United States
Environmental Protection
Agency

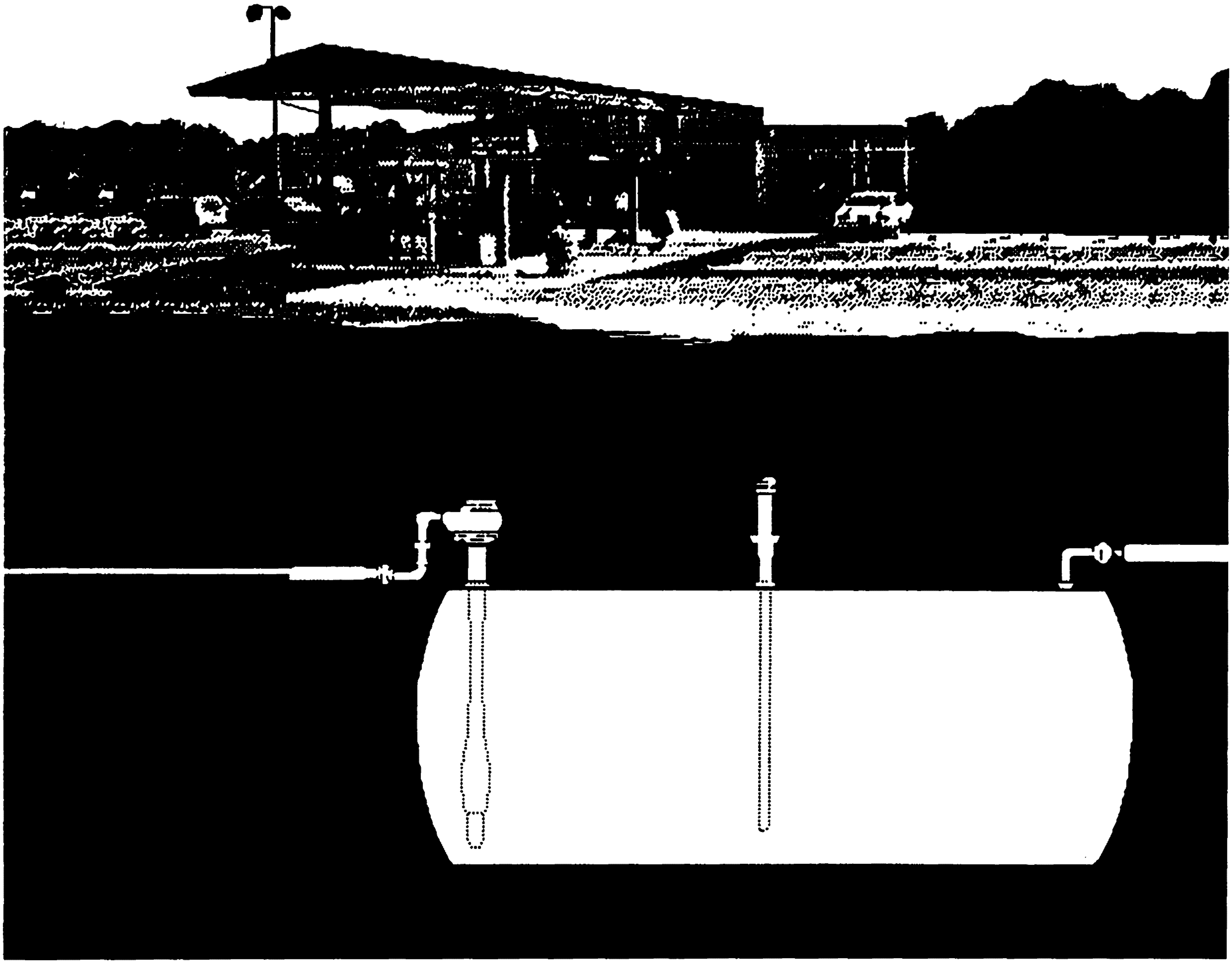
Office of Pesticides
and Toxic Substances
Washington, DC 20460

EPA 560/5-86-013
May 1986

Toxic Substances

Underground Motor Fuel Storage Tanks: A National Survey

VOL. II. APPENDICES



50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. EPA 560/5-86-013

2.

3. Recipient's Accession No.

4. Title and Subtitle

Underground Motor Fuel Storage Tanks: A National Survey

5. Report Date May, 1986

6.

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8. Performing Organization Rept. No.

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10. Project/Task/Work Unit No. Task 3

11. Contract(C) or Grant(G) No.

(C) EPA No. 68-02-4243
and
(G) EPA No. 68-02-3938

12. Sponsoring Organization Name and Address

Environmental Protection Agency
Office of Toxic Substances
Exposure Evaluation Division
401 M Street, S.W.
Washington, D.C. 20460

13. Type of Report & Period Covered

Final Report
Feb. '84 - May '86

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A nationally representative sample of 2,812 establishments were interviewed to determine the presence of underground motor fuel storage tanks. This sample represented establishments in fuel-related industries (1,612), large establishments in all other industries (600), and farms (600). A total of 890 of these establishments were found to have a total of 2,445 underground motor fuel storage tanks. Only 19 farms with 34 tanks were found. The following national estimates were made: there are 796,000 underground motor fuel storage tanks at 326,000 establishments in the Unisted States -- 158,000 of these are on 79,000 farms. A subsample of 218 establishments was selected for tank tightness testing, using a modification of a commercially available test. The method over-filled the tank system into a standpipe, and thus detected leakage anywhere in the system of tank vessel, pipes, lines, joints, and fittings. Among the non-farm establishments tested, the following estimates were made: 35 percent (189,000) of tank systems were judged to be leaking under test conditions; the average leak rate of those systems with quantifiable leak rate, adjusted for test pressure, was 0.32 gallons per hour; half the leaks among all systems judged to be leaking were 0.25 gallons per hour or less.

17. Document Analysis a. Descriptors

Establishment characteristics, leaking underground tanks, survey design, tank characteristics, tank establishments, tank tightness testing, underground motor fuel storage tanks

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report) Unclassified

20. Security Class (This Page) 11

21. No. of Pages
Vol I: 227
Vol II: 330

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

UNDERGROUND MOTOR FUEL STORAGE TANKS:

A NATIONAL SURVEY

Appendices

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May 1, 1986

DISCLAIMER

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APPENDIX A

SAMPLE DESIGN AND ESTIMATION OF WEIGHTS AND VARIANCES

I. TARGET UNIVERSE, OVERVIEW OF SAMPLE DESIGN

The target universe, or population of interest, for the Survey of Underground Storage Tanks consisted of all underground tanks which store motor fuel prior to dispensing it for use as fuel, with exceptions as noted below. For example, in the retail gasoline sector, this includes all underground tanks at service stations but excludes large holding tanks at a distributor. In sampling, we used a tank establishment, that is, a location with eligible tanks, as the sample unit. Once a given establishment was sampled, all its tanks were in the sample for the initial data collection phase. For the physical tank testing stage, a subsample of the sampled establishments was drawn, and all tanks at the subsampled establishments were physically tested. For purposes of list building, the target universe of establishments was defined as a number of segments, with certain exclusions as noted. The following types of establishments were identified as potentially having underground motor fuel storage tanks:

- Gasoline service stations;
- Other establishments almost certain to have underground storage tanks, including:
  - Transit and transportation fleets (such as taxi, trucking, and bus companies; auto and truck rental companies; railroads; and auto and truck dealers);
  - Marinas;

  - Airports and other air transportation related industries; and
  - Golf courses and country clubs;
- Government fleet service pumps, including:
  - Federal;
  - State;
  - Local -- county, city, etc.; and
  - Military;
- Large companies with 20 or more employees in other (non fuel-related) industries which have private fleet service pumps; and
- Farms with underground motor fuel storage tanks.

Underground tanks containing motor fuels maintained by private homeowners and tanks for private fleets maintained by companies with fewer than 20 employees were excluded from the scope of this survey. They were not estimated to account for a large number of underground storage tanks. In addition, the cost necessary to screen out businesses and residences with no underground tanks was judged to be too great in comparison with the anticipated low addition to the total universe from these establishments.

A. Overview of Sample Design

The sample of establishments was drawn using a multi-stage cluster design. The continental U.S. was divided into six regions of interest. The sample was drawn to provide estimates both at the national and regional levels. The first stage of sampling was Primary Sampling Units (PSUs) consisting of counties or groups of contiguous counties with designated minimum estimated numbers of underground tank establishments. The sample of PSUs was allocated to the regions and drawn within region proportionally to their total estimated number of underground tank establishments. Thirty-four PSUs were drawn.

Within each selected PSU, three establishment frames were developed:

- Fuel tank establishments - consisting of gas stations, establishments in other fuel-related Standard Industrial Classification (SIC) groups, and government tank locations;
- Large establishments - consisting of all businesses with 20 or more employees not already listed as fuel tank establishments; and
- Farms - consisting of all farms.

A national sample was drawn from each frame. For large establishments and for farms, 600 establishments were selected from each frame. For the fuel tank establishments, a national sample size of 1,618 was allocated to the regions, and six regional samples were drawn. In each case, the establishment sample was drawn taking account of the PSU probabilities of selection in such a way that the establishment samples were self-weighting, nationally for the large establishments and farms, and by region for the fuel tank establishments.

Once the three samples were drawn, the large establishment and farm samples were telephone screened for the presence of underground tanks. All large establishments and farms which have underground fuel storage tanks became part of the field sample, as did cases which could not be resolved over the telephone. No substitutions were made for large establishments or farms with no underground fuel storage tanks. The fuel establishment tank sample consisted of establishments which were thought likely to have underground fuel storage tanks. Initial field work showed that this list actually produced about a 50 percent survey eligibility rate; that is, about half the sampled establishments sampled were still in business and had underground motor fuel storage tanks. Although lower than anticipated, this eligibility rate indicates that the coverage of the target universe by the selected SICs was probably quite good. In order to attain our target sample size of 800 eligible establishments, the initial sample sizes per region were doubled for the fuel establishment segment, for a total sample draw of 1,618 cases.

B. Definition of Regions; PSU Sample Design

Table A-1 lists the regions, giving the states included in each. They are shown on a map in Figure A-1. The PSU frame was developed for the entire continental U.S. as detailed in the following paragraphs.

For each county, the following counts were developed:

- Number of gas stations based on the 1981 County Business Patterns data (count for SIC 5541);
- Additional estimated number of gas stations allocated to counties within states on a population basis to bring the state totals up to the estimate provided by Versar to the EPA; and
- Total number of establishments in the selected other SICs (list in Table A-2) as given by the County Business Patterns data.

These three counts were summed for each county to form the estimated number of fuel tank establishments for the county.

The counties were grouped into initial PSUs by using the Westat Master PSU Frame developed on a population basis, which

Table A-1. Six regions for National Survey of Underground Fuel Storage Tanks

1 -- Northeast

Maine
New Hampshire
Vermont
Connecticut
Massachusetts
Rhode Island
New York
New Jersey
Pensylvania
Maryland
Delaware
Virginia
West Virginia
Washington, D. C.

2 -- Southeast

Kentucky
Tennessee
Arkansas
Louisiana
Mississippi
Alabama
Georgia
North Carolina
South Carolina
Florida

3 -- Midwest

Wisconsin
Minnesota
Iowa
Missouri
Illinois
Indiana
Ohio
Michigan

4 -- Central

North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas

5 -- Mountain

Montana
Wyoming
Idaho
Nevada
Utah
Colorado
Arizona
New Mexico

6 -- Pacific

Washington
Oregon
California

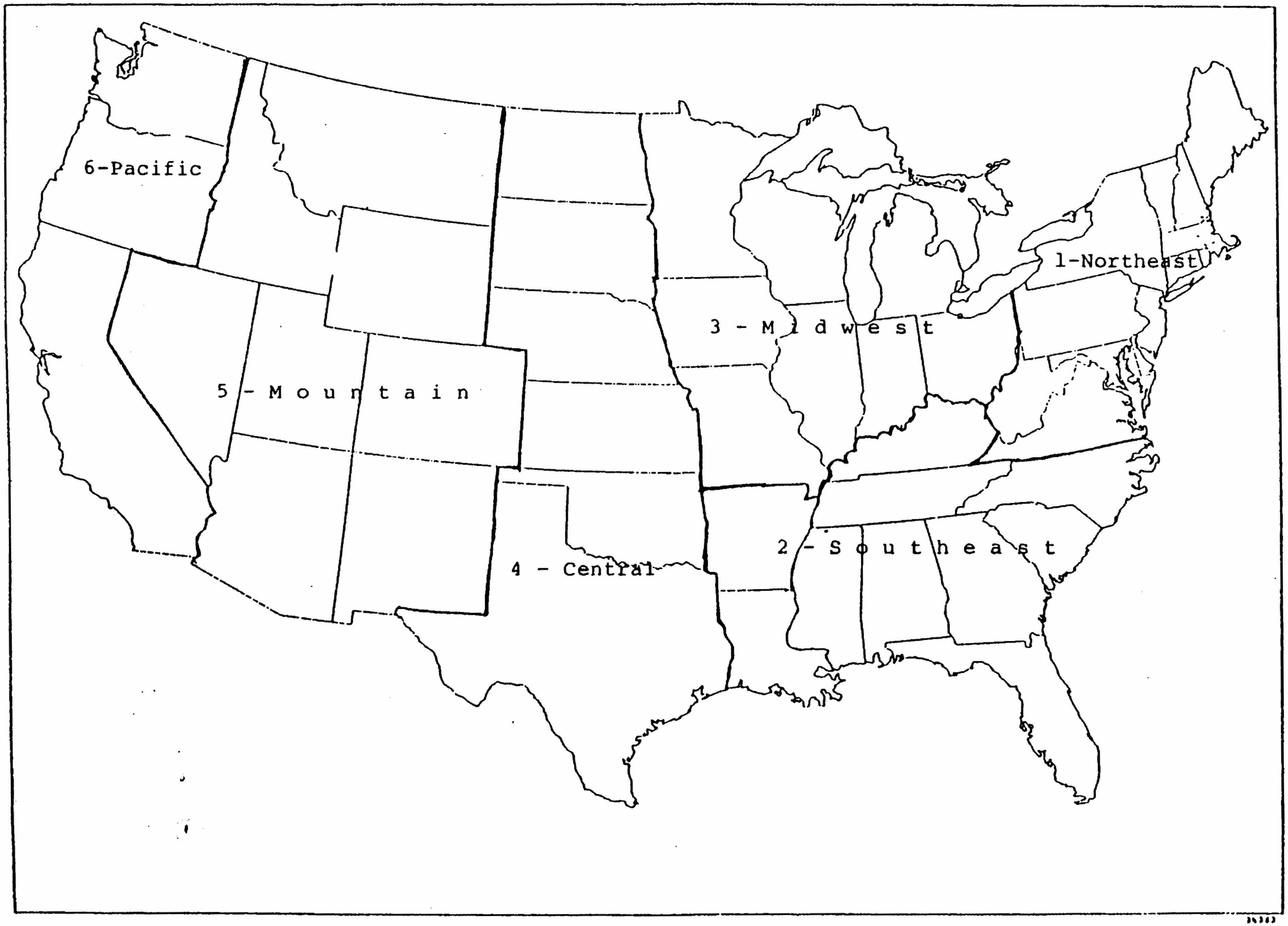

Figure A-1. Underground Storage Tank Survey Regions

Table A-2. Selected SIC codes for fuel tank establishment frame

SIC code	Description
4010	Railroads, switching and terminal companies
4110+	Local and suburban passenger transportation companies (includes airport transportation, ambulance and limousine services)
4121+	Taxicab companies
4131+	Intercity highway transportation services
4140+	Passenger transportation charter services (includes bus charter, rentals and tours)
4151	School bus companies
4170	Passenger transportation terminal and service facilities
4210+	Trucking companies
4231+	Motor freight terminals
4469A	Marinas
4511	Air transportation, certificated carriers
4521+	Aircraft charter, rental and leasing -- non-certificated carriers
4582A	Airports
4582B+	Aircraft maintenance services
4583	Airport terminal services
5511+	Auto and truck dealers (new and used)
5521+	Used car dealers
5541+	Gasoline service stations
7512+	Passenger car rental and leasing agencies
7513+	Truck rental and leasing agencies
7519+	Utility and house trailer rental agencies
7992+	Public golf courses
7997B+	Golf and country clubs

follows the PSUs used by the Census Bureau in designing the Current Population Survey. This initial list of PSUs was transformed to a final list by splitting PSUs which had large total counts into smaller sets of counties and combining PSUs with insufficient counts, resulting in a set of PSUs which were as small as possible while still containing a minimum number of fuel tank establishments.

Once the PSUs were defined, the sample of PSUs was drawn as follows. For each region, a target number of PSUs was established. This was six PSUs per region, except in Region 5 (Mountain) where four PSUs were drawn. Within each region, the PSUs were sorted by an urban versus rural designation, then by state, and finally by size (total estimated number of fuel tank establishments). The sample of PSUs was then drawn within each region on a probability proportional to size basis.

C. Tank Establishment Frames Within PSUs; Sample of Establishments

Once the thirty-four PSUs were selected, three establishment frames were built for each PSU. A sample was drawn from each frame, and eligible establishments in the three samples formed the sample of establishments.

The first frame was the fuel tank establishment frame. It consisted of establishments considered to be extremely likely to have underground fuel storage tanks. The frame was constructed from several sources. A list of business establishments with one of the target SICs (refer to Table A-2) in the selected counties was purchased from National Business Lists (NBL). This was supplemented by any establishments found to have one of the selected SICs in the large establishments list (see below).

Lists of Federal, state, and local government establishments in the sampled counties with underground fuel storage tanks were developed by extensive telephone contacts with government officials. In addition, a list of military establishments with underground fuel storage tanks was provided by the military to EPA. These lists were keypunched and added to the fuel tank establishment frame.

The sample of fuel tank establishments consisted of 1,618 establishments in the country (in order to achieve a target of 800 eligible establishments). Based on the regional totals of number of such establishments developed in the PSU frame-building effort, the total sample size was allocated to the six regions. Within each region, the establishments were sorted by PSU and SIC, and a self-weighting sample was drawn. Since the PSUs were sampled proportionately to the estimated number of establishments, this resulted in an approximately equal number of establishments per PSU within each region. There was not a precisely equal number per PSU for two reasons: the PSUs were sampled based on CBP counts and the establishments were sampled based on actual frame counts; and the PSU sample measure of size did not include an estimate for number of government establishments.

The second frame to be developed was the large establishments frame. This frame consisted of a list of business establishments in the sampled counties with 20 or more employees purchased from Dun's Marketing Identifiers (DMI). The establishments on this list with the fuel tank SICs (Table A-2) were clerically compared with NBL lists, county by county, to eliminate duplication between the two frames. Duplicates were deleted from the DMI list, and any establishment on the DMI list with one of these SICs not found on the NBL list were moved to the NBL list. The resulting DMI list was the frame for large establishments not in fuel tank SICs.

The sample of large establishments was drawn by first sorting the frame by region, PSU, and number of employees. Then a self-weighting sample of 600 establishments was drawn across the whole country. These establishments were contacted by telephone to determine whether they had underground fuel storage tanks. Those that did were part of the sample for initial data collection; no substitution was made for establishments with no tanks.

The third frame was farms. This was constructed by obtaining a list of all farms in the sampled counties from the U.S. Department of Agriculture, through EPA. The list included crop acreage for each farm. Any establishment on the DMI list with an agricultural SIC code was deleted from the DMI list and added to the farm frame if it did not already appear there.

The farm frame was sorted by region, PSU, and acreage. A national self-weighting sample of 600 farms was selected. These were screened by telephone to determine the presence of underground tanks. As with large establishments, no substitution was made for farms with no tanks.

II. PRIMARY SAMPLE UNIT (PSU) SAMPLE

This subsection discusses the first stage sample of Primary Sampling Units (PSUs). Appendix H discusses the sample of farms from PSU selection though the final sample of farms. Thus, this subsection and the following ones concentrate on the fuel establishments and large establishments, although some data on farms are included for completeness.

This subsection begins with a statistical description of the six survey regions based on data gathered in the construction of the Primary Sampling Unit (PSU) frame. It goes on to describe the PSU sampling process and concludes with a discussion of the sample of PSUs drawn.

A. Survey Regions

The six survey regions are defined in A-I, above, which includes a list of states in each region (Table A-1) and a map of the regions (Figure A-1). Here we describe the regions statistically in terms of characteristics important to the present study. Table A-3 gives several characteristics by region, both the amounts and the percent distributions.

The number of states and counties in each region is simply based on the definitions of the regions. The number of states ranged from three states in the Pacific Region (Region 6) to 14 states in the Northeast Region (Region 1). Alaska and Hawaii are not included, and the District of Columbia is counted as a state, making the total 49. In these 49 states there are 3,111 counties. The number per region ranges from a low of 133, again in the Pacific Region, to a high of 874 in the Southeast Region (Region 2).

The first step in constructing the PSU frame was to define PSUs, a process described in Subsection A-I. These consist of counties or groups of counties with a minimum estimated number of fuel establishments. The minimum was set separately for each region based on the expected number of establishments to be sampled per PSU in each region. The resulting PSU definition groups the 3,111 counties into 1,362 PSUs. The number per region

Table A-3. Statistical description of Underground Storage Tank Survey Regions [percent distribution in parentheses (4)]

Survey region	Number of states (Incl. DC)	Number of counties	Number of primary sampling units	1980 Population (1,000's) U.S. Census	Land area (sq. mi.)	Number of gas stations Versar report (1)	Number of facilities, selected other SICs 1981 CBP (2)	Sampling measure of size (3)	Number of large establishments (>20 empl.) 1981 CBP (2)	Number of farms, 1982 Census of Agriculture
1 Northeast	14	436	219	61,881 (27%)	238,400 (8%)	46,616 (24%)	34,829 (31%)	81,445 (27%)	157,843 (27%)	222,099 (10%)
2 Southeast	10	874	348	45,371 (20%)	466,678 (16%)	59,576 (31%)	19,403 (17%)	78,979 (26%)	108,367 (19%)	548,926 (24%)
3 Midwest	8	738	333	53,589 (24%)	448,419 (15%)	35,935 (19%)	27,124 (24%)	63,059 (21%)	138,742 (24%)	725,699 (32%)
4 Central	6	650	259	22,531 (10%)	634,346 (21%)	24,634 (13%)	11,738 (10%)	36,372 (12%)	61,756 (11%)	464,680 (21%)
5 Mountain	8	280	117	11,373 (5%)	855,193 (29%)	8,755 (5%)	5,273 (5%)	14,028 (5%)	29,144 (5%)	121,777 (5%)
6 Pacific	3	133	86	30,433 (14%)	318,994 (11%)	18,142 (9%)	13,843 (12%)	31,985 (10%)	87,461 (15%)	152,630 (7%)
Total	49	3,111	1,362	225,178	2,962,030	193,658	112,210	305,868	583,313	2,235,811

(1) Versar Corp. report to EPA, 1984

(2) County Business Patterns, 1981

(3) Sum of Gas Stations and Facilities with Other SICs

(4) Percent distributions may not add to 100% due to rounding.

ranges from a low of 86, again in the Pacific Region, to a high of 348 in the Southeast Region.

Two further statistics help set the stage for the survey in describing the regions: the number and percent of 1980 population in each region; and the square miles and percent of continental land area in each region. In terms of population, Regions 1-3 (the eastern block of regions) contain 27, 20 and 24 percent of the population, respectively, for a total of 71 percent of the population. Regions 4-6 have 10, 5 and 14 percent of the population, respectively. For land area the situation is reversed, though not as dramatic. Regions 1-3 contain 39 percent of the land area, while Regions 4-6 contain 61 percent.

The next three statistics form the basis of the PSU selection. The number of gas stations was estimated per state by Versar.[1] The distribution by region ranged from 5 percent in the Mountain Region (Region 5) to 31 percent in the Southeast Region (Region 2). Regions 1-3 contain an estimated 73 percent of the gas stations. The number of establishments with a Standard Industrial Classification (SIC) code among those selected as likely to have underground motor fuel storage tanks (see list in Table A-2) was found as counted in the 1981 County Business Patterns data.[2] Seventy-three percent of these other fuel establishments are in Regions 1-3. The percent by region ranges

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[1] Leaking Underground Storage Tanks Containing Engine Fuels, draft, March 1984, prepared by Versar, Inc. The gas station estimates were based on figures given in the 1983 Petroleum Marketing News Fact Book and include all retail outlets for branded gasoline.

[2] At the time of PSU sample selection, the 1982 CBP data were not yet available. They became available in time to use for final weights, as discussed in Subsection A-V.

from a low, again in the Mountain Region, of 5 percent to a high of 31 percent in the Northeast Region. These two figures (gas stations and other fuel establishments) are summed to form the sampling measure of size. The distribution of gas stations and other fuel establishments follows that of the population.

Although the PSUs were sampled based on the number of fuel establishments, a sample of large establishments (with 20 or more employees) and of farms was also to be drawn from the sample PSUs. The region statistics show that large establishments follow the same general pattern as population and fuel establishments: 5 percent are found in the Mountain Region and 27 percent in the Northeast Region; Regions 1-3 contain 69 percent of the large establishments as reported by the 1981 County Business Patterns data. Farms are found mostly in Regions 2-4, which have 78 percent of farms as shown in the 1982 Census of Agriculture. Looking at the East versus West breakdown we have been considering, the Eastern regions (Regions 1-3) contain 67 percent of the farms.

In Table A-4 some of these statistics are shown for the urban/rural breakdown. Each PSU is designated as urban or rural according to whether it is part of a Statistical Metropolitan Area or not. The majority of PSUs and constituent counties are designed as rural (65 percent of PSUs, 77 percent of counties), but the majority of the fuel establishments plus gas stations are found in urban PSUs (69 percent). The large establishments are even more concentrated in urban PSUs, with 85 percent found there.

B. Sampled PSUs

The sample of PSUs was drawn as stated in Section A-I, using the number of fuel establishments as a sampling measure of size.

Table A-4. Summary of PSU sampling frame, urban versus rural PSUs (percent distributions in parentheses)

Urban/ Rural	Number of counties	Number of PSU's	Sampling measure of size (1)	Large establishments (>20 empl.) 1981 CBP (2)
Urban	722	482	212,164 (69%)	479,461 (85%)
Rural	2,389	880	93,704 (31%)	103,852 (15%)
Continental Total	3,111	1,362	305,868	583,313

(1) Number of gas stations (Versar) plus other fuel-related establishments (CBP)

(2) County Business Patterns data

Thirty-four PSUs were drawn -- six from each region, except Region 5 where four were drawn. Tables A-5 and A-6 give estimates of frame counts that would result from weighting the PSU sample data by inverse of the sampling probability. This gives an indication of how closely the sample reflects the frame from which it was drawn. Not surprisingly, the sampling measure of size (number of fuel establishments) tracks the population very closely, with the same percent distribution by region and only one percentage point different for the urban/rural breakdown. The large establishment counts are reproduced fairly well by the weighted sample. The percent distribution by region is within one or two percentage points of the population distribution, but the urban/rural breakdown is not as close. While 85 percent of large establishments were in the urban PSUs nationally, in the weighted sample PSUs, 79 percent are in the urban PSUs.

