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DIGITAL COMPUTER SIMULATION OF WATER AND WASTEWATER SLUDGE DEWATERING ON SAND BEDS

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By

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Ph.D.

VITAE

Kuang-mei Lo was born June 13, 1938 in Hunan, China. He attended primary schools in various cities of China during the period of World War II and the Chinese Civil War. In 1950 he moved to Taiwan, China and attended Pong-Chu High School at Taipei. He graduated from the National Taiwan University in 1960 with a Bachelor of Science degree in Agricultural Engineering. After serving one year in the Army he worked for two years as a full time research assistant at the Farm Machinery Research Center, National Taiwan University. Then he taught a machine shop course in theDepartment of Agricultural Engineering until he left China for the United States in September, 1964.

On graduation in 1968 with a Master of Science in Agricultural Engineering, University of Massachusetts, he transferred to the Environmental Engineering Program, and was awarded the Master of Science in Environmental Engineering in 1970. Since August, 1970 he was employed by Curran Associates, Inc., Northampton, Massachusetts,as an Environmental Systems Engineer.

ABSTRACT

Conventional criteria for sand bed design are largely based on rules of thumb deduced from limited field observations. The lack of a rational design method encourages many design engineers to select a more costly alternative sludge dewatering process for which a clear cut design procedure is available.

This study was primarily concerned with the development of design criteria with which an engineer could design the beds based on the nature of the sludge to be dewatered and climatic conditions, while also ensuring that the entire system would be economically efficient. This exploration has opened several significant dimensions in the study of sand bed dewatering. It first demonstrated the usefulness of computer simulation for studying the performance of open sand bed dewatering, in which uncertainty was involved due to the presence of weather effects. Second, it attained an optimum system design through an effective union of engineering and economical analysis. This study has been carried out through the following steps: 1. formulation of mathematical models for sludge dewatering (drainage and drying) on sand beds, 2. preparation of input data for mathematical models, 3. validation of simulation experiments, 4. analysis of the outputs generated by simulation to attain an optimum system design.

Four different types of wastewater sludges and two water sludges were simulated for 20 years under six weather conditions encountered across the United States. The output of this simulation was a random variable, the required dewatering time, and its associated frequency

distribution. The overall results indicated that the range and shape of the frequency distribution was clearly affected by the weather conditions, as the dewatering time was reduced considerably in regions of more sunshine and less rainfall. Among the parameters describing the sludge characteristics, solids content was the most important one affecting the dewatering time, it in most cases dominated the effects of specific resistance.

Economic analyses were applied to the outputs of simulation for finding an optimum system design. Two different types of approaches were used, the first was to find an optimum system design that would fulfill the target output at a minimum cost among the known alternatives. The second approach using the concept of marginal analysis was to assign a cash value to the end product (dry solids) of the dewatering process, so that the optimum system design was obtained at the point where the cost of inputs (land and operation) were just equal to the marginal value of output.

The final results of this study have been compiled in such a way that one may easily use the information to design beds based on the land and operation costs, as well as the local weather and sludge conditions.

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NOTATION

(Dimension in Mass (M), Length (L), Time (T) and Force (F))

A = Area (L^2)

A_n = Number of bed applications per year

A_r = Bed area (L^2/cap. or L^2/lb)

b = Slope of a graph of $\frac{t}{v}$ vs. V as indicated in Eq. 1

C = A constant, it is defined as the weight of dry cake solids per unit volume of filtrate per unit area

C_1 = Cost associated with required land area ($)

C_2 = Cost associated with the number of applications per unit land area per year ($)

D = Depth of free water surface into sand bed (L), or duration of rainfall (T)

d = A parameter of Modified Poisson distribution

E_1 = The height of sludge lost due to drying at t = 1 (L)

g = Acceleration constant (L/T^2)

H_o = Initial hydraulic head (L)

H_c = Reference hydraulic head (L)

H = Hydraulic head at time t (L)

H_f = Head loss at time t (L)

H_{fn} = Head loss at t = n, n = 1, 2, ...n (L)

I_{sc} = Constant drying rate ($F/L^2/T$)

I_{sf} = Drying rate during the falling rate drying period ($F/L^2/T$)

I = Intensity of rainfall (L/T)

k = Intrinsic permeability of the cake (L^2)

L = Thickness of cake (L)

M = Moisture content after rain, dry basis (%)

M_o = Moisture content before rain, dry basis (%)

N = Sample size, or random variable of bed application

P_i = Probability of occurrence

P_n = The proportion of the sample from a population that belongs to the group under consideration

R_c = Specific resistance of cake at reference head loss, H_c (T^2/M)

R_f' = Resistance of the cake $(1/L^2)$

R = Specific resistance of the cake (T^2/M)

R_d = Daily Rainfall (L)

R_n = Depth of rainfall at t_n, $n = 1, \ldots n$ (L)

R^2 = Coefficient of correlation

S_o = Initial solids content of sludge (%)

S_o' = Solids content of sludge after raining (%)

S_n = Solids content of sludge at t_n, $n = 1, \ldots n$ (%)

S_c = Solids content of cake (%)

t = Time (T)

T = Total dewatering time available per year (T)

T_d = The required dewatering time per application (T)

T_p = The required bed preparing time (T)

t_s = The standard normal deviate corresponding to the confidence level

U_{cr} = The reduced critical moisture content of sludge, dry basis (%)

U_o = Initial moisture content of sludge, dry basis (%)

U_p = Equilibrium moisture content of sludge, dry basis (%)

U = Moisture content of sludge, dry basis (%)

V = Filtrate volume (L^3)

W_s = Mass of solids in the suspended sludge (M)

W_w = Mass of water in the suspended sludge (M)

W_{wc} = Mass of water in the cake (M)

W_c = Mass of solids in the cake (M)

W_{ts}/A = Mass of solids (M/L^2)

W_d = Weight of dry solids expected to be dewatered under the design condition without consideration of "the state of nature" (F)

W_{ts} = Total dry solids expected per year (F)

X = Solid content of sludge (%)

Y = Gross bed loading (lb/sq ft - 30 days)

Z = Net bed loading (lb/sq ft - 30 days), or total cost of sand bed dewatering ($)

α = Percentage of confidence level

β = Percentage of confidence level

λ = A parameter of modified Poisson distribution

ρ_s = Density of solids (M/L^3)

ρ = Density of water (M/L^3)

σ = Coefficient of compressibility

μ = Filtrate viscosity (poises)

ν = The rate of flow (L^3/T)

CHAPTER I

INTRODUCTION

1.1 Problem Background

Water and wastewater sludge solids are not immediately disposable for various reasons, but generally because they are mixed with large quantities of water. Solids concentrations in wastewater sludge of up to 10% may be obtained for digested primary sludge and up to about 2.5% for plain activated sludge. In water treatment sludge, the solids content may range from 3% to about 0.7% depending on the quality of the raw water, the degree of treatment obtained, the amounts and kinds of chemicals added, and the rate and method of sludge removal. Obviously, the first step in the sludge disposal process, therefore, is to separate the bulk of the water from the solids in order to reduce the final disposal volume. This is the function of the sludge dewatering system, which presently represents between 50 and 75 percent of the total capital and operating cost of primary and secondary wastewater treatment plants although the treated volume is less than 1 percent of the total plant influent. Costs for disposing of sludge from water treatment plants are dependent upon the raw water quality and the type of treatment which the water undergoes. Higher levels of water and wastewater treatment will produce larger volumes of sludge with less amenability to dewatering than the sludge produced by lower standards of treatment. Thus, study of present sludge handling methods as well as engineering and economic comparisons among various dewatering methods are needed in order to effect optimization of the complete disposal system.

In many cases the drying bed method has been considered to be the most economical dewatering process with a relatively dry sludge cake cleaned from it. Approximately 72 percent of the wastewater treatment plants in the United States (4) utilize this method despite its space requirements. A recent survey (28) showed approximately 90 percent of the water treatment plants in the United States discharged their sludge solids back to the raw water source. Current emphasis on control of pollution sources will make this direct discharge of the wastewater unacceptable in the near future. One of the treatment methods presently utilized at water treatment plants for handling sludge is sand bed drying. The beds used are basically identical to those employed in sewage treatment. Reports (28) indicate that alum sludge can be dried to 20 percent solids content on drying beds in 70 to 100 hours.

The conventional design criteria for sand bed design are largely based on rules of thumb deduced from limited field observations. The absence of a rational design method results in:

1. The design engineer may select a more costly alternative process for which a clear cut design procedure is available.

2. The design sand bed size may be under or overestimated, because the conventional rules fail to consider the difference in the nature of the sludge and the role of weather.

3. The drying bed may not be operated at optimal conditions because of the improper design; consequently, the operating cost may be high and the usage of the bed may be low.

With this background in mind, a study is necessary to develop a rational design formulation with which an engineer could design dewatering beds based on the nature of the sludge to be dewatered and the climatic conditions involved to ensure that the beds will be economically efficient.

In this study the distinction between drying and dewatering has been maintained although the technical literature frequently refers to "sand drying beds". Dewatering is used to refer to the removal of water from sludge, whether by mechanical means e.g., vacuum filtration, centrifugation, or non mechanical means e.g., evaporation to the open air. Thus for sand beds dewatering refers to both water removal by gravity drainage and water removal by evaporation. As both gravity drainage and evaporation are important, the sand bed on which they occur is referred to as a "sand dewatering bed" or simply as a "sand bed".

1.2 Related Research

Research activity related to the gravity drainage of sludge has been conducted at the University of Massachusetts since 1967. The results of the investigations by Nebiker, Sanders and Adrian (3) have yielded a theoretical formula to describe the drainage performance of drying beds and lagoons. Works on sludge drying by Nebiker (18) and Clark (29) provided some theoretical as well as experimental insight toward water and wastewater sludge drying on sand beds. All of these previous investigations led to the conclusion that the design engineer may have available a rational basis on which to predict dewatering performance of drying beds. Combining these developed models on drainage and drying, Meier and Ray (30) used the technique of simulation to study the reduction in moisture from sludge applied to sand beds. Their results showed that minimum cost can be calculated based on the given capital and operating cost data, thus an optimum application depth can be determined under each condition. However, the climatic condition, a stochastic variable which may have a significant influence on the required bed area, was not considered directly in their study. The research activity reported herein was an attempt to incorporate all the foregoing climatological conditions into the drainage and drying models, so that the Monte Carlo simulation method could then be employed in predicting the probabilistic variation of the time necessary for the sludge to remain on the beds. The results of this simulation were used in actual decision making.

1.3 Objectives

The essence of this investigation was to conduct sludge dewatering experiments on a digital computer based on the developed drainage and drying models that described the real behavior of sludge on sand beds. The ultimate objective was to optimize the complete dewatering system. In order to reach this goal, three specific objectives were established:

1. To develop mathematical models for sludge dewatering which can describe the rate of water removal based on the nature of the sludge and climatic conditions.

2. To simulate sludge dewatering on sand drying beds by computer techniques in order to describe the natural phenomena in terms of the outcomes with certain probabilities.

3. To apply economic analysis to the sand bed dewatering system in order to effect optimization of the complete system.

CHAPTER II

LITERATURE REVIEW

2.1 General Description of Sludge

Sludge has been defined as "the accumulated semi-liquid suspension of settled solids deposited from wastewater, raw or treated in a tank or basin" (4). In general, it can be divided into two categories: water treatment sludge, and wastewater treatment sludge.

Water treatment sludge. The composition of water treatment sludge withdrawn from settling and coagulation basins in municipal water treatment works and in the wash water from rapid or slow filters varies with the nature of the water treated, the amounts and kinds of additives, and the reactions taking place during treatment. Some water works sludges are quite putrescible, coagulated, and colored; their solids content may be as little as 0.1% before thickening to about 2.5% after thickening (5). Observed values vary with the nature of the raw water and concentration of chemicals employed.

The quality of water treatment sludge may be described either physically or chemically. Physical characteristics include particle density, specific resistance, coefficient of compressibility, total solids and texture. Chemical characteristics include volatile solids, total nitrogen, hardness, manganese, iron and phosphates. Tables 1 and 2 show these characteristics for sludges from the Albany, New York and Amesbury, Massachusetts water treatment plants. Both sludges are produced by chemical coagulation processes and contain water impurities as well as

Table 1. Physical Characteristics of Water Treatment Sludge.

Type of Sludge	Color	Total Solids %	Specific* Resistance Sec^2/gm	Coefficient of Compressibility
Albany Sludge	Black	1.3	8.0×10^9	0.49
Amesbury Sludge	Black	1.5	5.8×10^8	0.99

*At pressure P = 38.0 cm of Hg.

Table 2. Chemical Characteristics of Water Treatment Sludge. (Clark) (22)

Type of Sludge	Volatile Solids*	Total Nitrogen mg/l	Total Phosphate mg/l	Manganese and Iron mg/l	Total Hardness mg/l**
Albany Sludge	46	479	2.64	70.0	12,900
Amesbury Sludge	43	4.7	1.4	57.6	23,600

*As % of total solids
**As $CaCO_3$

the chemicals used in the process. These two sludges are of particular interest, because their drainage rates are significantly different. The Amesbury sludge has a much more rapid drainage rate at pressures ordinarily encountered in filtration than does the Albany sludge.

Wastewater treatment sludge. The solids in wastewater sludge are composed of three prime constituents, biodegradable material, stable organic matter, and inerts in approximately the following proportions according to Levin (6):

Biologically degradable organics	30%
Stable organics	25%
Inert material	35%

Primary and secondary sludge differ considerably in their dewatering characteristics. Primary sludge has a solids content in the range of 1% to 4%, while biological sludge generally has a solids content of less than 1%. Primary sludge is much simpler to process, dewater, stabilize and dispose of. Generally speaking, the raw sludge cannot be dewatered by sand bed or lagoon methods because of odor problems. Some form of pretreatment - digestion, elutriation, and/or chemical treatment is usually required. Well digested sludge will dewater more readily than partly digested sludge (1).

The quality of wastewater sludge may also be expressed like that of water treatment sludge according to its physical and chemical properties. Representative characteristics of sludges from different treatment processes are given in Tables 3 and 4.

Table 3. Physical Characteristics of Wastewater Treatment Sludge (Sanders (37))

Type of Sludge	Total Solids %	Specific Resistance* Sec^2/gm	Coefficient of Compressibility
Primary	9.5	2.6×10^{10}	0.68
Primary and Activated Sludge	3.6	4.8×10^{10}	0.66
Primary and Trickling Filter	6.1	8.25×10^{9}	0.8
Aerobically Digested Sludge	4.5	1.15×10^{9}	0.97

*At a pressure of 38 cm of Hg

Table 4: Chemical Characteristics of Wastewater Treatment Sludge. (Zack, (30))

Type of Sludge	Volatile Matter	Ammonium Nitrate	Total Phosphorous	K_2O	Fats
Primary	65	2.0	1.67	0-4	10.0
Trickling Filter	45	2.0	1.2	-	6.0
Activated Sludge	65	5.75	2.75	0.86	7.5

Based on percent dry basis.

2.2 Sludge Dewatering Tests

Sludge testing for the purpose of dewatering should at least include the following determinations; percent total solids, specific resistance and the coefficient of compressibility.

The tests for solids determination are described in Standard Methods (7) and will not be reviewed here.

The formulation and the test of specific resistance and coefficient of compressibility have been described by Nebiker, Sanders and Adrian (2). The test is performed by filtering a large volume of sludge through a Buchner funnel or fritted glass funnel apparatus at a constant pressure. Readings of filtrate volume are taken at certain invervals of one minute or less. Specific resistance is calculated from the following equation as:

$$\frac{t}{V} = \frac{\mu C R V}{2 \rho g A^2 H} + \mu L_f R_f \qquad (1)$$

Let $$b = \frac{\mu C R}{2 \rho g A^2 H_f}$$

It is seen that where $\frac{t}{V}$ is a linear function of V.

b = slope of a graph of $\frac{t}{V}$ vs. V as indicated in Eq. 1

t = time (sec.)

V = filtrate volume (ml)

H_f = head loss (or filtration pressure) (cm)

A = area of funnel (cm^2)

μ = filtrate viscosity (poises)

C = a constant, it is defined as the weight of dry cake solids per unit volume of filtrate per unit area

ρ = density of the filtrate (gm/cm^3)

g = acceleration constant (cm/sec^2)

R'_f = resistance of the cake ($1/cm^2$)

L_f = thickness of the dewatering cake (cm)

it yields; $R = \frac{2b \rho g A^2 H_f}{\mu C}$

The value of R is dependent not only on the sludge characteristics, but also on the pressure at which the test is run. The nature of the relationship between specific resistance and pressure is uncertain, for Lewis and his co-workers (8) found $R = R_s P^s$ represented their results accurately, while Gilse and Waterman (8) used the linear function $R = C + R_s P^s$ to indicate the influence of pressure drop on the resistance of the cake. Testing with water and wastewater sludge, Adrian and Nebiker (2) showed that when the resistance of a cake was plotted as a function of the pressure drop under which the cake was formed, the value of the resistance appeared to lie on a straight line on log-log paper. This line corresponds with the following equation as:

$$\log R = \log C' + \sigma \log H$$

or

$$R = C' H^{\sigma} \qquad (2)$$

Where the exponent σ is known as the coefficient of compressibility which is dependent on the sludge characteristics such as the nature and structure of the solids, and the shape and the size of the voids. Its value can be determined as the slope of the best fit line through the points of specific resistances under various filtering pressure conditions.

2.3 Sludge Dewatering Processes

The dewatering process usually occurs as the unit process preceding incineration or land disposal. It can be carried out by a variety of methods. The recently issued Water Pollution Control Federation Sludge Dewatering Manual of Practice (4) lists four major groups of sludge dewatering methods as:

1. land methods,
2. vacuum filters,
3. centrifuges,
4. others, (these may include dual-cell gravity dewatering units, vibrating screens, roto plug, screw press, carbofloc process).

Only land methods are reviewed here. This method, developed over 50 years ago, is still a commonly used method for municipal wastewater treatment plants, particularly for these communities of small and medium size. It may include the use of open or covered sand beds, and the lagooning of wet sludge. Table 5 shows the number of sludge drying beds used by 27 states in 1967 (4), in which, 6 states reported having covered beds, 14 states reported they would continue with sludge beds in new plants, and 13 states reported the use of beds with paved surface in lieu of sand.

In operating drying beds, sludge is run into the bed at one or more points to a depth of 6 in. to 18 in., and allowed to stand until it has dried sufficiently to be removed by a spade, fork, or mechanical cleaner. The filter beds are made up of 12 to 15 in. of sand, underlaid by about 12 in. of coarse gravel covering 6 to 8 in. diameter open-joint tile underdrains to a depth of at least 6 in. The drainage from the underdrains returns to the primary tank. The side walls of the filters are made of concrete, planks or low earth embankments.

Another land method of dewatering is to lagoon wet sludge in a natural or artificial earth basin for digestion, drying and storage. The basin may be loaded over a period of years and then dried out and cleaned. This method has been used either for peak loads or as a regular means of sludge dewatering, and is considered to be the easiest and cheapest method of sludge dewatering where its use is practical.

Table 5. Number of Sludge Drying Beds Reported by 12 State Health Department in 1967.

Population of Cities	Number	With Sludge Beds	
		(%)*	(%)**
less than 5,000	1886	67	73
5,000 to 25,000	750	27	22
more than 25,000	168	6	5
total	2804	100	100

*Percent of reported totals for 1967 survey.
**Percent of reported totals for 1957 survey.

2.4 Design Considerations for Gravity Dewatering

The design considerations for the drying bed were: the yield of wet sludge expected per year, the type of sludge to be dewatered, the depth of sludge applied and the climatic conditions involved. These criteria were usually suggested either as the area required in square feet per capita or as the number of applications of sludge per year. For example, the following ranges of required areas have been suggested in publications (1,4) as the bases for design specified in the northern United States for domestic sewage sludge.

Type of Sludge	Area (sq ft/cap)	
	Open Beds	Covered Beds
Primary digested	1.00 to 1.5	0.75 to 1.00
Primary and humus digested	1.25 to 1.75	1.00 to 1.25
Primary and activated digested	1.75 to 2.50	1.25 to 1.5
Primary and chemically precipitated digested	2.00 to 2.25	1.25 to 1.5

Haseltine (31) in 1951 suggested another design criterion termed "gross bed loading". This unit was defined as the pounds of solids applied per square foot per 30 days of actual bed use. Since this unit did not consider the solids content at removal, it follows that the lower the solids content of the sludge removed, the shorter the time on the beds and, hence, the higher the gross bed loading. In order to take into consideration this variable, Haseltine proposed a second unit, termed "net bed loading". It was the product of the gross bed loading multiplied by the percent solids in the sludge removed. Furthermore, Haseltine indicated that from the data observed at 14 different plants over periods of 1 to 14 years, there appeared to be a definite relationship between the solids content of the applied sludge and the bed loadings. The relationships were expressed by

$$Y = 0.96X - 1.75 \tag{3}$$

$$Z = 0.35X - 0.5 \tag{4}$$

in which X was the percentage of solids in the applied sludge, Y was the gross bed loading, and Z was the net bed loading.

The 1962 British Water Pollution Research Report (32) suggested that specific resistance was another important design criterion. Their experiments shown in Fig. 1 indicated an exponential relation between specific resistance and dewaterability.

Clearly, all of these proposed design criteria were not adjusted for the prolonging effects of rainfall. In a 1965 British Water Pollution Research Report (13), the dewatering time for 12 inches of digested sludge was reported as ranging from 12 days to 111 days due to the effects of rainfall on the performance of the drying bed. In order to count this weather effect, the Report suggested a graphical method to determine the required bed area. This method depended on the estimation of the portion of the rainfall drained through the sludge and the portion evaporated. For example, the reported mean values of

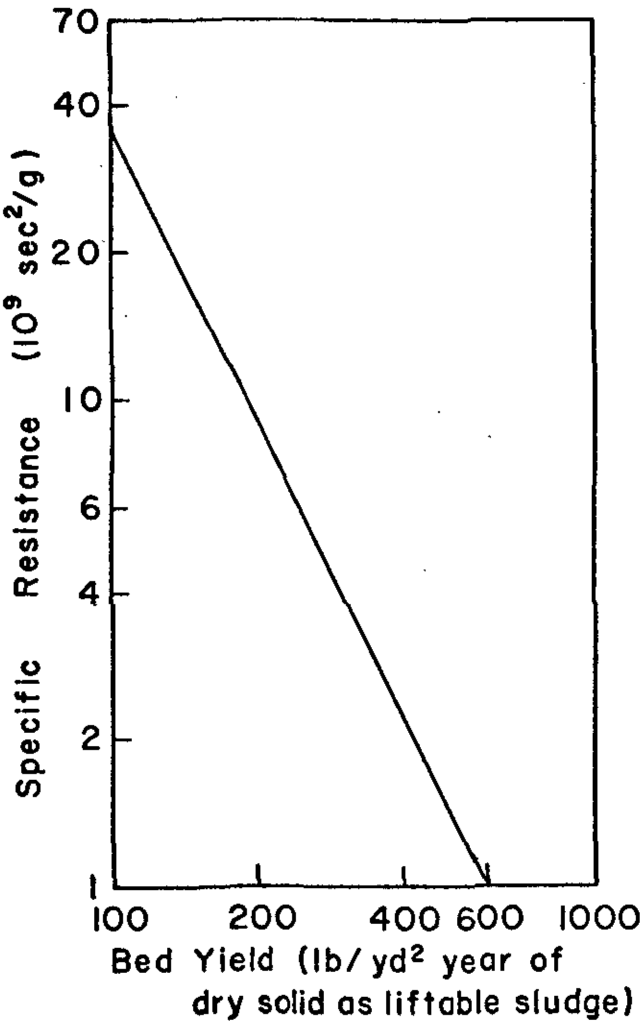


Fig 1. Relation between specific resistance and bed yield.

15 separate observations suggested that 43% of the rainfall drained through the sludge and 57% evaporated. In order to predict the drying time, a plot was made of 0.57 X cumulative rainfall against time; the resulting curve then represented the amount of rainfall which would be evaporated from the sludge. Another plot was made on the same (monthly) time scale of 0.75 X cumulative evaporation from a free water surface; this curve thus represented the evaporation from sludge. From the two plots a graphical calculator was made by cutting away the portion of the evaporation graph below the curve and placing the remaining portion on the rainfall graph. The time scales of both curves are kept coincident and the upper curve is moved in a direction parallel to the rainfall (or evaporation) axis until the two curves cross on the date on which sludge was applied to the bed. Then, the drying time would be found by observing the subsequent date when the two were separated by a distance representing the amount of water to be evaporated from the sludge. The use of this method is illustrated in Fig. 2.

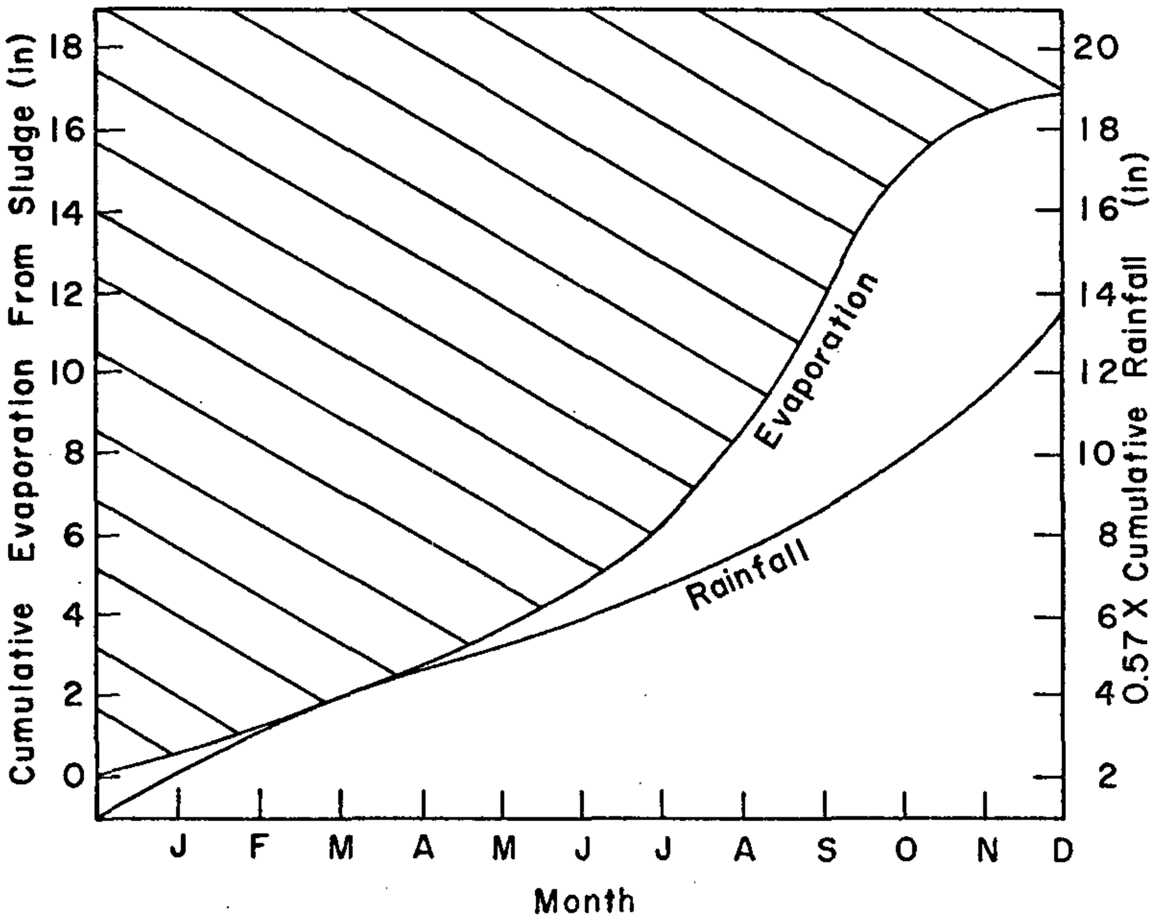


Fig 2. Illustration of use of a graphical calculator for predicting time required to dewater sludge on sand beds.

CHAPTER III

THEORETICAL CONSIDERATIONS OF SLUDGE DEWATERING ON SAND BEDS

Water is removed from sludge on sand drying beds by way of drainage, decantation and drying. Decantation may be possible if the sludge solids settle rapidly, which may occur with some water softening sludges, but it is not an important process in wastewater sludge dewatering. For most sludge, dewatering starts by drying and drainage in the early stage of dewatering when ample water is available in the sludge. As the dewatering process goes on, the sludge is progressively depleted of water: at a certain point drainage will cease and water is then removed by drying alone. From a dewatering standpoint, drainage and drying are both important because, with most sludge, more water is removed by drainage than by evaporation, but more time is required for evaporation than for drainage. Also, the water that is not removed by drainage must be removed by evaporation. In fact, drainage alone will not remove enough water to leave the sludge cake in an easily handleable form, so evaporation is necessary to dry the cake to a solid form. Therefore the total time the sludge must remain on the bed is controlled by the amount of water that must be removed by evaporation, and this in turn is determined by the drainable water in the sludge. As a result the amount of water that can be removed by drainage is also extremely important.

3.1 Basic Considerations of Drainage

The application of the concept of specific resistance to gravity drainage of water and wastewater sludge on sand beds has been investigated by Nebiker, Sanders and Adrian (3). The results supported by experimental verification have proven satisfactory for sludge dewatering on sand beds. Their derivation of a drainage equation started from Darcy's law. The flow length is equal to the thickness of the cake giving;

$$v = k \frac{\rho \; g \; h_f}{\mu \; L} \qquad (5)$$

Where v is the rate of flow, cm/sec; h_f the head drop across the cake, cm; k is the intrinsic permeability of the cake, cm^2; ρ is the fluid density, gm/cm^3, g is the acceleration of gravity, cm/sec^2; and L is the thickness of the cake, cm. Adopting the convention used in chemical engineering, the intrinsic permeability may be equated to the cake resistance through the relation $k = \frac{1}{R'}$, where R' is the cake resistance. The lack of clarity of the sludge makes it impossible to measure visually the thickness of the cake. Therefore a modified form of the equation is obtained by considering the weight of dry solids W to be proportional to the thickness of the cake, that is;

$$L \; R' = W \; R \qquad (6)$$

Where W is the solids content of the sludge cake and R is the specific resistance of the sludge cake. If C is defined as the weight of dry cake solids per unit volume of filtrate per unit area, the term W then can be expressed as W = CV/A, where V denotes the total volume of fil-

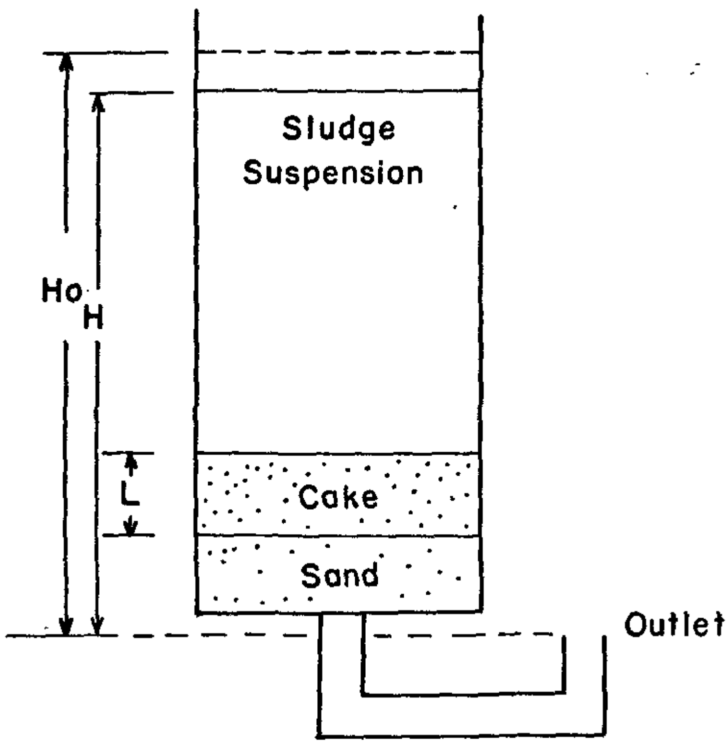


Fig. 3. Definition sketch for gravity drainage.

trate. By inserting the above expressions into Eq. 5, the basic dewatering equation is obtained as,

$$v = \frac{\rho\ g\ h_f\ A}{\mu\ C\ V\ R} \qquad (7)$$

The velocity in the above equation is related to the rate of drop of the sludge surface by the relation $v = dH/dt$. Also, the volume of filtrate is related to the head drop because $V = A(H_o - H)$. The head loss $h_f = -H$ and the resulting differential equation for dewatering is

$$\frac{dH}{dt} = \frac{-\rho\ g\ H}{\mu\ C\ R\ (H_o - H)} \qquad (8)$$

where H is the head of sludge and H_o is the initial head. The head is usually larger than the depth of sludge on the sand bed in that the lower liquid free surface is normally some depth into the sand bed.

The specific resistance can be written as a function of head loss as $R = C'H^{\sigma}$ to account for the variation in the sludge cake's flow resistance as it compresses. The exponent σ is called the coefficient of compressibility. The coefficient C' can be obtained by knowing a value of specific resistance at any arbitrary head loss as $C' = R_c/H_c^{\sigma}$. Substituting C' into the equation, one obtains

$$R = R_c \left(\frac{H}{H_c}\right)^{\sigma} \qquad (9)$$

Again substituting R into Eq. 8 yields

$$\frac{dH}{dt} = \frac{-\rho\ g\ H}{\mu\ C\ R_c \left(\frac{H}{H_c}\right)^{\sigma} (H_o - H)} \qquad (10)$$

The above differential equation may be integrated using the condition $H = H_o$ at $t = t_o$ to yield

$$t = \frac{\mu\ C\ R_c}{\sigma\ (\sigma + 1)\ H^{\sigma}} (H_o^{\sigma + 1} + \quad H^{\sigma + 1} - (\sigma + 1)\ H_o\ H^{\sigma}) \qquad (11)$$

The term C, defined as the weight of dry cake solid per unit volume of filtrate per unit area is inferred as a constant dependent on the initial and final cake solids content; a relation between the value C and these measurable parameters is found necessary for determination of the drainage rate of sludge. In the following derivation, the solids content of the suspension is considered as constant during dewatering. This assumption is necessary to fulfill the basic filtration concept that equal volumes of filtrate will deposit equal weights of solids on the sludge cake.

Let, S_o = solids content in the suspended sludge

S_c = solids content in the cake

W_s = weight of solids in the suspended sludge

W_w = weight of water in the suspended sludge

W_{wc} = weight of water in the cake

W_c = weight of solids in the cake

Since the solids content in the sludge can be expressed as

$$S_o = \frac{100\ W_s}{W_s + W_w} \qquad (12)$$

$$W_s = \frac{S_o\ W_w}{100 - S_o} \qquad (13)$$

After differentiating on both sides one obtains

$$dW_s = \left(\frac{S_o}{100 - S_o}\right) dW_w \qquad (14)$$

According to the principle of conservation of mass for the solids, it appears that the weight of solids deposited on the sludge cake must be equal to the change of weight of solids in the suspension, therefore

$$dW_s = dW_c \tag{15}$$

Following the same reasoning, the change of weight of water in the suspension must be equal to the change of weight of water in the cake plus that lost as filtrate.

$$dW_w = -\rho\ g\ A\ dH + \frac{100 - S_c}{S_c}\ dW_c \tag{16}$$

Substituting Eq. 15 and 16 into Eq. 14, one obtains

$$dW_c = \left(\frac{S_o}{100 - S_o}\right)\left(-\rho\ g\ A\ dH + \frac{100 - S_c}{S_c}\ dW_c\right)$$

or

$$dW_c = \frac{-\rho\ g\ A\ S_o\ S_c}{100\ (S_c - S_o)}\ dH \tag{17}$$

The above equation can be integrated subject to the conditions that $W_c = 0$ at $H = H_o$, and $W_c = W_c$ at $H = H$ to yield

$$W_c = \frac{\rho\ g\ S_o\ S_c}{100\ (S_c - S_o)}\ A\ (H_o - H) \tag{18}$$

Since $A\ (H_o - H)$ is equal to the total volume of filtrate V, the term C can be expressed in terms of the solids content of the suspended sludge and cake as,

$$\frac{W_c}{V} = C = \frac{\rho\ g\ S_o\ S_c}{100\ (S_c - S_o)} \tag{19}$$

The experimental verification of above equation was carried out in the laboratory. The results shown in Table 6 and Fig. 4 indicated that the derived relation between C and solids content was satisfactory.

Table 6. Experimental and Calculated Value of C*

Suspension Sludge Solids Content	Cake Solids Content	Calculated Value of C	Experimental Values of C
0.067	0.122	0.148	0.132
			0.128
			0.139
0.043	0.125	0.066	0.061
			0.060
			0.062
0.022	0.086	0.030	0.035
			0.033
			0.034

*C is defined as the dry solid material in the cake per unit volume of filtrate per unit time.

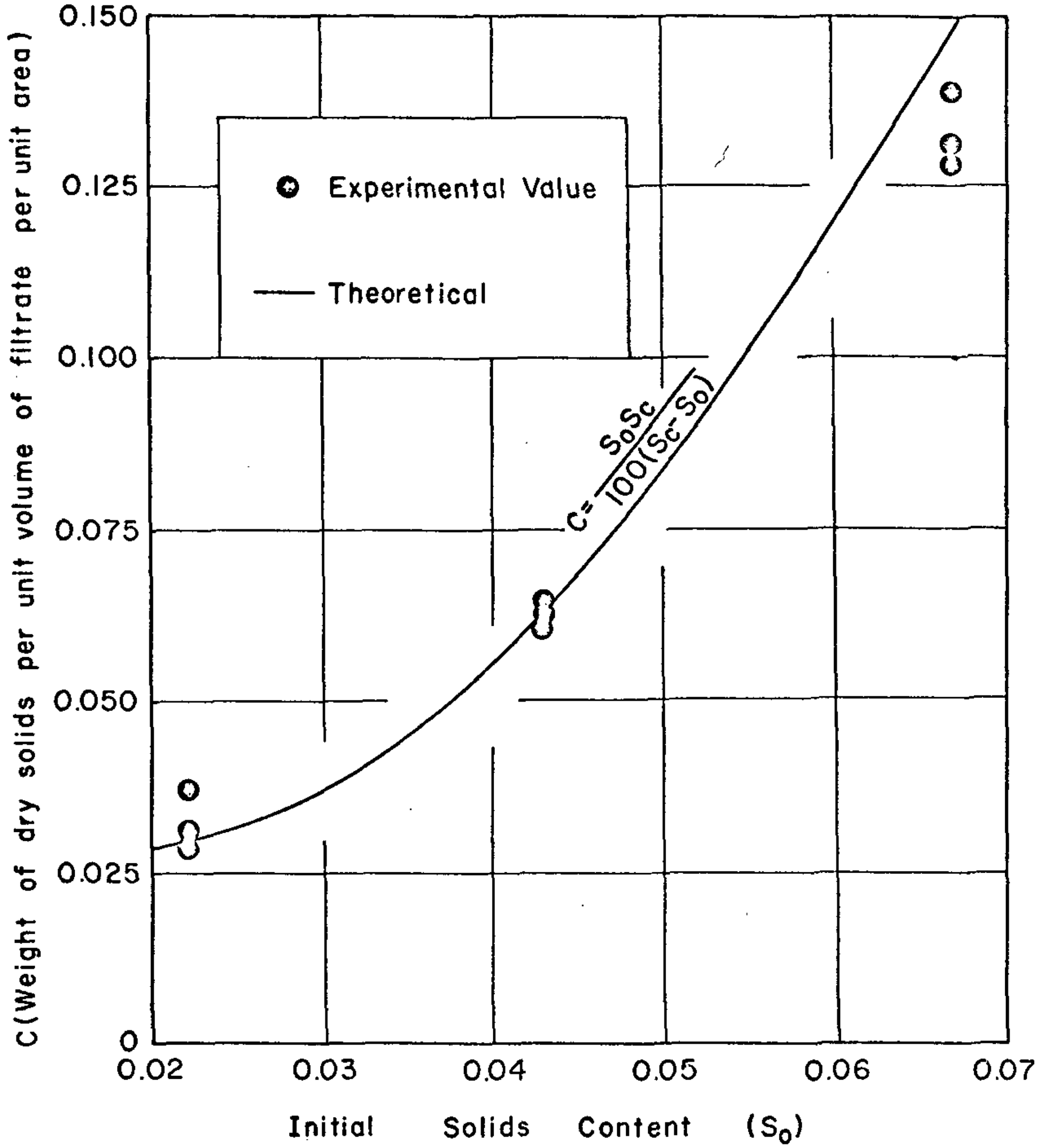


Fig 4. Comparision between calculated and experimental values of C.

3.2 Basic Considerations of Drying

Drying by evaporation is important for removing water from sludge on dewatering beds. Gravity drainage occurs mainly in the first few days after filling, yielding a sludge with approximately 15-20% solids content (18). Thereafter, water losses come from drying until the sludge becomes forkable.

The rate-of-drying for a typical sludge is shown in Fig. 5. Section BC represents the constant-rate period: within this period ample water is available in the sludge, and the delivery of water from the interior to the surface is sufficient to keep the surface completely wet. Therefore the rate of drying is considered to be constant. As the drying process goes on, the pores are progressively depleted of water, and at the critical point C, the surface layer of water begins to recede into the solid cake to start the falling-rate period. In this period, the curve can be divided into two sections. Section CD is the period in which the water in pores is in a continuous phase and the air is the dispersed phase. The rate of drying curve in this section is usually linear. The other section DE is the period when there is insufficient water left to maintain continuous films across the pores, the interfacial tension in the capillaries breaks, and the pores fill with air, which now becomes the continuous phase. This falling rate drying period will continue until the point E, called equilibrium moisture content, is reached.

Constant rate drying for water and wastewater sludge. Experimental investigations as well as theoretical considerations of the dry-

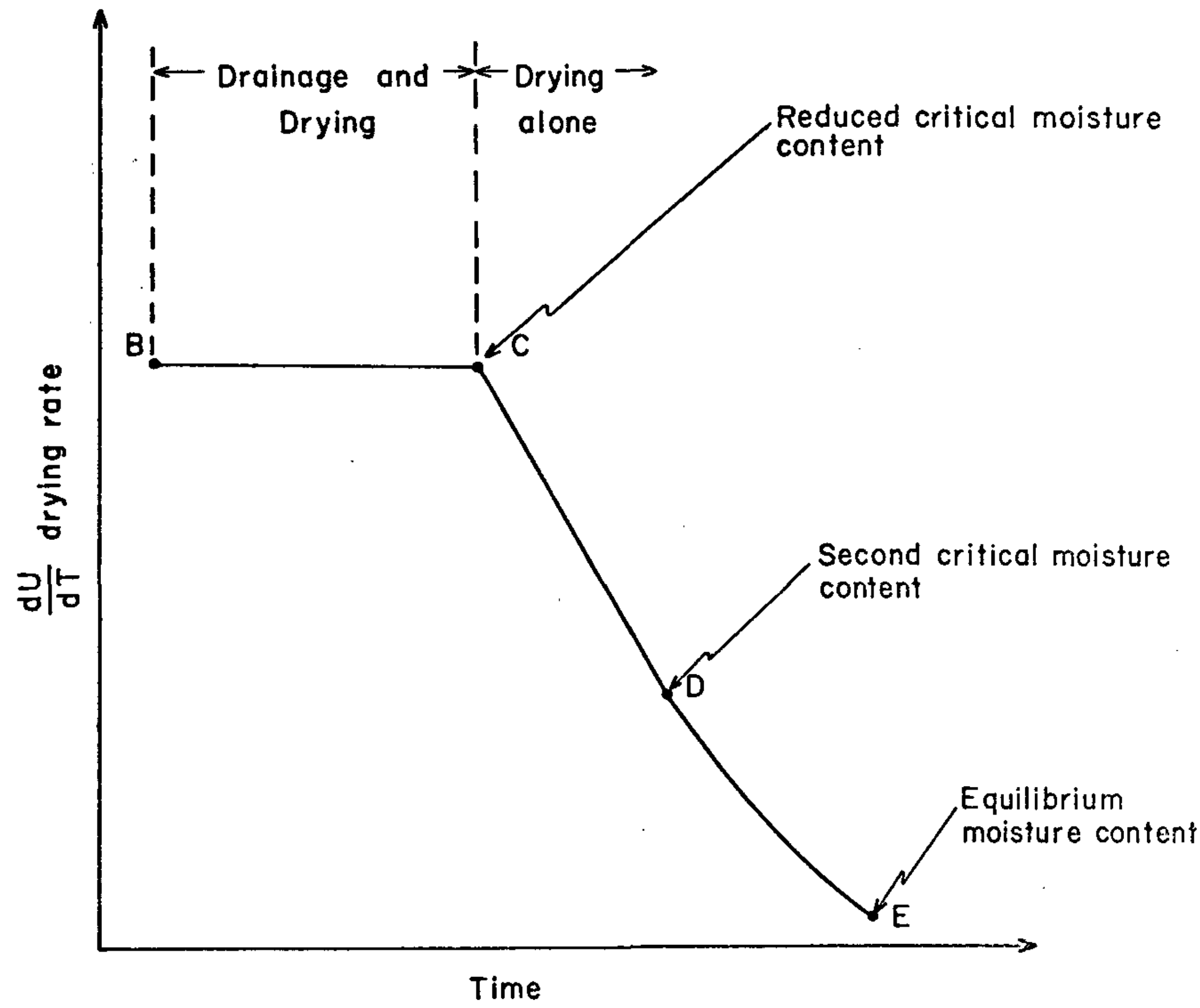


Fig 5. Drainage and Drying process vs. time.

ing rate of porous solids have appeared in many publications (18, 19, 20, 21). The investigations, concerned with constant rate drying, have led to the conclusion that the drying rates of various sludges in this stage, regardless of whether they are water or wastewater sludge, are very similar, and can be approximated by the drying rate of free water surface. Nebiker (18) reported that the sludge drying rate during this period, for sewage sludge drying outside, was an average of 5% greater than the evaporation rate of a free water surface because of the greater heat absorption of the dark sludge liquor. Some smaller drying intensities have been also reported (21, 22) with a range of 100 to 90 percent of that of a free water surface. The variations in sludge drying intensities from 90 to 105 percent of that obtained with a free water surface were probably due to the effect of floating sludge, color, or the absence of radiation heating in the indoor controlled drying experiments. However, in this study the constant drying rate was approximated by the local evaporation rate of a free water surface without modification.

Critical moisture content for wastewater sludge. The first critical moisture content, which marks the beginning of falling rate drying, was found to be a function of the evaporation potential of the air and weight of solids per unit plan area by Nebiker (18) for wastewater sludge, the function being represented by the following empirical formula (18) as;

$$U_{cr} = 500 \left(\frac{I_{sc} W_{ts}}{A}\right)^{0.5} \tag{20}$$

Where U_{cr} = The moisture content (dry basis) at the first critical point, which is also known as the reduced critical moisture content.

W_{ts}/A = Mass of solids in kg. per square meter of surface area.

I_{sc} = Constant drying rate in kg/sq m/hr.

Critical moisture content for water sludge. For water treatment sludge, because of its high internal moisture transport rate and settlement rate, the relation took a different form from that of wastewater sludge. Clark (29) found that the critical moisture content was inversely proportional to the initial solids content and depth of applied sludge, and could be written as:

$$U_{cr} = 4000\ S_o^{0.32}\ H_o^{0.2}\ I_{sc}^{0.5} \tag{21}$$

Where S_o = The percent of initial solids.

H_o = Initial sludge depth applied on bed in cm.

Both equations for water and wastewater sludge show positive relations between the critical moisture content and the constant drying rate I_{sc}. If meteorological evaporation data is used for the drying rate, the value of the reduced critical moisture content will show seasonal variations as I_{sc} changes. Its highest value will occur for the sludge dried in summer.

Falling rate drying for wastewater sludge. Nebiker developed the falling rate drying on the assumption that the rate of drying was linear with time so that a differential equation to express the water loss by drying was

$$\frac{du}{dt} = b - mt \tag{22}$$

Where m is the slope on Fig. 5 and b is a constant obtained from the boundary conditions, such as the location of points C and D on the figure. The time required to dry the material from a moisture content U_o to any moisture content U_t was found by integration of the equation subject to conditions such as $t = 0$, $U = U_o$; $t = t$, $U = U$.

An expression giving the relationship between the moisture content and time applicable to any portion of the drying curve when there was no drainage was

$$dt = \frac{-W_{ts}}{100\ A\ I_s}\ dU \qquad (23)$$

Experiments (22) have shown that the rate of drying I_s was related linearly with the moisture content during the falling rate period so that the following expression could be easily obtained.

$$I_{sf} = I_{sc}\ \left(\frac{U - U_p}{U_{cr} - U_p}\right) \qquad (24)$$

Where I_{sf} = drying rate during the falling rate drying period

U_p = equilibrium moisture content

According to Nebiker (18), the equilibrium moisture content averaged about 8% (wet basis), which was negligible in comparison to the value of U_{cr}. As a result, the following relationship was suggested;

$$I_{sf} = \frac{I_{sc}\ U}{U_{cr}} \qquad (25)$$

Substituting the above equation into Eq. (23) and integrating yields

$$t = \left(\frac{W_{ts}\ U_{cr}}{100\ A\ I_{sc}}\right)\ \ln\ \left(\frac{U_o}{U_t}\right) \qquad (26)$$

or

$$U_t = U_o\ \mathrm{Exp}\ \left(\frac{100\ A\ I_{sc}\ t}{W_{ts}\ U_{cr}}\right)$$

From the above equation, it is possible to calculate the moisture content of the sludge at any time during the falling rate drying period.

Falling rate drying for water treatment sludge. For water treatment sludge, a relationship for calculating the drying duration in the falling rate period was developed by Clark (29). Assuming that the drying intensity and moisture content were parabolic, the relationship can be expressed:

$$I_s^2 = 4 P U \tag{27}$$

or

$$I_s = 2P^{0.5} U^{0.5}$$

$$= I_{sc} \left(\frac{U}{U_{cr}}\right)^{0.5}$$

where

$$2P = I_s \tag{28}$$

From Eq. 23

$$t = \frac{W_{ts}}{100\ A} \int_{U_t}^{U_o} \frac{dU}{I_s} \tag{29}$$

Substituting Eq. 28 into Eq. 29 and performing the integration gave the drying duration in the fall-rate period as

$$t_f = \frac{2\ W_{ts}\ U_{cr}^{0.5}}{100\ A\ I_{sc}} (U_o^{0.5} - U_t^{0.5}) \tag{30}$$

CHAPTER IV

THE EFFECT OF RAINFALL ON SLUDGE DEWATERING ON SAND BEDS

4.1 The Effect of Rainfall on Drainage

The fundamental gravity drainage equation to describe water flowing through a compressible sludge cake has been discussed in the previous chapter as

$$t = \frac{\mu C R_c}{(\sigma + 1) H_c^{\sigma}} (H_o^{\sigma + 1} + \sigma H^{\sigma + 1} - (\sigma + 1) H_o H^{\sigma})$$

$$C = \frac{\rho g S_c S_o}{100 (S_c - S_o)}$$

The effect of rainfall on the rate of drainage was not considered. In this portion of the study an effort has been made to include this parameter in the drainage equation, so that a drainage model could be established with daily rainfall as a stochastic input.

The addition of rainfall on the surface of sludge may not only prolong the drainage time but also it may dilute the suspended sludge. This diluting effect, according to the basic equations, will increase the rate of drainage. As a result, an assumption is important to the behavior of the dewatering system. For simplicity in analysis, two models were studied to represent two extreme conditions of water on the surface of the sludge. They were, namely, a mixing and ponding model. In the mixing model the rainfall was assumed to be thoroughly mixed with the sludge suspension as soon as it was added on the surface of the sludge. But in the ponding model it was assumed that the water and sludge were immiscible, therefore the rainfall was ponded on the surface as supernatant.

Mixing model for sludge drainage. It is assumed that R_1 unit of rainfall are added to the surface of draining sludge at time t_1, in which a cake has been formed at sludge depth H_1 as shown in Fig. 6.

