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The Resuspension of Material Dispersed by Atmospheric Diffusion from a Point Source

December 1975

Prepared for the U.S. Energy Research and Development Administration under Contract E(45-1):1830

Battelle
Pacific Northwest Laboratories

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THE RESUSPENSION OF MATERIAL DISPERSED BY ATMOSPHERIC DIFFUSION FROM A POINT SOURCE

Thomas W. Horst

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December 1975

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ABSTRACT

A mathematical analysis was made of the resuspension of material initially deposited on the ground consequent to atmospheric diffusion from a surface point source. It is concluded that the air concentration of the initial plume without depletion due to deposition is in general greater than the sum of the air concentrations of the depleted initial plume and the resuspended plume. The major qualification to this result is that redeposition from the resuspended plume and subsequent additional resuspension was neglected in the calculations.

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Errata

The Resuspension of Material Dispersed by Atmospheric Diffusion from a Point Source

Page 10 In equations (11) and (12) v_dC, v_dC_d and $v_d'C_r$ should read: $\overline{v_dC}$, $\overline{v_dC_d}$ and $\overline{v_c'C_r}$.

Page 18 The last line should read: "$v_d/u = 10^{-3}$ ..."

Page 20 The dimensions of the ordinate should read: (sec/m^3).

Page 22 The right-hand label on the abscissa should read: 10^4.

Page 23 The dimensions of the ordinate should read: (sec/m^3).

Page 38 The line preceding equation (C-3) should read: "...times equation (9) ..."

THE RESUSPENSION OF MATERIAL DISPERSED BY ATMOSPHERIC DIFFUSION FROM A POINT SOURCE

Thomas W. Horst

INTRODUCTION

In the Systems Safety Task of the Waste Fixation Program, risk assessment is being used to identify dominant sequences for the accidental release of radionuclides during the management of commercial high level waste. This assessment, sponsored by the Division of Nuclear Fuel Cycle and Production, U. S. Energy Research and Development Administration, is based on a conceptual system that includes liquid storage, solidification, basin storage, rail transport, and retrievable surface storage facilities.

The handling of nuclear waste may involve both chronic and accidental releases of these materials into the environment, and it has been tentatively established (Winegardner (1975)) that release to the atmosphere is associated with the dominant failure sequences. Thus atmospheric transport is a primary pathway for exposure of man to these materials, and estimates of atmospheric transport and diffusion are an important ingredient of quantitative evaluations of the long term radiological consequences of waste management.

These estimates need to primarily consider two distinct routes between source and receptor. One is the direct atmospheric route, which can be quantitatively evaluated by accounting for atmospheric dilution of the material and depletion processes, such as deposition on the underlying terrain, which directly remove material from the airborne plume. A second route is a consequence of the deposition of material from the initial plume. This deposited material forms a secondary source of material which may subsequently be resuspended by the wind and contribute to the air concentration at downwind receptors. Proper evaluation of the atmospheric concentration of contaminant must account for both of these routes.

Much research has been applied to understanding the dilution or diffusion of material released into the atmosphere, and the results have been distilled into routine methodologies for estimating the airborne concentrations of materials directly transported from source to receptor. A great deal less has been done to understand the process of resuspension and to apply existing knowledge of atmospheric diffusion to the determination of the airborne contamination downwind of this secondary source of pollutant. Consequently, quantitative evaluation of the hazards associated with resuspension presently must be made with much less confidence than for direct transport. It is the intent of this study to provide a basis for simplifying the procedures for accounting for the additional air concentration caused by resuspension and to investigate the relative magnitude of the resuspended material compared with that of the initial plume. The techniques developed are sufficiently general for application to chronic as well as other accidental releases to the atmosphere.

SUMMARY AND CONCLUSIONS

One year of hourly data from the Hanford Meteorological Tower has been selected to represent a typical climatological distribution of the meteorological variables which control atmospheric diffusion, deposition and resuspension. This data has been used in the surface flux model of Horst (1974a) to predict the probable value of both the initial air concentration C_d, accounting for the depletion due to deposition, and the consequent air concentration of resuspended material C_r whose source is the material deposited on the ground by the initial plume. The computations of C_d and the resulting deposition flux and surface contamination were made for two values of the ratio of deposition velocity to wind speed, $v_d/u = 10^{-2}$ and 10^{-3}, corresponding for the Hanford data to particles with a specific gravity of 3 and diameters of 10 μm and 1 μm respectively. The resuspended air concentration was calculated using as its source only the material deposited from the initial plume. Redeposition from the resuspended plume and the consequent formation of a secondary resuspension source was neglected. The deposition from the resuspended plume decreases C_r and the secondary resuspension increases C_r, and thus it is likely that the net effect of redeposition is small. Also neglected was the effect of weathering or fixation of a portion of the surface contamination, making it unavailable for resuspension. Since this process is assumed to result in an irreversible loss of material from the atmosphere, its neglect is conservative in the sense that the atmospheric concentration of resuspended material is maximized.

Due to the ground acting as both a source and a sink for atmospheric contamination, the air and surface concentrations are strongly dependent upon one another. If it were not for the small value of the resuspension rate Λ, this would require an hour-by-hour computation of the air and ground concentrations using the sequential history of the appropriate meteorological variables. However the surface contamination changes with a time constant of years, while the diffusion, deposition and resuspension processes respond to the hour-by-hour changes of the weather. It is shown that this makes it possible to compute the climatologically-averaged values of the air and ground concentrations using only the joint probability distributions of the relevant meteorological variables. This conclusion greatly simplifies the computational effort required for the evaluation of resuspension.

The most important result of this study, however, follows from a comparison of C_d and C_r with the initial air concentration undepleted by deposition, C_o. The computations show that

$$C_o \geq C_d + C_r$$

or that

$$E_o \geq E_d + E_r \quad ,$$

where E is the exposure or time integral of the corresponding air concentration. In words, the air concentration (and exposure) due to both the depleted initial plume and the resuspended plume is less than or equal to that due to the initial plume without allowing for depletion by deposition. A conservative estimate of the air concentration or exposure may therefore be made in the simplest manner possible, by neglecting both deposition and resuspension.

The only qualification to this result is the neglect of redeposition. It is likely, however, that the net effect of redeposition is small and in a sense to reduce C_r. Moreover, this result also includes the conservative neglect of losses due to weathering. In addition, C_r in the preceding equation is the maximum, steady-state value even though this value may be attained only after a release for a continuous period of many years. Correspondingly, the exposure to the resuspended air concentration has been calculated over the entire period required to resuspend all of the deposited contamination. Since a single receptor may not be exposed for this extended period, this assumption is also conservative.

DISCUSSION

The Surface Flux Model

As indicated in the Introduction, the atmospheric dilution of material released from a point source can be calculated by well-established methods. The most common of these is the Gaussian plume model,

$$C_o = \frac{\dot{Q}}{u} D = \frac{\dot{Q}}{\pi u \sigma_y \sigma_z} e^{-y^2/2\sigma_y^2} e^{-z^2/2\sigma_z^2} \tag{1}$$

which describes the air concentration C_o (quantity of contaminant per m^3) of non-depositing material released at a rate $\dot{Q}$ (quantity per sec) from a surface point source. C_o is evaluated at a height z and at horizontal distances x downwind and y crosswind of the source. Additionally, u is the mean wind speed (blowing toward positive x) and σ_y and σ_z are standard deviations of the plume cross-section. This equation is also used to define the diffusion function D which describes the dilution of the airborne material due to crosswind spread of the plume.

The diffusion parameters σ_z and σ_y may be calculated with the interpolation formulas of Briggs (1973) which are based on several series of atmospheric diffusion experiments and are shown in Table 1. These are a function of downwind distance x (in meters) and the turbulent state of the atmosphere or atmospheric stability. The stability in turn is a function of wind speed and the input of heat from the ground to the air. This may be determined by a simple scheme due to Briggs, also listed in Table 1.

The deposition flux (quantity per m^2 per sec) is calculated by multiplying the air concentration at the reference height z_d by a deposition velocity v_d,

$$F_d = - v_d C(x,y,z_d) \quad . \tag{2}$$

Table 1.

Formulas for the Determination of σ_z and σ_y (x, σ_z, σ_y in meters)

Stability Class	σ_z	σ_y
A	$.20x$	$.22x(1 + 10^{-4}\ x)^{-1/2}$
B	$.12x$	$.16x(1 + 10^{-4}\ x)^{-1/2}$
C	$.08x(1 + 2*10^{-4}\ x)^{-1/2}$	$.11x(1 + 10^{-4}\ x)^{-1/2}$
D	$.06x(1 + 1.5*10^{-3}\ x)^{-1/2}$	$.08x(1 + 10^{-4}\ x)^{-1/2}$
E	$.03x(1 + 3*10^{-4}\ x)^{-1}$	$.06x(1 + 10^{-4}\ x)^{-1/2}$
F	$.02x(1 + 3*10^{-4}\ x)^{-1}$	$.04x(1 + 10^{-4}\ x)^{-1/2}$

Stability Class

Wind Speed, mph:	0-3	4-7	8-12	13 & greater
Day	A	B	C	D
Night	F	E	D	D

For this study deposition velocities were determined for particles of specific gravity 3 and diameters of 1μm and 10μm by applying the correlations of Sehmel and Hodgson (1974). It was found that a good approximation for the surface roughness at Hanford was

$$v_d = Au_{50} \tag{3}$$

where $A = 10^{-3}$ for the 1 μm particles and 10^{-2} for the 10 μm particles and u_{50} is the mean wind speed at a height of 50 ft.

The resuspension flux is calculated by multiplying the surface contamination G (quantity per m^2) by a resuspension rate Λ (fraction per sec),

$$F_r = \Lambda\ G \quad . \tag{4}$$

The surface contamination, in turn, depends on the competing processes of deposition and resuspension and perhaps also on a fixation or weathering process which makes surface contamination unavailable for resuspension,

$$\frac{\partial G}{\partial t} = v_d C - \Lambda G - \alpha G \tag{5}$$

where α is a rate of fixation. A very limited number of measurements (Sehmel and Lloyd (1975)) indicate that the resuspension rate is typically on the order of 10^{-10} to 10^{-8} sec^{-1}, corresponding to half lives of the surface contamination on the order of years. The weathering process will be henceforth neglected in this analysis, both due to great uncertainty about the value of α and in order to maximize the predicted air concentration due to resuspension.

Deposition and resuspension are combined with the Gaussian plume model in the surface flux model of Horst (1974a),

$$C(x,y,z) = \frac{\dot{Q}}{u} D(x,y,z) + \int_o^x \int_{-\infty}^{\infty} F(\xi,\eta) \frac{D}{u}(x-\xi,y-\eta,z)\, d\eta\, d\xi \quad . \tag{6}$$

Here F is the net flux from the ground to the air and for the general case would be equal to the sum of (2) and (4),

$$C = \frac{\dot{Q}D}{u} + \int_o^x \int_{-\infty}^{\infty} \left[\Lambda G(\xi,\eta) - v_d C(\xi,\eta,z_d) \right] \frac{D}{u}(x-\xi,y-\eta,z)\, d\eta\, d\xi \quad . \tag{7}$$

For the purpose of this study, the air concentration will be divided into two components,

$$C = C_d + C_r \tag{8}$$

The initial air concentration C_d is that due to direct transport from the release point, accounting for losses due to deposition, and is calculated by setting Λ equal to zero in (7). The air concentration of resuspended material C_r is similarly calculated from (7) by setting $\dot{Q}$ equal to zero.

The Initial Plume

Since the equations presented thus far apply only for a given micrometeorological situation, and we are interested here chiefly in long-term air concentrations, they must be averaged over the appropriate distribution of wind speed, wind direction and atmospheric stability. Wind direction is commonly recorded to the nearest of the 16 points of the compass, e.g., N, NNE, NE and hence (1) must be averaged over each of the 16 sectors. If it is assumed that the wind has an equal probability of blowing in any of the directions enclosed by a single sector, an approximate average is

$$D(x,\theta,z) = \frac{16}{\pi x \sqrt{2\pi}\, \sigma_z} e^{-z^2/2\sigma_z^2} \tag{9}$$

within the sector designated by θ and zero outside of it. This assumes that the portions of the plume which actually overlap into adjacent sectors are balanced by an equal overlap from those adjacent sectors.

The initial air concentrations were calculated for a receptor at a height of 1 m, the deposition reference height z_d. Substituting (9) into (7) with $\Lambda = 0$ and with $z = z_d$,

$$C_d(x,\theta,z_d) = \frac{2}{\sqrt{2\pi}\, u} \left\{ \frac{8\dot{Q}}{\pi x \sigma_z} e^{-z_d^2/2\sigma_z^2} - \int_0^x v_d C_d(\xi,\theta,z_d) \frac{e^{-z_d^2/2\sigma_z^2}}{\sigma_z} d\xi \right\} . \tag{10}$$

Calculations of C_d and the deposition flux $v_d C_d$ were made with this equation for all possible combinations of wind speed, wind direction and atmospheric stability. Each was then multiplied by its probability of occurrence and they were summed to give the climatologically-averaged values $\bar{C}_d$ and $\overline{v_d C_d}$. Results were obtained for no deposition ($\bar{C}_o$), $v_d/u = 10^{-2}$ and $v_d/u = 10^{-3}$ at downwind distances from 15 m to 100 km and for all 16 wind directions. Although the Gaussian model is a poor representation of the plume at downwind distances as great as 100 km, it is used here to match current practice in environmental evaluations.

Since the intent of this study is generic rather than particular, one year (1970) of Hanford Meteorological Tower data was selected as representing a typical distribution of the micrometeorological variables. It is also for this reason that the Gaussian plume model and the coarse stability classification of the latter part of Table 1 are entirely adequate. Due to the lag in response of the ground to changes in insolation, day was considered to start one hour after sunrise and night to start one hour after sunset. The wind speed and direction data from the 50 ft level of the tower were selected as most appropriate for the long transport distances considered here. This diffusion climatology is summarized in Appendix A.

The calculated initial air concentrations and deposition fluxes, normalized by $\dot{Q}$, are listed in Appendix B as a function of azimuthal direction and of radial distance from the release point. The distributions calculated as above with the surface flux or surface depletion model are used exclusively in the work reported in the main body of this report. Also included in Appendix B are the results of similar calculations using the less accurate source depletion model. This model is described in Appendix C and its predictions are compared with those of the surface depletion model.

The Resuspended Plume

A particular investigation of the resuspension problem would require the simultaneous solution of (5) and (7) for each hour of meteorology over the period of interest, probably years considering the small value of the resuspension rate. This is not practical since (7) in most cases requires a numerical computation of the integral, a procedure which is especially tedious due to the appearance in the integrand of the upper limit of the integral. However, the large difference between the time scale of variation of the relevant meteorological processes (hours and days) and the time scale for decay of the surface contamination (years) permits an alternate method of analysis for the climatologically-averaged problem.

Due to the small value of the resuspension rate, the current value of the surface contamination is the cumulative result of the preceding months and years of meteorology, the only exception possibly occurring immediately after a windstorm which significantly depletes G in a short period. Thus the current value of G will be uncorrelated with the current meteorology, and the climatologically-averaged value $\bar{G}$ may be used in (7) for evaluating the climatologically-averaged value of the resuspended air concentration. If now we further assume that the time scale for the decay of G is greater than the time required to obtain stationary averages of $v_d C$ and Λ, $\bar{G}$ is found by climatologically-averaging the solution of (5)

$$\bar{G}(t) = \overline{v_d C}(1 - e^{-\bar{\Lambda} t})/\bar{\Lambda} \quad . \tag{11}$$

Thus, rather than using the sequential time history of meteorology to solve (5) and (7), the joint probability distribution of wind speed, wind direction and stability may be used to find the climatologically-averaged resuspension rate $\bar{\Lambda}$, the surface contamination $\bar{G}$ due to the deposition flux $\overline{v_d C}$, and finally the resuspended air concentration $\bar{C}_r$.

$\bar{G}$ may be divided into two components by substituting (8) into (11),

$$\bar{G} = \bar{G}_d + \bar{G}_r = (v_d C_d + v_d' C_r) \ (1 - e^{-\bar{\Lambda} t})/\bar{\Lambda} \quad . \tag{12}$$

Here we have allowed for the possibility of a different deposition velocity v_d' for the resuspended material. Substitution of (12) into (7) with $\dot{Q} = 0$ would then give an equation for C_r or $v_d' C_r$, but solution of the integral would require prior knowledge of $\overline{v_d' C_r}$ and at this point we know only $\overline{v_d C_d}$. Thus an estimate of C_r will first be calculated by neglecting deposition from the resuspended plume or redeposition. Setting $v_d' = 0$,

$$C_r'(x,y,z_d) = \frac{(1 - e^{-\bar{\Lambda} t})}{\bar{\Lambda}} \int_0^x \int_{-\infty}^{\infty} \Lambda \ \overline{v_d C_d}(\xi,\eta) \ \frac{D}{u}(x-\xi,y-\eta,z_d) \ d\xi \ d\eta . \tag{13}$$

This equation may then be evaluated for each set of micrometeorological conditions and subsequently the climatologically-averaged value $\bar{C}_r'$ may be calculated.

Neglecting redeposition maximizes the resuspended air concentration whose source $\bar{G}_d$ is material deposited from the direct plume. However, the redeposition flux generates a secondary surface contamination $\bar{G}_r$ which will increase the resuspended air concentration as it in turn is resuspended. The resulting net error in C_r, whose source is both $\bar{G}_d$ and $\bar{G}_r$, due to neglecting redeposition is discussed in Appendix E.

The climatologically-averaged values of C_d, v_dC_d, G_d, Λ and C_r' have been presented thus far as the time-averaged mean values for a long term continuous or chronic release of material. For the case of a short term accidental release, $\bar{C}_d$ and $\overline{v_dC_d}$ may be considered to be the mean or probable values in a statistical sense. Substituting the quantity of material released Q for the rate of release $\dot{Q}$, $\overline{v_dC_d}$ is the probable deposition per unit area and the solution of (5) is

$$\bar{G}_d = \overline{v_dC_d}\ e^{-\bar{\Lambda}t} \quad . \tag{14}$$

$\bar{C}_r'$ is calculated as before and is the climatologically-averaged value of the resuspended air concentration due to the statistically averaged consequences of an accidental release.

Since (13) is most easily calculated in a cartesian coordinate system, the polar distribution of the deposition flux $\overline{v_dC_d}$ was first mapped onto a cartesian system with x increasing in the downwind direction. The expense of numerically calculating (13) limits the number of grid points used, and a 40 x 40 grid was selected as a reasonable compromise between resolution and expense. Calculations were made for several values of the grid interval to cover the horizontal range of interest, 15 m to 100 km. The calculated values were then mapped back into a 16 direction polar coordinate system to facilitate computation of the climatological average and to match the resolution of $\bar{C}_r'$ with that of $\bar{C}_d$ and of the original climatological data upon which it is based. Appendix D lists the values of $\bar{C}_r'$

calculated for a constant resuspension rate. The factor $(1 - e^{-\bar{\Lambda}t})$ was set equal to its maximum value of unity $(t \to \infty)$, corresponding to a steady-state value of C_r' and making the results independent of Λ.

One problem arises from the need to increase the grid interval to calculate C_r' for large downwind distances. The surface contamination distribution is sharply peaked near the center of the polar coordinate system, the source point for the original release of the material. As the grid interval is increased this peak is not adequately resolved. A correction has therefore been made at the cartesian grid points closest to the source point. The value of $\overline{v_d C_d}$ at these points has been increased to compensate for the amount of surface contamination in the vicinity of the source which has not been accounted for in the coordinate transformation. However, even though this produces a surface contamination distribution which has the proper amount of material, the peak of the cartesian distribution is unavoidably broader and lower than the actual peak. It will be seen later that the errors generated by this problem do not seriously affect the results of this study.

Comparison of the Climatologically-Averaged Initial and Resuspended Plumes

Figures 1 and 2 show the calculated air concentrations, normalized by the release rate $\dot{Q}$, for the 1 μm ($v_d/u = 10^{-3}$) and 10 μm ($v_d/u = 10^{-2}$) particles respectively. Recall that these deposition velocities are also dependent on the specific gravity of the particle (3) and the roughness of the deposition surface (Hanford z_o = 3 cm). These air concentrations have been polar-averaged over all wind directions and are plotted as a function of distance from the original source. Four different curves are found in each figure: the undepleted air concentration $\bar{C}_o$, the depleted air concentration $\bar{C}_d$, their difference $\bar{C}_o - \bar{C}_d$, and the resuspended air concentration $\bar{C}_r'$.

