VI. SELECTING ESTABLISHMENTS WITHIN SAMPLE PSUs

Sample establishments within PSUs were selected independently in each size class using a systematic selection procedure. 5,983 establishments were selected in the initial sample. Establishments within sample PSUs were stratified by size class and 4-digit SIC. Sampling rates were applied to select establishments with less than 2,500 employees. Since the sampling rate for establishments with greater than 2,500 employees was so high, selection was done across all establishments nation-wide in these categories sequenced by zip code and 4-digit SIC. A sample of establishments not included in the survey because less than eight employees were listed for them on the DMI was interviewed, and it was found that a loss of about 5.5 percent in coverage of these small establishments existed in the NOES. This under-coverage in NOES might have existed because of growth in the number of employees in these establishments between the time the DMI was compiled and the time of the survey.

Workload control for the field interview phase of NOES was accomplished by enlarging the initial sample by 25 percent and dividing each PSU into 4 random subsamples. Each subsample was to be assigned in sequence. This was done to minimize the chance that an untimely termination of the survey would result in a non-representative sample. The enlarged sample was called the screening sample or telephone screening sample because it was comprised of establishments to be screened by telephone to determine if they were eligible or not for the survey, and if they would participate in it. If an establishment would not participate in the NOES, a suitable substitute was to be found from a sample of reserve establishments. This reserve sample was called the shadow sample.

A. The Number of Establishments

The proportion of establishments to be selected in a given size class was determined by the sampling rate $f = n_a/N_a$, where n_a was the number of establishments in size class a in the sample, and N_a was the total number of establishments in size class a.

In the NOES, sampling rates in each size class were determined from the formula:

$$f = \frac{n_a}{N_a} = \frac{S(\bar{Y}_a)C}{\left[\left(\sum_a N_a S(\bar{Y}_a)\sqrt{C_a}\right)\right]\sqrt{C_a}}$$

derived in Chapter IV (equation 5) and in Appendix D. For convenience in presentation f is expressed in terms of the sampling fraction or sampling interval $k = 1/f$. The sampling fraction is the reciprocal of the sampling rate. If all establishments in size class a were arranged in a list, the sampling fraction or interval would indicate the number of establishments passed over between selections.

Sampling fractions in each size class a were compared by the oversampling ratio $f_a = k_1/k_a$. In the NOES sampling fractions in each stratum were compared to the value k_1 for employee size class 1. The oversampling ratio is the ratio of sampling rates in each size class and indicates how much more frequent sample selection in a given size class is compared to another, in this case employee size class 1. Since fewer establishments were found to be sampled from in each successively larger size class, the sampling rate increased in each employee size class. K_a, the inverse of the sampling rate, decreased in each size class. F_a is the ratio of the sampling rate in size class a to the sampling rate in size class 1 (the size class with the lowest sampling rate) and increased with increasing sampling rates across size classes. Since f_a increased with employee size class, sample selection for establishments was proportional to size.

Values of cost C_a and variation $S(\bar{Y}_a)$ (from prior experience in the NOHS) were used to calculate sampling rates. Values of N_a, C_a, n_a, k_a, and f_a by employee size class calculated for the NOES are shown in Table 1 of Chapter IV. The sampling rates shown in Table 1 were calculated assuming that the CBP data most accurately reflected the national economy. DMI counts were not used in determining sampling rates because the DMI was known to contain listings for out-of-business firms, duplicate listings, etc.

It should be noted that according to the NOES design, selection of sample establishments with less than 2,500 employees was restricted to sample PSUs. The oversampling ratio f_a shown in Table 1 assumed selection from the total number of U.S. establishments in a given size class, however, and to obtain equal probability of selection among all establishments within each size class in the sample PSU, selection probabilities should also have taken into account the probability of selecting the sample PSU from its stratum. Selection probabilities for establishments in strata a are completely defined by the condition:

$$\frac{f_a}{k} = \left(\frac{M_{hj}}{M_h}\right) x \left(\frac{M_h}{M_{hj}} \times \frac{f_a}{k}\right)$$

equation 7 in Chapter V. The first term on the right side of the equation represents the probability of selecting the PSU from its stratum, and is 1.0 for establishments in self-representing strata, while the second term shows the probability of selecting establishments from the a^{th} size class within the PSU.

B. Selecting Establishments

1. General Plan

Sample establishments within employee size classes were selected in each of the 98 sample PSUs using a systematic selection procedure. Systematic selection was used in order to insure that sampling in each size class would be done proportional to the total number of establishments in each size category.

The 98 PSUs were first arranged in order and establishments within PSUs were stratified by employee size class. Establishments within size strata were then sequenced by 4-digit SIC code. Systematic selection in each size category was carried out using k_a (the sampling interval in size class a). The first establishment in each size category was chosen using a random number table. The next (k_a-1) establishments on the sequenced list were skipped, and the next establishment on the list was chosen as the next sample establishment. The process was repeated choosing every k_a^{th} establishment until the end of the list was reached. Note that, since the selection procedure was carried out across PSUs in a given size category, k_a was considered to be constant in each size category. This procedure was followed for size classes 1-8 and 11. For classes 9 and 10, systematic selection was applied to a list of all large U.S. establishments in each of the two size classes 2,500-4,999 and 5,000+ employees. The list for these two size classes was sequenced by zip code within 4-digit SIC.

2. Establishments in Size Classes 1-8 and 11

Systematic sampling of establishments across PSUs was done in size classes 1-8 and 11. Since the oversampling ratios f_a were considered to be constant over PSUs for each size class a, the complete set of selection probabilities in these size classes was defined when the PSU selection probabilities (M_{hj}/M_h), oversampling factors f_a, and sampling interval k_a were known. Values of f_a are shown in Table 1, values of k_a are shown in Table 1 and Table 3, and values of the PSU selection probabilities are shown in Appendix B. Size class 11 refers to those establishments for which the number of employees was not reported in the DMI, but which were reported as operating in a target SIC. Including these establishments in the survey posed a problem in defining sampling rates because the sampling rates for size classes 1-10 were derived using CBP counts and experience from the previous NOHS survey, neither of which gave any indication of the expected numbers or time required to survey firms whose number of employees were not available. It was decided to group these firms in a separate size class (size class 11) and sample them at rates equivalent to size class 1.