Tables A-7 and A-8 give unweighted counts for the sampled PSUs. In Table A-7, we see that the 34 PSUs are composed of 76 counties. The number of fuel establishments plus gas stations as estimated from the Versar and CBP sources for the sampled PSUs is 27,753, and the estimated number of large establishments is 74,768. Table A-8 shows that 11 of the 34 PSUs are rural, with 36 of the 76 counties. The rural PSUs tend to have more counties in order to contain the minimum number of fuel establishments. The vast majority of both fuel and large establishments in the sampled PSUs are in the urban PSUs (95 and 98 percent, respectively). In the sample, one county, Los Angeles, was large enough to be self-representing. This PSU accounts for the large unweighted counts for Region 6 (Pacific) throughout the tables.

Overall, the PSU universe appears to be well reflected in the sample of PSUs. Figure A-2 shows the location of the sampled PSUs to indicate their geographic representation, as well. The

Table A-5. Weighted data from sampled PSUs, region summary (percent distributions in parentheses

Survey region	Number of counties	Number of PSU's	Sampling measure of size (1)	Large establishments (>20 empl.) 1981 CBP (2)
1 Northeast	561	210	81,364 (27%)	148,906 (25%)
2 Southeast	635	341	78,974 (26%)	123,360 (21%)
3 Midwest	912	328	63,139 (21%)	135,842 (23%)
4 Central	1,660	327	36,374 (12%)	57,475 (10%)
5 Mountain	344	120	14,030 (5%)	29,440 (5%)
6 Pacific	114	73	31,988 (10%)	89,358 (15%)
Total	4,227	1,399	305,868	584,381

(1) Gas stations plus other fuel establishments

(2) County Business Patterns data, 1981

(3) Percentages may not add to 100 due to rounding.

Table A-6. Weighted data from sampled PSUs, urban versus rural summary (percent distribution in parentheses)

Urban/ Rural	Number of counties	Number of PSU's	Sampling measure of size (1)	Large establishments (>20 empl.) 1981 CBP (2)
Urban	613	364	207,558 (68%)	462,468 (79%)
Rural	3,614	1,036	98,309 (32%)	121,913 (21%)
Total	4,227	1,399	305,867	584,381

(1) Gas stations plus other fuel-related establishments

(2) County Business Patterns data

Table A-7. Unweighted PSU sample data, region summary

Survey region	Number of counties	Number of PSU's	Sampling measure of size (1)	Large establishments (>20 empl.) 1981 CBP (2)
1 Northeast	13	6	5,453	9,051
2 Southeast	12	6	3,321	5,888
3 Midwest	14	6	2,317	6,555
4 Central	19	6	5,074	12,573
5 Mountain	10	4	1,144	3,058
6 Pacific	8	6	10,444	37,643
Total	76	34	27,753	74,768

(1) Gas stations plus other fuel-related establishments

(2) County Business Patterns data

Table A-8. Unweighted PSU sample data, urban versus rural summary

Urban/ Rural	Number of counties	Number of PSU's	Sampling measure of size (1)	Large establishments (>20 empl.) 1981 CBP (2)
Urban	40	23	26,627	73,305
Rural	36	11	1,126	1,463
Continental Total	76	34	27,753	74,768

(1) Gas stations plus other fuel-related establishments

(2) County Business Patterns data

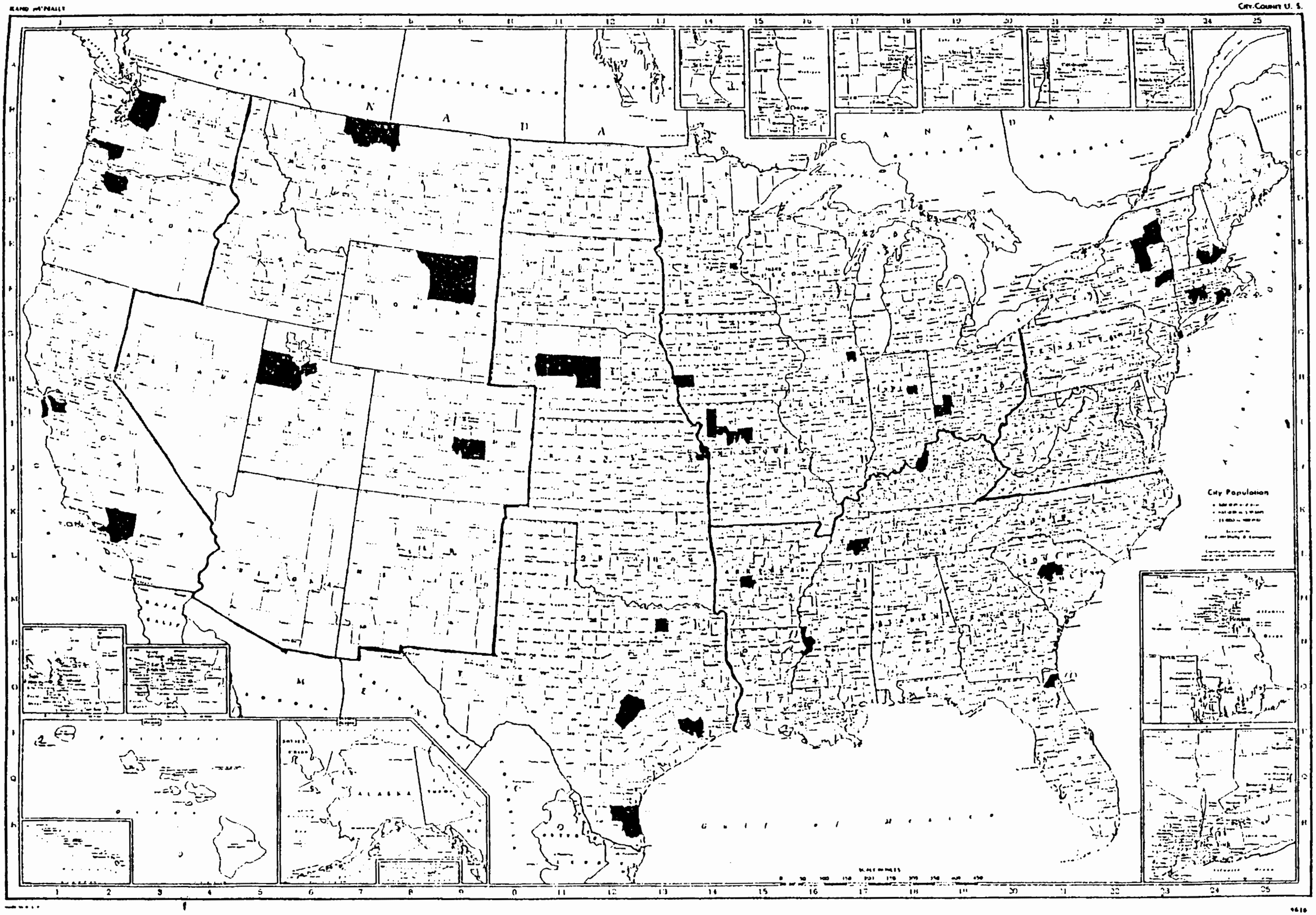

Figure A-2. Sample PSU locations

establishment sampling frame construction and establishment sample draw are described in the next section.

III. ESTABLISHMENT SAMPLE

Once the 34 PSUs were drawn, lists of all establishments in the three sampling sectors were constructed for the 76 counties which comprise the 34 PSUs. These lists are known as sampling frames. The initial sample of 2,818 establishments was drawn from these frames and screened for eligibility. Since so little was known initially about what type of establishment would have underground motor fuel storage tanks, the eligibility rates themselves were an early finding of the survey. The 896 eligible establishments form the final sample for the survey. This process is described in detail below for the fuel establishment and large establishment sectors (which account for 2,218 initial sample cases and 876 eligible cases). Appendix H reviews the process for the farm sector (600 initial cases and 20 eligible cases).

A. Sample Frames for Fuel-Related Establishments and Large Establishments

The sample frames were constructed as described in Section A-I, above. For the fuel-related establishments, several methods of list-building were combined to result in a single list. A list of government agencies with eligible tanks was developed for each PSU by a telephone search. Federal, state and local government officials were contacted to generate lists of all such civilian agencies, and a list of military establishments with eligible tanks in the sampled counties was provided to EPA by the Department of Defense (DoD). A list of the fuel-related business establishments (gas stations and other industries, see list in Table A-2) was purchased from National Business Lists (NBL) and supplemented by any additional establishments with one of the selected SICs that appeared on the purchased DMI list of large establishments. The constructed government and military lists were appended to the purchased establishment list to form the fuel establishment sampling frame.

The large establishment sampling frame was purchased from Dun and Bradstreet's list of business establishments, the Dunn's Market Identifiers (DMI). This list source is more expensive than NBL but was required since it contains the number of employees for each establishment, which NBL does not. A list of all establishments in the sampled counties with 20 or more employees was purchased. The establishments on this list with any of the fuel-related SIC codes were selected from the large establishment frame and printed out. They were clerically compared with the fuel establishment frame, county by county, and any such establishment not already on the fuel establishment frame was added to it.

Table A-9 shows the resulting frame counts by survey region for these two frames. The counts show fairly good (by no means perfect) agreement with the counts in Table A-7, based on CBP and Versar data. For large establishments not in fuel-related industries, the frame count is about 10 percent lower than the CBP count. Region 6 (Pacific) shows a higher percent deficit, about 15 percent, and also the bulk of the amount, 5,000 cases. For the fuel establishment sample, the total measure of size in Table A-7 (27,753 establishments) does not include any allowance for government and military cases, of which there were 3,139 on the frame. Subtracting these from the frame total leaves 30,583 establishments, or about 10 percent more than the sampling measure of size. Table A-10 shows the frame counts broken down

Table A-9. Number of establishments on the frames for 34 sampled PSUs (unweighted), by survey region

Survey region	Fuel establishment frame count	Large, non-fuel establishment (≥ 20 employees) frame count
1 Northeast	5,403	8,472
2 Southeast	3,023	4,811
3 Midwest	3,355	6,193
4 Central	6,027	13,227
5 Mountain	1,650	2,698
6 Pacific	14,264	32,677
Total	33,722	68,078

Table A-10. Number of establishments on the frames for sampled PSUs (unweighted), by urban versus rural

Type of PSU	Fuel establishment frame count	Large, non-fuel establishment (≥ 20 employees) frame count
Urban	33,208	66,935
Rural	1,723	1,143
Total	34,931	68,078

by urban versus rural PSUs, which agrees well with the breakdown found in Table A-8.

B. Establishment Sample Draw

As described in Section A-I, above, the fuel establishment and large establishment samples were drawn separately.

For the large establishments, a single national self weighting sample of 600 establishments was drawn. The frame was sorted by PSU and by number of employees within PSU. Each case was given a measure of size in inverse proportion to the sampling probability of the PSU it was in. A systematic sample (based on a random start) of 600 establishments was drawn using probability proportional to this measure of size.

The fuel establishment sample was drawn one region at a time so that sampling could begin before all frames were completed. The target number of 800 eligible establishments was allocated to the six survey regions based on their sampling measure of size. Based on early results for eligibility rates of government and gas station establishments, and based on the relative proportion of the frame in each region that fell into these two categories, the target number of eligibles was inflated to an allocated initial sample size for each region. The net result was an approximate doubling of the sample size. The detailed figures appear in Table A-11.

Table A-11. Target sample size, by region, for fuel establishment sample

Survey region	Target number of eligible establishments	Allocated size for sample draw
1 Northeast	213	449
2 Southeast	206	415
3 Midwest	165	325
4 Central	95	194
5 Mountain	37	75
6 Pacific	84	160
Total	800	1,618

C. Eligibility Rates for Fuel and Large Establishment Sample

Once the samples were drawn, they were screened for eligibility. Table A-12 shows the initial sample draw and number of eligible cases, by region, for both samples. There were several possible reasons for a sampled establishment being ruled out of the scope of the survey. Some establishments were found to be not actually located in the sampled county (48 cases for these two samples), out of business (85 cases), or ineligible for other similar reasons (22 cases). Six were duplicates of another sampled listing. Of establishments found to be in the survey counties and in business, 97 had only abandoned tanks and 1,084 had no underground storage tanks, or stored only non-motor fuel substances, leaving 876 eligible establishments.

Table A-13 shows weighted eligibility rates by type of establishment for the survey regions and overall. It shows that about 80 percent of sampled gas stations were survey-eligible. Ineligible gas stations were generally out of business. Eighty percent of government and military were eligible. Some had been mistakenly included on the frame. Ineligible government cases were generally out of area or storing non-motor fuel substances. The other fuel-related industries category shows about one-quarter eligible. Here, the out of business rates were lower than for gas stations, and most ineligible cases had abandoned tanks or no tanks. For large establishments the overall eligibility rate was 13 percent. Almost all of the ineligibles in this sample were establishments which simply had no tanks.

These varying eligibility rates show that although underground motor fuel storage tanks are concentrated in certain industries, they occur in establishments in a broad range of industries.

Table A-12. Sample eligibility, by region, unweighted counts of sampled cases

Survey region	Fuel establishments		Large establishments	
	Total sample draw[1]	Number of eligible establishments	Total sample draw	Number of eligible establishments
1 Northeast	447	225	158	21
2 Southeast	413	197	116	18
3 Midwest	324	161	142	13
4 Central	193	92	68	7
5 Mountain	75	42	29	4
6 Pacific	160	83	87	13
Total	1,612	800	600	76

[1] 1,618 cases were drawn, but 6 were found to be duplicates during the screening process.

Table A-13. Weighted eligibility rates (percent eligible), by region and type of establishment

Survey region	Type of establishment				
	Gas stations (%)	Other fuel-related industries (%)	Government and military (%)	Fuel establishment sample combined (%)	Large establishments (%)
1 Northeast	83	27	70	53	13
2 Southeast	81	19	85	51	16
3 Midwest	83	21	81	53	9
4 Central	79	23	89	54	10
5 Mountain	84	27	100	60	14
6 Pacific	86	30	82	59	15
Total	83	24	80	54	13

IV. SUBSAMPLE OF ESTABLISHMENTS FOR TANK TIGHTNESS TESTS

The eligible sampled establishments had approximately 2,000 underground motor fuel storage tanks or manifold systems. A subsample was drawn for physical tank testing. For the survey at large, the target number of tank tests was 500. Fifty were set aside for farms (during the planning stage, it was not known how many farm tanks would be found), leaving 450 tank tests for the subsample of fuel-related and large establishments.

At the time the subsample was drawn, it was assumed that a manifolded system of two or more tanks connected by piping would always be physically tested as one unit and therefore would count as one test. During the process of doing the testing it was found that, in fact, some systems were relatively simple to break apart for testing, and this was done where possible. In this section, we count tanks or manifolded systems; but in the sections reporting on tightness tests, the counts of individuals tanks or of separate tests are generally given.

Table A-14 shows the allocation of the 450 tank tests by survey region. This allocation is the estimated number of tanks or tank systems to be tested for each category; some variation occurred in the final sample since establishments rather than tanks were the sampling unit. For the farms, the number of tank tests depended on what was found during the interviewing and tank test scheduling.

The allocation was made as follows. Of the 450 tank tests, 40 were allocated to Region 5 to assure a minimum sample size for that region. The remaining 410 tank tests were allocated to Survey Regions 1-4 and 6 in approximately the same proportion as

Table A-14. Subsampling establishments for tank tightness testing (fuel and large establishments combined

Survey region	List of eligible establishments		Subsample for tank tightness testing		
	Number of eligible establishments (at time of subsampling)	Number of tank systems[1] at eligible establishments	Target Number of tank systems[1] to subsample	Number of establishments subsampled	Number of tank systems[1] at subsampled establishments
1 Northeast	248	587	115	51	112
2 Southeast	214	544	110	47	111
3 Midwest	175	426	90	38	86
4 Central	100	231	50	23	52
5 Mountain	46	116	40	17	43
6 Pacific	96	207	45	22	46
Total	879	2,111	450	198	450

[1] In allocating and drawing the subsample of establishments for tightness testing, a manifolded tank system was counted as one unit. Some such systems were separated for physical testing.

the fuel establishment sample allocation. Allocating the sample in advance permitted us to draw the sample on a region by region basis as the final eligibility results came in from the field interview phase of the survey.

For each region, a sampling frame was created, containing eligible fuel and large establishments at which tanks were found (including establishments that refused to be interviewed). The frame construction waited until all cases had reached a final status and preferably had a known number of tanks or manifolded systems. The frame contained the establishment ID, the number of tanks or manifolded systems, and the establishment sampling weight. This list was then sorted by number of tanks, then by PSU (from ID), and then by fuel establishment versus large establishment (also part of ID). The weights were cumulated down the entire list. The number of facilities to select, M_j, was based on the allocated number of tanks, N_j, and the weighted average number of tanks per establishment, T_j, as shown in the following equation:

$$M_j = N_j/T_j$$

The sampling interval, SI_j, was the grand total of the weights divided by M_j (M_j was not rounded). The sample was drawn in systematic fashion, beginning with a random start between 0 and SI_j. The establishments selected in each survey region have a total number of tanks or manifolded systems close to N_j (see Table A-14). Within each survey region, all underground fuel storage tanks or manifolded systems have an equal probability of selection for physical tightness testing.

V. FINAL SAMPLE WEIGHTS

A. Questionnaire Weights for Business and Government Establishments

1. Other Fuel-Related SICs (Other Than Gas Stations)

The final questionnaire weights for establishments sampled with fuel-related SICs other than gas stations were based on a ratio adjustment of the initial sample weights for all such screened establishments to 1982 CBP counts of these SICS, followed by a nonresponse adjustment among the eligible other fuel-related establishments to account for the few nonrespondents. The adjustments were made by survey region. The ratio adjustment served to put the initial sample on a known basis, the number of establishments with one of the fuel-related SICs in each region. Then the eligible cases weight up to an estimate of the number of such establishments with eligible tanks, by region. The nonresponse adjustment assures that the weighted results based on questionnaires received will equal the estimates based on screening results.

2. Gas Stations (SIC 5541)

The gas stations were weighted in the same way as other fuel-related SICs. First, the initial sample was ratio-adjusted by region to CBP totals for gas stations. The eligible cases then weight up to an estimate of the number of gas stations with eligible tanks, by region. A nonresponse adjustment again assures that the weighted results based on questionnaires received will equal the estimates based on screening.

3. Other Industries (Establishments With 20 or More Employees)

The sample sector of establishments with 20 or more employees in industries not otherwise sampled (the large establishments) was weighted the same way as the gas stations and other fuel-related industries. The CBP totals of establishments of this size in all but the selected fuel-related SICs (which include SIC 5541, gas stations) were used for a region by region ratio adjustment of the initial sample. The weighted eligible large establishments then estimate the number of such establishments with eligible tanks in the country, by region. Since all eligible large establishments participated in the interview phase of the survey, no nonresponse adjustment was needed.

Table A-15 shows the totals based on 1982 County Business Patterns data which were used as the fixed totals the initial sample weights were adjusted to sum to.

4. Government Agencies

No national statistics are currently available to estimate the number of individual government agencies with underground motor fuel storage tanks, which is the universe our frame was built to cover. Therefore, no ratio adjustments can be made. Nonresponse adjustments were made to account for the small amount of nonresponse.

Table A-15. Known totals from 1982 County Business Patterns data base used for ratio adjustment

Survey region	Type of establishment		
	Gas station (SIC = 5541)	Other selected fuel-related industries	Large establishments (≥ 20 employees) not in selected industries
1 Northeast	28,212	42,173	158,320
2 Southeast	22,623	29,825	109,137
3 Midwest	27,551	37,391	131,769
4 Central	12,473	17,786	67,150
5 Mountain	6,100	7,881	30,129
6 Pacific	13,840	18,565	84,998
Total	110,799	153,621	581,503

B. Physical Test Result Weights for Business and Government Establishments

After calculating final questionnaire weights for all responding establishments as described above, the sampling weights for establishments chosen for physical testing were adjusted to sum to the estimated totals for four establishment types (government, gas station, other fuel-related, and other industry) by region. This adjustment was made by an iterative rating procedure in which the weights were adjusted first to regional totals, then to establishment type totals, then readjusted to regional totals, and so forth, until no further adjustment was needed. This took five and a half iterations to achieve.

A final adjustment was made for tank test result weights. If all selected tanks had been tested, the weight for an individual tank or tank system test would be equal to the establishment physical test weight. However, some tanks were not tested. Thus a "tank nonresponse" adjustment was made to the tank/tank system weights to account for the untested tanks. A single tank counted once (added its weight) in the count of tanks selected and once in the count of tanks selected. A manifolded tank system which was not tested counted once for each tank in the count of tanks selected. A manifolded tank system which was broken apart and tested as separate tanks also counted once for each tank in each count. A manifolded tank system which was tested as one system counted once for each tank in the count of tanks selected and once for each tank in the count of tanks tested. The ratio of the weighted count of tanks selected to the weighted count of tanks tested was used to form the final adjustment to tank weights. This was done over the sample as a whole rather than by region.

C. Farm Questionnaire and Physical Test Weights

Due to the distribution of farms within the survey regions (both overall and in our sample) and the low yield of eligible farms from the screening, for weighting and any regional analysis purposes the survey regions have been consolidated into three areas for farms (see Appendix H). These are:

- East (combines Northeast and Southeast Survey Regions);
- Midwest; and
- West of the Mississippi (combines Central, Mountain and Pacific Survey Regions.

Total counts of farms for these areas were obtained from the 1982 Census of Agriculture and used to form ratio adjustments for eligible farms. Due to one refusal among farms, a nonresponse adjustment was also made.

Since so few farm tanks were tightness tested, no weighted estimates will be presented for that data, and hence final weights were not prepared for physical test results for farm tanks.

VI. VARIANCE ESTIMATION

A. Jackknife Approach to Variance Estimation

In a complex survey such as this one, it is difficult or impossible to estimate the variance of survey estimates directly from algebraic formulas. An alternative approach often used, and adopted for this survey, is the so-called jackknife method of variance estimation through replication. The idea behind the method is to draw a collection of subsets of the sample, called replicates, and use the subsets to form national estimates of the statistic whose sampling variance is being estimated. The variability among these estimates is used to estimate the sampling variance of the estimate based on the full sample. [See Sampling Techniques, 3rd Edition, W.B. Cochran, J. Wiley & Sons, 1977 for a brief discussion of the principles of this method.]

B. Replicate Formation

To form the replicates, the sampled PSUs were paired and one PSU dropped from each pair in turn. Since there were 34 PSUs, there were 17 pairs and 17 replicates. The pairs were formed as follows. Thirty-four PSUs were drawn in six survey regions. Except for one certainty PSU in Region 6, they were paired into strata in straightforward fashion -- PSU 1 with 2, PSU 3 with 4, and so on. Region 6 required some special consideration. The sample in the region consisted of PSUs 29 through 34, with PSU 31 being a certainty PSU. PSUs 29 and 30 were paired. Establishments in PSU 31 were separated into "odds" and "evens" and these sets were treated as a pair of PSUs. This left PSUs 32, 33, and 34 to consider. These three PSUs were grouped into one stratum; PSU 33 was randomly paired with 32, giving the paired PSUs 3/4's their initial weight; and PSU 34 was given 3/2's its initial weight. Then either the singleton or the paired PSUs are randomly selected to be dropped for one replicate.

The resulting strata and random selection of which PSU to drop from each stratum, in turn, to form a replicate (17 replicates in all) are shown in Table A-16.

Table A-16. Definition of strata and replicates for jackknife estimation of variance

Stratum	PSU 1	PSU 2	PSU to drop
1	1	2	1
2	3	4	4
3	5	6	6
4	7	8	8
5	9	10	9
6	11	12	12
7	13	14	14
8	15	16	16
9	17	18	17
10	19	20	19
11	21	22	22
12	23	24	23
13	25	26	26
14	27	28	27
15	29	30	29
16	31, odds	31, evens	31, odds
17	(32 & 33) (3/4's)	34 (3/2's)	(32 & 33)

C. Jackknife Replicate Weights and Variance Estimates

Seventeen replicates were formed by dropping a randomly selected PSU from each stratum, in turn. Weights were calculated for each replicate as follows. As an initial sampling weight for the replicate, establishments at the selected PSU of a pair were assigned twice their initial weight, while establishments in the dropped PSU were assigned zero. Establishments in all other PSUs kept their initial sampling weight. Then the ratio adjustment to CBP totals by industry type and region and the nonresponse adjustment by the same categories were done as described above for the full sample final weights. For tank test replicate weights, the subsampled establishments in the replicate had their weights adjusted by raking to the replicate total by region and industry type, and replicate tank test nonresponse adjustments were made. Repeating all steps of final weight adjustment in calculating the replicate weights ensures that the variance estimates will reflect the impact of weight adjustments on the variance.

Subscripting the 17 replicates by r = 1 ..., 17, the variance of a national estimate, $\hat{X}$, of a statistic X is given by:

$$\hat{S}_X^2 = \sum_{r=1}^{17} (\hat{X}_{(r)} - \hat{X})^2$$

where $\hat{X}_{(r)}$ is the estimate based on the $r^{\underline{th}}$ replicate. The flexibility of this method of variance estimation can be realized by noting that the statistic X could be not only a total (such as number of establishments with tanks) or a proportion (percent of all tanks that leak) but any statistic that can be estimated from the full sample and from each replicate in turn.

APPENDIX B

SURVEY PROCEDURES AND ELIGIBILITY AND RESPONSE RATES

I. IN-PERSON INTERVIEW PRETEST

In July and October of 1984, survey packages (including introductory letter, questionnaire, general instruction booklets, and inventory forms) were mailed to a pretest group of 10 establishments which were previously determined to have underground storage tanks in use. They were selected through liaison with local government and military officials rather than by random sampling or from developed survey listings. The July pretest group consisted of seven "fuel-related" establishments and the October group included three military installations. Using government-operated establishments in the pretest allowed us to prepare for problems not normally encountered in non-government situations. The purpose of the pretest was to evaluate the format and wordings of the questions in the interview for clarity and administerability; to determine the length of administration time for the interview; and to assess specific and overall response to the flow of the interview and individual items in the interview. In addition, several on-site procedures were tested including meter testing, tank sticking, site diagraming and soil sampling. Several revisions to materials and adjustments to on-site procedures were made prior to the field period. No results from the pretest are included in the final estimates of the survey.