It is seen that the filter resistance after time t_1 will consist of the formed cake resistance plus a gradually increasing resistance due to the newly forming cake as the filtration goes on. Based on the basic drainage equation, the friction losses can be written in terms of the corresponding specific resistance and the discharged filtrates. If H_{f1} represents the friction loss of the formed cake and H_{f2} the friction loss of the forming cake, these two equations will be:

$$H_{f1} = \frac{dv}{dt}[\mu \ C \ R \ (H_o + D - H_1) \ / \ (\rho \ g \ A)] \qquad (31)$$

$$H_{f2} = \frac{dv}{dt}[\mu \ C \ R' \ (H_1 + D + R_1 - H) \ / \ (\rho \ g \ A)] \qquad (32)$$

$$C = \rho \ g \ S_o \ S_c \ / \ (S_c - S_o) \cdot 100 \qquad (33)$$

$$C' = \rho \ g \ S_o' \ S_c \ / \ (S_c - S_o') \cdot 100 \qquad (34)$$

$$R = R_c \ (\frac{H_1}{H_c})^{\sigma} \qquad (35)$$

$$R' = R_c \ (\frac{H}{H_c})^{\sigma} \qquad (36)$$

Where S_o = solids content in the suspended sludge before raining

S_o' = solids content in the suspended sludge

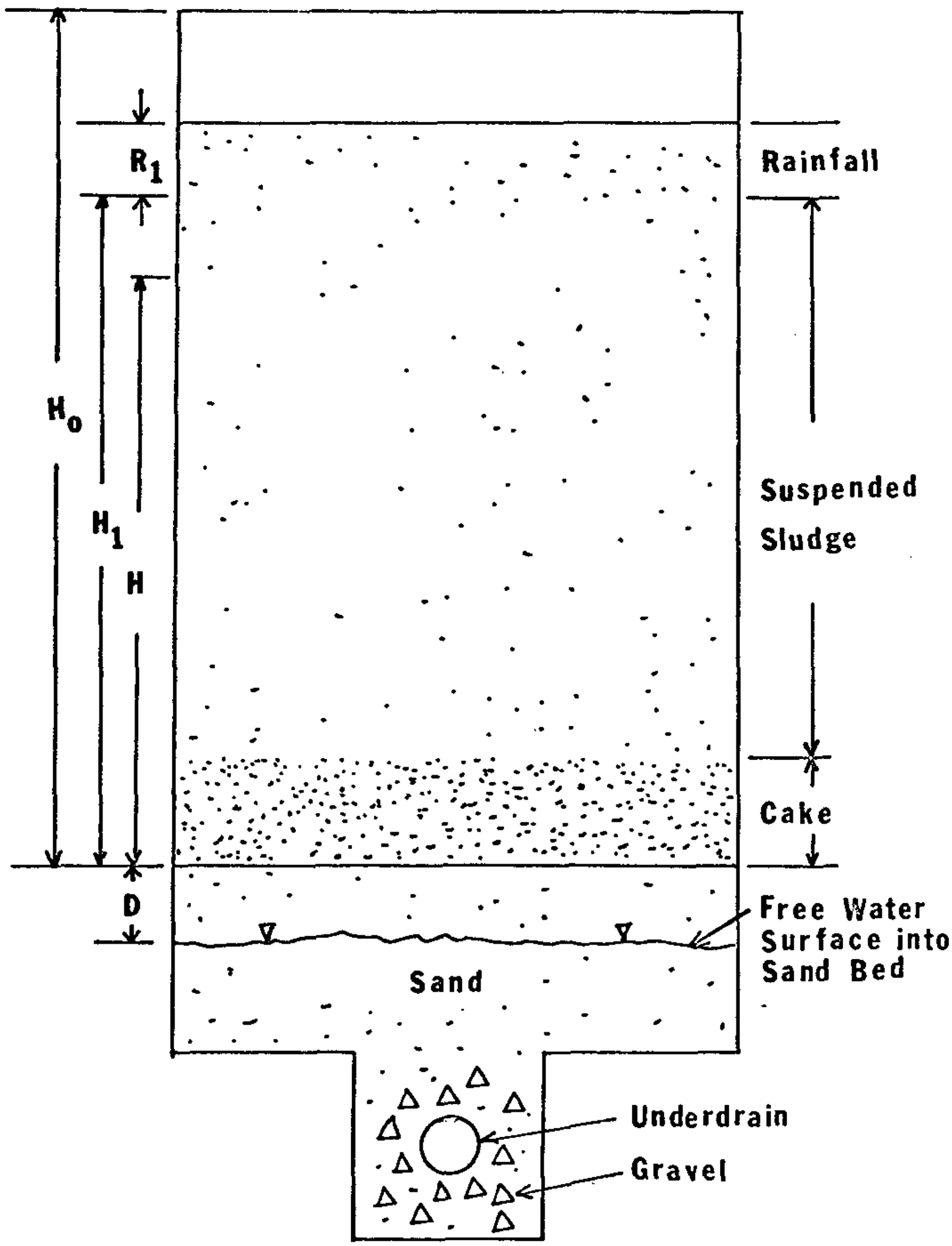


Fig 6. Definition sketch of mixing drainage

after raining

S_c = solids content in the cake

D = depth of free water surface into sand bed

Since total friction loss $H_f = H_{f1} + H_{f2}$

$$\frac{dv}{dt} = \rho\ g\ A\ H_f\ /\ (\mu\ C\ R\ (H_o + D - H_1) + \mu\ C'\ R'\ (H_1 + D + R_1 - H)) \quad (37)$$

The term $\frac{dv}{dt}$ may be rewritten in terms of the head as $-A\frac{dH}{dt}$ and the total friction loss H_f is none other than the head, H. Then Eq. 37 becomes:

$$\frac{dH}{dt} = -\rho\ g\ H\ /\ (\mu\ C\ R\ (H_o + D - H_1) + \mu\ C'\ R'\ (H_1 + D + R_1 - H)) \quad (38)$$

This equation can be integrated from $H = H_1 + R_1 - E_1$ at $t = t_1$ to $H = H$ at $t = t_2$ where E_1 is the height of sludge lost due to evaporation during the period t_1. The equation becomes

$$t_2 - t_1 = \frac{\mu\ R_c}{100\ H_c^{\sigma}\ \sigma\ (\sigma + 1)} [\sigma\ (\sigma + 1)\ \frac{S_c\ S_o}{(S_c - S_o)}\ H_1^{\sigma}\ (H_o + D - H_1)$$
$$\log\ (\frac{H_1 + D + R_1 - E_1}{H}) + (\sigma + 1) \frac{S_o'\ S_c}{S_c - S_o'} (H_1 + D + R_1)$$
$$((H_1 + D + R_1 - E_1)^{\sigma} - H^{\sigma}) - \frac{S_o'\ S_c}{S_c - S_o'} (H_1 + D$$
$$+ R_1 - E_1)^{\sigma + 1} - H^{\sigma + 1})] \quad (39)$$

Where S_o', the solids content in the suspended sludge after raining, will depend on the amount of rainfall, the height of suspended sludge and the initial solids content. An attempt has been made to express this after-raining solids content in terms of known parameters.

By definition, the after-raining solids content can be written as

$$S_o' = \frac{W_s\ 100}{W_w + \rho\ g\ A\ R_1 + W_s}$$

or

$$W_s = \frac{S_o'}{100 - S_o'}\ (W_w + \rho\ g\ A\ R_1) \tag{40}$$

Where W_s = The weight of dry solid material in the suspension after raining.

W_w = The weight of water in the suspension before raining.

Since the solid material will be the same before or after raining, the W_s can be also expressed in terms of the initial solids content as;

$$W_s = \frac{S_o}{100 - S_o}\ W_w \tag{41}$$

Substituting the above equation into Eq. 40, gives

$$\frac{S_o}{100 - S_o}\ W_w = \frac{S_o'}{100 - S_o'}\ (W_w + \rho\ g\ A\ R_1) \tag{42}$$

W_w, the amount of water in the suspension, can be again expressed as the total amount of water on the drying bed minus the amount of water in the cake and that discharged as the filtrate. Since the total volume of water in the sludge was found equal to

$$A\ H_o\ \left(\frac{\rho_s\ (1 - \frac{S_o}{100})}{\frac{S_o}{100}\rho + \rho_s\ (1 - \frac{S_o}{100})}\right)$$

therefore

$$W_w = \rho\ g\ A\ H_o\ \left(\frac{\rho_s\ (1 - \frac{S_o}{100})}{\frac{S_o}{100}\rho + \rho_s\ (1 - \frac{S_o}{100})}\right) - W_{sc}\frac{100 - S_c}{S_c} - A\ \rho\ g\ (H_o - H) \tag{43}$$

where W_{sc} denotes the dry solid material in the cake, and ρ_s the density of total solids. Since C_o has been defined in the previous section as the dry solid material in the cake per unit volume of filtrate, therefore, W_{sc} can be replaced by the term $C_o A (H_o - H)$. This makes Eq. 43 become;

$$W_w = \rho\ g\ A\ H_o \left(\frac{\rho_s \left(1 - \frac{S_o}{100}\right)}{\frac{S_o}{100}\rho + \rho_s \left(1 - \frac{S_o}{100}\right)}\right) - C_o\ A\ (H_o - H_1)$$

$$\left(\frac{100 - S_c}{S_c}\right) - A\ \rho\ g\ (H_o - H_1) \qquad (44)$$

Inserting $C_o = \dfrac{\rho\ g\ S_o\ S_c}{100\ (S_c - S_o)}$ into Eq. 44,

$$W_w = \rho\ g\ A\ H_o \left(\frac{\rho_s \left(1 - \frac{S_o}{100}\right)}{\frac{S_o}{100}\rho + \rho_s \left(1 - \frac{S_o}{100}\right)}\right) + \frac{\rho\ g\ S_o\ A}{100\ (S_c - S_o)}$$

$$(H_o - H_1)\ (100 - S_c) - A\ \rho\ g\ (H_o - H_1) \qquad (45)$$

Substituting Eq. 45 into Eq. 42, yields

$$\frac{S_o}{100 - S_o} = \frac{S_o'}{100 - S_o'} \left[\left(H_1 - \frac{S_o\ \rho\ H_o}{S_o\ \rho + \rho_s\ (100 - S_o)} + \frac{S_o\ (100 - S_c)\ (H_o - H_1)}{100\ (S_o - S_o)}\right) /\right.$$

$$\left.\left(H_1 - \frac{S_o\ \rho\ H_o}{S_o\ \rho + \rho_s\ (100 - S_o)} + \frac{S_o\ (100 - S_c)\ (H_o - H_1)}{100\ (S_c - S_o)}\right)\right] \qquad (46)$$

If $\quad G = H_1 - \dfrac{S_o\ \rho\ H_o}{S_o\ \rho + \rho_s\ (100 - S_o)} + \dfrac{S_o\ (100 - S_c)\ (H_o - H_1)}{100\ (S_c - S_o)}$

Then

$$S_o' = \frac{S_o\ G}{\left(G + R - \frac{S_o}{100} R_1\right)} \qquad (47)$$

Eq. 47 is an expression of the after-raining solids content in terms of the known parameters S_o, H_o, H_1, R_1, ρ_s, ρ.

For a general case, the above drainage equation can be easily extended to the condition that there are many raining days with various amounts of rainfall added on the surface of the sludge at various heights.

If the friction losses due to the resistance of the various cakes formed after each rainfall are denoted as H_{fn}, n=0, 1 .. n then,

$$H = h_{f1} + h_{f2} + \ldots\ldots + h_{fn}$$

$$= \frac{dv}{dt}[\mu\ C_o\ R_c\ (\frac{H_1}{H_c})^\sigma\ (H_o + D + R_1 - H_1) +$$

$$\mu\ C_1\ R_c\ (\frac{H_2}{H_c})^\sigma\ (H_1 + D + R_2 - H_2) +$$

$$\ldots\ldots + \ldots\ldots + \qquad (48)$$

$$\mu\ C_{n-1}\ R_c\ (\frac{H_n}{H_c})^\sigma\ (H_{n-1} + D + R_n - H)]/\rho\ g\ A$$

Rearranging the above equation;

$$\frac{dv}{dt} = \frac{\rho\ g\ A\ H}{\frac{\mu\ R_c}{100\ H_c^\sigma}[\sum_{n=0}^{n+1} C_n\ H_{n+1}\ (H_n + D + R_{n+1} - H_{n+1})]} \qquad (49)$$

After integration, the above equation yields;

$$t_{n+1} = t_n + \frac{\mu\ R_c}{100\ H_c^\sigma}\{[\sum_{n=0}^{n} \frac{S_n\ S_c}{S_c - S_n} H_{n+1}\ (H_n + D + R_{n+1} - H_{n+1})$$

$$\log\ (\frac{H_n + R_n + D - E_n}{H})] + \frac{S_n\ S_c}{S_c - S_n}[(H_n + D + R_n - E_n)^\sigma$$

$$- H^\sigma]\} \qquad (50)$$

Where S_n is;

$$S_n = \frac{S_{n-1}\left(H_n - \dfrac{S_n\ \rho\ H_{n-1}}{S_{n-1}\ \rho + \rho_s\ (100 - S_n - 1)} + \dfrac{S_{n-1}\ (100 - S_c)\ (H_{n-1} - H_n)}{100\ (S_c - S_{n-1})}\right)}{\left(H_n - \dfrac{S_{n-1}\ H_{n-1}\ \rho}{S_{n-1}\ \rho + \rho_s\ (100\ S_{n-1})} + \dfrac{S_{n-1}\ (100 - S_c)\ (H_{n-1} - H_n)}{100\ (S_c - S_{n-1})} + R_n - \dfrac{S_{n-1}}{100}\ R_n\right)} \quad (51)$$

Ponding model for sludge drainage. In the development of this model, the rainfall added on the surface of the sludge is assumed immisicible with the sludge and therefore it is ponded on the surface as supernatant. The equation, which calculates the drainage rate of the sludge, is derived below.

Let R_1 units of rainfall be ponded on the surface of sludge at time t_1 while the sludge depth is known as H_1 shown on Fig. 7. It is seen that the resistance to the flow of supernatant will include resistance from the sludge suspension, the formed cake and the supporting material. If the resistance from the suspended sludge and the supporting material are neglected, the rate of drainage can be expressed as;

$$\frac{dV_s}{dt} = \frac{\rho\ g\ A\ h_f}{\mu\ C\ \frac{RV}{A}} \quad (52)$$

Where

$$\frac{dV_s}{dt} = -A\ \frac{d(H_1 + D + R_1)}{dt} \quad (53)$$

if H_1 is considered as a constant for a short period, then

$$dV_s = -A\ dR_1 \quad (54)$$

and

$$h_f = H_1$$

then

$$\frac{dR_1}{dt} = \frac{-\ \rho\ g\ (H_1 + D)}{\mu\ C\ R_c\ \left(\frac{H_1}{H_c}\right)^{\sigma}\ (H_o + D - H_1)} \quad (55)$$

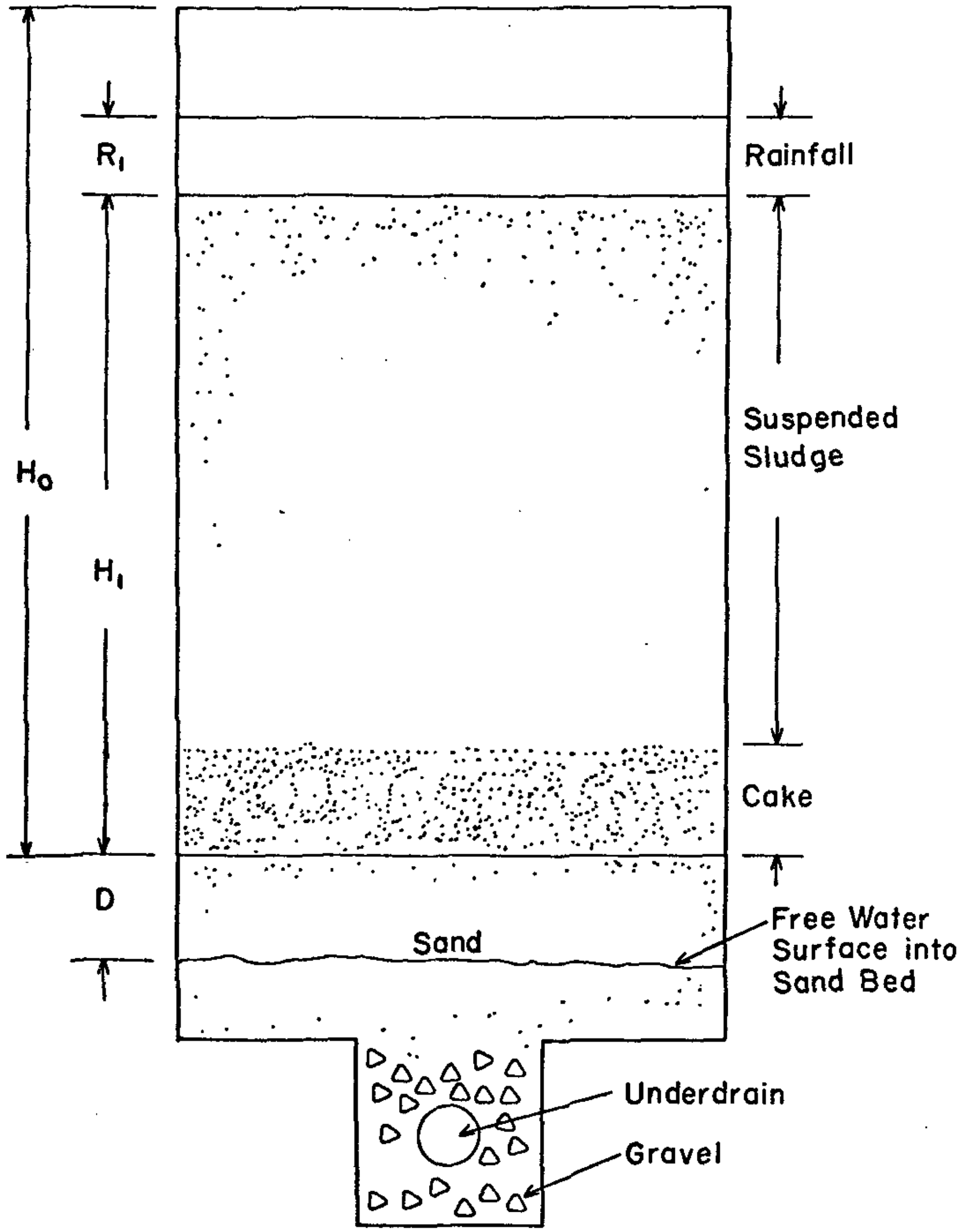


Fig 7. Definition sketch of ponding drainage.

Integrating the above equation from $R_1 = R_1$ at $t = 0$, to $R_1 = R$ at $t = t$ yields;

$$R = R_1 - \frac{\rho\ g\ (H_1 + D)\ t}{\mu\ C\ R_c\ (\frac{H_1^\sigma}{H_c^\sigma})\ (H_o + D - H_1)} \tag{56}$$

where
$$C = \frac{\rho\ g\ S_o\ S_c}{(S_c - S_o)\ 100}$$

or
$$R_1 - R = \Delta R = \frac{\rho\ g\ (H_1 + D)\ t}{\mu\ C\ R_c\ (\frac{H_1}{H_c})^\sigma\ (H_o + D - H_1)}$$

or
$$\Delta R = \frac{(H_1 + D)\ t}{\frac{\mu\ S_o\ S_c}{100\ (S_c - S_o)}\ (\frac{H_1}{H_c})^\sigma\ R_c\ (H_o + D - H_1)} \tag{57}$$

Eq. 57 allows determination of the amount of supernatant drained at a certain period of time, while the depth of the sludge is assumed to be kept constant. This means that the dewatering of sludge is temporarily halted during the course of draining the supernatant. Of course, it is not true in a real sense, but the error may not be significant if the time of drainage is chosen very small.

Verification of drainage models. After developing the mixing and ponding models, tests were made to see if these two models yielded the same results under various rainfall conditions. The aim of this investigation was to test the sensitivity of the assumption about mixing and ponding models which represented two extreme conditions of rain-water on the surface of sludge. The results showed that under identical conditions the ponding model usually had a more rapid drainage rate than the mixing model. The reason was simply because the mixing model treated rainwater as sludge while the ponding model did not. A representative comparison is shown in Fig. 8. The overall results indicated that the difference in most cases were within 5 percent to demonstrate that the assumption on miscibility of rainwater and sludge would not affect the final results significantly. Of course, in the real condition the rainwater in the sludge would behave in between these two models.

Since the mixing drainage model gave a conservative drainage rate, and lent itself well to computer programming applications, it was chosen as the drainage model used to predict the required drainage time for water and wastewater sludge in the rest of the study.

To test whether or not this model really describes the behavior of sludge drainage on sand bed, the use of the mixing model was further investigated in the laboratory by column tests. The test apparatus and procedure were identical with that employed by Sanders (37) and Clark (29). Results shown in Fig. 9 indicated that the observed sludge heads on sand beds were very close to that predicted by the mixing model equation, and proved that the model was verified experimentally, provided the adjusted specific resistance and a media factor 0.36 were used.

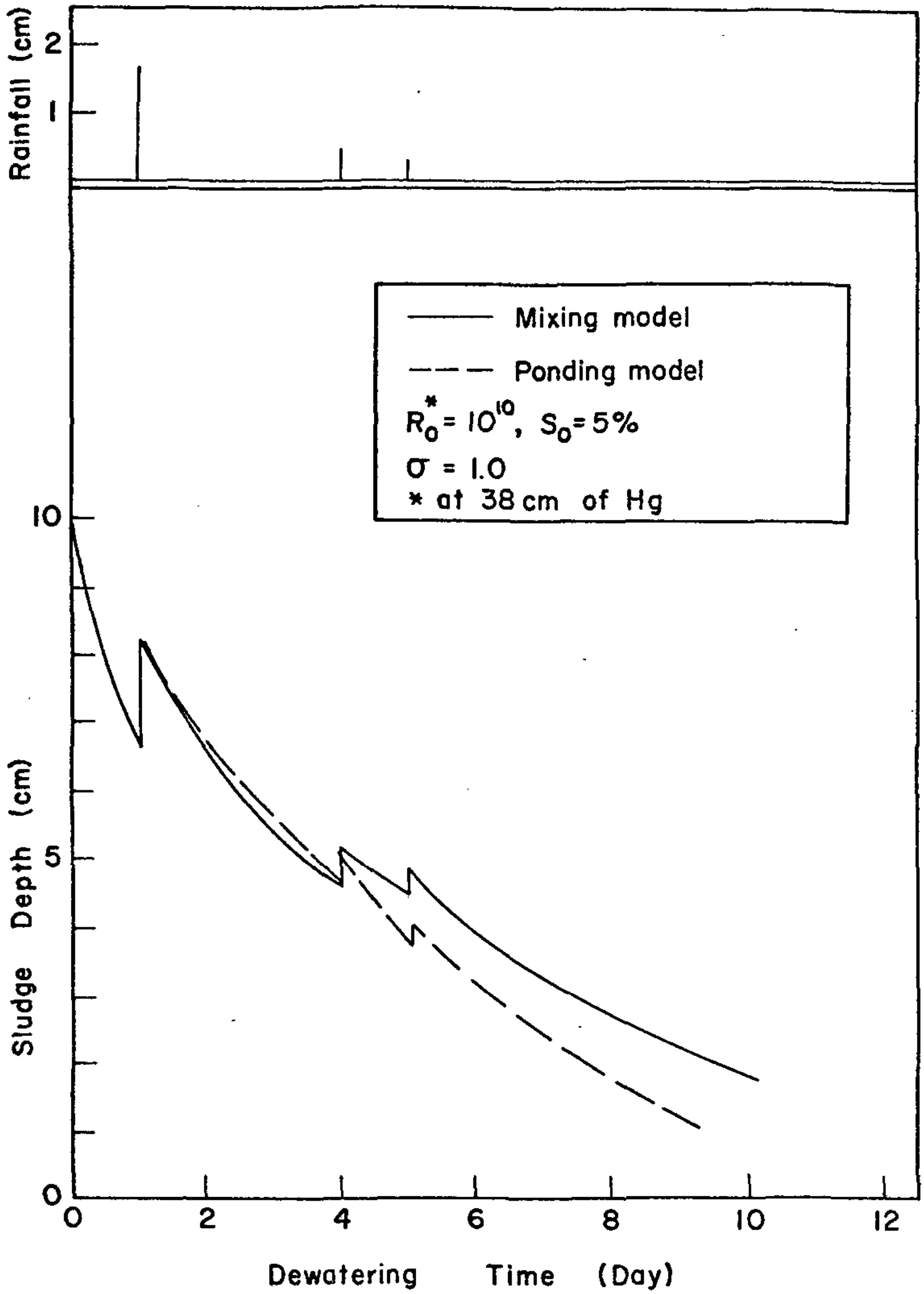


Fig 8 Comparison between mixing and ponding models.

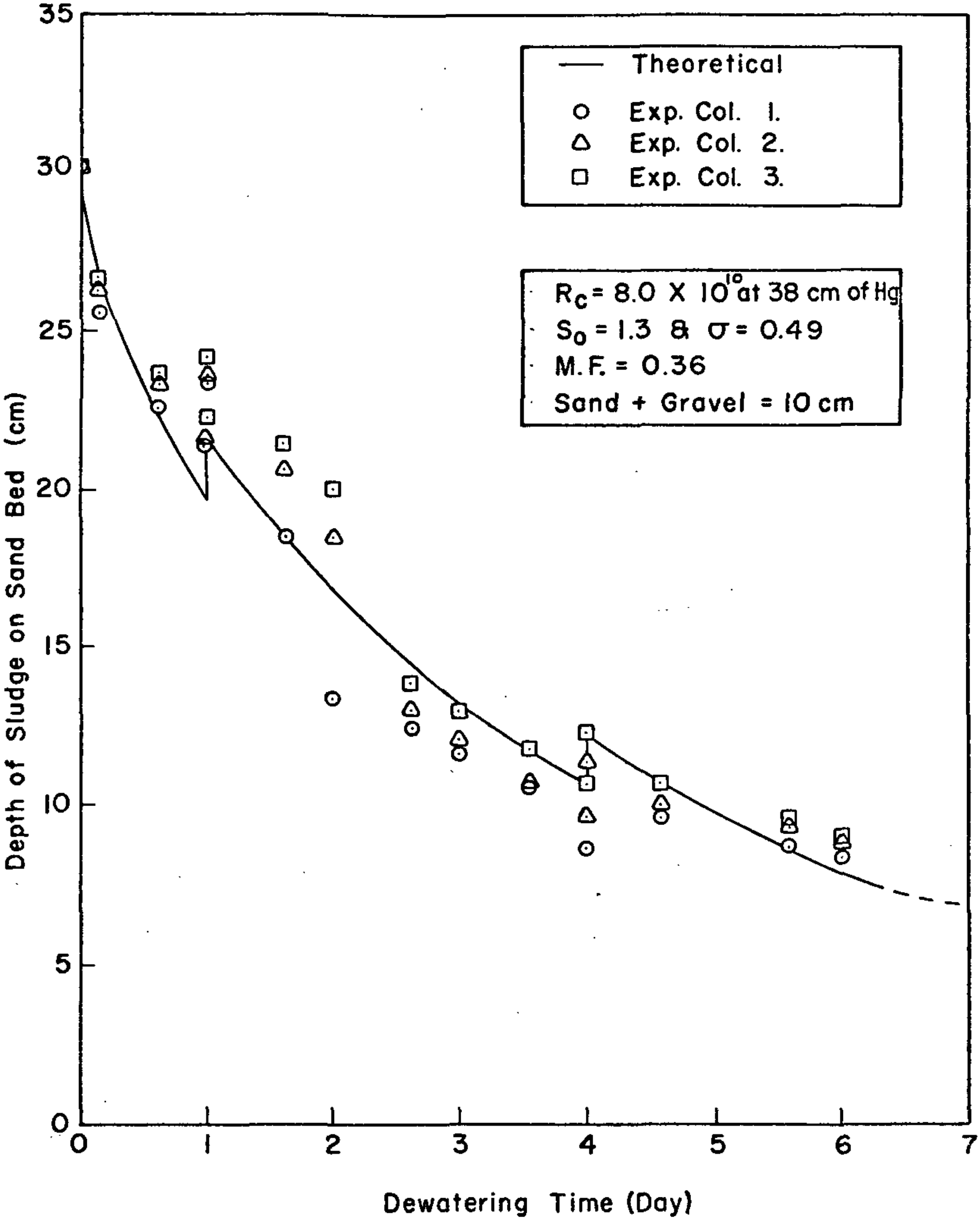


Fig 9. Comparison between mixing drainage model and experimental data.

4.2 The Effect of Rainfall on Drying

When rain occurs during the constant rate drying period, the effects of the rainfall on the rate of drainage may be determined by the models discussed previously. But, during the falling rate drying period, very little information exists on the effects of the rainwater on the process of drying. In all cases, rainfall will prolong the length of time a drying sludge must remain on the sand bed. A previous investigation (19) indicated that this effect varied considerably, depending on the time when rain occurred and the intensity and duration of the rainfall. If rain occurs during the falling rate drying period, a portion of the rainwater is absorbed by the sludge, while the remainder, depending on factors such as the depth and frequency of cracks, the cake moisture content, and the sludge cake's permeability, may be drained through the sludge cake to appear as filtrate, or be ponded on the surface as supernatant.

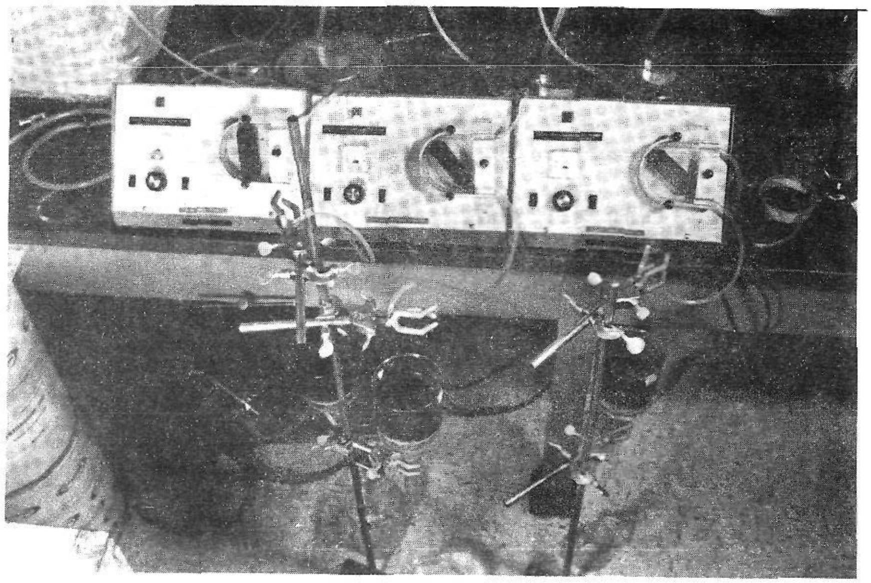
However, the primary parameter, which is important with respect to drying, is the amount of the rainwater retained by the sludge as contrasted with the amount that is drained readily. In this study experiments were run to develop an equation which would predict the amount of rainwater absorbed by the sludges after each rain for different sludge conditions.

<u>Experimental determination of rainfall effects on drying.</u> These experiments were concerned primarily with the amount of rainwater absorbed by the sludge after each rain for different sludge conditions. Variables considered were: (1) the moisture content of the sludge after

rain, (2) the moisture content of the sludge before rain, (3) the intensity of rainfall, (4) the duration of rainfall. In order to make the tests representative of field conditions, the initial moisture contents of the sludge were intentionally made to cover the range that would normally be found during the falling rate drying period for water and wastewater sludge drying on sand beds.

The rainfall effects were determined through experiments with intensities of 0.1 in/hr, 0.5 in/hr and 1 in/hr for durations of 1, 2, and 4 hr. at each intensity. The experimental apparatus is shown in Fig. 10.

The test procedure started by pouring 500 ml of well mixed sludge into a fritted glass funnel in which the sludge was first allowed to dewater until it reached to the desired moisture content. Then, after being weighed, this glass funnel was installed on the testing equipment to receive the artificial rainfall at the designated intensity and duration. After treatment, the sludge was removed from the test apparatus and weighed again to measure the increase of weight due to the absorption of rainfall. The results of the experiments revealed that only a portion of rainwater was absorbed by the sludge, the percentage of rainwater retained varied considerably with the cake moisture content and the intensity and duration of the rainfall. Generally there was a rapid initial absorption of rainwater by the sludge during the earily stage of testing, then the rate of absorption decreased with an increase in the duration of rainfall. This initial intake was even more significant for higher intensities of rainfall. The occurance



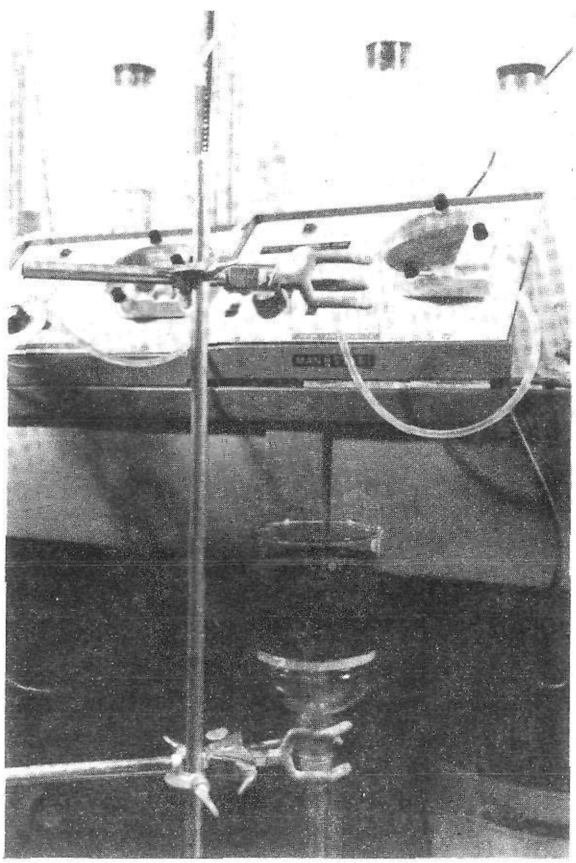


Fig. 10 Apparatus for determining the effect of rainfall on drying

of that phenomenon was a result of a highly porous sludge surface, which showed a rapid initial intake of water when there was a sufficient water supply as in the case of high intensities of rainfall. After the surface was saturated, the water than migrated from the high moisture surface portion to the inner part of the sludge.

In order to establish the water-absorbing characteristics of sludge, the moisture contents after rain were related by multiple regression analysis to the moisture content before rain, the intensity, and the duration of the rainfall. In general, statistically significant relationships were discovered, and the signs of the regression coefficients were consistent with intuitive judgment of cause and effect. The regression equations for water and wastewater sludge are shown below.

(1) Water treatment sludge

$$M = 3.44\, M_o^{\,0.812} \times I^{0.008} \times D^{0.012} \qquad (58)$$

$R^2 = 0.9956$ $\qquad$ $N = 30$

(2) Wastewater treatment sludge

$$M = 5.44\, M_o^{\,0.751} \times I^{0.062} \times D^{0.041} \qquad (59)$$

$R^2 = 0.9759$ $\qquad$ $N = 27$

Where
M = Moisture content after rain
M_o = Moisture content before rain
D = Duration of rainfall (hr)
I = Intensity of rainfall (in/hr)

It is interesting to note that the exponents for intensity and duration were close to each other for each type of sludge. This suggested that the effects of intensity on the moisture content after rain seemed very similar to the duration; therefore, these two factors were combined together to become a new variable which is the daily rainfall in inches. This combination was important practically because daily rainfall records are more readily available than records of continuous rainfall. When the moisture content after rainfall was related to the parameters of initial moisture content and daily rainfall, the equations obtained were:

(1) For water treatment sludge

$$M = 3.55\ M_o^{0.807} \times R_d^{0.0095} \qquad (60)$$

$$R^2 = 0.9953 \qquad N = 30$$

(2) For wastewater sludge

$$M = 4.93\ M_o^{0.766} \times R_d^{0.056} \qquad (61)$$

$$R^2 = 0.9727 \qquad N = 27$$

Where R_d = daily rainfall (inch)

The comparison between the predicted moisture contents by Eqs. 60 and 61 and the experimental values are shown in Tables 7 and 8.

Table 7. The Effect of Rainfall on Wastewater Sludge Drying During the Falling Rate Period.

Rainfall In Inch (R_d)	Moist. Cont. Before Rain (M_o)	Experimental Moist. Cont. After Rain (M)	Calculated Moist. Cont. After Rain (M)	Residual
.1	267.5	310.7	313.3	-2.7
.1	272.2	326.5	317.5	9.1
.1	276.6	305.3	321.4	-16.1
.2	243.6	292.3	303.2	-10.9
.2	269.6	338.5	327.7	10.8
.2	174.7	236.7	235.0	1.6
.4	289.6	364.7	359.8	4.9
.4	179.1	243.6	249.0	-5.4
.4	330.2	396.3	397.8	-1.6
.5	250.8	326.9	326.4	.6
.5	317.2	381.7	390.6	-9.0
.5	290.7	371.7	365.4	6.3
1.0	257.5	342.2	346.2	-4.0
1.0	280.0	381.0	369.2	11.8
1.0	201.4	289.3	286.8	2.6
2.0	195.6	287.7	291.5	-3.8
2.0	278.4	383.5	382.1	1.5
2.0	329.9	420.9	435.1	-14.3
1.0	272.9	375.4	361.9	13.5
1.0	345.0	436.2	433.1	3.0
1.0	297.5	398.8	386.6	12.2
2.0	285.4	392.6	389.4	3.2
2.0	321.6	463.3	426.7	36.7
2.0	254.5	359.6	356.7	2.9
4.0	245,5	358.2	360.7	-2.4
4.0	369.6	469.1	493.5	-24.3
4.0	342.5	452.9	465.5	-12.6

Table 8. The Effect of Rainfall on Water Treatment Sludge Drying During the Falling Rate Period.

Rainfall In Inch (R_d)	Moist. Cont. Before Rain (M_o)	Experimental Moist. Cont. After Rain (M)	Calculated Moist. Cont. After Rain (M)	Residual
.1	580.0	592.9	604.6	-11.7
.1	560.0	578.6	587.7	-9.1
.1	572.3	583.7	598.1	-14.4
.2	548.3	572.6	578.1	-5.5
.2	521.7	548.9	555.4	-6.5
.2	559.1	572.3	587.3	-15.1
.2	362.6	405.7	413.9	-8.2
.4	540.0	569.4	571.4	-2.0
.4	526.6	562.0	559.9	2.1
.4	508.6	546.3	544.4	1.9
.5	575.4	596.3	601.7	-5.4
.5	564.3	585.7	592.3	-6.5
.5	571.4	594.3	598.3	-4.0
1.0	546.3	576.9	577.3	-.5
1.0	546.9	576.3	577.8	-1.5
1.0	556.0	584.3	585.6	-1.3
1.0	418.6	466.3	465.6	.7
2.0	548.9	577.4	579.9	-2.5
2.0	544.3	579.1	576.0	3.1
2.0	457.4	505.7	500.5	5.2
1.0	568.6	591.4	596.3	-4.9
1.0	564.3	597.1	592.7	4.5
1.0	568.6	595.7	596.3	-.6
2.0	530.0	564.9	563.8	1.1
2.0	544.0	585.7	575.8	9.9
2.0	537.7	577.1	570.4	6.7
2.0	423.7	471.4	470.5	.9
4.0	538.6	578.9	571.5	7.3
4.0	547.7	584.3	579.4	4.9
4.0	518.6	560.3	554.3	6.0

CHAPTER V

SYNTHETIC RAINFALL

Rainfall has a profound influence upon the total behavior of the dewatering system. In this section the factors which entered into the selection of the rainfall probability function are discussed. This function was then utilized to sequentially generate rainfall data, which was used as an input to the dewatering model.

Rainfall was generated sequentially using the Monte Carlo method. The generated rainfall data could not be distinguished from the historical rainfall data by means of the statistical tests of significance.

5.1 Probability Distribution Function of Daily Rainfall

Frequently hydrological observations are not independent of preceding conditions, although this dependence decreases with increased lengths of time intervals between successive observations. For example, it has been noted that the yearly amount of rainfall bears little or no relation to the measured rainfall in the preceding year. While the amount for a particular month is sometimes related to a small extent to the amount recorded during the previous month, the probability of precipitation on a given day increases if it rained the previous day. This is due to the rainfall and the cause of rain tending to cluster together from day to day. This persistent effect might be subject to the seasonal change depending on the geographical location, but it was usually so gradual that this effect during any month could be assumed as a constant without adversely affecting the solution.

Beside this persistent effect, it was also seen that the distribution of rainfall appeared highly skewed regardless of geographical location. Consequently, light rain occurred most frequently, and days with increasing amounts occurred more and more rarely. Based on the above observations, it was hoped that the Poisson probability distribution function would fit the historical data and would serve as the rainfall model for sequential generation.

The Poisson distribution has been applied to many problems concerned with the occurrence of rare events such as hail or heavy storms. But the modified Poisson distribution, suggested by Wanner, (14) was used by Bagley (15) to represent the frequency distribution of daily rainfall for San Francisco, Sacramento and Spokane. Originally, the modified Poisson distribution was developed to investigate deaths caused by infectious diseases. The infection parameter was analogous to the persistence characteristic of daily rainfall. A comparison of the Poisson and modified Poisson distribution is indicated in Table 9.

It is seen that the modified Poisson distribution is a function of two parameters λ, and d. The introduction of the additional parameter, d, makes it more flexible than the ordinary Poisson distribution, and able to represent the degree of dependence of one event upon another. When d is zero, it is easy to show that the modified Poisson distribution approaches to the Poisson distribution as a limit.

In many textbooks of probability, the parameter λ of the Poisson distribution has been shown to be equal to the expected value based on independent events. The modified Poisson distribution deals with events that may depend on each other. Hence, we may intuitively expect that the parameter λ in the modified Poisson distribution to take values other than the expected value as used by Bagley (15). Therefore, the problem to be considered here is how to estimate these parameters λ and d based on the observed rainfall records. The procedure used here is illustrated by the following example calculation in which Amherst rainfall records are used.

Table 9. Comparison of the Poisson and Modified Poisson Distribution.

Probability of units of rain (P_i)	Poisson distribution	Modified Poisson distribution
P_o	$e^{-\lambda}$	$1/(1+d)^{\lambda/d}$
P_1	$\lambda e^{-\lambda}/1!$	$\lambda/1!(1+d)^{\lambda/d+1}$
.	.	.
.	.	.
.	.	.
P_i	$\lambda e^{-\lambda}/1!$	$\dfrac{\lambda(\lambda+d)\ldots(\lambda+(i-1)d)}{i!\,(1+d)^{(\lambda/d+i)}}$

λ: a parameter.
d: persistence parameter to represent the degree of dependence of one event upon another.

Within the period from 1961 to 1965 there were 1224 observation days for the interval March to October of each year. In this entire period, 377 days were considered as having measurable rainfall. The average rainfall in this period was 0.087 inch/day.

If one lets

M = total no. of days in the period

N = total no. of days with rain

U = average daily rainfall for the whole period

Then the probability of no rain was (M - N)/M, which must be equal to P_o as shown in Table 9.

$$(M - N) / M = P_o = 1 / (1 + d)^{\lambda/d} \quad (62)$$

$$\text{or } (1225-377) / 1225 = 1/ (1 + d)^{\lambda/d} \quad (63)$$

At the same time, we might expect that the expected value of the modified Poisson distribution must be equal to U, the average daily rainfall for the entire period. The relationship can be written as in the following equation with the unit increment of rainfall to be 0.05 inch.

$$\frac{U}{0.05} = \frac{\lambda}{1 ! \, (1 + d)^{\lambda/d + 1}} + \frac{2 \lambda (\lambda + d)}{2 ! \, (1 + d)^{\lambda/d + 2}} + \ldots + \frac{i \lambda (\lambda + d) \ldots (\lambda + (i - 1) d)}{i ! \, (1 + d)^{\lambda/d + i}} \quad (64)$$

Rearranging Eq. 62 as

$$\lambda = - [d \log ((M - N) / M) / M)] / \log (1 + d) \quad (65)$$

Solving the above two equations simultaneously, we get d = 13.8, and $\lambda = 0.094$. Once the parameters have been determined, the probabilities for the unit rainfall amounts can be readily calculated from the relations outlined above. These calculated frequencies compared with the recorded frequencies are shown in Table 10.

Table 10. Observed and Calculated Frequencies of Daily Rainfall Amounts, Amherst.

Daily Rainfall Class (in.)	Observed Frequencies (%)	(Accum.%)	Calculated Frequencies (%)	(Accum.%)	Residue
0	69.22	69.22	69.22	69.22	0
.05	9.00	78.22	8.81	78.03	.19
.10	3.67	81.89	4.66	82.69	-.80
.15	2.12	84.01	3.10	85.79	-1.78
.20	1.96	85.97	2.27	88.06	-2.09
.25	1.88	87.85	1.75	89.81	-1.96
.30	1.88	89.73	1.40	91.21	-1.48
.35	1.30	91.03	1.14	92.35	-1.32
.40	.65	91.68	.95	93.30	-1.62
.45	.49	92.17	.80	94.10	-1.93
.50	1.14	93.31	.68	94.78	-1.47
.55	.90	94.21	.59	95.37	-1.16
.60	.65	94.86	.51	95.88	-1.02
.65	.33	95.19	.44	96.32	-1.13
.70	.33	95.52	.39	96.71	-1.19
.75	.41	95.93	.34	97.05	-1.12
.80	.08	96.01	.30	97.35	-1.34
.85	.57	96.58	.27	97.62	-1.04
.90	.16	96.74	.24	97.86	-1.12
.95	.40	97.14	.21	98.07	-.93
1.00	.08	97.22	.19	98.26	-1.04
1.05	.32	97.54	.17	98.43	-.89
1.10	.16	97.70	.15	98.58	-.88
1.15	.24	97.94	.14	98.72	-.78

χ^2 = 30.6 39.12 at 95% level.

5.2 Statistical Tests for the Probability Distribution Function

Frequently the calculated probabilities of rainfall are to be tested to see whether they represent the same or different populations as that of the historical records. The chi-square test is often used to compare a set of observed frequencies within a set of frequencies that would be expected from the presumed distribution. If this comparison is favorable, the assumed probability distribution function will be accepted, otherwise it is rejected. The test procedure is as follows: let f_1, f_2, ... f_3 be the observed frequencies of k class, and let F_1, F_2 . . . . F_k be frequencies that would be expected from the assumed probability distribution function, then

$$\chi^2 = \sum_{i=1}^{K} (f_i - F_i)^2/F_i \tag{66}$$

The probability distribution function will be accepted if the calculated χ^2 value is less than the critical χ^2 value which is chosen to correspond to the α percentage point. As an example, the Amherst data presented in Table 9 were tested under the above criteria. The χ^2 value obtained was 30.663, which was less than the critical value of 39.172. Therefore it led to the conclusion that the modified Poisson distribution was accepted to represent the daily rainfall in the Amherst area.

The Kolomogorov-Smirnov test is another goodness-of-fit test whenever the assumed form of the distribution is completely specified. According to Hillier and Lieberman (16) it is a more powerful test and should be used in this situation. This test compares the observed cumulative distribution function F_n (X) with the assumed F(X), and defines a random variable as

$$D_n = \max_{\text{All } X} \left[F_n (X) - F (X) \right] \tag{67}$$

The distribution of D_n is independent of F(X) and has been computed for various sample sizes and can be found in most textbooks on mathematical statistics. If D_n^* is the α percentage point of the distribution of D_n, the F(X) will be accepted as the appropriate cumulative distribution function if $D_n < D_n^*$. Again testing with the data presented in Table 9, $D_n = 0.02$ which was much less than $D_n^* = 0.225$. This was further evidence that the modified Poisson distribution was a good model for daily rainfall.

5.3 Monte Carlo Simulation of Rainfall

After constructing the probability distribution function of rainfall, it is then possible to generate the synthetic rainfall to represent the real-world precipitation. This was done by means of the Monte Carlo simulation technique, in which a subroutine available at the University of Massachusetts Computer Center was used to generate a uniformly distributed random number sequence; then applying a table interpolation method for the inverse probability integral transformation, the random samples of daily rainfall were obtained. Comparison of the generated and recorded rainfall was plotted in Figure 11.

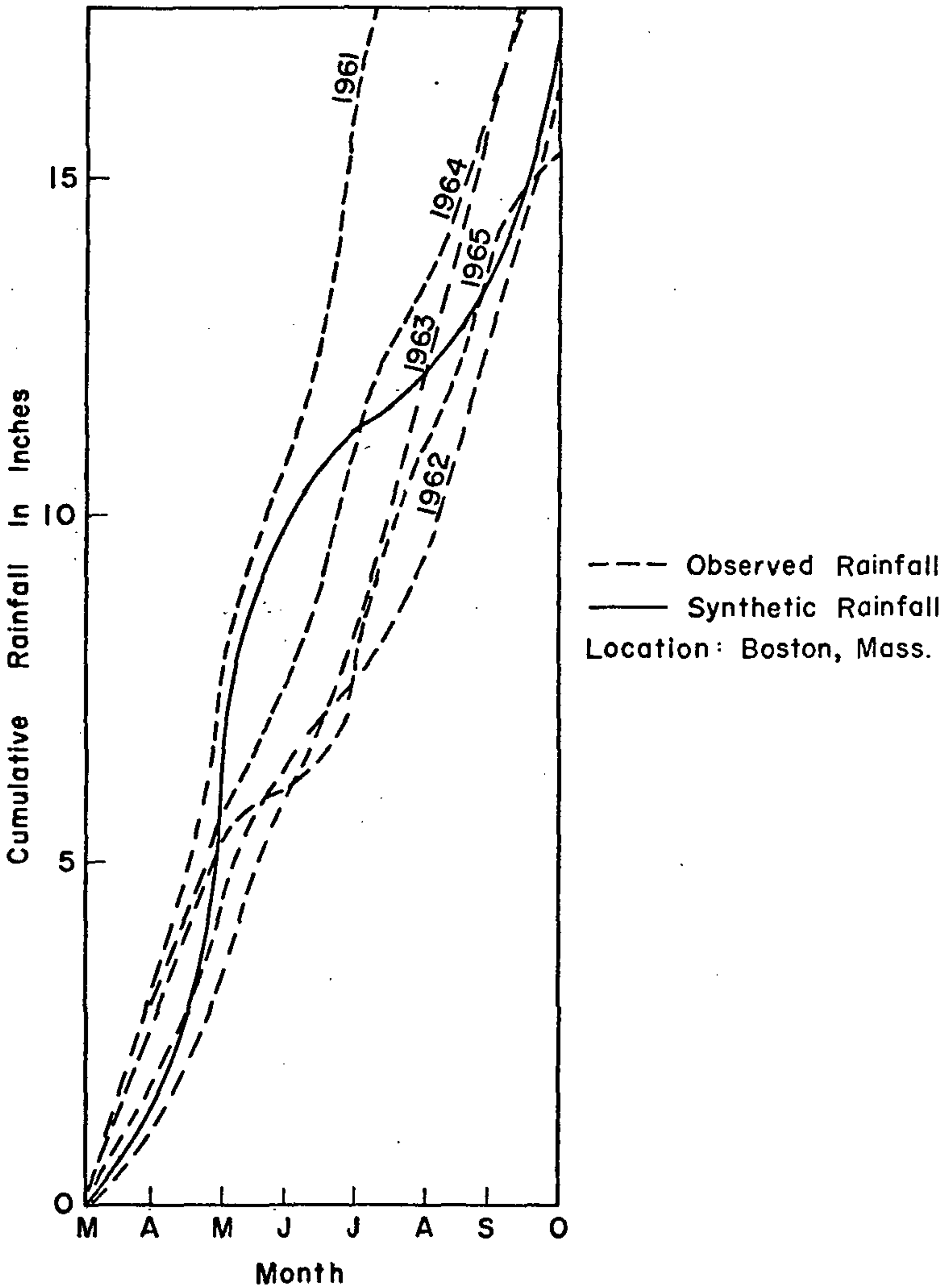


Fig 11. Comparison of the generated and recorded rainfall.

5.4 Statistical Test of Synthetic Rainfall

For the purpose of ensuring that the synthetic rainfall was from the same population as the historical records, it was desired to know if the means of the population generated by the Monte Carlo method were equal to the observed means. The null hypothesis in this case was $\overline{X} = U$, where $\overline{X}$ was the monthly mean generated rainfalls, or the monthly average number of rainy days. While U was the mean of the observed records. The hypothesis was rejected if the calculated t-statistic exceeded the critical t value found in the critical value of Student's t distribution table. The t-statistic was defined as

$$t = \frac{\overline{X} - U}{S/N} \qquad (68)$$

$$S = \left(\frac{\Sigma x_i^2}{(n - 1)} - \frac{(\Sigma x_i)^2}{n (n - 1)}\right)^{0.5}$$

$$\overline{X} = \frac{1}{n} \Sigma x_i$$

The comparison between the recorded monthly average rainfall and the recorded number of rainy days with the synthetic ones are presented in Table 11 along with statistical analysis. The results clearly indicated that they were not distinguishable based on the statistical test.

Table 11. Comparison Between the Observed and Synthetic Monthly Average Rainfall and the Number of Rainy Days.

Location	Month	Monthly Average Rainfall (Inches) 30-year Records	Monthly Average Rainfall (Inches) 30-year Simulation	Calculated t Value	Average Number of Rainy Days 30-year Records	Average Number of Rainy Days 30-year Simulation	Calculated t Value
Boise	Jan.	1.33	1.57	2.6333	12.0	11.8	-0.5320**
	Feb.	1.35	1.65	3.3453	11.0	12.0	1.8724*
	Mar.	1.34	1.59	2.2822*	10.0	10.0	0.0775**
	Apr.	1.10	1.18	0.9044**	8.0	7.9	-0.2505**
	May	1.09	1.38	2.3853*	9.0	8.3	-1.7335*
	Jun.	0.84	1.13	3.0785	7.0	7.5	1.1259**
	Jul.	0.18	0.18	-0.1144**	2.0	1.9	-0.2730**
	Aug.	0.21	0.28	1.4308*	2.0	2.1	0.2585**
	Sep.	0.46	0.48	0.3055**	3.0	3.0	0.0000**
	Oct.	0.94	1.19	2.3264*	7.0	6.5	-1.0451**
	Nov.	1.35	1.58	2.5880	10.0	10.0	0.0680**
	Dec.	1.29	1.46	2.0950*	12.0	11.4	-1.6450**
Boston	Jan.	3.50	3.93	1.6289**	12.0	11.9	-0.2704**
	Feb.	2.93	3.13	0.8223**	10.0	10.1	0.2435**
	Mar.	3.43	3.30	-0.4949**	12.0	11.5	-0.8263**
	Apr.	3.46	3.53	0.2425**	11.0	10.6	-0.8261**
	May	2.91	3.08	0.6503**	11.0	10.3	-1.3418**
	Jun.	3.48	3.64	0.5862**	10.0	10.2	0.4902**
	Jul.	3.18	3.70	1.4300**	10.0	10.1	0.2273**
	Aug.	3.32	2.81	-2.0567*	10.0	9.3	-1.4711**
	Sep.	2.99	2.86	-0.4754**	9.0	8.9	-0.2032**
	Oct.	2.79	2.52	-1.5716**	9.0	8.3	-1.8228*
	Nov.	3.49	3.85	1.0092**	10.0	10.4	0.7446**
	Dec.	3.37	3.32	-0.2122**	11.0	10.3	-1.4791**

Recorded data based on standard 30 year period 1931-1960.
* Insignificant difference between recorded and simulated data at 0.05 level.
** Insignificant difference between recorded and simulated data at 0.01 level.