As mentioned previously, $\bar{C}_r'$ has been calculated in several overlapping ranges of downwind distance, grid intervals of 25 m, 200 m, 1 km and 5 km for $v_d/u = 10^{-3}$ and 25 m, 100 m, 500 m and 5 km for $v_d/u = 10^{-2}$, and this is evident in the results. For each grid interval value $\bar{C}_r'$ appears to

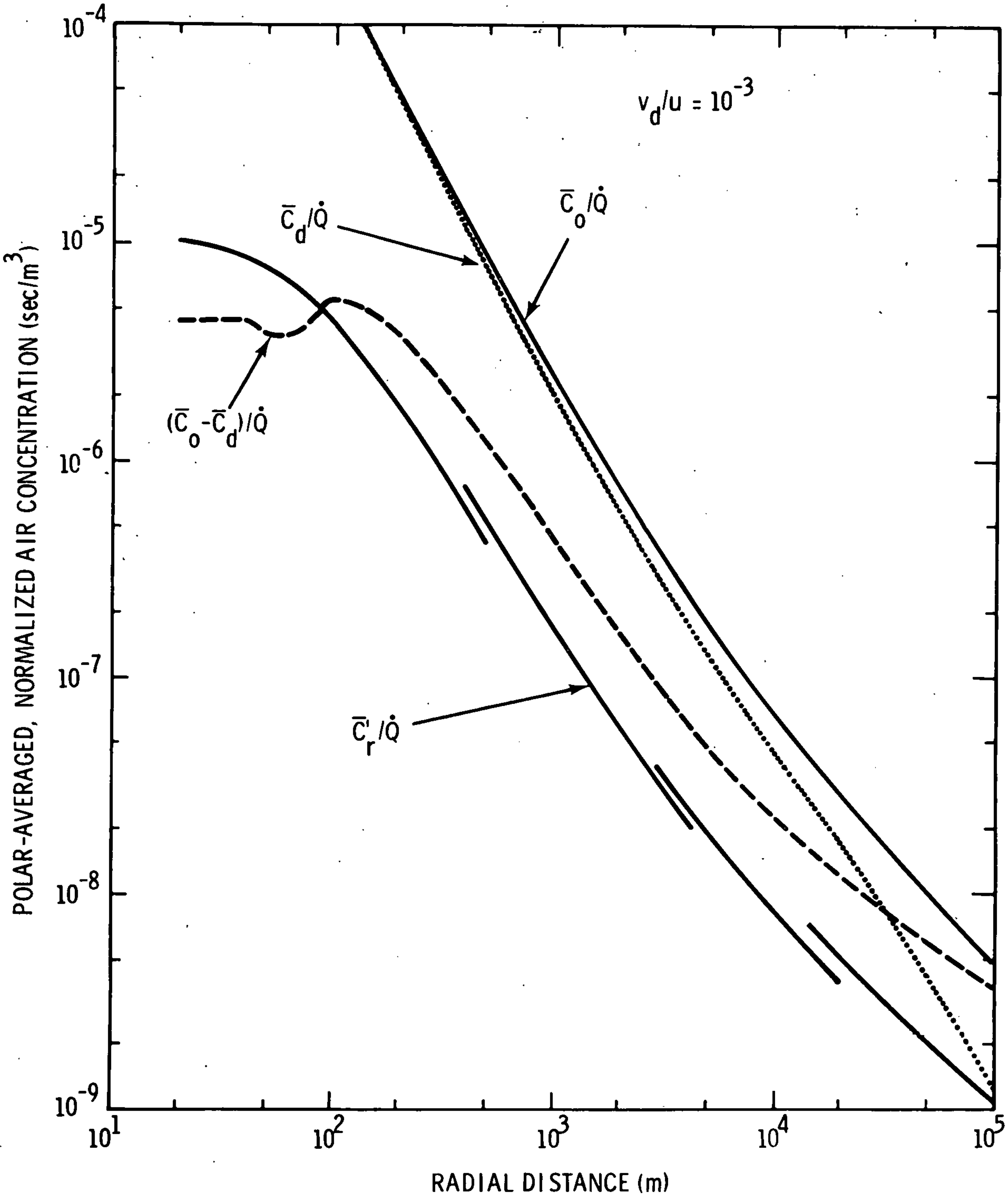

Figure 1. Polar-Averaged, Normalized Air Concentrations vs. Radial Distance for $v_d/u = 10^{-3}$.

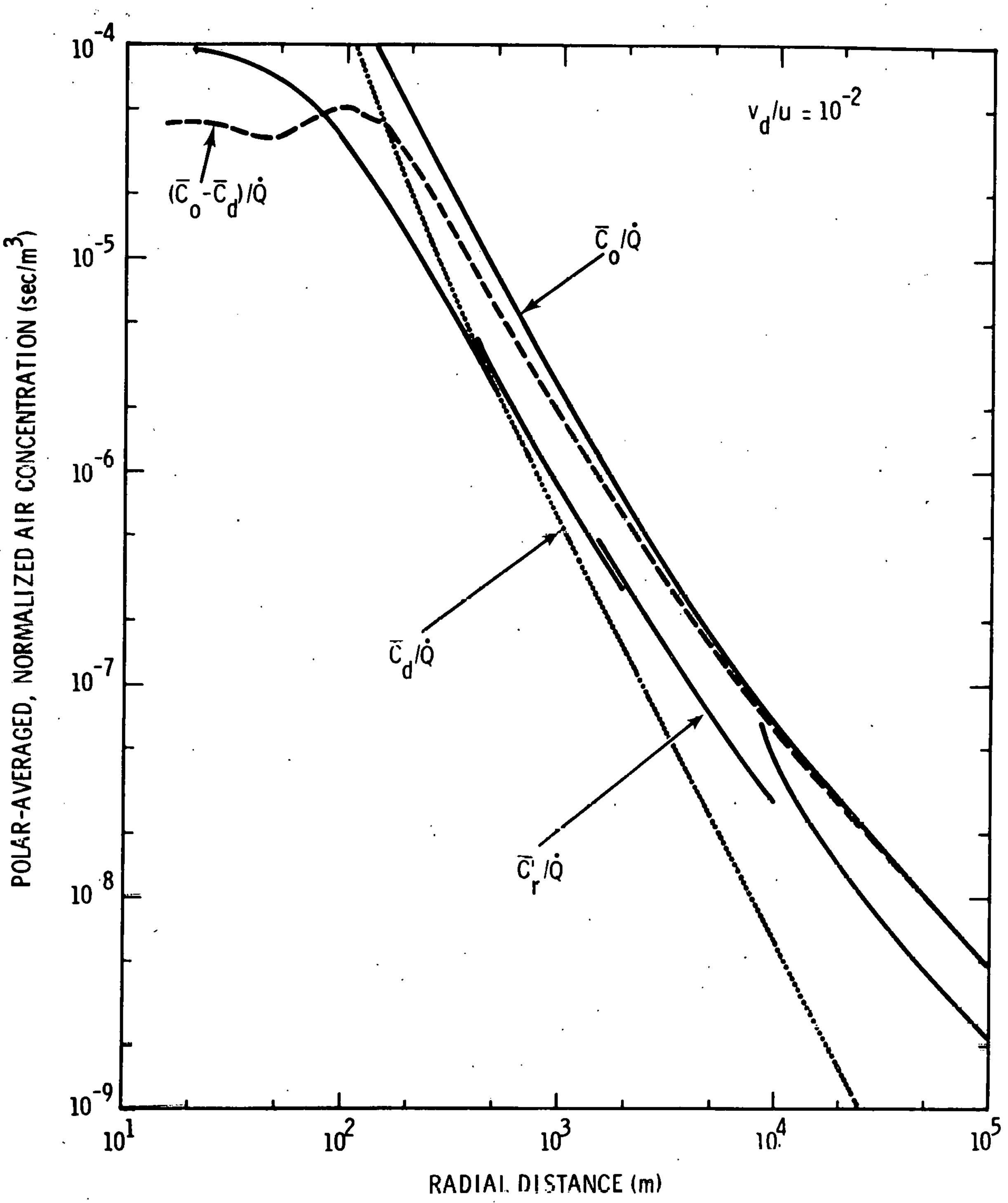

Figure 2. Polar-Averaged, Normalized Air Concentrations vs. Radial Distance for $v_d/u = 10^{-2}$.

be overestimated at those points closest to the original source point. This is apparently due to the previously-mentioned manner in which the surface contamination in the vicinity of the source has been accounted for. Some has been located at an artificially large distance from the source, and hence $\bar{C}'_r$ at larger distances has been overestimated because the material resuspended from those central points has less travel distance in which to diffuse in the atmosphere. Since this effect will become less important for each grid interval as the travel distance from the source is increased, the $\bar{C}'_r$ at the largest distances should have the least error and the best estimate of $\bar{C}'_r$ from these calculations should be a curve connecting the $\bar{C}'_r$ at x = 20 grid intervals.

The risk associated with these air concentrations is most commonly related to the exposure to the airborne contamination. This is either the average air concentration multiplied by the time during which an individual is exposed to the contamination or the time integrated air concentration

$$E \equiv \int_0^T C\, dt \quad . \tag{15}$$

If the quantity of material released Q is substituted for the rate of release $\dot{Q}$, the normalized curves for $\bar{C}_o$ and $\bar{C}_d$ may be interpreted as the respective exposures per unit of material released. The exposure to the resuspended material is found by replacing (11) in equation (13) by (14) and integrating over the time of exposure since deposition, giving

$$\bar{E}'_r/Q = \bar{C}'_r/\dot{Q} \quad . \tag{16}$$

The maximum exposure to the resuspended material is received by increasing the exposure time until all of the material is resuspended, and this corresponds to $(1 - e^{-\bar{\Lambda} t}) = 1$. Thus the normalized curve for $\bar{C}'_r$ in Figs. 1 and 2 may be interpreted as this maximum exposure.

We may now proceed to a very useful comparison of the initial plume with the resuspension plume. Horst (1974c) has shown that for the special case of a single wind speed, wind direction and stability

$$C_r + C_d = C_o \tag{17}$$

when the system reaches a steady state. What occurs is that the surface contamination G increases until the resuspension flux ΛG exactly balances the deposition flux $v_d C$. Thus there is no longer any net transfer from the air to the ground and G is equal to its steady state value $v_d C/\Lambda$. Further, the sum of the depleted, initial air concentration and the resuspended air concentration is for the same reason then equal to the air concentration as it would have been without the occurrence of either deposition or resuspension. It is evident from the curves for $\bar{C}'_r$ and $\bar{C}_o - \bar{C}_d$ in Figs. 1 and 2 that

$$\bar{C}'_r + \bar{C}_d < \bar{C}_o \tag{18}$$

rather than (17). (Recall that $\bar{C}'_r$ as plotted is the steady state value.) Equally important

$$\bar{E}'_r + \bar{E}_d < \bar{E}_o \tag{19}$$

where $\bar{E}'_r$ is the maximum value of the exposure, calculated by allowing all of the material to resuspend. Thus a conservative estimate of the exposure could have been made by ignoring both deposition and resuspension!*

There are two important qualifications to the preceding statement. One is the already-mentioned neglect of redeposition and subsequent additional resuspension. It cannot be conclusively stated at this time whether this results in a net loss or a net gain to $\bar{C}_r$, but it is likely that it is a small effect. The second qualification occurs in the immediate vicinity of the original source.

* Actually (18) and (19) should also include the possibility of equality in the limit as v_d goes to zero.

It can be seen in Figs. 1 and 2 that (18) and (19) are not valid for distances less than about 100 m. This may be explained by examining

$$C_o(z_d) - C_d(z_d) = \frac{v_d}{u}\int_o^x C_d(\xi,\theta,z_d)\, D(x-\xi,\theta,z_d)\, d\xi \quad . \tag{20}$$

Independent of the values of C_d and D, $C_o - C_d$ goes to zero at $x = 0$ since for very small downwind travel distances the deposition has had insufficient opportunity to decrease C_d below its undepleted value C_o. Further, in the immediate vicinity of the original source $C_o(z_d)$ and $C_d(z_d)$ (or equivalently $D(x,\theta,z_d)$) are themselves quite small since the diffusion process as represented by the Gaussian plume model requires a travel distance of several meters to generate a substantial air concentration at a height of $z_d = 1$ m from a surface source. Thus D, C_o and C_d initially increase with travel distance to a peak in the vicinity of $x \sim 15$ m. The difference $C_o - C_d$ is proportional to the convolution of C_d and D and hence increases more slowly, peaking in the vicinity of $x \sim 100$ m.

The resuspended air concentration, on the other hand, has as its source the material deposited from C_d. For any given wind direction this material has also been deposited upwind of the origin due to previous winds which blew in the opposite direction. Thus C_r' does not go to zero at the origin. Further the peak in the ground contamination corresponds to the peak in C_d, i.e., it lies at a radius of about 15 m from the origin, and thus the peak of C_r' also occurs in this same region. This explains the fact that $\bar{C}_r'$ exceeds $\bar{C}_o - \bar{C}_d$ for distances less than about 100 m. $\bar{C}_o$ can nevertheless be seen to still be a conservative approximation to $\bar{C}_r' + \bar{C}_d$ except perhaps within several meters of the original source where $\bar{C}_o$ and $\bar{C}_d$ both become very small. Although this may be an unrealistic prediction of the Gaussian plume model for $z = 1$ m and a surface release, it would be very reasonable to expect $\bar{C}_r$ to exceed $\bar{C}_o$ and $\bar{C}_d$ at ground level immediately below an elevated source such as the chronic release from a process stack.

Figures 1 and 2 display the polar-averaged air concentrations or exposures. Figure 3 shows the polar distributions of $\bar{C}_o - \bar{C}_d$ and $\bar{C}_r'$ for both $v_d/u = 10^{-3}$ and 10^{-2} at a radial distance of 400 m from the primary source. The qualitative relationships (18) and (19) are valid for all θ. The peak corresponds to the direction toward which the wind blows most frequently, ESE. Note that the ratio of $\bar{C}_r'$ to $\bar{C}_o - \bar{C}_d$ is smallest in this direction. This may also be inferred from Figure 4 which shows $\bar{C}_o - \bar{C}_d$ and $\bar{C}_r'$ as a function of radial distance for two individual azimuths, ESE and WSW. Recalling the results of Horst (1974c) for a single wind speed, wind direction and stability, it may be hypothesized that (17) is the limiting case of (18) when the wind direction is constant. Additional investigation is necessary to substantiate this.

The results reported thus far have been calculated with a constant resuspension rate. Although little is presently known about the resuspension rate, it should realistically be a function of both the current value of such variables as wind speed, atmospheric turbulence and soil moisture and of their past history. The wind speed is probably the most important of the atmospheric parameters. Bagnold (1941) has shown that the horizontal flux of resuspended material is proportional to the third power of the amount by which the wind speed exceeds a threshhold value. If the vertical resuspension flux is directly proportional to the horizontal flux, this would imply a dependence of the resuspension rate on the cube of the wind speed. Sehmel and Lloyd (1975), on the other hand, have measured the resuspension rate to be proportional to a power of the wind speed as great as 6.5.

In order to investigate the dependence of $\bar{C}_r'$ on the functional relationship between resuspension rate and wind speed, calculations were made assuming that

$$\Lambda = Au^N \tag{21}$$

for several values of the exponent N. Fig. 5 shows the resulting polar-averaged values of $\bar{C}_r'$ over a limited range of downwind distance and for $v_d/u = 10^{-2}$. Increasing the dependence of Λ on wind speed decreases $\bar{C}_r'$

below that previously calculated for a constant Λ (N = 0). Fig. 6, the polar distribution of $\bar{C}_r'$ at a radial distance of 2 km, shows that this is still true despite the enhancement of the peak in the ESE direction with increasing N. Thus (18) and (19) are only strengthened by allowing Λ to increase with the wind speed.

The decrease of $\bar{C}_r'$ with increasing N is directly due to the fact that the atmospheric diffusion is inversely proportional to the wind speed. Thus the numerator of (13) does not increase as rapidly with increasing N as does the denominator. A simple analysis shows that the decrease of $\bar{C}_r'$ with increasing N appears to reach an asymptotic limit at about 0.2 $\bar{C}_r'$(N = 0), and this is also suggested by Figs. 5 and 6.

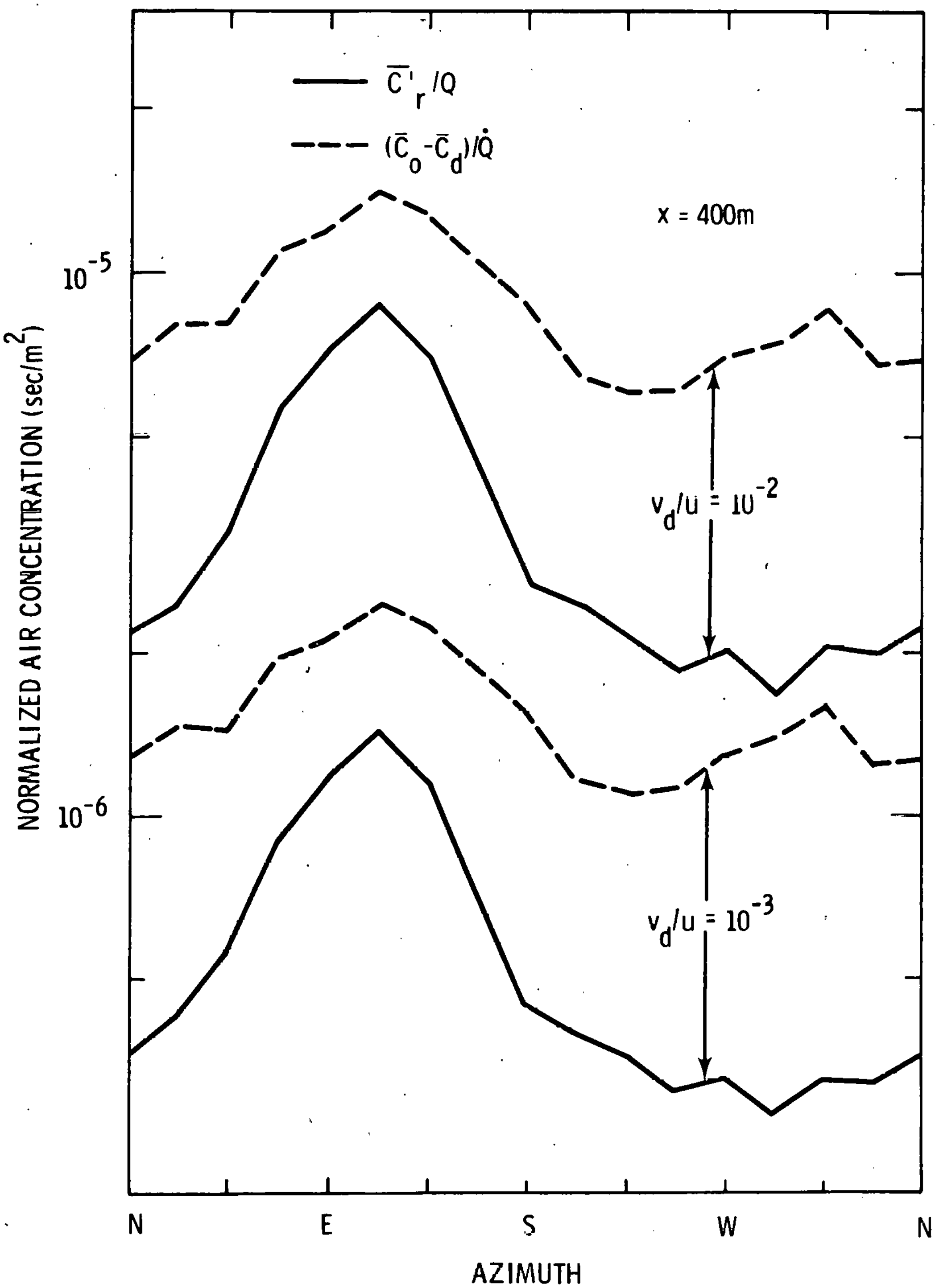

Figure 3. Normalized Air Concentrations vs. Azimuth at a Radial Distance of 400 m.