In self-representing (SR) PSUs, the PSU selection probabilities are 1.0, so that the selection probability of sample establishments within these PSUs was f_a/k_1. In non-self-representing (NSR) PSUs, the probability of selection for establishments within the PSU was:

$$\left(\frac{M_h}{M_{hj}}\right) \times \left(\frac{f_a}{k_1}\right)$$

3. Establishments in Size Classes 9 and 10

The proportion of establishments to be selected from size classes 9 and 10 was so large that sample efficiency would have been impaired if sampling were confined to the sample PSUs. For example, the probability of selection for establishments in size class 10 was, from Table 1 in Chapter IV:

$$\frac{f_a}{k_1} = \left(\frac{91.100}{199.53}\right) = \left(\frac{1}{2.190}\right)$$

Many of the sample PSUs in the NOES were selected with probabilities smaller than 1/2.190 (see Appendix B). For establishments in size class 10 to have been selected from the sample PSUs, however, at least 1/2.190 (about 46 percent) of the establishments in size class 10 should have been included in each sample PSU. If the sample of size class 10 establishments had been restricted to sample PSUs, it would not have been possible to obtain the desired sampling rates even if all size class 10 establishments within the PSU had been included in the survey. The problem was similar, although not as severe, for establishments in size class 9 (2,500-4,999 employees).

Location was therefore not considered in selecting the sample for the two largest size classes. Systematic selection was done across all U.S. establishments, sequenced by zip code and 4-digit SIC code. Many of these large establishments were located in or near a sample PSU, however, and could be surveyed by a team working in a nearby PSU.

4. Establishments with Fewer than Eight Employees

Although the NOES was limited to those establishments on DMI lists reporting eight or more employees and operating within the set of target SICs, rejecting facilities with seven or fewer employees as out of scope could have introduced bias into the survey. This could have occurred since the DMI employee reports were not current. Establishments not eligible to be included in the survey according to the DMI could have grown by the time of the survey to the point that they were eligible for inclusion in it. Under-coverage of smaller establishments could have been possible.

To measure this potential source of bias, a sample of 200 establishments reporting seven or fewer employees was screened over the telephone. This screening was done to determine the current number of employees and whether or not current activities were within the target SICs.

Results from the 200 telephone interviews are shown in Table 2. Eleven of these establishments actually had 8 or more employees and operated within the target SICs. This suggests a loss of about 5.5 percent in coverage of these small establishments in

TABLE 2. TELEPHONE INTERVIEWS OF 200 ESTABLISHMENTS REPORTING SEVEN OR FEWER EMPLOYEES ON THE 1980 DMI FILE NOES 1981-1983

Telephone interview reports	Number
Total	200
Non-working phone	50
No answer	3
Out of business	6
Less than 8 employees	123
Non-target SIC	2
Refusal	5
Reported 8 or more employees	11

the NOES. However, the estimation procedure used for national projections adjusted NOES levels to be consistent with the levels from the 1980 CBP (10); this reduced (although not entirely eliminated) the coverage bias.

C. Workload Control - Defining Shadow and Screening Samples

The sampling rates and expected sample sizes shown in Table 1 in Chapter IV are initial results calculated using assumptions discussed in Chapter IV, i.e., similar survey costs (as person hours) to NOHS, constant relvariance, and a field team of 21 surveyors for the survey period. These assumptions did not apply in every instance, however. For example, it was unrealistic to expect that survey teams would be equally proficient at all times, non-interview problems would not appear, the number of surveyors would remain constant over the survey period, or other scheduling problems would not arise. Some flexibility in the sample design was needed to account for problems arising during the course of the field work and to allow for the possibility that the surveyors might work faster than expected. An expanded 'screening' sample was selected and subdivided into a number of random subsamples for workload control, and a 'shadow' sample was selected in case of non-response. Screening and shadow samples were selected using DMI listings. The number of establishments selected in the initial screening and shadow samples, and their respective sampling intervals are shown in Table 3. Results if the sample could have been selected from CBP records are also shown for comparison.

The schedule for surveying sample establishments was based on a predicted length of stay determined from PSU person hour needs. All PSUs were to be covered during the expected two-year period for field work. To maintain such a schedule each team had to finish each of its survey assignments in the allotted time. However, the time per establishment was not identical in all PSUs. Since the period of time that could be spent in a PSU was fixed, a variable workload was necessary for an efficient field operation. This variable workload enabled supervisors to better react to problems in the field. The system was as follows:

1. The initial sample of 5,983 establishments was expanded by 25 percent to a total of 7,478 establishments. This sample was called the "screening sample" because it was comprised of establishments to be screened by telephone to determine if they were eligible for the NOES, and if they would participate.

2. Four random subsamples of the expanded sample were formed as follows:

   Subsample A = 1/2 of the expanded sample,
   Subsample B = 1/4 of the expanded sample,
   Subsample C = 1/8 of the expanded sample,
   Subsample D = 1/8 of the expanded sample,

3. At the beginning of its scheduled stay in the PSU each team was assigned a portion of the expanded workload to interview (e.g.,

TABLE 3. EXPECTED NUMBER OF ESTABLISHMENTS BY SIZE CLASS IN INITIAL, SCREENING, AND SHADOW SAMPLES NOES 1981-1983

Size class	Reported number of employees	From CBP[1]	Expected Number of Establishments From DMI Listings		
			Initial[2]	Screening	Shadow plus screening
1	8 - 19	1,190	1,393	1,742	3,483
2	20 - 49	914	1,073	1,341	2,681
3	50 - 99	675	785	981	1,961
4	100 - 249	838	1,003	1,253	2,507
5	250 - 499	512	604	755	1,510
6	500 - 999	344	409	511	1,023
7	1,000 - 1,499	123	163	204	407
8	1,500 - 2,499	108	142	177	355
9	2,500 - 4,999	94	124	155	309
10	5,000 and over	97	139	174	261
11	N/A	--	148	185	371
Total expected sample establishments		4,895	5,983	7,478	14,868
Sampling interval[3], k, in size class 1		199.53	199.53	159.62	79.81

1 Expected total sample at the U.S. level assuming it could be selected from a file of CBP establishment records for 1978. Also shown in Table 1 in Chapter IV.

2 Expected number of selections from the 1980 DMI file before eliminating duplications and out-of-scope cases.

3 For the Chicago PSU only, $k_1 = 212.13$, $k_2 = 169.7$ and $k_3 = 84.85$ for the initial, screening, and the screening plus shadow samples respectively.

subsamples A and C). The portions were chosen such that, over all PSUs, the total sample interviewed would approximate the number of establishments computed for the initial sample. The team was expected to survey all of the assigned subsamples during its stay in that PSU.

4. With the completion of the initial assignment in the PSU, the team supervisor was assigned additional subsamples where possible. All additional subsamples assigned had to be completed in the time originally fixed as the length of stay for the PSU.

Establishments included in the screening sample also had a reserve establishment selected with them for use in replacing attrition due to non-response. The sample of reserve establishments was called the shadow sample and was used as a substitute for non-cooperating establishments if all efforts during the telephone interview and by the surveyor and the team leader failed in obtaining cooperation from the establishment. The reserve was used as a substitute only for those original sample establishments currently in business and eligible for the survey. Furthermore, if the substituted shadow was found not to be eligible, or refused to cooperate, the initial sample unit was retained in sample and a court order (warrant) was obtained to secure cooperation from the originally designated unit. Original sample establishments found at the time of the survey to be out of business, or not doing business in any of the target SICs, were treated as ineligible and shadows were not substituted for them.