Table 11 (cont.). Comparison Between the Observed and Synthetic Monthly Average Rainfall and the Number of Rainy Days.

Location	Month	Monthly Average Rainfall (Inches) 30-year Records	30-year Simulation	Calculated t Value	Average Number Of Rainy Days 30-year Records	30-year Simulation	Calculated t Value
Duluth	Jan.	1.01	1.22	2.2051*	10.0	9.7	-0.8277**
	Feb.	1.02	1.30	3.3910	8.0	8.7	1.8836*
	Mar.	1.54	1.62	0.6255**	10.0	10.0	-0.0636**
	Apr.	2.21	2.40	0.7769**	9.0	8.8	-0.4803**
	May	2.95	2.91	-0.1885**	12.0	11.7	-0.5141**
	Jun.	3.72	4.16	1.5412	13.0	12.8	-0.4178**
	Jul.	3.31	3.43	0.5720**	11.0	10.4	-1.4587**
	Aug.	3.19	3.83	1.9404*	11.0	11.1	0.2829**
	Sep.	3.03	3.62	2.2689*	11.0	11.8	1.6026**
	Oct.	1.96	2.37	1.6958*	9.0	9.2	0.3283**
	Nov.	1.67	2.23	3.7826	9.0	9.4	0.9707**
	Dec.	1.00	1.45	4.0020	9.0	8.8	-0.4271**
Miami	Jan.	2.15	2.55	1.4385**	8.0	8.0	0.0000**
	Feb.	1.73	1.68	-0.2610**	6.0	6.0	0.0000**
	Mar.	2.15	2.17	0.0696**	6.0	5.9	-0.2206**
	Apr.	3.44	3.90	1.7114*	7.0	7.7	1.8160*
	May	4.27	4.07	-0.5704**	11.0	11.0	-0.1079**
	Jun.	5.55	5.84	0.6061**	13.0	13.1	0.2423**
	Jul.	4.36	4.88	1.9276*	15.0	14.9	-0.1193**
	Aug.	5.06	5.47	1.1425**	15.0	14.7	-0.5509**
	Sep.	6.72	7.38	1.7706*	18.0	18.1	0.2872**
	Oct.	7.88	8.12	0.4587**	15.0	14.7	-0.8503**
	Nov.	2.16	2.76	2.8263	9.0	9.6	1.1166**
	Dec.	1.73	1.75	0.0980**	7.0	6.7	-0.7371**

Recorded data based on standard 30 year period 1931-1960.

* Insignificant difference between recorded and simulated data at 0.05 level.

** Insignificant difference between recorded and simulated data at 0.01 level.

Table II (cont.). Comparison between the observed and Synthetic Monthly Average Rainfall and the Number of Rainy Days.

Location	Month	Monthly Average Rainfall (Inches) 30-year Records	Monthly Average Rainfall (Inches) 30-year Simulation	Calculated t Value	Average Number Of Rainy Days 30-year Records	Average Number Of Rainy Days 30-year Simulation	Calculated t Value
Phoenix	Jan.	0.61	0.60	-0.1097**	4.0	3.4	-1.9514*
	Feb.	0.82	0.93	1.0298**	4.0	4.9	2.1910*
	Mar.	0.68	0.60	-1.0072**	3.0	2.7	-1.3295**
	Apr.	0.37	0.46	1.2446**	2.0	2.2	0.8932**
	May	0.16	0.16	-0.0440**	1.0	1.0	-0.1827**
	Jun.	0.10	0.12	0.8524**	1.0	1.2	1.0300**
	Jul.	0.68	0.75	0.8310**	5.0	4.7	-0.7709**
	Aug.	0.90	0.93	0.2702**	5.0	4.9	-0.2505**
	Sep.	0.96	1.89	2.4452*	2.0	2.4	1.7951*
	Oct.	0.40	0.43	0.5545**	3.0	3.0	0.1220**
	Nov.	0.50	0.90	2.0993*	2.0	1.7	-1.0717**
	Dec.	0.98	0.95	-0.2858**	4.0	3.5	-1.7429**
San Francisco	Jan.	4.03	4.47	1.3480**	11.0	11.3	0.6902**
	Feb.	3.91	3.75	-0.3789**	10.0	9.5	-0.9334**
	Mar.	2.78	3.39	2.0390*	10.0	9.8	-0.5055**
	Apr.	1.49	1.59	0.5898**	6.0	6.1	0.2754**
	May	0.59	0.75	2.1600*	4.0	3.8	-0.5490**
	Jun.	0.15	0.45	1.5336**	2.0	2.1	0.5592**
	Jul.	0.10	0.37	4.2741	1.0	1.1	0.6425**
	Aug.	0.10	0.48	3.4490	1.0	1.0	-0.1712**
	Sep.	0.13	0.76	2.7750	1.0	0.7	-2.1917*
	Oct.	1.07	1.20	0.9056**	5.0	5.1	0.3239**
	Nov.	2.27	1.93	-1.3999**	7.0	6.7	-0.7471**
	Dec.	4.07	4.17	0.3192**	11.0	10.7	-0.6383**

Recorded data based on standard 30 year period 1931-1960.
* Insignificant difference between recorded and simulated data at 0.05 level.
** Insignificant difference between recorded and simulated data at 0.01 level.

CHAPTER VI

SIMULATION OF WATER AND WASTEWATER DEWATERING ON SAND BEDS

Because of the stochastic nature of rainfall and its resultant effect on drainage and drying on open sand beds, a simulation approach was used in this study to test how a particular design would perform under conditions representative of a given area of the country. To achieve this simulation, drainage and drying models were developed, as discussed previously, to relate sludge characteristics and weather to the amount of water lost by drying and drainage. The synthetic rainfalls were used as input to determine the response of the models.

The local evaporation data were another important input to the models. They not only represented the water losses during the constant rate drying period, but also determined the drying rate during the falling rate period. Therefore, the time required for drainage and drying was treated as a function of local meteorological conditions and the nature of the sludge.

6.1 Scope of the Simulation

The computer simulation included four different types of wastewater sludges and two types of water sludges. The wastewater sludges were anaerobically digested primary sludge, primary and trickling filter digested sludge, primary and activated sludge and aerobically digested sludge. Alum sludges from the Albany, New York, and Amesbury, Massachusetts treatment plants were used to represent the water sludges. These two alum sludges exhibited significant differences in drainage rates permitting them to serve as the upper and lower limits of sludge properties. Softening sludge was not considered in this study because this sludge settles so rapidly that a lagoon disposal method might be more suitable. The parameters of the sludges related to dewatering are presented in Table 12.

In order to cover weather conditions encountered across the United States, six locations were chosen to represent six different meteorological conditions. Geographically these selected cities range from San Francisco to Boston, and from Duluth to Miami. Meteorologically, they included a range of precipitation from Miami to Phoenix, and a range from hot weather in the South to cold weather in the North. Table 13 shows the normal weather data for these cities, and clearly indicates their variation in the annual precipitation cycle. In San Francisco precipitation was a minimum during the summer, while a summer maximum of precipitation was observed in Duluth. But a uniform distribution prevailed in Boston.

In recognition of the decreased drainage and drying in cold weather, winter months at each location were excluded from simulation. The occurrence of freezing in selected cities is shown in Table 14 based on Environmental Science Service Administration records (38). Excluding from simulation the periods during which freezing occurs is a conservative approach as some drainage and drying still occurs during such intervals.

All six sludges were simulated for their performance on sand beds in various locations with at least six different application depths.

Table 12. Characteristics of Sludges.

Types of Sludge		Solids Content	Specific Resistance* Sec^2/gm	Coefficient of Compressibility	Reference
Water Sludge	Alum Sludge (Albany)	1.3%	8.0×10^9	0.49	Lo
	Alum Sludge (Amesbury)	1.5%	5.8×10^8	0.99	Adrian (2)
Waste Water Sludge	Primary Anaerobically Digested Sludge	9.5%	2.6×10^{10}	0.68	Lo
	Anaerobically Digested Sludge Mixed with Activated Sludge	3.6%	4.8×10^{10}	0.66	Sanders (37)
	Anaerobically Digested Sludge Mixed with Trickling Filter	6.1%	8.25×10^9	0.8	Quon (20)
	Aerobically Digested Sludge	4.5%	1.15×10^9	0.97	Cummings (29)

*At pressure P = 38.1 cm of Hg

Table 13. Normal Monthly Weather Data - Selected Cities.

Stations	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Phoenix, Arizona	2.90	3.50	5.40	7.40	10.4	13.5	14.8	13.5	11.7	8.20	5.10	3.10*
	0.61	0.82	0.68	0.37	0.16	0.06	0.68	0.90	0.96	0.40	0.50	0.98**
	4.0	4.0	3.0	2.0	1.0	1.0	5.0	5.0	2.0	3.0	2.0	4.0 ***
San Francisco, California	1.3	1.5	2.1	2.5	2.7	2.9	2.7	2.5	2.9	2.9	2.4	1.7 *
	4.03	3.91	2.78	1.49	0.59	0.15	0.01	0.01	0.13	1.07	2.27	4.07**
	11.0	10.0	10.0	6.0	4.0	2.0	1.0	1.0	1.0	5.0	7.0	11.0***
Boise, Idaho	0.79	1.2	2.4	3.8	5.3	7.1	10.6	10.1	6.3	3.5	1.8	0.92*
	1.33	1.35	1.34	1.10	1.09	0.84	0.18	0.21	0.46	0.94	1.35	1.29**
	12.0	11.0	10.0	8.0	9.0	7.0	2.0	2.0	3.0	7.0	10.0	12.0***
Miami, Florida	3.0	3.4	4.1	4.9	5.0	4.8	5.3	5.1	4.3	4.1	4.3	2.7 *
	2.15	1.73	2.15	3.44	4.27	5.55	4.36	5.06	6.72	7.88	2.16	1.73**
	8.0	6.0	6.0	7.0	11.0	13.0	15.0	15.0	18.0	15.0	9.0	7.0 ***
Boston, Massachusetts	0.97	1.1	1.4	2.2	3.1	4.2	5.0	4.5	3.6	2.9	1.9	1.3 *
	3.50	2.93	3.43	3.46	2.91	3.48	3.18	3.23	2.99	2.79	3.49	3.37**
	12.0	10.0	12.0	11.0	11.0	10.0	10.0	10.0	9.0	9.0	10.0	11.0***
Duluth, Minnesota	0.26	0.32	0.69	1.4	2.1	2.4	3.7	4.2	3.6	2.4	1.0	0.31*
	1.01	1.02	1.54	2.21	2.95	3.72	3.31	3.19	3.03	1.96	1.67	1.00**
	10.0	8.0	10.0	9.0	12.0	13.0	11.0	11.0	11.0	9.0	9.0	9.0 ***

* Monthly evaporation in inches.
** Monthly precipitation in inches
***Number of rainy days.

The starting depth was 10 cm for each sludge, its value was increased by 5 or 10 cm wherever possible.

Table 14. Occurrence of Freezing at Selected Cities.

(Freezing data based on records from 1921 to 1950)

Station	Occurrence of Freezing 32°F Mean Fall Date	Mean Spring Date	Mean Number of Days Minimum Temperature 32°F or less
Phoenix	Dec. 6	Feb. 2	17
San Francisco	Dec. 22	Jan. 17	less than 10
Miami	-	-	-
Boise	Oct. 16	Apr. 29	128
Boston	Oct. 25	Apr. 16	94
Duluth	Oct. 3	May 13	189

6.2 Estimation of the Simulation Sample Size

Before starting any simulation, it was necessary to estimate approximately the required sample size, so that it would be neither too large to be costly nor too small to be reliable. In this study the sample size was the number of sludge applications necessary to be generated in this computer simulated experiment. For most cases this size would be determined according to the following equation given by Chow and Ramaseshan (17) provided that the required level of precision and the confidence level for a specified proportion of the sample are given.

$$n > (t_\beta/\alpha)^2[(1 - P_n)/P_n] \qquad (69)$$

Where P_n = the proportion of the sample from a population that belongs to the group under consideration.

α = percentage of error level.

β = percentage of confidence level.

t_β = the standard normal deviate corresponding to the confidence level.

In this study, a confidence level of 80% resulted in a standard normal deviate of 0.842 for the equation. Also, the error level was selected as 15%. The value of the proportion of the generated dewatering times that were different from the actual dewatering time was 15%. Then the desired size was;

$$N = \left(\frac{0.842}{0.15}\right)^2 \left(\frac{1 - 0.15}{0.15}\right) = 180 \qquad (70)$$

Unfortunately, because the dewatering time varied widely depending on the type of sludge, the applied depth, and location, 180 application times might mean a 20-year simulated operation under one condition and only 10 years under another. The longer the period of simulation, the greater the chance of encountering higher intensities of rainfall. The chance of a 10 year simulation having a 20-year storm was only 30%. Consequently, the use of the number of applications as the criterion for sample size was biased based on the hydrological point of view. In order to correct this, the sample size used in this study was chosen to be at least 200 application times and a 20-year simulation.

This dual criteria for sample size control provided the required level of accuracy and also ensured that a 20-year storm or higher was considered in this simulation; therefore, the bed designed based on the results of this study is expected to have a useful life of 20 years or more.

6.3 Simulation Procedure

Once the models for the component parts of the dewatering system were formulated, the complex process of simulating sludge dewatering on sand beds could be initiated. Input parameters were the physical properties of the sludge, local daily rainfall and evaporation data. The models were operated in computer in accordance with the following operating rules:

1. The total amount of daily rainfall was considered to fall on the ground instantaneously at zero hour of each raining day.

2. The drainage process for wastewater sludge was terminated when the moisture content reached the first critical point (U_{cr}). For water treatment sludge the drainage was stopped according to the following relation found by Clark (29), $S_d = 4.3 + 0.7\ S_o$, where S_d is the solids content at which the drainage stops and S_o is the initial solids content.

3. The final solids content for wastewater sludge was selected as 35%, while 20% was selected for water treatment sludge. The values were considered to be representative of past practice.

The simulation started at the beginning of each day with the addition of the daily rainfall on the surface of the sludge; if it was not a raining day, a zero amount of rainfall was added. Then, by applying the drainage model (Eqs. 50 and 51), the depth of sludge on the drying bed at the end of 24 hours dewatering was obtained. This depth of sludge, after subtracting the amount of water lost by drying, would be used as an entry for the drainage model in the second day's operation. This procedure was repeated until the drainage-terminate moisture content was obtained. From this moisture content onward water was lost only by drying. During this period, the moisture content of sludge was calculated by Eqs. 26 and 30 for wastewater and water sludge respectively, with Eq.s 60 and 61 accounting for rainfall effects. A result of this operation is shown in Fig. 12.

6.4 Verification of Simulation

In order to test the degree to which simulated sludge dewatering time conformed to known data, verification was carried out by comparing dewatering performance obtained from simulation with observed data. Haseltine (31) reported data for covered beds at wastewater treatment plants located from Salinas, Calif. to Huntington, N. Y., and open beds at Grove City, Pa. The comparison used weather records for nearby locations to obtain the parameters for the rainfall generation model. Haseltine had not reported rainfall data for the particular periods corresponding to his field observations of net bed loadings. For this reason the weather pattern existing when Haseltine collected his data was assumed the same as the average obtained from a 20 year simulation.

The comparison for covered beds is shown in Table 15. The results indicate that the reported net bed loading at the various plants was within the limit established by the expected dewatering time for the

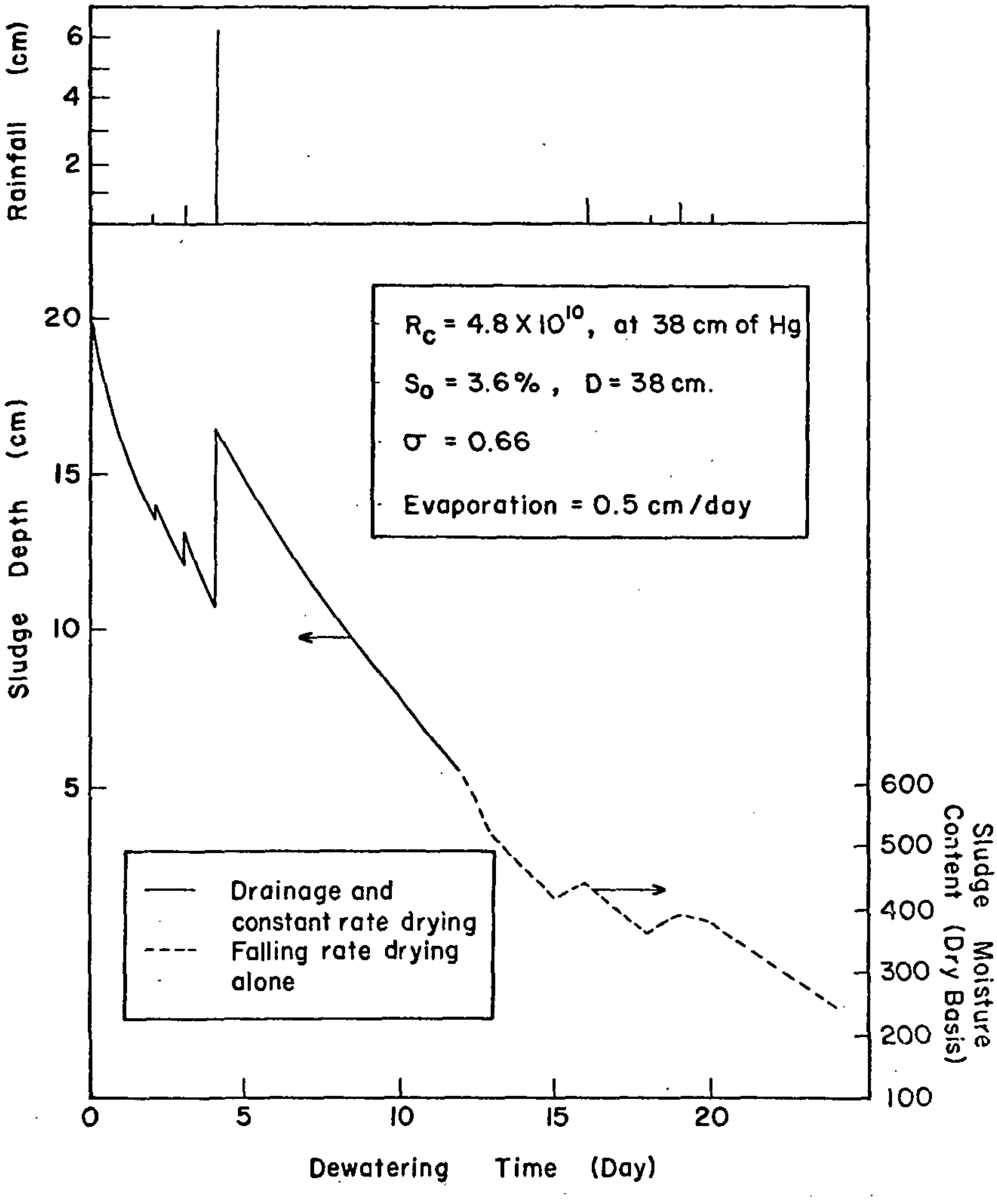


Fig 12 Sample operation of drainage and drying models.

Table 15. Comparison Between Computer Simulation and Field Observations for Covered Beds at Various Locations.

Plants	Field Observation Solids (%) On	Field Observation Solids (%) Off	Field Observation Net Bed Loading	Computer Simulation Solids (%) On	Computer Simulation Solids (%) Off	Net Bed Loading for Applied Sludge Depth, in. 4	6	8	10
Butler, Pa.	6.1-9.2	26.7-37.9	1.05-1.99	7.0	35.0	1.42	0.94	0.75	0.63
Grove City, Pa.	3.6-4.8	38-50	0.66-1.0	4.3	40.0	2.14	1.33	1.07	0.85
Dayton, Ohio	4-5	36-56	1.04-1.71	5.0	40.0	1.79	1.18	0.91	0.81
Huntington, N. Y.	8.4	27.0	2.92	8.4	27.0	1.44	0.93	0.71	0.66
Rockville, N. Y.	5.4	24.5	1.66	5.4	24.5	3.35	1.58	1.13	0.89
Salinas, Calif.	5.4	62.8	1.35	5.4	62.8	1.49	1.08	0.92	0.83
San Antonio, Tex.	4.0	45.5	0.86	4.0	45.5	2.14	1.41	1.20	1.0
Springfield, Ill.	9.2	54.1	2.66	9.2	54.1	1.08	0.82	0.80	0.74

$R_c = 8.25 \times 10^9$ at P = 38 cm of Hg
M.F. = 0.36
$\sigma = 0.66$

20 year simulation at different application depths. The results for open beds in Table 16 and 17 show that the reported dewatering times for various application depths were slightly **less than** the expected dewatering time for the 20-year simulation, but the observed values still fell within the range of the simulated dewatering times. Statistical tests between the observed and simulated values were not considered because the sample size of observed data was not large enough.

6.5 Output of Simulation

The output of this simulation was a random variable (the required drying time) and its associated probability distribution. A sample output was shown in Table 18. Essentially, it described the natural phenomena of sand bed dewatering in terms of outcomes with certain frequency. For example, the output given in Table 18 illustrated that if applying 20 cm of mixed digested primary and activated sludge in Boise, Idaho, twice in 20 years it would be possible to remove the sludge at 35% solids content within 14 days, and 40 times it would be possible within 15 days, and so on. The mean period which the sludge had to remain on the beds was 19.9 days with a standard deviation of 5 days. The output also revealed the shape of the frequency distribution. In this case, it showed that the low limit of the dewatering time was 14 days with short dewatering times occurring more frequently than long ones, suggesting that dewatering time might be a Poisson distribution.

The overall outputs for the entire simulation are presented in Appendix A in a summary form. They include the data for mean and

Table 16. Comparison Between 20-year Computer Simulation Results and Haseltine's (31) Field Observation for Open Sand Beds at Grove City, Pa.

Field Observations					20-yr. Computer Simulation Results						
								Total Drying Time (days)			
Depth Applied (in)	Solids on (%)	Solids off (%)	Total Dry Time (day)	Net Bed Loading	Depth Applied (in)	Solids on (%)	Solids off (%)	Exp. Dry Time	Range of Dry Time	Net Bed Loading
8 1/2	3.4	34.1	18	0.86	8 1/2	3.4	34.1	22.6	12-59	0.68
9	3.55	40.1	19	1.05	9	3.55	40.0	36.6	19-58	0.54
9	3.5	34.1	16	1.05	9	3.5	34.1	26.1	15-57	0.64

$R_c = 8.25 \times 10^9$
M.F. = 0.36
$\sigma = 0.66$

Table 17. Comparison Between 20-year Computer Simulation Results and Haseltine's (31) Field Observation for Covered Sand Beds at Grove City, Pa.

Field Observations					20-yr. Computer Simulation Results					
Applied Depth (in)	Solids on (%)	Solids off (%)	Total Drying Time (day)	Net Bed Loading	Applied Depth (in)	Solids on (%)	Solids off (%)	Total Drying Time: Exp. Dry Time	Total Drying Time: Range of Dry Time	Net Bed Loading
10	3.8	41.8	20	1.26	10	3.8	41.8	26.8	25-29	0.93
10	4.1	42.4	20	1.37	10	4.1	42.4	29	29-31	0.94

$R_c = 8.25 \times 10^9$
M.F. = 0.36
$\sigma = 0.66$

Table 18. The Output of Simulation of Mixed Digested Primary and Activated Sludge Dewatering on Sand Beds at Boise, Idaho with 20 cm. Application.

Dewatering Time (day)	Frequency of Occurrence	Probability	Cumulative Probability
14.0	2.0	0.01000	0.01000
15.0	38.0	0.19000	0.20000
16.0	20.0	0.10000	0.30000
17.0	21.0	0.10500	0.40500
18.0	24.0	0.12000	0.52500
19.0	12.0	0.06000	0.58500
20.0	15.0	0.07500	0.66000
21.0	9.0	0.04500	0.70500
22.0	9.0	0.04500	0.75000
23.0	6.0	0.03000	0.78000
24.0	4.0	0.02000	0.80000
25.0	8.0	0.04000	0.84000
26.0	8.0	0.04000	0.88000
27.0	7.0	0.03500	0.91500
28.0	1.0	0.00500	0.92000
29.0	4.0	0.02000	0.94000
30.0	2.0	0.01000	0.95000
31.0	2.0	0.01000	0.06000
32.0	4.0	0.02000	0.98000
33.0	1.0	0.00500	0.98500
34.0	1.0	0.00500	0.99000
37.0	2.0	0.01000	1.00000

The expectation mean dewatering time is 19.9 days.
The standard deviation of dewatering time is 5.0 days.
The net bed loading is 0.81 lb/ft^2/30 days. (Based on the mean dewatering time).

range of dewatering times and their corresponding standard deviations. The net bed loadings calculated from the mean dewaterin time are also included in the tables.

CHAPTER VII

PERFORMANCE OF SAND DEWATERING BEDS

In the previous chapter, the dewatering times for various sludges at different locations were determined. Knowing the dewatering time, the depth of application and the solids content of the applied sludge, the design engineer will be able to size the bed if the dewatering time is a single valued variable. However, due to the effect of weather, the dewatering time obtained in the previous chapter was a random variable which exhibited a wide range of outcomes (see Appendix A). The practical consequence of the design engineer adopting any particular course of action depends not only on the choice made but also upon the local meteorological conditions. In Table 18 as an example, the time required to dewater a 20 cm mixed digested primary and activated sludge in Boise, Idaho ranged from 14 days to 37 days. If the design engineer chose 15-days as the design dewatering time, the calculated bed area would be 1.45 square feet per capita based on the method suggested by the Water Pollution Control Federation in their Sewage Treatment Plant Design Manual (1). The designed bed would be undersized because Table 18 shows that 80% of the time in 20 years the sludge actually required more than 15 days to dewater. As a result, the yield of dry solids from the bed, or the bed performance, would not satisfy the design purpose. In this chapter the bed performance has been related to drying time and bed area based on the outputs shown in the previous chapter.

7.1 An Application of Statistical Decision Theory

Before seeking the relationship between dewatering time, bed area and bed performance, a new random variable N was introduced to represent the total number of bed applications per year. N was obtained by substituting the results of the dewatering time obtained in the previous chapter into the equation;

$$N = \frac{T}{T_d + T_p} \tag{71}$$

Where; N = total number of bed applications per year.

T = total dewatering time available (day/year).

T_d = the required dewatering time per application (day/applic.).

T_p = the required bed preparing time (day/applic.).

Since the number of bed applications had a definite relationship with dewatering time, it could serve as a design criteria as well. For example, a 15-day dewatering time in Boise, Idaho was equivalent to 12 bed applications per year. In mathematical manipulation it was more convenient to consider bed applications per year instead of the length of the dewatering time.

In order to measure the consequence of an engineer's selecting a larger number of bed applications than "Nature" allowed, it was assumed that there existed a loss function which reflected a penalty for the loss of bed performance brought about by taking too short a design dewatering time. Consequently, some amount of dry solids was left undewatered. If the amount of undewatered solids is represented by the random variable Z,

$$Z(n) = \begin{cases} (A_n - N)\ A_r\ H\ S_o\ \rho & A_n > n \\ 0 & A_n \leq n \end{cases} \tag{72}$$

When A_n is the number of bed applications taken by the designer.

N is the random variable of bed applications which represents the "state of nature".

A_r is the required bed area in ft^2 (for wastewater sludge it is the area needed per capita, per year, for water treatment sludge, it is the area needed per pound of dry solids per day).

H is the depth of sludge in ft.

S_o is the solids content of the applied sludge.

ρ is the density of sludge.

Then the expected value of the total solids left undewatered per year can be calculated as;

$$\begin{aligned} E(Z) &= \sum_{K=o}^{\infty} Z(K)\ P_n(K) \\ &= \sum_{K=o}^{A_n-1} (A_n - N)\ A_r\ H\ S_o\ \rho\ P_n(K) \\ &\quad + \sum_{K=A_n}^{\infty} 0\ P_n(K) \\ &= (A_n\ A_r\ H\ S_o\ \rho)\ (P\ [n < A_{n-1}\ ]) - \\ &\quad (A_r\ H\ S_o\ \rho)\ (\sum_{K=o}^{A_n-1} K\ P_n(K)) \end{aligned} \tag{73}$$

Where $P\ [n < A_{n-1}]$ is the probability that the random variable N is less than A_{n-1}. Its value can be calculated or found in statistics tables under the chosen probabilistic model.

Again using the data in Table 18 as an example, it is shown below that the use of 15-days as the design dewatering time results in 5.3 lb. as the expected dry solids left undewatered. The data used will be

A_n = 12 bed applications per year,

A_r = 1.45 ft^2/capita,

H = 0.657 ft,

S_o = 0.034, and

ρ = 62.5 lb/ft^3.

Substituting the above data into Eq. 73

$$
\begin{aligned}
E(Z) &= 12 \times 1.45 \times 0.657 \times 0.034 \times 62.4 \times 0.8 \\
&\quad - 1.45 \times 0.657 \times 0.034 \times 62.4 \times (11 \times 0.205 \\
&\quad + 10 \times 0.18 + 9 \times 0.12 + 8 \times 0.135 + 7 \times 0.1 \\
&\quad + 6 \times 0.05 + 5 \times 0.01) \\
&= 5.3 \text{ lb/yr/capita.}
\end{aligned}
$$

7.2 Performance Index

For the purpose of expressing bed performance as a function of inputs such as bed area, application depth and the local weather conditions, a term called performance index (PI) was introduced to measure the weighted average of sludge dewatered by drying beds each year under various conditions. It was defined as

$$
\text{PI } (\%) = \frac{\text{Wt. of sludge dewatered} \times 100}{\text{total Wt. of sludge}} \tag{74}
$$

By applying Eq. 73 to the above relationship, the performance index was written as;

$$PI\ (\%) = [W_d - \{A_n\ A_r\ H\ S_o\ \rho\ (P_n\ (n < A_{n-1}) - A_r\ H\ S_o\ \rho\ (\sum_{K=o}^{A_{n-1}} K\ P_n\ (K))\} \times 100]/W_{ts} \quad (75)$$

Where W_d: Weight of dry solids expected to be dewatered under the design condition without consideration of "the state of nature". The terms enclosed in parenthesis { } represent the dry weight of undewatered sludge.

W_{ts}: Total dry solids expected per year.

In words the equation states that the performance index depends upon the inputs, A_n, A_r, and H. The design engineer may increase or decrease the output (performance index) by increasing or decreasing the quantities of all inputs used, or increase it to some maximum level by increasing the quantity of one input while holding the quantities of other inputs constant. Since this equation expresses the physical relation between the inputs of resources (such as the bed area, the number of applications and the applied depth) and their output (performance index - the percentage of the total dry solids dried on the drying beds) per unit of time, it is often called a production function. What is more, since this particular production function also involves a random variable N to describe the "state of nature", the function is then appropriately called a stochastic production function (26).

The overall performance for sludge dewatering on sand beds at various locations is shown in the tables of Appendix B. In each table, the data show the corresponding performance index for each possible dewatering time and bed area.

CHAPTER VIII

ECONOMIC ANALYSIS FOR SLUDGE DEWATERING ON SAND BEDS

8.1 Introduction

The objective of this chapter is to utilize computer simulation results presented in previous chapters to improve sludge dewatering bed design methodology so that an optimal system can be obtained. Conventional design procedure for dewatering beds is largely dependent on rules of thumb deduced from limited field observations and fails to consummate an effective union of engineering and economic analysis. A typical dewatering bed design basis is 1.0 to 1.5 square foot per capita for primary digested sludge in northern United States giving no consideration to the cost of land, labor and operation. Furthermore, in engineering practice, there has been a tendency to consider these design criteria as professional engineering standards, so that contact with the realities on which they were adopted is forgotten. In this chapter, an objective function was established which included the design criteria and the associated cost terms. The objective function used in this study was basically the same one that was suggested by Meier (30) in his study of dewatering bed system design. However, efforts were made in this chapter to minimize the objective function by utilizing a simulation approach and a marginal analysis approach.

8.2 Simulation Approach

Simulation has been used by Meier and Ray (30) to study the optimum dewatering bed system design. In their study, an objective function Z was suggested as

$$Z = C_1 A_r + C_2 A_r A_n \tag{76}$$

in which Z is the total cost of sand bed dewatering, C_1 is a cost associated with the required land area, C_2 is a cost associated with the number of applications per land area. A_r is the area of land required and A_n is the number of applications.

A_r and A_n are functions of the dewatering time. Therefore knowing C_1, C_2, the dewatering time and the depth of sludge application, the total cost of sand bed dewatering can be determined if this dewatering time is a single value variable as in the case of Meier and Ray's study. However, due to the effects of weather, the actual dewatering time for a sludge in a particular location has been shown to be a random variable with a wide range of outcomes. For example, the dewatering time shown in Table 18 for 20 cm of digested primary and activated sludge on a sand bed in Boise, Idaho was found to range from 14 days to 37 days. For each possible dewatering time, there was a corresponding combination of A_n and A_r which, in turn, yielded a different cost. Therefore, the design engineer in this case was left to make a choice among a large number of possible outcomes. In order to choose a dewatering time that would best represent the actual field conditions and serve as a basis for design and comparison between alternatives the following two criteria were used in this study: expected value of dewatering time and performance index.

Expected value of dewatering time. Again using the example of 20 cm of mixed digested primary and activated sludge in Boise, Idaho, the entire frequency distribution of possible dewatering times was shown in Table 17. It indicated that there were 2 times in 20 years when the required dewatering time was 14 days or less, and 40 times when it was 15 days or less, and so on. This frequency distribution may be considered to be the probability distribution* of the random variable, drying time. Then the expected value of this random variable can be obtained as

$$E\ (t) = \sum_{i=1}^{n} P_i t_i \qquad (77)$$

where t_i is the value of the ith possible outcome of the dewatering time, and P_i is its probability of occurrence.

By applying the above equation to the data in Table 17, the expected dewatering time was found to be 19.9 days. This means that 19.9 days only represents the average dewatering time for an infinite number of applications. It should be realized that on a single dewatering, one and only one of the dewatering times from 14 to 37 days can occur. Therefore, if one uses this expected dewatering time as a basis of design, it is almost certain that the bed so designed would not be sufficient for certain periods of time during a 20-year period. Nevertheless, this expected value of dewatering time does give a single number which significantly characterizes the random variable over its range of occurrence. In many cases, it alone is an adequate basis for choice

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*By the law of large numbers, the frequency distribution would approach the probability distribution as a limit, when the sample size approaches infinity (34).

among alternatives, especially when all alternatives have approximately the same shape of probability distribution. Therefore, based on the above discussion, the expected value of drying time was suggested in this study as one of the criteria to determine the variables A_n and A_r. The data concerning these expected drying times for various sludges dewatered in different locations at different depths of application can be found in Appendix A.

Performance index. In the last section the expected dewatering time was suggested as a criterion to determine the variables A_n and A_r. The advantages of using this familar statistic are: 1. it makes use of all outcomes, and develops a weighted sum in which the contribution of each outcome is afforded an equal weight, 2. Tchebycheff's Inequality (35) asserts that for any probability distribution that has a finite standard deviation σ, the probability that an outcome of dewatering time larger than K days away from its mean is at most $1/K^2$, 3. it is relatively easy and straightforward to determine; also it gives the option of using only the mean or the mean plus one or more standard deviations as criteria.

On the other hand, the main disadvantage of using this expected dewatering time is that it is affected by its probability distribution, by which the expected drying time from a positively skewed distribution (like the Poisson distribution) is considerably smaller than that from a symmetric distribution (like the normal distribution) over the same range of occurrence. Consequently, two outcomes with the same expected dewatering time would not yield the same performance level (performance index) if their probability distributions were different. In order to avoid this problem, an alternative decision criterion based on the idea of performance index was suggested. The actual probability distribution generated by the computer simulation was treated as an empirical discrete distribution so that the performance index would not be affected by the shape of the distribution. One may design the bed based on any expected performance level. However, 100% performance index is not recommended for use because it is overly conservative.

Since the rainfall distribution appeared highly skewed regardless of geographical location, the shorter dewatering times occurred most frequently, and longer dewatering times occurred more and more rarely. As a result of this, the performance index determined by the expected dewatering time was found to be very high. In most cases it was in the range of 90% to 95%. Therefore, based on the above observation, it was recommended that the concepts of expected dewatering time and performance index should be used jointly to design the bed in such a way that the target performance index is in close agreement with the expected dewatering time.

Economic factors. Upon completing the criteria for determining A_n and A_r, consideration has been given to economic parameters C_1, the cost associated with the required land, and C_2 the cost associated with the number of applications per land area. Items which must be included in C_1 would be land cost, construction cost, maintenance and repairing cost, also the salvage land value and rehabilitation cost at the end of the economical life span. For example, of one assumes

land cost	\$10,000/Acre
construction cost	\$10,000/Acre
maintenance cost	\$ 1,000/Acre/Year
repair of bed cost	\$ 5,000/Acre/Year
salvage value	\$10,000/Acre
rehabilitation cost	\$ 2,000/Acre/30 Years
economic life	30 Years

and selects an appropriate interest rate, the value of C_1 can be readily calculated as follows:

land cost (6%, 30 Years)	= \$ 726/Acre
construction cost (6%, 30 Years)	= \$ 726/Acre
maintenance cost	= \$1,000/Acre
repair cost (6%, every 10 Years)	= \$ 320/Acre
salvage value (6%, 30 Years)	= \$ 125/Acre
rehabilitation cost (6%, 30 Years)	= \$ 25/Acre
	Total C_1 = \$2,672/Acre/Year

In C_2 there are the costs of applying and removing sludge associated with each application per unit area. This cost would vary depending on the method of removing the sludge. To remove cake by hand instead of by machine requires a low capital investment, but requires more labor. In addition, machine removal causes a greater loss of sand and requires frequent sand renewal. The depth of application may also affect the removing cost. A shallow application may result in a thin layer of cake which might impede the removal operation. Unfortunately, there is very little information in the literature concerning sludge removal. Conversation with the operators (36) at the Northampton Sewage Treatment Plant revealed that it took 2 man-day to remove sludge from beds by machine. In 2 man-days sludge could be removed from 2 beds by hand. The dimension of the bed was 25 feet by 150 feet. On the average the bed required sand renewal after every 8 applications for either machine or hand removal.

By using the above information and assuming that labor cost is \$4/hr, and the sand renewal operation is \$50/bed, C_2 can be determined for a plant utilizing hand methods to remove sludge as:

labor cost:

$$\frac{2 \text{ man-day/Applic} \times 8 \text{ hr/man-day} \times 4 \text{ \$/hr} \times 43560 \text{ ft}^2\text{/AC}}{2 \text{ Bed} \times 25 \text{ ft} \times 150 \text{ ft/bed}} = \$370\text{/application/Acre}$$

Sand renewal cost:

$$\frac{50 \text{ \$/bed} \times 43560 \text{ ft}^2\text{/AC}}{8 \text{ Apply.} \times 25 \text{ ft} \times 150 \text{ ft/bed}} = \$\ 73\text{/application/Acre}$$

Total C_2 = \$443/application/Acre

Determination of optimum system design. By including the calculated C_1 and C_2 into the objective function of Eq. 76, simulation results were obtained for the optimum application depth of sludge. The method utilized was to take A_n and A_r for different application depths and calculate the annual cost. The global optimum was then determined as the depth which yielded a minimum cost. The results shown in Table 19 using the output from Boise, Idaho as an example, indicate that the optimum sludge depth would be 25 cm for a digested primary and activated sludge with 95% performance index as the target output. The required bed area would be 3.23 ft^2/cap with 6 applications per year. The annual cost of sand bed drying would be $0.281/person.

Table 19. Annual Cost of Sludge Dried in Boise, Idaho at Different Application Depths (Sludge removed by hand).

Application Depth (cm)	Dewatering Time (day)	Bed Area (ft^2/cap)	No. of Application Per Yr.	Annual Cost ($/cap)
10	5	1.40	26	0.445
15	12	1.66	14	0.331
20	20 - 21	1.98	9	0.299
25	30 - 35	2.32	6	0.281*
30	44 - 57	2.90	4	0.293
35	58 - 81	2.32	3	0.301

(1) Type of Sludge: Digested Primary and Activated Sludge.
(2) C_1 = $ 2672/AC = $ 0.061/ft^2
C_2 = 443/AC/Applic. = $ 0.01/ft^2/Applic.
(3) PI = 95%

*Optimum Depth.

However, as an alternative, the design engineer may choose to use a mechanical method instead of the hand method to remove the dry sludge from the bed. Under this alternative situation, the cost of C_2 would reduce to:

labor cost:

$$\frac{2 \text{ man-day/Applic} \times 8 \text{ hr/man-day} \times 4 \text{ \$/hr} \times 43560 \text{ ft}^2\text{/Ac}}{7 \text{ Bed} \times 15 \text{ ft} \times 150 \text{ ft/bed}} = \text{\$105/application/Acre}$$

sand renewal cost:

$$\frac{50\ \$/\text{Bed} \times 43560\ \text{ft}^2/\text{Ac}}{8\ \text{Apply.} \times 25\ \text{ft} \times 150\ \text{ft/bed}} = \$\ 73/\text{application/Acre}$$

C_2 = \$178/application/Acre

Substituting this cost factor into Eq. 76 produces the output shown in Table 20, indicating that the optimum depth reduces to 20 cm and the required bed area to 1.98 ft^2/cap., with an increase in applications to 9 per year. What is more, a saving of \$0.089/cap/year would be obtained by mechanical sludge removal. Therefore the decision of whether or not to use a machine to remove sludge would depend on whether this savings would cover the annual per capita cost of a machine.

Table 20. Annual Cost of Sludge Dried in Boise, Idaho for Different Application Depths (dry sludge removed by machine).

Application Depth (cm)	Dewatering Time (day)	Bed Area (ft^2/cap)	No. of Application Per Year	Annual Cost (\$/cap)
10	5	1.40	26	0.230
15	12	1.66	14	0.194
20	20 - 21	1.98	9	0.192*
25	30 - 35	2.32	6	0.198
30	44 - 57	2.90	4	0.224
35	58 - 81	3.32	3	0.242

(1) Type of Sludge: Digested Primary and Activated Sludge.
(2) C_1 = \$ 2672/AC = \$ 0.061/ft^2
C_2 = \$ 178/AC/Applic. = \$0.004/ft^2/Applic.
(3) Pi = 95%

*Optimum Depth.

A method has been illustrated in the above example to determine the optimum system design from the results of simulation by relating C_1 and C_2 to their associated variables, A_r and A_n. Appendix C shows the optimum depths of application for sludges dried in various locations under different cost ratios C_2/C_1.

This information is used by first determining the cost terms C_1 and C_2, then using expected drying time and/or performance index as the design criterion, selecting the optimum depth such that it accounts for the local weather and sludge condition. After determining the optimum applied depth enter Appendix B with the expected performance index so the required land area and the number of applications per year can be found (ft^2/cap was used for sizing wastewater sludge dewatering beds and ft^2/lb of dry solids was used for sizing water treatment sludge dewatering beds.

8.3 Marginal Analysis Approach

In the last section, a simulation approach has been demonstrated to determine the optimum dewatering bed system design. An example illustrating this simulation methodology indicated that the 95% performance level could be attained in Boise, Idaho by either using a bed area of 2.32 ft^2/cap with 6 applications per year, or 1.98 ft^2/cap with 9 applications per year. Of course, the applied depth in the latter case was reduced from 25 to 20 cm in order to shorten the necessary dewatering time and make the additional 3 applications possible. This demonstrated that there existed a trade off between the land and applications, in other words between land and labor, because applications mainly consist of labor.

Land and labor both are economic resources which command a price at a given time and condition. In production theory, they have long been analyzed in order to find an optimum combination that will produce the greatest amount of product for a given cost outlay. In this section, a production theory approach was taken to determine the optimum dewatering bed design, by which the whole process of dewatering was treated from the viewpoint of a firm that attempted to maximize the product (dry solids) with any given cost outlay by way of securing and combining resource inputs (bed area and applications).

The approach began with the determination of a production function. In this study, Eq. 75 was used as the production function because it expressed the physical relation between the inputs of resources and their output, leaving price aside. It has been shown as;

$$PI\ (\%) = [W_d - \{A_n\ A_r\ H\ S_o\ \rho\ (P_n\ (n < A_{n-1})) - A_r\ H\ S_o\ \rho\ (\sum_{K=1}^{A_n - 1} K\ P_n\ (K))\} \times 100]/W_{ts} \qquad (75)$$

in which the output of product is represented by performance index, PI, that is the percentage of the total dry solids dewatered on the sand beds; the inputs of resources are represented by A_n, the applications per year; A_r, the required bed area; and H, the applied depth; W_d, S_o, ρ, W_{ts} are parameters.

Marginal analysis for one input. In many cases, the engineer may face a restriction of the use of land. For example, it is often desirable to increase the dewatering capacity of an existing plant in which the bed area is fixed, and auxiliary means of dewatering is sought. Before the results can be put into a least cost manner, the relationship between the output and the input of sand bed dewatering must be conceived in terms of the law of diminishing returns.

The following example should illustrate the law of diminishing returns numerically and graphically. Suppose that for a secondary sewage treatment plant in the Boston area the dewatering bed was fixed as 1.5 ft^2/cap. If different quantities of input, bed applications per year, were applied to the bed, the performance index calculated from Eq. 75 would be observed as shown in Table 21. It indicates that the performance index would increase linearly with an increase in the number of applications for the first four units. Then, beginning with 6 applications per year, the law of diminishing returns becomes operative, and the marginal physical product of "application" decreases with an increase of this input resource. This marginal physical product of a resource

Table 21. Increase of Performance Index With Increase of Bed Applications.

Bed Area (ft^2/cap)	No. of Applic. per year (labor)	Total Product (performance) index
1.5	2	11.954
1.5	4	23.908
1.5	6	35.855
1.5	8	47.755
1.5	10	59.438
1.5	12	70.481
1.5	14	80.211
1.5	16	87.954
1.5	18	93.395
1.5	20	96.729
1.5	22	98.502
1.5	24	99.321
1.5	26	99.651

*Type of Sludge: Mixed digested primary and activated sludge.
Location: Boston
Applied Depth: 10 cm

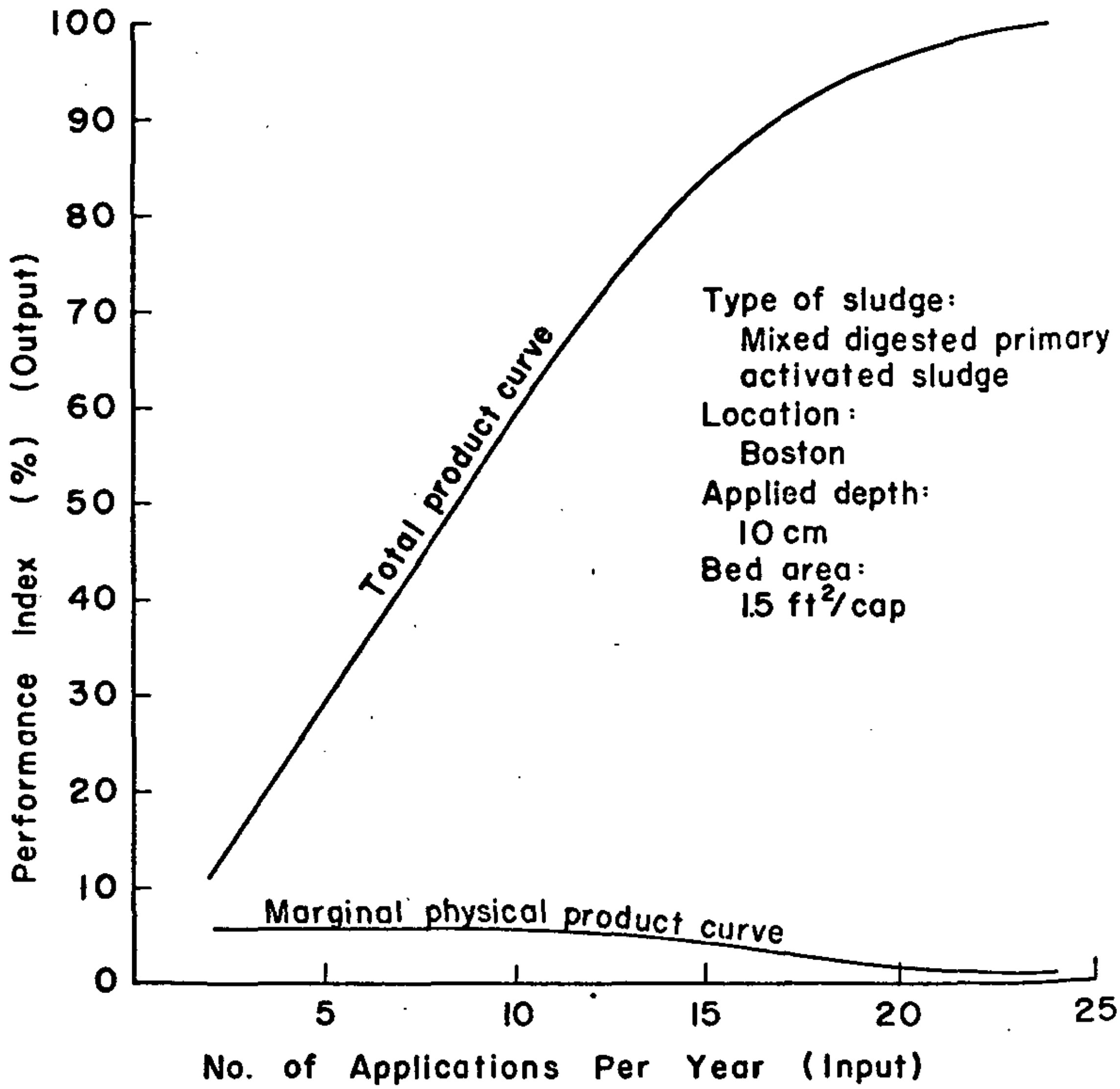

Fig 13. An input–output relation showing the Law of Diminishing Returns.

of applications is increased from 6 to 8 per year the input-output results in Table 20 would yield an additional value of

$$\frac{(47.755 - 35.855) \times 1.25}{100} = \$0.149/\text{capita/yr}$$

at an additional cost of

$$2 \times 0.026 = \$0.051/\text{capita/yr}$$

As the value per additional unit of input is greater than the additional unit of input cost, it pays to increase the number of applications and the output. However, in order to find the optimum output the value of the total product and the marginal physical product have to be determined. For this particular example, they were obtained by multiplying 1.25 by the total product and the marginal physical product, and are shown in column 5 and 6 of Table 20. Economists have proven that the optimum use of a variable input is obtained when the value of the marginal physical product is equal to the cost of unit input. The marginal analysis implies (1) that if the last incremental increase in the number of applications does not pay for itself, fewer applications should be used, (2) that if the last increase of applications more than pays for itself, additional applications should be considered, and (3) the number of applications should be stopped at the point at which the last application just pays for itself.

Applying the above concept to an example, produces the results shown in Fig. 14 indicating that the optimum number of applications per year is 19 at the applied depth of 10 cm. The results for other application depths are shown in Table 23. Therefore the optimum operation of dewatering beds in Boston with a fixed bed area of 1.5 ft^2/cap is to apply 15 cm sludge on the beds with 13 application per year at a cost of $0.026/application. For this optimum condition, the dewatering bed would handle about 82% of the sludge (since the performance index is at 82%), the untreated sludge is more economically treated by other means at a cost of $1.25/cap. Therefore, if mechanical methods are used as an auxiliary means of dewatering, the capacity of the equipment should be designed to handle 18% of the sludge. Of course, this optimum condition would change when the value of the output and the cost of the input varied.

The fundamental difference between this approach and the simulation approach in the last section is that the output in this approach was assigned a cash value, so that the logical optimum point in this method is the cost of input just equal to the marginal value of output. In the simulation approach the value of output was not considered. The purpose was to find a combination of inputs that fulfilled the target (say 95% performance index) at a minimum cost.