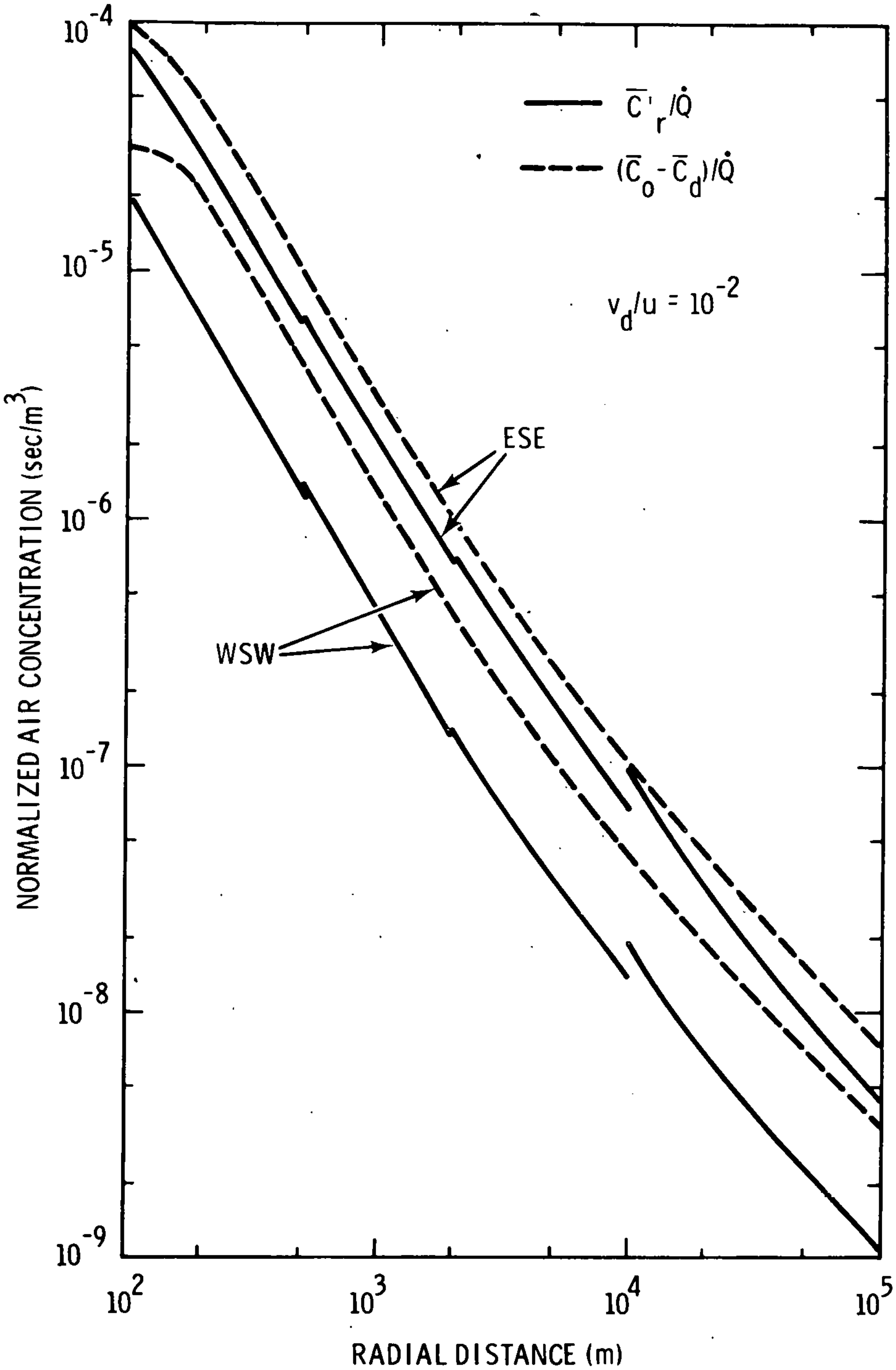

Figure 4. Normalized Air Concentrations vs. Radial Distance for the ESE and WSW Directions.

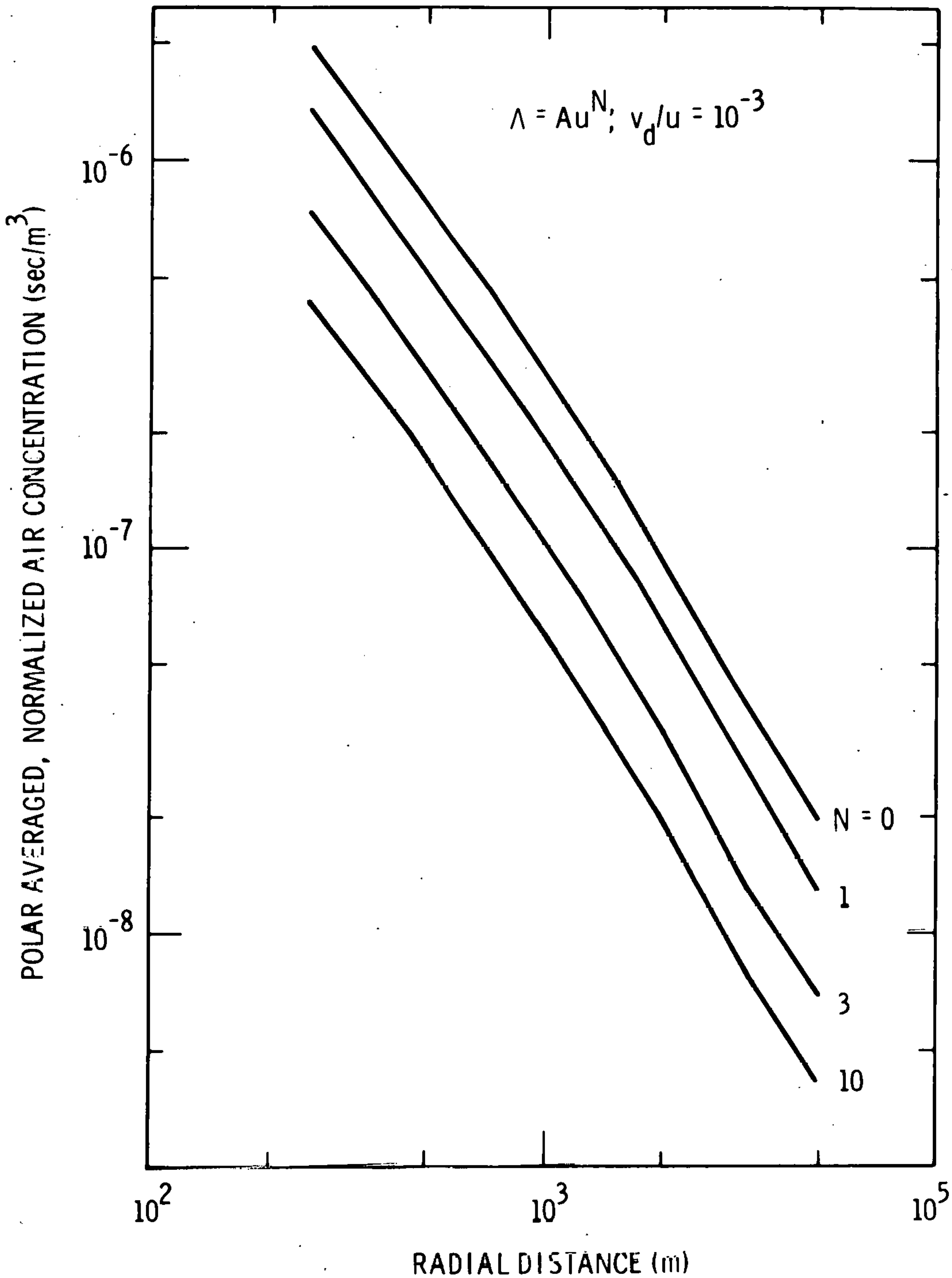

Figure 5. Polar-Averaged, Normalized Resuspended Air Concentrations vs. Radial Distance for $\Lambda = Au^N$.

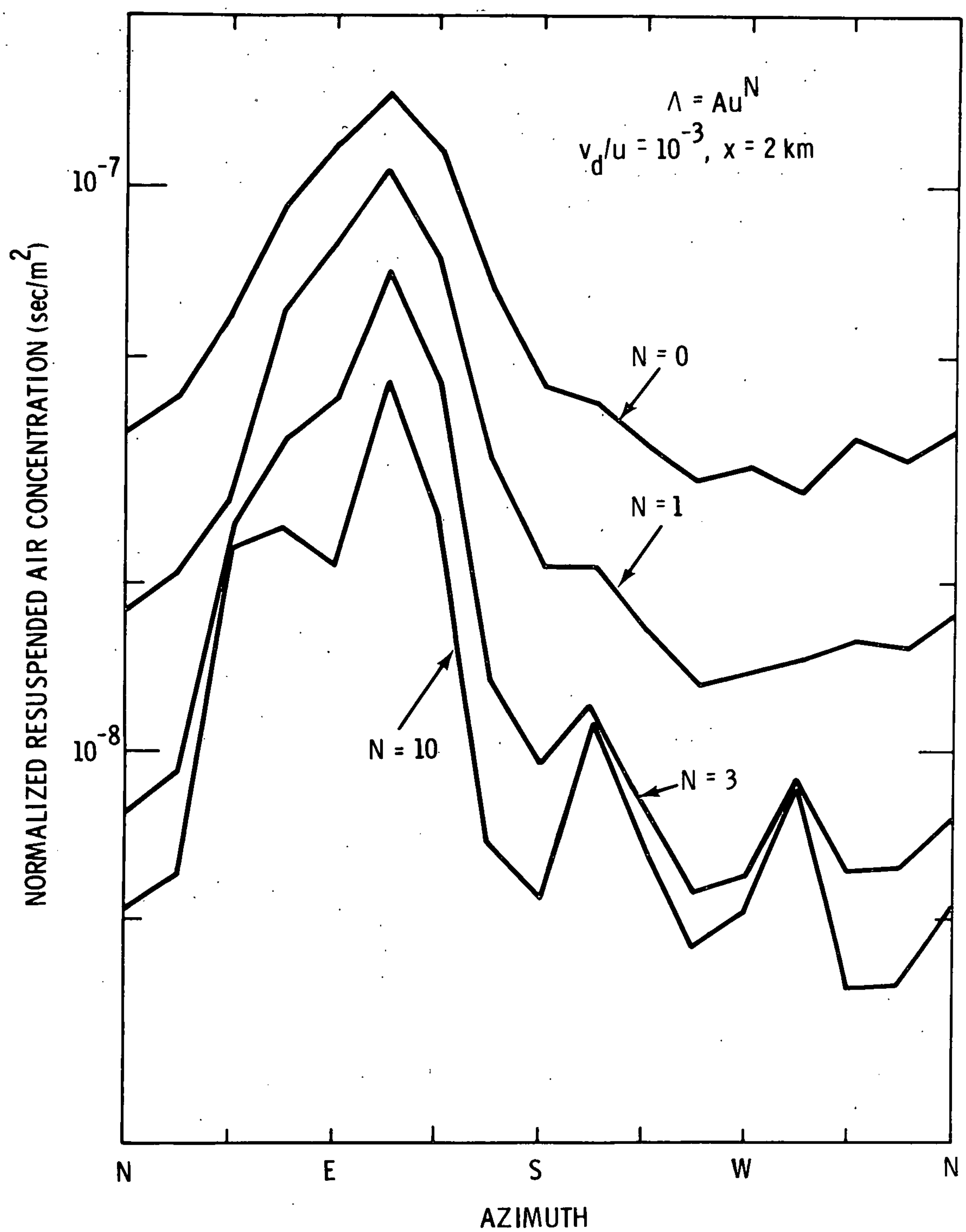

Figure 6. Normalized Resuspended Air Concentrations vs. Azimuth at a Radial Distance of 2 km for $\Lambda = Au^N$.

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APPENDIX A: Hanford Climatology Used for Computations

The following table summarizes the 8760 hours of Hanford Meteorological Tower data for 1970 which were used for the computations of this report. The numbers shown are the joint probability density of wind direction (from which the wind is blowing), wind speed class and stability class. The stability was classified according to the wind speed vs. day or night scheme of Table 1. Below each probability entry is the corresponding average wind speed in mph.

These data include 253 hours during which the wind direction was classified as variable and 262 hours during which the wind speed was classified as calm. The hours of variable direction were placed in the appropriate speed class according to the measured wind speed and they, along with the calms, were distributed equally over the 16 wind directions. The calms were arbitrarily assigned a wind speed of 0.5 mph and thus, for computing the initial plumes, were classified as stability A (95 hours) or F (167 hours) according to whether they occurred during the day or night. No resuspension was attributed to the calms, even for the case of resuspension rate independent of wind speed.

TABLE A-1

JOINT PROBABILITY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION AT 50-FOOT-LEVEL VS. ATMOSPHERIC STABILITY

Speed Class (MPH)	Stabil.	Direction from which Wind Blows: NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	Total
Calm	A	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0007 .5	.0108 .5
	F	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0012 .5	.0191 .5
1-3	A	.0108 2.1	.0107 2.2	.0066 2.1	.0069 2.0	.0069 2.4	.0067 2.3	.0039 2.1	.0039 2.1	.0031 2.0	.0023 2.1	.0030 2.0	.0031 2.2	.0044 2.2	.0067 2.2	.0068 2.3	.0119 2.0	.0979 2.2
	F	.0032 1.9	.0033 2.0	.0034 2.0	.0042 1.8	.0048 1.8	.0059 1.9	.0038 1.9	.0042 2.2	.0043 1.8	.0030 2.0	.0063 2.2	.0051 2.1	.0058 2.1	.0066 2.2	.0074 2.1	.0051 1.8	.0765 2.0
4-7	B	.0162 5.1	.0119 5.0	.0054 5.0	.0073 5.2	.0098 5.1	.0097 5.2	.0076 5.1	.0068 5.2	.0066 5.0	.0099 5.5	.0073 5.4	.0077 5.6	.0143 5.7	.0236 5.6	.0178 5.3	.0171 5.2	.1790 5.3
	E	.0015 5.2	.0015 4.9	.0016 4.7	.0020 4.9	.0024 5.3	.0043 5.2	.0036 5.2	.0056 5.1	.0070 5.4	.0140 5.5	.0171 5.8	.0306 5.8	.0260 5.7	.0227 5.6	.0093 5.0	.0043 4.9	.1535 5.5
8-12	C	.0047 9.9	.0019 9.7	.0011 8.9	.0019 9.1	.0027 9.0	.0039 9.4	.0029 10.2	.0019 9.9	.0062 9.9	.0071 10.1	.0105 10.0	.0050 9.8	.0199 9.8	.0251 9.5	.0037 9.2	.0035 9.7	.1021 9.7
	D	.0006 10.0	.0003 10.3	.0001 12.0	.0002 8.0	.0002 9.5	.0015 9.3	.0032 9.3	.0018 10.1	.0016 10.2	.0063 9.3	.0220 9.5	.0287 9.4	.0551 9.7	.0264 9.7	.0025 9.4	.0014 8.9	.1519 9.6
13-18	D	.0043 14.9	.0015 15.8	.0001 17.0	.0000 0.0	.0005 14.3	.0013 14.5	.0010 14.4	.0018 15.4	.0075 15.2	.0156 15.2	.0176 15.1	.0153 14.7	.0434 15.1	.0237 15.1	.0025 14.6	.0038 14.4	.1400 15.0
19-24	D	.0033 21.2	.0009 20.9	.0000 0.0	.0000 0.0	.0000 0.0	.0000 0.0	.0005 22.3	.0011 20.4	.0035 21.2	.0072 21.5	.0049 21.2	.0014 20.8	.0215 20.8	.0123 20.9	.0000 0.0	.0007 20.3	.0573 21.0
25-Up	D	.0010 25.8	.0001 25.0	.0000 0.0	.0000 0.0	.0000 0.0	.0000 0.0	.0001 25.0	.0002 27.5	.0014 27.8	.0029 26.3	.0017 26.3	.0001 25.0	.0031 25.6	.0013 25.9	.0000 0.0	.0000 0.0	.0119 26.2
Total	A	.0115 2.0	.0114 2.1	.0072 1.9	.0076 1.9	.0076 2.2	.0074 2.2	.0046 1.8	.0046 1.9	.0038 1.7	.0030 1.8	.0037 1.8	.0038 1.9	.0051 1.9	.0074 2.1	.0075 2.2	.0126 2.0	.1088 2.0
	B	.0162 5.1	.0119 5.0	.0054 5.0	.0073 5.2	.0098 5.1	.0097 5.2	.0076 5.1	.0068 5.2	.0066 5.0	.0099 5.5	.0073 5.4	.0077 5.6	.0143 5.7	.0236 5.6	.0178 5.3	.0171 5.2	.1790 5.3
	C	.0047 9.9	.0019 9.7	.0011 8.9	.0019 9.1	.0027 9.0	.0039 9.4	.0029 10.2	.0019 9.9	.0062 9.9	.0071 10.1	.0105 10.0	.0050 9.8	.0199 9.8	.0251 9.5	.0037 9.2	.0035 9.7	.1021 9.7
	D	.0092 18.1	.0029 17.2	.0002 14.5	.0002 8.0	.0007 12.7	.0027 11.7	.0048 12.0	.0050 15.1	.0140 17.3	.0320 16.5	.0462 13.5	.0454 11.6	.1231 13.9	.0637 14.2	.0050 12.0	.0058 13.8	.3611 14.1
	E	.0015 5.2	.0015 4.9	.0016 4.7	.0020 4.9	.0024 5.3	.0043 5.2	.0036 5.2	.0056 5.1	.0070 5.4	.0140 5.5	.0171 5.8	.0306 5.8	.0260 5.7	.0227 5.6	.0093 5.0	.0043 4.9	.1535 5.5
	F	.0044 1.6	.0045 1.6	.0046 1.6	.0054 1.5	.0060 1.6	.0071 1.7	.0050 1.6	.0054 1.8	.0055 1.5	.0042 1.6	.0075 1.9	.0063 1.8	.0070 1.8	.0078 2.0	.0086 1.9	.0063 1.5	.0955 1.7

APPENDIX B: The Climatologically-Averaged Initial Plume

The following tables show the climatologically-averaged values of the initial plume air concentration $\bar{C}_d$ and deposition flux $\overline{v_d C_d}$ for no deposition ($\bar{C}_o$), $v_d/u = 10^{-2}$, and $v_d/u = 10^{-3}$. $\bar{C}_d$ and $\overline{v_d C_d}$ have both been normalized by the source strength $\dot{Q}$ and hence have dimensions of sec/m^3 and m^{-3}, respectively. The results are tabulated as a function of azimuthal direction and of radial distance from the original source. Those labeled "Surface Depletion Model" are the result of computations made with equation (10) and were utilized in the body of this report. The tables labeled "Source Depletion Model" are discussed in Appendix C.

TABLE B-1. INITIAL PLUME AIR CONCENTRATION.

NO DEPOSITION

RADIAL DISTANCE (KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.6803E-03	.7471E-03	.6904E-03	.5730E-03	.4497E-03	.2779E-03	.1523E-03	.7262E-04	.4226E-04	.1958E-04
NE	.1217E-02	.1038E-02	.8449E-03	.6522E-03	.4942E-03	.2964E-03	.1599E-03	.7568E-04	.4395E-04	.2035E-04
ENE	.1583E-02	.1366E-02	.1122E-02	.8713E-03	.6624E-03	.3985E-03	.2154E-03	.1021E-03	.5938E-04	.2754E-04
E	.1691E-02	.1567E-02	.1300E-02	.9919E-03	.7453E-03	.4432E-03	.2380E-03	.1124E-03	.6529E-04	.3026E-04
ESE	.3178E-02	.2581E-02	.1822E-02	.1306E-02	.9545E-03	.5548E-03	.2947E-03	.1386E-03	.8042E-04	.3731E-04
SE	.2758E-02	.2182E-02	.1571E-02	.1148E-02	.8481E-03	.4976E-03	.2654E-03	.1249E-03	.7238E-04	.3346E-04
SSE	.1256E-02	.1022E-02	.9110E-03	.7477E-03	.5841E-03	.3596E-03	.1966E-03	.9360E-04	.5441E-04	.2516E-04
S	.1514E-02	.1089E-02	.8483E-03	.6707E-03	.5171E-03	.3153E-03	.1716E-03	.8146E-04	.4729E-04	.2183E-04
SSW	.1401E-02	.9599E-03	.6887E-03	.5286E-03	.4027E-03	.2434E-03	.1319E-03	.6245E-04	.3621E-04	.1670E-04
SW	.1146E-02	.7938E-03	.6028E-03	.4759E-03	.3672E-03	.2242E-03	.1221E-03	.5797E-04	.3364E-04	.1552E-04
WSW	.7299E-03	.5503E-03	.5020E-03	.4252E-03	.3377E-03	.2109E-03	.1162E-03	.5551E-04	.3230E-04	.1494E-04
W	.8235E-03	.6259E-03	.5764E-03	.4897E-03	.3893E-03	.2433E-03	.1341E-03	.6408E-04	.3729E-04	.1726E-04
WNW	.8432E-03	.6507E-03	.6041E-03	.5135E-03	.4082E-03	.2551E-03	.1405E-03	.6718E-04	.3910E-04	.1809E-04
NW	.9385E-03	.7499E-03	.7022E-03	.5943E-03	.4711E-03	.2937E-03	.1616E-03	.7718E-04	.4492E-04	.2079E-04
NNW	.7769E-03	.6223E-03	.5724E-03	.4803E-03	.3794E-03	.2358E-03	.1296E-03	.6186E-04	.3600E-04	.1667E-04
N	.7312E-03	.6143E-03	.5799E-03	.4864E-03	.3835E-03	.2379E-03	.1306E-03	.6230E-04	.3625E-04	.1679E-04
TOTAL	.2147E-01	.1716E-01	.1394E-01	.1095E-01	.8394E-02	.5088E-02	.2760E-02	.1310E-02	.7611E-03	.3523E-03

