2	1
40	12.28	64.59	3.3	2
45	13.96	73.38	2.4	2
50	15.60	81.89	2.6	3
60	19.00	99.48	2.3	3
70	22.88	119.08	2.1	1

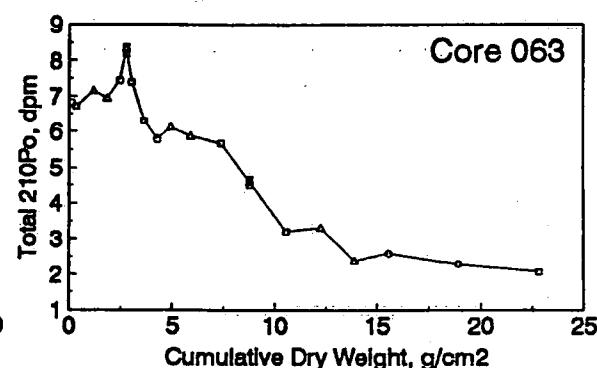
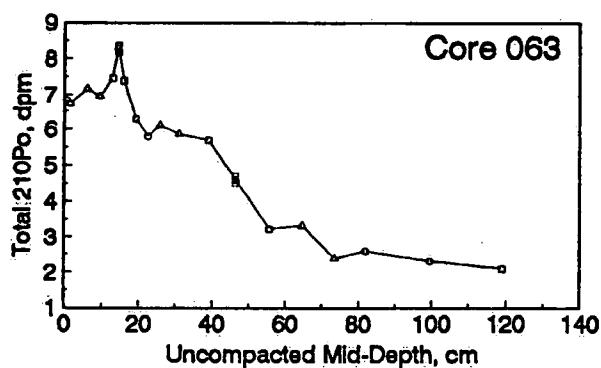


Figure 3. Distribution of Total  $^{210}\text{Po}$  activity in  $\text{dpm} \cdot \text{g}^{-1}$  in relation to uncompacted mid-depth and cumulative dry weight for core 063.

$^{210}\text{Pb}$  Analysis of Antelope Lake core 063, using the CIC model.

For the first CIC model, the unsupported activity is plotted against uncompacted mid-depth (Figure 4) using the expanded equation (6). Based on the graphical solution, the y-intercept is  $\ln(P/w) = 1.6112$  and the slope of the line ( $\lambda/S_0$ ) is  $-0.0394$  (see Appendix D). Samples 6 to 18 were used to calculate an average sedimentation rate of  $0.79 \text{ cm} \cdot \text{yr}^{-1}$ , an average mass sedimentation rate of  $0.15 \text{ g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$  and a flux of  $0.75 \text{ pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$ .

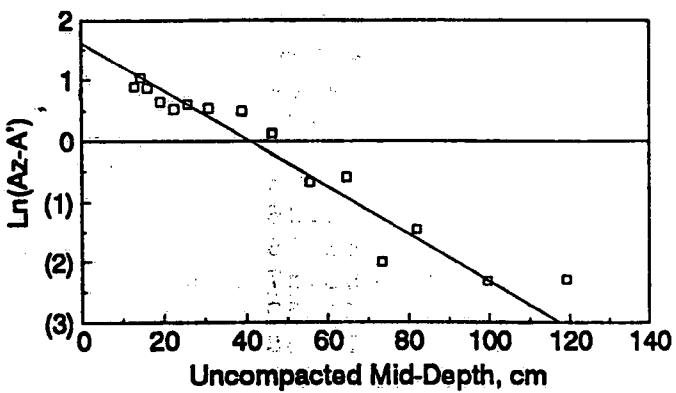


Figure 4. The distribution of uncompacted mid-depth against  $\ln(A_z - A')$  for core 063. The y intercept of the regression line = 1.6112, the slope = -0.0394.

The mean dates calculated for each core section, based on a division of the uncompacted mid-depth by the sedimentation rate (equation 3), are given in Appendix G. The '±' values are two standard deviations based on data calculated for the top, bottom, and mid-depth of the sample.

For the second CIC model, the unsupported activity is plotted against cumulative dry weight (Figure 5) using the expanded equation (6a). Based on the graphical solution, the y-intercept is  $\ln(P/w) = 1.5930$  and the slope of the line ( $\lambda/w$ ) is  $-0.2077$  (see Appendix E). Samples 6 to 18 were used to calculate an average mass sedimentation rate of  $0.15 \text{ g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$  and a flux of  $0.74$

$\text{pCi}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ . The dates calculated for each core section, based on a division of the cumulative dry weight by the mass sedimentation rate (equation 3a) are given in Appendix G. The ' $\pm$ ' values are two standard deviations based on data calculated for the top, bottom, and mid-section of the sample.