Marginal analysis for two inputs. In the previous section, marginal analysis was introduced to increase the economical efficiency for an existing plant which had limited land. This section takes up the more complicated aspect of drying bed optimization including more

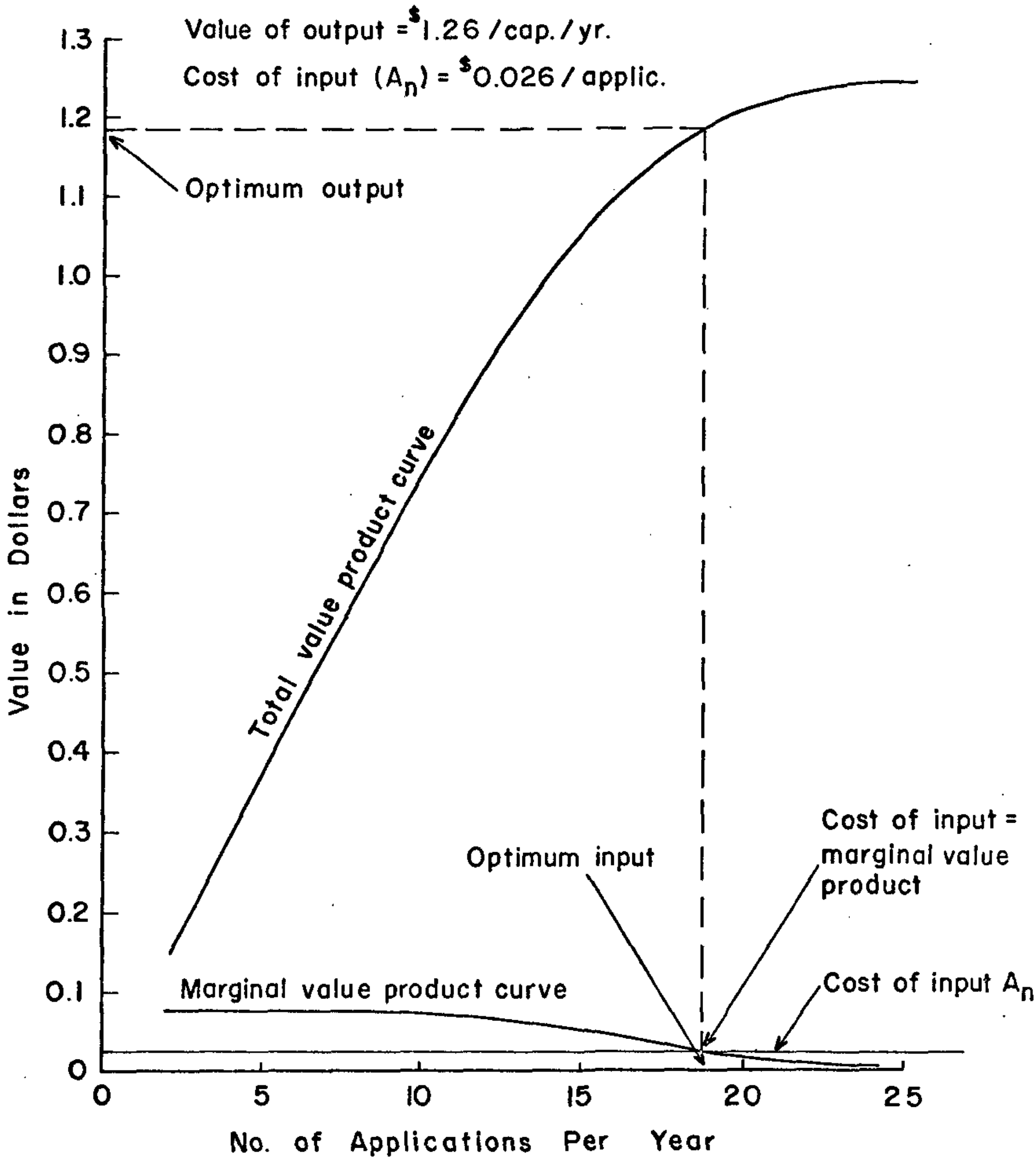

Fig 14. Determination of the optimum input and output.

Table 23. The Results of Optimum Sand Bed Dewatering in Boston With a Fixed Bed Area 1.5 ft^2/capita.

applied depth of sludge (cm)	optimum bed applications per year	optimum sand bed dewatering (performance index)	cost of sand bed dewatering (at $0.026/ applic)	cost of mechanical dewatering (at $1.25/ cap)	total cost per capita
5	34	99%	0.885	0.013	0.898
10	19	95%	0.495	0.063	0.558
15	13	82%	0.325	0.223	0.548
20	9	71%	0.234	0.363	0.597

The Type of Sludge: Mixed digested primary and activated sludge.

than one variable.

In designing a new plant, the restriction on land area usually does not exist, therefore the output (performance index) as shown in Eq. 75 is conceived of as depending upon two important inputs, the bed applications per year (A_n), and the bed area (A_r). When two inputs are combined together to produce a given output, two questions are likely raised concerning the optimization: the first has to do with the proportion in which the two inputs should be used, the second has to do with the amount of the two inputs which would be produced. In this section, these two questions are answered by means of marginal analysis.

Under the concepts of marginal analysis for multi-variables, it is usually considered that different resources can be technical substitutes for each other. Therefore one input can be "traded-off" for the other at a certain ratio, but in most cases they are not perfect substitutes. Leftwich (23) pointed out that if labor and capital were used in digging a ditch of a certain length, width and depth, they could be substituted for each other within certain limits. But the more labor and the less capital used to dig the ditch, the more difficult it becomes to substitute additional labor for capital. Finally, additional units of labor just compensate for smaller and smaller amounts of capital. In our analysis, the inputs, bed applications per year (A_n) and the bed area (A_r), bear resemblance to the labor and capital example. Theoretically, the output of applying 10 cm sludge on 2 units of land should be the same as that of two applications on one unit of land. However, in actuality, this substitution is complicated by the fact that the number of bed applications is limited by the duration of the drying season and the "state of nature". Because dewatering sludge on beds takes a certain time, consequently the number of bed applications per year are limited, which can not be increased freely for substituting the bed area. As a result, for a given applied depth the calculated performance index will decrease as the number of applications increases to substitute the bed area. Therefore, "trade-off" between the number of applications and land area at a given depth of sludge application is not practical in this case because of the complications mentioned above. Nevertheless, in the last section it was shown that a perfect substitution of land and applications was possible if the applied depth was reduced for the purpose of shortening the necessary dewatering time. A possible increase in bed applications to trade off for a smaller bed area thus resulted. This substitution has been demonstrated clearly in Table 18, in which five different combinations of A_n and A_r were possible to obtain a constant output of 95% performance index. By drawing the above information as a smooth curve, an isoquant curve shown in Fig. 15 is obtained, with which one can produce the same amount of output by using A_n in one direction and A_r in other direction. Furthermore, by using the information contained in Appendix B, a family of isoquant lines may be drawn to indicate the different levels of output.

At this point, an economizing procedure was applied to locate the optimum amount of output, dry solids, and the optimum proportions of inputs, bed application and bed area, which should be used to dewater the sludge under a given economical condition.

1. Optimum proportion of using the bed application, A_n, and

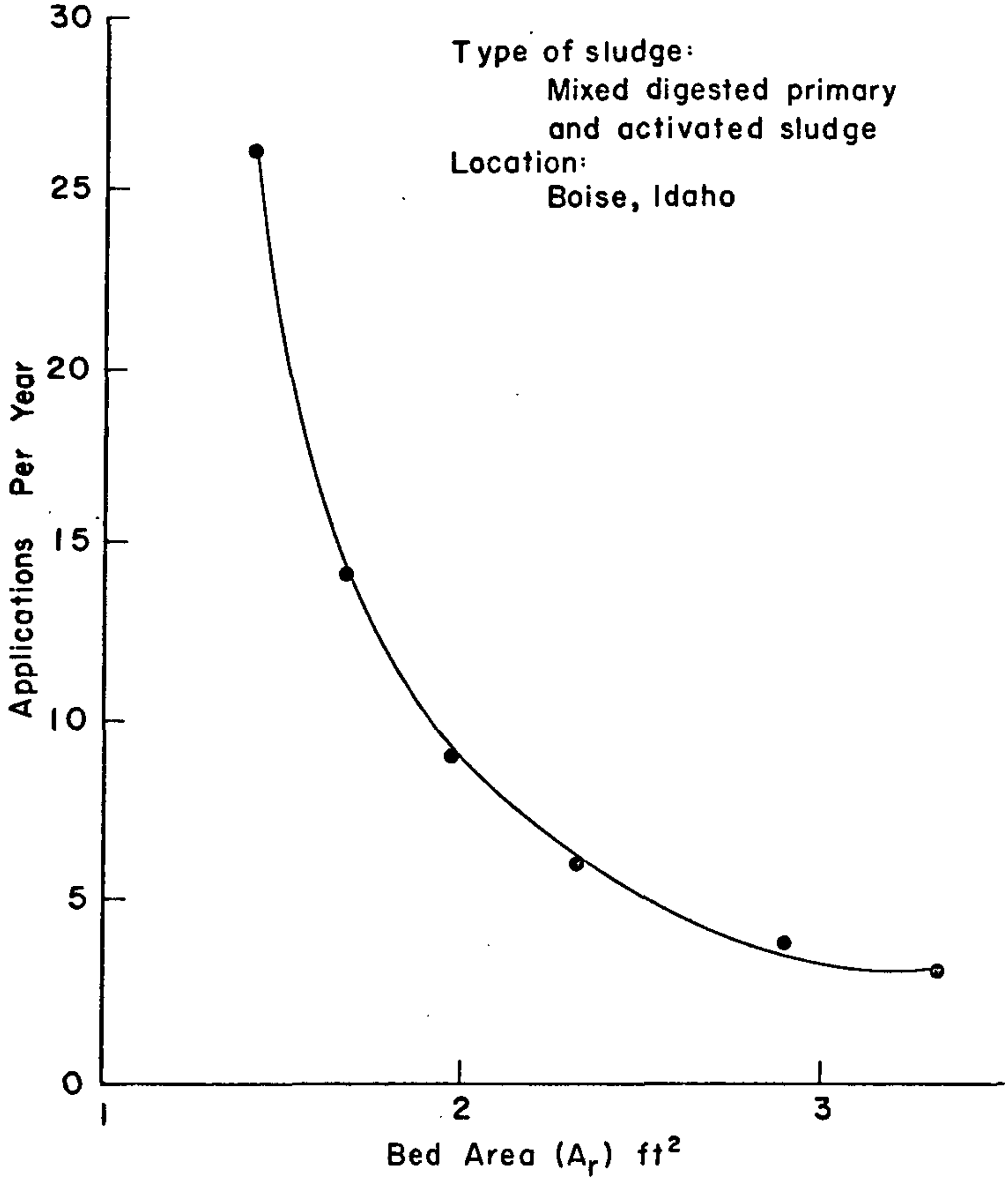

Fig 15. Iso-quant curve showing five different combinations of A_n and A_r to yield a constant output of 95% performance index.

the bed area, A_r. It is obvious that the best way to spend a given amount of money or two inputs is such that they will produce the highest output. In order to achieve this, the cost of drying must be first decided upon before any optimization can be undertaken. A cost function introduced in the last section was;

$$C = C_1A_r + C_2A_nA_r \tag{76}$$

in which C_1 and C_2 are costs associated with these two inputs, A_r and A_n, respectively. Based on the above equation, an isocost curve can be determined which shows not only that different combinations of resources A_n and A_r can be allocated to produce output at a given cost outlay but also the price per unit of each resource. In Fig. 16 each curve represented a given cost outlay.

Up to this point, the problem of optimization was reduced to combining isoquant and isocost curves, and then getting on the highest possible isoquant that its isocost curve would allow, so that the idea of getting the greatest amount of product from the given cost outlay on resources could be materialized.

The point at which the isoquant line is tangent to a isocost line yields the highest value of output attainable for that input. Therefore, it is the point of optimum combination. In Fig. 17 it is easily seen that a greater cost outlay would be necessary if some non-optimum resource combination were used to produce the same quantity of output. Since this particular cost function gave a curved isocost line, it has been difficult to determine the points of tangency. The curves shown in Fig. 17 were set by trial, the isocost curves being drawn in the

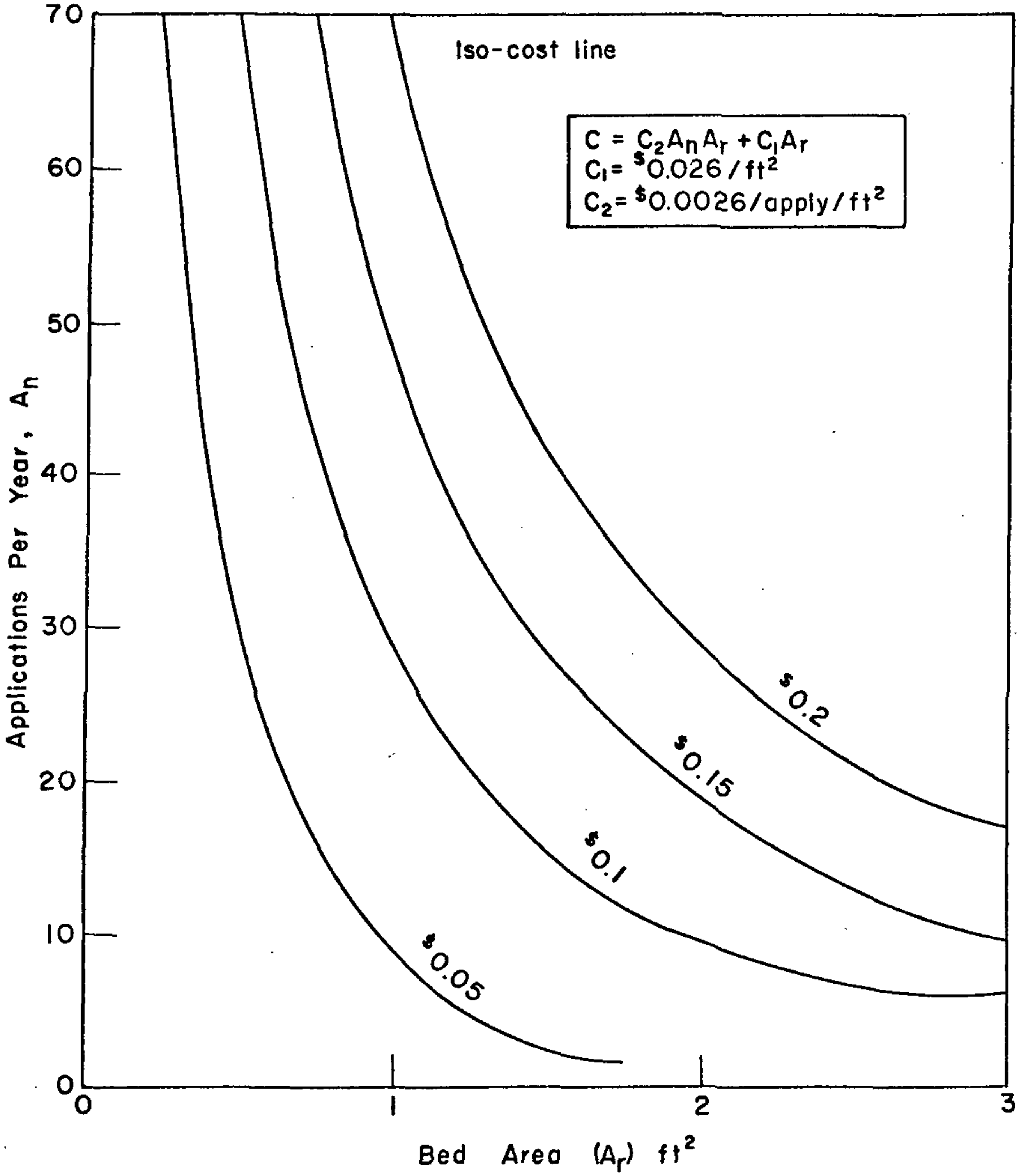

Fig 16. Curves of iso-cost lines.

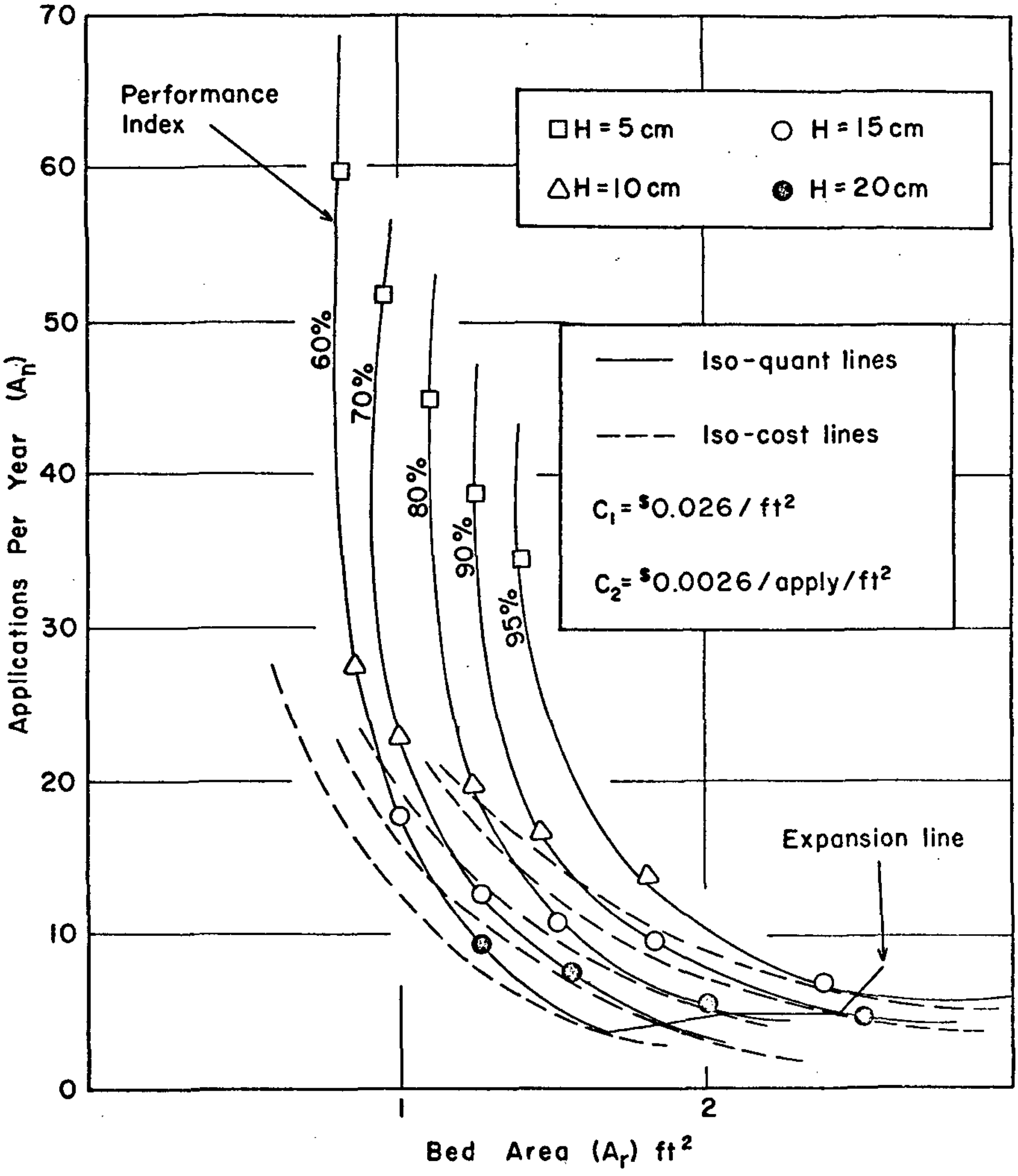

Fig 17 Diagram illustrating procedure for locating the points of optimum proportions.

region of apparent tangency.

Two important features have been noted in Fig. 17; (1) change in the cost of resources will shift the isocost curve. For example. an increase in the land cost would shift the curve to the left to favor the more applications and less land. But when the land cost decreases, the curve would shift to the right to use more land and fewer applications. However, at any cost level of resources, the tangent point would be the least possible cost of producing the given output, (2) after locating the optimum point on the isoquant curve, the optimum application depth was determined by interpolation because the isoquant curve was drawn from the points at different applied depths.

2. The optimum output level. The line which connects the optimum combination points in Fig. 17 is called the expansion line by economists. It indicates the amount of output which should be produced at various investment levels. Since increased investment will result in a higher performance index, the optimum level of sand bed dewatering would obviously depend on the cost of treating the remaining sludge. This may be the cost of mechanical dewatering the excess sludge, or it may be the charge imposed by a regulatory agency. However, the optimum performance index is the least-cost-combination of sand bed dewatering and other auxiliary means. The cost of sand bed dewatering for various performance index levels using Boston as an example is presented in Table 24. From this table it is easy to find that the optimum level for gravity dewatering is at a performance index of 90% with the sludge application depth between 15 to 20 cm. At this level the required bed area is 2.0 ft^2/capita with 8 bed applications per year.

Table 24. The Cost of Sludge Dewatering.

Performance Index	cost of* sand bed drying	cost of mechanical dewatering**	total cost per capita	sludge application depth (cm)
0%	-	0.12500	0.1250	-
60%	0.0546	0.0500	0.1046	20
70%	0.0623	0.0375	0.1008	20
80%	0.0649	0.0250	0.0899	15 - 20
90%	0.0728	0.0125	0.0853	15 - 20
95%	0.0879	0.0063	0.0942	12 - 20

*The Cost of Land = $0.026/ft^2/yr.
The Cost of Application = 0.0026/Applic.
**The Cost of Mechanical Dewatering = $1.25/Capita.

CHAPTER IX

RESULTS, DISCUSSION AND RECOMMENDATIONS

9.1 Results and Discussion

This study was concerned primarily with the development of rational design criteria for sand dewatering beds, with which an engineer could design beds based on the nature of the sludge to be dewatered and the climatic conditions involved to ensure that beds will be economically efficient. This exploration has opened several significant dimensions to the study of sand bed dewatering. First of all, it has demonstrated the usefulness of computer simulation for studying the performance of open sand bed dewatering in which uncertainty is involved due to the presence of weather effects. Secondly, it has revealed that the results of this engineering analysis can be effectively joined with traditional economic analysis to attain an optimum system design, by which the suggested bed area and the bed applications were associated with all relevant cost terms. This study has been carried out through the following steps.

1. Formulation of mathematical models for sludge dewatering on sand beds. Simulation of sludge dewatering on sand beds is a numerical technique for conducting "experiments" on a digital computer. In order to carry out the experiments mathematical models have been developed to describe the real behavior of drainage and drying in the field in terms of mathematical equations. The drainage equation were formulated based on the basic dewatering equation developed by Nebiker,

Sanders and Adrian (3). In addition, efforts have been made in this study to include rainfall effects on the rate of drainage. Two drainage models were developed to represent two extreme conditions of rainwater on the surface of the sludge. The first model, called the mixing model, assumed that rainfall was thoroughly mixed with the sludge suspension as soon as it was added on the surface of the sludge. The second, called the ponding model, assumed that the water and sludge were immiscible, therefore the rainfall was ponded on the surface as supernatant. The motivation for developing these two models was to test the sensitivity of drainage model to assumptions concerning the miscibility of water and sludge suspension. The results showed that under identical conditions the ponding model usually had a more rapid drainage rate than the mixing model. The reason for this was simply because the mixing model treated rainwater as sludge while the ponding model did not. However, the overall results demonstrated that the assumption on miscibility of rainwater would not affect the drainage rate significantly, therefore, either model could be used to describe the behavior of sludge drainage on sand beds. Of course, under field conditions rainwater in the sludge would behave in between these two models. Since the mixing-drainage model gave a conservative drainage rate, it was then chosen as the drainage model for this study.

For the drying portion of the sand bed operation, the process usually consisted of two periods. The first period occurred when ample water was available in the sludge. The delivery rate of water from the interior to the surface was sufficient to maintain a constant rate of drying. During this period, regardless of whether water or wastewater sludge were considered, the drying rates were similar, and were approximated by the drying rate of a free water surface. As drying continued the sludge was progressively depleted of water. After the critical moisture content was reached, the sludge began to lose water at a falling rate. For this falling rate drying period, the drying equations developed by Nebiker (18) for wastewater sludge, and Clark (33) for water sludge were used to determine the water losses by evaporation.

When rain occurred during the constant rate drying period, the effect of rainfall was determined by the drainage model because, at this stage, drainage and drying occurred simultaneously. But during the falling rate drying period drainage ceased, and cracks were formed in most of the sludges. If rain occurred during this period, a portion of the rainwater was absorbed by the sludge, while the remainder drained through the sludge cake to appear as filtrate or ponded on the surface as supernatant. In order to measure the rainfall effects during the falling rate drying period, laboratory experiments were conducted to find the amount of rainwater absorbed by the sludge after each rain. The results of these experiments were studied by multiple regression analysis, by which the moisture content of sludge after rain was found to be a function of the moisture content before rain, the intensity and the duration of the rainfall. These regression equations were used as the basis for determining the effect of rainfall during the falling rate drying period on prolonging the drying period.

2. <u>Preparation of input data for mathematical models.</u> In

general, there were two types of inputs for the models. First were those to describe the characteristics of sludges. They were solids content, specific resistance, and coefficient of compressibility. Four different types of wastewater sludges and two types of water sludges were included in this study. The wastewater sludges were an aerobically digested activated sludge, primary and trickling filter anaerobically digested sludge, anaerobically digested primary and activated sludge and aerobically digested activated sludge. Alum sludge from the Albany, New York and Amesbury, Massachusetts treatment plants were used to represent the water sludge.

The second type of inputs were the local daily rainfall and evaporation data. In this study, synthetic daily rainfall was used to determine the prolonging effect of rainfall on the rate of drainage and drying. These synthetic rainfall data were generated by Monte Carlo techniques according to the chosen modified Poisson distribution. This distribution was characterized by two parameters which were determined by the monthly average rainfall and the number of raining days.

For the purpose of ensuring that the synthetic rainfall was from the same population as the historical records tests were conducted to compare the synthetic rainfall with the recorded data. Results showed that the generated rainfall data could not be distinguished from the historical rainfall by means of statistical tests of significance.

The local evaporation data were another important input to the models. They not only represented the water losses during the constant rate drying period, but also determined the drying rate during the falling rate drying period. This information for various locations was found from evaporation maps.

In order to cover weather conditions encountered across the United States, rainfall and evaporation data from Phoenix, San Francisco, Boise, Miami, Boston and Duluth were used to represent six different meteorological conditions. They included a range of precipitation from Miami to Phoenix, and a range from hot weather in the South to cold weather in the North.

3. Validation of simulation experiments. The problem of validating computer simulation experiments is a difficult one because is involves practical, theoretical, statistical and even philosophical complexities according to Naylor et al. (37). The ultimate goal of this validation is the degree of accuracy with which the simulation model predicts the future behavior of the actual system which is being simulated. The results of this simulation, in most cases, is a suggested policy or criterion. Theoretically, the accuracy of this result would be known only had the policy been implemented, and the results of this actual practice been collected and used as a basis for differentiating between the true and simulated results. Obviously this type of validation is impossible in this study. However, as an alternative, historical verification was used to test the degree to which simulated sludge drying time conformed to known data. This verification was carried out by comparing the dewatering performance obtained from simulation with the observed data reported by Haseltine (31). Haseltine included data for 8 covered beds at wastewater treatment plants located from Salinas, Calif. to Huntington, N. Y., and open beds at Grove City, Pa. The re-

sults for open and covered beds showed that the reported dewatering times and bed loadings at various plants were within the limits of simulation results established by the method used in this study.

4. Results of simulation experiments. After becoming satisfied with the validity of the mathematical models, actual simulation experiments were conducted for all six sludges at the selected locations with various depths of application. The output of this simulation result was a random variable, the required dewatering time, and its associated frequency distribution. For example, when applying 20 cm of mixed primary and activated anaerobically digested sludge in Boise, Idaho, the output indicated that there were 2 times in 20 years the required dewatering time was within 14 days, 40 times when it was within 15 days and 60 times when it was within 16 days, and so on. The mean period which the sludge had to remain on the beds was 19.9 days with a standard deviation of 5 days. Besides the above information, there were several other interesting observations from these simulation outputs. They were:

a. The overall results showed that short dewatering times occurred more frequently than long ones. This was brought about by the effects of rainfall, because regardless of geographical location, light rain occurred most frequently, and days with increasing amounts occurred more and more rarely. The long dewatering time was the direct result of heavy storms occurring when the sludge was on the beds.

b. The dewatering time was reduced considerably in regions of more sunshine and less rainfall. For example, the mean dewatering time for 20 cm of mixed anaerobically digested primary and activated sludge was 17 days in Phoenix, Ariz. and 37 days in Boston, Mass. It clearly indicated the influence of weather on open sand bed performance.

c. For most sludges, the increased solids resistance due to the increased dosing depth has dominated the effect of hydraulic loading. As a result, the required dewatering times have show an increase of three or four times as the depth of application was doubled for all locations. But for alum sludge from Amesbury, Mass., due to its low solids content and specific resistance, the results were different, indicating that the hydraulic loading was more significant than the solids loading. Therefore, the optimum depth of application for this water sludge was at the maximum depth used in this simulation study.

d. Among the parameters describing the sludge characteristics, solids content was the most important one affecting the dewatering time. In most conditions, it dominated the effects of specific resistance. The reason for this was that solids content not only determined the drying rate during the falling rate period, but also affected the time when drainage ceased and falling rate drying began. The higher the solids content, the earlier drainage stopped and falling rate drying began, and therefore the longer the drying time required.

5. <u>The application of simulation results.</u> The final step in the procedure called for the application of the data generated by the computer from the system being simulated. Since the output of this simulation was a random variable, dewatering time, the application of this result to sludge bed design was complicated because the design engineer had to make a choice among a number of courses of action. The practical

consequence of adopting any particular course depended not only on the choice made but also upon the local meteorological conditions which affected the shape of the probability distribution of this random variable.

In order to relate the bed performance to dewatering time and bed area, a term called performance index (PI) was introduced to measure the percentage of the total dry solids produced by a treatment plant in the form of sludge which could be dewatered on the beds each year for certain values of bed area and number of applications. Actually, this performance index gave a single value of bed performance which one can expect from the drying beds based on the outputs generated from this simulation study. As a result, the physical relation between the inputs of resources (such as the bed area, the number of applications per year and the applied depth) and their output (performance index) was therefore established. Furthermore this relationship was used in the economic analysis for finding an optimum bed design.

Two different types of approach were used in the economic analysis, the first called the simulation approach was to find an optimum system design that would fulfill the target output at a minimum cost. The value of output and cost of inputs were not considered important in this approach as long as the cost of the suggested design system was a minimum among the known alternatives. The second approach was called the marginal analysis approach. In this approach, the output (the dry solids) was assigned a cash value, so that the optimum system design was at the point when the cost of inputs was just equal to the marginal value of the output. However, both approaches would determine the optimum dewatering bed system design for which the result would fulfill the objective better than any other option.

9.3 Recommendations

Based on this study, the following recommendations are proposed for improvement of the sand bed system design:

1. It is recommended that the results of this computer simulation be incorporated into the standards for dewatering bed design.

2. It is recommended that this simulation model (or computer program) be included as an alternative to other methods of sludge dewatering in any systems analysis approach for water and wastewater treatment plant design.

3. It is recommended that the performance index of 95% be adopted as a design criterion for sludge dewatering beds.

4. It is recommended that the environmental engineering profession re-evaluate their traditional design approach in order to consummate an effective union of engineering and economic analysis.

In addition to the above recommendations, the following areas, which are considered to be weak in this study, are suggested as future works.

1. More scientific evaluation of the quality of water drainable from different sludges is needed.

2. More sand dewatering bed construction cost data and operation cost data are needed to evaluate the costs of sand bed dewatering accurately.

3. More data concerning the quantities of sludge produced from waters of various qualities being treated in different ways are needed.

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APPENDIX A

Summary Computer Simulation Output For Water and Wastewater Sludge Dewatering on Sand Beds.

Type of Sludge: Alum (Albany Characteristics)
Location: Boise, Idaho
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days
10	2.6	2 - 11	1.0	1.12
20	6.2	4 - 22	2.3	0.94
30	11.1	7 - 27	11.1	0.78
40	18.3	12 - 39	6.1	0.63
50	25.1	17 - 52	8.4	0.58
60	32.0	22 - 62	10.0	0.54

Type of Sludge: Alum (Amesbury Characteristics)
Location: Boise, Idaho
Solids: On: 1.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Diviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days
10	2.9	2 - 10	0.9	1.17
20	4.2	4 - 14	0.9	1.58
30	5.1	4 - 18	1.1	1.95
40	6.1	4 - 13	1.0	2.21
50	6.6	5 - 15	1.4	2.54
60	7.4	5 - 19	1.6	2.73

Type of Sludge: Alum (Albany Characteristics)
Location: Boston, Massachusetts
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.7	2 - 15	1.9	0.76
20	10.3	5 - 45	6.0	0.56
30	19.9	9 - 76	11.2	0.44
40	41.2	20 - 101	17.1	0.28
50	62.2	29 - 162	24.3	0.23
60	92.1	43 - 202	30.0	0.19

Type of Sludge: Alum (Amesbury Characteristics)
Location: Boston, Massachusetts
Solids: On: 1.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days
10	3.7	2 - 19	2.1	0.91
20	5.1	3 - 46	4.4	1.30
30	7.2	3 - 66	8.0	1.40
40	8.3	3 - 73	9.9	1.62
50	10.1	4 - 196	16.9	1.66
60	11.1	4 - 122	17.1	1.81

Type of Sludge: Alum (Albany Characteristics)
Location: Duluth, Minnesota
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.6	2 - 22	2.5	0.8
20	13.1	5 - 45	7.2	0.44
30	26.4	10 - 89	15.1	0.33
40	57.7	20 - 134	24.8	0.20
50	88.7	35 - 178	30.2	0.16
60	119.8	52 - 178	25.2	0.15

Type of Sludge: Alum (Amesbury Characteristics)
Location: Duluth, Minnesota
Solids: On: 1.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.7	2 - 22	2.7	0.90
20	5.6	3 - 67	5.4	1.20
30	7.6	3 - 84	9.5	1.32
40	10.0	4 - 93	14.4	1.34
50	11.4	4 - 147	19.9	1.46
60	10.7	4 - 148	18.4	1.87

Type of Sludge: Alum (Albany Characteristics)
Location: Miami, Florida
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.6	2 - 13	1.5	0.81
20	9.1	5 - 29	3.7	0.64
30	17.5	9 - 78	8.8	0.50
40	36.7	17 - 86	14.3	0.32
50	58.3	27 - 160	24.2	0.25
60	88.9	39 - 275	42.3	0.2

Type of Sludge: Alum (Amesbury Characteristics)
Location: Miami, Florida
Solids: On: 1.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.7	3 - 20	1.6	0.91
20	4.9	3 - 32	2.7	1.37
30	6.6	4 - 51	4.9	1.53
40	8.0	4 - 65	6.9	1.68
50	9.9	4 - 108	10.9	1.68
60	10.9	4 - 88	11.4	1.85

Type of Sludge: Alum (Albany Characteristics)
Location: Phoenix, Arizona
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	2.4	2 - 11	0.7	1.20
20	5.3	4 - 23	2.0	1.08
30	10.0	7 - 27	3.0	0.87
40	15.0	10 - 37	5.4	0.78
50	20.7	14 - 42	7.0	0.7
60	26.5	19 - 61	8.8	0.66

Type of Sludge: Alum (Amesbury Characteristics)
Location: Phoenix, Arizona
Solids: On: 1.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	2.6	2 - 12	0.8	1.29
20	4.1	3 - 16	0.9	1.62
30	5.0	4 - 16	0.9	2.0
40	5.6	4 - 17	1.1	2.39
50	6.3	4 - 18	1.2	2.67
60	7.0	4 - 21	1.4	2.87

Type of Sludge: Alum (Albany Characteristics)
Location: San Francisco, California
Solids: On: 1.3% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	2.9	2 - 30	2.3	0.99
20	12.8	4 - 76	8.7	0.46
30	22.0	9 - 82	11.8	0.40
40	44.4	26 - 115	18.8	0.26
50	61.5	41 - 131	23.9	0.24
60	77.3	53 - 141	28.4	0.23

Type of Sludge: Alum (Amesbury Characteristics)
Location: San Francisco, California
Solids: On: 0.5% Off: 20%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	3.3	2 - 244	2.4	1.02
20	4.1	2 - 63	4.8	1.64
30	4.9	2 - 86	6.9	2.04
40	5.3	2 - 107	9.6	2.51
50	5.2	2 - 124	5.2	3.22
60	5.4	2 - 123	12.0	3.69

Type of Sludge: Activated aerobically digested
Location: Boise, Idaho
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	1.1	1 - 5	0.4	4.41
10	5.0	4 - 13	1.2	2.0
15	12.3	8 - 33	4.5	1.22
20	21.4	12 - 59	7.9	0.94
25	32.5	18 - 83	14.2	0.77
30	47.8	23 - 96	20.9	0.63
35	63.0	31 - 102	23.1	0.56

Type of Sludge: Primary anaerobically digested
Location: Boise, Idaho
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	5.8	4 - 12	1.2	1.83
10	24.3	13 - 64	9.3	0.87
15	52.1	26 - 96	22.3	0.61
20	76.6	41 - 109	25.3	0.55
25	107.0	66 - 126	7.9	0.50

Type of Sludge: Primary and activated anaerobically digested
Location: Boise, Idaho
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	2.1	2 - 4	0.3	1.92
10	5.5	5 - 9	0.8	1.45
15	11.6	9 - 25	2.6	1.04
20	19.9	14 - 37	5.0	0.81
25	29.3	21 - 62	8.0	0.69
30	42.4	29 - 81	13.2	0.57
35	53.6	35 - 95	16.9	0.52

Type of Sludge: Primary and trickling filter anaerobically digested
Location: Boise, Idaho
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewaterint Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	2.2	2 - 6	0.5	3.11
10	9.6	6 - 28	2.6	1.42
15	22.5	12 - 63	8.4	0.91
20	40.2	21 - 92	17.5	0.68
25	59.7	30 - 101	22.6	0.57
30	83.5	43 - 108	18.3	0.49

Type of Sludge: Activated aerobically digested
Location: Boston, Massachusetts
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	6.3	3 - 22	2.4	1.6
15	21.8	9 - 72	10.2	0.69
20	51.7	18 - 116	22.8	0.39
25	97.5	33 - 179	25.0	0.26
30	125.1	66 - 207	27.1	0.24

Type of Sludge: Primary anaerobically digested
Location: Boston, Massachusetts
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	7.6	4 - 29	2.9	1.40
10	61.7	22 - 117	23.8	0.34
15	129.5	75 - 209	31.5	0.25

Type of Sludge: Primary and activated anaerobically digested
Location: Boston, Massachusetts
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Ranged	Standard Deviation	
5	2.3	2 - 6	0.6	1.73
10	6.6	5 - 12	1.3	1.21
15	17.2	11 - 43	5.0	0.7
20	37.4	19 - 93	12.9	0.43
25	68.3	31 - 147	20.5	0.29
30	106.8	60 - 168	23.4	0.23

Type of Sludge: Primary and trickling filter anaerobically digested
Location: Boston, Massachusetts
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Range	Standard Deviation	
5	1.8	1 - 11.0	2.3	3.79
10	16.0	7 - 59	7.7	0.85
15	54.6	18 - 148	24.0	0.37
20	109.3	54 - 168	21.6	0.25
25	129.6	96 - 177	20.6	0.26

Type of Sludge: Activated aerobically digested
Location: Duluth, Minnesota
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	1.4	1 - 5	0.7	3.58
10	6.8	3 - 36	3.9	1.48
15	31.0	9 - 91	17.6	0.48
20	74.0	17 - 144	28.9	0.27
25	110.8	71 - 179	22.8	0.23
30	121.8	89 - 159	25.9	0.25

Type of Sludge: Primary anaerobically digested
Location: Duluth, Minnesota
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	8.6	4 - 40	5.0	1.23
10	89.6	24 - 158	27.6	0.24
15	116.5	99 - 139	24.7	0.27

Type of Sludge: Primary and activated anaerobically digested
Location: Duluth, Minnesota
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Range	Standard Deviation	
5	2.4	2 - 8	0.7	1.69
10	6.6	5 - 15	1.6	1.21
15	19.8	11 - 64	8.1	0.61
20	58.0	21 - 92	17.2	0.33
25	87.7	38 - 173	22.5	0.23
30	108.3	71 - 179	22.2	0.22

Type of Sludge: Primary and trickling filter anaerobically digested
Location: Duluth, Minnesota
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Range	Standard Deviation	
5	2.4	1 - 9	1.0	2.87
10	19.4	7 - 70	12.1	0.70
15	81.0	22 - 152	27.1	0.25
20	112.1	83 - 154	19.2	0.24

Type of Sludge: Activated aerobically digested
Location: Miami, Florida
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days
10	6.6	4 - 26	2.9	1.52
15	23.8	9 - 183	22.1	0.63
20	52.9	15 - 243	50.7	0.38
25	72.6	25 - 290	47.0	0.35
30	89.3	37 - 157	22.3	0.34

Type of Sludge: Primary anaerobically digested
Location: Miami, Florida
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	7.9	4 - 34	3.6	1.35
10	60.0	19 - 257	54.6	0.35
15	90.0	41 - 141	21.5	0.35

Type of Sludge: Primary and activated anaerobically digested
Location: Miami, Florida
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	6.9	5 - 20	1.9	1.16
15	18.4	11 - 79	9.1	0.66
20	43.1	19 - 220	30.9	0.37
25	73.8	29 - 249	53.8	0.27
30	91.8	44 - 351	55.4	0.26
35	102.4	59 - 349	35.7	0.27

Type of Sludge: Primary and trickling filter anaerobically digested
Location: Miami, Florida
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	16.8	7 - 84	12.9	0.81
15	59.1	18 - 256	56.2	0.35
20	87.4	32 - 355	52.1	0.31
25	97.3	54 - 144	19.6	0.35
30	106.0	82 - 135	19.5	0.39

Type of Sludge: Activated aerobically digested
Location: Phoenix, Arizona
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	1.1	1 - 3	0.3	4.7
10	4.6	4 - 9	0.7	2.2
15	10.4	8 - 21	2.0	1.45
20	17.3	12 - 34	3.6	1.16
25	26.8	18 - 46	5.5	0.94
30	37.0	25 - 72	8.9	0.81
35	48.8	33 - 110	13.6	0.72

Type of Sludge: Primary anaerobically digested
Location: Phoenix, Arizona
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	5.3	4 - 11	0.7	2.0
10	19.6	13 - 36	4.3	1.08
15	35.4	21 - 65	9.7	0.9
20	61.2	32 - 165	19.7	0.69
25	79.4	46 - 189	24.3	0.67
30	108.0	63 - 181	19.8	0.59

Type of Sludge: Primary and activated anaerobically digested
Location: Phoenix, Arizona
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Range	Standrad Deviation	
5	2.0	2 - 5	0.2	1.97
10	5.2	4 - 8	0.6	1.54
15	10.4	8 - 23	1.8	1.16
20	17.2	13 - 33	3.5	0.94
25	25.0	19 - 38	4.9	0.8
30	33.4	25 - 69	6.8	0.72
35	43.4	31 - 71	8.7	0.65

Type of Sludge: Primary and trickling filter anaerobically digested
Location: Phoenix, Arizona
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewatering Time (day)			Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
	Mean	Range	Standard Deviation	
5	2.1	2 - 5	0.3	3.26
10	8.4	6 - 21	1.6	1.62
15	18.2	13 - 34	3.8	1.12
20	31.4	22 - 80	6.9	0.87
25	46.4	31 - 97	11.7	0.73
30	63.9	40 - 160	17.4	0.64
35	78.4	50 - 178	20.6	0.61

Type of Sludge: Activated aerobically digested
Location: San Francisco, California
Solids: On: 4.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	4.8	3 - 35	2.2	2.9
15	14.6	8 - 73	9.5	1.03
20	28.1	15 - 98	18.9	0.72
25	45.2	24 - 120	26.2	0.56
30	64.7	33 - 142	36.6	0.47
35	88.6	45 - 160	35.9	0.40

Type of Sludge: Primary anaerobically digested
Location: San Francisco, California
Solids: On: 9.5% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
5	5.8	4 - 36	2.8	1.83
10	32.7	18 - 99	20.2	0.65
15	73.0	38 - 146	33.6	0.44
20	124.9	74 - 190	33.1	0.34
25	180.7	122 - 228	20.4	0.29
30	208.7	165 - 260	20.0	0.30

Type of Sludge: Primary and activated anaerobically digested
Location: San Francisco, California
Solids: On: 3.6% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	5.7	4 - 14	1.2	1.41
15	14.7	11 - 43	4.9	0.82
20	27.7	20 - 81	10.3	0.58
25	44.8	30 - 101	18.7	0.45
30	66.0	44 - 133	25.3	0.37

Type of Sludge: Primary and trickling filter anaerobically digested
Location: San Francisco, California
Solids: On: 6.1% Off: 35%

Depth Applied (cm)	Dewatering Time (day) Mean	Range	Standard Deviation	Net Bed Loading (lb of Dry Solids per Sq. Ft. per 30 Days)
10	11.5	7 - 66	7.1	1.19
15	30.8	17 - 98	19.4	0.66
20	53.2	28 - 133	28.1	0.51
25	83.6	44 - 158	34.7	0.41
30	118.0	69 - 178	33.5	0.35

APPENDIX B

The Performance of Sand Dewatering Beds in Six Selected Cities.

TABLE B- 1

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
26.0	5.0- 5.0	1.34	332.0	0.604	0.604	94.3
23.0	6.0- 6.0	1.52	155.0	0.282	0.885	98.7
21.0	7.0- 7.0	1.66	49.0	0.089	0.975	99.7
19.0	8.0- 8.0	1.83	8.0	0.015	0.989	99.9
18.0	9.0- 9.0	1.94	6.0	0.011	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
18.0	9.0- 9.0	1.29	78.0	0.257	0.257	82.9
16.0	10.0- 10.0	1.45	51.0	0.168	0.426	90.0
15.0	11.0- 11.0	1.55	51.0	0.168	0.594	93.2
14.0	12.0- 12.0	1.66	37.0	0.122	0.716	95.6
13.0	13.0- 13.0	1.79	23.0	0.076	0.792	97.4
12.0	14.0- 15.0	1.94	38.0	0.125	0.917	98.9
11.0	16.0- 17.0	2.11	16.0	0.053	0.970	99.6
10.0	18.0- 19.0	2.32	6.0	0.020	0.990	99.8
9.0	21.0- 21.0	2.58	1.0	0.003	0.993	99.9
8.0	23.0- 25.0	2.90	2.0	0.007	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
12.0	14.0- 15.0	1.45	40.0	0.200	0.200	80.5
11.0	16.0- 17.0	1.58	41.0	0.205	0.405	86.0
10.0	18.0- 19.0	1.74	36.0	0.180	0.585	90.6
9.0	20.0- 21.0	1.94	24.0	0.120	0.705	94.2
8.0	22.0- 25.0	2.18	27.0	0.135	0.840	97.1
7.0	26.0- 29.0	2.49	20.0	0.100	0.940	99.0
6.0	30.0- 34.0	2.90	10.0	0.050	0.990	99.8
5.0	37.0- 37.0	3.49	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
9.0	21.0- 21.0	1.55	8.0	0.040	0.040	75.8
8.0	22.0- 25.0	1.74	80.0	0.400	0.440	84.8
7.0	26.0- 29.0	1.99	39.0	0.195	0.635	90.6
6.0	30.0- 35.0	2.32	30.0	0.150	0.785	95.1
5.0	36.0- 42.0	2.79	29.0	0.145	0.930	98.4
4.0	45.0- 51.0	3.49	12.0	0.060	0.990	99.8
3.0	59.0- 62.0	4.65	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
7.0	29.0- 29.0	1.66	15.0	0.075	0.075	70.8

TABLE B- 1 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
6.0	30.0- 35.0	1.94	71.0	0.355	0.430	81.3
5.0	36.0- 43.0	2.32	40.0	0.200	0.630	89.0
4.0	44.0- 57.0	2.90	38.0	0.190	0.820	95.5
3.0	59.0- 81.0	3.87	36.0	0.180	1.000	100.0
APPLIED DEPTH IS 35.0 CM.						
6.0	35.0- 35.0	1.66	3.0	0.015	0.015	67.4
5.0	36.0- 43.0	1.99	90.0	0.450	0.465	80.6
4.0	44.0- 56.0	2.49	35.0	0.175	0.640	89.1
3.0	58.0- 81.0	3.32	57.0	0.285	0.925	97.5
2.0	84.0- 95.0	4.98	15.0	0.075	1.000	100.0

TABLE B- 2

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
26.0	5.0- 5.0	1.34	84.0	0.174	0.174	84.6
23.0	6.0- 6.0	1.52	171.0	0.353	0.527	93.4
21.0	7.0- 7.0	1.66	128.0	0.264	0.791	97.3
19.0	8.0- 8.0	1.83	68.0	0.140	0.932	99.2
18.0	9.0- 9.0	1.94	19.0	0.039	0.971	99.5
16.0	10.0- 10.0	2.18	3.0	0.006	0.977	99.8
15.0	11.0- 11.0	2.32	7.0	0.014	0.992	99.9
14.0	12.0- 12.0	2.49	4.0	0.008	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
15.0	11.0- 11.0	1.55	7.0	0.033	0.033	73.0
14.0	12.0- 12.0	1.66	13.0	0.061	0.094	78.0
13.0	13.0- 13.0	1.79	27.0	0.127	0.221	83.3
12.0	14.0- 15.0	1.94	50.0	0.235	0.455	88.4
11.0	16.0- 17.0	2.11	40.0	0.188	0.643	92.3
10.0	18.0- 19.0	2.32	28.0	0.131	0.775	95.1
9.0	20.0- 21.0	2.58	19.0	0.089	0.864	97.0
8.0	22.0- 25.0	2.90	11.0	0.052	0.915	98.4
7.0	26.0- 29.0	3.32	11.0	0.052	0.967	99.3
6.0	30.0- 33.0	3.87	4.0	0.019	0.986	99.8
5.0	36.0- 43.0	4.65	3.0	0.014	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
10.0	19.0- 19.0	1.74	1.0	0.005	0.005	56.9
9.0	21.0- 21.0	1.94	6.0	0.030	0.035	63.1
8.0	22.0- 25.0	2.18	18.0	0.090	0.125	70.6
7.0	26.0- 29.0	2.49	38.0	0.190	0.315	78.9
6.0	30.0- 35.0	2.90	45.0	0.225	0.540	86.8
5.0	36.0- 43.0	3.49	44.0	0.220	0.760	93.3
4.0	44.0- 56.0	4.36	30.0	0.150	0.910	97.6
3.0	60.0- 76.0	5.81	17.0	0.085	0.995	99.8
2.0	93.0- 93.0	8.71	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
6.0	31.0- 34.0	2.32	3.0	0.015	0.015	53.2
5.0	36.0- 43.0	2.79	22.0	0.110	0.125	63.6
4.0	44.0- 57.0	3.49	41.0	0.205	0.330	76.4
3.0	58.0- 81.0	4.65	80.0	0.400	0.730	90.8
2.0	82.0-120.0	6.97	53.0	0.265	0.995	99.8

TABLE B- 2 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
1.0	147.0-147.0	13.94	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
3.0	60.0- 81.0	3.87	13.0	0.127	0.127	74.5
2.0	82.0-137.0	5.81	78.0	0.765	0.892	100.0

TABLE B- 3

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
23.0	5.0- 5.0	1.52	107.0	0.259	0.259	83.5
20.0	6.0- 6.0	1.74	118.0	0.286	0.545	92.2
18.0	7.0- 7.0	1.94	95.0	0.230	0.775	96.4
16.0	8.0- 8.0	2.18	52.0	0.126	0.901	98.7
15.0	9.0- 9.0	2.32	19.0	0.046	0.947	99.3
14.0	10.0- 10.0	2.49	10.0	0.024	0.971	99.6
13.0	11.0- 11.0	2.68	4.0	0.010	0.981	99.8
12.0	12.0- 12.0	2.90	6.0	0.015	0.995	100.0
11.0	14.0- 14.0	3.17	2.0	0.005	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
13.0	11.0- 11.0	1.79	3.0	0.015	0.015	66.7
12.0	12.0- 12.0	1.94	12.0	0.060	0.075	72.1
11.0	13.0- 14.0	2.11	36.0	0.180	0.255	78.0
10.0	15.0- 15.0	2.32	18.0	0.090	0.345	83.2
9.0	16.0- 18.0	2.58	48.0	0.240	0.585	88.6
8.0	19.0- 21.0	2.90	28.0	0.140	0.725	92.4
7.0	22.0- 24.0	3.32	14.0	0.070	0.795	95.2
6.0	25.0- 29.0	3.87	25.0	0.125	0.920	97.8
5.0	30.0- 37.0	4.65	8.0	0.040	0.960	99.0
4.0	38.0- 46.0	5.81	6.0	0.030	0.990	99.8
3.0	62.0- 64.0	7.75	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
8.0	21.0- 21.0	2.18	1.0	0.005	0.005	60.8
7.0	23.0- 24.0	2.49	8.0	0.040	0.045	67.3
6.0	25.0- 29.0	2.90	18.0	0.090	0.135	75.3
5.0	30.0- 37.0	3.49	43.0	0.215	0.350	84.6
4.0	38.0- 48.0	4.36	46.0	0.230	0.580	93.3
3.0	49.0- 69.0	5.81	54.0	0.270	0.850	100.0
APPLIED DEPTH IS 25.0 CM.						
4.0	38.0- 48.0	3.49	6.0	0.044	0.044	58.3
3.0	49.0- 69.0	4.65	15.0	0.111	0.156	74.1
2.0	70.0-117.0	6.97	105.0	0.778	0.933	100.0
APPLIED DEPTH IS 30.0 CM.						
2.0	71.0-117.0	5.81	39.0	0.722	0.722	100.0