II. WESTAT TELEPHONE PRESCREENING AND LIST CONSTRUCTION PROCEDURES

Since lists of establishments with underground motor fuel storage tanks do not exist, it was necessary to develop establishment frame lists for each of the 34 PSUs. As described in detail in Appendix A, the universe of all establishments with underground motor fuel storage tanks was divided into three segments: the fuel-related establishments, large establishments (with more than 20 employees), and farms. Lists of fuel-related establishments, large establishments and farms were purchased or obtained for the 34 PSUs in the survey. Since a list of government establishments and locations was not available, a telephone list construction procedure (described in Section B-II.B below) was used to construct government tank establishments lists in the 34 PSUs. In the 34 PSUs a sample of 1,618 fuel-related establishments (including government and military establishments), 600 large establishments, and 600 farms was drawn to be surveyed. Since eligibility rates were expected to be low (less than 50%) telephone screening procedures were implemented using the Westat Research Telephone Center in order to determine which farms and large establishments were "eligible" (had underground storage tanks) for the survey. (Fuel establishments, including government and military establishments were screened in the field.)

A. Government Tank Establishment List Construction

Because there is no central listing source for government establishments with underground motor fuel storage tanks, federal, state, county, and city lists were developed using extensive telephone research. Initial contacts with officials at different government levels (i.e., state and county Fire Marshall's Office, Public Works Department, local Police Department) provided the telephone interviewer with the location of underground storage tanks or referrals to other contacts who could furnish information on underground storage tank locations. Hard-copy listings were accepted by mail if the data was too extensive to be given over the phone. After all leads were exhausted, using a minimum number of calls, and the lists were determined to be complete. They were then added in as part of the fuel-establishment sample frame.

B. Farm and Large Establishment Screening

Using the farm and large establishment sample lists, telephone interviewers contacted the owner or operator of the establishment and asked whether the farm or business had any underground storage tanks in use to store motor fuel. For those establishments which were eligible, a contact name was obtained to assist the field interviewer. All establishments that could not be located by phone (19%) or refused the screening interview (1%), were included in the field screening efforts. All but two percent of the farms and large establishment that could not be located or screened by telephone were located and screened in the field screening effort.

III. UST SURVEY MAILOUT

The mailout for the UST Survey began on November 26, 1984 with survey Region 6 (West coast) and continued in phases working through Region 4 (Southwest), then Region 2 (Southeast), Region 1

(Northeast) and Region 3 (central U.S.). (See survey region map in Figure B-1.) The last phase of the mailout was completed on May 3, 1985, with packages being sent to Region 5 (Midwest). Survey packages were sent certified mail to a sample of 1,965 establishments. Included in this sample were those farms and large establishments which could not be located through the initial Westat telephone screening. Survey packages were mailed according to the schedule of the field interviewers, so that the respondents received the survey materials approximately two weeks prior to the interviewer's arrival at the site. The purpose of the survey mailout package was to allow the respondent time to prepare for the in-person interview.

Because the packages were sent certified mail, the date the package was received and the name of the recipient was available for the interviewer. The field interviewer used this information to trace those establishments which could not be located by phone. Each day, certified mail receipt cards returned were keyed into an automated receipt control system (discussed in Section 5-V.B). For survey packages returned by the post office to Westat, a log was kept indicating establishment identification numbers and reason for return. This information was passed on to the interviewer, who then took responsibility for getting the survey materials to the respondent. Eleven percent of the packages were returned by the post office, and less than one percent were refused. However, field interviewers were able to contact nearly all of the establishments for which the package was returned.

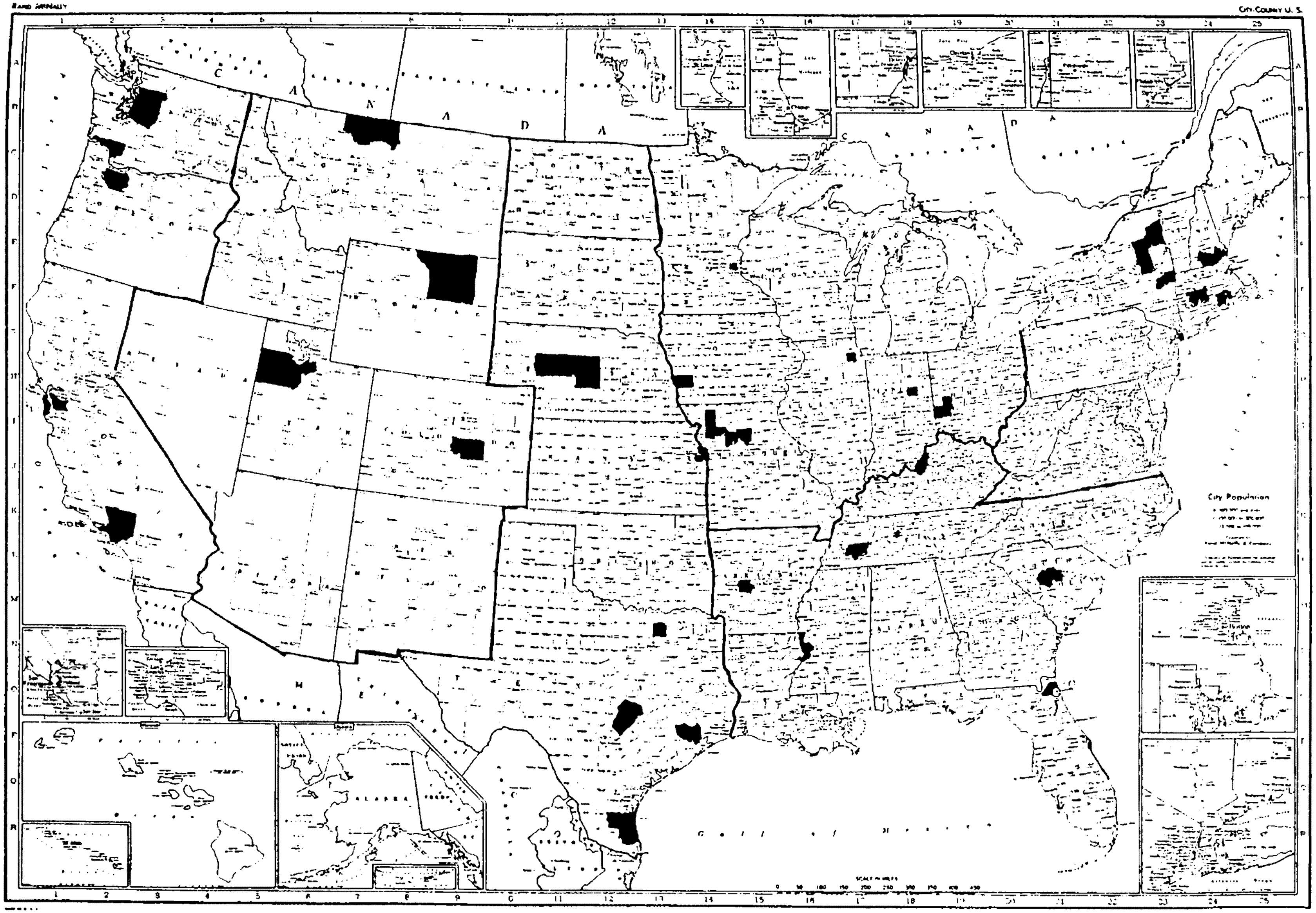
RAND McNALLY
CITY-COUNTY U.S.
CANADA
City Population
Gulf of Mexico
ALASKA

Figure B-1

A. UST Survey Package

Every establishment received the same package of survey materials, which were labeled with the establishment survey I.D. number, establishment name, and address. The package consisted of the following items, which are included as Exhibits in Appendix F:

- Open Letter to Owners and Managers of Underground Motor Fuel Storage Tanks -- An introductory letter that informed respondents of the need and purpose of the survey;
- "Certification Statement for Establishments without Tanks" -- A labeled form for the respondent to sign and return to Westat if there were no underground motor fuel storage tanks located at the establishment;
- "Reporting Responsibilities of Tank Owners and Operators" letter -- A one-page information sheet quoting the amended RCRA regulation that requires respondents to participate in the study;
- <u>General Instruction Booklet</u> -- A booklet describing procedures for completing the questionnaire and inventory forms. A "Request for Confidential Treatment of Business Information" form was included in the instruction booklet for the respondent to sign if necessary;
- <u>Underground Storage Tank Survey Establishments Operator's Questionnaire</u> -- One labeled copy was included to be reviewed by the respondent prior to the in-person interview;
- Inventory Sheet for Tanks with Metered Dispensing Pumps and Dispenser Meter Recording Sheet -- Six labeled copies were included in the package so that the respondent could begin to keep inventory prior to the interview;
- Manifolded Tank System Recording Sheet -- One labeled copy was included in the package; and
- Inventory Sheet for Tanks without Metered Disposal Pumps -- One labeled copy was included in the package.

A toll-free Westat "hot line" number was included in the introductory letter as well as in the General Instruction Booklet to provide survey assistance for the respondent.

IV. FIELD PROCEDURES

Fieldwork for the UST Survey began December 2, 1984. A staff of seven field interviewers was trained to collect data from the sampled establishments. Between one and three interviewers were assigned to cover a PSU depending on the numbers of establishments sampled per PSU. The interviewer's tasks in each PSU included eliminating ineligible establishments using field screening techniques, and scheduling and conducting on-site interviews. These procedures are discussed below in Section B-IV.A and B-IV.B. On the average, work in each PSU was completed in 15 days. The field phase of the UST survey concluded on June 29, 1985. However, data collection efforts through the mail and by telephone for incomplete cases continued until November 18, 1985.

A. Field Screening

An interviewer's assignment list for a PSU consisted of a call record folder for each establishment to be screened and interviewed. (See Appendix F for a copy of the UST call record folder). These lists included the farm and large establishments which could not be located through the Westat Telephone Research Center screening procedure. As a part of the initial appointment-making telephone call or visit, the interviewer determined whether the establishment did indeed have underground motor fuel storage tanks on site. In most cases, the interviewer was able to determine whether or not the establishment was eligible through an initial phone contact. Where phone contact was not possible, the interviewer traveled directly to the establishment site to speak with the respondent. Once eligibility for an establishment was determined, the interviewer then scheduled appointments for the in-person interview. Those establishments that sent the signed "Certification for Establishments without Tanks" prior to the beginning of fieldwork in a PSU were taken off the interviewer's assignment lists, and were not field-screened.

1. Statistics on Eligible Establishments

Table B-1 shows the number of establishments which were sampled, screened, and eligible for the UST Survey. Approximately three percent of all farms and 13 percent of all large establishments sampled were eligible for the survey (had underground motor fuel storage tanks). Almost 50 percent of all fuel-related establishments sampled were eligible. Reasons for ineligibility are discussed in Section 5-IV.A.2.

Table B-1. Number of sampled, contacted, and survey-eligible establishments, by sample stratum

	Farms	Large establishments	Fuel-related establishments	Total
Number sampled	598[1]	600	1,612[2]	2,810
Number contacted	596	596	1,608	2,800
Number of establishments contacted that have tanks ("eligibles")	20 (3.4%)	76 (12.8%)	800 (49.8%)	896

[1] 600 farms were sampled. Two farms were found to be duplicates in the telephone pre-screening.

[2] 1,618 fuel establishments were sampled. Six were found to be duplicates in the field screening.

2. <u>Statistics on Ineligible Establishments</u>

When a sampled establishment was determined to be ineligible for the survey the interviewer assigned an appropriate status code on the establishment's call record, and notified the Westat field director. Table B-2 contains the reasons for ineligibility and their frequency of occurrence by type of establishment. The majority of establishments were found to be ineligible because they had no tanks. Approximately 95 percent of all ineligible farms and large establishments fall under this category. Among the fuel-related establishments ineligible, 73 percent had no underground storage tanks. All establishments in Regions 1 through 5 found to have no underground motor fuel storage tanks through field screening procedures were instructed to sign and

Table B-2. Statistics on ineligible establishments

	Farms[1]	Large Establishments[1]	Fuel Establishments	Total
A. No. of establishments contacted	596	596	1,608	2,800
B. No. of ineligible establishments	576	520	808	1,904
C. Percent of establishments contacted that were inelible	97%	87%	50%	68%
D. No. of establishments with no underground tanks	544 (94.4%)	495 (95.2%)	589 (72.9%)	1,628 (85.5%)
E. No. of establishments with abandoned tanks	13 (2.3%)	5 (1.0%)	92 (11.4%)	110 (5.8%)
F. No. of establishments out of business	11 (2.0%)	10 (1.9%)	75 (9.3%)	96 (5.0%)
G. No. of establishments out of PSU	6 (1.0%)	7 (1.3%)	41 (5.1%)	54 (2.8%)
H. No. of establishments out of scope of the survey	2 (.3%)	3 (.6%)	11 (1.3%)	16 (.9%)

[1] Statistics for farms and large establishments are a combination of the Telephone Research Center and field screening results.

return a statement certifying their establishment has no tanks (See Appendix F). Of the 745 establishments in the survey Regions 1-5 with no underground motor fuel storage tanks, 82 percent returned the "No Tank" form. For establishments in Region 6 with no underground tanks, the interviewer went directly to the site, observed there were no tanks, and picked up the signed form from the respondent. This was a quality control measure to check the accuracy of the certification.

Establishments which had abandoned tanks, were out of business, out of PSU, or out of the scope of the survey accounted for about 15 percent of the ineligible establishments.

It should be noted that if an establishment moved from the site sampled to a different location within the PSU, the establishment was considered eligible and the interviewer followed the establishment to the new location to conduct the interview. Also, if the owner of the establishment had sold the business, the current owner/operator was interviewed.

B. On-Site Procedures

Once at the establishment the interviewer had several types of data to collect. On-site procedures included an in-person interview using the EPA Underground Storage Tank Survey Questionnaire, a discussion on keeping inventory records, checking the accuracy of the fuel dispenser meters, making fill-pipe and drop-tube measurements, preparing or obtaining a site sketch map, and locating the establishment on topographical maps. The respondent was to gather the necessary data prior to the interview to prepare for the on-site visit as instructed in the survey package.

1. The Call Record Folder

All information and associated material gathered from the on-site visit of each establishment were kept in an individually labeled call record folder (Appendix F) for that establishment. The call record folder became the case jacket for the establishment and was preprinted with forms for address and name updating interview status reporting, contact and call recording, interview procedures guidelines, and an interviewer debriefing form. All materials, such as questionnaires and inventory information, collected at an establishment were labeled with the establishment identification number and filed in the establishment's call record folder.

For each PSU worked, the interviewer received a package of pre-labeled call record folders, each call record folder representing a sampled establishment. The label placed on the outside of each call record folder contained the establishment name, survey I.D. number, mailing address, tank location address, contact name, contact telephone number, and the county and state the establishment was located in. Below this label, in the Label Verification area, the interviewer noted any changes in the original information on the label. These changes were entered into the automated receipt control system described in Section B-V.B. Also on the front of the call record folder, the interviewer indicated the completion status of each on-site procedure. Printed inside each folder was a script the interviewer followed which led him/her through the interview. Also printed inside the folder were a set of debriefing questions which asked how willing and prepared the respondent was for the on-site visit. A record of all calls to the establishment or the respondent was kept on the back of the folder. Each call record folder had additional survey identification labels stapled inside to be used for labeling any materials or records received during the interview.

2. The Questionnaire

The questionnaire body is divided into eight sections, with each section focusing on a particular topic or concern.

o Section A: Establishment Descriptive Information

Section A has two purposes. The first purpose of the section was to describe the type of establishment that was being interviewed. (Question A1 was an industrial classification, for example.) The second purpose of the section was to find and "screen out" any remaining "out-of-scope" cases. Question A1 had a screening-out route for bulk fuel plants and private residences, for example. (Private residences were completely out of scope. Bulk fuel plants were only in scope if they had motor fuel storage that was non-bulk, for use directly by motor vehicles. Private residences and bulk fuel plants were asked to call the Westat home office for instructions on how to proceed.)

Question A6 was another screening question. Naturally, given the nature of the survey, establishments that did not have underground motor fuel storage tanks were not to be interviewed. (Also, in Question A6 any underground storage tanks that were permanently out of service or that were used only to store non-motor fuels such as chemicals of heating oil were excluded.) Question A11 was used as a lead-in to the Tank Description Sheet (which is described below) and also asked the respondent to provide or draw a map of the establishment. The primary purpose of the map was to help the field interviewer establish the location and linkages between the tanks, pumps, and meters at the establishment. The tank testing crews also used the map to help identify the tanks to be tested, as well as to correctly number the tanks on their data forms.

o The Tank Description Sheet

The Tank Description Sheet is a two-page sheet containing specific questions about each tank at the establishment. A total of 44 items about each tank include questions on the amount of fuel held in the tank, the materials of construction, year of installation, safety features, leak history, etc.

Tank Description Sheet information is used in conjunction with tank test results in order to learn more about the factors and features of tanks that are associated with leaking. The information from the Tank Description Sheets was also used by the tank testing crews. For these reasons it was of great importance that the tank identification number of the Tank Description Sheet and the tank identification number on the map and the inventory were all the same.

- Section B: Operating Practices

The particular focus of Section B is on the establishment's typical inventory record-keeping and inventory management practices. The interest here is in the establishment-kept records, in factors associated with the accuracy of those records, and in the kinds of records that were kept.

- Section C: Operating History

This section contains questions that fill in the establishment's past tank history. The Tank Description Sheets provide basic historical information about the tanks currently in use. In Section C information is obtained on tanks that have been replaced, removed without being replaced, or abandoned in place, and in the number, the date and the reason for each of these three actions.

- Section D: Permits and Licenses

Section D comprises two questions about permits and licenses a respondent has to install and operate his tank.

- Section E: Installation

Section E is a short series of questions about the methods by which the tanks were installed at the establishment.

- Section F: Protection

Section F asks about the types of leak-protection, corrosion-protection, and leak-detection devices that have been installed at the establishment, and the kinds of operating and maintenance practices for the devices.

- Section G: Information Needs and Availability

Section G focuses on the kinds of information and training relating to tank operating and monitoring that were available to the respondent. Also included were questions which asked the respondent about types of liability insurance held by the establishment to cover sudden and non-sudden spills (and leaks) of motor fuel.

Interview responses varied depending on how knowledgeable the respondent was and how willing he/she was to participate. Often, it was necessary for the interviewer to speak with more than one respondent to get enough information to complete the questionnaire. In some instances, the interviewer was unable to get any information from the on-site respondents at all. Operators of establishments owned by multi-establishment corporate structures occasionally referred the questionnaire to their home office, which was always off-site and generally outside the PSU where the interviewer was located. In these cases, followup calls from Westat were made to obtain the completed questionnaire. Interview response rates are discussed in Section B-V.F.

3. Reviewing the Inventory Sheets

After completing the interview with the respondent, the next step for the interviewer was to review the inventory forms. Included in the survey package the respondent received were four kinds of motor fuel inventory sheets, a schematic diagram of the seven most common tank and dispenser hookup systems (in the General Instruction Booklet), and an Inventory Recording Table (in the General Instruction Booklet) to help him choose the correct inventory sheets to use for his establishment. The respondent should have started keeping inventory on these forms prior to the interview. Because of the complexity of the data being gathered, the interviewer was instructed to always review the inventory sheets with the person responsible for keeping them. This was not always the same respondent who answered the questionnaire. Depending on the size and type of establishments, several people were sometimes involved in keeping the inventory records. It was the interviewer's job to make sure the respondent understood the inventory process and was filling the forms out correctly. If the respondent chose to provide 30 days of previously collected inventory, the interviewer reviewed the data carefully and made sure all the necessary information was provided (or that the respondent knew what information was necessary if previously collected inventory was to be mailed in from another location, for example, a home office where all records were kept).

Before reviewing the inventory forms, the interviewer had to verify that the tanks and meters were numbered the same on the map drawn by the respondent in the questionnaire, in the Tank Description Sheets, and on all inventory forms. It was very important to make sure these numbers corresponded in order to link data from inventory forms and tank tests to the questionnaire data. The interviewer used the Tank to Dispenser Meter Fuel Line Connections Sheet (Appendix F) to cross-check the linkage system. This was done at the actual physical location of the tanks, where tank and meter numbers were positively identified.

After the inventory review, respondents were told that someone would be contacting them within the next two weeks to check on the status of the inventory forms. They were given a toll free 800 number to call if they had any problems or questions with the inventory recording procedures. The interviewer also gave the respondent a postage-paid pre-addressed envelope for returning the completed forms. Inventory response rates are discussed in Section B-II.F.

4. Checking Meter Accuracy

Once all tank and meter numbers were verified and inventory sheets reviewed, the interviewer checked the accuracy of all dispenser meters using a five-gallon certified meter calibration can. For each meter tested, a calibration (adjustment) ratio was recorded on the appropriate inventory form. Using this ratio, the inventory records were adjusted by computer to account for the meter error.

The accuracy testing procedure was the same procedure used by agencies that certify meter accuracy. The interviewer first pumped approximately one gallon of fuel into the can to wet the inside. This reduced the surface tension inside the can and allowed for a more accurate measurement. After wetting the can, the fuel was returned back into the appropriate tank and the meter reset to the zero (0.0) reading. Next, the interviewer pumped five gallons of fuel into the test can and read the level of fuel according to the measuring gauge on the front of the can. The can was used to measure error in liters or gallons. A "calibration ratio," which equaled the gauge reading divided by the amount pumped into the can, was recorded for each meter tested. The ratio was recorded in "cubic inches" (in^3) if the fuel was dispensed in gallons or in "milliliters" (ml) if the fuel was dispensed in liters. A negative (-) or positive (+) sign was always recorded with the ratio, to indicate whether the pump was dispensing less or more than the amount indicated by the meter.

After recording the calibration ratio, the interviewer returned the fuel to the tank from which it came. The calibration of all meters associated with the same tank were checked before going to the next. If the respondent had already started keeping inventory records, the amount of fuel returned to the tank was recorded as a "delivery" on the inventory sheet, in order to balance with the meter readings in the inventory records.

5. Measuring the Fill Pipe/Drop Tube

The next procedure after checking meter accuracy was to measure the diameter of the tank fill pipe. The interviewer also had to determine whether or not a drop tube was present inside the fill pipe and, if present, whether the drop tube was permanent or removable. This was done for each underground storage tank and the data recorded on the Site Observations Recording Sheet (Appendix F). This information was collected by the interviewer to help prepare the MRI crew for tank tightness testing. Certain factors, such as the size of the fill pipe or the presence of a permanent drop tube hindered or prevented a tank test. Knowing this beforehand, the crew was prepared to solve the problem once on site for the test.

6. Map Reading

The interviewer was provided with topographical maps of each PSU, which were included in the package with the call record folders for establishments to be interviewed. These are U.S. Geological Survey maps and are graphic representations of selected man-made and natural features of the earth's surface plotted to definite scales. Such maps record physical characteristics of the terrain as determined by precise engineering surveys and assessments. Using a standard symbol guide to help read the maps, the interviewer located the tanks on the map, circled the location, and identified it using the survey I.D. number for that establishment. The interviewer returned the unused maps to EPA. The maps with tanks located on them were returned to Westat, where they were reviewed to make sure all establishments for that PSU were mapped, copied, then sent to EPA. Using the precise longitude and latitude of the tanks from the map, soil characteristics and other physical characteristics of the site could be matched to the tanks specific for that location. There were fewer than 20 sites for which USGS topographic maps could not be obtained, and these were covered to the extent possible by local street or road maps. The data obtained through the map linkage are discussed in Appendix H.

C. Interviewer Evaluation

Immediately after leaving the site, the interviewer completed the debriefing questions printed inside the call record. These eight questions were used to evaluate the overall character of the interview and the cooperation and knowledge of the respondents. Table B-3 shows the debriefing statistics for the 890 establishments surveyed.

Table B-3. Debriefing statistics

	Percent
Percent of respondents who had questionnaire completed prior to interview	28%
Percent of respondents who had inventory sheets started	12%
Percent of respondents who had problems or errors in completed parts of inventory	31%
Percent of respondents who understood inventory process	98%
Percent of respondents who understood most/all questions in questionnaire	99%
Percent of respondents who were cooperative	94%
Percent of respondents who were hostile	3%
Percent of respondents who were guessing a lot in answering interviewer's questions	4%
Percent of establishments where it was necessary to talk to more than one person to obtain all required information	29%

Less than one-third of the respondents had prepared for the on-site interview by completing the questionnaire prior to the interviewer's arrival on site. Only 12 percent had started keeping inventory records prior to the interview. Of those respondents who had started keeping inventory records, the interviewers found that 31 percent had errors in the completed parts of the inventory. Almost 100 percent of the respondents understood the inventory process and the questions in the questionnaire. In approximately 30 percent of all cases it was necessary to talk to more than one respondent to obtain all required information. Even though most respondents were unprepared for the survey, 94 percent were willing to cooperate.

After completing the debriefing questions, the interviewer made necessary name and address changes to the label in the Label Verification section of the call record. If it was necessary to talk to more than one respondent, a contact name and phone number for each respondent interviewed was written on the front of the call record. The interviewer then assigned a questionnaire completion status for the case and circled the appropriate completion status codes for the inventory record keeping, the meter accuracy test, the site mapping, the debriefing, and the confidentiality request form. After checking to make sure that all materials in the call record were properly labeled and editing the questionnaire for completeness, the interviewer returned the completed case to Westat, where it was reviewed and entered into the receipt control system (discussed in Section B-V).

D. Refusals

Each sampled establishment received a survey package containing a copy of the Resource Conservation and Recovery Act (RCRA) amendments to Section 9005(a) stating that the responsibility of the tank owners and/or operators to furnish information for the UST Survey. Nevertheless, a small number of respondents still refused to participate. When an interviewer encountered a refusal to participate either over the phone or in person, he/she told the respondent that the EPA legal office would be informed of the refusal. The interviewer then contacted the Westat field director immediately. The field director notified EPA's Office of Enforcement and Compliance Monitoring of the refusal by phone and by letter. In most cases, the respondent agreed to participate after a phone call from an EPA attorney. In other cases, a warning letter from the Waste Enforcement Division was sent to the respondent when a phone call did not result in cooperation.

Some respondents refused to participate in any part of the interview, while others only refused to keep the inventory records. The number of interview and inventory final refusals is shown in Table B-4, lines F and J respectively. Overall, less than one percent of respondents refused to complete the interview and less than two percent refused to complete the inventory recordkeeping.