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.1136E-04	.7477E-05	.4012E-05	.2107E-05	.1038E-05	.6410E-06	.3349E-06	.2164E-06	.1563E-06
NE	.1182E-04	.7780E-05	.4181E-05	.2198E-05	.1085E-05	.6699E-06	.3497E-06	.2254E-06	.1624E-06
ENE	.1601E-04	.1056E-04	.5684E-05	.2996E-05	.1482E-05	.9166E-06	.4795E-06	.3093E-06	.2230E-06
E	.1759E-04	.1160E-04	.6250E-05	.3297E-05	.1633E-05	.1011E-05	.5296E-06	.3421E-06	.2468E-06
ESE	.2173E-04	.1435E-04	.7747E-05	.4094E-05	.2030E-05	.1255E-05	.6544E-06	.4203E-06	.3014E-06
SE	.1942E-04	.1278E-04	.6863E-05	.3604E-05	.1774E-05	.1092E-05	.5672E-06	.3639E-06	.2611E-06
SSE	.1458E-04	.9583E-05	.5131E-05	.2687E-05	.1320E-05	.8132E-06	.4237E-06	.2733E-06	.1972E-06
S	.1263E-04	.8288E-05	.4426E-05	.2310E-05	.1129E-05	.6926E-06	.3585E-06	.2301E-06	.1654E-06
SSW	.9652E-05	.6328E-05	.3375E-05	.1757E-05	.8565E-06	.5236E-06	.2699E-06	.1725E-06	.1236E-06
SW	.8974E-05	.5885E-05	.3139E-05	.1636E-05	.7981E-06	.4887E-06	.2524E-06	.1617E-06	.1161E-06
WSW	.8658E-05	.5687E-05	.3043E-05	.1592E-05	.7811E-06	.4807E-06	.2502E-06	.1613E-06	.1164E-06
W	.9999E-05	.6569E-05	.3515E-05	.1839E-05	.9028E-06	.5556E-06	.2894E-06	.1866E-06	.1347E-06
WNW	.1049E-04	.6889E-05	.3687E-05	.1930E-05	.9475E-06	.5833E-06	.3039E-06	.1960E-06	.1415E-06
NW	.1206E-04	.7924E-05	.4244E-05	.2223E-05	.1093E-05	.6734E=06	.3512E-06	.2267E-06	.1637E-06
NNW	.9668E-05	.6357E-05	.3407E-05	.1786E-05	.8785E-06	.5415E-06	.2825E-06	.1823E-06	.1316E-06
N	.9735E-05	.6401E-05	.3432E-05	.1800E-05	.8860E-06	.5464E-06	.2854E-06	.1844E-06	.1332E-06
TOTAL	.2044E-03	.1345E-03	.7213E-04	.3785E-04	.1864E-04	.1149E-04	.5982E-05	.3852E-05	.2774E-05

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.9779E-07	.6112E-07	.3688E-07	.2619E-07	.1646E-07	.1196E-07	.9380E-08	.6543E-08	.4494E-08
NE	.1012E-06	.6288E-07	.3766E-07	.2659E-07	.1656E-07	.1199E-07	.9364E-08	.6496E-08	.4440E-08
ENE	.1389E-06	.8620E-07	.5152E-07	.3632E-07	.2258E-07	.1629E-07	.1271E-07	.8797E-08	.5999E-08
E	.1540E-06	.9570E-07	.5730E-07	.4043E-07	.2517E-07	.1818E-07	.1419E-07	.9828E-08	.6707E-08
ESE	.1859E-06	.1139E-06	.6693E-07	.4657E-07	.2844E-07	.2026E-07	.1566E-07	.1070E-07	.7202E-08
SE	.1614E-06	.9942E-07	.5893E-07	.4131E-07	.2551E-07	.1832E-07	.1425E-07	.9820E-08	.6671E-08
SSE	.1233E-06	.7709E-07	.4657E-07	.3311E-07	.2085E-07	.1517E-07	.1191E-07	.8323E-08	.5727E-08
S	.1028E-06	.6390E-07	.3838E-07	.2719E-07	.1705E-07	.1238E-07	.9710E-08	.6772E-08	.4653E-08
SSW	.7646E-07	.4726E-07	.2823E-07	.1993E-07	.1244E-07	.9009E-08	.7050E-08	.4905E-08	.3363E-08
SW	.7211E-07	.4477E-07	.2687E-07	.1903E-07	.1194E-07	.8670E-08	.6799E-08	.4744E-08	.3261E-08
WSW	.7283E-07	.4555E-07	.2755E-07	.1961E-07	.1237E-07	.9009E-08	.7080E-08	.4953E-08	.3412E-08
W	.8426E-07	.5271E-07	.3189E-07	.2269E-07	.1431E-07	.1043E-07	.8194E-08	.5732E-08	.3949E-08
WNW	.8854E-07	.5539E-07	.3351E-07	.2385E-07	.1504E-07	.1096E-07	.8609E-08	.6021E-08	.4148E-08
NW	.1025E-06	.6413E-07	.3879E-07	.2760E-07	.1739E-07	.1267E-07	.9950E-08	.6956E-08	.4789E-08
NNW	.8233E-07	.5146E-07	.3108E-07	.2209E-07	.1390E-07	.1011E-07	.7939E-08	.5544E-08	.3813E-08
N	.8344E-07	.5223E-07	.3159E-07	.2248E-07	.1416E-07	.1031E-07	.8098E-08	.5659E-08	.3895E-08
TOTAL	.1728E-05	.1074E-05	.6437E-06	.4550E-06	.2842E-06	.2057E-06	.1609E-06	.1118E-06	.7652E-07

TABLE B-2. INITIAL PLUME AIR CONCENTRATION.

SURFACE DEPLETION MODEL, VD/U = .010

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.8521E-03	.7181E-03	.6642E-03	.5492E-03	.4245E-03	.2426E-03	.1080E-03	.3601E-04	.1676E-04	.6389E-05
NE	.1189E-02	.1006E-02	.8102E-03	.6168E-03	.4561E-03	.2504E-03	.1107E-03	.3815E-04	.1829E-04	.7116E-05
ENE	.1554E-02	.1330E-02	.1078E-02	.8237E-03	.6109E-03	.3368E-03	.1491E-03	.5127E-04	.2452E-04	.9537E-05
E	.1663E-02	.1533E-02	.1256E-02	.9407E-03	.6854E-03	.3690E-03	.1617E-03	.5620E-04	.2718E-04	.1062E-04
ESE	.3136E-02	.2520E-02	.1731E-02	.1206E-02	.8522E-03	.4514E-03	.2001E-03	.7200E-04	.3566E-04	.1425E-04
SE	.2700E-02	.2110E-02	.1489E-02	.1067E-02	.7664E-03	.4120E-03	.1828E-03	.6485E-04	.3176E-04	.1256E-04
SSE	.1208E-02	.9737E-03	.8723E-03	.7152E-03	.5509E-03	.3140E-03	.1399E-03	.4682E-04	.2187E-04	.8353E-05
S	.1445E-02	.1024E-02	.7998E-03	.6334E-03	.4834E-03	.2756E-03	.1229E-03	.4214E-04	.1992E-04	.7698E-05
SSW	.1339E-02	.9000E-03	.6428E-03	.4936E-03	.3729E-03	.2119E-03	.9575E-04	.3300E-04	.1574E-04	.6136E-05
SW	.1090E-02	.7420E-03	.5655E-03	.4484E-03	.3435E-03	.1970E-03	.8890E-04	.3027E-04	.1430E-04	.5532E-05
WSW	.6920E-03	.5168E-03	.4789E-03	.4083E-03	.3218E-03	.1878E-03	.8434E-04	.2791E-04	.1290E-04	.4897E-05
W	.7824E-03	.5888E-03	.5502E-03	.4702E-03	.3710E-03	.2166E-03	.9735E-04	.3214E-04	.1409E-04	.5825E-05
WNW	.8044E-03	.6141E-03	.5770E-03	.4929E-03	.3386E-03	.2267E-03	.1017E-03	.3357E-04	.1548E-04	.5866E-05
NW	.8983E-03	.7116E-03	.6729E-03	.5708E-03	.4478E-03	.2597E-03	.1162E-03	.3843E-04	.1776E-04	.6735E-05
NNW	.7455E-03	.5920E-03	.5484E-03	.4605E-03	.3596E-03	.2078E-03	.9295E-04	.3085E-04	.1430E-04	.5437E-05
N	.7017E-03	.5863E-03	.5580E-03	.4679E-03	.3639E-03	.2090E-03	.9309E-04	.3091E-04	.1434E-04	.5452E-05
TOTAL	.2080E-01	.1647E-01	.1329E-01	.1036E-01	.7799E-02	.4368E-02	.1946E-02	.6645E-03	.3156E-03	.1222E-03

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.3339E-05	.2044E-05	.9873E-06	.4665E-06	.2032E-06	.1143E-06	.5166E-07	.2986E-07	.1951E-07
NE	.3753E-05	.2311E-05	.1127E-05	.5368E-06	.2360E-06	.1335E-06	.6076E-07	.3519E-07	.2304E-07
ENE	.5034E-05	.3103E-05	.1516E-05	.7241E-06	.3194E-06	.1811E-06	.8268E-07	.4796E-07	.3142E-07
E	.5612E-05	.3461E-05	.1693E-05	.8100E-06	.3562E-06	.2036E-06	.9335E-07	.5432E-07	.3569E-07
ESE	.7619E-05	.4738E-05	.2344E-05	.1132E-05	.5048E-06	.2876E-06	.1320E-06	.7652E-07	.5008E-07
SE	.6678E-05	.4132E-05	.2027E-05	.9701E-06	.4279E-06	.2422E-06	.1102E-06	.6365E-07	.4160E-07
SSE	.4367E-05	.2672E-05	.1289E-05	.6072E-06	.2634E-06	.1477E-06	.6641E-07	.3825E-07	.2494E-07
S	.4048E-05	.2485E-05	.1203E-05	.5679E-06	.2459E-06	.1375E-06	.6137E-07	.3510E-07	.2276E-07
SSW	.3240E-05	.1994E-05	.9682E-06	.4577E-06	.1982E-06	.1107E-06	.4925E-07	.2806E-07	.1814E-07
SW	.2911E-05	.1788E-05	.8652E-06	.4080E-06	.1763E-06	.9837E-07	.4374E-07	.2494E-07	.1614E-07
WSW	.2555E-05	.1562E-05	.7515E-06	.3533E-06	.1526E-06	.8529E-07	.3810E-07	.2166E-07	.1421E-07
W	.2933E-05	.1792E-05	.8621E-06	.4052E-06	.1750E-06	.9783E-07	.4372E-07	.2510E-07	.1631E-07
WNW	.3057E-05	.1867E-05	.8977E-06	.4218E-06	.1822E-06	.1019E-06	.4557E-07	.2617E-07	.1702E-07
NW	.3512E-05	.2145E-05	.1033E-05	.4858E-06	.2103E-06	.1178E-06	.5285E-07	.3042E-07	.1982E-07
NNW	.2839E-05	.1736E-05	.8370E-06	.3945E-06	.1711E-06	.9597E-07	.4312E-07	.2483E-07	.1618E-07
N	.2849E-05	.1739E-05	.8382E-06	.3951E-06	.1715E-06	.9627E-07	.4336E-07	.2502E-07	.1633E-07
TOTAL	.6434E-04	.3957E-04	.1924E-04	.9136E-05	.3996E-05	.2252E-05	.1018E-05	.5873E-06	.3832E-06

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.1036E-07	.5267E-08	.2369E-08	.1311E-08	.5379E-09	.2721E-09	.1538E-09	.6161E-10	.2205E-10
NE	.1226E-07	.6248E-08	.2817E-08	.1567E-08	.6500E-09	.3325E-09	.1906E-09	.7819E-10	.2892E-10
ENE	.1673E-07	.8521E-08	.3836E-08	.2132E-08	.8836E-09	.4525E-09	.2599E-09	.1072E-09	.4003E-10
E	.1909E-07	.9773E-08	.4422E-08	.2465E-08	.1023E-08	.5225E-09	.2985E-09	.1209E-09	.4361E-10
ESE	.2660E-07	.1349E-07	.6053E-08	.3371E-08	.1411E-08	.7346E-09	.4309E-09	.1857E-09	.7376E-10
SE	.2206E-07	.1120E-07	.5044E-08	.2813E-08	.1180E-08	.6139E-09	.3592E-09	.1540E-09	.6086E-10
SSE	.1320E-07	.6696E-08	.3008E-08	.1663E-08	.6811E-09	.3437E-09	.1936E-09	.7698E-10	.2723E-10
S	.1193E-07	.5997E-08	.2672E-08	.1474E-08	.6056E-09	.3087E-09	.1766E-09	.7303E-10	.2761E-10
SSW	.9462E-08	.4730E-08	.2098E-08	.1157E-08	.4773E-09	.2455E-09	.1422E-09	.6056E-10	.2394E-10
SW	.8425E-08	.4217E-08	.1875E-08	.1031E-08	.4229E-09	.2158E-09	.1237E-09	.5163E-10	.1975E-10
WSW	.7475E-08	.3769E-08	.1682E-08	.9253E-09	.3762E-09	.1892E-09	.1063E-09	.4233E-10	.1511E-10
W	.8588E-08	.4333E-08	.1935E-08	.1065E-08	.4329E-09	.2177E-09	.1222E-09	.4867E-10	.1735E-10
WNW	.8970E-08	.4531E-08	.2025E-08	.1115E-08	.4535E-09	.2280E-09	.1280E-09	.5089E-10	.1810E-10
NW	.1047E-07	.5303E-08	.2375E-08	.1310E-08	.5343E-09	.2680E-09	.1510E-09	.5999E-10	.2125E-10
NNW	.8550E-08	.4329E-08	.1938E-08	.1069E-08	.4361E-09	.2198E-09	.1237E-09	.4932E-10	.1757E-10
N	.8654E-08	.4395E-08	.1974E-08	.1091E-08	.4453E-09	.2239E-09	.1255E-09	.4943E-10	.1720E-10
TOTAL	.2028E-06	.1028E-06	.4612E-07	.2556E-07	.1055E-07	.5389E-08	.3086E-08	.1270E-08	.4743E-09

TABLE B-3. DEPOSITION FLUX.

SURFACE DEPLETION MODEL, VD/U = .010

RADIAL DISTANCE (KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.2371E-04	.1819E-04	.1147E-04	.7597E-05	.5214E-05	.2693E-05	.1155E-05	.4427E-06	.2238E-06	.9064E-07
NE	.4239E-04	.3306E-04	.2001E-04	.1266E-04	.6406E-05	.4192E-05	.1852E-05	.7091E-06	.3670E-06	.1511E-06
ENE	.5610E-04	.4410E-04	.2696E-04	.1720E-04	.1150E-04	.5761E-05	.2558E-05	.9723E-06	.5007E-06	.2056E-06
E	.5484E-04	.4660E-04	.3070E-04	.2006E-04	.1348E-04	.6725E-05	.2931E-05	.1103E-05	.5658E-06	.2307E-06
ESE	.1327E-03	.1009E-03	.5719E-04	.3466E-04	.2247E-04	.1103E-04	.4921E-05	.1938E-05	.1020E-05	.4266E-06
SE	.9479E-04	.7088E-04	.4093E-04	.2536E-04	.1670E-04	.8305E-05	.3694E-05	.1431E-05	.7453E-06	.3083E-06
SSE	.2347E-04	.1772E-04	.1204E-04	.8454E-05	.6000E-05	.3183E-05	.1409E-05	.5061E-06	.2503E-06	.9941E-07
S	.2436E-04	.1669E-04	.9992E-05	.6667E-05	.4642E-05	.2451E-05	.1101E-05	.4069E-06	.2047E-06	.8265E-07
SSW	.2629E-04	.1736E-04	.9399E-05	.5895E-05	.3979E-05	.2064E-05	.9389E-06	.3591E-06	.1847E-06	.7599E-07
SW	.1622E-04	.1061E-04	.6158E-05	.4110E-05	.2880E-05	.1540E-05	.6975E-06	.2576E-06	.1294E-06	.5226E-07
WSW	.7804E-05	.5450E-05	.3826E-05	.2845E-05	.2102E-05	.1165E-05	.5223E-06	.1825E-06	.8813E-07	.3453E-07
W	.9878E-05	.6857E-05	.4710E-05	.3462E-05	.2544E-05	.1405E-05	.6297E-06	.2210E-06	.1071E-06	.4203E-07
WNW	.1256E-04	.8687E-05	.5772E-05	.4156E-05	.3021E-05	.1654E-05	.7415E-06	.2626E-06	.1281E-06	.5054E-07
NW	.1544E-04	.1127E-04	.7675E-05	.5492E-05	.3961E-05	.2144E-05	.9556E-06	.3393E-06	.1661E-06	.6561E-07
NNW	.1371E-04	.1010E-04	.6593E-05	.4563E-05	.3228E-05	.1719E-05	.7660E-06	.2767E-06	.1372E-06	.5478E-07
N	.1320E-04	.1040E-04	.7281E-05	.5151E-05	.3665E-05	.1947E-05	.8599E-06	.3076E-06	.1517E-06	.6021E-07
TOTAL	.5675E-03	.4288E-03	.2607E-03	.1683E-03	.1138E-03	.5800E-04	.2577E-04	.9715E-05	.4970E-05	.2031E-05

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.4872E-07	.3038E-07	.1509E-07	.7291E-08	.3252E-08	.1852E-08	.8484E-09	.4909E-09	.3210E-09
NE	.8184E-07	.5132E-07	.2568E-07	.1252E-07	.5638E-08	.3227E-08	.1488E-08	.8629E-09	.5648E-09
ENE	.1114E-06	.6984E-07	.3498E-07	.1708E-07	.7704E-08	.4415E-08	.2040E-08	.1184E-08	.7757E-09
E	.1244E-06	.7776E-07	.3680E-07	.1889E-07	.8509E-08	.4879E-08	.2260E-08	.1317E-08	.8649E-09
ESE	.2331E-06	.1472E-06	.7436E-07	.3660E-07	.1665E-07	.9562E-08	.4430E-08	.2569E-08	.1680E-08
SE	.1674E-06	.1050E-06	.5261E-07	.2564E-07	.1153E-07	.6585E-08	.3028E-08	.1751E-08	.1145E-08
SSE	.5283E-07	.3265E-07	.1597E-07	.7604E-08	.3330E-08	.1875E-08	.8464E-09	.4867E-09	.3172E-09
S	.4429E-07	.2751E-07	.1353E-07	.6465E-08	.2832E-08	.1591E-08	.7134E-09	.4071E-09	.2636E-09
SSW	.4110E-07	.2570E-07	.1275E-07	.6137E-08	.2707E-08	.1524E-08	.6847E-09	.3898E-09	.2518E-09
SW	.2801E-07	.1740E-07	.8547E-08	.4073E-08	.1775E-08	.9933E-09	.4423E-09	.2510E-09	.1618E-09
WSW	.1825E-07	.1123E-07	.5453E-08	.2576E-08	.1115E-08	.6232E-09	.2779E-09	.1586E-09	.1028E-09
W	.2222E-07	.1368E-07	.6646E-08	.3139E-08	.1359E-08	.7591E-09	.3383E-09	.1931E-09	.1251E-09
WNW	.2678E-07	.1651E-07	.8034E-08	.3800E-08	.1648E-08	.9210E-09	.4108E-09	.2344E-09	.1519E-09
NW	.3481E-07	.2149E-07	.1049E-07	.4985E-08	.2177E-08	.1224E-08	.5507E-09	.3161E-09	.2057E-09
NNW	.2923E-07	.1812E-07	.8907E-08	.4262E-08	.1876E-08	.1059E-08	.4797E-09	.2759E-09	.1797E-09
N	.3203E-07	.1982E-07	.9725E-08	.4652E-08	.2050E-08	.1160E-08	.5275E-09	.3046E-09	.1991E-09
TOTAL	.1096E-05	.6856E-06	.3416E-06	.1657E-06	.7413E-07	.4225E-07	.1937E-07	.1119E-07	.7310E-08

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.1702E-09	.8633E-10	.3881E-10	.2171E-10	.9205E-11	.4860E-11	.2898E-11	.1288E-11	.5338E-12
NE	.2997E-09	.1519E-09	.6810E-10	.3807E-10	.1614E-10	.8527E-11	.5095E-11	.2270E-11	.9414E-12
ENE	.4119E-09	.2088E-09	.9356E-10	.5228E-10	.2214E-10	.1170E-10	.6993E-11	.3121E-11	.1297E-11
E	.4620E-09	.2356E-09	.1062E-09	.5941E-10	.2504E-10	.1307E-10	.7691E-11	.3307E-11	.1302E-11
ESE	.8889E-09	.4480E-09	.1995E-09	.1112E-09	.4717E-10	.2512E-10	.1517E-10	.6921E-11	.2959E-11
SE	.6057E-09	.3064E-09	.1374E-09	.7696E-10	.3288E-10	.1756E-10	.1062E-10	.4852E-11	.2079E-11
SSE	.1676E-09	.8498E-10	.3827E-10	.2136E-10	.8974E-11	.4662E-11	.2724E-11	.1161E-11	.4548E-12
S	.1377E-09	.6900E-10	.3075E-10	.1711E-10	.7224E-11	.3808E-11	.2270E-11	.1014E-11	.4246E-12
SSW	.1309E-09	.6513E-10	.2883E-10	.1603E-10	.6822E-11	.3655E-11	.2224E-11	.1036E-11	.4572E-12
SW	.8395E-10	.4177E-10	.1850E-10	.1026E-10	.4326E-11	.2285E-11	.1367E-11	.6175E-12	.2630E-12
WSW	.5389E-10	.2712E-10	.1213E-10	.6734E-11	.2806E-11	.1451E-11	.8436E-12	.3592E-12	.1414E-12
W	.6556E-10	.3301E-10	.1479E-10	.8220E-11	.3441E-11	.1767E-11	.1045E-11	.4498E-12	.1798E-12
WNW	.7956E-10	.4005E-10	.1795E-10	.9987E-11	.4197E-11	.2191E-11	.1289E-11	.5610E-12	.2278E-12
NW	.1085E-09	.5490E-10	.2470E-10	.1378E-10	.5802E-11	.3028E-11	.1780E-11	.7711E-12	.3100E-12
NNW	.9478E-10	.4791E-10	.2149E-10	.1198E-10	.5049E-11	.2644E-11	.1562E-11	.6834E-12	.2781E-12
N	.1056E-09	.5364E-10	.2416E-10	.1348E-10	.5648E-11	.2928E-11	.1707E-11	.7241E-12	.2815E-12
TOTAL	.3866E-08	.1954E-08	.8751E-09	.4886E-09	.2069E-09	.1093E-09	.6527E-10	.2914E-10	.1213E-10

TABLE B-4. INITIAL PLUME AIR CONCENTRATION.