TABLE B- 4

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
45.0	5.0- 5.0	0.77	137.0	0.171	0.171	82.8
40.0	6.0- 6.0	0.87	268.0	0.335	0.506	91.1
36.0	7.0- 7.0	0.97	179.0	0.224	0.730	95.6
33.0	8.0- 8.0	1.06	105.0	0.131	0.861	97.6
30.0	9.0- 9.0	1.16	45.0	0.056	0.917	98.8
28.0	10.0- 10.0	1.24	29.0	0.036	0.954	99.3
26.0	11.0- 11.0	1.34	16.0	0.020	0.974	99.6
24.0	12.0- 12.0	1.45	6.0	0.008	0.981	99.7
23.0	13.0- 13.0	1.52	8.0	0.010	0.991	99.8
21.0	14.0- 14.0	1.66	2.0	0.002	0.994	99.9
20.0	15.0- 15.0	1.74	1.0	0.001	0.995	99.9
16.0	19.0- 20.0	2.18	4.0	0.005	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
26.0	11.0- 11.0	0.89	19.0	0.054	0.054	71.5
24.0	12.0- 12.0	0.97	34.0	0.097	0.152	77.0
23.0	13.0- 13.0	1.01	39.0	0.112	0.264	79.7
21.0	14.0- 14.0	1.11	50.0	0.143	0.407	84.8
20.0	15.0- 15.0	1.16	27.0	0.077	0.484	87.0
19.0	16.0- 16.0	1.22	31.0	0.089	0.573	89.0
18.0	17.0- 17.0	1.29	23.0	0.066	0.639	90.8
17.0	18.0- 18.0	1.37	21.0	0.060	0.699	92.3
16.0	19.0- 20.0	1.45	26.0	0.074	0.774	93.7
15.0	21.0- 21.0	1.55	7.0	0.020	0.794	94.8
14.0	22.0- 23.0	1.66	17.0	0.049	0.842	95.9
13.0	24.0- 25.0	1.79	16.0	0.046	0.888	96.8
12.0	26.0- 28.0	1.94	12.0	0.034	0.923	97.5
11.0	29.0- 30.0	2.11	4.0	0.011	0.934	98.0
10.0	32.0- 34.0	2.32	4.0	0.011	0.946	98.4
9.0	35.0- 38.0	2.58	6.0	0.017	0.963	98.9
8.0	40.0- 43.0	2.90	3.0	0.009	0.971	99.2
7.0	47.0- 49.0	3.32	3.0	0.009	0.980	99.5
6.0	53.0- 55.0	3.87	2.0	0.006	0.986	99.7
5.0	63.0- 65.0	4.65	4.0	0.011	0.997	99.9
4.0	79.0- 79.0	5.81	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
16.0	19.0- 20.0	1.09	5.0	0.025	0.025	62.8
15.0	21.0- 21.0	1.16	6.0	0.030	0.055	66.7

TABLE B- 4 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
14.0	22.0- 23.0	1.24	17.0	0.085	0.140	71.0
13.0	24.0- 25.0	1.34	21.0	0.105	0.245	75.2
12.0	26.0- 28.0	1.45	21.0	0.105	0.350	79.2
11.0	29.0- 31.0	1.58	23.0	0.115	0.465	83.1
10.0	32.0- 34.0	1.74	23.0	0.115	0.580	86.6
9.0	35.0- 39.0	1.94	22.0	0.110	0.690	89.5
8.0	40.0- 45.0	2.18	14.0	0.070	0.760	91.8
7.0	46.0- 52.0	2.49	11.0	0.055	0.815	93.8
6.0	53.0- 60.0	2.90	6.0	0.030	0.845	95.5
5.0	64.0- 76.0	3.49	8.0	0.040	0.885	97.3
4.0	78.0- 98.0	4.36	11.0	0.055	0.940	99.0
3.0	108.0-138.0	5.81	8.0	0.040	0.980	100.0
APPLIED DEPTH IS 25.0 CM.						
11.0	29.0- 31.0	1.27	4.0	0.020	0.020	57.1
10.0	32.0- 34.0	1.39	9.0	0.045	0.065	62.7
9.0	35.0- 39.0	1.55	23.0	0.115	0.180	68.9
8.0	40.0- 45.0	1.74	38.0	0.190	0.370	75.3
7.0	46.0- 52.0	1.99	34.0	0.170	0.540	80.7
6.0	53.0- 62.0	2.32	23.0	0.115	0.655	85.2
5.0	63.0- 77.0	2.79	24.0	0.120	0.775	89.1
4.0	81.0- 97.0	3.49	10.0	0.050	0.825	92.0
3.0	107.0-137.0	4.65	8.0	0.040	0.865	95.2
2.0	152.0-233.0	6.97	25.0	0.125	0.990	99.5
1.0	241.0-249.0	13.94	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
8.0	44.0- 45.0	1.45	4.0	0.025	0.025	61.7
7.0	46.0- 52.0	1.66	14.0	0.088	0.113	69.5
6.0	53.0- 62.0	1.94	18.0	0.113	0.226	78.3
5.0	63.0- 77.0	2.32	54.0	0.340	0.566	88.4
4.0	78.0- 97.0	2.90	39.0	0.245	0.811	95.1
3.0	100.0-135.0	3.87	13.0	0.082	0.893	98.1
2.0	146.0-237.0	5.81	9.0	0.057	0.950	100.0
APPLIED DEPTH IS 35.0 CM.						
6.0	59.0- 59.0	1.66	1.0	0.013	0.013	60.8
5.0	70.0- 74.0	1.99	6.0	0.075	0.087	72.5
4.0	78.0- 98.0	2.49	36.0	0.450	0.537	88.1
3.0	101.0-138.0	3.32	34.0	0.425	0.962	99.2

TABLE B- 4 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
2.0	156.0-230.0	4.98	2.0	0.025	0.987	100.0

TABLE B- 5

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
47.0	4.0- 4.0	0.74	64.0	0.070	0.070	85.8
41.0	5.0- 5.0	0.85	635.0	0.699	0.769	97.3
37.0	6.0- 6.0	0.94	173.0	0.190	0.959	99.5
33.0	7.0- 7.0	1.06	33.0	0.036	0.996	100.0
30.0	8.0- 8.0	1.16	4.0	0.004	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
30.0	8.0- 8.0	0.77	29.0	0.055	0.055	84.2
28.0	9.0- 9.0	0.83	187.0	0.358	0.413	89.9
25.0	10.0- 10.0	0.93	100.0	0.191	0.604	95.7
24.0	11.0- 11.0	0.97	101.0	0.193	0.797	97.2
22.0	12.0- 12.0	1.06	54.0	0.103	0.901	98.7
21.0	13.0- 13.0	1.11	23.0	0.044	0.945	99.2
19.0	14.0- 14.0	1.22	14.0	0.027	0.971	99.7
18.0	15.0- 15.0	1.29	5.0	0.010	0.981	99.8
17.0	16.0- 17.0	1.37	6.0	0.011	0.992	99.9
16.0	18.0- 18.0	1.45	1.0	0.002	0.994	99.9
15.0	19.0- 19.0	1.55	2.0	0.004	0.998	100.0
13.0	23.0- 23.0	1.79	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
21.0	13.0- 13.0	0.83	13.0	0.039	0.039	79.5
19.0	14.0- 14.0	0.92	76.0	0.228	0.267	87.4
18.0	15.0- 15.0	0.97	59.0	0.177	0.444	90.8
17.0	16.0- 17.0	1.03	63.0	0.189	0.634	93.5
16.0	18.0- 18.0	1.09	24.0	0.072	0.706	95.4
15.0	19.0- 19.0	1.16	20.0	0.060	0.766	97.1
14.0	20.0- 21.0	1.24	48.0	0.144	0.910	98.5
13.0	22.0- 23.0	1.34	10.0	0.030	0.940	99.1
12.0	24.0- 25.0	1.45	6.0	0.018	0.958	99.5
11.0	26.0- 28.0	1.58	11.0	0.033	0.991	99.9
10.0	31.0- 31.0	1.74	1.0	0.003	0.994	99.9
9.0	32.0- 33.0	1.94	2.0	0.006	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
15.0	19.0- 19.0	0.93	17.0	0.076	0.076	80.5
14.0	20.0- 21.0	1.00	53.0	0.238	0.314	85.7
13.0	22.0- 23.0	1.07	34.0	0.152	0.466	89.9
12.0	24.0- 25.0	1.16	32.0	0.143	0.610	93.5

TABLE B- 5 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
11.0	26.0- 28.0	1.27	36.0	0.161	0.771	96.4
10.0	29.0- 31.0	1.39	22.0	0.099	0.870	98.3
9.0	32.0- 35.0	1.55	21.0	0.094	0.964	99.6
8.0	36.0- 38.0	1.74	8.0	0.036	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
12.0	25.0- 25.0	0.97	3.0	0.015	0.015	77.8
11.0	26.0- 28.0	1.06	52.0	0.260	0.275	84.8
10.0	29.0- 31.0	1.16	48.0	0.240	0.515	90.5
9.0	32.0- 35.0	1.29	36.0	0.180	0.695	94.8
8.0	36.0- 41.0	1.45	38.0	0.190	0.885	98.0
7.0	42.0- 47.0	1.66	15.0	0.075	0.960	99.4
6.0	48.0- 54.0	1.94	7.0	0.035	0.995	99.9
5.0	69.0- 69.0	2.32	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 35.0 CM.						
10.0	31.0- 31.0	1.00	3.0	0.015	0.015	73.2
9.0	32.0- 35.0	1.11	38.0	0.190	0.205	81.1
8.0	36.0- 41.0	1.24	57.0	0.285	0.490	88.7
7.0	42.0- 47.0	1.42	38.0	0.190	0.680	94.4
6.0	48.0- 56.0	1.66	51.0	0.255	0.935	98.8
5.0	58.0- 70.0	1.99	11.0	0.055	0.990	99.8
4.0	71.0- 71.0	2.49	2.0	0.010	1.000	100.0

TABLE B- 6

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
47.0	4.0- 4.0	0.74	30.0	0.035	0.035	81.7
41.0	5.0- 5.0	0.85	411.0	0.485	0.520	93.1
37.0	6.0- 6.0	0.94	280.0	0.330	0.850	97.6
33.0	7.0- 7.0	1.06	80.0	0.094	0.945	99.1
30.0	8.0- 8.0	1.16	24.0	0.028	0.973	99.6
28.0	9.0- 9.0	1.24	9.0	0.011	0.983	99.7
25.0	10.0- 10.0	1.39	9.0	0.011	0.994	99.9
22.0	12.0- 12.0	1.58	1.0	0.001	0.995	100.0
21.0	13.0- 13.0	1.66	2.0	0.002	0.998	100.0
19.0	14.0- 14.0	1.83	2.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
24.0	11.0- 11.0	0.97	3.0	0.008	0.008	81.6
22.0	12.0- 12.0	1.06	177.0	0.477	0.485	89.0
21.0	13.0- 13.0	1.11	55.0	0.148	0.633	90.9
19.0	14.0- 14.0	1.22	30.0	0.081	0.714	93.8
18.0	15.0- 15.0	1.29	22.0	0.059	0.774	95.0
17.0	16.0- 17.0	1.37	27.0	0.073	0.846	96.1
16.0	18.0- 18.0	1.45	7.0	0.019	0.865	96.8
15.0	19.0- 19.0	1.55	12.0	0.032	0.898	97.5
14.0	20.0- 21.0	1.66	6.0	0.016	0.914	98.0
13.0	22.0- 23.0	1.79	8.0	0.022	0.935	98.5
12.0	24.0- 25.0	1.94	5.0	0.013	0.949	99.0
11.0	26.0- 27.0	2.11	5.0	0.013	0.962	99.3
10.0	29.0- 31.0	2.32	5.0	0.013	0.976	99.6
9.0	33.0- 34.0	2.58	6.0	0.016	0.992	99.9
8.0	37.0- 38.0	2.90	2.0	0.005	0.997	100.0
7.0	43.0- 43.0	3.32	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
14.0	20.0- 21.0	1.24	65.0	0.325	0.325	82.9
13.0	22.0- 23.0	1.34	33.0	0.165	0.490	86.8
12.0	24.0- 25.0	1.45	28.0	0.140	0.630	90.0
11.0	26.0- 28.0	1.58	19.0	0.095	0.725	92.4
10.0	29.0- 31.0	1.74	12.0	0.060	0.785	94.4
9.0	32.0- 35.0	1.94	10.0	0.050	0.835	96.2
8.0	36.0- 41.0	2.18	15.0	0.075	0.910	97.8
7.0	42.0- 46.0	2.49	9.0	0.045	0.955	98.7
6.0	48.0- 57.0	2.90	3.0	0.015	0.970	99.3

TABLE B- 6 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
5.0	59.0- 69.0	3.49	3.0	0.015	0.985	99.7
4.0	71.0- 81.0	4.36	3.0	0.015	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
10.0	30.0- 31.0	1.39	5.0	0.025	0.025	78.5
9.0	32.0- 35.0	1.55	86.0	0.430	0.455	86.4
8.0	36.0- 41.0	1.74	44.0	0.220	0.675	91.0
7.0	42.0- 47.0	1.99	18.0	0.090	0.765	93.7
6.0	48.0- 57.0	2.32	8.0	0.040	0.805	95.8
5.0	58.0- 70.0	2.79	10.0	0.050	0.855	98.0
4.0	72.0- 91.0	3.49	20.0	0.100	0.955	100.0
APPLIED DEPTH IS 30.0 CM.						
7.0	44.0- 47.0	1.66	55.0	0.275	0.275	77.4
6.0	48.0- 57.0	1.94	70.0	0.350	0.625	85.6
5.0	58.0- 70.0	2.32	15.0	0.075	0.700	90.0
4.0	71.0- 91.0	2.90	16.0	0.080	0.780	94.8
3.0	93.0-127.0	3.87	42.0	0.210	0.990	100.0

TABLE B- 7

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
23.0	6.0- 6.0	0.89	1.0	0.003	0.003	74.7
21.0	7.0- 7.0	0.98	6.0	0.017	0.020	81.8
19.0	8.0- 8.0	1.08	154.0	0.438	0.457	90.2
18.0	9.0- 9.0	1.14	68.0	0.193	0.651	92.7
16.0	10.0- 10.0	1.29	44.0	0.125	0.776	96.1
15.0	11.0- 11.0	1.37	27.0	0.077	0.852	97.4
14.0	12.0- 12.0	1.47	18.0	0.051	0.903	98.3
13.0	13.0- 13.0	1.58	8.0	0.023	0.926	98.9
12.0	14.0- 15.0	1.71	13.0	0.037	0.963	99.4
11.0	16.0- 17.0	1.87	6.0	0.017	0.980	99.7
10.0	18.0- 19.0	2.06	4.0	0.011	0.991	99.8
9.0	20.0- 20.0	2.29	1.0	0.003	0.994	99.9
8.0	24.0- 24.0	2.57	1.0	0.003	0.997	100.0
7.0	28.0- 28.0	2.94	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
14.0	12.0- 12.0	0.98	2.0	0.010	0.010	63.8
13.0	13.0- 13.0	1.05	2.0	0.010	0.020	68.7
12.0	14.0- 15.0	1.14	5.0	0.025	0.045	74.2
11.0	16.0- 17.0	1.25	53.0	0.265	0.310	80.5
10.0	18.0- 19.0	1.37	38.0	0.190	0.500	85.5
9.0	20.0- 21.0	1.52	24.0	0.120	0.620	89.4
8.0	22.0- 25.0	1.71	23.0	0.115	0.735	92.9
7.0	26.0- 29.0	1.96	19.0	0.095	0.830	95.6
6.0	30.0- 34.0	2.29	15.0	0.075	0.905	97.8
5.0	36.0- 42.0	2.74	13.0	0.065	0.970	99.2
4.0	46.0- 48.0	3.43	4.0	0.020	0.990	99.8
3.0	60.0- 63.0	4.57	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
9.0	21.0- 21.0	1.14	1.0	0.005	0.005	61.6
8.0	22.0- 25.0	1.29	13.0	0.065	0.070	69.3
7.0	26.0- 29.0	1.47	64.0	0.320	0.390	78.1
6.0	30.0- 35.0	1.71	44.0	0.220	0.610	84.7
5.0	36.0- 43.0	2.06	18.0	0.090	0.700	89.4
4.0	44.0- 54.0	2.57	18.0	0.090	0.790	94.3
3.0	62.0- 81.0	3.43	38.0	0.190	0.980	99.3
2.0	83.0- 92.0	5.14	4.0	0.020	1.000	100.0

TABLE B- 7 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 25.0 CM.						
6.0	30.0- 35.0	1.37	31.0	0.155	0.155	64.8
5.0	37.0- 43.0	1.65	53.0	0.265	0.420	74.7
4.0	44.0- 57.0	2.06	24.0	0.120	0.540	82.9
3.0	58.0- 81.0	2.74	47.0	0.235	0.775	92.5
2.0	82.0-101.0	4.11	45.0	0.225	1.000	100.0

TABLE B- 8

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
21.0	7.0- 7.0	0.98	2.0	0.009	0.009	59.1
19.0	8.0- 8.0	1.08	16.0	0.071	0.080	65.3
18.0	9.0- 9.0	1.14	5.0	0.022	0.103	68.5
16.0	10.0- 10.0	1.29	23.0	0.103	0.205	75.7
15.0	11.0- 11.0	1.37	28.0	0.125	0.330	79.4
14.0	12.0- 12.0	1.47	12.0	0.054	0.384	82.7
13.0	13.0- 13.0	1.58	18.0	0.080	0.464	86.1
12.0	14.0- 15.0	1.71	29.0	0.129	0.594	89.4
11.0	16.0- 17.0	1.87	30.0	0.134	0.728	92.2
10.0	18.0- 19.0	2.06	12.0	0.054	0.781	94.1
9.0	20.0- 21.0	2.29	11.0	0.049	0.830	95.9
8.0	22.0- 25.0	2.57	14.0	0.063	0.893	97.5
7.0	26.0- 29.0	2.94	13.0	0.058	0.951	98.7
6.0	31.0- 35.0	3.43	4.0	0.018	0.969	99.3
5.0	36.0- 42.0	4.11	5.0	0.022	0.991	99.7
4.0	50.0- 50.0	5.14	1.0	0.004	0.996	99.9
3.0	59.0- 59.0	6.86	1.0	0.004	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
10.0	18.0- 18.0	1.37	1.0	0.005	0.005	43.9
8.0	22.0- 25.0	1.71	16.0	0.080	0.085	54.7
7.0	26.0- 29.0	1.96	16.0	0.080	0.165	61.3
6.0	30.0- 35.0	2.29	26.0	0.130	0.295	68.7
5.0	36.0- 43.0	2.74	20.0	0.100	0.395	76.6
4.0	44.0- 57.0	3.43	38.0	0.190	0.585	85.9
3.0	58.0- 81.0	4.57	54.0	0.270	0.855	95.0
2.0	83.0-116.0	6.86	28.0	0.140	0.995	99.8
1.0	148.0-148.0	13.71	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
4.0	54.0- 54.0	2.57	1.0	0.010	0.010	57.4
3.0	64.0- 80.0	3.43	5.0	0.051	0.061	72.4
2.0	82.0-137.0	5.14	81.0	0.827	0.888	100.0

TABLE B- 9

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
18.0	7.0- 7.0	1.14	3.0	0.015	0.015	54.2
16.0	8.0- 8.0	1.29	7.0	0.035	0.050	60.8
15.0	9.0- 9.0	1.37	10.0	0.050	0.100	64.4
14.0	10.0- 10.0	1.47	11.0	0.055	0.155	68.3
13.0	11.0- 11.0	1.58	14.0	0.070	0.225	72.3
12.0	12.0- 12.0	1.71	13.0	0.065	0.290	76.4
11.0	13.0- 14.0	1.87	31.0	0.155	0.445	80.7
10.0	15.0- 15.0	2.06	13.0	0.065	0.510	84.3
9.0	16.0- 18.0	2.29	33.0	0.165	0.675	87.9
8.0	20.0- 21.0	2.57	7.0	0.035	0.710	90.4
7.0	22.0- 24.0	2.94	14.0	0.070	0.780	93.1
6.0	25.0- 29.0	3.43	16.0	0.080	0.860	95.5
5.0	30.0- 37.0	4.11	9.0	0.045	0.905	97.3
4.0	38.0- 47.0	5.14	9.0	0.045	0.950	98.9
3.0	49.0- 67.0	6.86	9.0	0.045	0.995	100.0
APPLIED DEPTH IS 15.0 CM.						
7.0	22.0- 24.0	1.96	2.0	0.013	0.013	41.0
6.0	26.0- 29.0	2.29	7.0	0.046	0.059	46.7
5.0	30.0- 36.0	2.74	6.0	0.039	0.099	53.8
4.0	39.0- 48.0	3.43	12.0	0.079	0.178	63.5
3.0	50.0- 69.0	4.57	12.0	0.079	0.257	77.0
2.0	70.0-116.0	6.86	105.0	0.691	0.947	100.0
APPLIED DEPTH IS 20.0 CM.						
2.0	83.0-115.0	5.14	23.0	0.676	0.676	100.0

TABLE B-10

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
36.0	7.0- 7.0	0.57	2.0	0.005	0.005	61.5
33.0	8.0- 8.0	0.62	31.0	0.082	0.087	67.0
30.0	9.0- 9.0	0.69	33.0	0.087	0.175	72.8
28.0	10.0- 10.0	0.73	49.0	0.130	0.304	76.8
26.0	11.0- 11.0	0.79	36.0	0.095	0.399	80.3
24.0	12.0- 12.0	0.86	27.0	0.071	0.471	83.7
23.0	13.0- 13.0	0.89	31.0	0.082	0.553	85.3
21.0	14.0- 14.0	0.98	24.0	0.063	0.616	88.2
20.0	15.0- 15.0	1.03	20.0	0.053	0.669	89.5
19.0	16.0- 16.0	1.08	11.0	0.029	0.698	90.7
18.0	17.0- 17.0	1.14	19.0	0.050	0.749	91.8
17.0	18.0- 18.0	1.21	7.0	0.019	0.767	92.8
16.0	19.0- 20.0	1.29	20.0	0.053	0.820	93.8
15.0	21.0- 21.0	1.37	6.0	0.016	0.836	94.6
14.0	22.0- 23.0	1.47	8.0	0.021	0.857	95.4
13.0	24.0- 25.0	1.58	15.0	0.040	0.897	96.2
12.0	27.0- 28.0	1.71	7.0	0.019	0.915	96.7
11.0	29.0- 31.0	1.87	3.0	0.008	0.923	97.2
10.0	32.0- 34.0	2.06	3.0	0.008	0.931	97.6
9.0	37.0- 39.0	2.29	6.0	0.016	0.947	98.1
8.0	40.0- 44.0	2.57	6.0	0.016	0.963	98.6
6.0	61.0- 61.0	3.43	2.0	0.005	0.968	99.3
5.0	63.0- 76.0	4.11	9.0	0.024	0.992	99.8
4.0	78.0- 84.0	5.14	3.0	0.008	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
17.0	18.0- 18.0	0.81	2.0	0.010	0.010	51.5
16.0	19.0- 20.0	0.86	7.0	0.035	0.045	54.7
15.0	21.0- 21.0	0.91	4.0	0.020	0.065	58.0
14.0	22.0- 23.0	0.98	11.0	0.055	0.120	61.7
13.0	24.0- 25.0	1.05	11.0	0.055	0.175	65.5
12.0	26.0- 28.0	1.14	21.0	0.105	0.280	69.5
11.0	29.0- 31.0	1.25	18.0	0.090	0.370	73.3
10.0	32.0- 34.0	1.37	12.0	0.060	0.430	76.9
9.0	35.0- 39.0	1.52	21.0	0.105	0.535	80.7
8.0	40.0- 45.0	1.71	21.0	0.105	0.640	84.1
7.0	46.0- 52.0	1.96	17.0	0.085	0.725	87.0
6.0	53.0- 62.0	2.29	15.0	0.075	0.800	89.4
5.0	63.0- 76.0	2.74	6.0	0.030	0.830	91.3

TABLE B-10 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
4.0	82.0- 95.0	3.43	5.0	0.025	0.855	93.4
3.0	111.0-138.0	4.57	9.0	0.045	0.900	96.0
2.0	170.0-231.0	6.86	16.0	0.080	0.980	99.0
1.0	243.0-256.0	13.71	4.0	0.020	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
10.0	32.0- 32.0	1.03	2.0	0.015	0.015	49.8
9.0	37.0- 37.0	1.14	2.0	0.015	0.031	54.8
8.0	41.0- 45.0	1.29	10.0	0.077	0.108	60.9
7.0	47.0- 51.0	1.47	6.0	0.046	0.154	67.6
6.0	55.0- 62.0	1.71	8.0	0.062	0.215	75.8
5.0	63.0- 77.0	2.06	33.0	0.254	0.469	86.0
4.0	78.0- 99.0	2.57	41.0	0.315	0.785	95.0
3.0	100.0-138.0	3.43	22.0	0.169	0.954	99.5
2.0	153.0-223.0	5.14	2.0	0.015	0.969	100.0

TABLE B-11

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
37.0	6.0- 6.0	0.56	3.0	0.005	0.005	79.5
33.0	7.0- 7.0	0.62	136.0	0.217	0.221	89.1
30.0	8.0- 8.0	0.69	303.0	0.482	0.704	95.8
28.0	9.0- 9.0	0.73	102.0	0.162	0.866	97.6
25.0	10.0- 10.0	0.82	36.0	0.057	0.924	98.9
24.0	11.0- 11.0	0.86	17.0	0.027	0.951	99.2
22.0	12.0- 12.0	0.94	15.0	0.024	0.975	99.6
21.0	13.0- 13.0	0.98	5.0	0.008	0.982	99.7
19.0	14.0- 14.0	1.08	4.0	0.006	0.989	99.9
18.0	15.0- 15.0	1.14	1.0	0.002	0.990	99.9
17.0	16.0- 17.0	1.21	4.0	0.006	0.997	100.0
16.0	18.0- 18.0	1.29	1.0	0.002	0.998	100.0
14.0	21.0- 21.0	1.47	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
21.0	13.0- 13.0	0.65	9.0	0.030	0.030	75.9
19.0	14.0- 14.0	0.72	16.0	0.053	0.082	83.6
18.0	15.0- 15.0	0.76	57.0	0.188	0.270	87.8
17.0	16.0- 17.0	0.81	79.0	0.260	0.530	91.3
16.0	18.0- 18.0	0.86	35.0	0.115	0.645	93.7
15.0	19.0- 19.0	0.91	19.0	0.063	0.707	95.7
14.0	20.0- 21.0	0.98	35.0	0.115	0.822	97.5
13.0	22.0- 23.0	1.05	26.0	0.086	0.908	98.6
12.0	24.0- 25.0	1.14	12.0	0.039	0.947	99.3
11.0	26.0- 28.0	1.25	9.0	0.030	0.977	99.7
10.0	29.0- 31.0	1.37	4.0	0.013	0.990	99.9
9.0	32.0- 34.0	1.52	3.0	0.010	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
13.0	22.0- 23.0	0.79	3.0	0.015	0.015	75.9
12.0	24.0- 25.0	0.86	30.0	0.150	0.165	82.1
11.0	26.0- 28.0	0.94	54.0	0.270	0.435	88.0
10.0	29.0- 31.0	1.03	33.0	0.165	0.600	92.5
9.0	32.0- 35.0	1.14	30.0	0.150	0.750	96.1
8.0	36.0- 41.0	1.29	35.0	0.175	0.925	98.8
7.0	42.0- 46.0	1.47	12.0	0.060	0.985	99.6
6.0	48.0- 50.0	1.71	2.0	0.010	0.995	99.8
4.0	80.0- 80.0	2.57	1.0	0.005	1.000	100.0

TABLE 8-11 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 25.0 CM.						
10.0	31.0- 31.0	0.82	1.0	0.005	0.005	70.1
9.0	32.0- 35.0	0.91	21.0	0.105	0.110	77.8
8.0	36.0- 41.0	1.03	71.0	0.355	0.465	86.1
7.0	42.0- 47.0	1.18	34.0	0.170	0.635	91.6
6.0	48.0- 56.0	1.37	35.0	0.175	0.810	96.3
5.0	58.0- 70.0	1.65	29.0	0.145	0.955	99.2
4.0	71.0- 77.0	2.06	8.0	0.040	0.995	100.0
APPLIED DEPTH IS 30.0 CM.						
8.0	40.0- 41.0	0.86	3.0	0.015	0.015	65.8
7.0	42.0- 47.0	0.98	21.0	0.105	0.120	74.9
6.0	48.0- 57.0	1.14	61.0	0.305	0.425	85.3
5.0	58.0- 70.0	1.37	64.0	0.320	0.745	93.8
4.0	71.0- 89.0	1.71	38.0	0.190	0.935	98.5
3.0	93.0-128.0	2.29	12.0	0.060	0.995	100.0
APPLIED DEPTH IS 35.0 CM.						
6.0	50.0- 57.0	0.98	37.0	0.185	0.185	73.4
5.0	58.0- 68.0	1.18	32.0	0.160	0.345	83.7
4.0	71.0- 91.0	1.47	85.0	0.425	0.770	95.1
3.0	92.0-128.0	1.96	39.0	0.195	0.965	100.0

TABLE B-12

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
33.0	7.0- 7.0	0.62	11.0	0.024	0.024	77.3
30.0	8.0- 8.0	0.69	193.0	0.427	0.451	84.8
28.0	9.0- 9.0	0.73	47.0	0.104	0.555	87.6
25.0	10.0- 10.0	0.82	65.0	0.144	0.699	91.4
24.0	11.0- 11.0	0.86	28.0	0.062	0.761	92.3
22.0	12.0- 12.0	0.94	14.0	0.031	0.792	93.8
21.0	13.0- 13.0	0.98	22.0	0.049	0.841	94.5
19.0	14.0- 14.0	1.08	9.0	0.020	0.861	95.6
18.0	15.0- 15.0	1.14	12.0	0.027	0.887	96.1
17.0	16.0- 17.0	1.21	9.0	0.020	0.907	96.6
16.0	18.0- 18.0	1.29	2.0	0.004	0.912	96.9
15.0	19.0- 19.0	1.37	2.0	0.004	0.916	97.3
14.0	20.0- 21.0	1.47	5.0	0.011	0.927	97.7
13.0	22.0- 23.0	1.58	4.0	0.009	0.936	98.1
12.0	25.0- 25.0	1.71	4.0	0.009	0.945	98.5
11.0	26.0- 28.0	1.87	5.0	0.011	0.956	98.9
10.0	30.0- 31.0	2.06	5.0	0.011	0.967	99.2
9.0	33.0- 35.0	2.29	3.0	0.007	0.973	99.5
8.0	36.0- 41.0	2.57	7.0	0.015	0.989	99.8
7.0	44.0- 46.0	2.94	2.0	0.004	0.993	99.9
6.0	48.0- 48.0	3.43	2.0	0.004	0.998	100.0
5.0	66.0- 66.0	4.11	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
17.0	17.0- 17.0	0.81	1.0	0.005	0.005	70.1
16.0	18.0- 18.0	0.86	10.0	0.050	0.055	74.3
15.0	19.0- 19.0	0.91	42.0	0.210	0.265	78.8
14.0	20.0- 21.0	0.98	28.0	0.140	0.405	82.5
13.0	22.0- 23.0	1.05	32.0	0.160	0.565	85.6
12.0	24.0- 25.0	1.14	14.0	0.070	0.635	87.9
11.0	26.0- 28.0	1.25	19.0	0.095	0.730	90.0
10.0	29.0- 31.0	1.37	9.0	0.045	0.775	91.5
9.0	32.0- 35.0	1.52	8.0	0.040	0.815	92.9
8.0	36.0- 41.0	1.71	5.0	0.025	0.840	94.1
7.0	43.0- 47.0	1.96	4.0	0.020	0.860	95.4
6.0	48.0- 54.0	2.29	2.0	0.010	0.870	96.7
5.0	59.0- 70.0	2.74	6.0	0.030	0.900	98.3
4.0	71.0- 90.0	3.43	17.0	0.085	0.985	100.0

TABLE B-12 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 20.0 CM.						
11.0	28.0- 28.0	0.94	1.0	0.005	0.005	64.2
10.0	29.0- 31.0	1.03	17.0	0.085	0.090	70.5
9.0	32.0- 35.0	1.14	49.0	0.245	0.335	77.3
8.0	36.0- 41.0	1.29	49.0	0.245	0.580	82.7
7.0	42.0- 46.0	1.47	18.0	0.090	0.670	86.1
6.0	48.0- 57.0	1.71	16.0	0.080	0.750	89.3
5.0	59.0- 70.0	2.06	3.0	0.015	0.765	92.0
4.0	79.0- 91.0	2.57	12.0	0.060	0.825	95.8
3.0	93.0-127.0	3.43	34.0	0.170	0.995	100.0
APPLIED DEPTH IS 25.0 CM.						
7.0	44.0- 47.0	1.18	15.0	0.075	0.075	63.5
6.0	48.0- 57.0	1.37	54.0	0.270	0.345	72.8
5.0	58.0- 70.0	1.65	43.0	0.215	0.560	80.5
4.0	71.0- 89.0	2.06	13.0	0.065	0.625	86.6
3.0	98.0-129.0	2.74	43.0	0.215	0.840	94.7
2.0	130.0-158.0	4.11	32.0	0.160	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
5.0	69.0- 70.0	1.37	3.0	0.015	0.015	57.7
4.0	71.0- 91.0	1.71	69.0	0.345	0.360	71.8
3.0	92.0-129.0	2.29	30.0	0.150	0.510	83.7
2.0	130.0-178.0	3.43	98.0	0.490	1.000	100.0

TABLE B-13

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
30.0	4.0- 4.0	0.88	1.0	0.002	0.002	80.2
26.0	5.0- 5.0	1.02	224.0	0.557	0.560	92.5
23.0	6.0- 6.0	1.15	104.0	0.259	0.818	97.3
21.0	7.0- 7.0	1.26	41.0	0.102	0.920	98.7
19.0	8.0- 8.0	1.39	17.0	0.042	0.963	99.4
18.0	9.0- 9.0	1.47	4.0	0.010	0.973	99.6
16.0	10.0- 10.0	1.65	6.0	0.015	0.988	99.9
15.0	11.0- 11.0	1.76	3.0	0.007	0.995	100.0
14.0	12.0- 12.0	1.89	2.0	0.005	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
13.0	13.0- 13.0	1.02	1.0	0.005	0.005	65.3
12.0	14.0- 15.0	1.10	3.0	0.015	0.020	70.7
11.0	17.0- 17.0	1.20	45.0	0.225	0.245	76.9
10.0	18.0- 19.0	1.32	34.0	0.170	0.415	82.2
9.0	20.0- 21.0	1.47	27.0	0.135	0.550	86.7
8.0	22.0- 25.0	1.65	21.0	0.105	0.655	90.6
7.0	26.0- 29.0	1.89	23.0	0.115	0.770	94.2
6.0	30.0- 35.0	2.20	23.0	0.115	0.885	97.1
5.0	36.0- 43.0	2.64	14.0	0.070	0.955	98.8
4.0	45.0- 49.0	3.30	6.0	0.030	0.985	99.6
3.0	60.0- 64.0	4.40	3.0	0.015	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
7.0	26.0- 29.0	1.26	19.0	0.095	0.095	63.8
6.0	30.0- 35.0	1.47	47.0	0.234	0.328	72.8
5.0	36.0- 43.0	1.76	44.0	0.219	0.547	80.8
4.0	44.0- 57.0	2.20	20.0	0.100	0.647	87.3
3.0	61.0- 81.0	2.94	40.0	0.199	0.846	94.9
2.0	83.0- 96.0	4.40	31.0	0.154	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
5.0	41.0- 43.0	1.32	22.0	0.110	0.110	91.8
4.0	44.0- 57.0	1.65	54.0	0.270	0.380	98.2
3.0	58.0- 81.0	2.20	14.0	0.070	0.450	100.0
APPLIED DEPTH IS 25.0 CM.						
3.0	66.0- 77.0	1.76	3.0	0.024	0.024	100.0
2.0	99.0-136.0	2.20	107.0	0.907	0.907	100.0

TABLE B-14

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
30.0	4.0- 4.0	0.88	16.0	0.049	0.049	69.6
26.0	5.0- 5.0	1.02	52.0	0.160	0.210	79.5
23.0	6.0- 6.0	1.15	66.0	0.204	0.414	87.2
21.0	7.0- 7.0	1.26	56.0	0.173	0.586	91.5
19.0	8.0- 8.0	1.39	48.0	0.148	0.735	95.0
18.0	9.0- 9.0	1.47	30.0	0.093	0.827	96.2
16.0	10.0- 10.0	1.65	16.0	0.049	0.877	97.9
15.0	11.0- 11.0	1.76	15.0	0.046	0.923	98.5
14.0	12.0- 12.0	1.89	7.0	0.022	0.944	99.0
13.0	13.0- 13.0	2.03	5.0	0.015	0.960	99.3
12.0	14.0- 14.0	2.20	6.0	0.019	0.978	99.6
11.0	16.0- 17.0	2.40	4.0	0.012	0.991	99.8
10.0	18.0- 18.0	2.64	1.0	0.003	0.994	99.8
8.0	24.0- 24.0	3.30	1.0	0.003	0.997	100.0
7.0	29.0- 29.0	3.77	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
8.0	22.0- 25.0	1.65	5.0	0.025	0.025	47.9
7.0	26.0- 29.0	1.89	12.0	0.060	0.085	54.4
6.0	30.0- 35.0	2.20	22.0	0.110	0.195	62.0
5.0	36.0- 43.0	2.64	23.0	0.115	0.310	70.5
4.0	44.0- 57.0	3.30	26.0	0.130	0.440	80.4
3.0	59.0- 80.0	4.40	67.0	0.335	0.775	92.5
2.0	82.0-117.0	6.60	45.0	0.225	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
3.0	75.0- 75.0	2.94	1.0	0.031	0.031	79.2
2.0	89.0-128.0	4.40	20.0	0.625	0.656	100.0

TABLE B-15

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
26.0	4.0- 4.0	1.02	20.0	0.080	0.080	66.7
23.0	5.0- 5.0	1.15	35.0	0.139	0.219	74.4
20.0	6.0- 6.0	1.32	39.0	0.155	0.375	82.2
18.0	7.0- 7.0	1.47	37.0	0.147	0.522	87.2
16.0	8.0- 8.0	1.65	34.0	0.135	0.657	91.6
15.0	9.0- 9.0	1.76	23.0	0.092	0.749	93.3
14.0	10.0- 10.0	1.89	13.0	0.052	0.801	94.6
13.0	11.0- 11.0	2.03	11.0	0.044	0.845	95.7
12.0	12.0- 12.0	2.20	11.0	0.044	0.888	96.7
11.0	13.0- 14.0	2.40	7.0	0.028	0.916	97.4
10.0	15.0- 15.0	2.64	3.0	0.012	0.928	98.0
9.0	16.0- 18.0	2.94	6.0	0.024	0.952	98.5
8.0	20.0- 20.0	3.30	2.0	0.008	0.960	99.0
7.0	22.0- 24.0	3.77	3.0	0.012	0.972	99.4
6.0	26.0- 27.0	4.40	4.0	0.016	0.988	99.7
5.0	30.0- 34.0	5.28	2.0	0.008	0.996	99.9
4.0	40.0- 40.0	6.60	1.0	0.004	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
7.0	24.0- 24.0	1.89	1.0	0.008	0.008	41.9
6.0	27.0- 27.0	2.20	3.0	0.023	0.030	47.0
5.0	30.0- 37.0	2.64	6.0	0.045	0.076	53.6
4.0	39.0- 48.0	3.30	5.0	0.038	0.114	62.5
3.0	49.0- 69.0	4.40	8.0	0.061	0.174	76.0
2.0	70.0-116.0	6.60	95.0	0.720	0.894	100.0

TABLE B-16

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
51.0	4.0- 4.0	0.52	1.0	0.002	0.002	69.9
45.0	5.0- 5.0	0.59	118.0	0.216	0.218	79.2
40.0	6.0- 6.0	0.66	122.0	0.223	0.441	86.3
36.0	7.0- 7.0	0.73	101.0	0.185	0.626	91.0
33.0	8.0- 8.0	0.80	60.0	0.110	0.736	93.6
30.0	9.0- 9.0	0.88	40.0	0.073	0.810	95.6
28.0	10.0- 10.0	0.94	28.0	0.051	0.861	96.6
26.0	11.0- 11.0	1.02	18.0	0.033	0.894	97.5
24.0	12.0- 12.0	1.10	15.0	0.027	0.921	98.1
23.0	13.0- 13.0	1.15	9.0	0.016	0.938	98.4
21.0	14.0- 14.0	1.26	2.0	0.004	0.941	98.8
20.0	15.0- 15.0	1.32	8.0	0.015	0.956	99.1
19.0	16.0- 16.0	1.39	3.0	0.005	0.962	99.2
18.0	17.0- 17.0	1.47	4.0	0.007	0.969	99.4
17.0	18.0- 18.0	1.55	3.0	0.005	0.974	99.6
16.0	19.0- 20.0	1.65	6.0	0.011	0.985	99.7
15.0	21.0- 21.0	1.76	1.0	0.002	0.987	99.8
14.0	22.0- 23.0	1.89	3.0	0.005	0.993	99.9
12.0	26.0- 27.0	2.20	2.0	0.004	0.996	100.0
11.0	29.0- 29.0	2.40	1.0	0.002	0.998	100.0
10.0	34.0- 34.0	2.64	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
16.0	19.0- 20.0	0.83	3.0	0.015	0.015	53.3
15.0	21.0- 21.0	0.88	3.0	0.015	0.030	56.6
14.0	22.0- 23.0	0.94	11.0	0.055	0.085	60.3
13.0	24.0- 25.0	1.02	14.0	0.070	0.155	64.2
12.0	26.0- 28.0	1.10	14.0	0.070	0.225	68.0
11.0	29.0- 31.0	1.20	12.0	0.060	0.285	72.0
10.0	32.0- 34.0	1.32	11.0	0.055	0.340	76.2
9.0	35.0- 39.0	1.47	22.0	0.110	0.450	80.6
8.0	40.0- 45.0	1.65	26.0	0.130	0.580	84.8
7.0	46.0- 52.0	1.89	24.0	0.120	0.700	88.4
6.0	53.0- 62.0	2.20	13.0	0.065	0.765	91.1
5.0	63.0- 69.0	2.64	16.0	0.080	0.845	93.6
4.0	82.0- 98.0	3.30	6.0	0.030	0.875	95.4
3.0	101.0-138.0	4.40	5.0	0.025	0.900	97.3
2.0	152.0-230.0	6.60	16.0	0.080	0.980	100.0

TABLE B-16 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 15.0 CM.						
8.0	41.0- 42.0	1.10	2.0	0.033	0.033	72.7
7.0	49.0- 49.0	1.26	1.0	0.016	0.049	77.8
6.0	53.0- 57.0	1.47	3.0	0.049	0.098	84.2
5.0	68.0- 77.0	1.76	10.0	0.164	0.262	92.1
4.0	78.0- 99.0	2.20	24.0	0.393	0.656	100.0

TABLE B-17

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
47.0	4.0- 4.0	0.56	7.0	0.010	0.010	84.8
41.0	5.0- 5.0	0.64	510.0	0.759	0.769	97.0
37.0	6.0- 6.0	0.71	119.0	0.177	0.946	99.2
33.0	7.0- 7.0	0.80	24.0	0.036	0.982	99.7
30.0	8.0- 8.0	0.88	7.0	0.010	0.993	99.9
28.0	9.0- 9.0	0.94	2.0	0.003	0.996	99.9
25.0	10.0- 10.0	1.06	2.0	0.003	0.999	100.0
24.0	11.0- 11.0	1.10	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
21.0	13.0- 13.0	0.63	1.0	0.005	0.005	71.8
19.0	14.0- 14.0	0.70	7.0	0.033	0.038	79.3
18.0	15.0- 15.0	0.73	15.0	0.071	0.108	83.5
17.0	16.0- 17.0	0.78	61.0	0.288	0.396	87.8
16.0	18.0- 18.0	0.83	23.0	0.108	0.505	90.8
15.0	19.0- 19.0	0.88	24.0	0.113	0.618	93.5
14.0	20.0- 21.0	0.94	25.0	0.118	0.736	95.7
13.0	22.0- 23.0	1.02	22.0	0.104	0.840	97.4
12.0	24.0- 25.0	1.10	13.0	0.061	0.901	98.5
11.0	26.0- 28.0	1.20	10.0	0.047	0.948	99.3
10.0	29.0- 31.0	1.32	7.0	0.033	0.981	99.8
9.0	32.0- 35.0	1.47	3.0	0.014	0.995	99.9
8.0	36.0- 36.0	1.65	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
14.0	21.0- 21.0	0.63	5.0	0.025	0.025	65.0
13.0	22.0- 23.0	0.68	9.0	0.045	0.070	69.8
12.0	24.0- 25.0	0.73	12.0	0.060	0.130	75.0
11.0	26.0- 28.0	0.80	23.0	0.115	0.245	80.7
10.0	29.0- 31.0	0.88	36.0	0.180	0.425	86.3
9.0	32.0- 35.0	0.98	33.0	0.165	0.590	91.2
8.0	36.0- 41.0	1.10	36.0	0.180	0.770	95.2
7.0	42.0- 47.0	1.26	21.0	0.105	0.875	97.8
6.0	48.0- 57.0	1.47	19.0	0.095	0.970	99.5
5.0	59.0- 65.0	1.76	6.0	0.030	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
9.0	32.0- 35.0	0.73	5.0	0.025	0.025	62.6
8.0	36.0- 41.0	0.83	16.0	0.080	0.105	69.9

TABLE B-17 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
7.0	42.0- 47.0	0.94	21.0	0.105	0.210	78.1
6.0	48.0- 57.0	1.10	62.0	0.310	0.520	87.4
5.0	58.0- 70.0	1.32	42.0	0.210	0.730	94.2
4.0	71.0- 88.0	1.65	44.0	0.220	0.950	99.1
3.0	98.0-119.0	2.20	7.0	0.035	0.985	100.0
APPLIED DEPTH IS 25.0 CM.						
7.0	46.0- 47.0	0.75	2.0	0.010	0.010	63.9
6.0	48.0- 57.0	0.88	60.0	0.300	0.310	74.0
5.0	58.0- 68.0	1.06	10.0	0.050	0.360	82.1
4.0	72.0- 91.0	1.32	67.0	0.335	0.695	93.0
3.0	92.0-127.0	1.76	56.0	0.280	0.975	100.0
APPLIED DEPTH IS 30.0 CM.						
5.0	63.0- 70.0	0.88	6.0	0.032	0.032	66.8
4.0	72.0- 88.0	1.10	15.0	0.081	0.113	80.2
3.0	93.0-128.0	1.47	147.0	0.790	0.903	100.0

TABLE B-18

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 5.0 CM.						
47.0	4.0- 4.0	0.56	150.0	0.242	0.242	83.7
41.0	5.0- 5.0	0.64	262.0	0.422	0.663	92.4
37.0	6.0- 6.0	0.71	84.0	0.135	0.799	95.2
33.0	7.0- 7.0	0.80	50.0	0.081	0.879	97.1
30.0	8.0- 8.0	0.88	26.0	0.042	0.921	98.0
28.0	9.0- 9.0	0.94	13.0	0.021	0.942	98.4
25.0	10.0- 10.0	1.06	5.0	0.008	0.950	98.9
24.0	11.0- 11.0	1.10	9.0	0.014	0.965	99.1
22.0	12.0- 12.0	1.20	6.0	0.010	0.974	99.3
21.0	13.0- 13.0	1.26	1.0	0.002	0.976	99.4
19.0	14.0- 14.0	1.39	2.0	0.003	0.979	99.6
18.0	15.0- 15.0	1.47	6.0	0.010	0.989	99.7
17.0	16.0- 16.0	1.55	1.0	0.002	0.990	99.8
16.0	18.0- 18.0	1.65	1.0	0.002	0.992	99.8
15.0	19.0- 19.0	1.76	1.0	0.002	0.994	99.8
14.0	20.0- 21.0	1.89	2.0	0.003	0.997	99.9
9.0	32.0- 32.0	2.94	1.0	0.002	0.998	100.0
8.0	36.0- 36.0	3.30	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 10.0 CM.						
16.0	18.0- 18.0	0.83	4.0	0.020	0.020	70.8
15.0	19.0- 19.0	0.88	8.0	0.040	0.060	75.3
14.0	20.0- 21.0	0.94	56.0	0.280	0.340	80.1
13.0	22.0- 23.0	1.02	24.0	0.120	0.460	83.5
12.0	24.0- 25.0	1.10	25.0	0.125	0.585	86.4
11.0	26.0- 28.0	1.20	19.0	0.095	0.680	88.8
10.0	29.0- 31.0	1.32	12.0	0.060	0.740	90.7
9.0	32.0- 35.0	1.47	10.0	0.050	0.790	92.3
8.0	36.0- 41.0	1.65	8.0	0.040	0.830	93.7
7.0	42.0- 47.0	1.89	3.0	0.015	0.845	94.9
6.0	53.0- 56.0	2.20	4.0	0.020	0.865	96.3
5.0	67.0- 69.0	2.64	2.0	0.010	0.875	97.9
4.0	71.0- 91.0	3.30	21.0	0.105	0.980	100.0
APPLIED DEPTH IS 15.0 CM.						
8.0	38.0- 41.0	1.10	17.0	0.085	0.085	69.9
7.0	42.0- 47.0	1.26	40.0	0.200	0.285	77.6
6.0	48.0- 56.0	1.47	53.0	0.265	0.550	84.7
5.0	58.0- 69.0	1.76	18.0	0.090	0.640	89.2

TABLE 8-18 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
4.0	75.0- 91.0	2.20	8.0	0.040	0.680	93.8
3.0	97.0-128.0	2.94	50.0	0.250	0.930	100.0
APPLIED DEPTH IS 20.0 CM.						
4.0	74.0- 91.0	1.65	56.0	0.290	0.290	68.3
3.0	92.0-129.0	2.20	29.0	0.150	0.440	81.3
2.0	130.0-190.0	3.30	108.0	0.560	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
3.0	122.0-122.0	1.76	1.0	0.008	0.008	68.6
2.0	143.0-217.0	2.64	113.0	0.942	0.950	100.0

TABLE B-19

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
30.0	4.0- 4.0	0.93	225.0	0.381	0.381	88.4
26.0	5.0- 5.0	1.07	230.0	0.389	0.770	96.2
23.0	6.0- 6.0	1.21	85.0	0.144	0.914	98.7
21.0	7.0- 7.0	1.33	25.0	0.042	0.956	99.4
19.0	8.0- 8.0	1.47	16.0	0.027	0.983	99.8
18.0	9.0- 9.0	1.55	5.0	0.008	0.992	99.8
16.0	10.0- 10.0	1.74	2.0	0.003	0.995	99.9
15.0	11.0- 11.0	1.86	1.0	0.002	0.997	100.0
14.0	12.0- 12.0	1.99	1.0	0.002	0.998	100.0
13.0	13.0- 13.0	2.14	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
19.0	8.0- 8.0	0.98	4.0	0.014	0.014	76.7
18.0	9.0- 9.0	1.03	65.0	0.228	0.242	80.9
16.0	10.0- 10.0	1.16	65.0	0.228	0.470	87.9
15.0	11.0- 11.0	1.24	36.0	0.126	0.596	90.7
14.0	12.0- 12.0	1.33	22.0	0.077	0.674	92.9
13.0	13.0- 13.0	1.43	26.0	0.091	0.765	94.8
12.0	14.0- 15.0	1.55	24.0	0.084	0.849	96.4
11.0	16.0- 17.0	1.69	13.0	0.046	0.895	97.4
10.0	18.0- 19.0	1.86	9.0	0.032	0.926	98.2
9.0	20.0- 21.0	2.07	4.0	0.014	0.940	98.8
8.0	22.0- 25.0	2.32	8.0	0.028	0.968	99.4
7.0	26.0- 29.0	2.66	5.0	0.018	0.986	99.8
6.0	30.0- 33.0	3.10	4.0	0.014	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
14.0	12.0- 12.0	1.00	2.0	0.010	0.010	67.4
13.0	13.0- 13.0	1.07	5.0	0.025	0.035	72.5
12.0	14.0- 15.0	1.16	36.0	0.180	0.215	78.3
11.0	16.0- 17.0	1.27	42.0	0.210	0.425	83.5
10.0	18.0- 19.0	1.39	32.0	0.160	0.585	87.5
9.0	20.0- 21.0	1.55	20.0	0.100	0.685	90.8
8.0	22.0- 25.0	1.74	10.0	0.050	0.735	93.6
7.0	26.0- 29.0	1.99	24.0	0.120	0.855	96.4
6.0	30.0- 34.0	2.32	13.0	0.065	0.920	98.2
5.0	36.0- 40.0	2.79	12.0	0.060	0.980	99.5
4.0	45.0- 48.0	3.49	3.0	0.015	0.995	99.9
3.0	59.0- 59.0	4.65	1.0	0.005	1.000	100.0

TABLE B-19 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 25.0 CM.						
10.0	18.0- 19.0	1.12	4.0	0.020	0.020	66.5
9.0	20.0- 21.0	1.24	9.0	0.045	0.065	73.7
8.0	22.0- 25.0	1.39	81.0	0.405	0.470	82.1
7.0	26.0- 29.0	1.59	33.0	0.165	0.635	87.1
6.0	30.0- 35.0	1.86	19.0	0.095	0.730	91.0
5.0	36.0- 43.0	2.23	18.0	0.090	0.820	94.6
4.0	44.0- 57.0	2.79	19.0	0.095	0.915	97.8
3.0	61.0- 81.0	3.72	16.0	0.080	0.995	99.8
2.0	83.0- 83.0	5.58	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
8.0	23.0- 25.0	1.16	4.0	0.020	0.020	60.1
7.0	26.0- 29.0	1.33	23.0	0.115	0.135	68.4
6.0	30.0- 35.0	1.55	62.0	0.310	0.445	77.6
5.0	36.0- 43.0	1.86	34.0	0.170	0.615	84.2
4.0	44.0- 57.0	2.32	16.0	0.080	0.695	89.9
3.0	59.0- 80.0	3.10	41.0	0.205	0.900	96.7
2.0	82.0- 96.0	4.65	20.0	0.100	1.000	100.0
APPLIED DEPTH IS 35.0 CM.						
6.0	31.0- 35.0	1.33	26.0	0.130	0.130	79.3
5.0	36.0- 43.0	1.59	32.0	0.160	0.290	86.9
4.0	44.0- 57.0	1.99	41.0	0.205	0.495	94.4
3.0	60.0- 81.0	2.66	45.0	0.225	0.720	100.0