The values of f and k to determine sample size in the screening and shadow samples were computed by the methods discussed in Section A of this chapter and, except for classes 9 and 10, were based on a tabulation of the CBP establishment counts in the NOES target SICs for each size class. An early set of CBP counts (5) were used to derive the sampling rates by a clerical procedure before the more precise 1980 CBP counts (10) became available for size classes 9 and 10.

The screening sample was obtained by reducing the initial sampling interval, k_1, to $k_2 = (.8) * k_1$. For all size classes, except those reporting 5,000 or more employees, the screening sample and its reserve were designated in one operation by doubling the screening sample rate (that is, by using sampling intervals equal to half the intervals needed for the screening sample alone) and assigning alternate selections to the screening and shadow samples. The sampling intervals for the shadow and screening samples together for size classes 1-9, and 11 were then:

$$k_3 = (.5) * k_2 = (.5) * (.8) * k_1$$

Since the proportion of establishments to be selected from size class 10 was so high, the screening and shadow samples for it were selected with a systematic sampling interval 2/3 of the interval needed for the screening sample alone rather than 1/2 as for the other size classes. According to this, two sample establishments from size class 10 would share a single shadow establishment.

VII. THE FIELD INTERVIEW SAMPLE

Telephone screening of establishments in the screening sample was conducted to determine which of those establishments should be interviewed in the field. Telephone screening was intended to verify or correct basic information on sample establishments obtained from the DMI, collect further information, or modify the sample to include multi-facility establishments. 7,392 telephone interviews were conducted, and 4,850 establishments were found to be eligible for survey. Random subsamples A, B, C, D of the screened sample were determined for a variable field interview workload and were assigned individually to surveyor teams. The full A, B, C, D sample was interviewed in half of the selected PSUs, whereas interviews in subsamples A, B, and C were completed in the remaining PSUs. In all 4,490 establishments were interviewed in the field. The effective refusal rate for participation in the NOES was .3 percent.

A. The Field Interview Sample

The sampling scheme described in Chapters V and VI for selection of PSUs and selection of establishments within the PSUs provided the screening sample from which the field interview sample was derived. The screening sample was also referred to as the telephone screening sample since telephone screening was conducted on establishments in the screening sample to determine which establishments in this sample should be included in the survey, and should be interviewed in the field. The actual field interview operation was then accomplished most efficiently by dividing the workload into four random subsamples (see Chapter VI). The procedures followed during the field interview are discussed in Volume I of this series.

Field data for the NOES was collected after four steps:

1. A statistical sample of establishments was designated using the DMI file. The expanded sample (screening sample) and all shadows for each PSU were designated in one operation.

2. Telephone screening was carried out for the sample units. Telephone screening was intended to verify or correct basic information on sample establishments obtained from the DMI, and to collect further information. In addition, some screening information was used for sample modification. A single sample establishment might operate in more than one location or include several plants or branches, yet be listed only once on the DMI with a single address and employee total. If other establishments were owned or managed by the sample establishment, a search of the DMI file was done to determine if the new location should be treated as an addition to the sample. If the new location was not found on the DMI file, it was given a chance of selection to be included in the interview sample. In all, 93 multi-facility establishments were added to the screening sample in this way. Units not eligible for the survey which were identified during telephone screening were dropped from the survey.

3. Random subsamples A, B, C, D of the screened sample were determined. A variable interview workload was assigned to each surveyor team. The workload was designed so that each team could complete its assignment in a two week survey period. The assignment included subsamples A, B, C in size classes 1-8 and 11 and the full set of subsamples A, B, C, D in size classes 9 and 10. In roughly half of the PSUs it was possible to use the full sample by including subsample D. Expected times to complete the interviews are shown in Appendix B, and PSUs where the entire workload A, B, C, D was completed are shown in Appendices F (self-representing PSUs) and G (non-self-representing PSUs).

4. Field surveyors contacted each of the selected establishments to schedule an interview. A field surveyor visited each establishment, made a final determination of survey eligibility, and surveyed the establishment. Units determined not to be eligible at the time of the field survey were dropped from the study. If possible, substitutes from the shadow sample were found for eligible establishments refusing to participate in the study; if no substitute could be found, court warrants to require cooperation were obtained.

Results of the telephone screening interviews are shown in Table 4, and results from the field operations are shown in Table 5. Table 4 shows that 7,392 telephone interviews were conducted, of which 7,167 were of establishments included in the expanded screening sample and 225 were of establishments added because of refusals or determination of multi-facility establishments. Of the 7,392 establishments interviewed over the telephone, 4,850 (66%) establishments were found to be eligible for the field operations phase.

Each of the 4,850 establishments eligible for the survey were contacted for field interview. During the field interview, 346 establishments were found to be out-of-scope for the survey and 4,504 were determined to be in-scope (see Table 5). Only 4,379 (90%) of these in-scope establishments cooperated with a field interview, while 125 refused to cooperate. The shadow sample provided substitutes for 113 of these refusals, and warrants were used to complete the field operation in the remaining 12 establishments. Fourteen field interviews could not physically be completed during the survey period. This left 4,490 establishments for which field interviews for the NOES were completed.

The overall refusal rate for establishments to participate in either the telephone screening or field interview operations of the NOES was 7.1 percent. After substitution of establishments in the shadow sample for refusals and enforcing cooperation with court warrants, the effective refusal rate in the NOES dropped to .3 percent. The effective refusal rate was due to 14 establishments whose field interviews could not be completed during the survey period, and would better be described as the rate of non-response in the survey.