SURFACE DEPLETION MODEL, VD/U = .001

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.8775E-03	.7443E-03	.6877E-03	.5705E-03	.4470E-03	.2743E-03	.1476E-03	.6831E-04	.3882E-04	.1742E-04
NE	.1214E-02	.1035E-02	.8414E-03	.6485E-03	.4902E-03	.2915E-03	.1546E-03	.7118E-04	.4047E-04	.1821E-04
ENE	.1580E-02	.1362E-02	.1118E-02	.8664E-03	.6570E-03	.3920E-03	.2083E-03	.9605E-04	.5465E-04	.2462E-04
E	.1688E-02	.1564E-02	.1296E-02	.9866E-03	.7390E-03	.4354E-03	.2257E-03	.1056E-03	.6008E-04	.2709E-04
ESE	.3174E-02	.2575E-02	.1813E-02	.1296E-02	.9436E-03	.5438E-03	.2843E-03	.1305E-03	.7434E-04	.3365E-04
SE	.2752E-02	.2175E-02	.1563E-02	.1140E-02	.8394E-03	.4885E-03	.2564E-03	.1177E-03	.6688E-04	.3012E-04
SSE	.1251E-02	.1017E-02	.9069E-03	.7442E-03	.5805E-03	.3549E-03	.1906E-03	.8809E-04	.5002E-04	.2241E-04
S	.1508E-02	.1083E-02	.8432E-03	.6667E-03	.5134E-03	.3112E-03	.1666E-03	.7686E-04	.4362E-04	.1953E-04
SSW	.1395E-02	.9539E-03	.6839E-03	.5249E-03	.3995E-03	.2401E-03	.1280E-03	.5901E-04	.3348E-04	.1499E-04
SW	.1141E-02	.7886E-03	.5988E-03	.4730E-03	.3646E-03	.2214E-03	.1186E-03	.5474E-04	.3106E-04	.1390E-04
WSW	.7262E-03	.5469E-03	.4995E-03	.4234E-03	.3360E-03	.2086E-03	.1129E-03	.5229E-04	.2970E-04	.1329E-04
W	.8195E-03	.6222E-03	.5736E-03	.4876E-03	.3873E-03	.2406E-03	.1302E-03	.6036E-04	.3428E-04	.1535E-04
WNW	.8394E-03	.6470E-03	.6012E-03	.5113E-03	.4061E-03	.2522E-03	.1365E-03	.6326E-04	.3593E-04	.1609E-04
NW	.9345E-03	.7460E-03	.6991E-03	.5918E-03	.4686E-03	.2902E-03	.1568E-03	.7265E-04	.4127E-04	.1849E-04
NNW	.7738E-03	.6193E-03	.5699E-03	.4783E-03	.3773E-03	.2329E-03	.1257E-03	.5823E-04	.3308E-04	.1483E-04
N	.7283E-03	.6115E-03	.5776E-03	.4845E-03	.3815E-03	.2350E-03	.1266E-03	.5861E-04	.3330E-04	.1493E-04
TOTAL	.2140E-01	.1709E-01	.1387E-01	.1089E-01	.8331E-02	.5013E-02	.2673E-02	.1233E-02	.7010E-03	.3149E-03

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.9894E-05	.6400E-05	.3354E-05	.1717E-05	.8221E-06	.4966E-06	.2508E-06	.1578E-06	.1115E-06
NE	.1037E-04	.6724E-05	.3537E-05	.1818E-05	.8740E-06	.5291E-06	.2678E-06	.1685E-06	.1189E-06
ENE	.1404E-04	.9115E-05	.4804E-05	.2476E-05	.1193E-05	.7237E-06	.3671E-06	.2312E-06	.1632E-06
E	.1546E-04	.1004E-04	.5300E-05	.2736E-05	.1322E-05	.8031E-06	.4085E-06	.2579E-06	.1824E-06
ESE	.1927E-04	.1256E-04	.6657E-05	.3450E-05	.1672E-05	.1016E-05	.5154E-06	.3238E-06	.2279E-06
SE	.1717E-04	.1115E-04	.5869E-05	.3018E-05	.1450E-05	.8762E-06	.4418E-06	.2768E-06	.1947E-06
SSE	.1271E-04	.8215E-05	.4295E-05	.2194E-05	.1046E-05	.6305E-06	.3174E-06	.1993E-06	.1406E-06
S	.1107E-04	.7145E-05	.3728E-05	.1898E-05	.9010E-06	.5405E-06	.2702E-06	.1687E-06	.1185E-06
SSW	.8493E-05	.5480E-05	.2857E-05	.1453E-05	.6877E-06	.4115E-06	.2047E-06	.1273E-06	.8907E-07
SW	.7870E-05	.5076E-05	.2645E-05	.1344E-05	.6366E-06	.3811E-06	.1900E-06	.1183E-06	.8297E-07
WSW	.7532E-05	.4861E-05	.2537E-05	.1293E-05	.6149E-06	.3698E-06	.1857E-06	.1164E-06	.8202E-07
W	.8695E-05	.5612E-05	.2929E-05	.1493E-05	.7102E-06	.4272E-06	.2146E-06	.1345E-06	.9484E-07
WNW	.9115E-05	.5883E-05	.3071E-05	.1566E-05	.7453E-06	.4484E-06	.2254E-06	.1413E-06	.9966E-07
NW	.1048E-04	.6770E-05	.3537E-05	.1806E-05	.8609E-06	.5187E-06	.2611E-06	.1639E-06	.1157E-06
NNW	.8413E-05	.5436E-05	.2843E-05	.1453E-05	.6934E-06	.4180E-06	.2105E-06	.1322E-06	.9329E-07
N	.8470E-05	.5474E-05	.2864E-05	.1464E-05	.6996E-06	.4221E-06	.2130E-06	.1339E-06	.9460E-07
TOTAL	.1791E-03	.1159E-03	.6083E-04	.3118E-04	.1493E-04	.9012E-05	.4544E-05	.2852E-05	.2010E-05

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.6705E-07	.3984E-07	.2235E-07	.1488E-07	.8291E-08	.5396E-08	.3811E-08	.2177E-08	.1121E-08
NE	.7141E-07	.4233E-07	.2368E-07	.1574E-07	.8776E-08	.5727E-08	.4060E-08	.2341E-08	.1228E-08
ENE	.9802E-07	.5804E-07	.3241E-07	.2149E-07	.1195E-07	.7783E-08	.5508E-08	.3168E-08	.1659E-08
E	.1099E-06	.6532E-07	.3666E-07	.2440E-07	.1366E-07	.8948E-08	.6366E-08	.3694E-08	.1959E-08
ESE	.1359E-06	.7973E-07	.4400E-07	.2894E-07	.1595E-07	.1035E-07	.7314E-08	.4222E-08	.2239E-08
SE	.1162E-06	.6836E-07	.3793E-07	.2506E-07	.1389E-07	.9040E-08	.6401E-08	.3692E-08	.1947E-08
SSE	.8449E-07	.5018E-07	.2817E-07	.1876E-07	.1047E-07	.6820E-08	.4819E-08	.2754E-08	.1418E-08
S	.7066E-07	.4165E-07	.2319E-07	.1537E-07	.8514E-08	.5518E-08	.3884E-08	.2207E-08	.1127E-08
SSW	.5283E-07	.3095E-07	.1712E-07	.1129E-07	.6216E-08	.4012E-08	.2815E-08	.1592E-08	.8098E-09
SW	.4937E-07	.2904E-07	.1613E-07	.1067E-07	.5897E-08	.3813E-08	.2679E-08	.1516E-08	.7694E-09
WSW	.4919E-07	.2916E-07	.1633E-07	.1086E-07	.6034E-08	.3914E-08	.2754E-08	.1561E-08	.7921E-09
W	.5689E-07	.3374E-07	.1890E-07	.1257E-07	.6983E-08	.4530E-08	.3187E-08	.1807E-08	.9169E-09
WNW	.5981E-07	.3548E-07	.1988E-07	.1322E-07	.7350E-08	.4769E-08	.3357E-08	.1904E-08	.9672E-09
NW	.6950E-07	.4127E-07	.2315E-07	.1541E-07	.8576E-08	.5572E-08	.3927E-08	.2233E-08	.1140E-08
NNW	.5602E-07	.3324E-07	.1863E-07	.1239E-07	.6891E-08	.4476E-08	.3154E-08	.1794E-08	.9172E-09
N	.5692E-07	.3385E-07	.1902E-07	.1268E-07	.7074E-08	.4607E-08	.3254E-08	.1858E-08	.9548E-09
TOTAL	.1204E-05	.7122E-06	.3976E-06	.2637E-06	.1465E-06	.9527E-07	.6729E-07	.3852E-07	.1997E-07

TABLE B-5. DEPOSITION FLUX.

SURFACE DEPLETION MODEL, VD/U = .001

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.										
	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000	
	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000	
NNE	.2400E-05	.1864E-05	.1211E-05	.8273E-06	.5879E-06	.3312E-06	.1711E-06	.7818E-07	.4450E-07	.2015E-07
	.1154E-07	.7522E-08	.3987E-08	.2064E-08	.9979E-09	.6050E-09	.3055E-09	.1912E-09	.1341E-09	
	.7954E-10	.4638E-10	.2543E-10	.1666E-10	.9145E-11	.5928E-11	.4193E-11	.2428E-11	.1300E-11	
NE	.4274E-05	.3372E-05	.2112E-05	.1390E-05	.9646E-06	.5308E-06	.2710E-06	.1235E-06	.7040E-07	.3203E-07
	.1843E-07	.1207E-07	.6440E-08	.3358E-08	.1636E-08	.9966E-09	.5056E-09	.3168E-09	.2222E-09	
	.1315E-09	.7640E-10	.4164E-10	.2715E-10	.1484E-10	.9613E-11	.6805E-11	.3963E-11	.2150E-11	
ENE	.5646E-05	.4487E-05	.2841E-05	.1886E-05	.1316E-05	.7288E-06	.3735E-06	.1705E-06	.9730E-07	.4431E-07
	.2552E-07	.1672E-07	.8933E-08	.4666E-08	.2278E-08	.1389E-08	.7063E-09	.4431E-09	.3110E-09	
	.1843E-09	.1071E-09	.5834E-10	.3802E-10	.2075E-10	.1341E-10	.9479E-11	.5504E-11	.2975E-11	
E	.5516E-05	.4729E-05	.3202E-05	.2167E-05	.1523E-05	.8461E-06	.4337E-06	.1978E-06	.1127E-06	.5127E-07
	.2949E-07	.1930E-07	.1030E-07	.5377E-08	.2626E-08	.1604E-08	.8186E-09	.5158E-09	.3635E-09	
	.2171E-09	.1275E-09	.7039E-10	.4632E-10	.2565E-10	.1676E-10	.1193E-10	.6991E-11	.3805E-11	
ESE	.1334E-04	.1025E-04	.6065E-05	.3863E-05	.2635E-05	.1427E-05	.7242E-06	.3300E-06	.1888E-06	.8646E-07
	.5005E-07	.3293E-07	.1771E-07	.9308E-08	.4571E-08	.2796E-08	.1422E-08	.8906E-09	.6230E-09	
	.3665E-09	.2106E-09	.1130E-09	.7279E-10	.3909E-10	.2503E-10	.1759E-10	.1018E-10	.5533E-11	
SE	.9569E-05	.7252E-05	.4351E-05	.2812E-05	.1935E-05	.1057E-05	.5376E-06	.2446E-06	.1394E-06	.6338E-07
	.3646E-07	.2385E-07	.1271E-07	.6616E-08	.3213E-08	.1951E-08	.9853E-09	.6149E-09	.4297E-09	
	.2530E-09	.1460E-09	.7897E-10	.5122E-10	.2780E-10	.1792E-10	.1265E-10	.7348E-11	.3985E-11	
SSE	.2405E-05	.1841E-05	.1272E-05	.9068E-06	.6598E-06	.3795E-06	.1978E-06	.9041E-07	.5128E-07	.2303E-07
	.1309E-07	.8477E-08	.4443E-08	.2272E-08	.1084E-08	.6515E-09	.3262E-09	.2036E-09	.1428E-09	
	.8502E-10	.4999E-10	.2778E-10	.1839E-10	.1024E-10	.6689E-11	.4752E-11	.2754E-11	.1459E-11	
S	.2505E-05	.1748E-05	.1072E-05	.7294E-06	.5198E-06	.2941E-06	.1523E-06	.6942E-07	.3937E-07	.1768E-07
	.1005E-07	.6509E-08	.3408E-08	.1738E-08	.8249E-09	.4932E-09	.2444E-09	.1511E-09	.1052E-09	
	.6174E-10	.3573E-10	.1949E-10	.1274E-10	.6977E-11	.4509E-11	.3178E-11	.1825E-11	.9599E-12	
SSW	.2695E-05	.1814E-05	.1019E-05	.6592E-06	.4575E-06	.2530E-06	.1296E-06	.5894E-07	.3347E-07	.1508E-07
	.8602E-08	.5583E-08	.2934E-08	.1501E-08	.7134E-09	.4262E-09	.2103E-09	.1292E-09	.8928E-10	
	.5173E-10	.2941E-10	.1568E-10	.1008E-10	.5392E-11	.3434E-11	.2398E-11	.1365E-11	.7175E-12	
SW	.1676E-05	.1119E-05	.6656E-06	.4515E-06	.3222E-06	.1829E-06	.9485E-07	.4325E-07	.2451E-07	.1099E-07
	.6235E-08	.4029E-08	.2102E-08	.1068E-08	.5035E-09	.2996E-09	.1474E-09	.9064E-10	.6281E-10	
	.3665E-10	.2108E-10	.1143E-10	.7441E-11	.4047E-11	.2601E-11	.1825E-11	.1039E-11	.5397E-12	
WSW	.8099E-06	.5749E-06	.4063E-06	.3032E-06	.2269E-06	.1342E-06	.7094E-07	.3256E-07	.1846E-07	.8257E-08
	.4677E-08	.3017E-08	.1572E-08	.7987E-09	.3778E-09	.2259E-09	.1123E-09	.6984E-10	.4890E-10	
	.2905E-10	.1706E-10	.9475E-11	.6271E-11	.3479E-11	.2260E-11	.1596E-11	.9125E-12	.4717E-12	
W	.1023E-05	.7226E-06	.5012E-06	.3703E-06	.2758E-06	.1624E-06	.8568E-07	.3930E-07	.2227E-07	.9959E-08
	.5640E-08	.3638E-08	.1895E-08	.9619E-09	.4546E-09	.2716E-09	.1349E-09	.8375E-10	.5858E-10	
	.3475E-10	.2039E-10	.1131E-10	.7478E-11	.4145E-11	.2693E-11	.1901E-11	.1087E-11	.5628E-12	
WNW	.1297E-05	.9136E-06	.6156E-06	.4469E-06	.3298E-06	.1926E-06	.1013E-06	.4638E-07	.2628E-07	.1176E-07
	.6662E-08	.4298E-08	.2240E-08	.1137E-08	.5374E-09	.3209E-09	.1592E-09	.9874E-10	.6899E-10	
	.4084E-10	.2390E-10	.1322E-10	.8726E-11	.4828E-11	.3134E-11	.2213E-11	.1267E-11	.6577E-12	
NW	.1565E-05	.1175E-05	.8127E-06	.5892E-06	.4335E-06	.2523E-06	.1323E-06	.6063E-07	.3439E-07	.1543E-07
	.8764E-08	.5669E-08	.2966E-08	.1514E-08	.7206E-09	.4325E-09	.2161E-09	.1347E-09	.9437E-10	
	.5609E-10	.3292E-10	.1825E-10	.1206E-10	.6687E-11	.4351E-11	.3079E-11	.1772E-11	.9286E-12	
NNW	.1400E-05	.1047E-05	.6986E-06	.4932E-06	.3577E-06	.2055E-06	.1072E-06	.4904E-07	.2786E-07	.1254E-07
	.7144E-08	.4634E-08	.2436E-08	.1250E-08	.5981E-09	.3602E-09	.1805E-09	.1126E-09	.7886E-10	
	.4677E-10	.2734E-10	.1507E-10	.9912E-11	.5466E-11	.3548E-11	.2508E-11	.1445E-11	.7621E-12	
N	.1347E-05	.1073E-05	.7642E-06	.5506E-06	.4024E-06	.2324E-06	.1214E-06	.5561E-07	.3159E-07	.1422E-07
	.8108E-08	.5262E-08	.2770E-08	.1424E-08	.6835E-09	.4129E-09	.2081E-09	.1304E-09	.9168E-10	
	.5473E-10	.3223E-10	.1791E-10	.1185E-10	.6589E-11	.4300E-11	.3053E-11	.1768E-11	.9379E-12	
TOTAL	.5749E-04	.4599E-04	.2761E-04	.1845E-04	.1295E-04	.7210E-05	.3704E-05	.1690E-05	.9626E-06	.4365E-06
	.2505E-06	.1635E-06	.8684E-07	.4505E-07	.2182E-07	.1324E-07	.6683E-08	.4177E-08	.2925E-08	
	.1729E-08	.1004E-08	.5474E-09	.3571E-09	.1951E-09	.1262E-09	.8916E-10	.5165E-10	.2774E-10	

TABLE B-6. INITIAL PLUME AIR CONCENTRATION.