When a respondent who had initially refused the interview decided to participate (either as a result of a phone call or enforcement letter) the Westat field director was notified. If the field interviewer was still on site in that PSU, an interview was set up with the respondent. If the interviewer had already left the PSU, the person assigned to "clean-up" (see Section B-IV.E) these special cases made the appointment and completed the interview.

E. Interview "Clean-Up"

It was necessary to use a "clean-up" interviewer who followed behind the field teams, to handle special circumstances when all on-site procedures could not be completed during the

Table B-4. Field interviewing and inventory status statistics

		Farms	Large Estab- lishments	Fuel Estab- lishments	Total
A.	Number sampled	598[1]	600	1,612[2]	2,810
B.	Number contacted	596	596	1,608	2,800
C.	Number of establishments contacted that have tanks ("eligibles")	20	76	800	896
D.	Number of interview responses	19	76	795	890
E.	<u>Response Rate</u> (percent of eligible respondents who completed interview	95%	100%	99.4%	99.3%
F.	Number of interview refusals	1	0	5	6
G.	<u>Refusal rate</u> (percent of eligible respondents who refused interview)	5%	0%	0.6%	0.7%
H.	Number of inventory responses (includes both complete and partial complete)	7	60	630	697
I.	<u>Response rate</u> (percent of eligible respondents who returned inventory)	35%	79%	78.8%	77.8%
J.	Number of inventory refusals	6	1	8	15
K.	<u>Refusal rate</u> (percent of eligible respondents who refused to record inventory)	30%	1.3%	1%	1.7%
L.	Number of delinquent inventory responses	4	9	131	144
M.	Number of establishments for which inventory measurements are impossible	3	6	31	40

[1] 600 farms were sampled. Two farms were found to be duplicates in the telephone pre-screening.

[2] 1,618 fuel establishments were sampled. Six were found to be duplicates in the field screening.

time the interview team was working in a particular PSU. Some of these special circumstances included the following:

- The respondent most knowledgeable of the underground storage tanks was unavailable during the time the original interviewer was in the PSU.
- The respondent had refused to participate and decided to participate after the original interviewer left the PSU.
- The business was closed due to seasonal operation when interviews were being conducted in the PSU.
- The establishment was remodeling its underground storage tank systems and could not provide all necessary data at the time interviews were being conducted.
- A calibration check could not be done due to adverse weather conditions or seasonal operation of the establishment.
- An establishment could not be located by the original interviewer.

Work done by the "clean-up" interviewer accounted for five percent of all completed interviews.

F. Field Interview Data Collection Statistics

Table B-4 contains data collection statistics for the field interview portion of the survey. It covers statistics on interview and inventory response and refusal rates.

1. Interview Response Rate

The interview response rate for this mandatory survey is nearly 100 percent overall, as well as for each sample segment. Out of 2,800 establishments contacted, 896 had underground motor fuel storage tanks, and were therefore eligible for the survey. Of those, 890 or 99.3 percent completed interviews. The highest response rate among the sample segments was among the large establishments, where 100 percent of the eligible establishments provided interview data.

2. Inventory Response Rate

Nearly 78 percent of the eligible establishments have furnished complete or partial inventory data. Even this low response rate was achieved only after extensive edit and followup efforts by Westat's survey staff. Sixteen percent of the eligible establishments have not yet provided inventory records. It was impossible for 4.5 percent of the eligible establishments to keep inventory records. These reasons are discussed below in Section B-IV.F.3.

3. Problems Preventing Inventory Record Keeping

Of the 896 eligible establishments, 40 were unable to provide inventory records for any of their tanks using the designated record keeping procedures. The reasons are listed below.

- <u>No conversion chart</u> -- Twelve establishments were unable to obtain conversion charts needed to convert inches to gallons for their tanks because they did not know the dimensions of the tanks or the company which installed them.

- <u>Bent fill pipes</u> -- Nine establishments were unable to stick their tanks because the fill pipes were installed with a bend to prevent pilferage.

- <u>Facility closed</u> -- Seven establishments have closed down since the time of the interview.

- <u>Tanks abandoned/removed</u> -- Five establishments have either removed or abandoned their tanks since the time of the interview.

- <u>No inactive period</u> -- Inventory analysis procedures for tanks without meters to record the total product dispensed consists of an analysis of volume measurement changes for inactive periods. Four establishments, which have tanks without meters, dispense fuel 24 hours a day, so there is no inactive period to analyze.

- <u>No way to record deliveries</u> -- Two establishments pumped fuel at irregular intervals from an above-ground tank into the underground storage tanks with no means of measuring the amount pumped into the tanks.

- <u>No key to tank</u> -- The locked tank of one establishment was inaccessible due to delay caused by probation of the estate of the tank operator, who died with the only key in his possession.

V. <u>DATA PREPARATION</u>

Data preparation for the UST Survey began with a development phase involving questionnaire layout and code manual design. Inventory recording forms were developed by EPA. The coding format, however, was designed by Westat. Operational phases included document handling (including receipt control), coding/editing, data entry, and machine editing. Location coding from the topographic maps is discussed in Appendix H.

A. Questionnaire and Code Manual Design

The questionnaire layout was designed for ease of data preparation/data processing, as well as for ease of respondent understanding and recording. Many items were designed as "precoded" questions, that asked the respondent to answer by circling a code to indicate his/her response. This eliminated the need for a coder to translate check-marks or other non-code symbols into coded answers. Computer field positions were printed in the questionnaire for most data items. These field positions were useful as reference locations for coders, machine editors, and data entry staff.

A detailed code specification manual using an automated code book formatting program for the UST Survey Questionnaire was developed. This manual described the data to be encoded from the questionnaire, item by item. Figure B-2 lists the item characteristics by which each data item was described in the code manual. Figure B-3 is an example data item description from the Underground Storage Tank Survey Establishment Operators Questionnaire.

Item characteristics described in code manuals

a. Field position and record number

b. Item name (the name by which the item was called in all computer programs and other documentation)

c. Quotation of the item from the questionnaire

d. List of all code values and their definitions

e. List of reasons for legitimate item nonresponse (the "inapplicable" definition)

f. List of all missing value codes

g. Flags indicating logical relationships between the item and subsequent items.

Figure B-2. Item characteristics described in code manuals

```
F2A         020-022         FREQUENCY_OF_INSPECTION

                            ++                 = INAPPLICABLE, CODED 2, 8, CR 9 IN F1A,
                                                 COL 016, REC 09; OR CODED 1, 8 OR 9 IN
                                                 BOXF2, COL 19, REC 09
                            001-365            = FREQUENCY CF INSPECTION
                          * 998                = DON'T KNOW
                          * 999                = NCT ASCERTAINED

                          * SKIP F2UC, COL C23-C24, REC 09
```

Figure B-3. Code manual data item description

B. Inventory Data Editing

Inventory forms were designed to include "worksheets" for respondents to record individual meter and manifolded tank readings, and then to record the sums of the individual readings. Both the individual readings and the summary readings were edited and key punched. The raw data collected from the inventory recording process was entered or key punched (Section B-V.D) directly from the edited inventory forms. A code manual and editing instructions detailing the layout and the valid code ranges for the inventory forms was prepared to assist the editors and the data entry operators.

C. Receipt Control

All returns were tracked by Westat's automated receipt control system. Each day, documents received, including certified mail cards and "No Tank" Certification statements, were keyed into the system. All documents from an establishment were linked by a survey identification number specific to that establishment (discussed in Section B-V.B.1). Using this I.D. system, returns were tracked by type of document, and reports on the survey status and on an individual establishment status were produced.

For each document received, the date of receipt, a status code and "batch" number (Section B-V.B.2) were entered into the receipt control system using the procedure specific for that document. In addition, any name or address changes from the call record were also entered upon receipt of a questionnaire from the field.

1. Survey Identification Number

The survey I.D. number is a ten-digit number which shows the sampling frame from which the establishment was selected, the PSU in which it is located, and a sequential number. The survey I.D. uniquely identifies the establishment within the survey and links all documents and data records for the establishment.

2. Questionnaire and Inventory "Batching"

Questionnaires and inventory forms were "batched" into groups of 10 documents for coding, editing, and filing purposes. Each batch was given a number, which was written at the top of the Batch Control Sheet (Figure B-4), as well as on the questionnaire or inventory form. Questionnaires and inventories were batched separately. Listed on the Batch Control Sheet were the survey I.D. numbers of all the questionnaires (or inventories) and their statuses for that specific batch. Questionnaire and inventories remained in their batches until they were coded and sent to data entry. If they were removed from the batch for any reason, the date, person taking the document, and reason were noted on the front of the Batch Control Sheet. A copy of each Batch Control Sheet was kept in a log for quality control purposes for both questionnaire and inventory batches.

BATCH CONTROL SHEET

BATCH

____ ____ ____ ____

	ID LABEL	STATUS	CHECK OUT TO/ON	DATE RETURNED	VERIFIED BY
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

CODER: ____________________

DATE: ____________________

VERIFIER: ____________________

DATE: ____________ % VERIFIED: ______

Figure B-4

D. Coding/Editing

A staff of six coder-editors was trained to code the questionnaire and inventory. The initial training session covered procedural matters as well as specific coding of the UST Survey Operators Questionnaire and the four types of inventory recording forms. It included an item-by-item discussion of the coding of the documents, practice coding examples, and group review of the coding of practice examples. Training materials included code manuals, practice inventory and questionnaire examples, and a marked-up version of the questionnaire that linked the questionnaire to the code manual and the general coding instructions.

Coders were trained to edit questionnaire responses and inventory records for consistency and completeness as they were coding them. Coders flagged any problems they discovered during coding, and referred the problem documents to the coding supervisors. Some problems required the development of new codes -- such as when different units of measure than those specified in the questionnaire were specified for quantity questions. Other problems required that the respondent be called to verify a response or provide missing information (a process called "data retrieval"). In some instances, decisions could be made based on the evidence available, by the Project Officer or by other EPA staff. Decisions, both general and case-specific, were recorded in a Decision Log for future reference.

All coding was 100 percent sight verified by a senior coder or the coding supervisor prior to being sent for data entry.

E. Data Entry

Questionnaire and inventory data were entered ("key punched") by highly trained data entry operators, using a key-to-tape entry system. This key-to-tape system is computer-driven and provides a formatted entry keying program that minimizes many types of data entry errors. All data entry was 100 percent key verified by a different operator from the entry operator.

The questionnaire booklets and inventory records were sent to data entry in "key batches." Lists of the survey I.D. numbers associated with each key batch of inventory records were made and put into a Key Batch Control Log. All questionnaires sent to data entry were checked off against a list of completed interviews, which was generated by the receipt control system. This enabled the coders to make sure that all questionnaires were keyed.

F. Machine Editing

Machine editing is a means of data quality control that uses a computer program to test item ranges, skip patterns, and logical consistencies in a data file. Such a machine edit program was prepared for the questionnaire and for the inventory forms.

Machine editors were selected from among the trained coders available from the coding staff. The training consisted of procedural instructions, and a walk-through using an example edit problem.

The machine edit programs provided a list of test errors for each edited case, as well as a listing of each case in error. Each of the errors was checked, and often the hard copy of the case was reviewed. Updates to the data files were written on update sheets, key-entered and run against the data file to produce a new master file. Then the edit cycle was rerun to make sure that the update corrections had been made correctly. Because of the complexity of some of the data files (particularly inventory data files), it was necessary to rerun edit cycles several times: updates to some fields tended to unexpectedly impact consistencies with other fields.

After the final machine edit cycles, frequency distributions for all items of the data files were reviewed by supervisors to spot problems not captured by the machine edit programs.

VI. DATA RETRIEVAL

Data retrieval is the term used to refer to recontacting respondents for the purpose of verifying or clarifying responses to completed questionnaires for interviews. For this study, it was necessary to recontact respondents for problems found in the inventory records as well as questionnaires. These questionnaire and inventory data retrieval procedures are discussed separately below in Section B-VI.F.1 and B-VI.F.2. Part of the coding staff was trained for the data retrieval process.

A. Questionnaire Data Retrieval

Recontact of respondents for questionnaire problems generally took the form of a telephone call, though occasionally it was necessary to mail a list of questions to a respondent. Approximately 60 percent of all respondents were recontacted for questionnaire data retrieval.

B. Inventory Data Retrieval

Because of the complexity of the inventory record-keeping procedure, each respondent received a "prompt" call by Westat approximately two weeks after the field interviewer left the site. The purpose of the call, which was made by a staff member trained for inventory data retrieval, was to inquire about he status of the inventory and when the records would be completed. The prompt caller also assisted the respondent with any questions or problems that may have occurred about keeping the inventory.

A large proportion of the inventory records received from the respondents contained errors or inconsistencies ranging from minor to major. When these problems were spotted by coder-editors or coder-verifiers, the inventory form was flagged for inventory data retrieval. The inventory data retrieval process began with a phone call to the respondent with a discussion of the problem. Some problems were resolved on the telephone. Often, an explanatory letter and copies of the returned inventory with problem areas marked were sent to the respondent. The respondent then sent corrected inventory records back. It was sometimes necessary to send multiple letters explaining the problem before usable data was returned. Of the 697 inventory responses received to date, approximately 85 percent needed data retrieval, four percent of which needed multiple data retrieval efforts. At the writing of this report, there are still establishments which have not yet responded to the data retrieval efforts. They account for 25 percent of all cases needing data retrieval.

C. Followup of Inventory Nonrespondents

After multiple prompt calls were made to inventory nonrespondents, EPA sent a formal warning letter (Figure B-5) and Status Report form (Figure B-6) to respondents who were delinquent in returning inventory records. Of the 300 letters sent, 25 percent did not respond and two percent refused.

As a result of all data retrieval efforts made by Westat and EPA, 78 percent of all establishments have sent in inventory records, but approximately 50 percent of all inventory records received are complete enough for inventory reconciliation analysis. Of the 896 eligible respondents, 16 percent have not yet returned inventory records.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

AUG 16 1985

Dear

The Environmental Protection Agency (EPA) has been informed by Westat, the Agency's contractor for the National Survey of Underground Motor Fuel Storage Tanks, that as of July 31, 1985 the 30 days of motor fuel inventory data you are required to provide EPA had not been received.

As was explained in the survey instructions mailed earlier, Congress passed and President Reagan signed into law in 1984, amendments to the Resource Conservation and Recovery Act (42 U.S.C., Sec. 6901) that require EPA to conduct this study. This law also requires that you, as an owner or operator of an underground motor fuel storage tank, provide EPA with the information requested in this survey.

I wish to stress that the evaluation of inventory data is an essential part of this National study, and EPA is requiring this information from all establishments selected for the survey. Failure to comply with this requirement may result in an enforcement action.

Enclosed is a form for reporting the status of your 30-day inventory data collection. We ask that you complete and return the form within 24 hours of receipt to verify that you are complying with this requirement. Simply check and complete the correct inventory status block, sign and date the form, and mail it in the enclosed self-return envelope.

Thank you for your cooperation.

Sincerely,

Martin P. Halper, Director
Exposure Evaluation Division

Figure B-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

MOTOR FUEL INVENTORY STATUS REPORT

Please complete this form and mail in self-return envelope wihtin 24 hours.

☐ I have completed and mailed my 30-day inventory data Westat.

☐ I am still collecting my 30-day inventory data and wi mail it to Westat by ______.
(date)

☐ I have not yet begun my 30-day inventory data collect but will do so immediately and mail it to Westat by ______.
(date)

☐ I need further instructions to complete and submit my 30-day inventory data collection.*

☐ Other situation (please describe).______________________

____

____

____

____

____
(Signature)

____
(Date)

*Phone toll free (800) 638-8985

APPENDIX C

DEVELOPMENT OF A TANK TEST METHOD

This appendix is a summary of the report, "Development of a Tank Test Method for a National Survey of Underground Storage Tanks." The work was conducted under EPA Contract No. 68-02-3938, Work Assignment No. 25.[1]

The appendix first summarizes the search for a suitable tightness testing method and the reasons for the final selection. Then the field procedures developed in the pilot test are described. A more detailed description of the field tightness test plan may be found in the test and analysis plan.[2]

I. SELECTING A METHOD

In preparation for the field tightness testing, MRI first searched for a suitable test method. Their objectives were to evaluate potential test methods to be used for the national survey, to conduct a pilot survey using the test method selected, and to develop a test plan for the national survey. The research was conducted in five stages. The first stage consisted of a

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[1] "Development of a Tank Test Method for a National Survey of Underground Storage Tanks," H.K. Wilcox, J.D. Flora, C.L. Haile, M.J. Gabriel, and J.W. Maresca, April 1986.

[2] "Test and Analysis Plan for the Tank Testing Program of the National Survey of Underground Storage Tanks," H.K. Wilcox, J.W. Maresca, Jr., J.D. Flora, C.L. Haile, June 10, 1985.

review of current methodology for detecting leaks in underground tanks. Second, field observations were made of several methods in use. Third, of the several methods observed, five were selected to be evaluated by conducting tests of these methods on a single tank system at a closed service station. Three of these five methods were selected for further evaluation in the fourth stage by testing tank systems at four military installations and at an operating service station. In the final stage, the method chosen for use in the national survey program was tested in a pilot study of 17 tank systems.

II. GENERAL METHOD SELECTION CRITERIA

The main criteria used to select a method for the national program were:

1. Quantitative measurements were desired. However, this did not preclude consideration of other approaches.
2. A detection level of 0.05 gal/h as established by the National Fire Protection Association, Inc., was taken as the target detection limit.
3. Minimal disruption to the station operation was considered to be important.
4. The method and equipment had to be rugged for use on the national survey.
5. The test should be applicable in a wide variety of tank system configurations.
6. The method should allow a reliable assessment of accuracy, precision, and sensitivity.
7. Costs for testing and data analysis had to be within the available budget.
8. Sufficient equipment and manpower to conduct the national survey were required.

The scope of the method selection research and pilot study did not permit exhaustive method evaluation of all available test methods in order to select a procedure with optimum characteristics for all criteria. Hence, some compromise was necessary to proceed expeditiously with the survey.

III. PRELIMINARY REVIEW AND TESTING

The methods reviewed in the first stage are shown in Table 1. Those for which further evaluations were conducted are also indicated. The methods were classified into groups according to their measurement characteristics.

Five methods were selected for further testing at a closed service station in Kansas City. Brief descriptions of each are provided below. A more complete review of tank testing methods can be found in EPA's report.[3]

- The ARCO method utilizes a photo optical sensor to monitor the level of a partially filled tank. If the test conditions are set up properly, the device is self compensating for temperature changes. Only the portion of the tank containing the product is tested.
- The Certi-Tec method uses pressure transducers which are located just below the surface of the liquid to measure level changes. Seven thermistors are used to measure temperature at various levels in the tank during testing. The tank is overfilled during the test by adding an extension to the fill pipe. Both the tank and lines are tested at the same time.

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[3] "Underground Tank Leak Detection Methods: A State of the Art Review," EPA/600/2-86/001, January 1986.

Table 1. Leak Detection Methods Reviewed

Detection method	Literature review	Field site visits	Preliminary testing	Development study	Pilot study
<u>Volumetric</u>					
ARCO tank test	X	X	X	X	
Certi-Tec test	X	X	X		
Ethyl Tank Sentry	X				
Ezy-Chek	X				
Heath Petro-Tite tank and line testing system	X	X	X	X	X
Hydrostatic (standpipe) testing	X				
Lasar interferometry	X				
Leak Lokator test	X	X	X	X	
Mooney tank leak detector	X				
Pald-2 leak detector	X				
Pneumatic testing (air test method)	X				
<u>Non volumetric</u>					
Dye method	X				
Vacutect method	X				
Helium leak detection method	X	X	X		
Tracer Research	X				
<u>Inventory monitoring</u>					
Manual methods	X				
Automated	X	X			
<u>External monitoring</u>					
Pollulert	X				
Remote infrared sensing	X				
Ground water and soil core samples	X	X		X	
Underground radar	X	X			

- Leak Lokator uses a buoyancy probe to monitor level with a single thermistor located at the midpoint of the tank. The method can be used to test a partially filled tank (with lower sensitivity) or an overfilled tank. Either the tank or the tank and lines can be tested.

- The Petro-Tite method monitors level visually in an extended fill pipe. The product level is returned to the reference level at 15 minute intervals during the test. The product is stirred continuously during the test to achieve a uniform temperature. Temperature is monitored with a single thermistor located at the inlet to the pump near the top of the tank. The tank and lines are all tested at the same time.

- The Varian helium leak detection method, a nonvolumetric method, is based on the detection of helium outside a tank which has been slightly pressurized with helium. The tank should be empty during the test if the entire tank is to be tested. It is also helpful to drill a number of small holes in the surface above the tank to assist in the location of the leak. Pressure can be monitored simultaneously to provide a quantitative estimate of the leak rate. The lines are also tested at the same time.

A. Experimental Procedures

Each method was tested over a 2- to 3-day period. A leak simulation system was designed and fabricated by MRI and used to draw product from the tank at a known rate. The precision of the leak simulator was at least an order of magnitude better than that of the test methods. In testing the tank, the objective of each test group was to estimate different simulated leak rates. The leak rates measured by each method were compared with the rates used in the simulation.

The data from the quantitative tank tests were analyzed to determine the precision and accuracy of the tests. For these analyses the accuracy of the test (or bias) was estimated by the mean of the (signed) differences between the leak rate reported and the leak rate simulated. A paired t-test was used to test the hypothesis that the method was unbiased; that is, that the mean signed difference was 0. A linear regression of the reported leak rate on the simulated leak rate was calculated. An ideal regression equation in a tight tank would be $y = 0 + 1.0x$. The scatter of the data about the regression line (correlation coefficient, R) was used as an estimate of the precision of the method. The bias and precision were combined to obtain an estimate of the root mean squared (RMS) error.

B. Results

A summary of the statistical analysis for the quantitative methods as a group is presented in Table 2.

1. ARCO Underground

The ARCO method was used for 15 different simulated leak rates, including one zero rate. An average difference of 0.01 gal/h was observed between the rates reported by ARCO and those calculated by MRI. This estimated bias in the results was not significantly different from 0 ($t = 0.21$, 14 degrees of freedom). The intercept did not differ significantly from 0 and the slope did not differ significantly from 1. The R for the regression was 94.3 percent, indicating that most of the variability of the data was explained by the regression. The RMS error estimated for the method under the conditions of the Kansas City test was 0.05 gal/h. The tests averaged just under an hour (55.7 min) in length. In order to reduce the variability estimated with the method, either repeated determinations or a longer test time would be needed.

Table 2. Summary of Statistical Analyses of Quantitative Methods Tested at Kansas City Site

Method	n[a]	Bias	Intercept	Slope	Standard error	RMS	R²
ARCO	15	0.01	0.005	0.95	0.049	0.050	94.3%
Certi-Tec	12	-0.25	-0.30	0.71	0.166	0.302	38.9%
Leak Lokator	22	-0.01	-0.01	0.94	0.020	0.021	98.9%
Petro-Tite	18	0.05	0.06	1.05	0.101	0.113	75.9%

[a] n = number of simulated leaks.

2. Certi-Tec Method

The Certi-Tec method was used for 12 simulated leak rates, of which two were set at 0 and so represented the normal condition of a tank test. The leak rates reported by the Certi-Tec method took slightly over an hour (average 64.3 min) for each rate. The estimated bias in the results (difference between the reported rate and the simulated leak rate) averaged -0.25 gal/h. This bias was quite large and was significantly different from 0 (t = -5.23, 11 degrees of freedom). The intercept differs from 0 at the 5 percent significance level and the slope differs from 1 at the 5 percent significance level as well. The standard error of the regression was 0.167 gal/h. The R of the regression was only 38.9 percent, indicating that slightly less than 40 percent of the variability in the reported leak rates was explained by the simulated leak rates used in the test.

Thus this method, as implemented during this test, appears to have substantial bias and relatively low precision. Even though taking several repeated determinations of the leak rates and averaging them would reduce the random error, the bias would remain a problem.

3. Leak Lokator Method

The Leak Lokator method was used on 22 tests simulating leak rates. Of these, three were zero simulated leak rates and so represented tests of the tank without any simulated leak. Three simulated leaks into the tank were also used. Using the method, the average reported leak rate was 10.8 min.

The bias in the determinations was estimated to be -0.005 gal/h, which was not significantly different from 0 (t = -0.23, 21 degrees of freedom). Although the estimated slope and intercept agree closely with the ideal, both differed from the ideal values significantly at the 5 percent level although not at the 2 percent level.

These data showed a very small scatter about the regression line, resulting in small estimated values for the standard error of the slope, intercept, and regression. These small standard errors led to the borderline significances of the difference between the regression parameters and their theoretical values. In light of the nonsignificance of the other test for the bias and the small magnitude of both the intercept (-0.012 gal/h) and the bias (-0.005 gal/h), these are probably not of major importance.

4. Petro-Tite Method

The Petro-Tite method was tested under 18 simulated leak rates, of which three were zero rates, corresponding to a tight tank situation. While the usual Petro-Tite test takes an average of four leak rates each reported over a 15-min period, only five of these determinations were based on an hour's data. The remaining leak rates reported were each based on a 30-min test.

From all the tests, the bias was estimated at -0.05 gal/h but was smaller (0.040 gal/h) when restricted to the hour-long tests. The bias from the complete set of tests is significantly different from 0 at the 5 percent level but not at the 1 percent level. If attention is restricted to the 1-h tests, the bias is not significantly different from 0. The intercept is not significantly different from 0, suggesting that the bias is not statistically significant. The slope does not differ significantly from the ideal or theoretical value of 1 at the 5 percent significance level. The R for the regression was 75.9 percent and the standard error of the regression was 0.101. This standard error is interpreted as the precision of a single leak rate determination. It should be noted that the normal test with four 15-min rate determinations should be somewhat more precise than what was reported, and that precision could be improved further by testing for a longer period of time and averaging more individual leak rates reported.

5. Helium Detection Method

Two tests were conducted using the helium detection method. In the first test the tank was tested in its original state. Several large leaks were discovered during the first day's testing, which were repaired. The next day's test revealed substantial reduction in helium loss.

While some helium was detected around the tank, the amounts were generally very small and could have come from pipe fittings or the tank bungs. Low levels were, however, encountered in one area. The concrete was removed for inspection purposes to see if a line was located in that area. None was found, but helium levels in the excavation were moderate.

The basic problem encountered using the helium detection method is that helium can escape in measurable quantities through threaded connections which have been poorly coated with sealer. Gasoline will not normally pass through these poorly sealed connections at measurable rates under normal operating conditions. This can lead to results which are hard to interpret. In addition, no quantitative results can be produced.

C. Conclusions

As a result of the preliminary testing in Kansas City, the ARCO, Leak Lokator and Petro-Tite methods were selected for further evaluation. The helium method was dropped because of the decision that a quantitative method presented a better option for the national survey. The Certi-Tec method was dropped because of the prototype state of development and its relatively lower performance.