TABLE 4. RESULTS OF TELEPHONE SCREENING OPERATIONS
NOES 1981-1983

Telephone screening interviews	Screening sample	Added[1] sample	Total
Out-of-scope	2,535	7	2,542
Non-working phone	682	1	683
Out of business	230	2	232
Less than 8 employees	978	1	979
Non-target SIC	229	--	229
Govt. and administrative office	365	3	368
Out of PSU	51	--	51
In-scope	4,632	218	4,850
Refusals	221	--	221
Other In-scope	4,411	218	4,629
Total	7,167	225	7,392

1 Results from a subsample of 93 multi-facility establishments discovered during telephone screening.

TABLE 5. RESULTS OF FIELD OPERATIONS
NOES 1981-1983

Screening Field Operations	Added sample	sample[1]	Completed Total	interview	Not included[2]
Out-of-scope	339	7	346		
Out of business	64	2	66		
Less than 8 employees	186	1	187		
Non-target SIC	21	--	21		
Government	11	2	13		
Administrative office	39	1	40		
Work load subsamples	18	1	19		
In-scope	4,293	211	4,504	4,490	14
Cooperators	4,293	86	4,379	4,367	12
Subsampled plants	--	86	86	86	--
Screening sample establishments	4,293	--	4,293	4,281	12
Refusals	--	125	125	123	2
Shadows	---	113	113	111	2
Warrants	---	12	12	12	--
Total Field Operations	4,632	218	4,850	4,490	14

1 Results of a subsample of 93 multi-facility establishments discovered during telephone screening.

2 Could not be completed during survey period.

The overall attrition rate for establishments sampled, but found not to be eligible for inclusion in the study was 39.1 percent. This high value is due primarily to the expansion of the original sample by 25 percent for the telephone screening operation. This expanded sample for telephone screening was useful, however, to ensure that the sample of establishments actually surveyed in the field included enough eligible establishments to be as close as possible to the sample sizes calculated in Chapter VI. This feature of the sampling scheme minimized bias during the selection process. Non-response was so low as not to be a problem.

VIII. ESTIMATION PROCEDURES

National estimates of the number of employees and number of establishments conducting business in the SIC ranges covered by the NOES were obtained by assigning appropriate weighting factors to sample establishments and using these factors to project figures found in the NOES sample to the national level. A probability of selection was associated with each of the steps followed in determining the sample establishments which were interviewed. Inverses of these probabilities define sample weights which indicate how much each establishment's results contribute to national totals, and which can be used to provide estimates of the total number of establishments for the entire DMI file. Inflation estimates of totals were obtained by multiplying each establishment's totals by its sample weight and summing across establishments. These inflation estimates were followed by two stages of ratio estimation before the final publication estimate was determined. The first stage ratio estimation factor was based on establishment counts by employee size class as reported in the DMI. The second stage ratio estimation factor was based on employee counts (establishment counts for establishments with greater than 1,000 employees) by employee size class by SIC as reported in the CBP. Ratio estimation was used to improve the precision of the estimates.

Each estimate had a sample error associated with it. Furthermore, the complex survey design and estimation procedures used in the NOES lead to approximate and complicated expressions for estimation of the sampling error. Calculation of the sampling errors was handled using the method of replications. The method required that the estimation procedures be independently carried out several times (replicated) using subsamples of the original sample, and the variance of the replicate estimates be used to measure the variance of the full sample. Sampling error was taken as the square root of the variance. This system was flexible enough to provide measures of reliability for all tabulations planned for the NOES data.

National estimates of characteristics and of sampling errors were performed using computer software developed for this purpose.

A. Estimation of Totals

The inflation estimate was taken as an initial estimate of characteristics on the national level. Inflation weights, defined as the inverse of the probability of selecting the sample establishments from whom characteristics were to be estimated, were used to prepare unbiased estimates of characteristics for all sample establishments. If Y is a characteristic of all establishments, with y the value of that characteristic found in the sample, the simple inflation estimate Y_I would be:

$$Y_I = W \times y$$

where W is the inflation weight. For example, suppose y = 100 employees were reported working in a sample of establishments with probability of selection f = .05. The simple inflation estimate Y_1 of all employees working in the category from which the sample was selected would be $Y_1 = (1/.05) \times 100 = 2{,}000$ employees.

The simple inflation estimate involves only characteristics of the sample. If more information about the target population were available, more precise estimates for totals could be obtained. Ratio estimation uses independent sources of information about sample characteristics to determine an estimate which is often more precise than one determined from inflation estimates.

As an example, consider a characteristic x estimated from the sample, such as the number of employees in an industry surveyed in the NOES. Suppose X is a measure of the same characteristic but obtained from an independent source, such as the DMI. Then the ratio r = X/x may be used to alter the inflation estimate Y_1 described above. If Y_1 is an inflation estimate of a NOES item, the ratio estimate $Y_2 = Y_1 * r = W * y * r$ may be more precise than Y_1 alone. In ratio estimation the ratio (X/x) should vary in the same proportion as (Y/Y_1). It has been shown that, if values of X and Y are correlated, the estimate Y_2 will be more precise then Y_1 (10). In the NOES, two stages of ratio estimation were used, first using number of establishments and then using number of employees. The DMI and CBP listings of all establishments were used as outside sources in calculating the ratios.

1. Calculation of Inflation Weights

   In the NOES, inflation weights were determined in two stages. The telephone screening sample weight was first determined based on the sampling rates used to select the telephone screening sample, and then these weights were modified to take into account that portion of the sample actively used for field operations. Figure 2 shows the relationship between the telephone screening and field interview samples used to determine the weights, and Table 6 shows components of weights used in the NOES estimation procedure. Derivation of inflation weights (and ratio estimates) are also outlined there. The field interview weights were taken as the inflation weights used in the inflation estimates.

   A two step process was required in determining field interview weights since several of the survey operations had an impact on the exact values of the inflation weights and had to be accounted for. Telephone screening and the field interview operations both affected the sample weights, and it was simplest to correct for each phase separately. These operations involved:

   a. Assignment of variable workload subsamples to the PSUs.
   b. Sampling establishments with certainty in some PSUs.
   c. Results of the telephone interview.
   d. Substitution of shadow sample cases for refusals.
   e. Duplicate listing in the DMI file.