TABLE B-20

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
35.0	3.0- 3.0	0.80	4.0	0.008	0.008	67.6
30.0	4.0- 4.0	0.93	105.0	0.209	0.217	78.8
26.0	5.0- 5.0	1.07	115.0	0.229	0.446	87.5
23.0	6.0- 6.0	1.21	95.0	0.189	0.635	93.1
21.0	7.0- 7.0	1.33	81.0	0.161	0.797	96.0
19.0	8.0- 8.0	1.47	38.0	0.076	0.873	97.7
18.0	9.0- 9.0	1.55	25.0	0.050	0.922	98.3
16.0	10.0- 10.0	1.74	11.0	0.022	0.944	99.0
15.0	11.0- 11.0	1.86	7.0	0.014	0.958	99.3
14.0	12.0- 12.0	1.99	6.0	0.012	0.970	99.6
13.0	13.0- 13.0	2.14	7.0	0.014	0.984	99.8
12.0	14.0- 15.0	2.32	4.0	0.008	0.992	99.9
11.0	16.0- 17.0	2.53	2.0	0.004	0.996	99.9
10.0	18.0- 18.0	2.79	1.0	0.002	0.998	100.0
8.0	22.0- 22.0	3.49	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
18.0	9.0- 9.0	1.03	2.0	0.010	0.010	54.9
16.0	10.0- 10.0	1.16	4.0	0.020	0.030	61.5
15.0	11.0- 11.0	1.24	9.0	0.045	0.075	65.3
14.0	12.0- 12.0	1.33	10.0	0.050	0.125	69.4
13.0	13.0- 13.0	1.43	14.0	0.070	0.195	73.7
12.0	14.0- 15.0	1.55	25.0	0.125	0.320	78.1
11.0	16.0- 17.0	1.69	23.0	0.115	0.435	82.2
10.0	18.0- 19.0	1.86	23.0	0.115	0.550	86.0
9.0	20.0- 21.0	2.07	12.0	0.060	0.610	89.3
8.0	22.0- 25.0	2.32	23.0	0.115	0.725	92.8
7.0	26.0- 29.0	2.66	13.0	0.065	0.790	95.5
6.0	30.0- 35.0	3.10	21.0	0.105	0.895	98.1
5.0	36.0- 43.0	3.72	15.0	0.075	0.970	99.6
4.0	50.0- 51.0	4.65	4.0	0.020	0.990	100.0
APPLIED DEPTH IS 20.0 CM.						
10.0	18.0- 18.0	1.39	2.0	0.010	0.010	46.1
9.0	20.0- 21.0	1.55	4.0	0.020	0.030	51.1
8.0	22.0- 25.0	1.74	13.0	0.065	0.095	57.1
7.0	26.0- 29.0	1.99	16.0	0.080	0.175	63.9
6.0	30.0- 35.0	2.32	29.0	0.145	0.320	71.7
5.0	36.0- 43.0	2.79	29.0	0.145	0.465	79.6

TABLE B-20 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
4.0	44.0- 57.0	3.49	34.0	0.170	0.635	87.9
3.0	58.0- 81.0	4.65	49.0	0.245	0.880	96.0
2.0	82.0-116.0	6.97	24.0	0.120	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
6.0	33.0- 35.0	1.86	3.0	0.023	0.023	42.3
5.0	40.0- 40.0	2.23	1.0	0.008	0.031	49.4
4.0	49.0- 51.0	2.79	2.0	0.015	0.046	59.8
3.0	58.0- 81.0	3.72	27.0	0.208	0.254	76.7
2.0	82.0-135.0	5.58	91.0	0.700	0.954	100.0
APPLIED DEPTH IS 30.0 CM.						
3.0	66.0- 74.0	3.10	2.0	0.036	0.036	76.8
2.0	86.0-137.0	4.65	39.0	0.696	0.732	100.0

TABLE B-21

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
30.0	3.0- 3.0	0.93	1.0	0.002	0.002	67.5
26.0	4.0- 4.0	1.07	106.0	0.262	0.265	77.9
23.0	5.0- 5.0	1.21	85.0	0.210	0.475	84.6
20.0	6.0- 6.0	1.39	57.0	0.141	0.616	90.2
18.0	7.0- 7.0	1.55	53.0	0.131	0.748	93.3
16.0	8.0- 8.0	1.74	26.0	0.064	0.812	95.7
15.0	9.0- 9.0	1.86	19.0	0.047	0.859	96.6
14.0	10.0- 10.0	1.99	18.0	0.045	0.903	97.4
13.0	11.0- 11.0	2.14	7.0	0.017	0.921	97.9
12.0	12.0- 12.0	2.32	4.0	0.010	0.931	98.4
11.0	13.0- 14.0	2.53	11.0	0.027	0.958	98.9
10.0	15.0- 15.0	2.79	3.0	0.007	0.965	99.2
9.0	16.0- 18.0	3.10	7.0	0.017	0.983	99.5
8.0	19.0- 21.0	3.49	3.0	0.007	0.990	99.7
6.0	25.0- 29.0	4.65	2.0	0.005	0.995	99.9
5.0	33.0- 36.0	5.58	2.0	0.005	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
15.0	9.0- 9.0	1.24	4.0	0.020	0.020	47.6
14.0	10.0- 10.0	1.33	2.0	0.010	0.030	50.6
13.0	11.0- 11.0	1.43	4.0	0.020	0.050	54.0
12.0	12.0- 12.0	1.55	3.0	0.015	0.065	57.8
11.0	13.0- 14.0	1.69	13.0	0.065	0.130	62.1
10.0	15.0- 15.0	1.86	4.0	0.020	0.150	66.7
9.0	16.0- 18.0	2.07	25.0	0.125	0.275	72.1
8.0	19.0- 21.0	2.32	18.0	0.090	0.365	77.2
7.0	22.0- 24.0	2.66	24.0	0.120	0.485	82.5
6.0	25.0- 29.0	3.10	26.0	0.130	0.615	87.6
5.0	30.0- 37.0	3.72	20.0	0.100	0.715	92.1
4.0	38.0- 45.0	4.65	21.0	0.105	0.820	96.4
3.0	49.0- 69.0	6.20	29.0	0.145	0.965	100.0
APPLIED DEPTH IS 20.0 CM.						
9.0	17.0- 18.0	1.55	2.0	0.012	0.012	32.4
8.0	21.0- 21.0	1.74	3.0	0.018	0.030	36.3
7.0	22.0- 24.0	1.99	5.0	0.030	0.060	41.1
6.0	25.0- 29.0	2.32	9.0	0.054	0.113	46.9
5.0	30.0- 37.0	2.79	11.0	0.065	0.179	54.0
4.0	38.0- 47.0	3.49	11.0	0.065	0.244	63.1

TABLE B-21 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
3.0	49.0- 69.0	4.65	13.0	0.077	0.321	76.0
2.0	70.0-115.0	6.97	107.0	0.637	0.958	97.9
1.0	119.0-144.0	13.94	7.0	0.042	1.000	100.0

TABLE B-22

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
51.0	4.0- 4.0	0.55	170.0	0.205	0.205	78.0
45.0	5.0- 5.0	0.62	168.0	0.202	0.407	85.7
40.0	6.0- 6.0	0.70	174.0	0.209	0.616	91.3
36.0	7.0- 7.0	0.77	116.0	0.140	0.756	94.6
33.0	8.0- 8.0	0.84	65.0	0.078	0.834	96.3
30.0	9.0- 9.0	0.93	44.0	0.053	0.887	97.6
28.0	10.0- 10.0	1.00	23.0	0.028	0.915	98.3
26.0	11.0- 11.0	1.07	20.0	0.024	0.939	98.8
24.0	12.0- 12.0	1.16	15.0	0.018	0.957	99.2
23.0	13.0- 13.0	1.21	12.0	0.014	0.971	99.4
21.0	14.0- 14.0	1.33	6.0	0.007	0.978	99.6
20.0	15.0- 15.0	1.39	3.0	0.004	0.982	99.7
19.0	16.0- 16.0	1.47	3.0	0.004	0.986	99.8
18.0	17.0- 17.0	1.55	5.0	0.006	0.992	99.8
17.0	18.0- 18.0	1.64	2.0	0.002	0.994	99.9
15.0	21.0- 21.0	1.86	1.0	0.001	0.995	99.9
13.0	24.0- 25.0	2.14	2.0	0.002	0.998	100.0
12.0	26.0- 26.0	2.32	2.0	0.002	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
30.0	9.0- 9.0	0.62	1.0	0.004	0.004	59.5
28.0	10.0- 10.0	0.66	17.0	0.062	0.066	63.7
26.0	11.0- 11.0	0.71	17.0	0.062	0.128	68.0
24.0	12.0- 12.0	0.77	27.0	0.099	0.226	72.6
23.0	13.0- 13.0	0.81	25.0	0.091	0.318	74.8
21.0	14.0- 14.0	0.89	16.0	0.058	0.376	78.8
20.0	15.0- 15.0	0.93	14.0	0.051	0.427	80.9
19.0	16.0- 16.0	0.98	23.0	0.084	0.511	82.9
18.0	17.0- 17.0	1.03	10.0	0.036	0.547	84.6
17.0	18.0- 18.0	1.09	16.0	0.058	0.606	86.3
16.0	19.0- 20.0	1.16	15.0	0.055	0.661	87.9
15.0	21.0- 21.0	1.24	5.0	0.018	0.679	89.4
14.0	22.0- 23.0	1.33	20.0	0.073	0.752	90.9
13.0	24.0- 25.0	1.43	12.0	0.044	0.796	92.1
12.0	26.0- 28.0	1.55	9.0	0.033	0.828	93.1
11.0	29.0- 31.0	1.69	5.0	0.018	0.847	94.0
10.0	32.0- 34.0	1.86	9.0	0.033	0.880	94.9
9.0	35.0- 38.0	2.07	6.0	0.022	0.901	95.6
8.0	41.0- 44.0	2.32	2.0	0.007	0.909	96.2

TABLE B-22 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
7.0	46.0- 47.0	2.66	2.0	0.007	0.916	96.9
6.0	53.0- 57.0	3.10	3.0	0.011	0.927	97.7
5.0	68.0- 74.0	3.72	6.0	0.022	0.949	98.7
4.0	79.0- 95.0	4.65	8.0	0.029	0.978	99.5
3.0	104.0-129.0	6.20	5.0	0.018	0.996	100.0
APPLIED DEPTH IS 20.0 CM.						
20.0	15.0- 15.0	0.70	1.0	0.005	0.005	48.2
19.0	16.0- 16.0	0.73	1.0	0.005	0.010	50.7
18.0	17.0- 17.0	0.77	1.0	0.005	0.015	53.4
17.0	18.0- 18.0	0.82	6.0	0.030	0.045	56.4
16.0	19.0- 20.0	0.87	13.0	0.065	0.110	59.7
15.0	21.0- 21.0	0.93	4.0	0.020	0.130	62.9
14.0	22.0- 23.0	1.00	10.0	0.050	0.180	66.4
13.0	24.0- 25.0	1.07	15.0	0.075	0.255	70.1
12.0	26.0- 28.0	1.16	17.0	0.085	0.340	73.7
11.0	29.0- 31.0	1.27	18.0	0.090	0.430	77.3
10.0	32.0- 34.0	1.39	10.0	0.050	0.480	80.7
9.0	35.0- 39.0	1.55	24.0	0.120	0.600	84.3
8.0	40.0- 45.0	1.74	19.0	0.095	0.695	87.3
7.0	46.0- 50.0	1.99	13.0	0.065	0.760	89.7
6.0	53.0- 62.0	2.32	16.0	0.080	0.840	91.9
5.0	65.0- 77.0	2.79	4.0	0.020	0.860	93.4
4.0	83.0- 98.0	3.49	5.0	0.025	0.885	95.1
3.0	110.0-137.0	4.65	5.0	0.025	0.910	97.2
2.0	161.0-222.0	6.97	17.0	0.085	0.995	100.0
APPLIED DEPTH IS 25.0 CM.						
13.0	25.0- 25.0	0.86	2.0	0.010	0.010	46.0
12.0	27.0- 28.0	0.93	7.0	0.036	0.046	49.7
11.0	29.0- 31.0	1.01	8.0	0.041	0.088	53.8
10.0	32.0- 34.0	1.12	5.0	0.026	0.113	58.3
9.0	36.0- 38.0	1.24	7.0	0.036	0.149	63.5
8.0	40.0- 45.0	1.39	17.0	0.088	0.237	69.6
7.0	46.0- 51.0	1.59	21.0	0.108	0.345	76.1
6.0	53.0- 62.0	1.86	26.0	0.134	0.479	83.1
5.0	63.0- 77.0	2.23	45.0	0.232	0.711	90.1
4.0	78.0- 98.0	2.79	34.0	0.175	0.887	94.8
3.0	101.0-135.0	3.72	10.0	0.052	0.938	96.9
2.0	146.0-231.0	5.58	6.0	0.031	0.969	98.5

TABLE B-22 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
1.0	238.0-290.0	11.15	6.0	0.031	1.000	100.0

TABLE B-23

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
47.0	4.0- 4.0	0.59	559.0	0.558	0.558	93.4
41.0	5.0- 5.0	0.68	359.0	0.359	0.917	98.9
37.0	6.0- 6.0	0.75	58.0	0.058	0.975	99.7
33.0	7.0- 7.0	0.84	19.0	0.019	0.994	99.9
30.0	8.0- 8.0	0.93	5.0	0.005	0.999	100.0
28.0	9.0- 9.0	1.00	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
30.0	8.0- 8.0	0.62	23.0	0.044	0.044	84.1
28.0	9.0- 9.0	0.66	187.0	0.356	0.400	89.8
25.0	10.0- 10.0	0.74	151.0	0.288	0.688	95.8
24.0	11.0- 11.0	0.77	66.0	0.126	0.813	96.9
22.0	12.0- 12.0	0.84	44.0	0.084	0.897	98.3
21.0	13.0- 13.0	0.89	13.0	0.025	0.922	98.7
19.0	14.0- 14.0	0.98	11.0	0.021	0.943	99.4
18.0	15.0- 15.0	1.03	13.0	0.025	0.968	99.7
17.0	16.0- 17.0	1.09	10.0	0.019	0.987	99.8
16.0	18.0- 18.0	1.16	3.0	0.006	0.992	99.9
15.0	19.0- 19.0	1.24	1.0	0.002	0.994	100.0
14.0	20.0- 21.0	1.33	3.0	0.006	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
22.0	12.0- 12.0	0.63	3.0	0.009	0.009	75.5
21.0	13.0- 13.0	0.66	16.0	0.050	0.059	79.1
19.0	14.0- 14.0	0.73	47.0	0.146	0.206	86.8
18.0	15.0- 15.0	0.77	60.0	0.187	0.393	90.5
17.0	16.0- 17.0	0.82	75.0	0.234	0.626	93.5
16.0	18.0- 18.0	0.87	31.0	0.097	0.723	95.4
15.0	19.0- 19.0	0.93	21.0	0.065	0.788	96.9
14.0	20.0- 21.0	1.00	28.0	0.087	0.875	98.2
13.0	22.0- 23.0	1.07	18.0	0.056	0.931	99.1
12.0	24.0- 25.0	1.16	10.0	0.031	0.963	99.6
11.0	26.0- 28.0	1.27	8.0	0.025	0.988	99.9
10.0	29.0- 31.0	1.39	3.0	0.009	0.997	100.0
9.0	34.0- 34.0	1.55	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 25.0 CM.						
16.0	18.0- 18.0	0.70	4.0	0.020	0.020	71.2
15.0	19.0- 19.0	0.74	2.0	0.010	0.030	75.8

TABLE B-23 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
14.0	20.0- 21.0	0.80	17.0	0.084	0.113	81.0
13.0	22.0- 23.0	0.86	36.0	0.177	0.291	86.4
12.0	24.0- 25.0	0.93	45.0	0.222	0.512	91.1
11.0	26.0- 28.0	1.01	43.0	0.212	0.724	94.8
10.0	29.0- 31.0	1.12	15.0	0.074	0.798	97.0
9.0	32.0- 35.0	1.24	25.0	0.123	0.921	98.9
8.0	36.0- 41.0	1.39	12.0	0.059	0.980	99.8
7.0	42.0- 46.0	1.59	4.0	0.020	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
12.0	25.0- 25.0	0.77	2.0	0.010	0.010	71.7
11.0	26.0- 28.0	0.84	33.0	0.165	0.175	78.1
10.0	29.0- 31.0	0.93	32.0	0.160	0.335	84.1
9.0	32.0- 35.0	1.03	37.0	0.185	0.520	89.8
8.0	36.0- 41.0	1.16	41.0	0.205	0.725	94.5
7.0	42.0- 47.0	1.33	28.0	0.140	0.865	97.6
6.0	48.0- 57.0	1.55	22.0	0.110	0.975	99.5
5.0	58.0- 63.0	1.86	4.0	0.020	0.995	99.9
4.0	72.0- 72.0	2.32	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 35.0 CM.						
9.0	33.0- 35.0	0.89	11.0	0.055	0.055	75.8
8.0	36.0- 41.0	1.00	66.0	0.330	0.385	84.4
7.0	42.0- 47.0	1.14	43.0	0.215	0.600	90.7
6.0	48.0- 57.0	1.33	34.0	0.170	0.770	95.6
5.0	58.0- 70.0	1.59	33.0	0.165	0.935	99.0
4.0	73.0- 85.0	1.99	10.0	0.050	0.985	100.0

TABLE B-24

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
55.0	3.0- 3.0	0.51	68.0	0.072	0.072	80.0
47.0	4.0- 4.0	0.59	574.0	0.607	0.679	92.4
41.0	5.0- 5.0	0.68	142.0	0.150	0.830	96.0
37.0	6.0- 6.0	0.75	65.0	0.069	0.898	97.4
33.0	7.0- 7.0	0.84	29.0	0.031	0.929	98.3
30.0	8.0- 8.0	0.93	19.0	0.020	0.949	98.8
28.0	9.0- 9.0	1.00	15.0	0.016	0.965	99.1
25.0	10.0- 10.0	1.12	7.0	0.007	0.972	99.4
24.0	11.0- 11.0	1.16	7.0	0.007	0.980	99.5
22.0	12.0- 12.0	1.27	6.0	0.006	0.986	99.7
21.0	13.0- 13.0	1.33	1.0	0.001	0.987	99.7
19.0	14.0- 14.0	1.47	2.0	0.002	0.989	99.8
18.0	15.0- 15.0	1.55	3.0	0.003	0.993	99.9
17.0	16.0- 16.0	1.64	1.0	0.001	0.994	99.9
16.0	18.0- 18.0	1.74	3.0	0.003	0.997	99.9
15.0	19.0- 19.0	1.86	1.0	0.001	0.998	99.9
13.0	22.0- 22.0	2.14	1.0	0.001	0.999	100.0
9.0	35.0- 35.0	3.10	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 15.0 CM.						
30.0	8.0- 8.0	0.62	1.0	0.003	0.003	72.1
28.0	9.0- 9.0	0.66	56.0	0.153	0.156	77.2
25.0	10.0- 10.0	0.74	110.0	0.301	0.456	84.6
24.0	11.0- 11.0	0.77	41.0	0.112	0.568	86.2
22.0	12.0- 12.0	0.84	34.0	0.093	0.661	88.8
21.0	13.0- 13.0	0.89	12.0	0.033	0.694	89.9
19.0	14.0- 14.0	0.98	20.0	0.055	0.749	92.0
18.0	15.0- 15.0	1.03	8.0	0.022	0.770	93.0
17.0	16.0- 17.0	1.09	13.0	0.036	0.806	93.9
16.0	18.0- 18.0	1.16	13.0	0.036	0.842	94.7
15.0	19.0- 19.0	1.24	2.0	0.005	0.847	95.4
14.0	20.0- 21.0	1.33	16.0	0.044	0.891	96.2
13.0	22.0- 22.0	1.43	2.0	0.005	0.896	96.7
12.0	24.0- 25.0	1.55	8.0	0.022	0.918	97.2
11.0	27.0- 27.0	1.69	3.0	0.008	0.926	97.7
10.0	30.0- 31.0	1.86	3.0	0.008	0.934	98.2
9.0	33.0- 35.0	2.07	2.0	0.005	0.940	98.7
8.0	36.0- 39.0	2.32	8.0	0.022	0.962	99.2
7.0	42.0- 45.0	2.66	7.0	0.019	0.981	99.6

TABLE B-24 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
6.0	50.0- 56.0	3.10	3.0	0.008	0.989	99.9
5.0	59.0- 64.0	3.72	3.0	0.008	0.997	100.0
APPLIED DEPTH IS 20.0 CM.						
18.0	15.0- 15.0	0.77	2.0	0.010	0.010	73.1
17.0	16.0- 17.0	0.82	53.0	0.265	0.275	77.3
16.0	18.0- 18.0	0.87	16.0	0.080	0.355	80.3
15.0	19.0- 19.0	0.93	13.0	0.065	0.420	83.3
14.0	20.0- 21.0	1.00	30.0	0.150	0.570	86.1
13.0	22.0- 23.0	1.07	20.0	0.100	0.670	88.3
12.0	24.0- 25.0	1.16	9.0	0.045	0.715	90.0
11.0	26.0- 28.0	1.27	14.0	0.070	0.785	91.6
10.0	29.0- 31.0	1.39	8.0	0.040	0.825	92.8
9.0	32.0- 35.0	1.55	4.0	0.020	0.845	93.8
8.0	36.0- 41.0	1.74	4.0	0.020	0.865	94.9
7.0	44.0- 46.0	1.99	2.0	0.010	0.875	95.9
6.0	53.0- 54.0	2.32	2.0	0.010	0.885	97.2
5.0	62.0- 70.0	2.79	8.0	0.040	0.925	98.7
4.0	71.0- 85.0	3.49	13.0	0.065	0.990	100.0
APPLIED DEPTH IS 25.0 CM.						
12.0	24.0- 25.0	0.93	12.0	0.060	0.060	77.0
11.0	26.0- 28.0	1.01	48.0	0.240	0.300	82.5
10.0	29.0- 31.0	1.12	26.0	0.130	0.430	86.7
9.0	32.0- 35.0	1.24	25.0	0.125	0.555	90.4
8.0	36.0- 41.0	1.39	28.0	0.140	0.695	93.4
7.0	42.0- 46.0	1.59	15.0	0.075	0.770	95.4
6.0	50.0- 57.0	1.86	4.0	0.020	0.790	96.7
5.0	59.0- 61.0	2.23	2.0	0.010	0.800	98.1
4.0	76.0- 91.0	2.79	19.0	0.095	0.895	100.0
APPLIED DEPTH IS 30.0 CM.						
9.0	33.0- 35.0	1.03	10.0	0.050	0.050	67.9
8.0	36.0- 41.0	1.16	48.0	0.241	0.291	75.4
7.0	42.0- 47.0	1.33	43.0	0.216	0.508	81.6
6.0	48.0- 57.0	1.55	30.0	0.151	0.658	86.2
5.0	58.0- 66.0	1.86	9.0	0.045	0.704	89.6
4.0	71.0- 83.0	2.32	3.0	0.015	0.719	93.7
3.0	92.0-129.0	3.10	50.0	0.251	0.970	100.0

TABLE B-24 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ CAP	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 35.0 CM.						
7.0	45.0- 47.0	1.14	8.0	0.040	0.040	75.6
6.0	48.0- 57.0	1.33	46.0	0.230	0.270	83.8
5.0	58.0- 70.0	1.59	47.0	0.235	0.505	90.8
4.0	71.0- 90.0	1.99	18.0	0.090	0.595	95.4
3.0	100.0-129.0	2.66	37.0	0.185	0.780	100.0

TABLE B-25

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
42.0	2.0- 2.0	28.25	200.0	0.310	0.310	86.9
35.0	3.0- 3.0	33.91	399.0	0.619	0.929	98.1
30.0	4.0- 4.0	39.56	13.0	0.020	0.949	98.9
26.0	5.0- 5.0	45.64	17.0	0.026	0.975	99.5
23.0	6.0- 6.0	51.60	8.0	0.012	0.988	99.8
21.0	7.0- 7.0	56.51	4.0	0.006	0.994	99.9
19.0	8.0- 8.0	62.46	2.0	0.003	0.997	100.0
16.0	10.0- 10.0	74.17	2.0	0.003	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
30.0	4.0- 4.0	19.78	455.0	0.906	0.906	97.9
26.0	5.0- 5.0	22.82	22.0	0.044	0.950	99.0
23.0	6.0- 6.0	25.80	6.0	0.012	0.962	99.5
21.0	7.0- 7.0	28.25	8.0	0.016	0.978	99.7
19.0	8.0- 8.0	31.23	3.0	0.006	0.984	99.9
18.0	9.0- 9.0	32.96	7.0	0.014	0.998	100.0
APPLIED DEPTH IS 30.0 CM.						
30.0	4.0- 4.0	13.19	57.0	0.130	0.130	86.4
26.0	5.0- 5.0	15.21	326.0	0.744	0.874	97.6
23.0	6.0- 6.0	17.20	32.0	0.073	0.947	99.0
21.0	7.0- 7.0	18.84	10.0	0.023	0.970	99.4
19.0	8.0- 8.0	20.82	4.0	0.009	0.979	99.6
18.0	9.0- 9.0	21.98	3.0	0.007	0.986	99.7
16.0	10.0- 10.0	24.72	2.0	0.005	0.991	99.8
15.0	11.0- 11.0	26.37	2.0	0.005	0.995	99.9
13.0	13.0- 13.0	30.43	1.0	0.002	0.998	99.9
10.0	18.0- 18.0	39.56	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
30.0	4.0- 4.0	9.89	1.0	0.003	0.003	77.0
26.0	5.0- 5.0	11.41	72.0	0.187	0.190	88.9
23.0	6.0- 6.0	12.90	270.0	0.701	0.891	98.0
21.0	7.0- 7.0	14.13	13.0	0.034	0.925	98.8
19.0	8.0- 8.0	15.61	14.0	0.036	0.961	99.5
18.0	9.0- 9.0	16.48	7.0	0.018	0.979	99.7
16.0	10.0- 10.0	18.54	3.0	0.008	0.987	99.9
15.0	11.0- 11.0	19.78	4.0	0.010	0.997	100.0
13.0	13.0- 13.0	22.82	1.0	0.003	1.000	100.0

TABLE B-25 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 50.0 CM.						
26.0	5.0- 5.0	9.13	42.0	0.116	0.116	84.9
23.0	6.0- 6.0	10.32	174.0	0.481	0.597	94.5
21.0	7.0- 7.0	11.30	103.0	0.285	0.881	97.8
19.0	8.0- 8.0	12.49	18.0	0.050	0.931	98.8
18.0	9.0- 9.0	13.19	9.0	0.025	0.956	99.1
16.0	10.0- 10.0	14.83	6.0	0.017	0.972	99.6
15.0	11.0- 11.0	15.82	3.0	0.008	0.981	99.7
14.0	12.0- 12.0	16.95	3.0	0.008	0.989	99.9
13.0	13.0- 13.0	18.26	1.0	0.003	0.992	99.9
12.0	14.0- 15.0	19.78	3.0	0.008	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
26.0	5.0- 5.0	7.61	23.0	0.069	0.069	79.2
23.0	6.0- 6.0	8.60	31.0	0.093	0.162	88.6
21.0	7.0- 7.0	9.42	181.0	0.542	0.704	95.5
19.0	8.0- 8.0	10.41	61.0	0.183	0.886	98.2
18.0	9.0- 9.0	10.99	15.0	0.045	0.931	98.7
16.0	10.0- 10.0	12.36	9.0	0.027	0.958	99.4
15.0	11.0- 11.0	13.19	5.0	0.015	0.973	99.6
14.0	12.0- 12.0	14.13	5.0	0.015	0.988	99.8
13.0	13.0- 13.0	15.21	1.0	0.003	0.991	99.9
12.0	14.0- 14.0	16.48	1.0	0.003	0.994	99.9
11.0	17.0- 17.0	17.98	1.0	0.003	0.997	100.0
10.0	19.0- 19.0	19.78	1.0	0.003	1.000	100.0

TABLE B-26

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
42.0	2.0- 2.0	28.25	55.0	0.100	0.100	79.1
35.0	3.0- 3.0	33.91	377.0	0.684	0.784	93.0
30.0	4.0- 4.0	39.56	31.0	0.056	0.840	95.4
26.0	5.0- 5.0	45.64	28.0	0.051	0.891	97.1
23.0	6.0- 6.0	51.60	19.0	0.034	0.926	98.2
21.0	7.0- 7.0	56.51	13.0	0.024	0.949	98.7
19.0	8.0- 8.0	62.46	8.0	0.015	0.964	99.1
18.0	9.0- 9.0	65.93	5.0	0.009	0.973	99.3
16.0	10.0- 10.0	74.17	3.0	0.005	0.978	99.5
14.0	12.0- 12.0	84.76	4.0	0.007	0.985	99.7
13.0	13.0- 13.0	91.28	1.0	0.002	0.987	99.8
12.0	14.0- 14.0	98.89	4.0	0.007	0.995	99.9
11.0	17.0- 17.0	7.88	1.0	0.002	0.996	100.0
10.0	18.0- 19.0	18.67	2.0	0.004	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
35.0	3.0- 3.0	16.95	57.0	0.130	0.130	80.8
30.0	4.0- 4.0	19.78	274.0	0.626	0.756	92.1
26.0	5.0- 5.0	22.82	36.0	0.082	0.838	94.6
23.0	6.0- 6.0	25.80	20.0	0.046	0.884	96.0
21.0	7.0- 7.0	28.25	10.0	0.023	0.906	96.8
19.0	8.0- 8.0	31.23	7.0	0.016	0.922	97.4
18.0	9.0- 9.0	32.96	6.0	0.014	0.936	97.7
16.0	10.0- 10.0	37.08	5.0	0.011	0.947	98.2
15.0	11.0- 11.0	39.56	3.0	0.007	0.954	98.5
14.0	12.0- 12.0	42.38	2.0	0.005	0.959	98.7
13.0	13.0- 13.0	45.64	1.0	0.002	0.961	98.9
12.0	14.0- 15.0	49.45	3.0	0.007	0.968	99.1
11.0	16.0- 17.0	53.94	4.0	0.009	0.977	99.3
10.0	18.0- 19.0	59.33	3.0	0.007	0.984	99.5
9.0	20.0- 21.0	65.93	3.0	0.007	0.991	99.6
8.0	25.0- 25.0	74.17	1.0	0.002	0.993	99.7
5.0	43.0- 43.0	18.67	1.0	0.002	0.995	99.9
4.0	45.0- 46.0	48.34	2.0	0.005	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
35.0	3.0- 3.0	11.30	22.0	0.066	0.066	69.9
30.0	4.0- 4.0	13.19	49.0	0.147	0.213	80.5
26.0	5.0- 5.0	15.21	158.0	0.474	0.688	89.5

TABLE B-26 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
23.0	6.0- 6.0	17.20	36.0	0.108	0.796	92.3
21.0	7.0- 7.0	18.84	14.0	0.042	0.838	93.5
19.0	8.0- 8.0	20.82	9.0	0.027	0.865	94.5
18.0	9.0- 9.0	21.98	3.0	0.009	0.874	94.9
16.0	10.0- 10.0	24.72	5.0	0.015	0.889	95.9
15.0	11.0- 11.0	26.37	5.0	0.015	0.904	96.3
14.0	12.0- 12.0	28.25	5.0	0.015	0.919	96.8
13.0	13.0- 13.0	30.43	2.0	0.006	0.925	97.1
12.0	14.0- 15.0	32.96	6.0	0.018	0.943	97.5
11.0	17.0- 17.0	35.96	3.0	0.009	0.952	97.8
10.0	19.0- 19.0	39.56	2.0	0.006	0.958	98.1
8.0	23.0- 25.0	49.45	4.0	0.012	0.970	98.6
7.0	27.0- 27.0	56.51	1.0	0.003	0.973	98.9
6.0	32.0- 32.0	65.93	1.0	0.003	0.976	99.1
5.0	36.0- 36.0	79.11	2.0	0.006	0.982	99.5
4.0	44.0- 54.0	98.89	3.0	0.009	0.991	99.8
3.0	58.0- 66.0	31.85	3.0	0.009	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
35.0	3.0- 3.0	8.48	18.0	0.063	0.063	65.7
30.0	4.0- 4.0	9.89	28.0	0.098	0.161	75.6
26.0	5.0- 5.0	11.41	73.0	0.255	0.416	84.8
23.0	6.0- 6.0	12.90	78.0	0.273	0.689	90.4
21.0	7.0- 7.0	14.13	34.0	0.119	0.808	92.5
19.0	8.0- 8.0	15.61	15.0	0.052	0.860	93.7
18.0	9.0- 9.0	16.48	4.0	0.014	0.874	94.2
16.0	10.0- 10.0	18.54	4.0	0.014	0.888	95.0
15.0	11.0- 11.0	19.78	3.0	0.010	0.899	95.4
14.0	12.0- 12.0	21.19	4.0	0.014	0.913	95.8
13.0	13.0- 13.0	22.82	1.0	0.003	0.916	96.2
12.0	14.0- 15.0	24.72	2.0	0.007	0.923	96.5
11.0	16.0- 17.0	26.97	4.0	0.014	0.937	96.9
10.0	18.0- 19.0	29.67	2.0	0.007	0.944	97.2
9.0	20.0- 21.0	32.96	2.0	0.007	0.951	97.6
7.0	29.0- 29.0	42.38	2.0	0.007	0.958	98.3
6.0	30.0- 34.0	49.45	2.0	0.007	0.965	98.7
5.0	36.0- 43.0	59.33	2.0	0.007	0.972	99.1
4.0	44.0- 46.0	74.17	3.0	0.010	0.983	99.6
3.0	59.0- 73.0	98.89	5.0	0.017	1.000	100.0

TABLE B-26 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 50.0 CM.						
42.0	2.0- 2.0	5.65	33.0	0.136	0.136	54.7
30.0	4.0- 4.0	7.91	17.0	0.070	0.207	71.1
26.0	5.0- 5.0	9.13	16.0	0.066	0.273	78.8
23.0	6.0- 6.0	10.32	47.0	0.194	0.467	85.5
21.0	7.0- 7.0	11.30	54.0	0.223	0.690	89.2
19.0	8.0- 8.0	12.49	21.0	0.087	0.777	91.4
18.0	9.0- 9.0	13.19	10.0	0.041	0.818	92.1
16.0	10.0- 10.0	14.83	8.0	0.033	0.851	93.4
15.0	11.0- 11.0	15.82	7.0	0.029	0.880	94.0
14.0	12.0- 12.0	16.95	3.0	0.012	0.893	94.4
12.0	14.0- 15.0	19.78	3.0	0.012	0.905	95.2
11.0	16.0- 17.0	21.58	3.0	0.012	0.917	95.7
10.0	18.0- 19.0	23.73	2.0	0.008	0.926	96.1
9.0	21.0- 21.0	26.37	1.0	0.004	0.930	96.5
8.0	22.0- 23.0	29.67	2.0	0.008	0.938	96.9
6.0	30.0- 34.0	39.56	2.0	0.008	0.946	97.9
5.0	36.0- 40.0	47.47	5.0	0.021	0.967	98.6
4.0	44.0- 47.0	59.33	2.0	0.008	0.975	99.1
3.0	66.0- 77.0	79.11	4.0	0.017	0.992	99.6
2.0	89.0- 89.0	18.67	1.0	0.004	0.996	99.8
1.0	196.0-196.0	37.34	1.0	0.004	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
42.0	2.0- 2.0	4.71	34.0	0.170	0.170	54.2
30.0	4.0- 4.0	6.59	11.0	0.055	0.225	69.1
26.0	5.0- 5.0	7.61	11.0	0.055	0.280	76.2
23.0	6.0- 6.0	8.60	27.0	0.135	0.415	82.5
21.0	7.0- 7.0	9.42	28.0	0.140	0.555	86.4
19.0	8.0- 8.0	10.41	26.0	0.130	0.685	89.7
18.0	9.0- 9.0	10.99	21.0	0.105	0.790	90.9
16.0	10.0- 10.0	12.36	9.0	0.045	0.835	92.3
15.0	11.0- 11.0	13.19	5.0	0.025	0.860	92.9
14.0	12.0- 12.0	14.13	3.0	0.015	0.875	93.4
13.0	13.0- 13.0	15.21	1.0	0.005	0.880	93.9
12.0	14.0- 15.0	16.48	4.0	0.020	0.900	94.4
11.0	17.0- 17.0	17.98	1.0	0.005	0.905	94.8
10.0	19.0- 19.0	19.78	2.0	0.010	0.915	95.2
8.0	22.0- 24.0	24.72	3.0	0.015	0.930	96.1
6.0	33.0- 35.0	32.96	2.0	0.010	0.940	97.2

TABLE 8-26 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
5.0	37.0- 37.0	39.56	1.0	0.005	0.945	97.8
4.0	45.0- 51.0	49.45	3.0	0.015	0.960	98.6
3.0	58.0- 77.0	65.93	5.0	0.025	0.985	99.5
2.0	88.0-122.0	98.89	3.0	0.015	1.000	100.0

TABLE B-27

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
36.0	2.0- 2.0	32.96	139.0	0.299	0.299	81.5
30.0	3.0- 3.0	39.56	212.0	0.456	0.755	91.8
26.0	4.0- 4.0	45.64	29.0	0.062	0.817	94.3
23.0	5.0- 5.0	51.60	24.0	0.052	0.869	95.9
20.0	6.0- 6.0	59.33	15.0	0.032	0.901	97.3
18.0	7.0- 7.0	65.93	11.0	0.024	0.925	98.0
16.0	8.0- 8.0	74.17	5.0	0.011	0.935	98.7
15.0	9.0- 9.0	79.11	6.0	0.013	0.948	99.0
14.0	10.0- 10.0	84.76	8.0	0.017	0.966	99.3
13.0	11.0- 11.0	91.28	2.0	0.004	0.970	99.5
12.0	12.0- 12.0	98.89	4.0	0.009	0.978	99.7
11.0	13.0- 14.0	7.88	6.0	0.013	0.991	99.8
9.0	18.0- 18.0	31.85	1.0	0.002	0.994	100.0
8.0	19.0- 20.0	48.34	2.0	0.004	0.998	100.0
APPLIED DEPTH IS 20.0 CM.						
30.0	3.0- 3.0	19.78	83.0	0.239	0.239	80.6
26.0	4.0- 4.0	22.82	155.0	0.447	0.686	89.3
23.0	5.0- 5.0	25.80	30.0	0.086	0.772	91.9
20.0	6.0- 6.0	29.67	23.0	0.066	0.839	94.1
18.0	7.0- 7.0	32.96	7.0	0.020	0.859	95.2
16.0	8.0- 8.0	37.08	6.0	0.017	0.876	96.3
15.0	9.0- 9.0	39.56	7.0	0.020	0.896	96.9
14.0	10.0- 10.0	42.38	6.0	0.017	0.914	97.4
13.0	11.0- 11.0	45.64	5.0	0.014	0.928	97.8
12.0	12.0- 12.0	49.45	5.0	0.014	0.942	98.2
10.0	15.0- 15.0	59.33	4.0	0.012	0.954	99.0
9.0	16.0- 18.0	65.93	7.0	0.020	0.974	99.4
8.0	19.0- 21.0	74.17	2.0	0.006	0.980	99.6
7.0	22.0- 22.0	84.76	1.0	0.003	0.983	99.8
6.0	26.0- 29.0	98.89	4.0	0.012	0.994	100.0
5.0	31.0- 31.0	18.67	1.0	0.003	0.997	100.0
APPLIED DEPTH IS 30.0 CM.						
30.0	3.0- 3.0	13.19	54.0	0.204	0.204	73.8
26.0	4.0- 4.0	15.21	45.0	0.170	0.374	82.0
23.0	5.0- 5.0	17.20	84.0	0.317	0.691	87.8
20.0	6.0- 6.0	19.78	20.0	0.075	0.766	90.5
18.0	7.0- 7.0	21.98	14.0	0.053	0.819	92.0

TABLE B-27 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
16.0	8.0- 8.0	24.72	6.0	0.023	0.842	93.3
15.0	9.0- 9.0	26.37	4.0	0.015	0.857	93.8
14.0	10.0- 10.0	28.25	3.0	0.011	0.868	94.4
13.0	11.0- 11.0	30.43	3.0	0.011	0.879	94.9
12.0	12.0- 12.0	32.96	2.0	0.008	0.887	95.5
11.0	13.0- 14.0	35.96	5.0	0.019	0.906	96.1
10.0	15.0- 15.0	39.56	2.0	0.008	0.913	96.6
9.0	16.0- 18.0	43.95	4.0	0.015	0.928	97.1
8.0	19.0- 19.0	49.45	1.0	0.004	0.932	97.6
7.0	23.0- 23.0	56.51	2.0	0.008	0.940	98.2
6.0	25.0- 29.0	65.93	6.0	0.023	0.962	98.9
5.0	35.0- 37.0	79.11	3.0	0.011	0.974	99.3
4.0	38.0- 43.0	98.89	3.0	0.011	0.985	99.7
3.0	51.0- 55.0	31.85	3.0	0.011	0.996	100.0
APPLIED DEPTH IS 40.0 CM.						
36.0	2.0- 2.0	9.51	30.0	0.147	0.147	60.7
30.0	3.0- 3.0	11.41	19.0	0.093	0.240	69.5
26.0	4.0- 4.0	13.17	7.0	0.034	0.275	76.2
23.0	5.0- 5.0	14.88	39.0	0.191	0.466	82.3
20.0	6.0- 6.0	17.12	40.0	0.196	0.662	87.4
18.0	7.0- 7.0	19.02	12.0	0.059	0.721	89.5
16.0	8.0- 8.0	21.39	14.0	0.069	0.789	91.5
15.0	9.0- 9.0	22.82	5.0	0.025	0.814	92.2
14.0	10.0- 10.0	24.45	4.0	0.020	0.833	92.8
13.0	11.0- 11.0	26.33	3.0	0.015	0.848	93.4
12.0	12.0- 12.0	28.53	2.0	0.010	0.858	93.9
11.0	13.0- 13.0	31.12	1.0	0.005	0.863	94.5
10.0	15.0- 15.0	34.23	2.0	0.010	0.873	95.1
9.0	16.0- 18.0	38.03	2.0	0.010	0.882	95.8
8.0	20.0- 21.0	42.79	2.0	0.010	0.892	96.4
7.0	23.0- 24.0	48.90	2.0	0.010	0.902	97.2
6.0	26.0- 26.0	57.05	1.0	0.005	0.907	98.0
5.0	30.0- 37.0	68.46	7.0	0.034	0.941	99.1
4.0	38.0- 43.0	85.58	7.0	0.034	0.975	99.9
3.0	69.0- 69.0	14.10	1.0	0.005	0.980	100.0
APPLIED DEPTH IS 50.0 CM.						
36.0	2.0- 2.0	6.59	37.0	0.185	0.185	59.8
30.0	3.0- 3.0	7.91	28.0	0.140	0.325	68.1

TABLE B-27 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
26.0	4.0- 4.0	9.13	9.0	0.045	0.370	73.6
23.0	5.0- 5.0	10.32	16.0	0.080	0.450	78.3
20.0	6.0- 6.0	11.87	25.0	0.125	0.575	83.3
18.0	7.0- 7.0	13.19	21.0	0.105	0.680	86.2
16.0	8.0- 8.0	14.83	9.0	0.045	0.725	88.5
15.0	9.0- 9.0	15.82	10.0	0.050	0.775	89.5
14.0	10.0- 10.0	16.95	10.0	0.050	0.825	90.4
13.0	11.0- 11.0	18.26	1.0	0.005	0.830	91.0
12.0	12.0- 12.0	19.78	3.0	0.015	0.845	91.7
11.0	13.0- 14.0	21.58	4.0	0.020	0.865	92.3
10.0	15.0- 15.0	23.73	3.0	0.015	0.880	92.9
9.0	16.0- 16.0	26.37	1.0	0.005	0.885	93.4
8.0	21.0- 21.0	29.67	2.0	0.010	0.895	94.1
7.0	23.0- 24.0	33.91	2.0	0.010	0.905	94.7
6.0	25.0- 25.0	39.56	1.0	0.005	0.910	95.4
4.0	38.0- 47.0	59.33	8.0	0.040	0.950	97.6
3.0	50.0- 56.0	79.11	3.0	0.015	0.965	98.5
2.0	70.0- 97.0	18.67	5.0	0.025	0.990	99.5
1.0	136.0-147.0	37.34	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
36.0	2.0- 2.0	5.49	36.0	0.180	0.180	58.9
30.0	3.0- 3.0	6.59	21.0	0.105	0.285	67.1
26.0	4.0- 4.0	7.61	11.0	0.055	0.340	73.1
23.0	5.0- 5.0	8.60	23.0	0.115	0.455	78.2
20.0	6.0- 6.0	9.89	17.0	0.085	0.540	83.1
18.0	7.0- 7.0	10.99	18.0	0.090	0.630	86.3
16.0	8.0- 8.0	12.36	16.0	0.080	0.710	89.2
15.0	9.0- 9.0	13.19	14.0	0.070	0.780	90.4
14.0	10.0- 10.0	14.13	7.0	0.035	0.815	91.3
13.0	11.0- 11.0	15.21	6.0	0.030	0.845	92.1
12.0	12.0- 12.0	16.48	3.0	0.015	0.860	92.7
11.0	13.0- 14.0	17.98	2.0	0.010	0.870	93.3
10.0	15.0- 15.0	19.78	2.0	0.010	0.880	93.9
9.0	16.0- 18.0	21.98	3.0	0.015	0.895	94.6
8.0	20.0- 21.0	24.72	2.0	0.010	0.905	95.3
7.0	24.0- 24.0	28.25	1.0	0.005	0.910	95.9
6.0	26.0- 29.0	32.96	4.0	0.020	0.930	96.8
5.0	30.0- 37.0	39.56	3.0	0.015	0.945	97.5
4.0	39.0- 47.0	49.45	4.0	0.020	0.965	98.3

TABLE B-27 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
3.0	54.0- 55.0	65.93	2.0	0.010	0.975	98.8
2.0	77.0- 91.0	98.89	3.0	0.015	0.990	99.5
1.0	136.0-148.0	97.78	2.0	0.010	1.000	100.0

TABLE B-28

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
60.0	3.0- 3.0	19.78	725.0	0.766	0.766	93.0
51.0	4.0- 4.0	23.27	68.0	0.072	0.837	95.9
45.0	5.0- 5.0	26.37	50.0	0.053	0.890	97.5
40.0	6.0- 6.0	29.67	37.0	0.039	0.929	98.6
36.0	7.0- 7.0	32.96	22.0	0.023	0.952	99.2
33.0	8.0- 8.0	35.96	17.0	0.018	0.970	99.5
30.0	9.0- 9.0	39.56	14.0	0.015	0.985	99.8
28.0	10.0- 10.0	42.38	6.0	0.006	0.992	99.9
26.0	11.0- 11.0	45.64	5.0	0.005	0.997	99.9
24.0	12.0- 12.0	49.45	1.0	0.001	0.998	100.0
23.0	13.0- 13.0	51.60	1.0	0.001	0.999	100.0
16.0	20.0- 20.0	74.17	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
60.0	3.0- 3.0	9.89	83.0	0.107	0.107	80.1
51.0	4.0- 4.0	11.63	488.0	0.626	0.733	92.4
45.0	5.0- 5.0	13.19	79.0	0.101	0.834	94.9
40.0	6.0- 6.0	14.83	27.0	0.035	0.869	96.4
36.0	7.0- 7.0	16.48	24.0	0.031	0.900	97.4
33.0	8.0- 8.0	17.98	21.0	0.027	0.927	98.1
30.0	9.0- 9.0	19.78	14.0	0.018	0.945	98.7
28.0	10.0- 10.0	21.19	8.0	0.010	0.955	99.0
26.0	11.0- 11.0	22.82	10.0	0.013	0.968	99.2
24.0	12.0- 12.0	24.72	4.0	0.005	0.973	99.4
23.0	13.0- 13.0	25.80	7.0	0.009	0.982	99.5
21.0	14.0- 14.0	28.25	2.0	0.003	0.985	99.6
20.0	15.0- 15.0	29.67	1.0	0.001	0.986	99.7
19.0	16.0- 16.0	31.23	2.0	0.003	0.988	99.8
18.0	17.0- 17.0	32.96	1.0	0.001	0.990	99.8
17.0	18.0- 18.0	34.90	2.0	0.003	0.992	99.9
16.0	20.0- 20.0	37.08	2.0	0.003	0.995	99.9
15.0	21.0- 21.0	39.56	1.0	0.001	0.996	99.9
14.0	22.0- 22.0	42.38	1.0	0.001	0.997	100.0
13.0	25.0- 25.0	45.64	1.0	0.001	0.999	100.0
10.0	32.0- 32.0	59.33	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
51.0	4.0- 4.0	7.76	103.0	0.164	0.164	81.4
45.0	5.0- 5.0	8.79	301.0	0.479	0.643	90.1

TABLE B-28 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
40.0	6.0- 6.0	9.89	100.0	0.159	0.803	93.3
36.0	7.0- 7.0	10.99	25.0	0.040	0.842	94.8
33.0	8.0- 8.0	11.99	24.0	0.038	0.881	95.7
30.0	9.0- 9.0	13.19	15.0	0.024	0.904	96.5
28.0	10.0- 10.0	14.13	8.0	0.013	0.917	96.9
26.0	11.0- 11.0	15.21	3.0	0.005	0.922	97.3
24.0	12.0- 12.0	16.48	5.0	0.008	0.930	97.8
23.0	13.0- 13.0	17.20	5.0	0.008	0.938	98.0
21.0	14.0- 14.0	18.84	6.0	0.010	0.947	98.4
20.0	15.0- 15.0	19.78	3.0	0.005	0.952	98.6
18.0	17.0- 17.0	21.98	2.0	0.003	0.955	98.9
17.0	18.0- 18.0	23.27	4.0	0.006	0.962	99.1
16.0	19.0- 20.0	24.72	5.0	0.008	0.970	99.3
15.0	21.0- 21.0	26.37	2.0	0.003	0.973	99.5
14.0	22.0- 23.0	28.25	8.0	0.013	0.986	99.6
13.0	24.0- 25.0	30.43	3.0	0.005	0.990	99.7
12.0	26.0- 28.0	32.96	2.0	0.003	0.994	99.7
8.0	43.0- 43.0	49.45	1.0	0.002	0.995	99.9
7.0	46.0- 51.0	56.51	3.0	0.005	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
51.0	4.0- 4.0	5.82	45.0	0.084	0.084	74.2
45.0	5.0- 5.0	6.59	127.0	0.237	0.321	83.0
40.0	6.0- 6.0	7.42	168.0	0.314	0.636	89.3
36.0	7.0- 7.0	8.24	66.0	0.123	0.759	92.2
33.0	8.0- 8.0	8.99	37.0	0.069	0.828	93.7
30.0	9.0- 9.0	9.89	22.0	0.041	0.869	94.8
28.0	10.0- 10.0	10.60	11.0	0.021	0.890	95.3
26.0	11.0- 11.0	11.41	6.0	0.011	0.901	95.8
24.0	12.0- 12.0	12.36	4.0	0.007	0.908	96.3
23.0	13.0- 13.0	12.90	2.0	0.004	0.912	96.6
21.0	14.0- 14.0	14.13	4.0	0.007	0.920	97.1
20.0	15.0- 15.0	14.83	3.0	0.006	0.925	97.3
19.0	16.0- 16.0	15.61	2.0	0.004	0.929	97.6
18.0	17.0- 17.0	16.48	5.0	0.009	0.938	97.8
17.0	18.0- 18.0	17.45	4.0	0.007	0.946	98.1
16.0	19.0- 19.0	18.54	4.0	0.007	0.953	98.3
15.0	21.0- 21.0	19.78	1.0	0.002	0.955	98.5
14.0	23.0- 23.0	21.19	1.0	0.002	0.957	98.7
13.0	24.0- 25.0	22.82	3.0	0.006	0.963	98.9

TABLE B-28 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
12.0	26.0- 28.0	24.72	2.0	0.004	0.966	99.1
11.0	29.0- 30.0	26.97	5.0	0.009	0.976	99.4
10.0	32.0- 33.0	29.67	2.0	0.004	0.979	99.6
9.0	36.0- 38.0	32.96	4.0	0.007	0.987	99.7
8.0	40.0- 43.0	37.08	3.0	0.006	0.993	99.9
7.0	50.0- 52.0	42.38	3.0	0.006	0.998	99.9
5.0	65.0- 65.0	59.33	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 50.0 CM.						
51.0	4.0- 4.0	4.65	37.0	0.082	0.082	68.4
45.0	5.0- 5.0	5.27	44.0	0.098	0.180	76.5
40.0	6.0- 6.0	5.93	114.0	0.253	0.433	83.8
36.0	7.0- 7.0	6.59	87.0	0.193	0.627	88.3
33.0	8.0- 8.0	7.19	51.0	0.113	0.740	90.6
30.0	9.0- 9.0	7.91	22.0	0.049	0.789	92.3
28.0	10.0- 10.0	8.48	25.0	0.056	0.844	93.2
26.0	11.0- 11.0	9.13	12.0	0.027	0.871	93.9
24.0	12.0- 12.0	9.89	6.0	0.013	0.884	94.5
23.0	13.0- 13.0	10.32	6.0	0.013	0.898	94.7
21.0	14.0- 14.0	11.30	3.0	0.007	0.904	95.2
20.0	15.0- 15.0	11.87	2.0	0.004	0.909	95.4
19.0	16.0- 16.0	12.49	1.0	0.002	0.911	95.7
18.0	17.0- 17.0	13.19	1.0	0.002	0.913	95.9
17.0	18.0- 18.0	13.96	1.0	0.002	0.916	96.2
15.0	21.0- 21.0	15.82	3.0	0.007	0.922	96.8
14.0	22.0- 22.0	16.95	1.0	0.002	0.924	97.1
13.0	24.0- 25.0	18.26	2.0	0.004	0.929	97.5
12.0	28.0- 28.0	19.78	2.0	0.004	0.933	97.9
11.0	29.0- 31.0	21.58	4.0	0.009	0.942	98.3
10.0	32.0- 33.0	23.73	4.0	0.009	0.951	98.7
9.0	35.0- 39.0	26.37	8.0	0.018	0.969	99.1
8.0	40.0- 45.0	29.67	4.0	0.009	0.978	99.4
7.0	47.0- 52.0	33.91	4.0	0.009	0.987	99.6
6.0	54.0- 54.0	39.56	1.0	0.002	0.989	99.7
5.0	66.0- 76.0	47.47	4.0	0.009	0.998	99.9
3.0	108.0-108.0	79.11	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
51.0	4.0- 4.0	3.88	36.0	0.089	0.089	65.1
45.0	5.0- 5.0	4.40	27.0	0.067	0.156	72.5