SOURCE DEPLETION MODEL, VD/U = .010

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.										
	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000	
	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000	
NNE	.8473E-03	.7166E-03	.6561E-03	.5285E-03	.3989E-03	.2277E-03	.1127E-03	.4726E-04	.2500E-04	.1008E-04
	.5293E-05	.3213E-05	.1519E-05	.6965E-06	.2886E-06	.1547E-06	.6485E-07	.3491E-07	.2139E-07	
	.1004E-07	.4368E-08	.1592E-08	.7468E-09	.2508E-09	.1182E-09	.6787E-10	.3100E-10	.1397E-10	
NE	.1175E-02	.9952E-03	.7957E-03	.5954E-03	.4346E-03	.2420E-03	.1189E-03	.5005E-04	.2666E-04	.1090E-04
	.5780E-05	.3542E-05	.1700E-05	.7919E-06	.3350E-06	.1825E-06	.7836E-07	.4290E-07	.2668E-07	
	.1287E-07	.5793E-08	.2209E-08	.1070E-08	.3688E-09	.1723E-09	.9653E-10	.4187E-10	.1776E-10	
ENE	.1532E-02	.1310E-02	.1056E-02	.7951E-03	.5822E-03	.3251E-03	.1599E-03	.6733E-04	.3587E-04	.1466E-04
	.7784E-05	.4773E-05	.2295E-05	.1071E-05	.4543E-06	.2481E-06	.1068E-06	.5862E-07	.3650E-07	
	.1764E-07	.7961E-08	.3049E-08	.1483E-08	.5151E-09	.2412E-09	.1347E-09	.5752E-10	.2367E-10	
E	.1641E-02	.1508E-02	.1223E-02	.9018E-03	.6521E-03	.3601E-03	.1763E-03	.7423E-04	.3960E-04	.1624E-04
	.8644E-05	.5313E-05	.2564E-05	.1201E-05	.5120E-06	.2807E-06	.1217E-06	.6706E-07	.4192E-07	
	.2039E-07	.9235E-08	.3525E-08	.1694E-08	.5641E-09	.2518E-09	.1346E-09	.5415E-10	.2119E-10	
ESE	.3078E-02	.2465E-02	.1697E-02	.1179E-02	.8325E-03	.4526E-03	.2212E-03	.9380E-04	.5046E-04	.2100E-04
	.1131E-04	.7024E-05	.3444E-05	.1639E-05	.7123E-06	.3960E-06	.1746E-06	.9740E-07	.6144E-07	
	.3045E-07	.1418E-07	.5684E-08	.2868E-08	.1050E-08	.5044E-09	.2838E-09	.1201E-09	.4784E-10	
SE	.2661E-02	.2083E-02	.1469E-02	.1042E-02	.7437E-03	.4075E-03	.1995E-03	.8433E-04	.4518E-04	.1866E-04
	.9981E-05	.6158E-05	.2988E-05	.1406E-05	.6021E-06	.3310E-06	.1439E-06	.7953E-07	.4900E-07	
	.2446E-07	.1127E-07	.4466E-08	.2246E-08	.8273E-09	.4054E-09	.2346E-09	.1054E-09	.4572E-10	
SSE	.1205E-02	.9787E-03	.8656E-03	.6900E-03	.5187E-03	.2953E-03	.1460E-03	.6125E-04	.3242E-04	.1308E-04
	.6865E-05	.4167E-05	.1968E-05	.9007E-06	.3722E-06	.1990E-06	.8306E-07	.4457E-07	.2726E-07	
	.1275E-07	.5517E-08	.1997E-08	.9312E-09	.3101E-09	.1460E-09	.0431E-10	.3918E-10	.1817E-10	
S	.1449E-02	.1037E-02	.8035E-03	.6196E-03	.4610E-03	.2610E-03	.1291E-03	.5434E-04	.2886E-04	.1171E-04
	.6174E-05	.3760E-05	.1785E-05	.8204E-06	.3404E-06	.1825E-06	.7634E-07	.4104E-07	.2516E-07	
	.1184E-07	.5189E-08	.1938E-08	.9392E-09	.3391E-09	.1701E-09	.1023E-09	.4926E-10	.2317E-10	
SSW	.1340E-02	.9110E-03	.6499E-03	.4877E-03	.3594E-03	.2023E-03	.1000E-03	.4221E-04	.2248E-04	.9166E-05
	.4849E-05	.2962E-05	.1412E-05	.6520E-06	.2718E-06	.1462E-06	.6141E-07	.3313E-07	.2038E-07	
	.9659E-08	.4286E-08	.1642E-08	.8169E-09	.3091E-09	.1597E-09	.9755E-10	.4749E-10	.2234E-10	
SW	.1095E-02	.7546E-03	.5713E-03	.4405E-03	.3283E-03	.1862E-03	.9220E-04	.3884E-04	.2063E-04	.8372E-05
	.4412E-05	.2686E-05	.1274E-05	.5850E-06	.2423E-06	.1296E-06	.5402E-07	.2897E-07	.1773E-07	
	.8313E-08	.3634E-08	.1359E-08	.6622E-09	.2490E-09	.1245E-09	.7592E-10	.3716E-10	.1768E-10	
WSW	.6980E-03	.5259E-03	.4795E-03	.3953E-03	.3020E-03	.1741E-03	.8649E-04	.3628E-04	.1916E-04	.7699E-05
	.4026E-05	.2436E-05	.1144E-05	.5204E-06	.2132E-06	.1131E-06	.4662E-07	.2478E-07	.1503E-07	
	.6919E-08	.2940E-08	.1044E-08	.4831E-09	.1639E-09	.8019E-10	.4804E-10	.2338E-10	.1119E-10	
W	.7877E-03	.5982E-03	.5505E-03	.4551E-03	.3480E-03	.2007E-03	.9972E-04	.4182E-04	.2208E-04	.8868E-05
	.4635E-05	.2803E-05	.1316E-05	.5985E-06	.2451E-06	.1300E-06	.5356E-07	.2847E-07	.1726E-07	
	.7943E-08	.3373E-08	.1196E-08	.5531E-09	.1874E-09	.9168E-10	.5494E-10	.2675E-10	.1281E-10	
WNW	.8069E-03	.6218E-03	.5765E-03	.4768E-03	.3645E-03	.2102E-03	.1044E-03	.4376E-04	.2311E-04	.9276E-05
	.4848E-05	.2931E-05	.1376E-05	.6256E-06	.2562E-06	.1359E-06	.5602E-07	.2978E-07	.1806E-07	
	.8315E-08	.3533E-08	.1253E-08	.5786E-09	.1955E-09	.9527E-10	.5694E-10	.2765E-10	.1321E-10	
NW	.8995E-03	.7178E-03	.6697E-03	.5509E-03	.4199E-03	.2415E-03	.1198E-03	.5022E-04	.2653E-04	.1066E-04
	.5575E-05	.3374E-05	.1586E-05	.7226E-06	.2967E-06	.1578E-06	.6534E-07	.3485E-07	.2119E-07	
	.9805E-08	.4109E-08	.1493E-08	.6905E-09	.2311E-09	.1109E-09	.6533E-10	.3115E-10	.1468E-10	
NNW	.7453E-03	.5956E-03	.5452E-03	.4446E-03	.3378E-03	.1938E-03	.9611E-04	.4031E-04	.2131E-04	.8577E-05
	.4493E-05	.2723E-05	.1283E-05	.5859E-06	.2414E-06	.1288E-06	.5353E-07	.2863E-07	.1746E-07	
	.8114E-08	.3487E-08	.1254E-08	.5835E-09	.1962E-09	.9378E-10	.5476E-10	.2564E-10	.1183E-10	
N	.7024E-03	.5896E-03	.5526E-03	.4498E-03	.3409E-03	.1952E-03	.9666E-04	.4052E-04	.2142E-04	.8619E-05
	.4515E-05	.2736E-05	.1289E-05	.5890E-06	.2428E-06	.1296E-06	.5397E-07	.2890E-07	.1763E-07	
	.8206E-08	.3926E-08	.1260E-08	.5790E-09	.1006E-09	.8737E-10	.4990E-10	.2291E-10	.1051E-10	
TOTAL	.2066E-01	.1641E-01	.1316E-01	.1005E-01	.7424E-02	.4175E-02	.2059E-02	.8665E-03	.4608E-03	.1876E-03
	.9919E-04	.6060E-04	.2894E-04	.1341E-04	.5626E-05	.3045E-05	.1294E-05	.7035E-06	.4350E-06	
	.2077E-06	.9247E-07	.3496E-07	.1693E-07	.5941E-08	.2853E-08	.1642E-08	.7406E-09	.3258E-09	

TABLE B-7. DEPOSITION FLUX.

SOURCE DEPLETION MODEL, VD/U = .010

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.2323E-04	.1780E-04	.1129E-04	.7499E-05	.5179E-05	.2768E-05	.1346E-05	.5729E-06	.3098E-06	.1301E-06
NE	.4145E-04	.3220E-04	.1959E-04	.1252E-04	.8453E-05	.4433E-05	.2145E-05	.9170E-06	.4993E-06	.2124E-06
ENE	.5479E-04	.4284E-04	.2635E-04	.1699E-04	.1154E-04	.6080E-05	.2947E-05	.1260E-05	.6852E-06	.2911E-06
E	.5366E-04	.4535E-04	.2979E-04	.1952E-04	.1331E-04	.7019E-05	.3395E-05	.1445E-05	.7836E-06	.3311E-06
ESE	.1294E-03	.9769E-04	.5598E-04	.3464E-04	.2304E-04	.1195E-04	.5779E-05	.2487E-05	.1364E-05	.5877E-06
SE	.9266E-04	.6910E-04	.4029E-04	.2532E-04	.1698E-04	.8865E-05	.4288E-05	.1837E-05	.1002E-05	.4278E-06
SSE	.2320E-04	.1762E-04	.1195E-04	.8292E-05	.5851E-05	.3177E-05	.1550E-05	.6554E-06	.3515E-06	.1454E-06
S	.2412E-04	.1665E-04	.1004E-04	.6675E-05	.4632E-05	.2490E-05	.1215E-05	.5167E-06	.2789E-06	.1165E-06
SSW	.2595E-04	.1723E-04	.9468E-05	.6008E-05	.4077E-05	.2157E-05	.1050E-05	.4499E-06	.2448E-06	.1037E-06
SW	.1611E-04	.1065E-04	.6243E-05	.4148E-05	.2386E-05	.1557E-05	.7611E-06	.3241E-06	.1749E-06	.7303E-07
WSW	.7786E-05	.5496E-05	.3848E-05	.2803E-05	.2032E-05	.1129E-05	.5553E-06	.2343E-06	.1250E-06	.5115E-07
W	.9830E-05	.6901E-05	.4740E-05	.3419E-05	.2469E-05	.1367E-05	.6717E-06	.2836E-06	.1514E-06	.6203E-07
WNW	.1247E-04	.8717E-05	.5808E-05	.4117E-05	.2949E-05	.1623E-05	.7963E-06	.3365E-06	.1800E-06	.7400E-07
NW	.1527E-04	.1123E-04	.7652E-05	.5407E-05	.3358E-05	.2116E-05	.1036E-05	.4379E-06	.2344E-06	.9658E-07
NNW	.1351E-04	.9996E-05	.6550E-05	.4506E-05	.3173E-05	.1723E-05	.8417E-06	.3568E-06	.1918E-06	.7965E-07
N	.1302E-04	.1028E-04	.7180E-05	.5027E-05	.3560E-05	.1938E-05	.9466E-06	.4003E-06	.2147E-06	.8883E-07
TOTAL	.5565E-03	.4198E-03	.2568E-03	.1669E-03	.1140E-03	.6040E-04	.2933E-04	.1251E-04	.6792E-05	.2871E-05

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.7055E-07	.4403E-07	.2176E-07	.1043E-07	.4566E-08	.2553E-08	.1134E-08	.6367E-09	.4041E-09
NE	.1163E-06	.7321E-07	.3666E-07	.1780E-07	.7916E-08	.4476E-08	.2017E-08	.1142E-08	.7293E-09
ENE	.1593E-06	.1002E-06	.5016E-07	.2436E-07	.1084E-07	.6129E-08	.2763E-08	.1565E-08	.9991E-09
E	.1805E-06	.1132E-06	.5639E-07	.2725E-07	.1207E-07	.6802E-08	.3059E-08	.1728E-08	.1101E-08
ESE	.3252E-06	.2064E-06	.1047E-06	.5151E-07	.2325E-07	.1328E-07	.6054E-08	.3455E-08	.2216E-08
SE	.2349E-06	.1481E-06	.7431E-07	.3614E-07	.1610E-07	.9112E-08	.4111E-08	.2332E-08	.1491E-08
SSE	.7782E-07	.4802E-07	.2328E-07	.1093E-07	.4661E-08	.2555E-08	.1106E-08	.6091E-09	.3816E-09
S	.6284E-07	.3901E-07	.1908E-07	.9030E-08	.3884E-08	.2141E-08	.9315E-09	.5155E-09	.3242E-09
SSW	.5654E-07	.3540E-07	.1756E-07	.8422E-08	.3679E-08	.2052E-08	.9047E-09	.5059E-09	.3205E-09
SW	.3936E-07	.2440E-07	.1191E-07	.5622E-08	.2408E-08	.1322E-08	.5714E-09	.3149E-09	.1974E-09
WSW	.2713E-07	.1661E-07	.7945E-08	.3678E-08	.1539E-08	.8310E-09	.3515E-09	.1906E-09	.1179E-09
W	.3293E-07	.2018E-07	.9664E-08	.4478E-08	.1877E-08	.1014E-08	.4298E-09	.2334E-09	.1446E-09
WNW	.3939E-07	.2419E-07	.1163E-07	.5407E-08	.2277E-08	.1235E-08	.5258E-09	.2866E-09	.1782E-09
NW	.5153E-07	.3171E-07	.1531E-07	.7156E-08	.3036E-08	.1657E-08	.7128E-09	.3912E-09	.2444E-09
NNW	.4278E-07	.2648E-07	.1290E-07	.6094E-08	.2619E-08	.1443E-08	.6288E-09	.3482E-09	.2189E-09
N	.4759E-07	.2939E-07	.1428E-07	.6729E-08	.2885E-08	.1588E-08	.6913E-09	.3823E-09	.2399E-09
TOTAL	.1565E-05	.9805E-06	.4875E-06	.2350E-06	.1036E-06	.5819E-07	.2599E-07	.1464E-07	.9309E-08

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.2026E-09	.9578E-10	.3936E-10	.2033E-10	.7746E-11	.3842E-11	.2222E-11	.9817E-12	.4119E-12
NE	.3693E-09	.1763E-09	.7309E-10	.3781E-10	.1426E-10	.6942E-11	.3923E-11	.1658E-11	.6548E-12
ENE	.5058E-09	.2414E-09	.1001E-09	.5178E-10	.1957E-10	.9531E-11	.5383E-11	.2266E-11	.8861E-12
E	.5549E-09	.2625E-09	.1066E-09	.5390E-10	.1936E-10	.9014E-11	.4904E-11	.1960E-11	.7280E-12
ESE	.1132E-08	.5462E-09	.2301E-09	.1206E-09	.4641E-10	.2280E-10	.1289E-10	.5377E-11	.2048E-11
SE	.7584E-09	.3647E-09	.1534E-09	.8062E-10	.3143E-10	.1574E-10	.9128E-11	.4015E-11	.1661E-11
SSE	.1868E-09	.8588E-10	.3394E-10	.1704E-10	.6255E-11	.3071E-11	.1790E-11	.8219E-12	.3702E-12
S	.1601E-09	.7468E-10	.3047E-10	.1581E-10	.6174E-11	.3170E-11	.1900E-11	.8926E-12	.4039E-12
SSW	.1606E-09	.7641E-10	.3215E-10	.1712E-10	.6948E-11	.3636E-11	.2195E-11	.1028E-11	.4568E-12
SW	.9702E-10	.4512E-10	.1845E-10	.9642E-11	.3844E-11	.2012E-11	.1225E-11	.5872E-12	.2705E-12
WSW	.5643E-10	.2533E-10	.9799E-11	.4895E-11	.1837E-11	.9391E-12	.5707E-12	.2784E-12	.1326E-12
W	.6949E-10	.3137E-10	.1225E-10	.6176E-11	.2355E-11	.1217E-11	.7445E-12	.3660E-12	.1754E-12
WNW	.8618E-10	.3923E-10	.1551E-10	.7898E-11	.3049E-11	.1581E-11	.9677E-12	.4740E-12	.2258E-12
NW	.1191E-09	.5463E-10	.2163E-10	.1100E-10	.4166E-11	.2112E-11	.1265E-11	.6009E-12	.2778E-12
NNW	.1079E-09	.5008E-10	.2016E-10	.1030E-10	.3909E-11	.1959E-11	.1153E-11	.5283E-12	.2333E-12
N	.1178E-09	.5425E-10	.2142E-10	.1071E-10	.3875E-11	.1867E-11	.1066E-11	.4714E-12	.2027E-12
TOTAL	.4685E-08	.2224E-08	.9185E-09	.4756E-09	.1812E-09	.8944E-10	.5133E-10	.2231E-10	.9139E-11

TABLE B-8. INITIAL PLUME AIR CONCENTRATION.

SOURCE DEPLETION MODEL, VD/U = .001

RADIAL DISTANCE(KILOMETERS)

AZIMUTH DIR.	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
NNE	.8769E-03	.7440E-03	.6869E-03	.5684E-03	.4443E-03	.2724E-03	.1477E-03	.6954E-04	.4007E-04	.1830E-04
NE	.1213E-02	.1034E-02	.8398E-03	.6462E-03	.4879E-03	.2904E-03	.1552E-03	.7259E-04	.4177E-04	.1909E-04
ENE	.1578E-02	.1360E-02	.1116E-02	.8634E-03	.6539E-03	.3904E-03	.2091E-03	.9793E-04	.5642E-04	.2582E-04
E	.1680E-02	.1561E-02	.1292E-02	.9825E-03	.7354E-03	.4341E-03	.2309E-03	.1078E-03	.6206E-04	.2840E-04
ESE	.3168E-02	.2569E-02	.1809E-02	.1293E-02	.9415E-03	.5436E-03	.2863E-03	.1332E-03	.7670E-04	.3518E-04
SE	.2743E-02	.2172E-02	.1561E-02	.1137E-02	.8371E-03	.4878E-03	.2579E-03	.1200E-03	.6899E-04	.3151E-04
SSE	.1251E-02	.1018E-02	.9063E-03	.7417E-03	.5772E-03	.3526E-03	.1908E-03	.8967E-04	.5162E-04	.2353E-04
S	.1509E-02	.1084E-02	.8437E-03	.6654E-03	.5111E-03	.3094E-03	.1667E-03	.7818E-04	.4495E-04	.2046E-04
SSW	.1305E-02	.9548E-03	.6847E-03	.5244E-03	.3982E-03	.2389E-03	.1282E-03	.6000E-04	.3448E-04	.1568E-04
SW	.1141E-02	.7898E-03	.5995E-03	.4722E-03	.3631E-03	.2201E-03	.1187E-03	.5565E-04	.3200E-04	.1456E-04
WSW	.7266E-03	.5478E-03	.4997E-03	.4221E-03	.3339E-03	.2069E-03	.1128E-03	.5316E-04	.3063E-04	.1396E-04
W	.8199E-03	.6231E-03	.5737E-03	.4761E-03	.3849E-03	.2387E-03	.1301E-03	.6137E-04	.3535E-04	.1612E-04
WNW	.8595E-03	.6477E-03	.6012E-03	.5097E-03	.4036E-03	.2502E-03	.1364E-03	.6433E-04	.3706E-04	.1689E-04
NW	.9345E-03	.7466E-03	.6989E-03	.5828E-03	.4657E-03	.2860E-03	.1568E-03	.7390E-04	.4258E-04	.1942E-04
NNW	.7737E-03	.6196E-03	.5696E-03	.4766E-03	.3750E-03	.2312E-03	.1257E-03	.5924E-04	.3413E-04	.1557E-04
N	.7263E-03	.6118E-03	.5771E-03	.4826E-03	.3791E-03	.2332E-03	.1267E-03	.5965E-04	.3436E-04	.1568E-04
TOTAL	.2139E-01	.1708E-01	.1386E-01	.1086E-01	.8292E-02	.4968E-02	.2680E-02	.1256E-02	.7232E-03	.3302E-03

AZIMUTH DIR.	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000
NNE	.1051E-04	.6852E-05	.3627E-05	.1876E-05	.9069E-06	.5508E-06	.2806E-06	.1775E-06	.1257E-06
NE	.1098E-04	.7171E-05	.3806E-05	.1974E-05	.9575E-06	.5826E-06	.2972E-06	.1879E-06	.1330E-06
ENE	.1487E-04	.9724E-05	.5171E-05	.2689E-05	.1308E-05	.7970E-06	.4074E-06	.2579E-06	.1826E-06
E	.1636E-04	.1071E-04	.5698E-05	.2967E-05	.1445E-05	.8825E-06	.4523E-06	.2868E-06	.2035E-06
ESE	.2031E-04	.1332E-04	.7116E-05	.3716E-05	.1815E-05	.1108E-05	.5663E-06	.3575E-06	.2524E-06
SE	.1812E-04	.1184E-04	.6287E-05	.3260E-05	.1579E-05	.9591E-06	.4874E-06	.3069E-06	.2165E-06
SSE	.1349E-04	.8790E-05	.4642E-05	.2395E-05	.1154E-05	.6991E-06	.3551E-06	.2241E-06	.1586E-06
S	.1172E-04	.7626E-05	.4018E-05	.2066E-05	.9906E-06	.5977E-06	.3015E-06	.1893E-06	.1333E-06
SSW	.8976E-05	.5838E-05	.3072E-05	.1577E-05	.7541E-06	.4538E-06	.2278E-06	.1425E-06	.1000E-06
SW	.8329E-05	.5416E-05	.2850E-05	.1463E-05	.6999E-06	.4215E-06	.2120E-06	.1328E-06	.9344E-07
WSW	.7998E-05	.5207E-05	.2746E-05	.1414E-05	.6798E-06	.4112E-06	.2083E-06	.1313E-06	.9282E-07
W	.9235E-05	.6012E-05	.3171E-05	.1632E-05	.7854E-06	.4752E-06	.2409E-06	.1518E-06	.1073E-06
WNW	.9682E-05	.6304E-05	.3326E-05	.1713E-05	.8243E-06	.4988E-06	.2530E-06	.1595E-06	.1128E-06
NW	.1113E-04	.7253E-05	.3830E-05	.1975E-05	.9516E-06	.5766E-06	.2928E-06	.1845E-06	.1308E-06
NNW	.8934E-05	.5822E-05	.3076E-05	.1588E-05	.7658E-06	.4642E-06	.2359E-06	.1489E-06	.1054E-06
N	.6995E-05	.5863E-05	.3099E-05	.1601E-05	.7725E-06	.4687E-06	.2385E-06	.1508E-06	.1068E-06
TOTAL	.1896E-03	.1237E-03	.6553E-04	.3391E-04	.1639E-04	.9947E-05	.5057E-05	.3190E-05	.2255E-05

AZIMUTH DIR.	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000
NNE	.7594E-07	.4531E-07	.2548E-07	.1693E-07	.9383E-08	.6045E-08	.4217E-08	.2351E-08	.1150E-08
NE	.8026E-07	.4779E-07	.2683E-07	.1782E-07	.9906E-08	.6415E-08	.4503E-08	.2546E-08	.1283E-08
ENE	.1102E-06	.6553E-07	.3672E-07	.2436E-07	.1350E-07	.8728E-08	.6118E-08	.3454E-08	.1738E-08
E	.1231E-06	.7353E-07	.4141E-07	.2759E-07	.1540E-07	.1002E-07	.7069E-08	.4033E-08	.2065E-08
ESE	.1513E-06	.8926E-07	.4952E-07	.3264E-07	.1799E-07	.1162E-07	.8165E-08	.4653E-08	.2401E-08
SE	.1299E-06	.7680E-07	.4279E-07	.2830E-07	.1566E-07	.1012E-07	.7109E-08	.4034E-08	.2054E-08
SSE	.9570E-07	.5707E-07	.3210E-07	.2134E-07	.1184E-07	.7633E-08	.5326E-08	.2969E-08	.1450E-08
S	.7992E-07	.4733E-07	.2643E-07	.1748E-07	.9629E-08	.6175E-08	.4291E-08	.2376E-08	.1148E-08
SSW	.5965E-07	.3512E-07	.1949E-07	.1283E-07	.7028E-08	.4490E-08	.3110E-08	.1715E-08	.8245E-09
SW	.5589E-07	.3303E-07	.1840E-07	.1214E-07	.6672E-08	.4267E-08	.2957E-08	.1629E-08	.7796E-09
WSW	.5592E-07	.3329E-07	.1868E-07	.1239E-07	.6837E-08	.4383E-08	.3041E-08	.1676E-08	.8005E-09
W	.6469E-07	.3852E-07	.2162E-07	.1433E-07	.7913E-08	.5073E-08	.3520E-08	.1940E-08	.9267E-09
WNW	.6800E-07	.4050E-07	.2274E-07	.1508E-07	.8329E-08	.5342E-08	.3707E-08	.2045E-08	.9785E-09
NW	.7894E-07	.4706E-07	.2645E-07	.1756E-07	.9713E-08	.6241E-08	.4339E-08	.2402E-08	.1157E-08
NNW	.6357E-07	.3788E-07	.2127E-07	.1411E-07	.7805E-08	.5015E-08	.3488E-08	.1933E-08	.9343E-09
N	.6455E-07	.3855E-07	.2170E-07	.1443E-07	.8007E-08	.5159E-08	.3597E-08	.2003E-08	.9750E-09
TOTAL	.1357E-05	.8066E-06	.4516E-06	.2993E-06	.1656E-06	.1067E-06	.7456E-07	.4176E-07	.2066E-07

TABLE B-9. DEPOSITION FLUX.