FIGURE 2. RELATIONSHIP BETWEEN TELEPHONE SCREENING AND FIELD INTERVIEW SAMPLES NOES 1981-1983

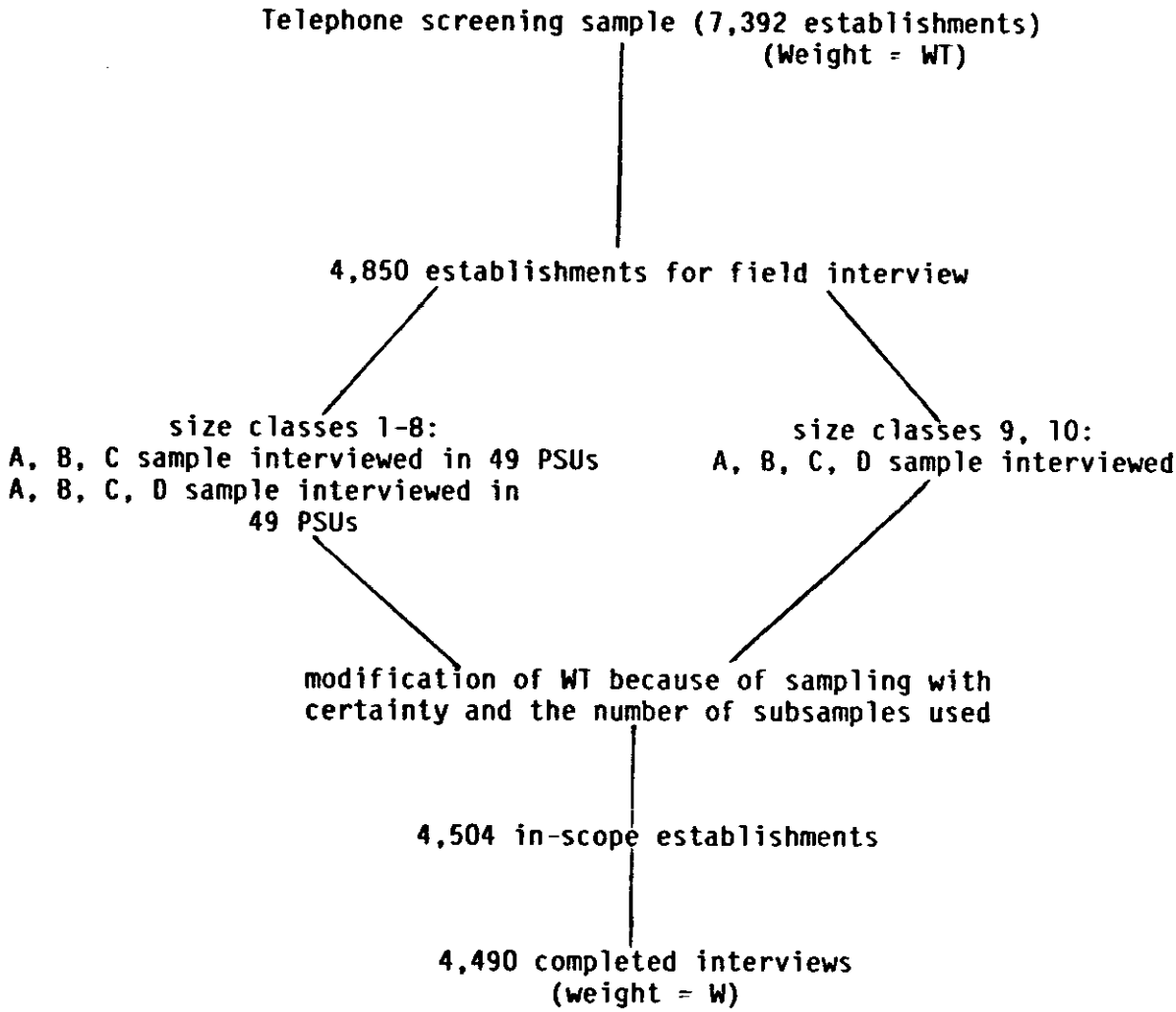

TABLE 6. COMPONENTS OF WEIGHTS USED IN THE NOES ESTIMATION PROCEDURE NOES 1981-1983

	Notation
Telephone screening sample weight:	WT
Assigned to each telephone sample establishment and based on the inverse of the probability of selecting DMI establishments in the sample.	
Field interview weight:	W
Assigned to each sample establishment interviewed in field, based on adjusted telephone sample weight.	
First stage ratio estimation factor:	R1
Numerator: DMI establishment counts by employee size class and area.	
Denominator: Estimates of numerator from telephone sample using weights = WT	
Second stage ratio estimation factor:	R2
Numerator: County Business Pattern employee counts (establishment counts for larger firms) by current size, and SIC.	
Denominator: Estimates of numerator from interviewed establishments using weights = W * R1	
First stage ratio estimates of characteristic from field interviews	W * R1
NOES estimates for publication	W * R1 * R2

Telephone sample weights were calculated considering a) and b) above, and the calculation of field interview weights considered points c), d), and e) above.

Subsamples A, B, C, D in each PSU were assigned for workload control as detailed in Chapter VI. Variable workloads consisted of either subsamples A, B, C or A, B, C, D of the expanded (screening) sample in each PSU, depending on which size class was being considered. Subsamples A, B, C were interviewed in size classes 1-8 and the full sample A, B, C, D was assigned in size classes 9 and 10. For half of the PSUs, however, it was possible to assign the full (sample) A, B, C, D for all size classes. Table 7 shows theoretical telephone sample weights by establishment size class for PSUs with A, B, C or A, B, C, D PSUs. Weights shown in Table 7 were calculated from counts of facilities appearing on the DMI, and so are different from the preliminary results shown in Table 1 in Chapter IV. Weights for the Chicago PSU are listed separately since sampling probabilities in that PSU were determined prior to a revision in sampling rates that occurred when more current CBP figures became available. PSUs assigned the full A, B, C, D sample in all size classes are listed in the Appendices G and H.

A second problem in determining telephone sample weights occurred because of sampling with certainty in some PSUs. This problem occurred with PSUs which could not meet the size criteria discussed in Chapter V. The probability of selection of establishments in these PSUs was so large in certain size classes that all establishments in those size classes would have been included in the sample: half of the establishments would be in the screening sample, and half in the shadow sample.

For example, consider samples selected from size class 5. From Table 7, the theoretical probability of selection of establishments from a PSU where the full A, B, C, D sample was interviewed would be 1 in 17.010 (the weights shown in Table 7 are inverses of the selection probabilities). Since a shadow sample equal in size to the full telephone sample was also selected in each PSU, the theoretical probability for establishments in size class 5 to be included in the combined screening and shadow sample would be: 2 x 1/17.010 = 1/8.005. The within PSU selection probability for establishments in size class 5 would then be: ((1/(probability of selection of sample PSU) x (1/1.8005)). This corresponds to the term $(M_h/M_{hj} \times f_a/k)$ in equation 7 in Chapter IV. Probabilities of selection for each of the 98 PSUs are shown in Appendix B.

The within PSU selection probability was less than 1 in most PSUs. For establishments in size class 5 in PSU 201, for example, the within PSU selection probability was 2.854 x (1/8.005) = .357. Consider another PSU, however, with a lower probability of selection. For PSU 206, the theoretical selection of probability of establishments in size class 5 would be: 11.984 x (1/8.005) = 1.50. If none of the assumptions made

TABLE 7. ESTABLISHMENT SIZE CLASSES AND THEORETICAL TELEPHONE SAMPLE WEIGHTS NOES 1981-1983

Size class	Number of employees	Theoretical weights for telephone sample		
		ABC PSUs	ABCD PSUs	Chicago
1	8-19	182.420	159.618	169.687
2	20-49	114.520	100.205	106.527
3	50-99	60.365	52.819	56.152
4	100-249	33.386	29.213	31.056
5	250-499	19.440	17.010	19.083
6	500-999	13.437	11.757	12.499
7	1000-1499	10.584	9.261	9.845
8	1500-2499	7.670	6.711	7.135
9[1]	2500-4999	---	4.436	---
10[1]	5000+	---	1.752	---
11	N/A	182.42	159.618	169.687

[1] ABCD samples selected from size classes 9 and 10 are not confined to sample PSUs.

in defining the sampling scheme had been violated, every establishment in size class 5 in PSU 206 should have been included as a sample establishment.