TABLE B-28 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
40.0	6.0- 6.0	4.94	62.0	0.153	0.309	79.5
36.0	7.0- 7.0	5.49	66.0	0.163	0.472	84.8
33.0	8.0- 8.0	5.99	53.0	0.131	0.602	88.2
30.0	9.0- 9.0	6.59	38.0	0.094	0.696	90.9
28.0	10.0- 10.0	7.06	32.0	0.079	0.775	92.3
26.0	11.0- 11.0	7.61	21.0	0.052	0.827	93.4
24.0	12.0- 12.0	8.24	10.0	0.025	0.852	94.2
23.0	13.0- 13.0	8.60	7.0	0.017	0.869	94.6
21.0	14.0- 14.0	9.42	5.0	0.012	0.881	95.3
20.0	15.0- 15.0	9.89	3.0	0.007	0.889	95.6
19.0	16.0- 16.0	10.41	2.0	0.005	0.894	95.9
18.0	17.0- 17.0	10.99	3.0	0.007	0.901	96.2
17.0	18.0- 18.0	11.63	2.0	0.005	0.906	96.5
16.0	19.0- 20.0	12.36	5.0	0.012	0.919	96.9
14.0	22.0- 22.0	14.13	1.0	0.002	0.921	97.5
13.0	24.0- 24.0	15.21	2.0	0.005	0.926	97.8
12.0	27.0- 27.0	16.48	2.0	0.005	0.931	98.2
11.0	29.0- 31.0	17.98	6.0	0.015	0.946	98.6
10.0	32.0- 33.0	19.78	3.0	0.007	0.953	98.9
9.0	35.0- 39.0	21.98	6.0	0.015	0.968	99.3
8.0	40.0- 40.0	24.72	1.0	0.002	0.970	99.5
7.0	48.0- 50.0	28.25	3.0	0.007	0.978	99.7
6.0	53.0- 61.0	32.96	4.0	0.010	0.988	99.9
5.0	67.0- 70.0	39.56	2.0	0.005	0.993	100.0

TABLE B-29

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
66.0	2.0- 2.0	17.98	504.0	0.470	0.470	90.6
55.0	3.0- 3.0	21.58	539.0	0.503	0.973	99.3
47.0	4.0- 4.0	25.25	12.0	0.011	0.984	99.7
41.0	5.0- 5.0	28.94	7.0	0.007	0.991	99.8
37.0	6.0- 6.0	32.07	4.0	0.004	0.994	99.9
33.0	7.0- 7.0	35.96	1.0	0.001	0.995	99.9
30.0	8.0- 8.0	39.56	3.0	0.003	0.998	100.0
24.0	11.0- 11.0	49.45	1.0	0.001	0.999	100.0
APPLIED DEPTH IS 20.0 CM.						
55.0	3.0- 3.0	10.79	1.0	0.001	0.001	84.6
47.0	4.0- 4.0	12.62	768.0	0.954	0.955	99.0
41.0	5.0- 5.0	14.47	10.0	0.012	0.968	99.4
37.0	6.0- 6.0	16.04	10.0	0.012	0.980	99.7
33.0	7.0- 7.0	17.98	8.0	0.010	0.990	99.9
30.0	8.0- 8.0	19.78	3.0	0.004	0.994	99.9
25.0	10.0- 10.0	23.73	2.0	0.002	0.996	100.0
21.0	13.0- 13.0	28.25	1.0	0.001	0.998	100.0
APPLIED DEPTH IS 30.0 CM.						
47.0	4.0- 4.0	8.42	98.0	0.140	0.140	88.0
41.0	5.0- 5.0	9.65	554.0	0.794	0.934	98.8
37.0	6.0- 6.0	10.69	25.0	0.036	0.970	99.4
33.0	7.0- 7.0	11.99	6.0	0.009	0.979	99.7
30.0	8.0- 8.0	13.19	6.0	0.009	0.987	99.8
28.0	9.0- 9.0	14.13	4.0	0.006	0.993	99.9
25.0	10.0- 10.0	15.82	1.0	0.001	0.994	100.0
24.0	11.0- 11.0	16.48	2.0	0.003	0.997	100.0
19.0	14.0- 14.0	20.82	1.0	0.001	0.999	100.0
APPLIED DEPTH IS 40.0 CM.						
47.0	4.0- 4.0	6.31	43.0	0.067	0.067	82.8
41.0	5.0- 5.0	7.24	243.0	0.377	0.444	93.9
37.0	6.0- 6.0	8.02	330.0	0.512	0.957	99.2
33.0	7.0- 7.0	8.99	13.0	0.020	0.977	99.6
30.0	8.0- 8.0	9.89	7.0	0.011	0.988	99.8
25.0	10.0- 10.0	11.87	2.0	0.003	0.991	99.9
24.0	11.0- 11.0	12.36	1.0	0.002	0.992	100.0
22.0	12.0- 12.0	13.49	3.0	0.005	0.997	100.0

TABLE B-29 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 50.0 CM.						
47.0	4.0- 4.0	5.05	3.0	0.005	0.005	77.2
41.0	5.0- 5.0	5.79	69.0	0.116	0.121	88.4
37.0	6.0- 6.0	6.41	387.0	0.652	0.773	96.6
33.0	7.0- 7.0	7.19	99.0	0.167	0.939	98.9
30.0	8.0- 8.0	7.91	12.0	0.020	0.960	99.4
28.0	9.0- 9.0	8.48	12.0	0.020	0.980	99.6
25.0	10.0- 10.0	9.49	5.0	0.008	0.988	99.8
22.0	12.0- 12.0	10.79	2.0	0.003	0.992	99.9
21.0	13.0- 13.0	11.30	1.0	0.002	0.993	99.9
19.0	14.0- 14.0	12.49	1.0	0.002	0.995	100.0
18.0	15.0- 15.0	13.19	1.0	0.002	0.997	100.0
17.0	16.0- 16.0	13.96	1.0	0.002	0.998	100.0
APPLIED DEPTH IS 60.0 CM.						
47.0	4.0- 4.0	4.21	3.0	0.006	0.006	71.4
41.0	5.0- 5.0	4.82	54.0	0.099	0.105	81.7
37.0	6.0- 6.0	5.35	42.0	0.077	0.182	89.4
33.0	7.0- 7.0	5.99	375.0	0.689	0.871	98.0
30.0	8.0- 8.0	6.59	37.0	0.068	0.939	99.1
28.0	9.0- 9.0	7.06	13.0	0.024	0.963	99.4
25.0	10.0- 10.0	7.91	10.0	0.018	0.982	99.8
24.0	11.0- 11.0	8.24	5.0	0.009	0.991	99.8
21.0	13.0- 13.0	9.42	1.0	0.002	0.993	99.9
17.0	16.0- 17.0	11.63	2.0	0.004	0.996	100.0
16.0	18.0- 18.0	12.36	1.0	0.002	0.998	100.0

TABLE B-30

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
66.0	2.0- 2.0	17.98	244.0	0.264	0.264	84.4
55.0	3.0- 3.0	21.58	580.0	0.628	0.892	96.0
47.0	4.0- 4.0	25.25	16.0	0.017	0.909	97.2
41.0	5.0- 5.0	28.94	21.0	0.023	0.932	98.1
37.0	6.0- 6.0	32.07	19.0	0.021	0.952	98.6
33.0	7.0- 7.0	35.96	14.0	0.015	0.968	99.0
30.0	8.0- 8.0	39.56	4.0	0.004	0.972	99.2
28.0	9.0- 9.0	42.38	6.0	0.006	0.978	99.3
25.0	10.0- 10.0	47.47	1.0	0.001	0.979	99.5
24.0	11.0- 11.0	49.45	2.0	0.002	0.982	99.5
22.0	12.0- 12.0	53.94	3.0	0.003	0.985	99.7
21.0	13.0- 13.0	56.51	2.0	0.002	0.987	99.7
19.0	14.0- 14.0	62.46	3.0	0.003	0.990	99.8
17.0	17.0- 17.0	69.81	2.0	0.002	0.992	99.9
16.0	18.0- 18.0	74.17	1.0	0.001	0.994	99.9
15.0	19.0- 19.0	79.11	1.0	0.001	0.995	99.9
14.0	21.0- 21.0	84.76	1.0	0.001	0.996	100.0
13.0	23.0- 23.0	91.28	2.0	0.002	0.998	100.0
12.0	24.0- 24.0	98.89	1.0	0.001	0.999	100.0
APPLIED DEPTH IS 20.0 CM.						
66.0	2.0- 2.0	8.99	102.0	0.129	0.129	80.1
55.0	3.0- 3.0	10.79	542.0	0.683	0.812	93.5
47.0	4.0- 4.0	12.62	76.0	0.096	0.908	95.6
41.0	5.0- 5.0	14.47	10.0	0.013	0.921	96.2
37.0	6.0- 6.0	16.04	8.0	0.010	0.931	96.7
33.0	7.0- 7.0	17.98	3.0	0.004	0.934	97.1
30.0	8.0- 8.0	19.78	4.0	0.005	0.939	97.5
28.0	9.0- 9.0	21.19	4.0	0.005	0.945	97.7
25.0	10.0- 10.0	23.73	4.0	0.005	0.950	98.1
24.0	11.0- 11.0	24.72	2.0	0.003	0.952	98.2
22.0	12.0- 12.0	26.97	3.0	0.004	0.956	98.5
21.0	13.0- 13.0	28.25	2.0	0.003	0.958	98.6
19.0	14.0- 14.0	31.23	1.0	0.001	0.960	98.9
18.0	15.0- 15.0	32.96	3.0	0.004	0.963	99.0
17.0	16.0- 17.0	34.90	6.0	0.008	0.971	99.2
16.0	18.0- 18.0	37.08	3.0	0.004	0.975	99.3
14.0	20.0- 21.0	42.38	3.0	0.004	0.979	99.5
13.0	23.0- 23.0	45.64	1.0	0.001	0.980	99.6

TABLE B-30 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
12.0	24.0- 25.0	49.45	6.0	0.008	0.987	99.8
11.0	27.0- 27.0	53.94	1.0	0.001	0.989	99.9
10.0	29.0- 30.0	59.33	6.0	0.008	0.996	99.9
9.0	32.0- 32.0	65.93	1.0	0.001	0.997	100.0
6.0	50.0- 50.0	98.89	1.0	0.001	0.999	100.0
APPLIED DEPTH IS 30.0 CM.						
66.0	2.0- 2.0	5.99	21.0	0.032	0.032	71.4
55.0	3.0- 3.0	7.19	188.0	0.291	0.323	85.0
47.0	4.0- 4.0	8.42	331.0	0.512	0.835	94.0
41.0	5.0- 5.0	9.65	45.0	0.070	0.904	95.5
37.0	6.0- 6.0	10.69	10.0	0.015	0.920	96.0
33.0	7.0- 7.0	11.99	5.0	0.008	0.927	96.5
30.0	8.0- 8.0	13.19	4.0	0.006	0.934	96.9
28.0	9.0- 9.0	14.13	3.0	0.005	0.938	97.1
25.0	10.0- 10.0	15.82	1.0	0.002	0.940	97.5
24.0	11.0- 11.0	16.48	2.0	0.003	0.943	97.6
22.0	12.0- 12.0	17.98	3.0	0.005	0.947	97.9
21.0	13.0- 13.0	18.84	3.0	0.005	0.952	98.0
19.0	14.0- 14.0	20.82	2.0	0.003	0.955	98.3
18.0	15.0- 15.0	21.98	4.0	0.006	0.961	98.5
17.0	16.0- 16.0	23.27	2.0	0.003	0.964	98.6
16.0	18.0- 18.0	24.72	2.0	0.003	0.968	98.7
14.0	20.0- 20.0	28.25	2.0	0.003	0.971	99.0
13.0	23.0- 23.0	30.43	1.0	0.002	0.972	99.1
12.0	24.0- 24.0	32.96	1.0	0.002	0.974	99.3
11.0	26.0- 27.0	35.96	3.0	0.005	0.978	99.4
10.0	29.0- 31.0	39.56	5.0	0.008	0.986	99.6
9.0	35.0- 35.0	43.95	1.0	0.002	0.988	99.7
8.0	39.0- 40.0	49.45	2.0	0.003	0.991	99.8
7.0	44.0- 44.0	56.51	1.0	0.002	0.992	99.8
6.0	50.0- 50.0	65.93	1.0	0.002	0.994	99.9
5.0	58.0- 68.0	79.11	3.0	0.005	0.998	100.0
APPLIED DEPTH IS 40.0 CM.						
66.0	2.0- 2.0	4.50	25.0	0.043	0.043	70.3
55.0	3.0- 3.0	5.39	147.0	0.256	0.299	83.4
47.0	4.0- 4.0	6.31	270.0	0.470	0.769	92.4
41.0	5.0- 5.0	7.24	54.0	0.094	0.863	94.6
37.0	6.0- 6.0	8.02	22.0	0.038	0.901	95.4

TABLE B-30 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
33.0	7.0- 7.0	8.99	4.0	0.007	0.908	96.0
30.0	8.0- 8.0	9.89	5.0	0.009	0.917	96.5
28.0	9.0- 9.0	10.60	6.0	0.010	0.927	96.8
25.0	10.0- 10.0	11.87	2.0	0.003	0.930	97.2
24.0	11.0- 11.0	12.36	4.0	0.007	0.937	97.4
22.0	12.0- 12.0	13.49	1.0	0.002	0.939	97.6
21.0	13.0- 13.0	14.13	1.0	0.002	0.941	97.8
18.0	15.0- 15.0	16.48	5.0	0.009	0.950	98.3
17.0	16.0- 16.0	17.45	3.0	0.005	0.955	98.5
16.0	18.0- 18.0	18.54	4.0	0.007	0.962	98.7
15.0	19.0- 19.0	19.78	2.0	0.003	0.965	98.8
13.0	23.0- 23.0	22.82	1.0	0.002	0.967	99.1
11.0	26.0- 28.0	26.97	6.0	0.010	0.977	99.4
10.0	31.0- 31.0	29.67	2.0	0.003	0.981	99.5
9.0	34.0- 34.0	32.96	1.0	0.002	0.983	99.6
8.0	37.0- 40.0	37.08	2.0	0.003	0.986	99.7
7.0	42.0- 42.0	42.38	1.0	0.002	0.988	99.8
6.0	48.0- 48.0	49.45	1.0	0.002	0.990	99.9
5.0	65.0- 65.0	59.33	1.0	0.002	0.991	99.9
4.0	71.0- 91.0	74.17	2.0	0.003	0.995	100.0
APPLIED DEPTH IS 50.0 CM.						
66.0	2.0- 2.0	3.60	17.0	0.031	0.031	70.7
55.0	3.0- 3.0	4.32	145.0	0.265	0.296	84.0
47.0	4.0- 4.0	5.05	256.0	0.467	0.763	93.1
41.0	5.0- 5.0	5.79	51.0	0.093	0.856	95.4
37.0	6.0- 6.0	6.41	27.0	0.049	0.905	96.4
33.0	7.0- 7.0	7.19	6.0	0.011	0.916	97.0
30.0	8.0- 8.0	7.91	7.0	0.013	0.929	97.4
28.0	9.0- 9.0	8.48	5.0	0.009	0.938	97.7
25.0	10.0- 10.0	9.49	2.0	0.004	0.942	98.1
24.0	11.0- 11.0	9.89	2.0	0.004	0.945	98.2
22.0	12.0- 12.0	10.79	2.0	0.004	0.949	98.4
21.0	13.0- 13.0	11.30	1.0	0.002	0.951	98.6
19.0	14.0- 14.0	12.49	2.0	0.004	0.954	98.8
18.0	15.0- 15.0	13.19	4.0	0.007	0.962	99.0
17.0	17.0- 17.0	13.96	5.0	0.009	0.971	99.1
15.0	19.0- 19.0	15.82	1.0	0.002	0.973	99.2
14.0	20.0- 20.0	16.95	1.0	0.002	0.974	99.3
11.0	27.0- 27.0	21.58	1.0	0.002	0.976	99.6

TABLE B-30 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
10.0	30.0- 31.0	23.73	2.0	0.004	0.980	99.7
9.0	35.0- 35.0	26.37	1.0	0.002	0.982	99.8
8.0	36.0- 36.0	29.67	1.0	0.002	0.984	99.8
7.0	44.0- 47.0	33.91	2.0	0.004	0.987	99.9
6.0	48.0- 48.0	39.56	1.0	0.002	0.989	100.0
5.0	65.0- 65.0	47.47	1.0	0.002	0.991	100.0
APPLIED DEPTH IS 60.0 CM.						
66.0	2.0- 2.0	3.00	25.0	0.047	0.047	70.6
55.0	3.0- 3.0	3.60	124.0	0.234	0.282	83.6
47.0	4.0- 4.0	4.21	252.0	0.476	0.758	92.8
41.0	5.0- 5.0	4.82	44.0	0.083	0.841	95.1
37.0	6.0- 6.0	5.35	25.0	0.047	0.888	96.2
33.0	7.0- 7.0	5.99	11.0	0.021	0.909	96.9
30.0	8.0- 8.0	6.59	6.0	0.011	0.921	97.4
28.0	9.0- 9.0	7.06	6.0	0.011	0.932	97.7
25.0	10.0- 10.0	7.91	4.0	0.008	0.940	98.1
24.0	11.0- 11.0	8.24	3.0	0.006	0.945	98.3
22.0	12.0- 12.0	8.99	2.0	0.004	0.949	98.5
21.0	13.0- 13.0	9.42	3.0	0.006	0.955	98.6
19.0	14.0- 14.0	10.41	3.0	0.006	0.960	98.8
18.0	15.0- 15.0	10.99	3.0	0.006	0.966	98.9
16.0	18.0- 18.0	12.36	1.0	0.002	0.968	99.1
14.0	20.0- 20.0	14.13	1.0	0.002	0.970	99.3
13.0	23.0- 23.0	15.21	1.0	0.002	0.972	99.3
12.0	25.0- 25.0	16.48	1.0	0.002	0.974	99.4
11.0	28.0- 28.0	17.98	1.0	0.002	0.975	99.5
10.0	30.0- 30.0	19.78	1.0	0.002	0.977	99.6
9.0	35.0- 35.0	21.98	1.0	0.002	0.979	99.7
7.0	42.0- 44.0	28.25	2.0	0.004	0.983	99.9
6.0	51.0- 54.0	32.96	2.0	0.004	0.987	99.9
4.0	71.0- 71.0	49.45	1.0	0.002	0.989	100.0

TABLE B-31

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
42.0	2.0- 2.0	32.60	394.0	0.575	0.575	91.4
35.0	3.0- 3.0	39.12	246.0	0.359	0.934	98.2
30.0	4.0- 4.0	45.64	14.0	0.020	0.955	99.0
26.0	5.0- 5.0	52.66	18.0	0.026	0.981	99.6
23.0	6.0- 6.0	59.53	2.0	0.003	0.984	99.7
21.0	7.0- 7.0	65.20	6.0	0.009	0.993	99.9
19.0	8.0- 8.0	72.07	2.0	0.003	0.996	99.9
18.0	9.0- 9.0	76.07	1.0	0.001	0.997	100.0
16.0	10.0- 10.0	85.58	1.0	0.001	0.999	100.0
15.0	11.0- 11.0	91.28	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
30.0	4.0- 4.0	22.82	1.0	0.003	0.003	78.6
26.0	5.0- 5.0	26.33	239.0	0.632	0.635	90.7
23.0	6.0- 6.0	29.77	44.0	0.116	0.751	94.2
21.0	7.0- 7.0	32.60	22.0	0.058	0.810	96.1
19.0	8.0- 8.0	36.03	31.0	0.082	0.892	97.6
18.0	9.0- 9.0	38.03	11.0	0.029	0.921	98.1
16.0	10.0- 10.0	42.79	7.0	0.019	0.939	98.9
15.0	11.0- 11.0	45.64	6.0	0.016	0.955	99.2
14.0	12.0- 12.0	48.90	4.0	0.011	0.966	99.5
13.0	13.0- 13.0	52.66	5.0	0.013	0.979	99.7
12.0	14.0- 15.0	57.05	5.0	0.013	0.992	99.8
11.0	17.0- 17.0	62.24	1.0	0.003	0.995	99.9
10.0	19.0- 19.0	68.46	1.0	0.003	0.997	99.9
8.0	22.0- 22.0	85.58	1.0	0.003	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
21.0	7.0- 7.0	21.73	2.0	0.009	0.009	74.1
19.0	8.0- 8.0	24.02	41.0	0.175	0.184	81.8
18.0	9.0- 9.0	25.36	40.0	0.171	0.355	85.4
16.0	10.0- 10.0	28.53	65.0	0.278	0.632	91.6
15.0	11.0- 11.0	30.43	13.0	0.056	0.688	93.5
14.0	12.0- 12.0	32.60	8.0	0.034	0.722	95.3
13.0	13.0- 13.0	35.11	18.0	0.077	0.799	97.0
12.0	14.0- 15.0	38.03	26.0	0.111	0.910	98.5
11.0	16.0- 17.0	41.49	13.0	0.056	0.966	99.1
10.0	19.0- 19.0	45.64	2.0	0.009	0.974	99.4
9.0	21.0- 21.0	50.71	1.0	0.004	0.979	99.6

TABLE B-31 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
8.0	22.0- 22.0	57.05	2.0	0.009	0.987	99.8
7.0	26.0- 27.0	65.20	3.0	0.013	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
14.0	12.0- 12.0	24.45	2.0	0.010	0.010	74.8
13.0	13.0- 13.0	26.33	26.0	0.130	0.140	80.5
12.0	14.0- 15.0	28.53	62.0	0.310	0.450	86.0
11.0	16.0- 17.0	31.12	34.0	0.170	0.620	89.7
10.0	18.0- 19.0	34.23	18.0	0.090	0.710	92.5
9.0	20.0- 21.0	38.03	18.0	0.090	0.800	94.9
8.0	22.0- 25.0	42.79	9.0	0.045	0.845	96.8
7.0	26.0- 29.0	48.90	13.0	0.065	0.910	98.5
6.0	30.0- 35.0	57.05	15.0	0.075	0.985	99.8
5.0	36.0- 39.0	68.46	3.0	0.015	1.000	100.0
APPLIED DEPTH IS 50.0 CM.						
11.0	17.0- 17.0	24.90	28.0	0.140	0.140	74.0
10.0	18.0- 19.0	27.39	45.0	0.225	0.365	80.0
9.0	20.0- 21.0	30.43	20.0	0.100	0.465	84.8
8.0	22.0- 25.0	34.23	29.0	0.145	0.610	89.6
7.0	26.0- 29.0	39.12	30.0	0.150	0.760	93.7
6.0	30.0- 35.0	45.64	17.0	0.085	0.845	96.7
5.0	36.0- 43.0	54.77	22.0	0.110	0.955	99.1
4.0	44.0- 52.0	68.46	9.0	0.045	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
8.0	22.0- 25.0	28.53	77.0	0.385	0.385	80.2
7.0	26.0- 29.0	32.60	22.0	0.110	0.495	86.2
6.0	30.0- 35.0	38.03	50.0	0.250	0.745	92.3
5.0	36.0- 43.0	45.64	13.0	0.065	0.810	95.9
4.0	44.0- 57.0	57.05	35.0	0.175	0.985	99.6
3.0	58.0- 62.0	76.07	3.0	0.015	1.000	100.0

TABLE B-32

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
42.0	2.0- 2.0	32.60	49.0	0.088	0.088	78.8
35.0	3.0- 3.0	39.12	378.0	0.680	0.768	92.8
30.0	4.0- 4.0	45.64	40.0	0.072	0.840	95.5
26.0	5.0- 5.0	52.66	26.0	0.047	0.887	97.2
23.0	6.0- 6.0	59.53	21.0	0.038	0.924	98.3
21.0	7.0- 7.0	65.20	14.0	0.025	0.950	98.9
19.0	8.0- 8.0	72.07	8.0	0.014	0.964	99.3
18.0	9.0- 9.0	76.07	8.0	0.014	0.978	99.5
16.0	10.0- 10.0	85.58	1.0	0.002	0.980	99.7
15.0	11.0- 11.0	91.28	2.0	0.004	0.984	99.8
14.0	12.0- 12.0	97.80	4.0	0.007	0.991	99.9
13.0	13.0- 13.0	5.33	1.0	0.002	0.993	99.9
12.0	14.0- 15.0	14.10	4.0	0.007	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
26.0	5.0- 5.0	26.33	6.0	0.024	0.024	68.8
23.0	6.0- 6.0	29.77	52.0	0.211	0.236	77.4
21.0	7.0- 7.0	32.60	47.0	0.191	0.427	82.5
19.0	8.0- 8.0	36.03	27.0	0.110	0.537	86.7
18.0	9.0- 9.0	38.03	25.0	0.102	0.638	88.5
16.0	10.0- 10.0	42.79	14.0	0.057	0.695	91.5
15.0	11.0- 11.0	45.64	10.0	0.041	0.736	93.0
14.0	12.0- 12.0	48.90	9.0	0.037	0.772	94.3
13.0	13.0- 13.0	52.66	10.0	0.041	0.813	95.6
12.0	14.0- 15.0	57.05	13.0	0.053	0.866	96.7
11.0	16.0- 17.0	62.24	11.0	0.045	0.911	97.6
10.0	18.0- 19.0	68.46	5.0	0.020	0.931	98.3
9.0	20.0- 21.0	76.07	3.0	0.012	0.943	98.8
8.0	23.0- 25.0	85.58	3.0	0.012	0.955	99.3
7.0	26.0- 29.0	97.80	6.0	0.024	0.980	99.8
6.0	30.0- 35.0	14.10	4.0	0.016	0.996	100.0
APPLIED DEPTH IS 30.0 CM.						
18.0	9.0- 9.0	25.36	1.0	0.005	0.005	59.4
16.0	10.0- 10.0	28.53	13.0	0.065	0.070	66.8
15.0	11.0- 11.0	30.43	23.0	0.115	0.185	70.8
14.0	12.0- 12.0	32.60	14.0	0.070	0.255	74.5
13.0	13.0- 13.0	35.11	12.0	0.060	0.315	78.3
12.0	14.0- 15.0	38.03	27.0	0.135	0.450	82.2

TABLE B-32 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
11.0	16.0- 17.0	41.49	17.0	0.085	0.535	85.5
10.0	18.0- 19.0	45.64	19.0	0.095	0.630	88.8
9.0	20.0- 21.0	50.71	17.0	0.085	0.715	91.6
8.0	22.0- 25.0	57.05	18.0	0.090	0.805	94.1
7.0	26.0- 29.0	65.20	13.0	0.065	0.870	96.1
6.0	30.0- 35.0	76.07	10.0	0.050	0.920	97.6
5.0	36.0- 42.0	91.28	8.0	0.040	0.960	98.7
4.0	46.0- 57.0	14.10	3.0	0.015	0.975	99.4
3.0	62.0- 76.0	52.14	5.0	0.025	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
9.0	20.0- 21.0	38.03	5.0	0.025	0.025	59.7
8.0	22.0- 25.0	42.79	22.0	0.110	0.135	66.9
7.0	26.0- 29.0	48.90	28.0	0.140	0.275	74.5
6.0	30.0- 35.0	57.05	37.0	0.185	0.460	82.3
5.0	36.0- 43.0	68.46	42.0	0.210	0.670	89.6
4.0	44.0- 57.0	85.58	37.0	0.185	0.855	95.3
3.0	58.0- 78.0	14.10	20.0	0.100	0.955	98.5
2.0	83.0-101.0	71.16	9.0	0.045	1.000	100.0
APPLIED DEPTH IS 50.0 CM.						
7.0	29.0- 29.0	39.12	1.0	0.005	0.005	52.9
6.0	30.0- 35.0	45.64	23.0	0.115	0.120	61.6
5.0	36.0- 43.0	54.77	33.0	0.165	0.285	71.5
4.0	44.0- 57.0	68.46	45.0	0.225	0.510	82.3
3.0	58.0- 81.0	91.28	55.0	0.275	0.785	92.7
2.0	82.0-131.0	36.93	42.0	0.210	0.995	99.8
1.0	162.0-162.0	73.85	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
5.0	43.0- 43.0	45.64	2.0	0.010	0.010	48.9
4.0	44.0- 56.0	57.05	24.0	0.126	0.136	60.9
3.0	58.0- 81.0	76.07	46.0	0.241	0.377	76.6
2.0	82.0-137.0	14.10	104.0	0.545	0.921	96.1
1.0	139.0-202.0	28.21	15.0	0.079	1.000	100.0

TABLE B-33

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
36.0	2.0- 2.0	38.03	128.0	0.272	0.272	81.3
30.0	3.0- 3.0	45.64	226.0	0.481	0.753	92.2
26.0	4.0- 4.0	52.66	31.0	0.066	0.819	94.8
23.0	5.0- 5.0	59.53	28.0	0.060	0.879	96.4
20.0	6.0- 6.0	68.46	21.0	0.045	0.923	97.7
18.0	7.0- 7.0	76.07	8.0	0.017	0.940	98.3
16.0	8.0- 8.0	85.58	7.0	0.015	0.955	98.9
15.0	9.0- 9.0	91.28	3.0	0.006	0.962	99.1
14.0	10.0- 10.0	97.80	4.0	0.009	0.970	99.3
13.0	11.0- 11.0	5.33	4.0	0.009	0.979	99.5
12.0	12.0- 12.0	14.10	2.0	0.004	0.983	99.6
11.0	13.0- 14.0	24.48	2.0	0.004	0.987	99.7
9.0	16.0- 18.0	52.14	4.0	0.009	0.996	99.9
8.0	19.0- 19.0	71.16	1.0	0.002	0.998	100.0
7.0	22.0- 22.0	95.61	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
23.0	5.0- 5.0	29.77	6.0	0.030	0.030	56.2
20.0	6.0- 6.0	34.23	10.0	0.050	0.080	64.1
18.0	7.0- 7.0	38.03	19.0	0.095	0.175	70.4
16.0	8.0- 8.0	42.79	21.0	0.105	0.280	77.0
15.0	9.0- 9.0	45.64	20.0	0.100	0.380	80.2
14.0	10.0- 10.0	48.90	22.0	0.110	0.490	83.3
13.0	11.0- 11.0	52.66	16.0	0.080	0.570	85.9
12.0	12.0- 12.0	57.05	11.0	0.055	0.625	88.3
11.0	13.0- 14.0	62.24	14.0	0.070	0.695	90.6
10.0	15.0- 15.0	68.46	10.0	0.050	0.745	92.8
9.0	16.0- 18.0	76.07	15.0	0.075	0.820	94.8
8.0	19.0- 21.0	85.58	10.0	0.050	0.870	96.4
7.0	22.0- 24.0	97.80	5.0	0.025	0.895	97.7
6.0	25.0- 29.0	14.10	12.0	0.060	0.955	99.1
5.0	30.0- 36.0	36.93	7.0	0.035	0.990	99.8
4.0	38.0- 45.0	71.16	2.0	0.010	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
14.0	10.0- 10.0	32.60	2.0	0.010	0.010	55.4
13.0	11.0- 11.0	35.11	10.0	0.050	0.060	59.3
12.0	12.0- 12.0	38.03	10.0	0.050	0.110	63.6
11.0	13.0- 14.0	41.49	17.0	0.085	0.195	68.1

TABLE B-33 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
10.0	15.0- 15.0	45.64	5.0	0.025	0.220	72.8
9.0	16.0- 18.0	50.71	24.0	0.120	0.340	78.1
8.0	19.0- 21.0	57.05	32.0	0.160	0.500	83.3
7.0	22.0- 24.0	65.20	16.0	0.080	0.580	87.7
6.0	25.0- 29.0	76.07	27.0	0.135	0.715	92.3
5.0	30.0- 37.0	91.28	24.0	0.120	0.835	95.9
4.0	38.0- 47.0	14.10	15.0	0.075	0.910	98.4
3.0	51.0- 69.0	52.14	13.0	0.065	0.975	100.0
APPLIED DEPTH IS 40.0 CM.						
8.0	20.0- 20.0	42.79	1.0	0.005	0.005	45.6
7.0	24.0- 24.0	48.90	1.0	0.005	0.010	51.7
6.0	25.0- 29.0	57.05	18.0	0.090	0.100	59.8
5.0	30.0- 37.0	68.46	38.0	0.190	0.290	69.4
4.0	38.0- 48.0	85.58	24.0	0.120	0.410	79.0
3.0	49.0- 69.0	14.10	60.0	0.300	0.710	91.0
2.0	70.0-112.0	71.16	54.0	0.270	0.980	100.0
APPLIED DEPTH IS 50.0 CM.						
5.0	35.0- 37.0	54.77	4.0	0.025	0.025	56.2
4.0	39.0- 48.0	68.46	12.0	0.076	0.102	66.2
3.0	49.0- 69.0	91.28	28.0	0.178	0.280	80.5
2.0	70.0-117.0	36.93	92.0	0.586	0.866	100.0
APPLIED DEPTH IS 60.0 CM.						
3.0	52.0- 61.0	76.07	3.0	0.032	0.032	84.2
2.0	70.0-117.0	14.10	45.0	0.474	0.505	100.0

TABLE B-34

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

AP/YR	RANGE OF DAYS ON BED	SQFT/ LB	FREQ. OCCUR	PROB.	ACC PROB	PI
APPLIED DEPTH IS 10.0 CM.						
72.0	2.0- 2.0	19.02	68.0	0.070	0.070	78.9
60.0	3.0- 3.0	22.82	674.0	0.696	0.766	93.3
51.0	4.0- 4.0	26.85	71.0	0.073	0.839	96.3
45.0	5.0- 5.0	30.43	60.0	0.062	0.901	97.9
40.0	6.0- 6.0	34.23	41.0	0.042	0.943	98.9
36.0	7.0- 7.0	38.03	21.0	0.022	0.965	99.4
33.0	8.0- 8.0	41.49	13.0	0.013	0.978	99.6
30.0	9.0- 9.0	45.64	9.0	0.009	0.988	99.8
28.0	10.0- 10.0	48.90	3.0	0.003	0.991	99.9
26.0	11.0- 11.0	52.66	6.0	0.006	0.997	100.0
24.0	12.0- 12.0	57.05	1.0	0.001	0.998	100.0
23.0	13.0- 13.0	59.53	2.0	0.002	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
45.0	5.0- 5.0	15.21	4.0	0.008	0.008	71.0
40.0	6.0- 6.0	17.12	112.0	0.233	0.241	79.7
36.0	7.0- 7.0	19.02	105.0	0.218	0.459	85.9
33.0	8.0- 8.0	20.75	58.0	0.121	0.580	89.5
30.0	9.0- 9.0	22.82	44.0	0.091	0.672	92.7
28.0	10.0- 10.0	24.45	38.0	0.079	0.751	94.5
26.0	11.0- 11.0	26.33	31.0	0.064	0.815	96.0
24.0	12.0- 12.0	28.53	23.0	0.048	0.863	97.2
23.0	13.0- 13.0	29.77	18.0	0.037	0.900	97.7
21.0	14.0- 14.0	32.60	11.0	0.023	0.923	98.4
20.0	15.0- 15.0	34.23	7.0	0.015	0.938	98.8
19.0	16.0- 16.0	36.03	5.0	0.010	0.948	99.0
18.0	17.0- 17.0	38.03	2.0	0.004	0.952	99.2
17.0	18.0- 18.0	40.27	2.0	0.004	0.956	99.5
16.0	19.0- 20.0	42.79	11.0	0.023	0.979	99.7
15.0	21.0- 21.0	45.64	5.0	0.010	0.990	99.8
14.0	22.0- 23.0	48.90	2.0	0.004	0.994	99.9
13.0	24.0- 24.0	52.66	1.0	0.002	0.996	100.0
12.0	27.0- 27.0	57.05	1.0	0.002	0.998	100.0
11.0	29.0- 29.0	62.24	1.0	0.002	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
30.0	9.0- 9.0	15.21	2.0	0.007	0.007	66.4
28.0	10.0- 10.0	16.30	38.0	0.142	0.149	71.1
26.0	11.0- 11.0	17.55	25.0	0.093	0.243	75.4

TABLE B-34 (CONTINUED)

AP/YR	RANGE OF DAYS ON BED	SQFT/ LB	FREQ. OCCUR	PROB.	ACC PROB	PI
24.0	12.0- 12.0	19.02	17.0	0.063	0.306	79.6
23.0	13.0- 13.0	19.84	26.0	0.097	0.403	81.8
21.0	14.0- 14.0	21.73	20.0	0.075	0.478	85.7
20.0	15.0- 15.0	22.82	15.0	0.056	0.534	87.6
19.0	16.0- 16.0	24.02	24.0	0.090	0.623	89.4
18.0	17.0- 17.0	25.36	11.0	0.041	0.664	90.9
17.0	18.0- 18.0	26.85	17.0	0.063	0.728	92.4
16.0	19.0- 20.0	28.53	16.0	0.060	0.787	93.6
15.0	21.0- 21.0	30.43	4.0	0.015	0.802	94.6
14.0	22.0- 23.0	32.60	5.0	0.019	0.821	95.6
13.0	24.0- 25.0	35.11	10.0	0.037	0.858	96.6
12.0	27.0- 28.0	38.03	8.0	0.030	0.888	97.5
11.0	29.0- 31.0	41.49	10.0	0.037	0.925	98.3
10.0	32.0- 34.0	45.64	6.0	0.022	0.948	98.9
9.0	35.0- 39.0	50.71	7.0	0.026	0.974	99.4
8.0	40.0- 45.0	57.05	3.0	0.011	0.985	99.6
7.0	48.0- 48.0	65.20	2.0	0.007	0.993	99.8
6.0	53.0- 53.0	76.07	1.0	0.004	0.996	99.9
4.0	78.0- 78.0	14.10	1.0	0.004	1.000	100.0
APPLIED DEPTH IS 40.0 CM.						
18.0	17.0- 17.0	19.02	1.0	0.005	0.005	56.1
17.0	18.0- 18.0	20.14	1.0	0.005	0.010	59.4
16.0	19.0- 20.0	21.39	7.0	0.035	0.045	63.0
15.0	21.0- 21.0	22.82	7.0	0.035	0.080	66.9
14.0	22.0- 23.0	24.45	16.0	0.080	0.160	71.1
13.0	24.0- 25.0	26.33	15.0	0.075	0.235	75.4
12.0	26.0- 28.0	28.53	25.0	0.125	0.360	79.7
11.0	29.0- 31.0	31.12	20.0	0.100	0.460	83.7
10.0	32.0- 34.0	34.23	20.0	0.100	0.560	87.4
9.0	35.0- 39.0	38.03	23.0	0.115	0.675	90.9
8.0	40.0- 45.0	42.79	13.0	0.065	0.740	93.9
7.0	46.0- 52.0	48.90	21.0	0.105	0.845	96.7
6.0	53.0- 62.0	57.05	19.0	0.095	0.940	98.8
5.0	64.0- 77.0	68.46	9.0	0.045	0.985	99.7
4.0	83.0- 86.0	85.58	3.0	0.015	1.000	100.0
APPLIED DEPTH IS 50.0 CM.						
12.0	27.0- 27.0	22.82	1.0	0.005	0.005	55.4
11.0	29.0- 31.0	24.90	6.0	0.030	0.035	60.4

TABLE B-34 (CONTINUED)

AP/YR	RANGE OF DAYS ON BED	SQFT/ LB	FREQ. OCCUR	PROB.	ACC PROB	PI
10.0	33.0- 34.0	27.39	12.0	0.060	0.095	66.0
9.0	35.0- 39.0	30.43	22.0	0.110	0.205	72.3
8.0	40.0- 45.0	34.23	30.0	0.150	0.355	78.8
7.0	46.0- 52.0	39.12	30.0	0.150	0.505	85.0
6.0	53.0- 62.0	45.64	32.0	0.160	0.665	90.8
5.0	63.0- 76.0	54.77	38.0	0.190	0.855	95.6
4.0	78.0- 99.0	68.46	18.0	0.090	0.945	98.1
3.0	105.0-135.0	91.28	7.0	0.035	0.980	99.3
2.0	143.0-160.0	36.93	4.0	0.020	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
9.0	39.0- 39.0	25.36	3.0	0.015	0.015	51.0
8.0	40.0- 45.0	28.53	12.0	0.060	0.075	57.2
7.0	46.0- 52.0	32.60	15.0	0.075	0.151	64.3
6.0	53.0- 62.0	38.03	21.0	0.106	0.256	72.5
5.0	63.0- 76.0	45.64	49.0	0.246	0.503	81.9
4.0	78.0- 97.0	57.05	42.0	0.211	0.714	89.8
3.0	100.0-140.0	76.07	35.0	0.176	0.889	96.0
2.0	146.0-216.0	14.10	20.0	0.101	0.990	99.5
1.0	238.0-254.0	28.21	2.0	0.010	1.000	100.0

TABLE B-35

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
66.0	2.0- 2.0	20.75	717.0	0.642	0.642	93.5
55.0	3.0- 3.0	24.90	370.0	0.332	0.974	99.4
47.0	4.0- 4.0	29.13	11.0	0.010	0.984	99.7
41.0	5.0- 5.0	33.40	11.0	0.010	0.994	99.9
37.0	6.0- 6.0	37.01	4.0	0.004	0.997	99.9
30.0	8.0- 8.0	45.64	2.0	0.002	0.999	100.0
24.0	11.0- 11.0	57.05	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
47.0	4.0- 4.0	14.57	268.0	0.402	0.402	87.2
41.0	5.0- 5.0	16.70	205.0	0.307	0.709	94.0
37.0	6.0- 6.0	18.50	100.0	0.150	0.859	96.5
33.0	7.0- 7.0	20.75	13.0	0.019	0.879	97.8
30.0	8.0- 8.0	22.82	39.0	0.058	0.937	98.8
28.0	9.0- 9.0	24.45	18.0	0.027	0.964	99.2
25.0	10.0- 10.0	27.39	8.0	0.012	0.976	99.5
24.0	11.0- 11.0	28.53	1.0	0.001	0.978	99.6
22.0	12.0- 12.0	31.12	5.0	0.007	0.985	99.7
21.0	13.0- 13.0	32.60	3.0	0.004	0.990	99.8
19.0	14.0- 14.0	36.03	4.0	0.006	0.996	99.9
17.0	16.0- 16.0	40.27	1.0	0.001	0.997	99.9
14.0	21.0- 21.0	48.90	1.0	0.001	0.999	100.0
13.0	23.0- 23.0	52.66	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 30.0 CM.						
33.0	7.0- 7.0	13.83	48.0	0.119	0.119	80.5
30.0	8.0- 8.0	15.21	101.0	0.250	0.369	87.4
28.0	9.0- 9.0	16.30	106.0	0.262	0.631	91.0
25.0	10.0- 10.0	18.26	29.0	0.072	0.703	94.3
24.0	11.0- 11.0	19.02	13.0	0.032	0.735	95.3
22.0	12.0- 12.0	20.75	32.0	0.079	0.814	97.3
21.0	13.0- 13.0	21.73	35.0	0.087	0.901	98.1
19.0	14.0- 14.0	24.02	9.0	0.022	0.923	98.9
18.0	15.0- 15.0	25.36	10.0	0.025	0.948	99.3
17.0	16.0- 17.0	26.85	13.0	0.032	0.980	99.5
15.0	19.0- 19.0	30.43	1.0	0.002	0.983	99.7
14.0	21.0- 21.0	32.60	1.0	0.002	0.985	99.8
13.0	22.0- 23.0	35.11	4.0	0.010	0.995	99.9
11.0	26.0- 27.0	41.49	2.0	0.005	1.000	100.0

TABLE B-35 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 40.0 CM.						
25.0	10.0- 10.0	13.69	30.0	0.109	0.109	79.0
24.0	11.0- 11.0	14.26	64.0	0.234	0.343	81.8
22.0	12.0- 12.0	15.56	31.0	0.113	0.456	86.2
21.0	13.0- 13.0	16.30	28.0	0.102	0.558	88.1
19.0	14.0- 14.0	18.02	18.0	0.066	0.624	91.5
18.0	15.0- 15.0	19.02	7.0	0.026	0.650	93.1
17.0	16.0- 17.0	20.14	26.0	0.095	0.745	94.8
16.0	18.0- 18.0	21.39	24.0	0.088	0.832	96.0
15.0	19.0- 19.0	22.82	9.0	0.033	0.865	96.9
14.0	20.0- 21.0	24.45	9.0	0.033	0.898	97.6
13.0	22.0- 23.0	26.33	5.0	0.018	0.916	98.2
12.0	24.0- 25.0	28.53	2.0	0.007	0.923	98.8
11.0	26.0- 28.0	31.12	9.0	0.033	0.956	99.4
10.0	29.0- 31.0	34.23	6.0	0.022	0.978	99.7
9.0	32.0- 34.0	38.03	5.0	0.018	0.996	100.0
8.0	37.0- 37.0	42.79	1.0	0.004	1.000	100.0
APPLIED DEPTH IS 50.0 CM.						
19.0	14.0- 14.0	14.41	17.0	0.083	0.083	78.1
18.0	15.0- 15.0	15.21	32.0	0.157	0.240	82.0
17.0	16.0- 17.0	16.11	56.0	0.275	0.515	85.4
16.0	18.0- 18.0	17.12	5.0	0.025	0.539	87.5
15.0	19.0- 19.0	18.26	10.0	0.049	0.588	89.7
14.0	20.0- 21.0	19.56	11.0	0.054	0.642	91.9
13.0	22.0- 23.0	21.07	20.0	0.098	0.740	94.1
12.0	24.0- 25.0	22.82	12.0	0.059	0.799	95.8
11.0	26.0- 28.0	24.90	15.0	0.074	0.873	97.2
10.0	30.0- 31.0	27.39	3.0	0.015	0.887	98.2
9.0	32.0- 35.0	30.43	10.0	0.049	0.936	99.2
8.0	36.0- 40.0	34.23	12.0	0.059	0.995	99.9
7.0	42.0- 42.0	39.12	1.0	0.005	1.000	100.0
APPLIED DEPTH IS 60.0 CM.						
15.0	19.0- 19.0	15.21	22.0	0.110	0.110	79.9
14.0	20.0- 21.0	16.30	67.0	0.335	0.445	84.8
13.0	22.0- 23.0	17.55	19.0	0.095	0.540	87.8
12.0	24.0- 25.0	19.02	19.0	0.095	0.635	90.6
11.0	26.0- 28.0	20.75	19.0	0.095	0.730	93.0

TABLE B-35 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
10.0	29.0- 31.0	22.82	14.0	0.070	0.800	95.0
9.0	32.0- 32.0	25.36	3.0	0.015	0.815	96.6
8.0	36.0- 41.0	28.53	15.0	0.075	0.890	98.4
7.0	42.0- 47.0	32.60	17.0	0.085	0.975	99.7
6.0	48.0- 49.0	38.03	4.0	0.020	0.995	100.0

TABLE B-36

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
APPLIED DEPTH IS 10.0 CM.						
66.0	2.0- 2.0	20.75	591.0	0.593	0.593	89.9
55.0	3.0- 3.0	24.90	299.0	0.300	0.893	96.0
47.0	4.0- 4.0	29.13	25.0	0.025	0.918	97.1
41.0	5.0- 5.0	33.40	14.0	0.014	0.932	97.9
37.0	6.0- 6.0	37.01	15.0	0.015	0.947	98.4
33.0	7.0- 7.0	41.49	13.0	0.013	0.960	98.9
30.0	8.0- 8.0	45.64	3.0	0.003	0.963	99.1
28.0	9.0- 9.0	48.90	12.0	0.012	0.975	99.3
25.0	10.0- 10.0	54.77	7.0	0.007	0.982	99.6
24.0	11.0- 11.0	57.05	5.0	0.005	0.987	99.6
22.0	12.0- 12.0	62.24	3.0	0.003	0.990	99.7
21.0	13.0- 13.0	65.20	1.0	0.001	0.991	99.7
19.0	14.0- 14.0	72.07	2.0	0.002	0.993	99.8
17.0	16.0- 17.0	80.54	2.0	0.002	0.995	99.9
14.0	21.0- 21.0	97.80	1.0	0.001	0.996	99.9
13.0	22.0- 23.0	5.33	2.0	0.002	0.998	100.0
12.0	24.0- 24.0	14.10	1.0	0.001	0.999	100.0
10.0	30.0- 30.0	36.93	1.0	0.001	1.000	100.0
APPLIED DEPTH IS 20.0 CM.						
47.0	4.0- 4.0	14.57	3.0	0.009	0.009	50.8
41.0	5.0- 5.0	16.70	4.0	0.012	0.021	58.1
37.0	6.0- 6.0	18.50	8.0	0.024	0.046	64.1
33.0	7.0- 7.0	20.75	6.0	0.018	0.064	71.3
30.0	8.0- 8.0	22.82	3.0	0.009	0.073	77.8
28.0	9.0- 9.0	24.45	59.0	0.179	0.252	82.8
25.0	10.0- 10.0	27.39	112.0	0.340	0.593	89.7
24.0	11.0- 11.0	28.53	35.0	0.106	0.699	90.9
22.0	12.0- 12.0	31.12	23.0	0.070	0.769	92.8
21.0	13.0- 13.0	32.60	8.0	0.024	0.793	93.5
19.0	14.0- 14.0	36.03	10.0	0.030	0.824	95.0
18.0	15.0- 15.0	38.03	8.0	0.024	0.848	95.7
17.0	16.0- 17.0	40.27	12.0	0.036	0.884	96.3
16.0	18.0- 18.0	42.79	5.0	0.015	0.900	96.8
15.0	19.0- 19.0	45.64	1.0	0.003	0.903	97.2
14.0	20.0- 21.0	48.90	5.0	0.015	0.918	97.7
13.0	22.0- 23.0	52.66	6.0	0.018	0.936	98.1
12.0	24.0- 25.0	57.05	6.0	0.018	0.954	98.5
11.0	26.0- 26.0	62.24	2.0	0.006	0.960	98.7

TABLE B-36 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
9.0	32.0- 33.0	76.07	3.0	0.009	0.970	99.2
8.0	36.0- 37.0	85.58	2.0	0.006	0.976	99.5
7.0	45.0- 47.0	97.80	2.0	0.006	0.982	99.7
6.0	54.0- 55.0	14.10	3.0	0.009	0.991	99.9
5.0	65.0- 67.0	36.93	2.0	0.006	0.997	100.0
APPLIED DEPTH IS 30.0 CM.						
28.0	9.0- 9.0	16.30	5.0	0.025	0.025	54.0
25.0	10.0- 10.0	18.26	1.0	0.005	0.030	60.1
22.0	12.0- 12.0	20.75	1.0	0.005	0.035	67.9
21.0	13.0- 13.0	21.73	2.0	0.010	0.045	70.9
19.0	14.0- 14.0	24.02	4.0	0.020	0.065	77.8
18.0	15.0- 15.0	25.36	26.0	0.130	0.195	81.8
17.0	16.0- 17.0	26.85	63.0	0.315	0.510	85.4
16.0	18.0- 18.0	28.53	12.0	0.060	0.570	87.5
15.0	19.0- 19.0	30.43	15.0	0.075	0.645	89.5
14.0	20.0- 21.0	32.60	14.0	0.070	0.715	91.3
13.0	22.0- 23.0	35.11	9.0	0.045	0.760	92.8
12.0	24.0- 25.0	38.03	7.0	0.035	0.795	94.1
11.0	26.0- 28.0	41.49	11.0	0.055	0.850	95.4
10.0	29.0- 31.0	45.64	6.0	0.030	0.880	96.4
9.0	32.0- 34.0	50.71	4.0	0.020	0.900	97.3
8.0	38.0- 41.0	57.05	4.0	0.020	0.920	98.1
7.0	42.0- 47.0	65.20	5.0	0.025	0.945	98.9
6.0	48.0- 56.0	76.07	5.0	0.025	0.970	99.6
5.0	62.0- 70.0	91.28	5.0	0.025	0.995	100.0
APPLIED DEPTH IS 40.0 CM.						
11.0	26.0- 26.0	31.12	1.0	0.005	0.005	72.7
10.0	31.0- 31.0	34.23	9.0	0.045	0.050	79.5
9.0	32.0- 35.0	38.03	81.0	0.405	0.455	87.3
8.0	36.0- 40.0	42.79	49.0	0.245	0.700	91.9
7.0	42.0- 47.0	48.90	16.0	0.080	0.780	94.4
6.0	49.0- 57.0	57.05	9.0	0.045	0.825	96.4
5.0	58.0- 70.0	68.46	9.0	0.045	0.870	98.3
4.0	71.0- 90.0	85.58	17.0	0.085	0.955	100.0
APPLIED DEPTH IS 50.0 CM.						
8.0	41.0- 41.0	34.23	1.0	0.005	0.005	71.6
7.0	42.0- 47.0	39.12	75.0	0.375	0.380	81.6

TABLE B-36 (CONTINUED)

APPL/YR	RANGE OF DAYS ON BED	SQFT/ LB	NUMBER OCCUR	PROB	ACCUM PROB	PI
6.0	48.0- 57.0	45.64	65.0	0.325	0.705	88.7
5.0	58.0- 70.0	54.77	10.0	0.050	0.755	92.1
4.0	71.0- 90.0	68.46	15.0	0.075	0.830	96.0
3.0	95.0-124.0	91.28	32.0	0.160	0.990	100.0
APPLIED DEPTH IS 60.0 CM.						
6.0	53.0- 57.0	38.03	66.0	0.330	0.330	80.1
5.0	58.0- 69.0	45.64	64.0	0.320	0.650	88.6
4.0	75.0- 90.0	57.05	8.0	0.040	0.690	93.4
3.0	96.0-129.0	76.07	53.0	0.265	0.955	100.0

APPENDIX C

Optimum Depthes of Application for Sludge Dewatered in Six Selected Cities Under Different Cost Ratio C_2/C_1.