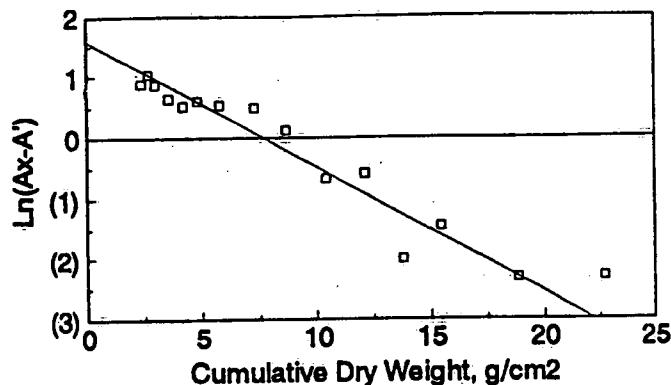
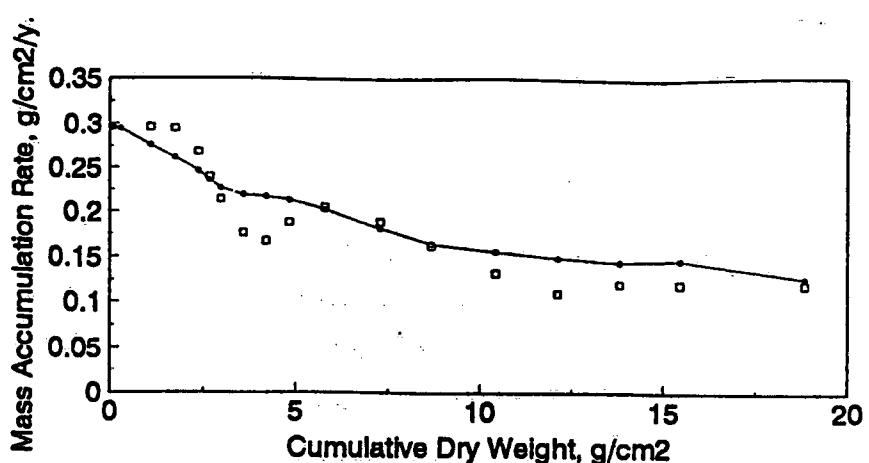


Figure 5. The distribution of cumulative dry weight against  $\ln(A_x - A')$  for core 063. The y intercept of the regression line = 1.5930, the slope = -0.2077.

Ideally, the CIC1 and CIC2 models should give almost identical results. A comparison of the mass sedimentation and atmospheric flux rates for this core shows good agreement for this core.

#### *$^{210}\text{Pb}$ Analysis of Antelope Lake core 063, using the CRS model.*

For the CRS model, the unsupported activity is plotted against cumulative dry weight (Figure 3). The profile is integrated to determine  $B(0)$  and  $B(x)$  and calculate time (see Appendix F) according to equation 20. Since not all samples were analyzed for  $^{210}\text{Pb}$  activity, a multiple regression analysis was performed to obtain the dates for each core section as given in Appendix G. Samples 1 to 18 were used in this example to calculate an average mass sedimentation rate of  $0.19 \pm 0.058 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  and flux of  $0.63 \text{ pCi}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ . The variation in mass sedimentation rate in core 063 is illustrated in figure 6.



**Figure 6.** Plot of mass sedimentation rate versus cumulative dry weight for core 063. Points represent mass sedimentation rates determined from integrated area defined by activity and cumulative dry weight for the sample, the line represents the running mean of the mass sedimentation rate.

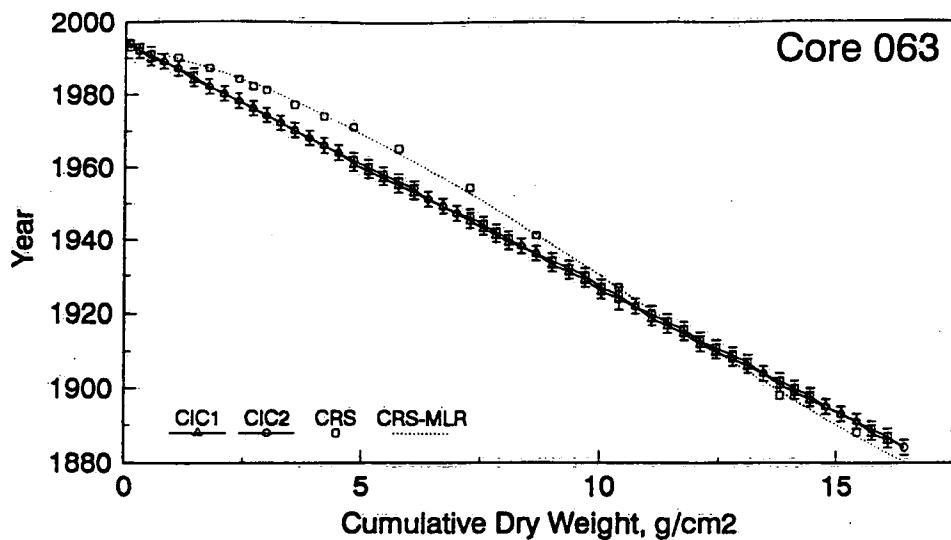
*Comparison of CIC and CRS  $^{210}\text{Pb}$  Analysis of Antelope Lake.*

Table 3 lists mass sedimentation and atmospheric flux rates as calculated from the CIC and CRS models. The rates are in fair agreement with the CIC models agreeing more closely. Variability in sedimentation rate is supported by the CRS model data (Figure 6) and the activity profile (Figure 3). Points 1 to 5 could not be used in the CIC models as they interfered in the regression of the profile. This indicates that the assumption of a 'constant sedimentation rate' for the CIC model was not acceptable. The year corresponding to individual core sections (Appendix H) as determined by the CIC and CRS models are plotted against cumulative dry weight in Figure 7. Figure 7 shows disagreement between the two models throughout most of the core. Due to the variability in sedimentation rate as indicated by the data, The dates given by the CRS model are considered as more representative of core 063.