SOURCE DEPLETION MODEL, VD/U = .001

RADIAL DISTANCE (KILOMETERS)

AZIMUTH DIR.										
	.015	.020	.030	.040	.050	.070	.100	.150	.200	.300
	.400	.500	.700	1.000	1.500	2.000	3.000	4.000	5.000	
	7.000	10.000	15.000	20.000	30.000	40.000	50.000	70.000	100.000	
NNE	.2395E-05	.1840E-05	.1200E-05	.8261E-06	.5875E-06	.3319E-06	.1727E-06	.7989E-07	.4590E-07	.2102E-07
	.1213E-07	.7950E-08	.4242E-08	.2212E-08	.1077E-08	.6561E-09	.3337E-09	.2098E-09	.1476E-09	
	.9903E-10	.5164E-10	.2846E-10	.1672E-10	.1029E-10	.6651E-11	.4683E-11	.2686E-11	.1406E-11	
NE	.4265E-05	.3362E-05	.2107E-05	.1388E-05	.9650E-06	.5332E-06	.2744E-06	.1263E-06	.7261E-07	.3336E-07
	.1932E-07	.1271E-07	.6921E-08	.3579E-08	.1755E-08	.1074E-08	.5483E-09	.3452E-09	.2428E-09	
	.1446E-09	.9451E-10	.4640E-10	.3040E-10	.1669E-10	.1081E-10	.7639E-11	.4428E-11	.2373E-11	
ENE	.5632E-05	.4473E-05	.2834E-05	.1883E-05	.1317E-05	.7319E-06	.3780E-06	.1745E-06	.1004E-06	.4617E-07
	.2677E-07	.1762E-07	.9471E-08	.4979E-08	.2447E-08	.1499E-08	.7670E-09	.4835E-09	.3403E-09	
	.2028E-09	.1186E-09	.6510E-10	.4262E-10	.2335E-10	.1509E-10	.1065E-10	.6154E-11	.3284E-11	
E	.5504E-05	.4715E-05	.3192E-05	.2161E-05	.1521E-05	.8486E-06	.4388E-06	.2025E-06	.1164E-06	.5350E-07
	.3099E-07	.2039E-07	.1095E-07	.5752E-08	.2828E-08	.1735E-08	.8912E-09	.5640E-09	.3987E-09	
	.2396E-09	.1414E-09	.7856E-10	.5194E-10	.2884E-10	.1881E-10	.1336E-10	.7773E-11	.4165E-11	
ESE	.1331E-04	.1022E-04	.6051E-05	.3861E-05	.2640E-05	.1437E-05	.7346E-06	.3379E-06	.1946E-06	.8985E-07
	.5229E-07	.3454E-07	.1867E-07	.9871E-08	.4877E-08	.2995E-08	.1533E-08	.9645E-09	.6768E-09	
	.4005E-09	.2319E-09	.1255E-09	.8136E-10	.4402E-10	.2828E-10	.1991E-10	.1154E-10	.6257E-11	
SE	.9547E-05	.7232E-05	.4343E-05	.2810E-05	.1938E-05	.1063E-05	.5446E-06	.2502E-06	.1436E-06	.6592E-07
	.3816E-07	.2507E-07	.1343E-07	.7033E-08	.3438E-08	.2097E-08	.1066E-08	.6681E-09	.4684E-09	
	.2770E-09	.1611E-09	.8782E-10	.5726E-10	.3123E-10	.2015E-10	.1421E-10	.8227E-11	.4417E-11	
SSE	.2403E-05	.1840E-05	.1271E-05	.9052E-06	.6583E-06	.3793E-06	.1992E-06	.9226E-07	.5289E-07	.2407E-07
	.1380E-07	.6993E-08	.4751E-08	.2450E-08	.1178E-08	.7118E-09	.3592E-09	.2253E-09	.1586E-09	
	.9486E-10	.5606E-10	.3127E-10	.2073E-10	.1151E-10	.7472E-11	.5262E-11	.2997E-11	.1533E-11	
S	.2503E-05	.1747E-05	.1073E-05	.7295E-06	.5198E-06	.2945E-06	.1534E-06	.7079E-07	.4052E-07	.1842E-07
	.1055E-07	.6872E-08	.3624E-08	.1863E-08	.8909E-09	.5354E-09	.2675E-09	.1663E-09	.1161E-09	
	.6854E-10	.3990E-10	.2168E-10	.1433E-10	.7842E-11	.5040E-11	.3526E-11	.1993E-11	.1014E-11	
SSW	.2691E-05	.1812E-05	.1020E-05	.6603E-06	.4586E-06	.2541E-06	.1309E-06	.6011E-07	.3440E-07	.1566E-07
	.8987E-08	.5862E-08	.3100E-08	.1597E-08	.7642E-09	.4588E-09	.2280E-09	.1408E-09	.9764E-10	
	.5693E-10	.3260E-10	.1750E-10	.1129E-10	.6057E-11	.3850E-11	.2677E-11	.1509E-11	.7762E-12	
SW	.1674E-05	.1119E-05	.6666E-06	.4520E-06	.3224E-06	.1831E-06	.9548E-07	.4405E-07	.2520E-07	.1143E-07
	.6539E-08	.4250E-08	.2234E-08	.1144E-08	.5437E-09	.3253E-09	.1613E-09	.9978E-10	.6939E-10	
	.4074E-10	.2358E-10	.1285E-10	.8378E-11	.4550E-11	.2906E-11	.2021E-11	.1131E-11	.5650E-12	
WSW	.8097E-06	.5753E-06	.4065E-06	.3028E-06	.2263E-06	.1337E-06	.7117E-07	.3315E-07	.1902E-07	.8636E-08
	.4939E-08	.3210E-08	.1688E-08	.8652E-09	.4131E-09	.2484E-09	.1246E-09	.7792E-10	.5473E-10	
	.3268E-10	.1929E-10	.1074E-10	.7105E-11	.3922E-11	.2524E-11	.1761E-11	.9835E-12	.4836E-12	
W	.1022E-05	.7229E-06	.5015E-06	.3699E-06	.2751E-06	.1619E-06	.8559E-07	.4001E-07	.2294E-07	.1041E-07
	.5953E-08	.3868E-08	.2033E-08	.1041E-08	.4967E-09	.2984E-09	.1495E-09	.9335E-10	.6551E-10	
	.3906E-10	.2303E-10	.1281E-10	.8465E-11	.4671E-11	.3006E-11	.2097E-11	.1172E-11	.5774E-12	
WNW	.1296E-05	.9138E-06	.6161E-06	.4465E-06	.3291E-06	.1923E-06	.1017E-06	.4724E-07	.2707E-07	.1229E-07
	.7024E-08	.4564E-08	.2399E-08	.1229E-08	.5860E-09	.3519E-09	.1760E-09	.1098E-09	.7697E-10	
	.4581E-10	.2694E-10	.1495E-10	.9866E-11	.5437E-11	.3498E-11	.2442E-11	.1368E-11	.6777E-12	
NW	.1583E-05	.1174E-05	.8125E-06	.5883E-06	.4325E-06	.2519E-06	.1331E-06	.6181E-07	.3545E-07	.1613E-07
	.9243E-08	.6020E-08	.3177E-08	.1636E-08	.7851E-09	.4737E-09	.2366E-09	.1495E-09	.1051E-09	
	.6278E-10	.3703E-10	.2061E-10	.1362E-10	.7529E-11	.4662E-11	.3407E-11	.1923E-11	.9680E-12	
NNW	.1398E-05	.1046E-05	.6981E-06	.4925E-06	.3571E-06	.2054E-06	.1079E-06	.5003E-07	.2871E-07	.1309E-07
	.7523E-08	.4911E-08	.2602E-08	.1346E-08	.6490E-09	.3926E-09	.1984E-09	.1244E-09	.8740E-10	
	.5211E-10	.3063E-10	.1696E-10	.1117E-10	.6155E-11	.3971E-11	.2786E-11	.1580E-11	.8062E-12	
N	.1345E-05	.1072E-05	.7631E-06	.5493E-06	.4013E-06	.2321E-06	.1222E-06	.5676E-07	.3259E-07	.1488E-07
	.8552E-08	.5586E-08	.2964E-08	.1536E-08	.7434E-09	.4513E-09	.2292E-09	.1443E-09	.1018E-09	
	.6107E-10	.3615E-10	.2017E-10	.1337E-10	.7419E-11	.4613E-11	.3389E-11	.1932E-11	.9915E-12	
TOTAL	.5737E-04	.4386E-04	.2756E-04	.1843E-04	.1295E-04	.7234E-05	.3744E-05	.1728E-05	.9923E-06	.4548E-06
	.2628E-06	.1724E-06	.9216E-07	.4813E-07	.2347E-07	.1430E-07	.7272E-08	.4567E-08	.3208E-08	
	.1907E-08	.1114E-08	.6116E-09	.4006E-09	.2195E-09	.1417E-09	.9982E-10	.5740E-10	.3030E-10	

APPENDIX C: A Climatologically-Averaged Comparison of the Source Depletion and Surface Depletion Models

The calculations used to substantiate the conclusions of this report utilized the surface depletion model, equation (10). A less realistic, but also computationally less complex, method is provided by the source depletion model described by Van der Hoven (1968).

The source depletion model accounts for deposition by reducing the source strength as a function of downwind distance, i.e.,

$$C(x,y,z) = \frac{\dot{Q}(x)}{u} D(x,y,z) \quad . \tag{C-1}$$

Conservation of the contaminant requires that

$$\frac{d\dot{Q}}{dx} = -\int_{-\infty}^{\infty} v_d \, C(x,y,z_d) \, dy$$

$$= - v_d \, \dot{Q}(x) \, D(x,z_d) \tag{C-2}$$

where $D(x,z_d)$ is the cross-wind-integrated value of $D(x,y,z_d)$, given by $\pi x/8$ times equation (2). Hence

$$\dot{Q}(x) = \dot{Q}_o \exp\left\{ - \frac{v_d}{u} \int_{-\infty}^{\infty} D(\xi,z_d) \, d\xi \right\} \quad . \tag{C-3}$$

Although the source depletion model correctly determines the deposition flux in terms of the air concentration near the surface ($z = z_d$), the material loss is instantaneously distributed throughout the vertical extent of the plume, retaining its Gaussian shape. This is not a serious error when the deposition is small; but for strong deposition the surface depletion model is needed to correctly predict the altered vertical distribution of contaminant, with the loss due to deposition concentrated near the surface. As a consequence of its artificially enhanced air concentration at $z = z_d$, the source depletion model consistently overpredicts the deposition loss. Horst (1974b) has shown that for individual micrometeorological situations the model predictions begin to diverge significantly for $v_d/u = 10^{-3}$.

Figure C-1 shows the climatologically and polar-averaged comparison of the two models for $v_d/u = 10^{-3}$ and 10^{-2}. The quantity plotted is the ratio, as predicted by both models, of the airborne contaminant for a depositing substance to that for a non-depositing contaminant. The results are very similar to those presented by Horst (1974b). The differences between the predictions increase with v_d/u, being only about 15% to 20% at $v_d/u = 10^{-3}$. The surface depletion model predicts a smaller air concentration near the surface because the deposition loss is concentrated near the surface rather than being distributed throughout the plume. At greater distances this is balanced by the greater deposition loss of the source depletion model, which eventually reduces its predicted air concentration below that of the surface depletion model.

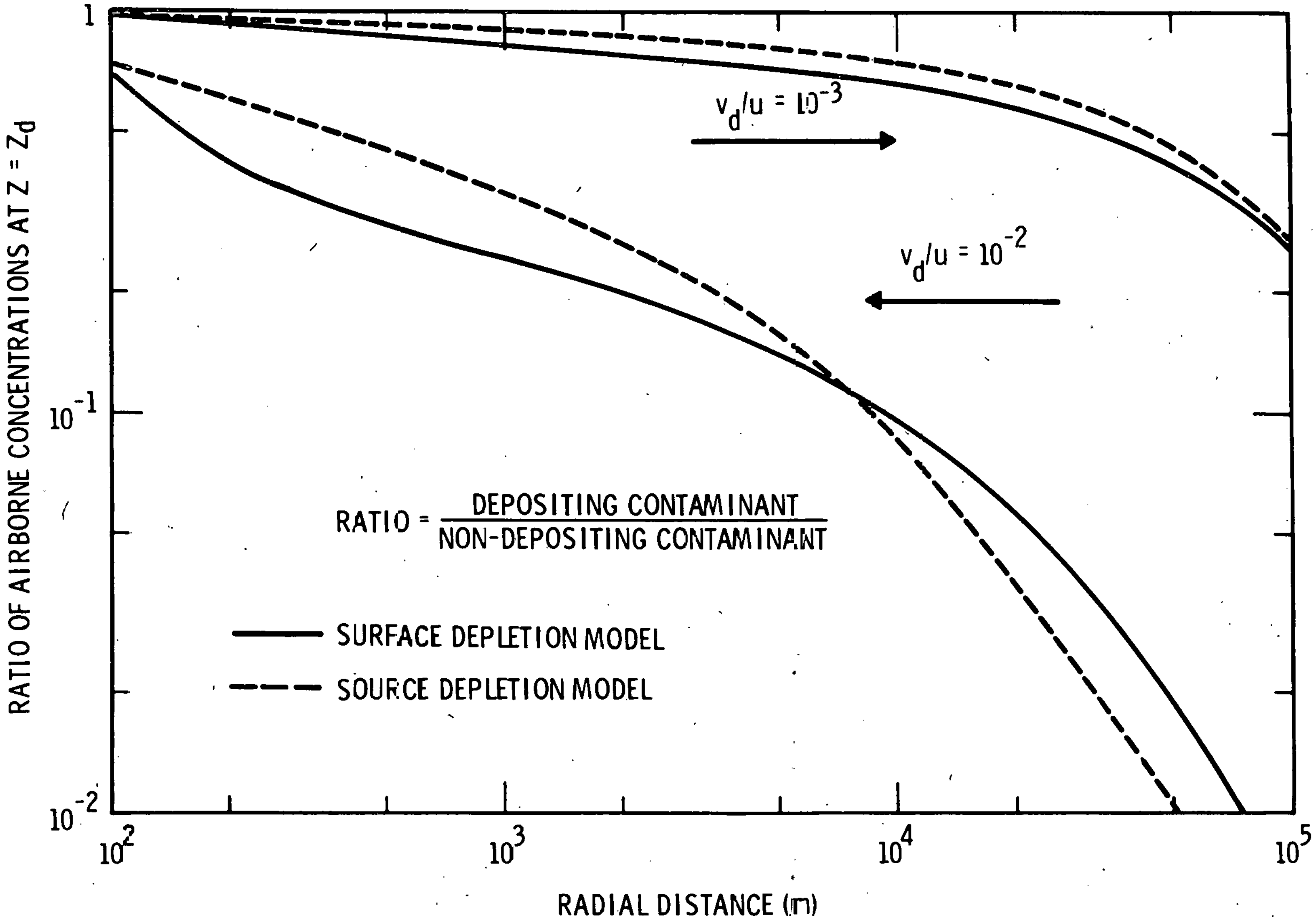

Figure C-1. Climatologically-Averaged Comparison Between Source Depletion and Surface Depletion Models.

APPENDIX D: The Climatologically-Averaged Resuspended Plume

The following tables show the climatologically-averaged resuspended air concentration as calculated with (13) for a constant resuspension rate and for $t \to \infty$. The resuspended air concentrations have been normalized with the initial source strength $\dot{Q}$ and hence have dimensions of sec/m^3. Tables D-1 and D-2 correspond to the deposition fluxes for $v_d/u = 10^{-2}$ (Table B-3) and 10^{-3} (Table B-5) respectively. As indicated in the main text, calculations were made for overlapping ranges of the radial distance from the original source by varying the cartesian grid interval DIX. The results are labeled with the grid interval used and are displayed as a function of radial distance and azimuthal direction, NNE through N, i.e.,

NNE	NE	ENE	E	ESE	SE	SSE	S
SSW	SW	WSW	W	WNW	NW	NNW	N .

Table D-1. Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-2}$.

DIX = 25 m

Radius = 30 m							
.789E-04	.920E-04	.116E-03	.141E-03	.145E-03	.127E-03	.102E-03	.805E-04
.722E-04	.705E-04	.644E-04	.577E-04	.523E-04	.527E-04	.614E-04	.711E-04
Radius = 40 m							
.661E-04	.790E-04	.109E-03	.142E-03	.146E-03	.122E-03	.924E-04	.667E-04
.590E-04	.602E-04	.548E-04	.489E-04	.431E-04	.428E-04	.515E-04	.602E-04
Radius = 50 m							
.561E-04	.680E-04	.978E-04	.132E-03	.136E-03	.112E-03	.813E-04	.564E-04
.495E-04	.511E-04	.475E-04	.418E-04	.361E-04	.359E-04	.435E-04	.510E-04
Radius = 70 m							
.404E-04	.497E-04	.769E-04	.106E-03	.111E-03	.909E-04	.625E-04	.406E-04
.354E-04	.367E-04	.340E-04	.305E-04	.254E-04	.261E-04	.312E-04	.362E-04
Radius = 100 m							
.258E-04	.319E-04	.521E-04	.714E-04	.771E-04	.624E-04	.421E-04	.261E-04
.228E-04	.233E-04	.208E-04	.200E-04	.161E-04	.173E-04	.200E-04	.227E-04
Radius = 150 m							
.138E-04	.172E-04	.292E-04	.393E-04	.441E-04	.355E-04	.233E-04	.142E-04
.125E-04	.124E-04	.107E-04	.110E-04	.874E-05	.986E-05	.108E-04	.120E-04
Radius = 200 m							
.845E-05	.108E-04	.184E-04	.244E-04	.280E-04	.225E-04	.145E-04	.891E-05
.792E-05	.756E-05	.646E-05	.681E-05	.550E-05	.636E-05	.669E-05	.744E-05
Radius = 300 m							
.413E-05	.543E-05	.926E-05	.121E-04	.142E-04	.114E-04	.718E-05	.451E-05
.404E-05	.366E-05	.312E-05	.337E-05	.279E-05	.334E-05	.330E-05	.369E-05
Radius = 400 m							
.245E-05	.330E-05	.562E-05	.724E-05	.869E-05	.696E-05	.431E-05	.273E-05
.245E-05	.215E-05	.184E-05	.201E-05	.168E-05	.206E-05	.197E-05	.221E-05
Radius = 487 m							
.169E-05	.231E-05	.394E-05	.505E-05	.612E-05	.488E-05	.300E-05	.189E-05
.169E-05	.145E-05	.126E-05	.138E-05	.115E-05	.144E-05	.135E-05	.153E-05

Table D-1 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-2}$.