IV. DEVELOPMENT STUDY TESTING

A. Experimental Procedures

Five facilities were selected by the EPA for tank testing. A total of 13 tanks were tested. The initial plan was for each tank to be tested by all three methods. Difficulties in scheduling and plumbing problems at some sites, however, precluded a complete round of testing.

Two types of tests were conducted at each sites: baseline tests which were conducted in the same manner as if no evaluations were being conducted, and leak simulation tests which consisted of measuring leaks under a variety of simulated leak rates (usually four). The process was nearly identical to that described for the preliminary testing.

Three sets of data from the development study were analyzed: baseline test data; leak simulations; and time series analysis of the ambient volume fluctuations after the simulated leaks were removed.

The baseline data for each method was tabulated and compared for each tank where more than one method was used to test the same tank. Where differing conclusions regarding the tightness of the tank were obtained, the data and conditions of the test were further examined in an effort to resolve the conflict.

The data from the leak simulations were analyzed by fitting a linear regression to the data from each tank and method by regressing the reported leak rate on the simulated leak rate. The intercept of this regression represents an estimate of the leak rate of the tank or tanks system when there is no simulated leak. The difference between the intercept of the regression line and the test result from the baseline test provides an estimate of bias or accuracy of the test. The variability of the data about the regression line provides an estimate of the precision of the test. Combining these two measures yields an estimate of the mean square (or root mean square error) associated with the testing method.

The third analysis consisted of a time series analysis of the ambient volume fluctuations after the simulated leaks were removed.

B. Results

1. ARCO Method

The ARCO method was used to test seven tanks during the development study. Of these seven tanks, one tank had only the baseline test run, one tank test resulted in the baseline test and one simulated leak rate, and the other five tank tests all had the baseline leak rate and several simulated leak rate tests.

The baseline test results for ARCO are summarized in Table 3. The ARCO result disagreed with the conclusion for three tanks. However, it must be noted that the ARCO system tested tanks approximately 75 percent full, under no additional head pressure. Thus, the ARCO system provides a test most representative of the usual operating conditions of the tank. If a tank system has a hole in or near the top or fill pipe, or if there is a leak in the lines, this would not result in product leaking under normal operating conditions. While it may be unlikely that all of the leaks encountered during the study are in the top of the tank, it is a possible explanation.

A summary of the results from the leak simulation tests using the ARCO method are summarized in Table 4. By this method of testing, none of the tanks tested were reported to be leaking. However, other test methods gave different results for some tanks.

The data indicate, however, that the ARCO test method performed well at the Damneck and Pitstop North test locations. If a single data point that appears to be an outlier is removed, the method also does reasonably well at the Langley facility. One of the sites (Scott Tank 18) showed essentially no regression of the reported leak rates on the simulated leak rates. This is disturbing because for that test the method could not quantify leak rates under the simulation. One other test, at Fort Lewis, gave a slope substantially different from 1, which indicates that an (unknown) interfering factor is present.

The ARCO method gave a precise determination of a leak rate under some operating conditions. In other cases, it failed to give valid results for reasons that were not understood. In other cases, it failed to give valid results for reasons that

Table 3. Summary of Baseline Results and Tank Tests Attempted

Facility and tank	ARCO	Leak Lokator	Petro-Tite	MRI conclusion
Damneck	+0.02 C[a]	-0.077 N[b]	+0.003 C	Tight
Pitstop				
1 (south)	+0.02[c] C	-0.741 N (Poor sensitivity)	-2.892 N	Leak
2 (north)	0.0 C	-0.012 C	-0.05 C	Tight
Scott				
1 (17)	Out of time	-0.299 N	+0.004 C	Tight[e]
2 (18)	+0.02[c] C	-0.178 N Problem, possibly manifolded	-0.812 N	Leak[e]
Ft. Lewis				
1 (8C25 north)	-0.04 C	Leak about gasket-could not test	--	Tight
2 (8C25 south)	0.0[c] C	-0.027 C	-0.342 N	Leak
3 (4194)	--	-0.172 N (Poor sensitivity)	-3.0 N	Leak
4 (10E10)	--	-0.191[d] N	-0.024 C	Tight
Langley				
1 (HS tank 3)	--	-0.448 N	--	Leak
2 (HS tank 5)	Physical problem with tank	-3.0[d] N	--	Leak
3 (MoGas)	-0.03 C	--	--	Tight
4 (Golf course)	--	--	-2.540 N	Leak

[a] Certifiable.

[b] Noncertifiable.

[c] Test OK, but leak (possibly in upper part or piping) not found.

[d] Test appeared OK, but data are inconsistent.

[e] Interactive effects between Tanks 17 and 18 were observed by Leak Lokator

- (negative sign) indicates leak out.

-- indicates testing was not conducted at that tank by the test company indicated.

Table 4. Results of Leak Simulation Tests Using ARCO Method

Tank	Baseline rate	Intercept	Bias	Slope	SE	RMS
Damneck	0.02	-0.023	-0.003	1.049	0.022	0.023
Pitstop south	0.02	-	-	-	-	-
north	0.0	-0.092	-0.092	0.809	0.041	0.101
Scott 18	0.02	-0.145	-0.165	-0.044	0.099	0.192
Fort Lewis						
8C25 south[a]	0.0	-0.005	-0.005	1.140	-	-
8C25 north	-0.04	-0.094	-0.054	0.493	0.047	0.072
Langley						
MoGas	-0.03	-0.336	-0.306	0.419	0.367	0.478
	-0.03[b]	-0.027	0.003	1.167	0.118	0.118

Negative = Leak out
Positive = Leak in
Bias = Intercept - base

[a] Two points only.
[b] Outlier removed.

were not understood. It can detect inflow or outflow, but would be defeated if the water table were at a level that approximately balances the hydrostatic pressure of the product. It is also subject to interference from wind and is sensitive to vibration. It has the advantage of not requiring an overfilled tank, but this is counterbalanced by the disadvantage of not being able to detect potential leaks in the upper quarter of the tank.

The ARCO method was not recommended for use on the national survey program for several reasons. The primary reason was the decision to test the entire tank. Secondary reasons were the sensitivity of the method to interference from vibration and the relatively high frequency of tests that did not adequately quantify the simulated leak rates.

2. Leak Lokator Method

The Leak Lokator method was used to test 10 tanks during the development study. Of these, two tanks had only baseline tests and no simulated leak tests conducted. The baseline test results are summarized in Table 5. The Leak Lokator test conclusions agreed with MRI's conclusion in 6 of the 10 tank tests. Of the other four, the Leak Lokator test failed to certify three tanks that had been concluded to be tight based on data from all test methods and certified one tank that had been determined to be leaking.

A summary of the results from the leak simulation tests using the Leak Lokator method is presented in Table 5. The RMS errors ranged from about 0.02 gal/h to 0.44 gal/h. The standard errors ranged from 0.015 to 0.304. Among the tanks judged to be tight, the standard errors ranged from 0.015 to 0.165 and the RMS error ranged from 0.021 to 0.437. The large values for the upper

Table 5. Results of Leak Simulation Tests Using Leak Lokator Method

Tank	Baseline rate	Intercept	Bias	Slope	SE	RMS
Damneck (@ 120")	-0.0775 @ 125 (+0.008 @ 118)	-0.0825 (-0.005)	-0.005 (-0.13)	0.786	0.025	0.0255 (0.028)
Pitstop south	-0.524	-	-	-	0.209	-
north	-0.012	-0.026	-0.014	0.879	0.015	0.021
Scott 17	-0.299	-0.366	-0.067	0.839	0.048	0.082
18[c]	-0.178	-	-	-	0.047	-
Fort Lewis						
8C25 south	-0.027	-0.010	0.017	0.734	0.097	0.099
4194	-0.171	-0.159	0.013	0.749	0.026	0.029
10E10 NTC[a]	-0.191	-0.596	0.405	0.541	0.165	0.437
TC[b]	-0.191	0.069	0.260	0.835	0.098	0.278
Langley						
HS 3	-0.448	-0.641	-0.193	-1.78	0.048	0.199
HS 5	-3 or more	0.126	0.126	2.43	0.304	0.329

Negative = Leak out
Positive = Leak in
Bias = Intercept of their (adjusted for base) regression
Intercept = Bias plus base

[a] NTC - not temperature corrected.
[b] TC - temperature corrected by Leak Lokator.
[c] Leak Lokator observed interactive effects between Tanks #17 and #18 during the testing of #18. The reasons for this are not understood.

end of the range are from a test that had problems. If that data point is excluded, the upper end of the ranges becomes 0.048 and 0.082. With the ability of Leak Lokator to obtain multiple leak rate determinations fairly rapidly (about one every 10 to 15 min), one could presumably reduce these error estimates by making several leak rate determinations at a tank and averaging them.

The Leak Lokator method gave valid estimates of leak rates in most cases. The variability of a single leak rate measurement tends to be somewhat large relative to a 0.05 gal/h criterion, but the ability of the system to obtain leak rate determinations in about 10 min once the test is running would allow multiple determinations and averaging to reduce this variability. The method has the advantage that its level monitoring system can be used at any desired level (head pressure). Thus, if line leaks are a problem, the testing could, in principle, be conducted using a level below the piping to determine the location of the leak.

The hydrostatic pressure from a water table could pose a problem for this test. Testing did not appear to be standardized to any specific product level. Since the leak rate through a given aperture would change with head pressure, testing different tanks at different levels makes leak rate determinations difficult to compare and quantify.

3. Petro-Tite Method

The Petro-Tite method was used to test nine tanks during the development study. The locations of these tank systems and reported leak rates were given in Table 3. Three of the systems tested had leak rates so large (in excess of 5 gal/h) that simulation of additional leak rates on the order of 0.2 gal/h was not feasible. Simulated leak rate testing was performed on five tank systems.

The baseline tests conducted by Petro-Tite agree with the conclusions reached by MRI based on analysis of all the data. It should be noted that in some cases (e.g. Ft. Lewis #1) where other testers experienced difficulties, Petro-Tite would have also had difficulty.

A summary of the results from the leak simulation tests using the Petro-Tite method is presented in Table 6. The RMS errors ranged from 0.036 to 0.193 for tanks judged to be tight. The 0.193 is rather large, but that tank posed special problems, leading to the conclusion that the 0.193 is not representative. Error estimates on tanks judged to be leaking were larger, ranging up to 0.24 gal/h. Larger errors are to be expected for systems with large leaks because large leaks make it difficult to maintain product level and so therefore to obtain an accurate volume. However, the errors remained acceptably low relative to the associated leak rates.

As a result of the more detailed analysis of Petro-Tite data, several suggestions for improving the errors involved in the Petro-Tite method were developed. None of these involve significant procedural changes. Improved algorithms could likely result in better test results.

The Petro-Tite method seems capable of identifying and successfully dealing with many types of interferences in tank testing. Although there are situations that can lead to invalid test results, for the tanks tested in this study all tests but one were believed to be valid. However, difficulties were encountered that increased the error associated with the estimated leak rates beyond that which is desirable. In

Table 6. Results of Leak Simulation Tests Using Petro-Tite Method

Tank	Baseline rate	Intercept	Bias	Slope	SE	RMS
Damneck	+0.003	-0.009	-0.012	1.01	0.052	0.054
Pitstop south	-2.89	-	-	-	0.240	-
north	+0.050	+0.069	+0.019	1.26	0.078	0.075
Scott 17	+0.004	+0.002	-0.002	1.075	0.036	0.036
18	-0.812	-0.774	0.038	0.608	0.109	0.115
Fort Lewis						
8C25 south	-0.342	-	-	-	0.107	-
4194	-3.0	-	(Could not fill tank)		-	-
10E10	-0.024	-0.038	-0.014	1.50	0.193	0.193
Langley golf course	-2.54	-	(Could not keep filled)		-	-

Negative = Leak out
Positive = Leak in
Bias = Intercept - base

difficult cases, the error rates were such that one could not reliably detect leak rates as small as 0.05 gal/h. Most of the situations with large error estimates were cases where a substantial leak was present, and hence the loss in precision did not interfere with the detection of the leak.

4. Time Series Analysis of Ambient Noise Data

Because the data obtained from ARCO was not sufficient, time series analyses were performed only on the Leak Lokator and Petro-Tite data.

a. Description of Ambient Noise Analysis

The second analytical approach was to remove the simulated leaks from the data to produce volume, temperature, and temperature compensated volume time series that were longer than normally used during a tank test. These data were analyzed to determine whether the results obtained during a standard tank test period (i.e., a baseline test) were consistent with longer test times and to determine whether the temperature-estimated volume changes required for compensation adequately accounted for the total volume changes in a non-leaking tank.

Petro-Tite Method

Continuous time series of the change in volume and the change in temperature (converted to volume using the product volume and the coefficient of thermal expansion) for an entire day of Petro-Tite testing were generated from the data collected every 15 min by subtracting the simulated leak volume from the measured volume. The volume change used for this 15-min interval was an average of the volume changes observed before and after this period. Cumulative time series of volume, temperature, and temperature-compensated volume were then generated for analysis. The temperature-compensated time series were generated by subtracting the temperature (expressed in volume) from the measured volume on a point-by-point basis. This is the same method used by Petro-Tite. A least squares line was then fit to each of the three time series to estimate the mean rate of change of volume, temperature, and temperature-compensated volume. The temperature-compensated volume was compared to the baseline test results. The standard Petro-Tite data analysis method was used to estimate the temperature-compensated volume rate for the baseline tests (i.e., sum of the temperature-compensated volume computed for four 15-min periods).

Leak Lokator Method

Time series of the cumulative volume and cumulative temperature were generated for each simulated leak sequence of the Leak Lokator data. Each time series ranged from a total of 40 min to over 100 min and included four to nine of the standard Leak Lokator volume rate measure periods. The simulated leak rate was subtracted from the uncompensated volume rate measurements made by Leak Lokator and converted to volume using the reported measurement time. These volume measurements were then summed to obtain the cumulative volume time series. The mean volume rate for each simulated leak sequence was taken from the Leak Lokator data sheets. A continuous time series of temperature was generated each day of testing from annotated readings of temperature made every 5 to 10 min and placed on the strip chart of temperature by Leak Lokator personnel. Those sections of the temperature time series which bracketed the volume data for each simulated leak sequence were used in the analysis to compensate for temperature. The temperature data was converted to a volume time series and a least squares line was fit to the data to estimate the average rate of change of volume caused by the rate of change of temperature over an hour. A mean temperature-compensated volume rate was then computed for each simulated leak period by subtracting the mean rate of change of temperature from the mean rate of change of volume and compared to the results from the baseline test and the other simulated leak test sequences.

b. Petro-Tite Ambient Noise Analysis Results

A summary of the mean and 95 percent confidence intervals on the mean volume rate, temperature rate, and temperature-compensated volume rate estimated from the long Petro-Tite time series is presented Table 7. The rates were obtained by fitting a least squares line to each time series. The confidence intervals are based on the standard deviation of the ordinate about the regression line. The site, tank number, number of 15 min data points, and the test result using Petro-Tite's 0.05 gal/h detection criterion are also given. For comparison, the baseline test result is added to the table. Agreement between the baseline test results and the long time series results is good, except for Pitstop Tank No. 2. The time series from the Fort Lewis Tank No. 4 indicate that a potential leak began several hours after the test had begun.

The time series of volume, temperature, and temperature-compensated volume were generated by removing the simulated leaks from the Petro-Tite volume time series. The time series are 3 to 6 times longer than the standard 1 h Petro-Tite test. The first hour of each time series contains the baseline data. Several

Table 7. Summary of the Petro-Tite Analysis

			Volume rate (gal/h)		Temperature volume rate (gal/h)		Temperature-compensation volume rate (gal/h)		Baseline test results		
Location	Tank	N	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	Test result	Temperature-compensated volume rate (gal/h)	Test results
Damneck	1	20	0.043	0.008	0.064	0.008	-0.021	0.003	Tight	+0.003	Tight
Fort Lewis	2	7	-0.287	0.036	0.084	0.038	-0.371	0.050	Leaking out	-0.0342	Leaking out
Fort Lewis	4	22	-0.025	0.022	0.017	0.025	-0.042	0.027	Tight	-0.024	Tight
	4[a]	9	0.023	0.035	-0.051	0.133	0.074	0.117	Leaking in[c]		
	4[b]	13	-0.104	0.027	-0.006	0.040	-0.098	0.435	Leaking out		
Pitstop	2	19	0.151	0.010	0.013	0.009	0.133	0.011	Leaking in	-0.05	Tight
Scott AFB	1	24	0.184	0.017	0.190	0.014	-0.006	0.005	Tight	0.004	Tight
Pitstop	1	8	-2.493	0.139	0.279	0.061	-2.773	0.089	Leaking out	-2.892	Leaking out
Scott AFB	2	16	-0.714	0.024	0.009	0.005	-0.722	0.028	Leaking out	-0.812	Leaking out

[a] First 2.25 h of the test.
[b] Last 3.5 h of the test.
[c] Direction of flow only; not statistically significant from zero.

observations about the strengths and weaknesses of the method can be made from the data.

First, the time series for Damneck Tank No. 1 and for Scott Air Force Base Tank No. 1, tanks declared to be tight, illustrates the high correlation between the low frequency trends of the temperature and volume data required for temperature compensation. This suggests that the method of temperature compensation, circulation of the product and measurement of the rate of change of temperature with one temperature sensor, is a reasonable approach.

Second, negative, high-frequency correlations were observed between the temperature and temperature-compensated volume rate time series for some of the tests. This suggests that the method is overcompensating for temperature effects. These high-frequency temperature fluctuations are probably caused by inadequate resolution of the Petro-Tite temperature sensor. This increase in the high-frequency fluctuations in the temperature-compensated volume data can be a problem if the test time is too short.

Third, inspection of the temperature-compensated volume rate time series for each test suggests that a one-hour test is too short to reliably detect small leaks. Within a test, fluctuations with period of 30 to 90 min are observed which are sufficiently different from the low frequency trend exhibited by the entire time series.

Fourth, the time series for the tests conducted on Fort Lewis Tank No. 2, Scott Air Force Base Tank No. 2, and Pitstop Tank No. 1 indicate that the tanks are leaking. The measured temperature changes are too small to account for measured volume changes.

c. Leak Lokator Ambient Noise Analysis Results

A summary of the mean and 95 percent confidence intervals on the mean volume rate, temperature rate, and temperature-compensated volume is presented in Table 8. The site, tank number, duration of the test sequence, the number of Leak Lokator volume rate measurementss in the test sequence, and the test result based on Leak Lokator's 0.05 gal/hr criterion are also given. For comparison, the baseline test results are also shown. Several observations about the data presented in Table 8 are noteworthy. First, the test sequence results for each tank tested are internally inconsistent. The results from five of the six tanks tested could be declared tight or leaking depending on which data sequence was used. The results of the other tank test (Ft. Lewis, Tank #3) indicate that the tank is leaking but cannot determine whether the flow is into or out of the tank. Second, temperature, volume, and temperature-compensated volume rate data exhibit a large range of variability compared to 0.05 gal/hr. The high variability in the temperature compensated volume rate suggests that the test time is too short and a single thermistor is not adequate for measuring the mean temperature change in the tank. These conclusions are based on the raw Leak Lokator data and an analysis similar to that used by Leak Lokator except (1) an average of four to nine standard Leak Lokator volume rate measurements were used instead of one and (2) the average rate of changes of temperature over one hour was determined by fitting a least squares line to 5 to 10 temperature values over the hour instead of the two end points. The uncertainty in the Leak Lokator temperature-compensated volume rate results presented in Table 8 is about a factor of five smaller than the uncertainty of a single 10 min volume rate measurement and a two-point temperature rate measurement.

Table 8. Summary of Leak Lokator--10-min Weighted Sample Analysis

					Volume rate (gal/h)		Temperature volume rate (gal/h)		Temperature-compensation volume rate (gal/h)		
Location	Tank	Test sequence	Total time (min)	N	$\bar{x}$	95% CI	$\bar{x}$	95% CI	$\bar{x}$	95% CI	Test result
Damneck	2	Baseline	1		-0.077						Leaking out
		1	101	8	-0.051	0.004	-0.011	0.007	-0.040	0.008	Tight
		2	112	9	-0.015	0.007	-0.052	0.011	0.037	0.013	Tight
		3	93	8	0.043	0.027	-0.041	0.005	0.084	0.027	Leaking in
		4	59	5	-0.028	0.010	-0.023	0.011	-0.005	0.015	Tight
Fort Lewis	2	Baseline			-0.027						Tight
		1	44	4	0.017	0.014	0.215	0.059	-0.198	0.061	Leaking out
		2	25	3	-0.044	0.028	0.096	0.096	-0.140	0.100	Leaking out
		3	40	4	0.019	0.020	0.001	0.026	0.018	0.032	Tight
Fort Lewis	3	Baseline			-0.172						Leaking out
		1	37	5	-0.130	0.012	0.043	0.004	-0.173	0.013	Leaking out
		2	35	5	-0.089	0.031	-0.001	0.010	-0.088	0.032	Leaking out
		3	43	7	-0.042	0.020	-0.104	0.041	0.062	0.046	Leaking in
Fort Lewis	4	Baseline			-0.191						Leaking out
		1	56	6	-0.203	0.052	-0.251	0.041	0.048	0.066	Tight
		2	41	6	0.157	0.068	-0.031	0.014	0.188	0.070	Leaking in
		3	41	5	0.158	0.034	-0.003	0.010	0.161	0.036	Leaking in
Pitstop	2	Baseline			-0.012						Tight
		1	48	7	0.096	0.009	0.079	0.033	0.017	0.035	Tight
		2	44	4	0.053	0.005	0.006	0.078	-0.003	0.079	Tight
		3	47	6	0.054	0.007	0.057	0.078	-0.003	0.079	Tight
		4	56	5	0.053	0.005	0.221	0.045	-0.168	0.045	Leaking out
Scott AFB	1	Baseline			-0.299						Leaking out
		1	55	6	-0.323	0.029	-0.262	0.075	-0.061	0.080	Leaking out
		2	44	6	-0.225	0.008	0.032	0.008	-0.193	0.011	Leaking out
		3	56	5	-0.241	0.005	-0.008	0.024	-0.233	0.024	Leaking out
		4	36	5	-0.206	0.0374	0.008	0.014	-0.214	0.040	Leaking out

The time series plots of temperature (converted to volume) and uncompensated volume were generated for each of the 21 sequences of Leak Lokator data. These cumulative time series plots illustrate the reasons for the inconsistent test results and the high variability. The volume and temperature time series, and the least squares line fit to the temperature data are presented in the report, "Development of a Tank Method for a National Survey of Underground Storage Tanks."[4]

Some difficulty is evident in using a two-point analysis approach. Depending on which two points are taken, a positive, nearly zero, or negative slope can be determined because of the large fluctuations in temperature.

C. Recommendations for the National Survey Testing

The findings of the development study have resulted in several recommendations concerning the method of tank testing to be used in the national survey program. These recommendations are summarized below.

- **The tank testing method should include putting a head of pressure on the tank.** There are two reasons for this. First, proper compensation for water table effects are necessary if the proper conclusion is to be reached under high water table conditions. Second, this process enhances the flow of product through small holes, making them more likely to be detected, particularly if they are near the top of the tank.

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[4] See Footnote 1.

- **The tank test method should provide frequent temperature measurements with a precise thermistor and adequate temperature compensation. The product should be circulated or mixed during the test.** Adequate temperature compensation is a key to successful interpretation of tank test data. Such data must consist of accurate temperature measurements at frequent intervals. The judgment to mix is a choice of techniques which is associated with the better performance achieved by the single thermistor approach used by Petro-Tite over the single thermistor approach used by Leak Lokator.

- **Data on temperature and level changes must be collected frequently.** This is necessary to minimize aliasing of the high frequency fluctuations (out of the signal band) into the lower frequencies (in the signal band). This conclusion is based large on data analysis performed by Vista Research, Inc.[5]

- **Data collection must continue for an adequate period of time so that sufficient data for a precise analysis can be provided. A minimum of 4 to 6 hours with frequent temperature and tank level change intervals is needed.** While a test length of 4 to 6 hours with frequent temperature and level readings is desirable, the practical considerations of cost and disruption to an establishment are also factors.

- **The test method must incorporate an adequate statistical analysis of the data to draw supportable conclusions about the leak rate.** None of the techniques were found to collect either sufficient test data or to provide adequate analysis algorithms. Improved analysis protocols will be required.

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[5] "Analysis of the Pilot Study Tank Test Data," Vista Research, Inc., July 1985.

V. PILOT STUDY

A. Objectives

The results from the earlier stages led to the recommendation that a test using modified Petro-Tite equipment and procedures be adopted for the national survey. The major objective of this final stage was to modify and evaluate the performance of the Petro-Tite method as it was to be used on the national survey. This process included:

- Determining the best sampling interval for collecting the data; that is, the time interval at which product in the standpipe should be re-leveled and data readings made;
- Determining the best length of the test;
- Developing and testing the analysis algorithm;
- Implementing the procedures operationally in the field to identify operating difficulties and correct them;
- Field testing the entire survey data collection effort including scheduling, data collection, and analysis;
- Estimating the detection performance of the method; and
- Finalizing the test protocol.

B. Overview

A sample of 25 tanks was selected from two primary sampling units (PSUs) on the west coast for use in the pilot study. The owners and operators of these tanks were contacted to arrange for the tanks to be tested and to schedule the tests. Timing of the contacts and arrangements for fuel delivery, payments, and scheduling presented difficulties. Recommendations for mitigating these on the national survey were developed. Notifying owners earlier of the test and giving a longer lead time to arrange and schedule the tests were found to be necessary to expedite testing.

Data were collected at three different time intervals and for three different total time periods. The resulting data were analyzed by various methods to select the most practical and effective data collection interval and test length. A standard data analysis protocol was developed for use when no testing or data problems are identified. Data management procedures for the national survey were developed which included the use of on-site computers to collect data. Data and test review procedures were developed to check each tank test for validity and to ensure that the standard analysis was adequate. A simplified analysis that can be used in the field to visually inspect the data and identify potential testing problems was developed and implemented. The tank test data were analyzed and a data report prepared and submitted to EPA.

C. Data Collection

Data identifying the tank, size, location, product, etc., were entered onto the top of a spreadsheet data file utilizing a portable computer. Then test data are entered as each data point becomes available. This provided a preliminary analysis and estimated volume change rate that can be obtained on the scene.