**Table 3. Summary of Mass Sedimentation Rate and Atmospheric Flux.**

Model	Average Mass Sedimentation Rate $\text{g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$	Atmospheric Flux $\text{pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$
CIC1	0.15	0.75
CIC2	0.15	0.74
CRS	$0.19 \pm 0.058^*$	0.63

\* Based on incremental mass sedimentation rates (Appendix F)



**Figure 7.** Plot of the Year determined from CIC (squares and circles)/CRS (triangles) models versus cumulative dry weight for Antelope Lake Core 063.

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Appendix A: Wet and dry weights for core 063.

063 Core Number Station ALS1  
 2.520 Specific Gravity g·cm<sup>-3</sup>  
 81.0734 Surface area cm<sup>2</sup>, 10.16 cm Tube diameter  
 49.5144 Surface area cm<sup>2</sup>, 7.94 cm Cutter diameter

O NUMBER OF SAMPLES BELOW THE SURFACE BEFORE THE DIAMETER CHANGES TO  
 CUTTER DIAMETER; IF "ZERO" SURFACE AREA =49.514 OR VALUE OF LINE 4.

Sample No.	Wet* Wt.	Dry* wt.	Vial Wt.	Spec. Grav.	Sample No.	Wet* Wt.	Dry* wt.	Vial Wt.	Spec. Grav.
1	60.390	18.876	10.500	2.438**	41	72.047	27.363	10.336	2.519
2	69.675	21.899	10.423	2.451	42	71.914	26.951	10.469	2.521
3	68.495	23.133	10.428	2.464	43	69.054	26.083	10.435	2.523
4	64.448	24.523	10.485	2.477	44	73.819	28.087	10.477	2.525
5	67.735	26.179	10.417	2.490**	45	72.585	26.734	10.473	2.527
6	71.129	26.902	10.463	2.489	46	70.651	25.627	10.344	2.529
7	68.384	25.744	10.469	2.489	47	75.598	27.911	10.326	2.531
8	70.785	26.273	10.442	2.488	48	70.400	26.473	10.424	2.533
9	69.389	25.281	10.414	2.488	49	74.691	27.143	10.432	2.535
10	73.019	25.538	10.435	2.487**	50	70.440	26.167	10.387	2.537**
11	65.445	24.084	10.366	2.495	51	69.663	26.250	10.356	2.541
12	71.135	25.947	10.449	2.503	52	73.283	27.318	10.350	2.546
13	65.327	24.635	10.414	2.510	53	71.737	27.658	10.344	2.550
14	73.183	26.545	10.448	2.518	54	71.153	27.976	10.450	2.554
15	66.734	25.135	10.327	2.526**	55	69.714	27.389	10.457	2.559
16	71.246	26.781	10.437	2.521	56	70.875	27.260	10.450	2.563
17	69.276	26.056	10.423	2.517	57	71.066	27.376	10.414	2.567
18	67.554	25.388	10.344	2.512	58	67.365	26.364	10.431	2.571
19	72.646	26.834	10.318	2.508	59	70.366	26.736	10.473	2.576
20	71.642	26.501	10.478	2.503**	60	71.071	27.869	10.470	2.580**
21	69.229	25.774	10.461	2.505	61	71.838	28.556	10.397	2.582
22	68.657	25.568	10.410	2.506	62	70.866	28.993	10.486	2.585
23	68.242	25.301	10.455	2.508	63	78.882	31.924	10.333	2.587
24	67.471	24.804	10.354	2.509	64	73.373	29.475	10.479	2.590
25	65.116	23.760	10.381	2.511	65	70.951	28.179	10.429	2.592
26	70.188	24.201	10.398	2.512	66	75.637	29.613	10.396	2.594
27	68.416	23.512	10.418	2.514	67	72.685	29.176	10.433	2.597
28	65.446	23.214	10.417	2.515	68	73.397	30.336	10.344	2.599
29	66.558	24.538	10.343	2.516	69	72.213	29.814	10.441	2.602
30	70.090	26.560	10.456	2.518**	70	73.886	30.572	10.457	2.604**
31	72.293	27.802	10.446	2.518	71	74.471	30.866	10.464	2.604
32	71.432	27.667	10.362	2.518	72	76.849	32.166	10.337	2.604
33	66.933	26.817	10.493	2.518	73	75.917	32.059	10.450	2.604
34	71.001	28.372	10.478	2.518	74	77.874	33.137	10.407	2.604
35	72.632	28.526	10.377	2.518	75	79.606	32.094	10.487	2.604
36	71.556	27.238	10.453	2.517	76	74.988	31.187	10.316	2.604
37	72.147	27.308	10.436	2.517					
38	69.801	26.986	10.326	2.517					
39	72.760	27.732	10.447	2.517					
40	70.127	27.045	10.421	2.517**					

\*Includes Vial Weight  
 \*\* Measured, other values are calculated by linear regression

Appendix B: Calculation of porosity and uncompacted depths given sample wet and dry weights, (Delorme 1991) and specific gravity for core 063.