TABLE C- 1

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (98.7)	15.0	15.0	10.0	10.0
0.02	15.0 (95.6)	15.0	15.0	15.0	10.0
0.03	15.0 (95.6)	20.0	15.0	15.0	10.0
0.04	15.0 (95.6)	20.0	15.0	15.0	10.0
0.05	20.0 (94.2)	20.0	20.0	15.0	10.0
0.06	20.0 (94.2)	20.0	20.0	15.0	10.0
0.07	30.0 (89.0)	20.0	20.0	15.0	10.0
0.08	30.0 (89.0)	20.0	25.0	25.0	10.0
0.09	30.0 (89.0)	20.0	25.0	25.0	30.0
0.10	30.0 (89.0)	20.0	25.0	25.0	30.0
0.11	35.0 (89.1)	20.0	25.0	25.0	30.0
0.12	35.0 (89.1)	25.0	25.0	25.0	30.0
0.13	35.0 (89.1)	35.0	25.0	25.0	30.0
0.14	35.0 (89.1)	35.0	25.0	25.0	30.0
0.15	35.0 (89.1)	35.0	25.0	25.0	30.0
0.16	35.0 (89.1)	35.0	25.0	25.0	30.0
0.17	35.0 (89.1)	35.0	25.0	25.0	30.0
0.18	35.0 (89.1)	35.0	25.0	25.0	30.0
0.19	35.0 (89.1)	35.0	25.0	25.0	30.0
0.20	35.0 (89.1)	35.0	25.0	25.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 2

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (97.3)	10.0	10.0	10.0	10.0
0.02	10.0 (97.3)	10.0	1C.0	10.0	10.0
0.03	10.0 (97.3)	10.0	10.0	10.0	10.0
0.04	10.0 (97.3)	15.0	10.0	10.0	10.0
0.05	10.0 (97.3)	15.0	10.0	10.0	10.0
0.06	15.0 (95.1)	15.0	15.0	15.0	10.0
0.07	15.0 (95.1)	15.0	15.0	15.0	10.0
0.08	15.0 (95.1)	15.0	15.0	15.0	10.0
0.09	15.0 (95.1)	15.0	15.0	15.0	10.0
0.10	15.0 (95.1)	15.0	15.0	15.0	10.0
0.11	15.0 (95.1)	15.0	15.0	15.0	10.0
0.12	15.0 (95.1)	15.0	15.0	15.0	10.0
0.13	15.0 (95.1)	15.0	15.0	15.0	10.0
0.14	15.0 (95.1)	15.0	15.0	15.0	10.0
0.15	15.0 (95.1)	15.0	15.0	15.0	30.0
0.16	15.0 (95.1)	15.0	15.0	15.0	30.0
0.17	15.0 (95.1)	20.0	15.0	15.0	30.0
0.18	15.0 (95.1)	20.0	15.0	15.0	30.0
0.19	15.0 (95.1)	20.0	15.0	15.0	30.0
0.20	15.0 (95.1)	20.0	15.0	15.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 3

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.4)	10.0	10.0	10.0	10.0
0.02	10.0 (96.4)	10.0	10.0	10.0	10.0
0.03	10.0 (96.4)	10.0	10.0	10.0	10.0
0.04	10.0 (96.4)	10.0	10.0	10.0	10.0
0.05	10.0 (96.4)	10.0	10.0	10.0	10.0
0.06	10.0 (96.4)	10.0	10.0	10.0	10.0
0.07	10.0 (96.4)	10.0	10.0	10.0	10.0
0.08	10.0 (96.4)	15.0	10.0	10.0	10.0
0.09	15.0 (92.4)	15.0	10.0	10.0	10.0
0.10	15.0 (92.4)	15.0	15.0	10.0	10.0
0.11	15.0 (92.4)	15.0	15.0	10.0	10.0
0.12	15.0 (92.4)	15.0	15.0	15.0	10.0
0.13	15.0 (92.4)	15.0	15.0	15.0	30.0
0.14	15.0 (92.4)	15.0	15.0	15.0	30.0
0.15	15.0 (92.4)	15.0	15.0	15.0	30.0
0.16	15.0 (92.4)	15.0	15.0	15.0	30.0
0.17	15.0 (92.4)	15.0	15.0	15.0	30.0
0.18	15.0 (92.4)	15.0	15.0	15.0	30.0
0.19	15.0 (92.4)	15.0	15.0	15.0	30.0
0.20	15.0 (92.4)	15.0	15.0	15.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 4

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (95.6)	10.0	10.0	10.0	10.0
0.02	10.0 (95.6)	10.0	10.0	10.0	10.0
0.03	10.0 (95.6)	15.0	10.0	10.0	10.0
0.04	10.0 (95.6)	15.0	15.0	10.0	10.0
0.05	15.0 (93.7)	15.0	15.0	10.0	10.0
0.06	15.0 (93.7)	15.0	15.0	15.0	10.0
0.07	15.0 (93.7)	15.0	15.0	15.0	10.0
0.08	15.0 (93.7)	15.0	15.0	15.0	10.0
0.09	15.0 (93.7)	15.0	15.0	15.0	10.0
0.10	15.0 (93.7)	20.0	15.0	15.0	10.0
0.11	15.0 (93.7)	35.0	15.0	30.0	10.0
0.12	15.0 (93.7)	35.0	15.0	30.0	35.0
0.13	30.0 (95.1)	35.0	15.0	30.0	35.0
0.14	30.0 (95.1)	35.0	30.0	30.0	35.0
0.15	30.0 (95.1)	35.0	30.0	30.0	35.0
0.16	30.0 (95.1)	35.0	30.0	30.0	35.0
0.17	30.0 (95.1)	35.0	30.0	30.0	35.0
0.18	30.0 (95.1)	35.0	30.0	30.0	35.0
0.19	30.0 (95.1)	35.0	30.0	30.0	35.0
0.20	30.0 (95.1)	35.0	30.0	30.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 5

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	15.0 (97.2)	15.0	20.0	15.0	10.0
0.02	15.0 (97.2)	20.0	20.0	15.0	10.0
0.03	25.0 (93.5)	25.0	20.0	20.0	10.0
0.04	25.0 (93.5)	25.0	30.0	20.0	25.0
0.05	25.0 (93.5)	25.0	30.0	20.0	25.0
0.06	30.0 (94.8)	35.0	30.0	25.0	25.0
0.07	30.0 (94.8)	35.0	30.0	25.0	25.0
0.08	35.0 (94.4)	35.0	30.0	30.0	25.0
0.09	35.0 (94.4)	35.0	30.0	30.0	25.0
0.10	35.0 (94.4)	35.0	30.0	30.0	25.0
0.11	35.0 (94.4)	35.0	30.0	30.0	25.0
0.12	35.0 (94.4)	35.0	30.0	30.0	25.0
0.13	35.0 (94.4)	35.0	30.0	35.0	25.0
0.14	35.0 (94.4)	35.0	30.0	35.0	25.0
0.15	35.0 (94.4)	35.0	30.0	35.0	25.0
0.16	35.0 (94.4)	35.0	35.0	35.0	25.0
0.17	35.0 (94.4)	35.0	35.0	35.0	25.0
0.18	35.0 (94.4)	35.0	35.0	35.0	25.0
0.19	35.0 (94.4)	35.0	35.0	35.0	35.0
0.20	35.0 (94.4)	35.0	35.0	35.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 6

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY AND ACTIVATED ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (97.6)	10.0	10.0	10.0	10.0
0.02	10.0 (97.6)	15.0	10.0	10.0	10.0
0.03	10.0 (97.6)	15.0	15.0	10.0	10.0
0.04	15.0 (95.0)	15.0	15.0	15.0	10.0
0.05	20.0 (92.4)	20.0	15.0	15.0	10.0
0.06	20.0 (92.4)	20.0	20.0	15.0	10.0
0.07	20.0 (92.4)	25.0	20.0	15.0	10.0
0.08	20.0 (92.4)	25.0	20.0	15.0	10.0
0.09	20.0 (92.4)	25.0	25.0	15.0	10.0
0.10	20.0 (92.4)	25.0	25.0	15.0	25.0
0.11	20.0 (92.4)	25.0	25.0	15.0	25.0
0.12	25.0 (93.7)	25.0	25.0	25.0	25.0
0.13	25.0 (93.7)	25.0	25.0	25.0	25.0
0.14	25.0 (93.7)	25.0	25.0	25.0	25.0
0.15	30.0 (90.0)	25.0	25.0	25.0	25.0
0.16	30.0 (90.0)	25.0	25.0	25.0	25.0
0.17	30.0 (90.0)	30.0	25.0	25.0	30.0
0.18	30.0 (90.0)	30.0	25.0	25.0	30.0
0.19	30.0 (90.0)	30.0	25.0	25.0	30.0
0.20	30.0 (90.0)	30.0	25.0	25.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 7

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.1)	10.0	10.0	10.0	10.0
0.02	10.0 (96.1)	10.0	10.0	10.0	10.0
0.03	10.0 (96.1)	10.0	10.0	10.0	10.0
0.04	10.0 (96.1)	10.0	10.0	10.0	10.0
0.05	10.0 (96.1)	15.0	10.0	10.0	10.0
0.06	10.0 (96.1)	15.0	10.0	10.0	10.0
0.07	15.0 (92.9)	15.0	10.0	10.0	10.0
0.08	15.0 (92.9)	15.0	10.0	10.0	10.0
0.09	15.0 (92.9)	15.0	10.0	10.0	10.0
0.10	15.0 (92.9)	15.0	15.0	15.0	10.0
0.11	20.0 (89.4)	15.0	15.0	15.0	10.0
0.12	20.0 (89.4)	15.0	15.0	15.0	10.0
0.13	20.0 (89.4)	15.0	15.0	15.0	25.0
0.14	20.0 (89.4)	15.0	15.0	15.0	25.0
0.15	20.0 (89.4)	15.0	15.0	15.0	25.0
0.16	20.0 (89.4)	15.0	15.0	15.0	25.0
0.17	20.0 (89.4)	15.0	15.0	15.0	25.0
0.18	20.0 (89.4)	15.0	15.0	15.0	25.0
0.19	20.0 (89.4)	15.0	25.0	15.0	25.0
0.20	20.0 (89.4)	15.0	25.0	15.0	25.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 8

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (92.2)	10.0	10.0	10.0	20.0
0.02	10.0 (92.2)	10.0	10.0	10.0	20.0
0.03	10.0 (92.2)	10.0	10.0	10.0	20.0
0.04	10.0 (92.2)	10.0	10.0	10.0	20.0
0.05	10.0 (92.2)	10.0	10.0	10.0	20.0
0.06	10.0 (92.2)	10.0	10.0	10.0	20.0
0.07	10.0 (92.2)	10.0	10.0	10.0	20.0
0.08	10.0 (92.2)	10.0	10.0	10.0	20.0
0.09	10.0 (92.2)	10.0	10.0	10.0	20.0
0.10	10.0 (92.2)	10.0	10.0	10.0	20.0
0.11	10.0 (92.2)	10.0	10.0	10.0	20.0
0.12	10.0 (92.2)	10.0	10.0	10.0	20.0
0.13	10.0 (92.2)	10.0	10.0	10.0	20.0
0.14	10.0 (92.2)	10.0	10.0	10.0	20.0
0.15	10.0 (92.2)	10.0	10.0	10.0	20.0
0.16	10.0 (92.2)	10.0	10.0	10.0	20.0
0.17	10.0 (92.2)	10.0	10.0	10.0	20.0
0.18	10.0 (92.2)	10.0	10.0	10.0	20.0
0.19	10.0 (92.2)	10.0	10.0	10.0	20.0
0.20	10.0 (92.2)	10.0	10.0	10.0	20.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C- 9

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (90.4)	10.0	10.0	10.0	20.0
0.02	10.0 (90.4)	10.0	10.0	10.0	20.0
0.03	10.0 (90.4)	10.0	10.0	10.0	20.0
0.04	10.0 (90.4)	10.0	10.0	10.0	20.0
0.05	10.0 (90.4)	10.0	10.0	10.0	20.0
0.06	10.0 (90.4)	10.0	10.0	10.0	20.0
0.07	10.0 (90.4)	10.0	10.0	10.0	20.0
0.08	10.0 (90.4)	10.0	10.0	10.0	20.0
0.09	10.0 (90.4)	10.0	10.0	10.0	20.0
0.10	10.0 (90.4)	10.0	10.0	10.0	20.0
0.11	10.0 (90.4)	10.0	10.0	10.0	20.0
0.12	10.0 (90.4)	10.0	10.0	10.0	20.0
0.13	10.0 (90.4)	10.0	10.0	10.0	20.0
0.14	10.0 (90.4)	10.0	10.0	10.0	20.0
0.15	10.0 (90.4)	10.0	10.0	10.0	20.0
0.16	10.0 (90.4)	10.0	10.0	10.0	20.0
0.17	10.0 (90.4)	10.0	10.0	20.0	20.0
0.18	10.0 (90.4)	10.0	10.0	20.0	20.0
0.19	10.0 (90.4)	10.0	10.0	20.0	20.0
0.20	10.0 (90.4)	10.0	10.0	20.0	20.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-10

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (91.8)	10.0	10.0	10.0	20.0
0.02	10.0 (91.8)	10.0	10.0	10.0	20.0
0.03	10.0 (91.8)	10.0	10.0	10.0	20.0
0.04	10.0 (91.8)	10.0	10.0	10.0	20.0
0.05	10.0 (91.8)	10.0	10.0	10.0	20.0
0.06	10.0 (91.8)	10.0	10.0	10.0	20.0
0.07	10.0 (91.8)	10.0	10.0	10.0	20.0
0.08	10.0 (91.8)	10.0	10.0	10.0	20.0
0.09	10.0 (91.8)	10.0	10.0	10.0	20.0
0.10	10.0 (91.8)	10.0	10.0	10.0	20.0
0.11	10.0 (91.8)	10.0	10.0	20.0	20.0
0.12	10.0 (91.8)	20.0	10.0	20.0	20.0
0.13	10.0 (91.8)	20.0	10.0	20.0	20.0
0.14	20.0 (95.0)	20.0	10.0	20.0	20.0
0.15	20.0 (95.0)	20.0	20.0	20.0	20.0
0.16	20.0 (95.0)	20.0	20.0	20.0	20.0
0.17	20.0 (95.0)	20.0	20.0	20.0	20.0
0.18	20.0 (95.0)	20.0	20.0	20.0	20.0
0.19	20.0 (95.0)	20.0	20.0	20.0	20.0
0.20	20.0 (95.0)	20.0	20.0	20.0	20.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-11

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (97.6)	10.0	10.0	10.0	10.0
0.02	10.0 (97.6)	10.0	15.0	10.0	10.0
0.03	15.0 (95.7)	15.0	15.0	10.0	10.0
0.04	15.0 (95.7)	15.0	15.0	15.0	10.0
0.05	15.0 (95.7)	25.0	15.0	15.0	15.0
0.06	25.0 (91.6)	25.0	15.0	15.0	35.0
0.07	25.0 (91.6)	25.0	20.0	20.0	35.0
0.08	25.0 (91.6)	30.0	25.0	35.0	35.0
0.09	25.0 (91.6)	30.0	25.0	35.0	35.0
0.10	25.0 (91.6)	30.0	25.0	35.0	35.0
0.11	25.0 (91.6)	30.0	25.0	35.0	35.0
0.12	25.0 (91.6)	30.0	25.0	35.0	35.0
0.13	35.0 (95.1)	30.0	35.0	35.0	35.0
0.14	35.0 (95.1)	30.0	35.0	35.0	35.0
0.15	35.0 (95.1)	30.0	35.0	35.0	35.0
0.16	35.0 (95.1)	30.0	35.0	35.0	35.0
0.17	35.0 (95.1)	30.0	35.0	35.0	35.0
0.18	35.0 (95.1)	30.0	35.0	35.0	35.0
0.19	35.0 (95.1)	30.0	35.0	35.0	35.0
0.20	35.0 (95.1)	30.0	35.0	35.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-12

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY AND TRICKLING FILTER ANAEROBICALLY DIG.

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (93.8)	10.0	10.0	10.0	30.0
0.02	10.0 (93.8)	10.0	10.0	10.0	30.0
0.03	10.0 (93.8)	10.0	10.0	10.0	30.0
0.04	10.0 (93.8)	10.0	10.0	10.0	30.0
0.05	10.0 (93.8)	15.0	10.0	10.0	30.0
0.06	10.0 (93.8)	15.0	10.0	10.0	30.0
0.07	15.0 (91.5)	15.0	15.0	10.0	30.0
0.08	15.0 (91.5)	15.0	15.0	10.0	30.0
0.09	15.0 (91.5)	15.0	15.0	10.0	30.0
0.10	20.0 (89.3)	15.0	15.0	10.0	30.0
0.11	20.0 (89.3)	15.0	15.0	10.0	30.0
0.12	20.0 (89.3)	15.0	15.0	10.0	30.0
0.13	20.0 (89.3)	20.0	15.0	15.0	30.0
0.14	20.0 (89.3)	20.0	15.0	15.0	30.0
0.15	20.0 (89.3)	20.0	15.0	15.0	30.0
0.16	20.0 (89.3)	20.0	15.0	15.0	30.0
0.17	20.0 (89.3)	20.0	15.0	15.0	30.0
0.18	30.0 (83.7)	20.0	15.0	20.0	30.0
0.19	30.0 (83.7)	20.0	15.0	20.0	30.0
0.20	30.0 (83.7)	20.0	15.0	20.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-13

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (97.3)	5.0	5.0	5.0	25.0
0.02	5.0 (97.3)	20.0	20.0	5.0	25.0
0.03	5.0 (97.3)	20.0	20.0	20.0	25.0
0.04	10.0 (90.6)	20.0	20.0	20.0	25.0
0.05	10.0 (90.6)	20.0	20.0	20.0	25.0
0.06	10.0 (90.6)	20.0	20.0	20.0	25.0
0.07	25.0 (100.0)	20.0	20.0	20.0	25.0
0.08	25.0 (100.0)	20.0	20.0	20.0	25.0
0.09	25.0 (100.0)	20.0	20.0	25.0	25.0
0.10	25.0 (100.0)	20.0	20.0	25.0	25.0
0.11	25.0 (100.0)	20.0	20.0	25.0	25.0
0.12	25.0 (100.0)	20.0	20.0	25.0	25.0
0.13	25.0 (100.0)	20.0	20.0	25.0	25.0
0.14	25.0 (100.0)	20.0	20.0	25.0	25.0
0.15	25.0 (100.0)	20.0	20.0	25.0	25.0
0.16	25.0 (100.0)	20.0	20.0	25.0	25.0
0.17	25.0 (100.0)	20.0	20.0	25.0	25.0
0.18	25.0 (100.0)	20.0	20.0	25.0	25.0
0.19	25.0 (100.0)	20.0	20.0	25.0	25.0
0.20	25.0 (100.0)	20.0	20.0	25.0	25.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-14

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (99.8)	5.0	5.0	5.0	5.0
0.02	5.0 (99.8)	5.0	5.0	5.0	5.0
0.03	5.0 (99.8)	5.0	5.0	5.0	5.0
0.04	5.0 (99.8)	5.0	5.0	5.0	5.0
0.05	5.0 (99.8)	5.0	5.0	5.0	5.0
0.06	5.0 (99.8)	5.0	5.0	5.0	5.0
0.07	10.0 (80.4)	5.0	5.0	5.0	15.0
0.08	10.0 (80.4)	5.0	5.0	5.0	15.0
0.09	10.0 (80.4)	5.0	5.0	5.0	15.0
0.10	10.0 (80.4)	5.0	5.0	5.0	15.0
0.11	10.0 (80.4)	5.0	5.0	5.0	15.0
0.12	10.0 (80.4)	5.0	5.0	5.0	15.0
0.13	10.0 (80.4)	5.0	5.0	5.0	15.0
0.14	10.0 (80.4)	5.0	5.0	5.0	15.0
0.15	10.0 (80.4)	5.0	5.0	5.0	15.0
0.16	10.0 (80.4)	5.0	5.0	5.0	15.0
0.17	10.0 (80.4)	5.0	5.0	5.0	15.0
0.18	10.0 (80.4)	5.0	15.0	15.0	15.0
0.19	10.0 (80.4)	15.0	15.0	15.0	15.0
0.20	10.0 (80.4)	15.0	15.0	15.0	15.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-15

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (93.3)	5.0	5.0	5.0	10.0
0.02	5.0 (93.3)	5.0	5.0	5.0	10.0
0.03	5.0 (93.3)	5.0	5.0	5.0	10.0
0.04	5.0 (93.3)	5.0	5.0	5.0	10.0
0.05	5.0 (93.3)	5.0	5.0	5.0	10.0
0.06	5.0 (93.3)	5.0	5.0	5.0	10.0
0.07	5.0 (93.3)	5.0	5.0	5.0	10.0
0.08	5.0 (93.3)	5.0	5.0	5.0	10.0
0.09	5.0 (93.3)	5.0	5.0	5.0	10.0
0.10	5.0 (93.3)	5.0	5.0	5.0	10.0
0.11	5.0 (93.3)	5.0	5.0	5.0	10.0
0.12	5.0 (93.3)	5.0	5.0	5.0	10.0
0.13	5.0 (93.3)	5.0	5.0	5.0	10.0
0.14	5.0 (93.3)	5.0	5.0	5.0	10.0
0.15	5.0 (93.3)	5.0	5.0	5.0	10.0
0.16	5.0 (93.3)	5.0	5.0	5.0	10.0
0.17	5.0 (93.3)	5.0	5.0	5.0	10.0
0.18	5.0 (93.3)	5.0	5.0	5.0	10.0
0.19	5.0 (93.3)	5.0	5.0	5.0	10.0
0.20	5.0 (93.3)	5.0	5.0	5.0	10.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-16

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (93.6)	5.0	5.0	5.0	15.0
0.02	5.0 (93.6)	5.0	5.0	5.0	15.0
0.03	5.0 (93.6)	5.0	5.0	5.0	15.0
0.04	5.0 (93.6)	5.0	5.0	5.0	15.0
0.05	5.0 (93.6)	5.0	5.0	5.0	15.0
0.06	5.0 (93.6)	5.0	15.0	5.0	15.0
0.07	5.0 (93.6)	15.0	15.0	5.0	15.0
0.08	15.0 (100.0)	15.0	15.0	15.0	15.0
0.09	15.0 (100.0)	15.0	15.0	15.0	15.0
0.10	15.0 (100.0)	15.0	15.0	15.0	15.0
0.11	15.0 (100.0)	15.0	15.0	15.0	15.0
0.12	15.0 (100.0)	15.0	15.0	15.0	15.0
0.13	15.0 (100.0)	15.0	15.0	15.0	15.0
0.14	15.0 (100.0)	15.0	15.0	15.0	15.0
0.15	15.0 (100.0)	15.0	15.0	15.0	15.0
0.16	15.0 (100.0)	15.0	15.0	15.0	15.0
0.17	15.0 (100.0)	15.0	15.0	15.0	15.0
0.18	15.0 (100.0)	15.0	15.0	15.0	15.0
0.19	15.0 (100.0)	15.0	15.0	15.0	15.0
0.20	15.0 (100.0)	15.0	15.0	15.0	15.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-17

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (99.2)	5.0	5.0	5.0	5.0
0.02	10.0 (95.7)	10.0	10.0	5.0	30.0
0.03	10.0 (95.7)	15.0	10.0	10.0	30.0
0.04	15.0 (95.2)	15.0	15.0	15.0	30.0
0.05	15.0 (95.2)	15.0	15.0	15.0	30.0
0.06	15.0 (95.2)	15.0	15.0	15.0	30.0
0.07	25.0 (93.0)	15.0	15.0	15.0	30.0
0.08	25.0 (93.0)	15.0	15.0	15.0	30.0
0.09	25.0 (93.0)	15.0	15.0	30.0	30.0
0.10	25.0 (93.0)	15.0	25.0	30.0	30.0
0.11	25.0 (93.0)	20.0	25.0	30.0	30.0
0.12	25.0 (93.0)	20.0	25.0	30.0	30.0
0.13	25.0 (93.0)	20.0	25.0	30.0	30.0
0.14	25.0 (93.0)	20.0	25.0	30.0	30.0
0.15	25.0 (93.0)	20.0	25.0	30.0	30.0
0.16	25.0 (93.0)	20.0	25.0	30.0	30.0
0.17	25.0 (93.0)	25.0	25.0	30.0	30.0
0.18	30.0 (100.0)	30.0	30.0	30.0	30.0
0.19	30.0 (100.0)	30.0	30.0	30.0	30.0
0.20	30.0 (100.0)	30.0	30.0	30.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-18

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - PRIMARY ANAEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	5.0 (95.2)	5.0	5.0	5.0	25.0
0.02	5.0 (95.2)	5.0	5.0	5.0	25.0
0.03	5.0 (95.2)	5.0	5.0	5.0	25.0
0.04	5.0 (95.2)	10.0	5.0	5.0	25.0
0.05	5.0 (95.2)	10.0	5.0	5.0	25.0
0.06	10.0 (92.3)	10.0	10.0	5.0	25.0
0.07	10.0 (92.3)	10.0	10.0	5.0	25.0
0.08	10.0 (92.3)	10.0	10.0	5.0	25.0
0.09	10.0 (92.3)	10.0	10.0	5.0	25.0
0.10	10.0 (92.3)	10.0	10.0	25.0	25.0
0.11	10.0 (92.3)	10.0	10.0	25.0	25.0
0.12	20.0 (81.3)	10.0	10.0	25.0	25.0
0.13	20.0 (81.3)	10.0	10.0	25.0	25.0
0.14	20.0 (81.3)	10.0	10.0	25.0	25.0
0.15	20.0 (81.3)	10.0	10.0	25.0	25.0
0.16	20.0 (81.3)	15.0	10.0	25.0	25.0
0.17	20.0 (81.3)	15.0	25.0	25.0	25.0
0.18	20.0 (81.3)	15.0	25.0	25.0	25.0
0.19	20.0 (81.3)	15.0	25.0	25.0	25.0
0.20	20.0 (81.3)	15.0	25.0	25.0	25.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-19

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.2)	10.0	10.0	10.0	10.0
0.02	10.0 (96.2)	10.0	15.0	10.0	10.0
0.03	10.0 (96.2)	15.0	15.0	10.0	10.0
0.04	15.0 (94.8)	15.0	15.0	10.0	10.0
0.05	15.0 (94.8)	35.0	15.0	10.0	35.0
0.06	25.0 (91.0)	35.0	15.0	15.0	35.0
0.07	25.0 (91.0)	35.0	20.0	15.0	35.0
0.08	25.0 (91.0)	35.0	35.0	15.0	35.0
0.09	25.0 (91.0)	35.0	35.0	15.0	35.0
0.10	25.0 (91.0)	35.0	35.0	20.0	35.0
0.11	25.0 (91.0)	35.0	35.0	20.0	35.0
0.12	25.0 (91.0)	35.0	35.0	35.0	35.0
0.13	25.0 (91.0)	35.0	35.0	35.0	35.0
0.14	25.0 (91.0)	35.0	35.0	35.0	35.0
0.15	25.0 (91.0)	35.0	35.0	35.0	35.0
0.16	25.0 (91.0)	35.0	35.0	35.0	35.0
0.17	25.0 (91.0)	35.0	35.0	35.0	35.0
0.18	25.0 (91.0)	35.0	35.0	35.0	35.0
0.19	25.0 (91.0)	35.0	35.0	35.0	35.0
0.20	25.0 (91.0)	35.0	35.0	35.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-20

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.0)	10.0	10.0	10.0	10.0
0.02	10.0 (96.0)	10.0	10.0	10.0	10.0
0.03	10.0 (96.0)	10.0	10.0	10.0	10.0
0.04	10.0 (96.0)	10.0	10.0	10.0	10.0
0.05	10.0 (96.0)	10.0	10.0	10.0	10.0
0.06	10.0 (96.0)	10.0	10.0	10.0	10.0
0.07	10.0 (96.0)	10.0	10.0	10.0	10.0
0.08	10.0 (96.0)	10.0	10.0	10.0	10.0
0.09	10.0 (96.0)	15.0	10.0	10.0	10.0
0.10	10.0 (96.0)	15.0	10.0	10.0	10.0
0.11	15.0 (92.8)	15.0	10.0	10.0	30.0
0.12	15.0 (92.8)	15.0	15.0	10.0	30.0
0.13	15.0 (92.8)	15.0	15.0	10.0	30.0
0.14	15.0 (92.8)	15.0	15.0	10.0	30.0
0.15	15.0 (92.8)	15.0	15.0	15.0	30.0
0.16	15.0 (92.8)	15.0	15.0	15.0	30.0
0.17	15.0 (92.8)	15.0	15.0	15.0	30.0
0.18	15.0 (92.8)	15.0	15.0	15.0	30.0
0.19	15.0 (92.8)	15.0	15.0	15.0	30.0
0.20	15.0 (92.8)	15.0	15.0	15.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-21

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (93.3)	10.0	10.0	10.0	10.0
0.02	10.0 (93.3)	10.0	10.0	10.0	10.0
0.03	10.0 (93.3)	10.0	10.0	10.0	10.0
0.04	10.0 (93.3)	10.0	10.0	10.0	10.0
0.05	10.0 (93.3)	10.0	10.0	10.0	10.0
0.06	10.0 (93.3)	10.0	10.0	10.0	10.0
0.07	10.0 (93.3)	10.0	10.0	10.0	15.0
0.08	10.0 (93.3)	10.0	10.0	10.0	15.0
0.09	10.0 (93.3)	10.0	10.0	10.0	15.0
0.10	10.0 (93.3)	10.0	10.0	10.0	15.0
0.11	10.0 (93.3)	10.0	10.0	10.0	15.0
0.12	10.0 (93.3)	10.0	10.0	10.0	15.0
0.13	10.0 (93.3)	10.0	10.0	10.0	15.0
0.14	10.0 (93.3)	10.0	10.0	10.0	15.0
0.15	10.0 (93.3)	10.0	10.0	10.0	15.0
0.16	10.0 (93.3)	10.0	10.0	10.0	15.0
0.17	10.0 (93.3)	10.0	10.0	10.0	15.0
0.18	10.0 (93.3)	10.0	10.0	10.0	15.0
0.19	10.0 (93.3)	15.0	10.0	10.0	15.0
0.20	10.0 (93.3)	15.0	10.0	10.0	15.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-22

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (94.6)	10.0	10.0	10.0	10.0
0.02	10.0 (94.6)	10.0	10.0	10.0	10.0
0.03	10.0 (94.6)	10.0	10.0	10.0	10.0
0.04	10.0 (94.6)	10.0	10.0	10.0	10.0
0.05	10.0 (94.6)	10.0	10.0	10.0	10.0
0.06	10.0 (94.6)	15.0	10.0	10.0	10.0
0.07	10.0 (94.6)	15.0	15.0	10.0	10.0
0.08	15.0 (92.1)	15.0	15.0	10.0	10.0
0.09	15.0 (92.1)	15.0	15.0	10.0	10.0
0.10	15.0 (92.1)	15.0	15.0	10.0	10.0
0.11	25.0 (90.1)	15.0	15.0	10.0	10.0
0.12	25.0 (90.1)	15.0	15.0	10.0	10.0
0.13	25.0 (90.1)	15.0	25.0	10.0	10.0
0.14	25.0 (90.1)	15.0	25.0	15.0	10.0
0.15	25.0 (90.1)	20.0	25.0	15.0	10.0
0.16	25.0 (90.1)	20.0	25.0	15.0	10.0
0.17	25.0 (90.1)	20.0	25.0	15.0	10.0
0.18	25.0 (90.1)	25.0	25.0	15.0	10.0
0.19	25.0 (90.1)	25.0	25.0	15.0	10.0
0.20	25.0 (90.1)	25.0	25.0	15.0	10.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-23

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	15.0 (96.9)	15.0	10.0	15.0	10.0
0.02	15.0 (96.9)	20.0	20.0	15.0	10.0
0.03	20.0 (95.4)	20.0	20.0	20.0	10.0
0.04	20.0 (95.4)	20.0	20.0	20.0	20.0
0.05	25.0 (94.8)	25.0	20.0	20.0	20.0
0.06	25.0 (94.8)	25.0	25.0	20.0	20.0
0.07	25.0 (94.8)	25.0	35.0	20.0	20.0
0.08	25.0 (94.8)	25.0	35.0	35.0	25.0
0.09	30.0 (94.5)	35.0	35.0	35.0	25.0
0.10	30.0 (94.5)	35.0	35.0	35.0	25.0
0.11	30.0 (94.5)	35.0	35.0	35.0	25.0
0.12	30.0 (94.5)	35.0	35.0	35.0	25.0
0.13	30.0 (94.5)	35.0	35.0	35.0	35.0
0.14	35.0 (95.6)	35.0	35.0	35.0	35.0
0.15	35.0 (95.6)	35.0	35.0	35.0	35.0
0.16	35.0 (95.6)	35.0	35.0	35.0	35.0
0.17	35.0 (95.6)	35.0	35.0	35.0	35.0
0.18	35.0 (95.6)	35.0	35.0	35.0	35.0
0.19	35.0 (95.6)	35.0	35.0	35.0	35.0
0.20	35.0 (95.6)	35.0	35.0	35.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-24

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ACTIVATED AEROBICALLY DIGESTED

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.0)	10.0	10.0	10.0	10.0
0.02	10.0 (96.0)	15.0	10.0	10.0	10.0
0.03	10.0 (96.0)	15.0	10.0	10.0	35.0
0.04	15.0 (93.0)	15.0	25.0	10.0	35.0
0.05	15.0 (93.0)	25.0	25.0	10.0	35.0
0.06	15.0 (93.0)	25.0	25.0	25.0	35.0
0.07	15.0 (93.0)	25.0	25.0	25.0	35.0
0.08	25.0 (95.4)	25.0	25.0	25.0	35.0
0.09	25.0 (95.4)	25.0	25.0	25.0	35.0
0.10	25.0 (95.4)	25.0	25.0	25.0	35.0
0.11	25.0 (95.4)	25.0	35.0	25.0	35.0
0.12	25.0 (95.4)	25.0	35.0	25.0	35.0
0.13	35.0 (95.4)	25.0	35.0	35.0	35.0
0.14	35.0 (95.4)	25.0	35.0	35.0	35.0
0.15	35.0 (95.4)	35.0	35.0	35.0	35.0
0.16	35.0 (95.4)	35.0	35.0	35.0	35.0
0.17	35.0 (95.4)	35.0	35.0	35.0	35.0
0.18	35.0 (95.4)	35.0	35.0	35.0	35.0
0.19	35.0 (95.4)	35.0	35.0	35.0	35.0
0.20	35.0 (95.4)	35.0	35.0	35.0	35.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-25

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (98.2)	60.0	60.0	60.0	60.0
0.02	60.0 (98.2)	60.0	60.0	60.0	60.0
0.03	60.0 (98.2)	60.0	60.0	60.0	60.0
0.04	60.0 (98.2)	60.0	60.0	60.0	60.0
0.05	60.0 (98.2)	60.0	60.0	60.0	60.0
0.06	60.0 (98.2)	60.0	60.0	60.0	60.0
0.07	60.0 (98.2)	60.0	60.0	60.0	60.0
0.08	60.0 (98.2)	60.0	60.0	60.0	60.0
0.09	60.0 (98.2)	60.0	60.0	60.0	60.0
0.10	60.0 (98.2)	60.0	60.0	60.0	60.0
0.11	60.0 (98.2)	60.0	60.0	60.0	60.0
0.12	60.0 (98.2)	60.0	60.0	60.0	60.0
0.13	60.0 (98.2)	60.0	60.0	60.0	60.0
0.14	60.0 (98.2)	60.0	60.0	60.0	60.0
0.15	60.0 (98.2)	60.0	60.0	60.0	60.0
0.16	60.0 (98.2)	60.0	60.0	60.0	60.0
0.17	60.0 (98.2)	60.0	60.0	60.0	60.0
0.18	60.0 (98.2)	60.0	60.0	60.0	60.0
0.19	60.0 (98.2)	60.0	60.0	60.0	60.0
0.20	60.0 (98.2)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-26

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (93.4)	60.0	60.0	40.0	10.0
0.02	60.0 (93.4)	60.0	60.0	60.0	10.0
0.03	60.0 (93.4)	60.0	60.0	60.0	10.0
0.04	60.0 (93.4)	60.0	60.0	60.0	10.0
0.05	60.0 (93.4)	60.0	60.0	60.0	10.0
0.06	60.0 (93.4)	60.0	60.0	60.0	10.0
0.07	60.0 (93.4)	60.0	60.0	60.0	10.0
0.08	60.0 (93.4)	60.0	60.0	60.0	10.0
0.09	60.0 (93.4)	60.0	60.0	60.0	10.0
0.10	60.0 (93.4)	60.0	60.0	60.0	10.0
0.11	60.0 (93.4)	60.0	60.0	60.0	10.0
0.12	60.0 (93.4)	60.0	60.0	60.0	10.0
0.13	60.0 (93.4)	60.0	60.0	60.0	10.0
0.14	60.0 (93.4)	60.0	60.0	60.0	10.0
0.15	60.0 (93.4)	60.0	60.0	60.0	10.0
0.16	60.0 (93.4)	60.0	60.0	60.0	10.0
0.17	60.0 (93.4)	60.0	60.0	60.0	10.0
0.18	60.0 (93.4)	60.0	60.0	60.0	10.0
0.19	60.0 (93.4)	60.0	60.0	60.0	10.0
0.20	60.0 (93.4)	60.0	60.0	60.0	10.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-27

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (92.7)	60.0	60.0	60.0	40.0
0.02	60.0 (92.7)	60.0	60.0	60.0	40.0
0.03	60.0 (92.7)	60.0	60.0	60.0	40.0
0.04	60.0 (92.7)	60.0	60.0	60.0	40.0
0.05	60.0 (92.7)	60.0	60.0	60.0	40.0
0.06	60.0 (92.7)	60.0	60.0	60.0	40.0
0.07	60.0 (92.7)	60.0	60.0	60.0	40.0
0.08	60.0 (92.7)	60.0	60.0	60.0	40.0
0.09	60.0 (92.7)	60.0	60.0	60.0	40.0
0.10	60.0 (92.7)	60.0	60.0	60.0	40.0
0.11	60.0 (92.7)	60.0	60.0	60.0	40.0
0.12	60.0 (92.7)	60.0	60.0	60.0	40.0
0.13	60.0 (92.7)	60.0	60.0	60.0	40.0
0.14	60.0 (92.7)	60.0	60.0	60.0	40.0
0.15	60.0 (92.7)	60.0	60.0	60.0	40.0
0.16	60.0 (92.7)	60.0	60.0	60.0	40.0
0.17	60.0 (92.7)	60.0	60.0	60.0	40.0
0.18	60.0 (92.7)	60.0	60.0	60.0	40.0
0.19	60.0 (92.7)	60.0	60.0	60.0	40.0
0.20	60.0 (92.7)	60.0	60.0	60.0	40.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-28

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (93.4)	60.0	60.0	60.0	60.0
0.02	60.0 (93.4)	60.0	60.0	60.0	60.0
0.03	60.0 (93.4)	60.0	60.0	60.0	60.0
0.04	60.0 (93.4)	60.0	60.0	60.0	60.0
0.05	60.0 (93.4)	60.0	60.0	60.0	60.0
0.06	60.0 (93.4)	60.0	60.0	60.0	60.0
0.07	60.0 (93.4)	60.0	60.0	60.0	60.0
0.08	60.0 (93.4)	60.0	60.0	60.0	60.0
0.09	60.0 (93.4)	60.0	60.0	60.0	60.0
0.10	60.0 (93.4)	60.0	60.0	60.0	60.0
0.11	60.0 (93.4)	60.0	60.0	60.0	60.0
0.12	60.0 (93.4)	60.0	60.0	60.0	60.0
0.13	60.0 (93.4)	60.0	60.0	60.0	60.0
0.14	60.0 (93.4)	60.0	60.0	60.0	60.0
0.15	60.0 (93.4)	60.0	60.0	60.0	60.0
0.16	60.0 (93.4)	60.0	60.0	60.0	60.0
0.17	60.0 (93.4)	60.0	60.0	60.0	60.0
0.18	60.0 (93.4)	60.0	60.0	60.0	60.0
0.19	60.0 (93.4)	60.0	60.0	60.0	60.0
0.20	60.0 (93.4)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-29

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (98.0)	60.0	60.0	60.0	60.0
0.02	60.0 (98.0)	60.0	60.0	60.0	60.0
0.03	60.0 (98.0)	60.0	60.0	60.0	60.0
0.04	60.0 (98.0)	60.0	60.0	60.0	60.0
0.05	60.0 (98.0)	60.0	60.0	60.0	60.0
0.06	60.0 (98.0)	60.0	60.0	60.0	60.0
0.07	60.0 (98.0)	60.0	60.0	60.0	60.0
0.08	60.0 (98.0)	60.0	60.0	60.0	60.0
0.09	60.0 (98.0)	60.0	60.0	60.0	60.0
0.10	60.0 (98.0)	60.0	60.0	60.0	60.0
0.11	60.0 (98.0)	60.0	60.0	60.0	60.0
0.12	60.0 (98.0)	60.0	60.0	60.0	60.0
0.13	60.0 (98.0)	60.0	60.0	60.0	60.0
0.14	60.0 (98.0)	60.0	60.0	60.0	60.0
0.15	60.0 (98.0)	60.0	60.0	60.0	60.0
0.16	60.0 (98.0)	60.0	60.0	60.0	60.0
0.17	60.0 (98.0)	60.0	60.0	60.0	60.0
0.18	60.0 (98.0)	60.0	60.0	60.0	60.0
0.19	60.0 (98.0)	60.0	60.0	60.0	60.0
0.20	60.0 (98.0)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-30

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ALUM (AMESBURY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (96.2)	60.0	60.0	60.0	50.0
0.02	60.0 (96.2)	60.0	60.0	60.0	50.0
0.03	60.0 (96.2)	60.0	60.0	60.0	50.0
0.04	60.0 (96.2)	60.0	60.0	60.0	50.0
0.05	60.0 (96.2)	60.0	60.0	60.0	50.0
0.06	60.0 (96.2)	60.0	60.0	60.0	50.0
0.07	60.0 (96.2)	60.0	60.0	60.0	50.0
0.08	60.0 (96.2)	60.0	60.0	60.0	50.0
0.09	60.0 (96.2)	60.0	60.0	60.0	50.0
0.10	60.0 (96.2)	60.0	60.0	60.0	50.0
0.11	60.0 (96.2)	60.0	60.0	60.0	50.0
0.12	60.0 (96.2)	60.0	60.0	60.0	50.0
0.13	60.0 (96.2)	60.0	60.0	60.0	50.0
0.14	60.0 (96.2)	60.0	60.0	60.0	50.0
0.15	60.0 (96.2)	60.0	60.0	60.0	50.0
0.16	60.0 (96.2)	60.0	60.0	60.0	50.0
0.17	60.0 (96.2)	60.0	60.0	60.0	50.0
0.18	60.0 (96.2)	60.0	60.0	60.0	50.0
0.19	60.0 (96.2)	60.0	60.0	60.0	50.0
0.20	60.0 (96.2)	60.0	60.0	60.0	50.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-31

LOCATION - BOISE, IDAHO
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	30.0 (95.3)	30.0	30.0	30.0	30.0
0.02	40.0 (92.5)	30.0	30.0	30.0	50.0
0.03	40.0 (92.5)	40.0	30.0	30.0	50.0
0.04	60.0 (92.3)	60.0	30.0	30.0	50.0
0.05	60.0 (92.3)	60.0	60.0	30.0	50.0
0.06	60.0 (92.3)	60.0	60.0	60.0	50.0
0.07	60.0 (92.3)	60.0	60.0	60.0	50.0
0.08	60.0 (92.3)	60.0	60.0	60.0	50.0
0.09	60.0 (92.3)	60.0	60.0	60.0	50.0
0.10	60.0 (92.3)	60.0	60.0	60.0	50.0
0.11	60.0 (92.3)	60.0	60.0	60.0	50.0
0.12	60.0 (92.3)	60.0	60.0	60.0	50.0
0.13	60.0 (92.3)	60.0	60.0	60.0	50.0
0.14	60.0 (92.3)	60.0	60.0	60.0	50.0
0.15	60.0 (92.3)	60.0	60.0	60.0	50.0
0.16	60.0 (92.3)	60.0	60.0	60.0	50.0
0.17	60.0 (92.3)	60.0	60.0	60.0	60.0
0.18	60.0 (92.3)	60.0	60.0	60.0	60.0
0.19	60.0 (92.3)	60.0	60.0	60.0	60.0
0.20	60.0 (92.3)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-32

LOCATION - BOSTON, MASSACHUSETTS
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (96.1)	60.0	60.0	60.0	20.0
0.02	60.0 (96.1)	60.0	60.0	60.0	20.0
0.03	60.0 (96.1)	60.0	60.0	60.0	20.0
0.04	60.0 (96.1)	60.0	60.0	60.0	20.0
0.05	60.0 (96.1)	60.0	60.0	60.0	20.0
0.06	60.0 (96.1)	60.0	60.0	60.0	20.0
0.07	60.0 (96.1)	60.0	60.0	60.0	20.0
0.08	60.0 (96.1)	60.0	60.0	60.0	20.0
0.09	60.0 (96.1)	60.0	60.0	60.0	20.0
0.10	60.0 (96.1)	60.0	60.0	60.0	20.0
0.11	60.0 (96.1)	60.0	60.0	60.0	20.0
0.12	60.0 (96.1)	60.0	60.0	60.0	20.0
0.13	60.0 (96.1)	60.0	60.0	60.0	20.0
0.14	60.0 (96.1)	60.0	60.0	60.0	20.0
0.15	60.0 (96.1)	60.0	60.0	60.0	20.0
0.16	60.0 (96.1)	60.0	60.0	60.0	20.0
0.17	60.0 (96.1)	60.0	60.0	60.0	20.0
0.18	60.0 (96.1)	60.0	60.0	60.0	20.0
0.19	60.0 (96.1)	60.0	60.0	60.0	20.0
0.20	60.0 (96.1)	60.0	60.0	60.0	20.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-33

LOCATION - DULUTH, MINNESOTA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	60.0 (100.0)	60.0	60.0	60.0	60.0
0.02	60.0 (100.0)	60.0	60.0	60.0	60.0
0.03	60.0 (100.0)	60.0	60.0	60.0	60.0
0.04	60.0 (100.0)	60.0	60.0	60.0	60.0
0.05	60.0 (100.0)	60.0	60.0	60.0	60.0
0.06	60.0 (100.0)	60.0	60.0	60.0	60.0
0.07	60.0 (100.0)	60.0	60.0	60.0	60.0
0.08	60.0 (100.0)	60.0	60.0	60.0	60.0
0.09	60.0 (100.0)	60.0	60.0	60.0	60.0
0.10	60.0 (100.0)	60.0	60.0	60.0	60.0
0.11	60.0 (100.0)	60.0	60.0	60.0	60.0
0.12	60.0 (100.0)	60.0	60.0	60.0	60.0
0.13	60.0 (100.0)	60.0	60.0	60.0	60.0
0.14	60.0 (100.0)	60.0	60.0	60.0	60.0
0.15	60.0 (100.0)	60.0	60.0	60.0	60.0
0.16	60.0 (100.0)	60.0	60.0	60.0	60.0
0.17	60.0 (100.0)	60.0	60.0	60.0	60.0
0.18	60.0 (100.0)	60.0	60.0	60.0	60.0
0.19	60.0 (100.0)	60.0	60.0	60.0	60.0
0.20	60.0 (100.0)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-34

LOCATION - MIAMI, FLORIDA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	20.0 (94.5)	20.0	20.0	20.0	30.0
0.02	30.0 (92.4)	30.0	30.0	20.0	30.0
0.03	30.0 (92.4)	30.0	30.0	30.0	30.0
0.04	30.0 (92.4)	30.0	30.0	30.0	30.0
0.05	30.0 (92.4)	30.0	30.0	30.0	30.0
0.06	30.0 (92.4)	30.0	30.0	30.0	30.0
0.07	30.0 (92.4)	30.0	30.0	30.0	30.0
0.08	30.0 (92.4)	30.0	30.0	30.0	30.0
0.09	30.0 (92.4)	30.0	30.0	30.0	30.0
0.10	40.0 (90.9)	50.0	30.0	30.0	30.0
0.11	40.0 (90.9)	50.0	30.0	30.0	30.0
0.12	50.0 (90.8)	50.0	50.0	30.0	30.0
0.13	50.0 (90.8)	50.0	50.0	50.0	30.0
0.14	50.0 (90.8)	50.0	50.0	50.0	30.0
0.15	50.0 (90.8)	50.0	50.0	50.0	30.0
0.16	50.0 (90.8)	50.0	50.0	50.0	30.0
0.17	50.0 (90.8)	50.0	50.0	50.0	30.0
0.18	50.0 (90.8)	50.0	50.0	50.0	30.0
0.19	50.0 (90.8)	50.0	50.0	50.0	30.0
0.20	50.0 (90.8)	50.0	50.0	50.0	30.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-35

LOCATION - PHOENIX, ARIZONA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	50.0 (91.9)	50.0	30.0	30.0	60.0
0.02	50.0 (91.9)	50.0	60.0	60.0	60.0
0.03	60.0 (93.0)	50.0	60.0	60.0	60.0
0.04	60.0 (93.0)	60.0	60.0	60.0	60.0
0.05	60.0 (93.0)	60.0	60.0	60.0	60.0
0.06	60.0 (93.0)	60.0	60.0	60.0	60.0
0.07	60.0 (93.0)	60.0	60.0	60.0	60.0
0.08	60.0 (93.0)	60.0	60.0	60.0	60.0
0.09	60.0 (93.0)	60.0	60.0	60.0	60.0
0.10	60.0 (93.0)	60.0	60.0	60.0	60.0
0.11	60.0 (93.0)	60.0	60.0	60.0	60.0
0.12	60.0 (93.0)	60.0	60.0	60.0	60.0
0.13	60.0 (93.0)	60.0	60.0	60.0	60.0
0.14	60.0 (93.0)	60.0	60.0	60.0	60.0
0.15	60.0 (93.0)	60.0	60.0	60.0	60.0
0.16	60.0 (93.0)	60.0	60.0	60.0	60.0
0.17	60.0 (93.0)	60.0	60.0	60.0	60.0
0.18	60.0 (93.0)	60.0	60.0	60.0	60.0
0.19	60.0 (93.0)	60.0	60.0	60.0	60.0
0.20	60.0 (93.0)	60.0	60.0	60.0	60.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS

TABLE C-36

LOCATION - SAN FRANCISCO, CALIFORNIA
TYPE OF SLUDGE - ALUM (ALBANY CHARACTERISTICS)

COST RATIO	OPTIMUM APPLICATION DEPTH (CM)				
C2/C1	EXPECTATION DRYING TIME	PERFORMANCE INDEX (PERCENT)			
		PI=85	PI=90	PI=95	PI=100
0.01	10.0 (96.0)	30.0	20.0	10.0	10.0
0.02	30.0 (92.8)	30.0	30.0	20.0	10.0
0.03	30.0 (92.8)	30.0	30.0	30.0	10.0
0.04	30.0 (92.8)	30.0	30.0	30.0	10.0
0.05	30.0 (92.8)	30.0	30.0	30.0	10.0
0.06	30.0 (92.8)	30.0	30.0	30.0	10.0
0.07	30.0 (92.8)	30.0	30.0	30.0	10.0
0.08	30.0 (92.8)	30.0	30.0	30.0	10.0
0.09	30.0 (92.8)	60.0	40.0	30.0	10.0
0.10	60.0 (93.4)	60.0	40.0	30.0	10.0
0.11	60.0 (93.4)	60.0	40.0	30.0	10.0
0.12	60.0 (93.4)	60.0	40.0	30.0	10.0
0.13	60.0 (93.4)	60.0	60.0	30.0	10.0
0.14	60.0 (93.4)	60.0	60.0	40.0	10.0
0.15	60.0 (93.4)	60.0	60.0	40.0	10.0
0.16	60.0 (93.4)	60.0	60.0	40.0	10.0
0.17	60.0 (93.4)	60.0	60.0	60.0	10.0
0.18	60.0 (93.4)	60.0	60.0	60.0	10.0
0.19	60.0 (93.4)	60.0	60.0	60.0	10.0
0.20	60.0 (93.4)	60.0	60.0	60.0	10.0

FIGURE IN PARENTHESIS REPRESENTS THE PERFORMANCE INDEX
OBTAINED BY USING EXPECTATION DRYING TIME AS BASIS