DIX = 100 m

Radius = 400 m							
.282E-05	.384E-05	.623E-05	.834E-05	.972E-05	.794E-05	.495E-05	.308E-05
.283E-05	.259E-05	.210E-05	.224E-05	.201E-05	.225E-05	.230E-05	.259E-05
Radius = 500 m							
.189E-05	.259E-05	.423E-05	.553E-05	.656E-05	.535E-05	.332E-05	.211E-05
.194E-05	.169E-05	.141E-05	.152E-05	.136E-05	.160E-05	.154E-05	.174E-05
Radius = 700 m							
.105E-05	.145E-05	.238E-05	.304E-05	.369E-05	.299E-05	.183E-05	.119E-05
.110E-05	.915E-06	.776E-06	.854E-06	.756E-06	.942E-06	.852E-06	.964E-06
Radius = 1000 m							
.567E-06	.796E-06	.130E-05	.165E-05	.203E-05	.164E-05	.981E-06	.648E-06
.602E-06	.489E-06	.417E-06	.462E-06	.412E-06	.525E-06	.462E-06	.524E-06
Radius = .150E+04 m							
.286E-06	.407E-06	.667E-06	.836E-06	.105E-05	.837E-06	.493E-06	.328E-06
.306E-06	.242E-06	.208E-06	.233E-06	.207E-06	.272E-06	.233E-06	.265E-06
Radius = .195E+04 m							
.183E-06	.262E-06	.433E-06	.540E-06	.681E-06	.540E-06	.316E-06	.208E-06
.193E-06	.151E-06	.132E-06	.148E-06	.130E-06	.175E-06	.148E-06	.170E-06

DIX = 500 m

Radius = .150E+04 m							
.329E-06	.453E-06	.727E-06	.997E-06	.116E-05	.941E-06	.567E-06	.340E-06
.323E-06	.307E-06	.230E-06	.247E-06	.232E-06	.246E-06	.269E-06	.300E-06
Radius = .200E+04 m							
.200E-06	.280E-06	.449E-06	.590E-06	.713E-06	.572E-06	.340E-06	.213E-06
.204E-06	.179E-06	.141E-06	.154E-06	.143E-06	.166E-06	.164E-06	.184E-06
Radius = .300E+04 m							
.105E-06	.147E-06	.239E-06	.301E-06	.373E-06	.297E-06	.176E-06	.115E-06
.110E-06	.875E-07	.741E-07	.822E-07	.743E-07	.966E-07	.850E-07	.967E-07

Table D-1 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-2}$.

Radius = .400E+04 m							
.680E-07	.956E-07	.156E-06	.194E-06	.241E-06	.192E-06	.114E-06	.748E-07
.720E-07	.555E-07	.481E-07	.536E-07	.478E-07	.648E-07	.553E-07	.631E-07
Radius = .500E+04 m							
.491E-07	.692E-07	.113E-06	.140E-06	.174E-06	.139E-06	.818E-07	.540E-07
.520E-07	.396E-07	.347E-07	.389E-07	.343E-07	.476E-07	.400E-07	.459E-07
Radius = .700E+04 m							
.306E-07	.430E-07	.704E-07	.871E-07	.108E-06	.860E-07	.510E-07	.336E-07
.324E-07	.242E-07	.216E-07	.244E-07	.210E-07	.303E-07	.250E-07	.288E-07
Radius = .975E+04 m							
.194E-07	.271E-07	.449E-07	.553E-07	.677E-07	.541E-07	.326E-07	.211E-07
.203E-07	.150E-07	.137E-07	.155E-07	.131E-07	.195E-07	.159E-07	.184E-07
			DIX = 5000 m				
Radius = .700E+04 m							
.942E-07	.122E-06	.170E-06	.218E-06	.235E-06	.202E-06	.146E-06	.976E-07
.769E-07	.728E-07	.653E-07	.583E-07	.514E-07	.542E-07	.662E-07	.790E-07
Radius = .100E+05 m							
.289E-07	.388E-07	.618E-07	.867E-07	.973E-07	.785E-07	.477E-07	.268E-07
.249E-07	.263E-07	.194E-07	.194E-07	.179E-07	.182E-07	.226E-07	.258E-07
Radius = .150E+05 m							
.149E-07	.195E-07	.312E-07	.422E-07	.482E-07	.390E-07	.237E-07	.138E-07
.137E-07	.133E-07	.994E-08	.108E-07	.976E-08	.111E-07	.124E-07	.138E-07
Radius = .200E+05 m							
.100E-07	.132E-07	.213E-07	.276E-07	.321E-07	.261E-07	.161E-07	.977E-08
.969E-08	.849E-08	.685E-08	.755E-08	.660E-08	.860E-08	.840E-08	.950E-08
Radius = .300E+05 m							
.601E-08	.789E-08	.129E-07	.160E-07	.185E-07	.154E-07	.989E-08	.623E-08
.613E-08	.463E-08	.420E-08	.476E-08	.391E-08	.600E-08	.502E-08	.578E-08

Table D-1 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-2}$.

Radius = .400E+05 m							
.427E-08	.554E-08	.918E-08	.113E-07	.128E-07	.108E-07	.713E-08	.451E-08
.443E-08	.319E-08	.301E-08	.346E-08	.275E-08	.449E-08	.358E-08	.415E-08
Radius = .500E+05 m							
.329E-08	.425E-08	.706E-08	.867E-08	.968E-08	.829E-08	.555E-08	.351E-08
.343E-08	.245E-08	.233E-08	.270E-08	.211E-08	.354E-08	.278E-08	.324E-08
Radius = .700E+05 m							
.225E-08	.287E-08	.482E-08	.590E-08	.646E-08	.562E-08	.386E-08	.242E-08
.237E-08	.166E-08	.160E-08	.188E-08	.143E-08	.249E-08	.192E-08	.224E-08
Radius = .975E+05 m							
.157E-08	.198E-08	.336E-08	.409E-08	.440E-08	.388E-08	.275E-08	.171E-08
.167E-08	.115E-08	.112E-08	.132E-08	.100E-08	.177E-08	.135E-08	.158E-08

Table D-2. Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-3}$.

DIX = 25 m

Radius = 30 m							
.875E-05	.101E-04	.127E-04	.152E-04	.156E-04	.137E-04	.112E-04	.893E-05
.804E-05	.782E-05	.717E-05	.646E-05	.592E-05	.597E-05	.689E-05	.791E-05
Radius = 40 m							
.746E-05	.837E-05	.120E-04	.154E-04	.158E-04	.133E-04	.102E-04	.756E-05
.672E-05	.679E-05	.619E-05	.556E-05	.495E-05	.494E-05	.587E-05	.680E-05
Radius = 50 m							
.646E-05	.779E-05	.109E-04	.145E-04	.149E-04	.124E-04	.912E-05	.651E-05
.574E-05	.536E-05	.545E-05	.482E-05	.422E-05	.422E-05	.503E-05	.584E-05
Radius = 70 m							
.486E-05	.595E-05	.889E-05	.121E-04	.127E-04	.104E-04	.722E-05	.486E-05
.428E-05	.438E-05	.406E-05	.365E-05	.310E-05	.318E-05	.374E-05	.432E-05
Radius = 100 m							
.331E-05	.408E-05	.638E-05	.865E-05	.941E-05	.760E-05	.510E-05	.330E-05
.291E-05	.296E-05	.267E-05	.253E-05	.209E-05	.222E-05	.253E-05	.287E-05
Radius = 150 m							
.195E-05	.244E-05	.390E-05	.524E-05	.592E-05	.474E-05	.306E-05	.195E-05
.174E-05	.172E-05	.152E-05	.151E-05	.124E-05	.136E-05	.148E-05	.167E-05
Radius = 200 m							
.128E-05	.163E-05	.262E-05	.349E-05	.403E-05	.321E-05	.203E-05	.130E-05
.116E-05	.113E-05	.979E-06	.992E-06	.826E-06	.925E-06	.975E-06	.109E-05
Radius = 300 m							
.682E-06	.889E-06	.143E-05	.189E-05	.224E-05	.178E-05	.109E-05	.700E-06
.630E-06	.592E-06	.509E-06	.527E-06	.447E-06	.512E-06	.516E-06	.580E-06
Radius = 400 m							
.425E-06	.564E-06	.910E-06	.120E-05	.144E-05	.114E-05	.685E-06	.439E-06
.396E-06	.363E-06	.311E-06	.326E-06	.279E-06	.325E-06	.318E-06	.360E-06
Radius = 487 m							
.299E-06	.403E-06	.654E-06	.859E-06	.104E-05	.319E-06	.486E-06	.309E-06
.274E-06	.250E-06	.216E-06	.227E-06	.191E-06	.226E-06	.220E-06	.252E-06

Table D-2 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-3}$.

DIX = 200 m

Radius = 400 m

.547E-06	.731E-06	.113E-05	.157E-05	.173E-05	.142E-05	.920E-06	.558E-06
.490E-06	.496E-06	.400E-06	.390E-06	.363E-06	.358E-06	.419E-06	.477E-06

Radius = 500 m

.360E-06	.479E-06	.744E-06	.103E-05	.116E-05	.942E-06	.594E-06	.364E-06
.328E-06	.328E-06	.263E-06	.264E-06	.245E-06	.248E-06	.283E-06	.317E-06

Radius = 700 m

.206E-06	.277E-06	.431E-06	.579E-06	.669E-06	.540E-06	.334E-06	.212E-06
.193E-06	.182E-06	.150E-06	.154E-06	.142E-06	.154E-06	.162E-06	.181E-06

Radius = 1000 m

.118E-06	.160E-06	.250E-06	.326E-06	.388E-06	.311E-06	.188E-06	.123E-06
.113E-06	.100E-06	.853E-07	.892E-07	.814E-07	.938E-07	.917E-07	.103E-06

Radius = .150E+04 m

.633E-07	.867E-07	.136E-06	.175E-06	.213E-06	.168E-06	.998E-07	.663E-07
.613E-07	.528E-07	.453E-07	.481E-07	.434E-07	.525E-07	.489E-07	.551E-07

Radius = .200E+04 m

.414E-07	.527E-07	.898E-07	.115E-06	.141E-06	.111E-06	.647E-07	.432E-07
.402E-07	.341E-07	.294E-07	.313E-07	.283E-07	.347E-07	.319E-07	.361E-07

Radius = .300E+04 m

.231E-07	.322E-07	.507E-07	.645E-07	.800E-07	.624E-07	.358E-07	.238E-07
.223E-07	.186E-07	.161E-07	.173E-07	.154E-07	.195E-07	.175E-07	.200E-07

Radius = .390E+04 m

.157E-07	.220E-07	.350E-07	.446E-07	.554E-07	.428E-07	.244E-07	.160E-07
.147E-07	.124E-07	.108E-07	.116E-07	.102E-07	.131E-07	.117E-07	.135E-07

DIX = 1000 m

Radius = .300E+04 m

.285E-07	.386E-07	.583E-07	.786E-07	.912E-07	.731E-07	.437E-07	.276E-07
.260E-07	.246E-07	.196E-07	.203E-07	.194E-07	.208E-07	.223E-07	.248E-07

Table D-2 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-3}$.

Radius = .400E+04 m

.191E-07	.260E-07	.393E-07	.513E-07	.616E-07	.487E-07	.287E-07	.187E-07
.178E-07	.160E-07	.132E-07	.138E-07	.130E-07	.150E-07	.148E-07	.167E-07

Radius = .500E+04 m

.144E-07	.194E-07	.295E-07	.379E-07	.458E-07	.361E-07	.213E-07	.141E-07
.135E-07	.116E-07	.988E-08	.104E-07	.966E-08	.117E-07	.111E-07	.125E-07

Radius = .700E+04 m

.955E-08	.128E-07	.195E-07	.248E-07	.301E-07	.236E-07	.139E-07	.935E-08
.893E-08	.749E-08	.655E-08	.697E-08	.629E-08	.803E-08	.727E-08	.828E-08

Radius = .100E+05 m

.633E-08	.844E-08	.129E-07	.163E-07	.197E-07	.155E-07	.914E-08	.612E-08
.585E-08	.489E-08	.432E-08	.460E-08	.408E-08	.535E-08	.479E-08	.549E-08

Radius = .150E+05 m

.403E-08	.534E-08	.820E-08	.104E-07	.124E-07	.981E-08	.582E-08	.384E-08
.365E-08	.305E-08	.273E-08	.292E-08	.251E-08	.340E-08	.301E-08	.349E-08

Radius = .195E+05 m

.301E-08	.395E-08	.615E-08	.782E-08	.925E-08	.730E-08	.436E-08	.281E-08
.266E-08	.223E-08	.202E-08	.216E-08	.180E-08	.250E-08	.221E-08	.258E-08

DIX = 5000 m

Radius = .150E+05 m

.548E-08	.710E-08	.104E-07	.137E-07	.155E-07	.125E-07	.769E-08	.496E-08
.468E-08	.449E-08	.373E-08	.381E-08	.362E-08	.399E-08	.430E-08	.479E-08

Radius = .200E+05 m

.404E-08	.520E-08	.762E-08	.980E-08	.113E-07	.904E-08	.558E-08	.368E-08
.350E-08	.321E-08	.277E-08	.286E-08	.263E-08	.314E-08	.315E-08	.354E-08

Radius = .300E+05 m

.271E-08	.342E-08	.507E-08	.640E-08	.731E-08	.590E-08	.371E-08	.248E-08
.235E-08	.205E-08	.186E-08	.195E-08	.171E-08	.222E-08	.208E-08	.237E-08

Table D-2 (Continued). Climatologically-Averaged Resuspended Air Concentration Distribution for $v_d/u = 10^{-3}$.

Radius = .400E+05 m							
.206E-08	.257E-08	.384E-08	.483E-08	.546E-08	.443E-08	.282E-08	.187E-08
.178E-08	.154E-08	.141E-08	.148E-08	.126E-08	.170E-08	.157E-08	.179E-08
Radius = .500E+05 m							
.166E-08	.206E-08	.309E-08	.390E-08	.438E-08	.357E-08	.228E-08	.150E-08
.142E-08	.124E-08	.114E-08	.120E-08	.997E-09	.137E-08	.126E-08	.145E-08
Radius = .700E+05 m							
.120E-08	.148E-08	.225E-08	.285E-08	.316E-08	.259E-08	.166E-08	.107E-08
.102E-08	.888E-09	.818E-09	.867E-09	.695E-09	.989E-09	.900E-09	.104E-08
Radius = .975E+05 m							
.887E-09	.108E-08	.167E-08	.211E-08	.231E-08	.190E-08	.124E-08	.780E-09
.740E-09	.646E-09	.594E-09	.634E-09	.491E-09	.719E-09	.652E-09	.761E-09

APPENDIX E: The Net Effect of Redeposition

C_r is correctly calculated as

$$C_r(x,y,z) = \int_0^x \int_{-\infty}^{\infty} \left[\Lambda \bar{G}(\xi,\eta) - v_d' C_r(\xi,\eta,z_d) \right] \frac{D}{u}(x-\xi, y-\eta, z)\ d\eta\ d\xi \quad . \qquad \text{(E-1)}$$

where v_d' characterizes the redeposition of the resuspended material. The climatologically-averaged value of G has been found in (12) to be

$$\bar{G} = \bar{G}_d + \bar{G}_r = (\overline{v_d C_d} + \overline{v_d' C_r})\ (1 - e^{-\bar{\Lambda} t})/\bar{\Lambda} \quad . \qquad \text{(E-2)}$$

However, the results presented thus far have neglected the effect of redeposition on the resuspended air concentration. By setting v_d' equal to zero in (E-1) and (E-2) we obtain $\bar{G}_d$, the surface contamination due to deposition from the direct plume only, and C_r', the air concentration due to resuspension from $\bar{G}_d$. Substituting (E-2) into (E-1) then gives (13), the equation used to calculate C_r'.

As discussed previously, redeposition from C_r' will form another source of resuspendable material which will in turn contribute to C_r. This additional surface contamination is

$$\bar{G}_r^1 = \overline{v_d' C_r^1}/\bar{\Lambda} \qquad \text{(E-3)}$$

where C_r^1 is the depleted value of C_r' ,

$$C_r^1 = \int_0^x \int_{-\infty}^{\infty} \left[\Lambda\ \overline{v_d C_d}/\bar{\Lambda} - v_d' C_r^1 \right] \frac{D}{u}\, d\eta\ d\xi \qquad \text{(E-4)}$$

and the growth factor $(1 - e^{-\bar{\Lambda} t})$ has been set equal to one. The resuspension from $\bar{G}_r^1$, including further redeposition, will then be

$$C_r^2 = \int_o^x \int_{-\infty}^{\infty} \left[\Lambda \ \overline{v_d' C_r^1} / \bar{\Lambda} - v_d' C_r^2 \right] \frac{D}{u} \, d\eta \, d\xi \quad , \tag{E-5}$$

and this too will contribute additional surface contamination

$$\bar{G}_r^2 = \overline{v_d' C_r^2} / \bar{\Lambda} \quad . \tag{E-6}$$

Thus both $\bar{G}_r$ and $\bar{C}_r$ may be calculated by means of an infinite series

$$\bar{G}_r = \sum_{N=1}^{\infty} \overline{v_d' C_r^N} / \bar{\Lambda} \tag{E-7}$$

$$\bar{C}_r = \sum_{N=1}^{\infty} \bar{C}_r^N \tag{E-8}$$

where

$$C_r^N = \int_o^x \int_{-\infty}^{\infty} \left[\Lambda \ \overline{v_d' C_r}^{N-1} / \bar{\Lambda} - v_d' C_r^N \right] \frac{D}{u} \, d\eta \, d\xi \quad . \tag{E-9}$$

C_r^N is the difference of the N-1 resuspension cycle R^{N-1} and the Nth deposition cycle DP^N. Hence

$$\bar{C}_r = \bar{R}^0 - \overline{DP}^1 + \bar{R}^1 - \overline{DP}^2 + \bar{R}^2 - \overline{DP}^3 + \ldots \tag{E-10}$$

where $\bar{R}^0 = \bar{C}_r'$. It should be apparent from (E-9) that $\overline{DP}^N < \bar{R}^{N-1}$. If also $\bar{R}^N < \overline{DP}^N$, then it may easily be shown from (E-10) that $\bar{C}_r < \bar{C}_r'$ and the net effect of redeposition is a reduction of $\bar{C}_r$. This needs to be investigated by the computation of (E-4) and higher-order terms.

Another approach has been taken to estimate the effect of redeposition. In this approach the diffusion function D has been approximated by

$$D(x-\xi, y-\eta, z_d) = \phi_o \delta(x-\xi)\delta(y-\eta) \quad \text{(E-11)}$$

for the calculation of deposition from the initial plume and by

$$D(x-\xi, y-\eta, z_d) = \phi_r \delta(x-\xi)\delta(y-\eta) \quad \text{(E-12)}$$

for the calculation of resuspension and redeposition. Here $\delta(x-\xi)$ and $\delta(y-\eta)$ are Dirac delta functions. This implies that the deposition loss depends only on the local air concentration and that the resuspended air concentration depends only on the local ground concentration. With this approximation (7) may be easily solved to get

$$C_d = C_o/(1 + \frac{v_d}{u}\phi_o) \quad \text{(E-13)}$$

and

$$C_r = \frac{\Lambda G}{u} \frac{\phi_r}{(1 + \frac{v_d'}{u}\phi_r)} \quad . \quad \text{(E-14)}$$

Substituting into (5) and solving gives then

$$G = \frac{v_d C_o}{(1 + \frac{v_d}{u}\phi_o)} (1 - e^{-\Lambda'\tau}) \quad \text{(E-15)}$$

where $\Lambda' = \Lambda/(1 + \frac{v_d'}{u}\phi_r)$. Substituting back into (E-14),

$$C_r = \frac{v_d}{u} \frac{\phi_r C_o}{(1 + \frac{v_d}{u} \phi_o)} (1 - e^{-\Lambda' t}) \quad . \tag{E-16}$$

Thus the only effect of redeposition in this solution is to reduce the resuspension rate by the factor $(1 + \frac{v_d'}{u} \phi_r)^{-1}$. This leads to an increase in the surface contamination, but a reduction of the resulting air concentration due to the slower approach of G to its equilibrium value. Further, the maximum exposure to resuspension is unaffected since it is independent of the magnitude of the resuspension rate.

In conclusion, both of these approaches hint that the net effect of redeposition is a reduction of the resuspended air concentration. However the first of these depends on the determination that $\bar{R}^N < \overline{DP}^N$ and, circularly, that is very similar to the conclusion expressed by (18) and (19) which has only been substantiated without redeposition. That conclusion may be summarized by the assertion that the exposure due to resuspension is less than the loss of exposure due to prior deposition.

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