Samp Numb	Wet Wt. g	Dry Wt. g	Cum. Dry Wt g/cm <sup>2</sup>	Water Vol. cm <sup>3</sup>	Total Vol. cm <sup>3</sup>	Comp. Depth cm	Comp. Mid-pt Depth cm	Sample Uncomp Poros. %	Uncomp Depth cm	Uncomp Mid-pt Depth cm
1	49.89	8.38	0.17	41.51	3.44	44.95	0.91	0.45	92.36	0.93
2	59.25	11.48	0.40	47.78	4.68	52.46	1.06	1.97	91.07	1.25
3	58.07	12.70	0.66	45.36	5.16	50.52	1.02	2.99	89.79	1.39
4	53.96	14.04	0.94	39.93	5.67	45.59	0.92	3.91	87.57	1.58
5	57.32	15.76	1.26	41.56	6.33	47.89	0.97	4.88	86.78	1.74
6	60.67	16.44	1.59	44.23	6.60	50.83	1.03	5.90	85.39	1.91
7	57.92	15.28	1.90	42.64	6.14	48.78	0.99	6.89	87.42	1.67
8	60.34	15.83	2.22	44.51	6.36	50.87	1.03	7.91	87.49	1.70
9	58.97	14.87	2.52	44.11	5.98	50.08	1.01	8.93	88.07	1.61
10	62.58	15.10	2.82	47.48	6.07	53.55	1.08	10.01	94.47	1.66
11	55.08	13.72	3.10	41.36	5.50	46.86	0.95	10.95	10.48	1.27
12	60.69	15.50	3.41	45.19	6.19	51.38	1.04	11.99	11.47	1.75
13	54.91	14.22	3.70	40.69	5.66	46.36	0.94	12.93	12.46	1.78
14	62.74	16.10	4.03	46.64	6.39	53.03	1.07	14.00	13.46	1.95
15	56.41	14.81	4.33	41.60	5.86	47.46	0.96	14.96	14.48	1.65
16	60.81	16.34	4.66	44.46	6.48	50.95	1.03	15.99	15.47	1.73
17	58.85	15.63	4.97	43.22	6.21	49.43	1.00	16.98	16.49	1.43
18	57.21	15.04	5.28	42.17	5.99	48.15	0.97	17.96	17.47	1.56
19	62.33	16.52	5.61	45.81	6.59	52.40	1.06	19.02	18.49	1.43
20	61.16	16.02	5.93	45.14	6.40	51.54	1.04	20.06	19.54	1.58
21	58.77	15.31	6.24	43.46	6.11	49.57	1.00	21.06	20.56	1.67
22	58.25	15.16	6.55	43.09	6.05	49.14	0.99	22.05	21.55	1.64
23	57.79	14.85	6.85	42.94	5.92	48.86	0.99	23.04	22.54	1.88
24	57.12	14.45	7.14	42.67	5.76	48.43	0.98	24.01	23.53	1.11
25	54.74	13.38	7.41	41.36	5.33	46.69	0.94	24.96	24.49	1.58
26	59.79	13.80	7.69	45.99	5.49	51.48	1.04	26.00	25.48	1.33
27	58.00	13.09	7.95	44.90	5.21	50.11	1.01	27.01	26.50	1.60
28	55.03	12.80	8.21	42.23	5.09	47.32	0.96	27.97	27.49	1.25
29	56.22	14.20	8.50	42.02	5.64	47.66	0.96	28.93	28.45	1.16
30	59.63	16.10	8.82	43.53	6.40	49.93	1.01	29.94	29.43	1.19

Appendix B continued.

Samp Numb	Wet Wt. g	Dry Wt. g	Cum. Dry Wt g/cm <sup>2</sup>	Water Cont. cm <sup>3</sup>	Sed. vol. cm <sup>3</sup>	Total Vol. cm <sup>3</sup>	Comp. Thick cm	Comp. Depth cm	Sample Poros. %	Uncomp Mid-pt cm	Uncomp Mid-pt cm
31	61.85	17.36	9.17	44.49	6.89	51.38	1.04	30.97	86.59	1.83	49.05
32	61.07	17.31	9.52	43.77	6.87	50.64	1.02	32.00	86.43	1.84	50.89
33	56.44	16.32	9.85	40.12	6.48	46.60	0.94	32.94	86.09	1.80	52.69
34	60.52	17.89	10.22	42.63	7.11	49.74	1.00	33.94	85.71	1.92	54.61
35	62.26	18.15	10.58	44.11	7.21	51.32	1.04	34.98	85.95	1.92	56.53
36	61.10	16.79	10.92	44.32	6.67	50.99	1.03	36.01	85.46	1.78	58.31
37	61.71	16.87	11.26	44.84	6.70	51.54	1.04	37.05	86.92	1.78	59.20
38	59.48	16.66	11.60	42.82	6.62	49.43	1.00	38.05	86.61	1.79	60.98
39	62.31	17.29	11.95	45.03	6.87	51.90	1.05	39.10	86.57	1.77	61.88
40	59.71	16.62	12.28	43.08	6.60	49.69	1.00	40.10	86.71	1.78	63.70
41	61.71	17.03	12.63	44.68	6.76	51.44	1.04	41.14	86.62	1.80	67.28
42	61.45	16.48	12.96	44.96	6.54	51.50	1.04	42.18	81.66	1.74	66.38
43	58.62	15.65	13.28	42.97	6.20	49.17	0.99	43.17	87.31	1.74	69.02
44	63.34	17.61	13.63	45.73	6.97	52.71	1.06	44.24	86.77	1.68	68.15
45	62.11	16.26	13.96	45.85	6.43	52.29	1.06	45.29	87.69	1.70	70.70
46	60.31	15.28	14.27	45.02	6.04	51.07	1.03	46.32	88.17	1.61	70.70
47	65.27	17.59	14.62	47.69	6.95	54.63	1.10	47.43	87.28	1.80	72.53
48	59.98	16.05	14.95	43.93	6.34	50.26	1.02	48.44	87.93	1.70	79.34
49	64.26	16.71	15.28	47.55	6.59	54.14	1.09	49.54	87.82	1.72	80.20
50	60.05	15.78	15.60	44.27	6.22	50.49	1.02	50.55	87.41	1.67	81.06
51	59.31	15.89	15.92	43.41	6.25	49.67	1.00	51.56	87.34	1.66	86.18
52	62.93	16.97	16.27	45.96	6.67	52.63	1.06	52.62	86.93	1.76	85.30
53	61.39	17.31	16.62	44.08	6.79	50.87	1.03	53.65	86.65	1.81	87.99
54	60.70	17.53	16.97	43.18	6.86	50.04	1.01	54.66	86.29	1.84	88.91
55	59.26	16.93	17.31	42.33	6.62	48.94	0.99	55.65	86.48	1.80	90.73
56	60.43	16.81	17.65	43.62	6.56	50.17	1.01	56.66	86.15	1.76	93.39
57	60.65	16.96	17.99	43.69	6.61	50.30	1.02	57.68	86.17	1.77	95.16
58	56.93	15.93	18.32	41.00	6.20	47.20	0.95	58.63	86.87	1.71	96.02
59	59.89	16.26	18.65	43.63	6.31	49.94	1.01	59.64	87.36	1.70	98.57
60	60.60	17.40	19.00	43.20	6.74	49.95	1.01	60.65	86.50	1.81	100.38