The problem of sampling with certainty in PSU 206 was solved in the NOES by taking half of the establishments in size class 5 in this PSU as the screening sample and half as the reserve sample, and assigning weights (2 x 11.984) = 23.968 for these establishments. The same problem would have occurred in size classes 6-8 in PSU 206 where the selection probabilities for establishments were even smaller, so half of the sample establishments in each of these size classes were included in the screening sample and half in the shadow sample, and weights of 23.968 were assigned to establishments in these size classes. Sampling establishments with certainty depended on the probability of selection of the PSU and size class. Other PSUs for which sampling with certainty was possible, and the weights determined for them, are shown in Appendix F.

Modifications to inflation weights in the telephone screening sample because of information collected during the screening operation were made on a case by case basis. The modified weights were the field interview weights. If the establishment was permanently out of business or ineligible for the NOES, a field inflation weight of 0 was assigned. If establishments were temporarily out of business, refused to interview, or were eligible for the NOES field interview inflation weights equal to their telephone sample weights were given. If establishments owned or managed other plant locations within the same PSU which were not originally included on the DMI list, these new locations were given a probability of selection. If sample establishments refused to participate in the NOES, establishments from the shadow sample were substituted for them. The weight of the refusal was set to 0, and the field interview weight for the shadow NOES was taken as the telephone screening sample weight.

The telephone screening operation might also have indicated duplicate listings of establishments in the DMI file. Searches for duplicate listings were confined to single PSUs. The field interview inflation weight for duplicates was modified depending on the size class of duplicate establishments: if size classes were the same for all of the 'n' duplicates the field interview weights were adjusted by 1/n; if the size class of the duplicate (non-sample) were less than that from the interviewed establishment, no adjustment was done; while if the size class of the (non-sample) duplicate was greater than that reported from the interview of the sample establishment, the field interview weight was taken as the inverse of the PSU selection probability. This last step was a compromise equivalent to treating the sample unit as though it had been selected with certainty within the PSU.

2. Ratio Estimation

Inflation estimates using the field interview inflation weights were modified with two stages of ratio estimation before using them to obtain national estimates. Ratios for each PSU size class were calculated using data from a subgroup of the 98 sample PSUs. These subgroups were defined to be as similar as possible within the PSU size class for which characteristics were to be defined. For the first stage ratio factor, PSUs were ordered and ratios (observed counts/estimated number) for establishments were calculated, adding results from each PSU one at a time. PSUs were added until the ratio fell between .3333 and 3.0000, and at least four plants contributed to the estimate of the denominator. The number of PSUs included in each ratio defined a ratio cell. The procedure was repeated starting with the next PSU, until ratio cells had been defined using all PSUs. If a ratio cell included results from the last PSU, yet the ratio factor did not meet the criteria above, it was combined with the previous ratio cell. For the second stage ratio factor, ratio cells were formed by including establishments in order by SIC code, and observed and estimated numbers of employees were used in the ratio.

For the first stage of ratio estimation, establishment size classes were as defined in Table 1 in Chapter IV. PSUs were ordered in pairs, determined so as to achieve homogeneity among size classes in adjacent PSUs in the listing. Homogeneity was considered in terms of proportion of employees in manufacturing, in large firms (1,000 or more employees), in the petroleum, chemical and rubber industries, and geography. The ordering was done in pairs for later use in the sampling error calculations. The ordering of NSR and SR PSUs are shown in Appendices G and H.

The first stage ratio numerator for size classes 1-8 and 11 was defined as the total number of establishments in PSUs in the ratio cell indicated on the DMI to be operating in the target SICs. The ratio denominator was taken as the inflation estimate of the numerator and was calculated from the telephone survey weights in the size class for sample PSUs included in the ratio cell. This ratio was denoted R1. The first stage ratio estimate of the characteristic would be W * R1.

A similar procedure was followed in obtaining first stage ratio estimates for size classes 9 and 10. The sample of establishments in size classes 9 and 10 were selected without regard to location with respect to a sample PSU, and so for each of these classes one area was defined for ratio estimation: all 50 states and the District of Columbia.

The second stage of ratio estimation used employee and establishment counts by size class and SIC from CBP information. It should be noted that CBP employee size classes are defined differently from those in the DMI; these are listed in Table 8. To make maximum use of the available data, then,

TABLE 8. EMPLOYEE SIZE CLASSES USED IN SECOND STAGE OF RATIO ESTIMATION (CBP SIZE CLASSES) NOES 1981-1983

Size Class	Number of Employees
1	8 - 9
2	10 - 19
3	20 - 49
4	50 - 99
5	100 - 249
6	250 - 499
7	500 - 999
8	1000 - 1499
9	1500 - 2499
10	2500 - 4999
11	5000+

three groups of establishments based on number of employees were considered in determining second stage ratio estimators: establishments reporting 10-999 employees and operating in a target SIC listed in group A in Appendix I, establishments reporting 1,000 or more employees and operating in a target SIC listed in group B in Appendix I, and all other NOES sample establishments. The iterative procedure used in determining ratio cells was similar to those used in determining first stage ratio cells, but characteristics of those establishments in ratio cells operating in particular SIC groups and employee size classes, rather than only in employee size classes, were combined.

Figure 3 outlines the second stage ratio estimation methods in the three groups of sample establishments. Numerators for Group A establishments were defined as the CBP count of employees in the establishments operating in the target SIC group(s) comprising the trial cell. The denominator was taken as the sample estimate of the number of employees in establishments operating in the target SIC group(s) included in the ratio cell. The denominator was determined using first stage tabulation weights as W * R1. The same conditions for the ratio as for the first stage ratio factors, i.e., ratio between .33 and 3.0, and denominator of the ratio being based on at least four establishments, were used. If the ratio cell was unacceptable, establishments in the adjacent SIC group (see Appendix I) were included in the ratio cell, and the procedure was repeated. If a final trial cell including the last SIC group was unsatisfactory, it was combined with the previous acceptable cell.

In some situations in Group A establishments, the number of employees in certain SIC groups could not be obtained from the CBP publication because of disclosure problems. Information about an individual establishment might have been revealed if the data were published. If disclosure were a problem, the average of ratio factors computed for other non-disclosure establishments in the same size class was assigned. SICs where disclosure was a problem are listed in Appendix I.

Procedures for Group B establishments were similar to those for Group A with the exception that numerators and denominators of ratios were based on observed and expected numbers of establishments rather than number of employees. The order of combination of SIC codes was the same as for those in Group A; however, the CBP count of these larger establishments could not be determined using a 2-digit SIC grouping and the procedures described below for Group C establishments were used. SIC codes where this was a problem are also indicated in Appendix I.