D. Data Analysis

The data from the pilot study tank tests were analyzed with two objectives. One was to determine the best sampling interval, and the second was to determine the best total test duration. Sampling intervals of 1, 5, 10, and 15 minutes were considered. Data collection at 1-min intervals was found to be impractical for the large scale survey. Both the 5- and 10-minute intervals provided improvements in the precision of the test data, but the 5-minute interval resulted in better precision. Thus, data collection at 5-minute intervals was selected as the standard. This analysis is presented in detail in Vista Research, Inc.'s report.[6]

Selection of the total time of the test was not so clear-cut. Longer test times were desirable from a data quality standpoint, but practical limitations were also considered. A compromise of 2 hours of data at the low level was selected as providing sufficient data while still proving to be practical for the field data collection.

The test protocol used the same equipment as for a standard Petro-Tite test. There were no changes in the test procedures except for the sample interval and length of the test.

The analysis algorithm was modified to include smoothing of the temperature data before applying the temperature correction. A regression line was then fitted to the corrected data to obtain the leak rate.

Seventeen tanks were tested in the pilot study. A summary of the test results is presented in Table 9.

A family of performance curves was generated for the large and small tanks to estimate detection performance for a given leak rate as a function of probability of detection, probability

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[6] Ibid.

Table 9 Summary of Pilot Study Results

Site no.	Tank no.	System leak rate (gal/h)	Standard Error (2 h) (gal/h)	OHM rate (gal/h)	Conclusion	Fuel	Tank size (gal)
1		0.036	0.0074	+0.037	C	UNL	11,907
2	T1	-0.036	0.0098	-0.038	C	UNL	1,034
2	T2	-1.381	0.0490	-1.518	N	D	7,896
2	T3	-0.263	0.0138	-0.367	N	D	7,896
2	T4	0.009	0.0107	+0.015	C	D	10,152
3		-0.012	0.0242	+0.032	C	PUNL	1,036
4		+0.294	0.0601	+0.256	N(I)	UNL	10,152
5	T1	0.026	0.0114	0.042	C	D	10,152
5	T2	-0.107	0.0041	-0.115	N	D	10,152
5	T3	+0.054	0.0047	-0.005	C	UNL	10,152
6		-0.008	0.0137	-0.024	C	UNL	8,000
7	T1	0.036	0.0245	+0.016	C	LR	6,006
7	T2	0.042	0.0307	+0.096	N(I)	LP	6,006
7	T3	0.013	0.0348	+0.031	C	UNL	6,006
8		-0.056	0.0067	-0.029	N	D	10,383
9	T1	-0.010	0.0098	+0.028	C	UNL	1,036
9	T2	-0.015	0.0130	-0.008	C	LR	1,036

C = Certifiable by NFPA standard.
N = Not certifiable (I) Inconclusive test
D = Diesel
UNL = Unleaded
PUNL = Premium unleaded
LR = Leaded regular
LP = Leaded premium

of false alarm, and test time. Detection performance for 0.05 gal/h leaks was unacceptable. A test period of 1 hour or less is too short to achieve reasonable detection performance. For the small tanks, test times of 1, 2, and 3 hours result in the detection of 0.10, 0.075, and 0.05 gallon per hour leak rates with a P_D = 95 percent and a P_{FA} < 5 percent. For the large tanks, test times of 1 and 2 hours result in the detection of 0.25 gal/h leak rates with a P_D = 95 percent and a P_{FA} = 2 percent and 5 percent, respectively.

Of the 17 tanks tested, one resulted in a clearly invalid test. One test was problematical, but the system is probably tight. Three tanks appear to have significant leaks, and the remainder appear to be tight. Due to the fact that the Petro-Tite method places a higher head pressure on the tank than is found in normal operation, the reported rates are overestimates of product loss or leakage in operation.

Since the pilot study data available for analysis was somewhat limited, the determination of the detection limit of the Petro-Tite method could not be established as well as hoped. Further data from the national survey will need to be examined.

VI. RECOMMENDATIONS FOR NATIONAL SURVEY

The recommendations for the national survey are:

1. Use a modified Petro-Tite test method;
2. Data should be collected at 5-minute intervals for 2 hours at each tank; and

3. Data analysis should use improved algorithms to fit data which exhibit curvilinearity in the test results.

The final proposed equipment configurations and data collection, environmental measurement, and data analysis procedures which resulted from the development and pilot studies were specified in a separate document.[7] The actual procedures and methods which were followed in the field are documented in Sections 6 and 7 and Appendix D of this report.

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[7] "National Survey of Underground Storage Tanks: Draft Test and Analysis Plan," Midwest Research Institute, June 10, 1985.

APPENDIX D

TANK TESTING DATA REDUCTION AND STATISTICAL ANALYSIS LEADING TO LEAK STATUS DETERMINATION

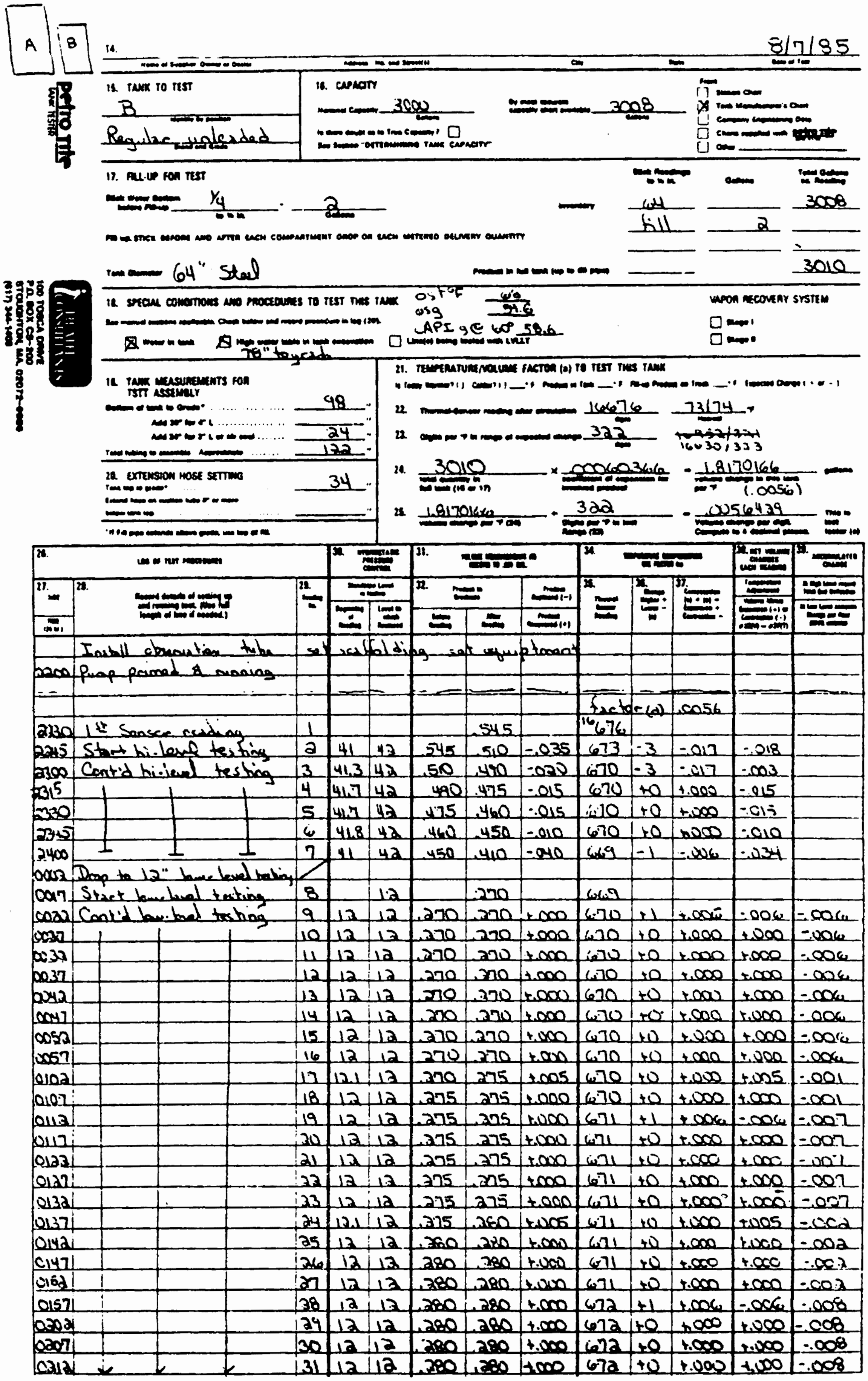
I. INTRODUCTION

This appendix contains additional detail and in some cases a more technical presentation of topics covered in Sections 7 and 8 of the report. Parts II and III of this appendix provide further details on the tightness test raw data and the initial reduction steps which produced the basic volume change rate estimates and the estimated within-test standard errors for these estimated rates. Part IV provides further detail on the retest results, which is summarized in Part V of Section 7. Part V of this appendix provides a more technical description of the estimation of total test variance than is given in Section 8. Part VI provides a more technical description of the leak status determination rule than appears in Part III of Section 8, and Part VII gives more details on the adjustment to test pressure than appears in Part II of Section 8.

I. DATA COLLECTION AND MANAGEMENT

A. Data Collected

The tank testing data collected consist of several data elements. A sample of a typical Petro-Tite data sheet is displayed as Figure D-1. Identifying information about the site, tank system, and product were determined and entered as header



A | B

Petro Tite Tank Tester

Heath Consultants
100 Tosca Drive
P.O. Box CS-200
Stoughton, MA 02072-0200
(617) 344-1400

14. 8/7/85
Name of Supplier Owner or Dealer | Address No. and Street(s) | City | State | Date of Test

15. TANK TO TEST
B
Identify by position
Regular unleaded
Brand and Grade

16. CAPACITY
Nominal Capacity 3000 Gallons
By most accurate capacity chart available 3008 Gallons
Is there doubt as to True Capacity? ☐
See Section "DETERMINING TANK CAPACITY"
From
☐ Station Chart
☒ Tank Manufacturer's Chart
☐ Company Engineering Data
☐ Chart supplied with Petro Tite
☐ Other

17. FILL-UP FOR TEST
Stick Water Bottom before Fill-up ¼ to ⅛ in. 2 Gallons
Fill-up: STICK BEFORE AND AFTER EACH COMPARTMENT DROP OR EACH METERED DELIVERY QUANTITY

	Stick Readings to ⅛ in.	Gallons	Total Gallons ea. Reading
Inventory	64		3008
	fill	2	
Product in full tank (up to fill pipe)			3010

Tank Diameter 64" Steel

18. SPECIAL CONDITIONS AND PROCEDURES TO TEST THIS TANK
OS F°F 66
OSG 94.6
API g @ 60° 58.6
See manual sections applicable. Check below and record procedure in log (28).
☒ Water in tank ☒ High water table in tank excavation ☐ Line(s) being tested with LVLLT
78" to grade

VAPOR RECOVERY SYSTEM
☐ Stage I
☐ Stage II

19. TANK MEASUREMENTS FOR TSTT ASSEMBLY
Bottom of tank to Grade* 98"
Add 30" for 4' L ____"
Add 24" for 3' L or ob end 24"
Total tubing to assemble Approximate 122"

20. EXTENSION HOSE SETTING
Tank top to grade* 34"
Extend hose on suction tube 8" or more below tank top ____"
* If fill pipe extends above grade, use top of fill.

21. TEMPERATURE/VOLUME FACTOR (a) TO TEST THIS TANK
Is today Warmer? ( ) Colder? ( ) ___°F Product in Tank ___°F Fill-up Product on Truck ___°F Expected Change (+ or −)

22. Thermal-Sensor reading after circulation 16676 digits 73/74 °F

23. Digits per °F in range of expected change 322 digits ~~16632/334~~ 16630/333

24. 3010 (total quantity in full tank (16 or 17)) × .00060366 (coefficient of expansion for involved product) = 1.8170166 gallons (volume change in this tank per °F) (.0056)

25. 1.8170166 (volume change per °F (24)) ÷ 322 (Digits per °F in test Range (23)) = .0056439 (Volume change per digit. Compute to 4 decimal places.) This is test factor (a)

27. Time	28. Record details of setting up and running test. (Use full length of line if needed.)	29. Reading No.	30. Standpipe Level in inches: Beginning of Reading	Level to which Restored	32. Product in Graduate: Before Reading	After Reading	Product Replaced (−) / Product Recovered (+)	35. Thermal Sensor Reading	36. Change Higher + Lower − (b)	37. Computation (a) × (b) = Expansion + Contraction −	38. Net Volume Change Each Reading	39. Accumulated Change
	Install observation tube set scaffolding set equipment											
2200	Pump primed & running											
--												
								factor (a)		.0056		
2230	1st Sensor reading	1				.545		$^{16}676$				
2245	Start hi-level testing	2	41	42	.545	.510	-.035	673	-3	-.017	-.018	
2300	Cont'd hi-level testing	3	41.3	42	.510	.490	-.020	670	-3	-.017	-.003	
2315		4	41.7	42	.490	.475	-.015	670	+0	+.000	-.015	
2330		5	41.7	42	.475	.460	-.015	670	+0	+.000	-.015	
2345		6	41.8	42	.460	.450	-.010	670	+0	+.000	-.010	
2400		7	41	42	.450	.410	-.040	669	-1	-.006	-.034	
0002	Drop to 12" lower level testing											
0017	Start low-level testing	8		12		.270		669				
0022	Cont'd low-level testing	9	12	12	.270	.270	+.000	670	+1	+.006	-.006	-.006
0027		10	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0032		11	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0037		12	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0042		13	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0047		14	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0052		15	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0057		16	12	12	.270	.270	+.000	670	+0	+.000	+.000	-.006
0102		17	12.1	12	.270	.275	+.005	670	+0	+.000	+.005	-.001
0107		18	12	12	.275	.275	+.000	670	+0	+.000	+.000	-.001
0112		19	12	12	.275	.275	+.000	671	+1	+.006	-.006	-.007
0117		20	12	12	.275	.275	+.000	671	+0	+.000	+.000	-.007
0122		21	12	12	.275	.275	+.000	671	+0	+.000	+.000	-.007
0127		22	12	12	.275	.275	+.000	671	+0	+.000	+.000	-.007
0132		23	12	12	.275	.275	+.000	671	+0	+.000	+.000	-.007
0137		24	12.1	12	.275	.280	+.005	671	+0	+.000	+.005	-.002
0142		25	12	12	.280	.280	+.000	671	+0	+.000	+.000	-.002
0147		26	12	12	.280	.280	+.000	671	+0	+.000	+.000	-.002
0152		27	12	12	.280	.280	+.000	671	+0	+.000	+.000	-.002
0157		28	12	12	.280	.280	+.000	672	+1	+.006	-.006	-.008
0202		29	12	12	.280	.280	+.000	672	+0	+.000	+.000	-.008
0207		30	12	12	.280	.280	+.000	672	+0	+.000	+.000	-.008
0212		31	12	12	.280	.280	+.000	672	+0	+.000	+.000	-.008

Figure D-1. Petro-Tite data sheet

information. Additional data needed to set up the test were recorded. These included the diameter of the tank, the depth from grade to the bottom and top of the tank, and the depth of the water table. An initial thermistor reading was taken and th internal check of the thermistor unit was performed. The specific gravity of the product was measured and used to determine the coefficient of expansion. The tank volume was determined. Presence of water in the tank was checked. If water was present the volume of water in the tank was calculated and subtracted from the tank volume to determine the volume of product. A fina adjustment to product volume was to add the volume in the test equipment (usually 2 to 3 gallons).

After the preliminary data had been entered in the header, the actual test data were taken and entered. The time of readin was entered. The reference level was noted. The volume in the graduated cylinder before releveling was found and entered. After releveling, the volume in the graduated cylinder was found and entered as "volume after." The fuel temperature in terms of the digit reading on the thermistor unit was found and entered. The actual test data used to calculate leak rates consist of the time, the volumes before and after, the temperature, the tank product volume, the digits per degree Farenheit, and the coefficient of expansion.

B. Data Management

The test data collected as described above were recorded on a Petro-Tite data sheet by the test crew. The MRI technician at the site keyed these data into a Lotus 123 worksheet file that had been configured to receive the data and perform preliminary calculations. An example printout of the data portion of this file is shown in Figure D-2. The MRI technician entered the

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19-Aug-85                            Page 1