Appendix B continued.

Samp Numb	Wet Wt. g	Dry Wt. g	Cum. g/cm <sup>2</sup>	Water Vol. cm <sup>3</sup>	Sed. cm <sup>3</sup>	Total Vol. cm <sup>3</sup>	Comp. Depth cm	Comp. Mid-pt Thickness cm	Sample Poros. %	Uncomp. Depth cm	Uncomp. Mid-pt Thickness cm	
61	61.44	18.16	19.36	43.28	7.03	50.31	1.02	61.66	86.02	1.89	102.27	
62	60.38	18.51	19.74	41.87	7.16	49.03	0.99	62.65	85.40	1.94	104.21	
63	68.55	21.59	20.17	46.96	8.35	55.30	1.12	63.77	84.91	2.13	106.34	
64	62.89	19.00	20.56	43.90	7.34	51.23	1.03	64.81	84.29	85.68	105.27	
65	60.52	17.75	20.92	42.77	6.85	49.62	1.00	65.81	85.31	1.95	108.29	
66	65.24	19.22	21.30	46.02	7.41	53.43	1.08	66.89	86.20	1.85	107.31	
67	62.25	18.74	21.68	43.51	7.22	50.73	1.02	67.91	86.34	1.93	110.14	
68	63.05	19.99	22.09	43.06	7.69	50.75	1.03	68.94	84.42	84.84	112.07	
69	61.77	19.37	22.48	42.40	7.45	49.85	1.01	69.94	85.06	2.05	116.05	
70	63.43	20.12	22.88	43.31	7.72	51.04	1.03	70.97	86.18	1.93	115.03	
71	64.01	20.40	23.30	43.61	7.83	51.44	1.04	72.01	85.77	2.05	118.05	
72	66.51	21.83	23.74	44.68	8.38	53.07	1.07	73.08	84.20	2.18	123.27	
73	65.47	21.61	24.17	43.86	8.30	52.16	1.05	74.14	84.09	2.18	124.36	
74	67.47	22.73	24.63	44.74	8.73	53.47	1.08	75.22	84.54	2.26	126.54	
75	69.12	21.61	25.07	47.51	8.30	55.81	1.13	76.34	83.67	2.26	128.80	
76	64.67	20.87	25.49	43.80	8.01	51.82	1.05	77.39	85.13	2.12	127.67	
									76.87	84.53	2.12	130.92
									77.39	84.53	2.12	133.04
									77.39	84.53	2.12	131.98

### Appendix C. Specific gravity determination.

The specific gravities ( $\text{g}\cdot\text{cm}^{-3}$ ) of Antelope Lake sediments were determined using an automated Accupyc pycnometer (Micromeritics, 1992).

<u>Sample</u>	<u>No. of Tests</u>	<u>Uncompacted Mid Depth</u>	<u>Specific Gravity</u>	<u>Mean</u>
Antelope Lake Station ALS1, Core 063				
1	5	0.47	2.438 ± 0.003	
5	5	6.02	2.490 ± 0.002	
10	5	14.43	2.487 ± 0.002	
15	5	22.46	2.526 ± 0.001	
20	5	30.90	2.503 ± 0.002	
30	5	46.36	2.518 ± 0.002	
40	5	64.59	2.517 ± 0.002	
50	5	81.89	2.537 ± 0.002	
60	5	99.48	2.580 ± 0.003	
70	5	119.08	2.604 ± 0.002	2.520 ± 0.045

Appendix D. Lead Sedimentation Rate Analysis, CIC1 Model.

$$\ln (A - A') = \ln (5.0089) - 3.935E-2 (Z) \quad R = -0.964$$

where  $(A - A')$  = unsupported  $^{210}\text{Pb}$  in  $\text{pCi} \cdot \text{g}^{-1}$ ,  
 and  $Z$  = uncompacted depth in cm.  
 based on data from lines 6 to 18

$$\text{Specific Gravity} = 2.52 \text{ g} \cdot \text{cm}^{-3} \quad P/\omega = 5.089 \quad \omega = 0.149$$