Ratios for Group C establishments were determined as average ratio factors of groups A and B. No iteration or testing to define suitable ratio cells was done. For sample establishments in size classes 2 through 11, the arithmetic average of ratio

FIGURE 3. SUMMARY OF SECOND STAGE RATIO ESTIMATION METHODS IN THREE GROUPS OF SAMPLE ESTABLISHMENTS NOES 1981-1983

<table>
<tr><td colspan="4">Number of employees at establishment when interviewed</td></tr>
<tr><td>8-
9</td><td>10-
19</td><td>20-
49 . . .</td><td>500-
999</td><td>1000-
1499</td><td>5000
+</td></tr>
<tr><td></td><td colspan="3">Group A Establishments

Ratio factors based on published counts and estimates of number of CBP employees.

Ratio cells determined by iteration.</td><td colspan="2">Group B Establishments

Ratio factors based on published counts on estimates of number of CBP establishments.

Ratio cells determined by iteration.</td></tr>
<tr><td colspan="6">Group C Establishments

Ratio factors based on averages of ratios computed for corresponding size classes in Groups A and B.

Iteration not involved.</td></tr>
</table>

factors determined for the corresponding size levels in Groups A and B was used. The average was taken as the sum of all ratios in the size class in Groups A and B divided by the number of ratios. For size class 1 the average ratio for establishments in size class 2 were used.

The second stage ratio estimation factor is denoted as R2. It was included in the record for each establishment. The final NOES publication weight included the field interview weight W, the first stage ratio estimation factor R1, and R2. The final publication weight was W * R1 * R2.

B. Estimation of Sampling Error

Sampling error refers to the deviation of actual values of the characteristic being studied from values of that characteristic estimated from the survey results. In the NOES, sampling errors were the result of estimates being based on results from a sample of the total number of plants. Statistically, sampling error is defined as the square root of the variance, where the variance for a group of independent observations $x_1 \ldots x_n$ with mean $\bar{x}$ is defined as: $\left(\sum_{i=1}^{n} (x_i - \bar{x})^2\right)/(n-1)$. The sample variance for the NOES was defined in Chapter IV. Sampling error was taken as the square root of the variance.

The calculation of variances using standard statistical formulas available in computer software packages assumes that sample observations are collected independently of one another, and that a uniform sampling rate is used for the entire sample. In the NOES, however, this assumption does not apply. Since the sample selection scheme employed grouping by PSUs and stratification by size, characteristics of establishments in the same PSUs or size classes might have been correlated. These correlations could affect the reliability of projected statistics based on this sample. The variability in sampling rates among size strata and modifications imposed because of operational considerations discussed in Part A above also affected sampling errors.

The method of Balanced Repeated Replications (BRR) was used to estimate variances (9, 12, 13). This method is flexible enough to provide measures of reliability for all tabulations for the NOES data. The method was first used on a large scale in analyzing complex sample surveys of the Bureau of the Census. It is one of a class of methods of calculating variances by resampling from the sample many times. BRR in the NOES uses random subsamples generated by combinations of data from pairs defined by PSUs in each of the SR and NSR strata. Pairs are defined in the two largest size classes, size classes 9 and 10, irrespective of PSU. The same selection sampling strategies as used for the full sample were used in each of the random subsamples. Sixty-four pairs (half-samples) and 32 replicates were formed. The half-samples are the repeated replications of BRR. They are "balanced" because the replicates were determined from pairs.

It should be noted that difficulties in estimating sampling errors are not limited to the NOES. Similar problems occur in any large, complex survey, since practical and economical sampling schemes often use stratification and clusters of sample units as in the NOES. Furthermore, BRR is one of several statistical techniques which have been developed for estimating sample errors. BRR, however, is a basic method offering a great deal of flexibility through efficient use of independent replications, besides being used for calculating sampling errors. BRR is particularly useful with complicated statistics or for tests of significance.

The sample selection methods used for NOES result in variance estimates that are slightly biased (usually overestimates), regardless of the type of variance estimation used. In this sense estimation of the variance is a conservative estimate. These biases arise because only one PSU was selected from each of the 9 size strata considered, so some strata had to be combined in the variance estimation procedure to obtain meaningful results. Combining PSU's from different strata introduced an extra element of variance for the estimation procedure; two sample PSU's could have been selected from each stratum at, however, the cost of a decrease in efficiency of the sampling scheme. Also systematic sampling of establishments within each sample PSU was used to select establishments. Defining half-samples for BRR from samples already determined by a systematic selection procedure also tends to yield slight overestimates of the variance. These biases were not considered serious.

Half samples were first constructed by treating the PSUs as pairs. All of the original records were used, sequenced by identification number, size class, and selection probability, to reflect the original survey sampling process. An identification number was not used in sequencing size classes 9 and 10. Alternating selections of establishments within each of the 26 self-representing PSUs and size classes 9 and 10 defined 28 pairs. Pairs of non-self-representing PSUs were formed by alternating selection of PSUs (rather than of establishments). See Appendices H and I for details on how NSR PSUs were combined into pairs. Sixty-four half samples were therefore defined: 1 from each of the 26 SR PSU's (26), 36 from pairing of the NSR strata (36); and 1 each from size classes 9 and 10.

Replicates were defined as a 50 percent subsample of the total sample obtained by choosing one member from each of the paired half-samples. Individual establishments in each pair were given codes 0 or 1 to identify which establishment in the pair would be included in the replicate. In each SR PSU size class 1-8, the sum of the PSU identification number and size class number was found. If the sum was odd, odd numbered establishments were given code 1 and even-numbered establishments were given code 0. If the sum was even, even-numbered establishments were given 1 and odd-numbered establishments 0. Sample units in the PSU with code 1 comprised one member of the pair, while units with code 0 comprised the second member.

Pair members in size classes 9 and 10 were defined in a similar manner. Establishments in the telephone screening sample in each size group were sequenced by order of selection, and 1 was assigned to even-numbered records in each size class and 0 was assigned to odd-numbered records. Members in each NSR pair were defined when the NSR PSUs were paired. Sample establishments in each PSU were taken as the same members of the pair as was the PSU.

Thirty-two replicates for BRR were defined. Each replicate included one member from each of the 64 pairs. Which member to choose from each pair ('first' or 'second') was determined using a random number table (see Appendix J). Somewhat more precise estimates of the sampling error might have been obtained with greater numbers of replicates, however, 32 replicates were chosen for convenience and to reduce costs.