        Survey ID               Fuel Type UNLEADED  Date      AUG 7 1985
  Tank  Test Firm DBL CHK       Tank Vol       3010 T digits       16676
  2 of  Test Crew             7 API Dens       58.6 T digits/F       322
      2 MRI Crew  STEVE         Exp Coef 0.00060366 Leak Rate      0.001
                                                    Std. Err   0.0058976
  Time     Level    V Before  V After   Fuel Temp  Tcorr dV Leak Rate
 Hr  Min   (div)     (gal)     (gal)    (digits)    (gal)    (gal/h)
-----------------------------------------------------------------------
  0  17       12      N/A       N/A        16669     N/A      N/A
  0  22       12      0.270     0.270      16670    -0.006    -0.068
  0  27       12       0.27      0.27      16670     0.000     0.000
  0  32       12       0.27      0.27      16670     0.000     0.000
  0  37       12       0.27      0.27      16670     0.000     0.000
  0  42       12       0.27      0.27      16670     0.000     0.000
  0  47       12       0.27      0.27      16670     0.000     0.000
  0  52       12       0.27      0.27      16670     0.000     0.000
  0  57       12       0.27      0.27      16670     0.000     0.000
  1   2       12       0.27     0.275      16670     0.005     0.060
  1   7       12      0.275     0.275      16670     0.000     0.000
  1  12       12      0.275     0.275      16671    -0.006    -0.068
  1  17       12      0.275     0.275      16671     0.000     0.000
  1  22       12      0.275     0.275      16671     0.000     0.000
  1  27       12      0.275     0.275      16671     0.000     0.000
  1  32       12      0.275     0.275      16671     0.000     0.000
  1  37       12      0.275      0.28      16671     0.005     0.060
  1  42       12       0.28      0.28      16671     0.000     0.000
  1  47       12       0.28      0.28      16671     0.000     0.000
  1  52       12       0.28      0.28      16671     0.000     0.000
  1  57       12       0.28      0.28      16672    -0.006    -0.068
  2   2       12       0.28      0.28      16672     0.000     0.000
  2   7       12       0.28      0.28      16672     0.000     0.000
  2  12       12       0.28      0.28      16672     0.000     0.000
  2  17       12       0.28      0.29      16673     0.004     0.052
-----------------------------------------------------------------------
```

Figure D-2. LOTUS data sheet

header data including the date, test crew, testing company, MRI person, and the time, level, volumes before and after, and fuel temperature (digits). The program calculated the leak rate, standard error, and other intermediate values.

After the data were entered into the computer on site, they were stored on a diskette. In order to facilitate expeditious data analysis, the data were transmitted to MRI via telephone using a modem. The diskettes containing the data files were shipped to MRI on a weekly basis. The original Petro-Tite data sheets were also shipped to MRI.

Upon receipt of the electronically transmitted data files, they were printed and the volume trends plotted. Figure D-3 shows an example of such a plot. The calculations of the leak rate and standard error were checked. Any unusual features of the data such as outliers or curvilinearity were noted. The computer file was archived as received and the hard copy was placed in an archive file. A copy of the computer file was placed in a working directory.

When the disk containing the data file was received, the disk file and the telephone file were compared using the IBM DOS utility file compare program to determine whether the data transfer was complete and accurate. If the files were found to differ, a new hard copy of the data and graph were printed.

Upon receipt of the Petro-Tite data sheets, the printed data from the computer file were checked against the raw data sheets. Any discrepancies were corrected in the computer file. If the final file differed, another hard copy of the data and graph was printed. The final form of the computer file was archived.

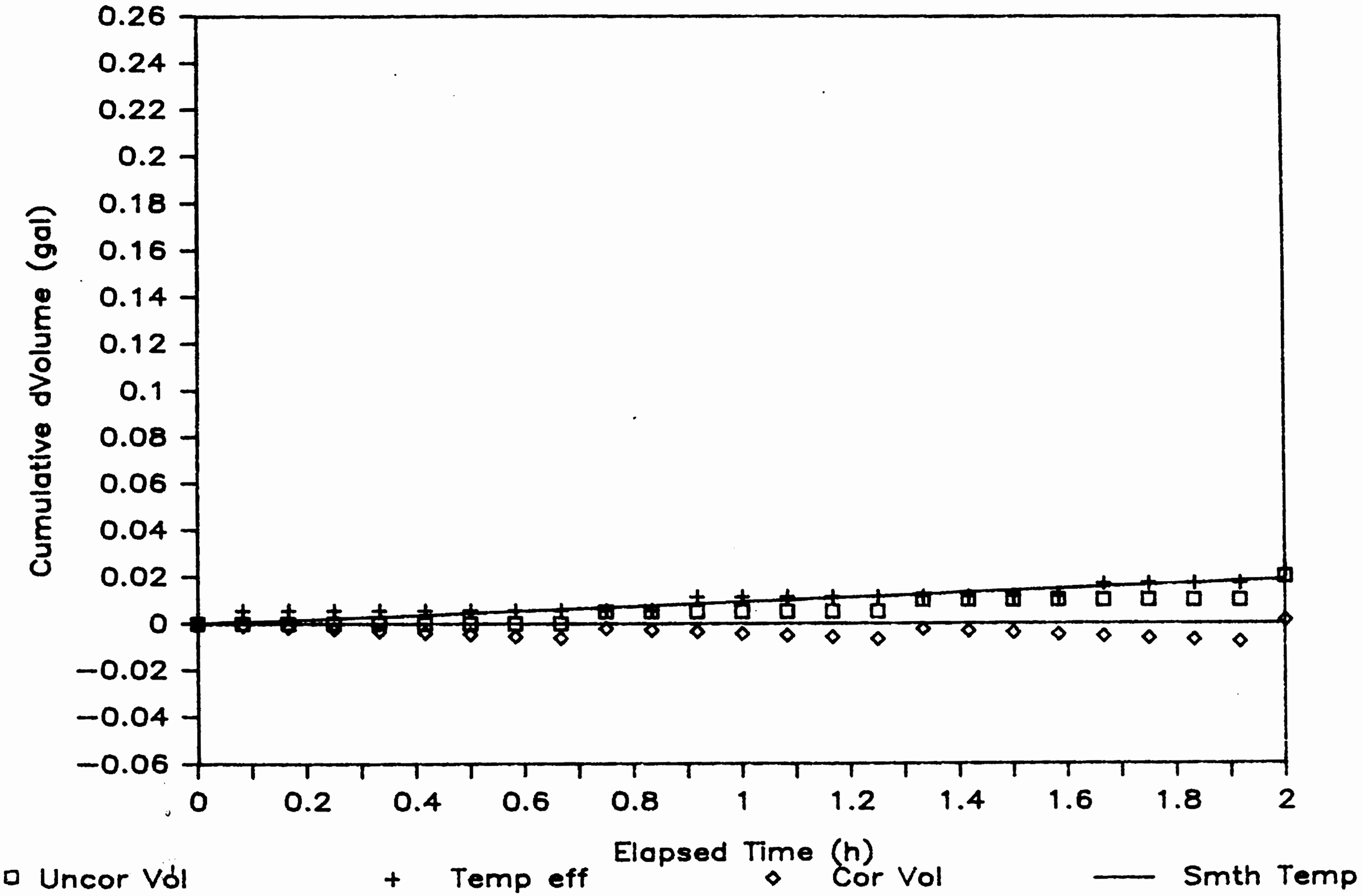

Figure D-3. Plot of data using Lotus Data File

After the data had been checked against the original sheet, the final data analysis was done for the tank or system. When the analysis was completed, a final copy of the data was printed, incorporating any special analysis with the final leak rate and standard error estimates. The final computer file was archived.

III. DATA REDUCTION ANALYSIS METHODS

A. Statistical Methods Considered and Choice

Several methods of statistical analysis of the tightness test data were considered for use on the national survey. This section presents a discussion of the advantages and disadvantages of each and gives the reasons for the selection of those used.

The test method produced a volume change measurement at 5 minute intervals. This change was measured directly by bringing the standpipe to a reference level and collecting the product recovered or measuring the additional product needed. The other measurement recorded at 5 minute intervals was a temperature measurement. This measurement was taken by means of a thermistor probe and box. To make this reading, a resistance bridge was balanced by means of a dial. The instrument reading was converted to a temperature by means of the calibration chart for the instrument. The readings--after conversion to temperature--were the temperature of the product in the tank at 5 minute intervals. The temperature record of the product as measured by the thermistor must be converted to an equivalent volume change using the volume of the tank and the thermal coefficient of expansion. One essential difference between the volume and temperature readings should be noted. The temperature was recorded as a cumulative reading--the tank temperature--while the volumes were recorded as differences.

In order to make the temperature and volume data comparable, they must be put in the same form. Either both must be changes or both must be cumulative. Several approaches can be used for the analysis. The standard Petro-Tite approach to the analysis of the data is to take differences in the temperature readings. The time interval used by Petro-Tite is 15 minutes rather than the 5 minute intervals selected for the national survey testing. After taking differences in the temperature readings, the change in temperature is multiplied by the volume of the tank and the thermal coefficient of expansion for the product to produce a volume change due to temperature. This is subtracted from the observed volume change at each point. The resulting differences are temperature-adjusted volume changes. The standard Petro-Tite analysis adds up four of these 15 minute readings to obtain the hourly leak rate that they report. An advantage of this method is its simplicity. A disadvantage is that no estimate of variability is provided. An additional disadvantage is that four 15 minute data points do not provide sufficient data to ensure that the test is valid.

A similar approach could be followed for analysis of the survey data. Consecutive temperatures could be differenced to obtain temperature changes for each 5 minute interval. This would provide a set of observed volume changes and temperature changes. The temperature changes would be converted to volume changes by use of the coefficient of expansion. At this point two different approaches to the analysis could be used.

One approach is to regard the observed volume changes and the temperature volume changes as a paired sample. In this analysis, one would calculate differences in each pair. These differences would be averaged to obtain an estimated leak rate. The variability of the differences would be used to obtain an estimate of the variability measured by the standard deviation. The variation of the mean would be estimated by the standard error of the differences (the standard deviation divided by the square root of the number of terms in the average). This would result in n-1 degrees of freedom for the standard error. Both the mean and standard error (or standard deviation) would be rescaled to an hourly leak rate.

There are a number of advantages to this approach. It is directly comparable to the standard Petro-Tite tests. It is relatively simple and should be easily understood. It does provide an estimate of variation. If the volume change and temperature changes are dependent, it accounts for this by pairing the data. In addition, if the differences were less variable than the original data, it would provide a more precise estimate than other approaches. A disadvantage is that if the data are not dependent, it sacrifices degrees of freedom unnecessarily. In addition, if pairing does not reduce variability, then this analysis would lose precision.

A slightly different approach is to regard the volume data and the temperature-volume data as two samples rather than as a paired sample. With this approach, the mean volume change would be calculated as would the mean temperature-volume change. The difference in these two means would be calculated. This would result in the same estimate of the leak rate or volume change as with the paired data. However, there would be a difference in the estimation of the variability. Each set of data--volume and temperature-volume--would have its variability estimated separately by the sample variance. If it were assumed that these variance estimates were estimating the same quantity, a pooled variance estimate could be calculated from these two. This would have a total of 2n-2 degrees of freedom, where n is the number of data points of each type. This approach has an advantage if there is no inherent dependence in the two types of readings. It also is advantageous if pairing does not reduce variability enough to offset the loss in the number of degrees of freedom.

If it were concluded that the variation of the two types of data is different, then the sample variances should not be pooled. In this case, the variance of the difference in sample means would be the sum of the two variances of the means (the variance of the mean is the sample variance divided by n). The assumption would be that n is large enough so that the sample mean would be approximately normally distributed. After the variance of the difference in the means is calculated, the square root of this number would be taken. Finally, the estimated leak rate and the standard error of it would be rescaled to an hourly leak rate as before. Thus, while the estimate of the leak rate would be the same, the estimate of the variability would differ. This approach has the same advantages of the previous approach. The essential difference is in the calculation of the variability. The choice between these two approaches should be based on whether the assumption that the temperature-related volume changes and the observed volume changes have the same variability is valid. Consideration of the precision of the two measuring instruments and of the rounding errors involved in the two measuring processes suggests that the temperature-related volume changes and the observed volume changes do not have the same variance in general. Consequently, this latter approach would be preferred.

The result that the variability in the temperature-related volume data is larger than the variability in the observed volume changes suggests that it may be advantageous to smooth the temperature data before adjusting the observed volumes for temperature. Basically, this approach would use some degrees of freedom to smooth the temperature data by fitting a curve of some sort to them prior to making the volume adjustments for temperature. It would use the fitted curve in the adjustments in order to reduce variability.

Since the temperature data as recorded represent the temperature of the tank over time, one approach is to fit a curve to these temperatures and use the expected or predicted values from the fitted curve for adjustment. In the typical test, the temperature increased smoothly in a nearly linear fashion over the period (about 2 hours) of the test. In this case, a linear regression through the origin (or the starting temperature) provides an adequate smoothing. The predicted values from the regression can be used to adjust the volume changes. In some cases, the temperature displayed a curvilinear form so that the straight line fit was inadequate. In these cases, adding a quadratic term to the regression provided a satisfactory fit. Occasionally, the temperature was not monotonic or displayed some other unusual behavior. In this event, moving averages were used to smooth the temperature-related volumes prior to adjusting the volumes.

The advantage of smoothing is that it may reduce the variability of the estimate and so improve the precision of the test. A disadvantage is that it is somewhat more complicated than a linear or quadratic fit. An additional potential disadvantage is that it may require a different form of analysis to be used depending on the temperature data. On the other hand, any method of analysis should allow for diagnostics to ensure that the data from the test meet the assumptions adequately. It should be anticipated that some tests will give data that do not meet the standard assumptions. Such tests will either be judged invalid or will require specialized analysis.

A rather different approach can be taken by cumulating the volume differences. This would provide two sets of cumulative data (one for volume, one for temperature-related volume) that can be viewed as time series. With this approach, time series models could be fit to both series. A transfer function could be used to relate the two series and form a third series of the temperature-adjusted volumes. The estimate of the temperature-adjusted volume change rate could be made from the parameters of the time series model of the derived series. This approach would have an advantage if the volume measurements and temperature measurements showed common forms of serial correlation that would leak to a particular form for a time series model in the majority of cases. There are some disadvantages of this approach. One is that a large number of data points is required in order to fit the time series models and have a sufficient number of degrees of freedom. A second is that the analysis is much more complicated and time consuming. A third is that the analysis must estimate the appropriate model form for each series. The major drawback is that time series analysis requires more data than was available from the tests in the national survey.

A spectral analysis of the data from a long test during the pilot study led to the conclusion that for test times exceeding one hour, a sophisticated time series algorithm was not necessary.

B. Standard Analysis

As a result of the considerations of the types of analyses available and the advantages and disadvantages of each, a standard analysis was designed. For the standard analysis, the temperature-related volume change and the observed volume change were both expressed in cumulative form, beginning at zero for the start of the low level (4-psig) test. A straight line through the origin was fit to the temperature-volume data by least squares. The predicted values of this line were calculated and used as a smoothed temperature correction. The data were plotted and inspected visually for outliers or deviations of the temperature data from linearity. Any questionable data were checked in detail or considered for special analysis.

If no problems with the data were found, the predicted values from the smoothed temperature line were used as the temperature correction. This smoothed temperature correction was subtracted from the observed volume data for each time point. The resulting differences were divided by the time interval to obtain a series of volume change rates expressed in gallons per hour, typically based on a 5 minute interval. The arithmetic mean of these rates was calculated and used as the estimate of the leak rate. The standard error of this mean was calculated and presented as the standard error of the estimate. In the variance computation, n-1 was used as the divisor, where n is the number of terms in the mean. The result was divided by n to form the variance of the mean. The square root of this is the within-test standard error reported before adjusting for between-test variation. (See Section D.V, below, for discussion of total variance.)

The question of the appropriate number of degrees of freedom was considered. It was possible that the terms in the mean might be correlated, implying that the actual degrees of freedom would be less than n-1. Spot checks of the serial correlation of the terms showed generally no significant (at the 10% level) correlations. For a few data sets some of the lag correlations were significant. However, this occurred in only about 20% of the data sets. Those where one or more significant correlations were found showed no consistent pattern of which serial correlations were significant. Consequently, this was interpreted as being likely to be due to chance. No adjustment of the degrees of freedom is thought necessary.

C. Special Analyses

A number of data set features called for a different or more detailed analysis than that described above. The most obvious case was that of a manifolded tank system. Within the set of manifolded systems, a slightly different analysis was needed for different numbers of tanks, and a different analysis was needed for systems tested together as opposed to those with tanks tested separately.

Manifolded tanks that were separated and tested separately provided two or more individual tank tests. As individual tank tests, these were subjected to the standard analysis (or special analysis if needed). This provided volume change rate estimates and standard errors for each tank (and its associated lines). These needed to be combined to estimate a system volume change rate. In the descriptive data presented in the first part of Section 9, the individual test results for tanks in a manifolded system were used separately when available. The multivariate analyses were restricted to single-tank systems. Thus, creating system volume change rates was done for completeness in the deliverable data file. This was done by summing the two estimates of volume change rates. The variability of this combined rate was estimated by taking the variances of the individual volume change rates and adding these. Taking the square root of this gave the standard error of the combined rate. This extends to any number of tanks in a manifolded system tested separately.

Manifold tanks tested together provided slightly different data. A single standpipe (or two connected by a siphon) was used. A single volume change was recorded for the system every 5 minutes. However, each tank had a circulation pump and the associated thermistor unit to measure temperature. In general, each tank could have a different volume, although the usual case was for tanks of the same volume to be manifolded.

A temperature-related volume change was calculated for each tank. These were summed. The result represented the total temperature-related volume change. This was used as the temperature effect. It was smoothed as before with a least squares line through the origin, and the temperature adjusted volume change rates calculated as before.

A number of other special cases were found and were dealt with on an individual basis. Occasionally apparent outliers were found. These were checked against the raw data and the test log to see if there was any physical reason for them. A few tests had thermistor boxes fail during the test for some reason (rain, FM interference). These generally gave temperature data that appeared as outliers. When outliers were found and a physical reason identified, the aberrant data were removed from the analysis. This generally required smoothing over the missing data by interpolation. If errors were identified, they were corrected and the analysis redone.

The typical data showed a monotonically increasing temperature, generally linear. A smaller proportion of the data sets showed linearly decreasing temperature. Some data sets showed evidence of temperature increase that was curvilinear. If this curvilinearity appeared or was suspected, a test for curvilinearity was done by fitting both a linear and quadratic to the temperature data by least squares (through the origin). If the quadratic improved the fit significantly, the curvilinear fit (using both linear and quadratic terms) was used for smoothing.

A few cases were found where both temperature and volume were not only non-linear, but also non-monotonic. Provided that they showed the same pattern, analysis proceeded. In this event, a five point moving mean was used to smooth the temperature data. Equal weights were used. This resulted in the loss of four data points; two at the start and two at the end of the test. The moving mean smoothed temperature volumes were subtracted from the volume changes to obtain temperature-corrected volumes. These were divided by the time intervals and expressed as gallons per hour. The arithmetic mean and standard error of these temperature corrected volume rates were calculated and used as the estimates of the volume change rate and its standard error, respectively.

Some tests showed volume change rates that were initially increasing rapidly and curvilinear, while the temperature changes were quite linear. The volumes typically increased rapidly for the first few times, then slowed. This was interpreted as relaxation of tank deformation. The apparent relaxation appeared to follow an exponential curve and to approach the temperature change rate as an asymptote. However, the constant of this asymptote differed by tank. The rate of relaxation may be related to the nature of the soil in backfill and water conditions. When this was identified, the initial points exhibiting this relaxation of the tank deformation were deleted before analysis.

D. Criteria for Invalid Data

A few of the data sets from the tank tests were judged invalid based on the analysis of the data. This occurred quite infrequently.

There were a number of criteria for declaring a data set to be invalid. The most common was that the data showed a volume increase even after adjusting for temperature. Since the test method places pressure on the tank, a volume increase cannot occur from inflow of water. Data that showed volume increases after temperature adjustment that exceeded levels that could be reasonably attributed to the variability of the measurement process were judged to be invalid tests. The reason for this is that such an apparent volume increase with no explanation could be eclipsing a small actual volume loss or leak. Generally any tank that showed a volume gain rate of more than 0.1 gallons per hour after temperature adjustment was judged to be an invalid test. The most likely explanation for such tests is that those tanks had trapped vapor pockets.

A variety of other data features led to the conclusion that the test was invalid. Some of these may also have been caused by trapped vapor. A few instances were found where the temperature as recorded fluctuated erratically during the test while the volume measurements were relatively stable. If the temperature data were so erratic as to preclude a temperature adjustment, then the test was declared to be invalid. One or two tests showed both temperature and volume measurements that were erratic and did not appear to track together. These tests were also judged invalid. Such behavior may have been caused by incomplete tank deformation, followed by relaxation, combined with mixing problems. No valid volume change rate could be estimated.

IV. RETEST RESULTS

Three types of retests were conducted as part of the national survey of underground storage tanks. One was a back to back retest, conducted immediately after the original test used to estimate the leak rate. The second was a leak simulation test also conducted immediately after the original test. The third type was a complete retest conducted on a different day and generally by a different crew. Each of these types estimates a different source of variation possible in the tank tests. A tabulation of all of the retests appears as Table D-1. (Note that a negative volume change is a leak, while a positive volume change represents net inflow. In the body of the report, leaks are reported without minus signs.) The simulated leak retests are tabulated in Table D-2. A table summarizing the estimates of bias (accuracy) and standard deviation (precision) based on each type of test is presented as Table D-3. It should be noted that the three types of retests estimate different sources of variation and so are not directly comparable to each other.

A. Leak Simulations

The leak simulation tests were conducted after the original test was concluded. Generally they were only conducted when the original test indicated that the tank was tight or had a small estimated volume change. The volume rate used for leak simulation was on the order of 0.1 gallons per hour, so a large volume change would overwhelm it.

The purpose of the leak simulation tests was to document that the testing method could detect leaks of known size in tanks that appeared to be tight. In addition, use of the leak

Table D-1. Retest Data Summary

Survey ID	Volume	Fueltype	Type	Initial Date	QC Date	Initial Rate	SE	Retest Rate	SE
N02784A	2007	DIESEL	BTB	0730	0731	-.015	.007	-.009	.005
N131078A	3985	UNLEADED	BTB	0822	0822	-.102	.018	-.079	.013
N171261A	3979	GASOHOL	BTB	0804	0804	.049	.019	.040	.010
N21581B	3973	PRE UNLD	BTB	0731	0801	-.822	.038	-1.315	.059
N281389B	11988	REGULAR	BTB	0806	0807	-.025	.019	-.032	.020
L01034A	1039	UNLEADED	RT	0709	0812	.013	.014	-.005	.009
L01036B	2005	DIESEL	RT	0712	0826	-.055	.049	-.009	.008
L01037A	4013	SUP UNLD	RT	0724	0828	.019	.013	-.028	.022
L01037B	4013	REGULAR	RT	0724	0828	.036	.016	.017	.012
L02068A	3989	REGULAR	RT	0809	0810	.039	.014	-.019	.012
G03018A	3010	DIESEL #1	RT	0731	0827	-.194	.01	-.226	.005
G03018B	3010	REGULAR	RT	0731	0827	.060	.009	-.005	.009
L03095A	6049	DIESEL	RT	0802	0826	-.036	.011	-.117	.006
L03095B	6048	DIESEL	RT	0802	0826	-.032	.013	-.047	.007
G06013A	6018	REGULAR	RT	0724	0828	-.153	.018	-.097	.016
G06013B	6018	DIESEL	RT	0724	0828	-.089	.011	-.325	.017
G06028A	2964	REGULAR	RT	0721	0829	.053	.016	.049	.008
G06028B	2964	DIESEL	RT	0721	0829	-.708	.018	-.613	.015
G07010A	277	DIESEL	RT	0628	0826	-.007	.054	-.001	.009
G07010B	566	REGULAR	RT	0628	0826	-.005	.027	-.017	.012
G10020T1	10155	REGULAR	RT	0625	0816	1.189	.322	.175	.022
G10020T2	10155	UNLEADED	RT	0626	0816	.584	.028	.109	.018
N141107A	1035	GASOHOL	RT	0817	0831	.006	.007	-.013	.010
N141107B	1033	DIESEL	RT	0817	0831	-.327	.010	-.377	.027
N151141A	10576	DIESEL	RT	0817	0824	-.621	.023	-.411	.015
N151141C	21154	DIESEL #1	RT	0817	0824	-.129	.008	-.009	.008
G16005AR	1003	UNLEADED	RT	0722	0828	-.006	.021	.025	.011
G16005BR	295	REGULAR	RT	0722	0828	.046	.015	.022	.011
L16394A	1023	REGULAR	RT	0728	0831	-.021	.012	-.030	.008
L16394B	1039	UNLEADED	RT	0728	0831	.018	.012	.011	.014
N171261G	576	DIESEL	RT	0804	0810	-.014	.007	-.010	.004
N181323C	1005	UNLEADED	RT	0721	0825	.025	.04	-.013	.008
N181323D	1005	REGULAR	RT	0721	0825	.034	.013	-.015	.008
N181326B	1033	UNLEADED	RT	0722	0829	-.076	.018	-.032	.007
G19068A	1005	REGULAR	RT	0715	0828	-.614	.014	-.559	.018
G19068B	4032	DIESEL	RT	0715	0828	.070	.008	-.002	.011
G19068C	1038	UNLEADED	RT	0715	0828	-.068	.014	-.076	.011
G19101A	566	DIESEL	RT	0712	0827	-.078	.02	-.100	.008
N19525A1	8060	UNLEADED	RT	0710	0822	.032	.05	.044	.030
N34128A	6262	SUP UNLD	RT	0617	0828	-.034	.009	.044	.003
N34128B	8000	UNLEADED	RT	0615	0828	-.080	.03	-.053	.014

Table D-2. Simulated Leak Summary

Survey ID	Test Date	Volume	Fuel Type	Bckgrd LR	SE	Obsrvd LR	SE	Simltd LR	Diff= Obs-Back	Sim-Diff
L01036A	0712	10154	UNLEADED	0.002	0.055	-.095	0.011	-.101	-.097	-.004
L05131B	0718	5955	REGULAR	-.082	0.200	-.055	0.012	-.049	0.027	-.076
N141107BL	0831	1036	DIESEL	-.377	0.027	-.200	0.008	-.059	0.177	-.236
N161191B	0731	10575	AV JET	-.485	0.010	-1.455	0.030	-.875	-.970	0.095
N181317A	0806	565	REGULAR	0.021	0.031	-.067	0.017	-.048	-.088	0.040
N181317A1	0806	565	REGULAR	0.021	0.031	-.084	0.019	-.113	-.105	-.008
N181326B	0829	1033	UNLEADED	-.032	0.007	-.184	0.006	-.154	-.152	-.002
G19068A	0828	4033	DIESEL	-.002	0.011	-.044	0.007	-.037	-.042	0.005
G19101A	0827	566	DIESEL	-.100	0.008	-.096	0.003	-.056	0.004	-.060
N19525A1	0710	4032	UNLEADED	0.032	0.050	-.079	0.020	-.059	-.111	0.052
N261347A	0820	10146	DIESEL	-.005	0.025	-.016	0.033	-.051	-.011	-.040
F271172A	0813	1037	REGULAR	0.019	0.012	-.070	0.019	-.090	-.089	-.001
N271375B	0817	1039	UNLEADED	0.017	0.010	-.094	0.012	-.115	-.111	-.004

Table D-3. Retest results

Type	Mean difference (gallons per hour)	N	Variance $(gph)^2$	Mean squared error $(gph)^2$	Standard deviation (gph)	Root mean squared error (gph)
Leak simulation	-0.00891	11	0.00066(1)	0.00074	0.0257(1)	0.0272
Back to back	0.00629	14	0.00053(1)	0.00057	0.0231(1)	0.0239
Retests	0.00297	34	0.00254(2)	0.00255	0.0504(2)	0.0505

(1) For the leak simulation and back to back retests, the variance of the simulated minus the differenced observed rates and the initial minus the retest rates is an estimate of twice the underlying within-test variance plus any variance due to testing at successive 2 hour periods. The corresponding estimated variance is reported here.

(2) For complete retests, the variance of the initial rates minus the retest rates estimates twice the total variance (within- and between-tests). The corresponding estimated total variance is estimated here.

simulation allows for an estimate of the accuracy of the test as well as its precision. The accuracy refers to the ability of the test to measure a known volume change, while the precision of the test refers to its ability to reproduce measured rates.

Thirteen leak simulation tests were conducted. Two of these were conducted on tanks that had estimated volume rates that indicated that the tanks were probably leaking. These tests were excluded from the analysis because variability is known to increase for leaking tanks. The results from all of the leak simulation tests are tabulated in Table D-2. Using the leak simulation results from the tanks with small estimated volume changes (less than 0.1 gallons per hour in absolute value) gave the following results.

Three rates were calculated from leak simulations. The first was a baseline rate for the tank. This was estimated during the regular tank test. While the leak simulation was conducted, a measured rate was estimated. This is the rate observed by the testing method during leak simulation. It is presumed to be composed of the tank rate plus the simulated rate. The simulated rate is calculated by collecting product drawn from the tank at a constant rate, weighing it on a triple beam balance, and converting the weight to volume at the temperature of the product in the tank. The difference between the observed rate during the simulation and the baseline rate provides an estimate of the simulated rate. The difference between this and the actual simulated rate can be used to assess the accuracy of the test.

The average difference between the measured rate and the simulated rate was -0.00891 gallons per hour, based on the 11 leak simulations where the tank was not estimated to be leaking. If the other two simulations are included, this mean difference increases to -0.0184 gallons per hour. The difference between the measured rate and the simulated rate is interpreted as an estimate of bias. The variance of the differences about their mean provides an estimate of twice the within-test precision plus any variance due to taking successive 2 hour test periods. Taking half the variance of differences estimates the variance itself. The estimate was 0.00066 gallons per hour squared for the 11 tests. (It was larger, 0.00291 gallons per hour, if all 13 tests were used.) A mean squared error (MSE) can be calculated to incorporate both types of error--accuracy and precision. The mean squared error is the sum of the bias squared plus the within-test variance. In this case it was 0.00o74 gallons per hour squared (or 0.00325 gallons per hour squared for all 13 tests).

The bias is clearly not significant, in that it does not differ significantly from zero (t = -0.347, 10 degrees of freedom). As a result, the variance and the mean squared error are nearly identical. A measure of variation often used is the standard deviation (or root mean squared error if bias is present), which is the square root of the variance (or MSE). This measure has the advantage that its units are the same as the measurement, gallons per hour. The standard deviation was estimated to be 0.0257 gallons per hour for these data.

B. Back to Back Retests

Back to back retests were conducted on a total of 18 tanks, which includes the 13 tanks with leak simulations. Five tanks had back to back retests without leak simulation. The purpose of the back to back retests was to estimate the stability of the test method. That is, to ensure that the volume change estimate did not differ markedly if based on the succeeding 2 hours after the test.

As with all of these tests, variability is expected to be larger if the initial leak rate or volume change is larger. For this reason, the results of the back to back retests are presented primarily for those tests with volume change rates less than 0.1 gallons per hour in absolute value. Retest results for tanks with larger volume rates were more variable but generally consistent.

The average difference between the original and retest for the 14 tests with small volume changes was 0.00629 gallons per hour. The estimate of within-test plus change over 2 hour periods variance was 0.00053 gallons per hour squared, giving a mean squared error of 0.00057 gallons per hour squared. The corresponding standard deviation was 0.0231 gallons per hour and the root mean squared error estimate was 0.0239 gallons per hour. The mean difference was not significantly different from zero (t = 0.272, 13 df).

If all 18 back to back retests are used, the estimates are slightly larger. The mean difference was -0.0134 gallons per hour, with the variance and MSE being 0.00893 and 0.00910 gallons per hour squared, respectively. The mean difference did not differ significantly from zero (t = -0.14, 17 df).

C. Complete Retests

The complete retests consist of revisits to the site on a different day. Typically this includes a different crew and involves rescheduling and refilling the tank. The complete retests incorporate all of the features of a tank test and so include all the sources of error including potential difference from crew to crew and differences due to weather conditions, nearby traffic flow, day of the week, etc. In addition, there is a possibility that the tank is different at the time of the retest. In fact, two of the retests originally scheduled were cancelled when it was found that the tanks had been repaired between the initial test and the scheduled retest. In addition, two retests were performed and it was then discovered that the tanks had been repaired between the initial test and retest. These data are also not included, as they would measure an additional source of variation which is not of interest, i.e., repair. Two other retests were performed on tanks that were initially determined to have large vapor pockets. These two tanks were retested later and on retesting were again found to have large vapor pockets. The results of the test and retest for these tanks with vapor problems agreed qualitatively; however, the numerical agreement was not close. The reason for this may be that the vapor pocket trapped in the tank was of different size. There were also different ambient conditions that would affect the vapor differently. For these reasons, the vapor retests were not included in the estimate of the variance from the retests.