The initial porosity at the sediment/water interface is 92.52

Atmospheric flux rate at the time of collection 1994.113 is  
 $1.658 \text{ dpm} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$  or  $0.747 \text{ pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$

Supported  $^{226}\text{Ra}$  activity =  $0.937 \text{ pCi} \cdot \text{g}^{-1}$  or  $2.080 \text{ dpm} \cdot \text{g}^{-1}$

Sedimentation Rate =  $0.791 \text{ cm} \cdot \text{yr}^{-1}$

Mass Sedimentation Rate =  $0.149 \text{ g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$

SUMMARY OF  $^{210}\text{Pb}$  ANALYSES

Uncomp Depth cm	Porosity	Total $^{210}\text{Pb}$ $\text{dpm} \cdot \text{g}^{-1}$	Total $^{210}\text{Pb}$ $\text{pCi} \cdot \text{g}^{-1}$	Unsupp. $^{210}\text{Pb}$ $\text{dpm} \cdot \text{g}^{-1}$	Unsupp. $^{210}\text{Pb}$ $\text{pCi} \cdot \text{g}^{-1}$	Sed. Rate $\text{cm} \cdot \text{yr}^{-1}$	Years (*)
14.43	0.8866	8.300	3.739	6.219	2.801	0.7731	1994
15.99	0.8827	7.390	3.329	5.310	2.392	0.8072	1974
19.19	0.8778	6.293	2.834	4.212	1.897	0.8088	1970
22.46	0.8765	5.798	2.612	3.717	1.674	0.8036	1966
25.83	0.8743	6.106	2.751	4.026	1.813	0.7909	1961
30.90	0.8758	5.869	2.644	3.789	1.707	0.7789	1954
38.96	0.8858	5.691	2.563	3.610	1.626	0.8104	1946
46.36	0.8719	4.595	2.070	2.514	1.133	0.7867	1935
55.57	0.8595	3.221	1.451	1.140	0.514	0.7776	1923
64.59	0.8671	3.310	1.491	1.230	0.554	0.7926	1913
73.38	0.8769	2.382	1.073	0.302	0.136	0.7710	1899
81.89	0.8768	2.596	1.169	0.515	0.232	0.7864	1890
99.48	0.8650	2.299	1.036	0.219	0.099		
119.08	0.8487	2.081	0.937	0.000	0.000		

(\*) Year calculated using the sedimentation rate of the sample

## Appendix E. Lead Sedimentation Rate Analysis, CIC2 Model.

$$\ln (A - A') = \ln (4.9183) - 0.2078 (X) \quad R = -0.965$$

where  $(A - A')$  = unsupported  $^{210}\text{Pb}$  in  $\text{pCi} \cdot \text{g}^{-1}$ ,  
and  $X$  = cumulative dry weight in  $\text{g} \cdot \text{cm}^{-2}$   
based on data from lines 6 to 18

Specific Gravity =  $2.52 \text{ g} \cdot \text{cm}^{-3}$        $P/\omega = 4.918$        $\omega = 0.150$

The initial porosity at the sediment/water interface is 92.52

Atmospheric flux rate at the time of collection 1994.113 is 1.637  
 $\text{dpm} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$  or  $0.737 \text{ pCi} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$

Supported  $^{226}\text{Ra}$  activity =  $0.937 \text{ pCi} \cdot \text{g}^{-1}$  or  $2.080 \text{ dpm} \cdot \text{g}^{-1}$

Mass Sedimentation Rate =  $0.150 \text{ g} \cdot \text{cm}^{-2} \cdot \text{yr}^{-1}$

FIGURE C41.0

### SUMMARY OF $^{210}\text{Pb}$ ANALYSES

MidSam	Cum. DryWt. $\text{g} \cdot \text{cm}^{-2}$	Porosity	Total $^{210}\text{Pb}$ $\text{dpm} \cdot \text{g}^{-1}$	Total $^{210}\text{Pb}$ $\text{pCi} \cdot \text{g}^{-1}$	Unsupp. $^{210}\text{Pb}$ $\text{dpm} \cdot \text{g}^{-1}$	Unsupp. $^{210}\text{Pb}$ $\text{pCi} \cdot \text{g}^{-1}$	Years (*)
2.67	0.8866	8.300	3.739	6.219	2.801		1994
2.96	0.8827	7.390	3.329	5.310	2.392		1974
3.56	0.8778	6.293	2.834	4.212	1.897		1970
4.18	0.8765	5.798	2.612	3.717	1.674		1966
4.81	0.8743	6.106	2.751	4.026	1.813		1962
5.77	0.8758	5.869	2.644	3.789	1.707		1956
7.27	0.8858	5.691	2.563	3.610	1.626		1946
8.66	0.8719	4.595	2.070	2.514	1.133		1936
10.40	0.8595	3.221	1.451	1.140	0.514		1925
12.11	0.8671	3.310	1.491	1.230	0.554		1913
13.80	0.8769	2.382	1.073	0.302	0.136		1902
15.44	0.8768	2.596	1.169	0.515	0.232		1891
18.83	0.8650	2.299	1.036	0.219	0.099		
22.68	0.8487	2.081	0.937	0.000	0.000		

(\*) Year calculated using the mass sedimentation rate of the sample.