To use the technique, estimates of characteristics in each of the replicates were found using the ratio estimation procedures described for the full sample estimation process. Variances in each replicate were then found, and summed. Variances were found using the standard formula:

$$\text{Var}(x') = \left[\sum_{r=1}^{32} (x'_r - x'_0)^2\right]/r, \text{ where}$$

$\text{Var}(x')$ = variance of estimate of characteristic x

x'_r = estimate of the characteristic x made from the r^{th} replicate,

x'_0 = estimate of the characteristic x made from the full sample.

r = replicate number

Estimates x'_0 of characteristic x were calculated for each replicate using the same methodologies to calculate weights and ratio estimates as were used for the full sample. Since each replicate was a 50 percent subsample of the total sample, numerical values for the inflation weights used in the estimation procedures varied from those used for calculations with the entire sample. Half of the 32 weights (1 for each of the 32 replicates) were zero if the establishment was not in the replicate, and half were about twice as large as for the entire sample.

Variance, as defined above, is an absolute numerical measure of variation. Absolute measures, such as the standard deviation or standard error, have as units of measurement the units that the variable was expressed in. The magnitude of the variance is also a function of the magnitude of the characteristic of interest. Since establishments' characteristics could have varied so greatly depending on establishment size and SIC code, a relative measure of variation was needed for comparisons in the NOES. In the NOES, the relative measure of variation was the element relvariance,

$$V_{x'}^2 = \text{Var}(x')/(x')^2.$$

Relvariance was calculated across all 32 replicates:

$$V_{x'}^2 = \left(\frac{1}{32(x'_0)^2}\right)\left(\sum_{r=1}^{32} (x'_r - x'_0)^2\right)$$

Sampling error may be determined as:

$$\text{S.E. } (x') = \sqrt{\text{Var}(x')}$$

$$\text{S.E. } (x') = \sqrt{(V_{x'}^2)\ (x')^2}.$$

It should be noted that the methodology described thus far may be used to calculate total variances of estimated characteristics. The within PSU variance, the component of variance resulting because only selected establishments from each PSU were interviewed, is also of interest. Within PSU variance may be investigated using the same methods as for total variance, however, each element in each half sample should reflect the alternate selections for the 50 percent subsample. The modification comes in defining first or second elements in each NSR pair: first and second elements should be defined in each NSR PSU in the same manner as was done for SR PSUs, and the first and second elements of both PSUs in the NSR pair combined to determine members for the replicate. The difference between the total variance and the within PSU variance would be an approximation of the between PSU variance.

Calculation of estimates and sampling errors of estimates was done using specially developed software written in the FORTRAN computer programming language. Three files are input: a file of identifiers of establishments with user-specified questionnaire responses, a file of establishment weights, and a file of national estimates of total numbers of plants and employees covered in the NOES. The user-selected estimates may include totals, ratios, and other functions of data collected on the questionnaire. Output includes, by size category (number of employees) for each characteristic analyzed:

1. National estimate of number of plants and number of employees with the characteristic.

2. Standard error of each estimate.

3. Percentage of the total estimated number of plants or employee in the specified size category with the characteristic.

Table 9 is a portion of a tabulation of the output. This particular table shows final NOES estimates, and associated standard errors of number of plants and employees in plants with industrial hygiene services. The table also shows the percentage of the total number of plants or employees estimated in the NOES to have industrial hygiene services. Results are presented by employee size class and SIC code.

Standard errors may be used to construct confidence intervals about the estimates. For example, if the NOES could be conducted several times, roughly two-thirds of the resulting estimates of the total number of small-sized plants (8-99 employees) with industrial hygiene services would be within 3,923 of the 60,895 estimated or between 56,972 and 64,818. Similarly, 95% of the estimates would be within 7,846 (2 x 3,923) of 60,895. In other words, confidence intervals for estimate may be found as the sum or difference of the standard error and the estimate.

Final estimates from NOES data of numbers of facilities and numbers of employees will be included in forthcoming reports in this series.

TABLE 9. FINAL NOES ESTIMATES OF NUMBER OF PLANTS AND EMPLOYEES IN PLANTS WITH INDUSTRIAL HYGIENE SERVICES NOES 1981-1983

SIC CODE	PLANTS SMALL (8-99)	PLANTS MEDIUM (100-49)	PLANTS LARGE (≥500)	PLANTS TOTAL	EMPLOYEES SMALL (8-99)	EMPLOYEES MEDIUM (100-499)	EMPLOYEES LARGE (≥500)	EMPLOYEES TOTAL
07	1179*	70*		1249*	24945*	7009*		31954*
	(563)	(67)	...	(553)	(14547)	(6680)	...	(15011)
	21.2%	100.0%		22.2%	24.1%	100.0%		28.9%
13	991*	214*		1204*	14324*	35006*		49330*
	(558)	(171)	...	(562)	(7654)	(21376)	...	(21576)
	11.5%	21.0%		12.5%	6.9%	20.1%		11.9%
15	1429*	167*	20*	1616*	49434*	37900*	25647*	112981*
	(553)	(84)	(18)	(539)	(17794)	(23840)	(18373)	(31712)
	5.7%	15.1%	14.7%	6.2%	8.8%	19.1%	19.0%	12.6%
16	1424*	339*	17*	1780*	43652*	58573*	21017*	123241*
	(435)	(189)	(28)	(542)	(14416)	(38147)	(21480)	(49050)
	12.6%	30.3%	15.9%	14.2%	15.4%	28.2%	20.8%	20.8%
17	3428*	236*		3664*	80525*	58191*		138716*
	(981)	(144)	...	(1020)	(21288)	(33125)	...	(44002)
	5.9%	12.3%		6.1%	6.4%	17.6%		8.8%
20	3283*	1849*	272*	5404	122972	429923	274301*	777197
	(648)	(303)	(99)	(781)	(19568)	(74103)	(66896)	(78024)
	28.8%	57.5%	48.6%	35.6%	31.7%	63.8%	45.6%	50.0%
21	30*		10*	40*	1866		29132*	30998*
	(43)	...	(19)	(45)	(2685)	...	(29367)	(28820)
	100.0%		12.2%	36.6%	100.0%		26.0%	27.2%
22	186*	877	203*	1267	8092*	198415	186252*	392759
	(100)	(169)	(69)	(169)	(5323)	(41864)	(78950)	(73153)
	6.4%	55.2%	68.0%	26.3%	7.6%	57.2%	71.3%	55.0%
23	1501*	830	73*	2404	53894*	146667*	44124*	244685
	(557)	(190)	(47)	(558)	(14487)	(44058)	(30217)	(44375)
	12.0%	26.7%	30.3%	15.2%	12.7%	24.0%	21.2%	19.7%
ALL TARGET SICs	60895	21397	5318	87610	2055236	4425522	6635891	13116649
	(3923)	(1526)	(394)	(3989)	(113248)	(316227)	(416179)	(512752)
	13.6%	42.8%	56.3%	17.2%	18.5%	44.9%	53.2%	39.3%

* Standard error > 25% of the estimate. The estimate may be unreliable.
... No facilities observed.