**Appendix F. Lead Sedimentation Rate Analysis, CRS Model.**

Depth Uncomp Mid-pt cm	Middson Cum. Dry Wt g/cm <sup>2</sup>	Cum. Dry Wt g/cm <sup>2</sup>	Unsupp. Activity pci/g	Area pci/cm <sup>2</sup>	Cum. Area pci/cm <sup>2</sup>	Time B.P.* Years	Mass SedRate g/cm <sup>2</sup> /yr	Date
0.47	0.17	0.09	2.141	0.182	0.288	0.295	1993	0.295
1.56	0.40	0.28	2.141	0.423	0.605	0.968	1993	0.294
6.02	1.26	1.10	2.091	1.785	2.390	4.005	1990	0.268
9.49	1.90	1.75	2.289	1.445	3.835	6.692	1987	0.240
12.83	2.52	2.37	2.191	1.441	5.276	9.618	1984	0.214
14.43	2.82	2.67	2.421	0.783	6.060	11.327	1982	0.175
15.99	3.10	2.96	2.801	0.753	6.813	13.061	0.227	1981
19.19	3.70	3.56	2.392	1.276	8.089	16.231	0.219	1977
22.46	4.33	4.18	1.897	1.116	9.205	19.286	0.217	1974
25.83	4.97	4.81	1.674	1.107	10.312	22.634	0.213	1971
30.90	5.93	5.77	1.813	1.681	11.993	28.495	0.202	1965
38.96	7.41	7.27	1.707	2.508	14.501	39.890	0.182	1954
46.36	8.82	8.66	1.626	1.911	16.412	52.484	0.165	1941
55.57	10.58	10.40	1.133	1.432	17.844	66.815	0.156	1927
64.59	12.28	12.11	0.514	0.916	18.760	81.123	0.149	1912
73.38	13.96	13.80	0.554	0.580	19.339	95.216	0.145	1898
81.89	15.60	15.44	0.136	0.303	19.642	106.108	0.146	1888
							0.213	Average 0.185
							0.049	Std.Dev. 0.058
							0.151	

\*B.P. = 1994

Based on data from lines 1 to 18  
Total Area equals 20.39123

Atmospheric flux rate at the time of collection 1994.113 is 0.63 pc<sup>i</sup>·cm<sup>-2</sup>·yr<sup>-1</sup>

Appendix G. Mean date calculated for each core slice, CIC Models.

Sample	Uncompacted	Cum.	Cum.	CIC1	CIC2	CRS*
	Mid Depth in cm	Dry Wt. g·cm <sup>-2</sup>	Dry Wt. Mid Sam	Year	Year	Year
1	0.47	0.17	0.09	1994 ± 1	1994 ± 1	1993
2	1.56	0.40	0.28	1992 ± 2	1992 ± 2	1992
3	2.88	0.66	0.53	1990 ± 2	1991 ± 2	1992
4	4.36	0.94	0.80	1989 ± 2	1989 ± 2	1991
5	6.02	1.26	1.10	1987 ± 2	1987 ± 2	1990
6	7.77	1.59	1.42	1984 ± 2	1985 ± 2	1989
7	9.49	1.90	1.75	1982 ± 2	1982 ± 2	1987
8	11.17	2.22	2.06	1980 ± 2	1980 ± 2	1986
9	12.83	2.52	2.37	1978 ± 2	1978 ± 2	1984
10	14.43	2.82	2.67	1976 ± 2	1976 ± 2	1983
11	15.99	3.10	2.96	1974 ± 2	1974 ± 2	1981
12	17.58	3.41	3.26	1972 ± 2	1972 ± 2	1980
13	19.19	3.70	3.56	1970 ± 2	1970 ± 2	1978
14	20.81	4.03	3.87	1968 ± 2	1968 ± 2	1976
15	22.46	4.33	4.18	1966 ± 2	1966 ± 2	1974
16	24.13	4.66	4.49	1964 ± 2	1964 ± 2	1972
17	25.83	4.97	4.81	1961 ± 2	1962 ± 2	1970
18	27.49	5.28	5.13	1959 ± 2	1960 ± 2	1968
19	29.18	5.61	5.45	1957 ± 2	1958 ± 2	1966
20	30.90	5.93	5.77	1955 ± 2	1956 ± 2	1964
21	32.58	6.24	6.09	1953 ± 2	1954 ± 2	1961
22	34.22	6.55	6.39	1951 ± 2	1951 ± 2	1959
23	35.85	6.85	6.70	1949 ± 2	1949 ± 2	1957
24	37.44	7.14	6.99	1947 ± 2	1947 ± 2	1955
25	38.96	7.41	7.27	1945 ± 2	1946 ± 2	1952
26	40.43	7.69	7.55	1943 ± 2	1944 ± 2	1950
27	41.86	7.95	7.82	1941 ± 2	1942 ± 2	1948
28	43.25	8.21	8.08	1939 ± 2	1940 ± 2	1946
29	44.72	8.50	8.35	1938 ± 2	1938 ± 2	1944
30	46.36	8.82	8.66	1936 ± 2	1936 ± 2	1941
31	48.13	9.17	8.99	1933 ± 2	1934 ± 2	1939
32	49.97	9.52	9.35	1931 ± 2	1932 ± 2	1936
33	51.79	9.85	9.69	1929 ± 2	1930 ± 2	1933
34	53.65	10.22	10.03	1926 ± 2	1927 ± 2	1930
35	55.57	10.58	10.40	1924 ± 3	1925 ± 2	1927
36	57.42	10.92	10.75	1922 ± 2	1922 ± 2	1924
37	59.20	11.26	11.09	1919 ± 2	1920 ± 2	1921
38	60.98	11.60	11.43	1917 ± 2	1918 ± 2	1918
39	62.79	11.95	11.77	1915 ± 2	1916 ± 2	1915
40	64.59	12.28	12.11	1912 ± 2	1913 ± 2	1913
41	66.38	12.63	12.45	1910 ± 2	1911 ± 2	1910
42	68.15	12.96	12.80	1908 ± 2	1909 ± 2	1907
43	69.86	13.28	13.12	1906 ± 2	1907 ± 2	1904
44	71.61	13.63	13.45	1904 ± 2	1904 ± 2	1902
45	73.38	13.96	13.80	1901 ± 2	1902 ± 2	1899
46	75.03	14.27	14.11	1899 ± 2	1900 ± 2	1897

47	76.74	14.62	14.44	1897 ± 2	1898 ± 2	1894
48	78.49	14.95	14.78	1895 ± 2	1895 ± 2	1892
49	80.20	15.28	15.11	1893 ± 2	1893 ± 2	1889
50	81.89	15.60	15.44	1891 ± 2	1891 ± 2	1887
51	83.57	15.92	15.76	1888 ± 2	1889 ± 2	1885
52	85.30	16.27	16.10	1886 ± 2	1887 ± 2	1883
53	87.09	16.62	16.44		1884 ± 2	1880

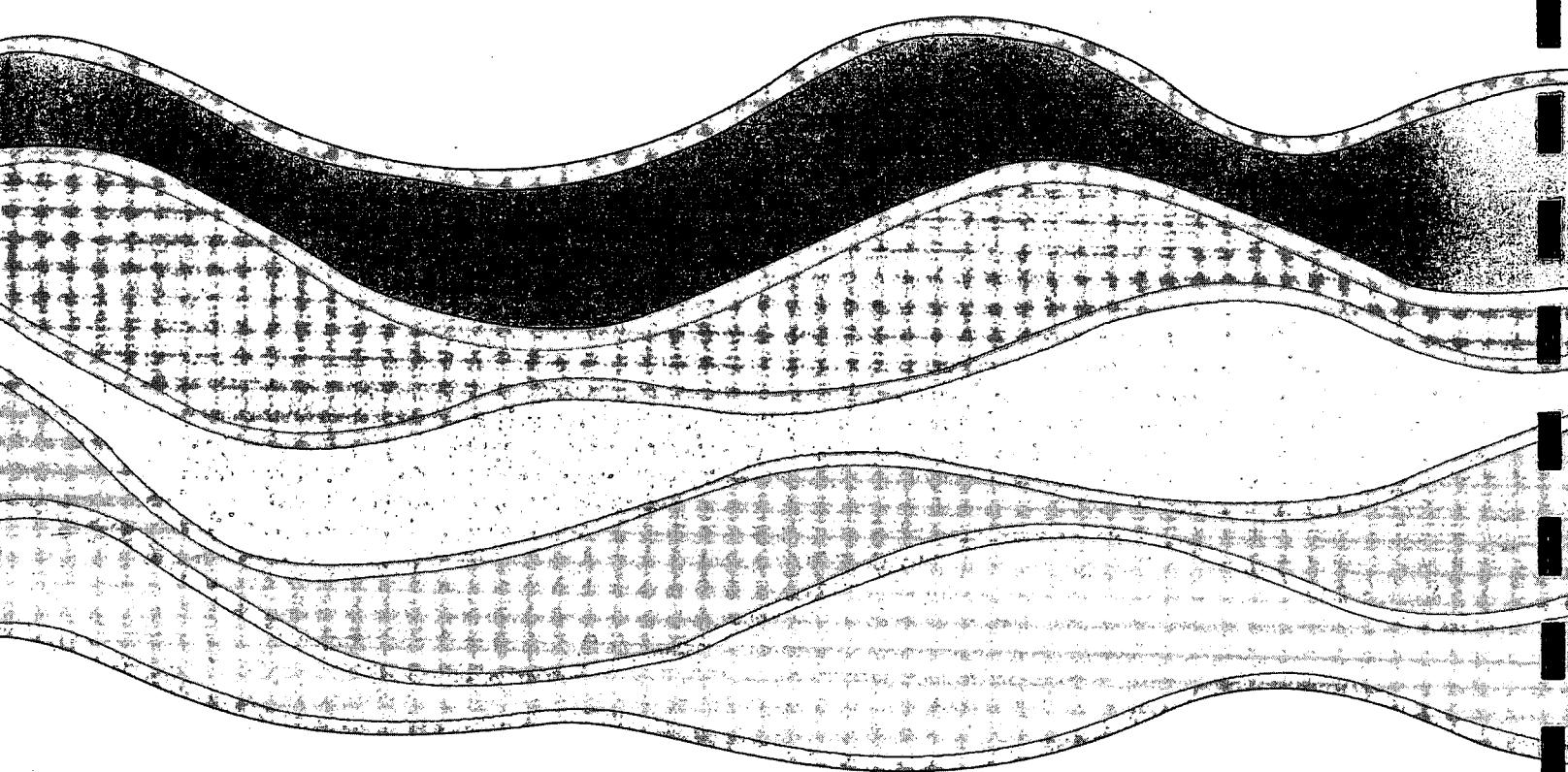
\* Calculation based on a Multiple Linear Regression with an R<sup>2</sup> of 0.9993 and a Standard Error of 0.8963.



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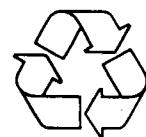
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