The mean difference from the subset of 34 good complete retests was 0.00297 gallons per hour. For complete retests, the variance of the differences between initial and retest rates estimates twice the total variance; that is, the within-test plus between-test components. We report here the corresponding estimated total variance. The estimated total variance was 0.00254 gallons per hour squared, giving a mean squared error of 0.00255 gallons per hour squared. If attention is restricted to initial tests with estimated volume change rates of less than 0.2 gallons per hour in absolute value, the results change slightly. For this set of 30 retests, the mean difference was 0.0137 gallons per hour, while the variance was 0.00181 gallons per hour squared. This resulted in a mean squared error of 0.00200 gallons per hour squared. Neither mean difference is significantly different from zero (t = 0.059, 33 df, t = 0.322, 29 df, respectively). The cases with larger volume change rates were somewhat more variable, however.

As noted above, there were two retests of tanks that had vapor problems. The initial test results showed volume increases of 1.189 gallons per hour and 0.584 gallons per hour, respectively, based on very short test times. The retests based on longer times gave volume increases of 0.175 gallons per hour and 0.109 gallons per hour, respectively, with again the conclusion of a trapped vapor pocket. Both of these retests agreed on the presence of vapor. The difference in apparent volume increase rates may be due to a number of factors. The initial test was terminated quite early. The early termination may have led to variable results. The size of the vapor pocket may have differed between the initial and retest. The changes in conditions--temperature, barometric pressure--that affect the vapor pocket may have differed. All of these could lead to the observed differences in apparent volume increase rates. However, the consistency of the test and retest in identifying the tank as having a problem with trapped vapor suggest that the test method is consistent in identifying problem tanks.

There were two tanks that were retested after the tank was repaired. One of these had an initial leak rate estimated to be -0.057 gallons per hour with a standard error of 0.004 gallons per hour. The rate estimated on the retest was -0.017 gallons per with a standard error of 0.0094 gallons per hour. Although the tank was considered to be leaking by the NFPA Standard 329 and the owner took corrective action, the volume change rate estimated initially was fairly small. The second tank had an initial leak rate estimated as -0.137 gallons per hour with a standard error of 0.009 gallons per hour. On the retest, the estimated volume change was -0.132 gallons per hour with a standard error of 0.007 gallons per hour. Little change was observed. However, on the retest, the testing company certified the tank as tight based on the last hour of data, where they estimated a rate of -0.044 gallons per hour. The data from this test showed little difference from the initial test. Except for the known fact that some repairs were done to the tank, there would be no reason to exclude it from the retest data. Even the former retest would not be viewed as suspect from the change in estimated leak rates.

The retest data analysis showed no evidence of bias in the test methods. Both the back to back retest and the leak simulations estimated within-test (plus variation from one 2 hour period to the next) standard deviations on the order of 0.025 gallons per hour. The complete retest data gave a total standard deviation estimate of 0.05 gallons per hour.

V. ESTIMATION OF TOTAL VARIANCE

The various types of retests offered not only a means of estimating both within- and between-test variation, but also evidence that the between-test variation is sizeable compared to the observed variance of a single test result. In order to use a statistical hypothesis testing approach to determine whether the observed leak rate in a given test is evidence of a leak rather than due to measurement fluctuation, the total variance must be estimated for each test. This was done by estimating the between-test variation from all the data taken together and adding this to the estimate of within-test variance generated by the data from each test. The within-test standard error was squared, the overall between-test variance added, and the square root of the sum was taken as the estimate of total standard error used in the leak status decision process.

Two sources of information were used to estimate the between-test variance. The two sources agreed fairly well, which served as a validity check on the results. The two estimates were then averaged (using relative weights based on the number of cases each estimate was based on) to form the needed estimate of between-test variance. Table D-4 summarizes this process.

The complete retests provided one data base from which to estimate between-test variance. For a retested tank i, let k index the test (1 or 2) and j index the 5-minute volume change measurement for a given test. Then a given 5-minute volume change measurement, x_{ikj}, can be written:

$$x_{ikj} = L_i + d_{ik} + e_{ikj} \qquad \text{[Equation D-1]}$$

where

L_i = tank i's true leak rate under test conditions;

d_{ik} = random measurement error of L_i due to differences from one test occasion to another; and

e_{ikj} = random measurement error of the individual 5-minute volume change measurement for this test.

Since the various quality assurance double-testing methods showed no evidence of bias, it is reasonable to assume that

$$E(e_{ikj}) = 0$$
$$E(d_{ik}) = 0.$$

Table D-4. Estimates of between-test variance (based on observed volume change rates not adjusted for test pressure)

Data Base	N	Estimated total variance (gph)	Estimated within-test variance (gph)^2	Estimated between-test variance (gph)^2	Estimated total standard error (gph)
Complete retest	34	0.00254	0.00033	0.00222	0.0504
Tank tests with measured volume change between 0.0 and 0.2 gph	133	0.00267	0.00073	0.00193	0.0517
Combined estimate	167	0.00264	0.00065	0.00199	0.0514

We also assume that

$$E(d_{i1}d_{i2}) = 0,$$
$$E(\bar{e}_{i1}\bar{e}_{i2}) = 0,$$
$$E(d_{ik}\bar{e}_{ik}) = 0,$$

and that the d_{ik} and e_{ikj} each have a constant variance, denoted as

$$\sigma_b^2 = \text{between-test variance} = E(d_{ik}{}^2)$$

and

$$\sigma_w^2 = \text{within-test variance} = E(\bar{e}_{ik}{}^2),$$

where the mean of the e_{ikj} is taken over all measurements for the k-th test of the i-th tank, usually 24.

Starting with Equation D-1, an estimate of total variance can be based on the two estimated leak rates, $\bar{x}_{i1}$ (the initial rate) and $\bar{x}_{i2}$ (the retest rate) as follows:

$$E(\bar{x}_{i1} - \bar{x}_{i2})^2$$
$$= E(d_{i1} + \bar{e}_{i1} - d_{i2} - \bar{e}_{i2})^2$$
$$= E(d_{i1} - d_{i2})^2 + E(\bar{e}_{i1} - \bar{e}_{i2})^2$$

because the d_{ik} and e_{ikj} are independent. This, in turn, equals:

$$2\sigma_b^2 + 2\sigma_w^2.$$

Thus

$$E((1/2)(1/n)\sum_{i=1}^{n}(\bar{x}_{i1} - \bar{x}_{i2})^2) = \sigma_b^2 + \sigma_w^2.$$

and

$$E((1/((2)\cdot(n)))\sum_{i=1}^{n}\ \sum_{k=1}^{2} s_{ik}^2) = \sigma_w^2$$

where

$$s_{ik}^2 = 1/(n_i(n_i-1))\sum_{i=1}^{n_i}(\bar{x}_{ik} - x_{ikj})^2.$$

Therefore, letting

$$s_{b,\text{retest}}^2 = (1/2)(1/n)\left\{\sum_{i=1}^{n}(\bar{x}_{i1} - \bar{x}_{i2})^2 - \sum_{i=1}^{n}\ \sum_{k=1}^{2} s_{ik}^2\right\} \qquad \text{[Equation D-2]}$$

we have

$$E(s_{b,\text{retest}}^2) = \sigma_b^2.$$

The 34 retest leak rates and their within-test standard errors were used in Equation D-2 to compute an estimate of σ_b^2 based on the retest results.

Tests on tanks which can be assumed not to be leaking provide a second estimate of σ^2. Here, the true leak rate is zero, and we have

$$x_{ij} = d_i + e_{ij} \qquad \text{[Equation D-3]}$$

with assumptions on d_i and e_{ij} as stated above. (We suppress k since only one test was done on these tanks.) In this case we have

$$E(\bar{x}_i{}^2) = \sigma_b^2 + \sigma_w^2$$

and

$$S^2_{b,\text{tight tanks}} = 1/n\left\{\sum_{i=1}^{n} \bar{X}_i^2 - \sum_{i=1}^{n} S_i^2\right\} \qquad \text{[Equation D-4]}$$

Clearly

$$E(S^2_{b,\text{tight tanks}}) = \sigma_b^2.$$

Defining tanks which can be assumed not to be leaking requires some decision-making. By limiting this group to tanks with measured average volume change between 0.0 and 0.2 gallons per hour, the tanks which may be leaking (negative measured volume change) are eliminated as are the test results which are likely due to vapor pockets (high positive measured inflow).

The results of applying Equation D-3 to the 34 retests and Equation D-4 to the 133 measured volume changes between 0.0 and 0.2 gallons per hour are shown in Table D-4. It can be seen that the two approaches yield similar estimates and in particular indicate the importance of the between-test component of the total variation in $\bar{x}_i$. It should be noted that these figures are all as <u>measured</u>, and <u>not</u> as adjusted for test pressure. The adjustment deflates the measured leak rate by about half (the factors range from 0.395 to .608), but is applicable only to actual leaks, since it adjusts the rate from test pressure to an assumed operating pressure.

To get one estimate of between-test variance to use in adjusting within-test standard error up to total standard error, the two estimates described above were averaged with relative weights based on the number of cases each was based on:

$$34/167\ (0.00222) + 133/167\ (0.00193) = 0.00199$$

Thus, to estimate the total standard error for a given observed leak rate, 0.00199 was added to the reported (within-test) standard error squared, and the square root taken. This total standard error was used in the statistical hypothesis test method for determining leak status described in Section 8 of this report.

VI. DETERMINATION OF LEAK STATUS

The physical tightness test for each tank system provided an unbiased estimate of volume change rate and an estimate of the within-test variability of that rate. The complete retest data provided an estimate of the between-test variability of the measured rates. However, the test itself did not provide a definitive leak status determination, that is, an unequivocal "yes" or "no" to the questions "Is this tank tight?" or "Is this tank leaking?" In order to estimate the number of tanks in the country that are leaking and to look at the subset of leaking tanks to investigate factors associated with leaking, such a determination must be made (or the test result ruled inconclusive) for each tested tank system. Two approaches were considered for making this determination: a cut-off rule, comparing the observed volume change rate to a pre-determined cut-off; or declaring a system leaking or not by a hypothesis testing approach. The latter approach was chosen for the study determination of leak status. Two drawbacks of the cut-off approach were that there was no scientific basis for establishing a specific level for the cut-off at the time of the survey, and that it did not take into account the differences in precision achieved by the individual tests.

The null hypothesis to be tested in determining leak status is:

$$H_o : L_i = 0$$

where L_i is the true leak rate of the tank. The alternative is

$$H_A : L_i > 0.$$

As shown in Part V, above, we model the test result, $\bar{x}_i$, as having a total variance composed of a within-test and between-test component. This total variance is estimated as

$$S_t^2 = s_{wi}^2 + s_b^2$$

where the first term is the within-test variance measured from the i-th tank test data and the second term was estimated as described above (Part V). The test statistic is therefore

$$Z = \bar{x}_i/S_t$$

and is compared to one-tailed tables of the Normal distribution to determine whether H_0 can be rejected at a certain level of significance. If H_0 is rejected, we say the tank system is judged to be leaking.

Several significance levels were examined, as was the trade-off between significance and power. The power was estimated for a specific leak rate after adjusting the leak rates and their associated standard errors for test pressure (see Part VII, below, for this adjustment procedure). A significance level of $\alpha = 0.05$ was used for the survey determination of leak status.

VII. ADJUSTMENT OF TEST LEAK RATES

The Petro-Tite test places increased hydrostatic pressure on the tank system for the test. As a consequence of this, any leak or flow through an orifice in the tank will be increased over what would occur under the (smaller) pressure encountered in operation. Similarly, the line test places a higher pressure on the delivery line and so the leak rates estimated under the test will be higher than what would occur in operation.

For systems, tanks, or lines that are determined to be leaking, it is useful to adjust the leak rates estimated under the test conditions to a standard set of operating conditions. It should be noted that the basis for the adjustment is the assumption that the leak is a flow of a liquid through an orifice or hole. Such flows are more rapid under higher pressure than under low pressure. However, if there is no orifice, no flow would occur under high or low pressure. Thus, it is not logically consistent to adjust test volume change rates for pressure in the event that the system was judged to be tight.

The adjustments are based on Bernoulli's law. More specifically, adjustments are based on Torricelli's form of the Bernoulli equation. In order for the adjustments to be reasonable, the assumptions for these physical laws must hold. It should be noted that the assumptions for Torricelli's and Bernoulli's law assume that the flow is through an orifice with neither resistance nor turbulence. In practice, this is not the case. While the flow rate will be generally small enough so that the assumption of a turbulence is reasonable, and so that the head change is slow enough to be neglected, in most cases, leaks will probably be through corroded sections and will be into soil which may present some resistance. The effect of resistance would be to lower the flow rate. However, how much the flow rate would be lowered under the different pressures is not known. Consequently, the effect of violation of these assumptions on the adjustment to the leak rates is not known. It is assumed to be negligible. There are some other, implicit assumptions. These include that the orifice is constant, that the temperature and density do not change, and that the product is not viscous.

Torricelli's form of Bernoulli's law can be used to calculate adjustments to the flow rates. In order to do this, several assumptions must be made. The set of assumptions used in these calculations is detailed below. A step by step procedure for the adjustments is given first. These are the adjustments to be made in the ideal situation where the tank system leak was quantifiable and a valid line test with quantifiable leak rate was done. In our data base, among tank systems judged to be leaking with quantifiable leak rates, only 39 percent had valid line test leak rates. Since the majority of cases had no valid line data and the separate analysis described in Section 8 of the report showed that line leaks accounted for a very small proportion of system leaks when they were done, leak status and leak rate as reported in the Major Findings are based on measured tank system leak rates adjusted directly to operating conditions, without adjusting for line test results. We present the line test adjustment procedure since it was used for the analysis in Part V of Section 8 and for future use in analyzing data collected in the national survey.

A. Adjusting the Line Leak Rate to the System Leak Rate

Since the line test is conducted at higher pressure than the system test, the leak rates estimated from the line test are not directly comparable to those estimated from the system test. This adjustment accounts for the difference in pressure and adjusts the line test rates to be comparable with the system test rates. These adjustments are calculated differently for pressure systems and suction systems and for gasoline and diesel fuels.

The assumptions made for this adjustment are the following. These are in addition to the assumptions needed for the use of Bernoulli's equation to adjust the flow rates.

- The orifice where the leak (if any) occurs is where the line joins the top of the tank.
- The tank is assumed to be buried to a depth of 3 feet to the top of the tank.
- The water table is assumed below the bottom of the tank.
- Three tank diameters are assumed: 48 inches, 64 inches, and 96 inches.

Table D-5 gives the adjustment factors to adjust the rates estimated from the line test to the conditions assumed for the system test. The factors as presented are multiplicative. To convert a rate estimated from the line test to the equivalent system rate, multiply the estimated line rate by the factor in the table.

The difference by type of delivery system results from the fact that the line test is conducted at 15 PSIG for suction lines and at 50 PSIG for pressure lines.

B. Subtracting Line Rates From System Rates When Valid Line Results are Present

After adjusting the line test results by the factors in Table D-5, the line test rates would be comparable to the system test results. The line test rates could be subtracted to obtain an approximate tank rate. This is the rate for the tank system excluding delivery lines, but still including any other plumbing such as fill pipes, vent pipes, etc.

If a system has more than one delivery line, each line test rate would be adjusted, then all line test rates subtracted from the system rate. For the tank systems for which the line was found to be untestable, the line rate cannot be separated from the system rate.

Table D-5. Adjustment factors for line test rates

Tank diameter	Suction	Pressure
48 inches (0 - 1,000 gallons)	0.431	0.236
64 inches (1,101 - 7,000 gallons)	0.395	0.216
96 inches (7,001 - 15,000 gallons)	0.317	0.174

C. Adjusting the Tank Rate (or System Rate) to Assumed Operating Rate

Since the test is conducted at elevated pressure, flow rates through any orifices will be larger under the test conditions than they would be under actual tank operation. The magnitude of the difference depends on a large number of variables. In particular, flow rates would vary by location of the hole in the tank (distance from the bottom), amount of fuel in the tank, and pressure of a water table part way up on the tank. The adjustment factors would also vary with diameter of the tank. Since diesel tanks were tested at the same pressure (hence at a lower head-distance) as gasoline tanks, the adjustment also varies with fuel type because of the density difference.

The standard assumptions for calculating the adjustment factors presented in Table D-6 are as follows. These are in addition to the basic assumptions of Bernoulli's law.

- The water table is assumed to be below the bottom of the tank.
- The tank is assumed to be buried to the depth of 3 feet from grade to top of tank.
- Three tank diameters are assumed (48, 64, and 96 inches).
- The average operating level of the tank is assumed to be half full.
- The orifice or hole is assumed to be in the bottom of the tank.

Table D-6 then gives adjustment factors to adjust the estimated tank system leak rate to the assumed standard set of operating conditions. The factors should be multiplied by the leak rate estimated under the system test to obtain the adjusted

Table D-6. Adjustment factors for tank (system) rates*

	Adjustment factor	
Tank diameter	Gasoline	Diesel
48 inches (0 - 1,000 gallons)	0.395	0.430
64 inches (1,101 - 7,000 gallons)	0.456	0.496
96 inches (7,001 - 15,000 gallons)	0.558	0.608

*If a standard height had been used for both fuels, the gasoline column would apply to both.

leak rate. Note that this adjustment can be done to the system test leak rate, or to the leak rate remaining after any relevant line leak rates have been adjusted to test conditions and subtracted off.

Multiplying the rates estimated under the system test by the adjustment factors given in Table D-6 will give adjusted rates for the assumed standard set of operating conditions described in the assumptions above.

APPENDIX E

INVENTORY RECONCILIATION METHODS

I. EPA INVENTORY RECONCILIATION METHOD

EPA has developed a simple method[1] for monitoring underground motor fuel storage tank inventory records to detect a systematic deficit which may be attributable to a leak. The method is based on counts of the number of daily underages found in the inventory record and is simple enough to be implemented by a tank operator without excessive calculation or burdensome record-keeping. As originally formulated, the method is intended for application as the "first line of defense against leaks" in an on-going monitoring program. Thus, the approach is sequential in nature and involves making a decision on the presence or absence of an inventory deficit at the end of each 30-business-day period, based on a comparison between the cumulative count of daily underages and certain statistically-derived "action numbers"[1]. A cumulative number of underages in excess of the appropriate action number was to be interpreted as evidence of a deficit. The statistical model and calculations underlying the method were detailed in the report from Battelle Columbus Laboratories to EPA[2]. The basic method required modification for application to the inventory data collected in the survey because each sampled facility provided only a single, one-time record of

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[1] U.S. EPA, Office of Toxic Substances, "More About Leaking Underground Storage Tanks: A Background Booklet for the Chemical Advisory," (October 1984).

[2] David C. Cox, "Performance of the Chemical Advisory Inventory Analysis Method Under Various Scenarios," Report from Battelle Columbus Laboratories to EPA under contract No. 68-01-6721 (April 1984).

30 days' inventory for analysis. The purpose of this section is to describe the statistical model on which the modified EPA method is based.

The decision rule for the proposed method will be defined by considering a well-run station where the only sources of discrepancy in the inventory records are (i) a daily leak of magnitude L and (ii) unavoidable random error in the daily stick measurement of the tank. Successive daily errors are assumed independent and identically normally distributed with mean zero; this assumption is supported by the research of Warren Rogers[3,4]. Hence, we can write:

$$X_i = x_i + e_i$$

where X_i is the i^{th} daily stick measurement, x_i is the true quantity of gasoline in the tank at the close of the i^{th} day, and $e_i \sim N(0, \sigma^2)$ is the stick measurement error. Now consider a period of n days, assuming for simplicity that the station is open every day. The process of balancing inventory at the end of each day, as described in the literature[5] and assuming that there is no metering error at the pump[6], leads to a set of daily variances (discrepancies),

$$d_i = -L + e_i - e_{i-1}, \ i = 1, \ldots n.$$

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[3] "Inventory Reconciliation system," Warren Rogers Associates.

[4] Warren Rogers, personal communication.

[5] American Petroleum Institute: "Recording Practices for Bulk Liquid Stock Control at Retail Outlets," (1977).

[6] Metering error, if present, can be estimated and removed from the record, see American Petroleum Institute, "Recommended Practice for Bulk Liquid Stock Control at Retail Outlets," (1977).

Let N be the total number of negative daily variances,

$$N = \#\{i \mid 1 \le i \le n,\ d_i < 0\}.$$

Clearly, large values of N suggest that there is a leak, i.e., L > 0. The exact probability distribution of N is, in general, very difficult to derive. However, of the special case of no leak, i.e., L = 0, the calculation has been carried out[7]. Table E-1 shows the distribution for the case n = 30 of most interest. In general, we must rely on a normal approximation to the distribution. This is derived as follows. We first find the mean E(N) and variance V(N) as follows. Define:

$$p = \Pr(d_i < 0)$$

$$p_1 = \Pr(d_i < 0,\ d_{i+1} < 0)$$

$$I_i = \begin{array}{l} 1\ ,\ \text{if } d_i < 0 \\ 0\ ,\ \text{else} \end{array}$$

Then $E(I_i) = p$, $E(I_iI_j) = p^2$ if $|j-i| > 1$ (because then I_i, I_j are independent), $E(I_iI_{i+1}) = p_1$. Thus

$$E(N) = E(\sum_{i=1}^{n} I_i) = np. \text{ Also,}$$

$$E(N^2) = E(\sum_{i=1}^{n} I_i^2 + 2\sum_{i<j} I_iI_j)$$

$$= E(\sum_{i=1}^{n} I_i^2 + 2\sum_{i=1}^{n-1} I_iI_{i+1} + 2\sum_{i<j-1} I_iI_j)$$

$$= np + 2(n-1)p_1 + [n(n-1) - 2\ (n-1)]p^2$$

Therefore

$$V(N) = E(N^2) - (E(N))^2 \qquad [1]$$

$$= np(1-p) - 2(n-1)(p^2 - p_1)$$

$$\equiv \sigma(L)^2$$

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[7] Warren Rogers, "The Exact Null Distribution of the Number of Negative Daily Variances," Report from Warren Rogers Associates to EPA, (September 1984).

Table E-1. Probability distribution of the number of negative daily variances, N, for the no-leak case, based on 30-day inventory

No. of negative variances	Probability of occurrence
$\leq$ 10	0.0024
11	0.0121
12	0.0456
13	0.1161
14	0.2022
15	0.2432
16	0.2022
17	0.1161
18	0.0456
19	0.0121
$\geq$ 20	0.0024

We approximate N by a normal distribution with mean np +0.5 and variance $\sigma(L)^2$. The mean is taken as np +0.5 to provide an approximate continuity correction for use in the upper tail of the distribution, in which our greatest interest lies.

To check the accuracy of the approximation, consider the case L = 0. Then,

$$\begin{aligned} p_i &= P_r(_i < o,\ d_i + 1 < o) = P_r(e_i < e_{i-1},\ e_{i+1} < e_i) \\ &= P_r(e_i + 1 < e_i < e_{i-1}) \\ &= 1/6 \end{aligned}$$

since all six orderings of e_{i-1}, e_i, $e_i + 1$ are equally likely. Thus, from Equation [1],

$$\sigma(L)^2 = n/4 - 2(n-1)/12 = (n+2)/12$$

Setting n = 30 we have the approximation,

$$N \sim N(15.5,\ 2.67)$$

Table E-2. shows the accuracy of the approximation.

Table E-2. Accuracy of normal approximation to distribution of N for the case L = 0 (no leak)

n	$P_r(N \geq n)$ (exact)	$P_r(N \geq n)$ (approximate)
15	0.6216	0.6217
16	0.3784	0.3783
17	0.1762	0.1788
18	0.0601	0.0630
19	0.0145	0.0162
20	0.0024	0.0029

Clearly the approximation is sufficiently accurate over the range of n reported. For $L \neq 0$, the exact distribution of N has not been derived. We will rely on the normal approximation in such cases. The mean and standard deviation of the approximating distribution have been calculated and are shown in Table E-3.

Table E-3. Mean and standard deviation of normal approximation to the distribution of N, the number of negative daily variances, for various values of the daily leak rate L, for a 30-day inventory

L (gallons)	Mean	Standard deviation
2	16.46	1.636
3	16.93	1.641
4	17.41	1.647
5	17.88	1.654
6	18.34	1.665
7	18.81	1.678
8	19.27	1.684
9	19.72	1.699
10	20.16	1.707

The final feature for which we must account before we can determine the decision rule is round-off error. In practice, inventory values are typically reported to the nearest gallon so that an exact inventory balance, i.e., a zero variance, can occur due to round-off. This is fairly common in actual inventory data. We will assume that a zero variance is reported if the actual variance is less than 0.5 gallons in absolute value. Thus, a negative variance is reported only if the actual variance is less than -0.5 gallons. Let N* be the number of negative variances actually reported and assume $\sigma\sqrt{2} = 25$ gallons. Then the distribution of N* should be approximated by a normal distribution with mean and standard deviation shown in Table E-4.

Table E-4. Mean and standard deviation of normal approximation to the distribution of N*, the number of negative daily variances accounting for round-off error, for various values of the leak rate L, for a 30-day inventory

L (gallons)	Mean	Standard deviation
0	15.26	1.633
1	15.74	1.634
2	16.22	1.635
3	16.69	1.638
4	17.17	1.644
5	17.64	1.650
6	18.11	1.660
7	18.58	1.672
8	19.04	1.681
9	19.49	1.687
10	19.94	1.703

Now suppose we have 30 days' inventory and there is <u>no leak</u>. Using the approximating distribution from Table E-4 the number of daily variances observed should have the distribution shown in Table E-5.

Table E-5. Probability distribution of the number of negative daily variances, N*, observed when <u>no leak is present</u>

n = number of negative variances	$(P_r(N^* \geq n)$
15	0.564
16	0.326
17	0.142
18	0.047
19	0.011
20	0.002

Thus, if we make 18 or more negatives our criterion for deciding that a deficit is present, there is approximately a five percent false-positive rate. That is, a tank with no leak and no source of error in inventory other than random measurement error due to sticking has approximately a five percent chance of being erroneously classified as a leaker. Note that false-positives due to other factors such as theft are not accounted for here. The detection capability of this version of the EPA inventory analysis method can now be calculated using the values given in Table E-4. Results are shown in Table E-6.

Table E-6. Probability of detection of leaks of various sizes using the modified EPA inventory method based on 30 days' data

Actual leak		Detection probability
Gallons/day	Gallons/hour	
1	.04	0.08
2	.08	0.14
3	.12	0.21
4	.17	0.31
5	.21	0.41
6	.25	0.53
7	.29	0.64
8	.33	0.73
9	.37	0.81
10	.42	0.87

Thus, leaks of at least nine gallons per day or more have better than 80 percent chance of detection. It should be noted that the detection capability of the simple inventory method based on only 30 days' data would be expected to be poor. The method was designed, as explained previously, for use as a tool for on-going monitoring programs.

II. WARREN ROGERS ASSOCIATES' INVENTORY RECONCILIATION METHOD

Warren Rogers Associates (WRA) has developed a computerized system for analyzing daily inventory data from underground storage tanks in order to identify leaks[8]. The details of the method are proprietary. This section provides a brief description of publicly-available information on the model and should not be interpreted as an evaluation or endorsement by EPA.

The WRA system was developed in response to the perceived inadequacy of conventional, routine inventory accounting in detecting small or moderate leaks. Typically, such leaks are masked in the data by a variety of errors. For example, a single delivery error of 300 gallons could mask a 10 gallon-per-day leak based on 30 days' inventory. The purpose of the model is to isolate, identify, and quantify these errors.

Errors accounted for include:

- Delivery errors;
- Unexplained additions;
- Pump meter error;
- Temperature effects;
- Stick error; and
- Tank or line leaks.

Occasionally, other, rarer, errors will appear, e.g., use of an incorrect tank conversion chart, or theft. The data required by the model include only daily stick readings, deliveries, and sales.

---

[8] Warren Rogers Associates, Inc., "Inventory Reconciliation System," (undated).

The basis for the model is that the major errors and discrepancies in the inventory data are very distinct in their characteristics and thus in the way they contribute to the total record. Thus, for example, an unrecorded over-delivery or an unrecorded removal will cause a permanent shift in the record which remains as a fixed component in all future observations. This effect can be estimated and removed from consideration when evaluating the possibility of a continuing day-to-day trend indicative of a leak. By contrast, a large stick error caused by a mistake in reading the stick or conversion chart will typically cause a large discrepancy in that day's inventory which will be followed the next day by a discrepancy of similar size in the opposite direction. The two discrepancies will tend to cancel out in the cumulative inventory record. The "signature" of a pump meter error is different: such an error will induce day-to-day errors of constant sign proportional to the through-put of the tank.

WRA's report to clients includes a record of day-to-day variances and the cumulative variance between book inventory and stick measurement for the period. It also provides:

- Over- or under-deliveries by date of occurrence and amount. That is, the discrepancy between the amount of product actually delivered as opposed to the amount reported;
- Unexplained one-time gains or losses also by date and amount;
- Meter errors at the pump;
- Trends which are indicative of either a tank or line leak; and
- Effects of possible disparities between the ambient air temperature and underground temperature.

As a special contribution to this study, WRA also provided a "data quality code" based on professional interpretation and experience. The data quality code is explained in Table E-7. A sample WRA inventory report is shown in Figure E-1. Based on a discussion with the developers of the WRA model, the false-positive rate is five percent, comparable to the modified EPA method.

Table E-7. WRA data quality code

Category	Definition
1	Confident of the result
2	The trend could have been delivery-induced
3	The trend is noisy but believable
4	No confidence in the trend due to the data
5	Data is questionable and requires further investigation.

III. ENTROPY LIMITED INVENTORY RECONCILIATION SYSTEM

Entropy Limited has developed the Precision Tank Inventory Control (PTIC) system[9]. The analysis is based on principles similar to the WRA system and accounts for the same types of errors and discrepancies. Entropy appears to consider thermal effects and vapor losses more comprehensively than does WRA. However, additional input data to the system is required for these analyses.

---

[9] Entropy Limited, "Precision Tank Inventory Control," (1984).

```
                     WARREN ROGERS ASSOCIATES, INC                     PAGE   1
                         65 BELLEVUE AVENUE
                         NEWPORT, RI  02840
                           (401) 846-4747                             10/27/85

                         INVENTORY ANALYSIS
                         ------------------

TANK ID :   1
PRODUCT :  UNLEADED

TANK SIZE:        10000

MONTH   DAY   SALES   DELIVERIES    STICK     BOOK   DAILY VARIANCE   CUM. VARIANCE
  4      3    1150.        0.       2926.    2901.          25.              25.
  4      4    1163.        0.       1733.    1738.         -30.              -5.
  4      5     628.        0.       1098.    1110.          -7.             -12.
  4      6    1444.     4100.       3759.    3766.           5.              -7.
  4      7     902.        0.       2864.    2864.           7.               0.
  4      8     466.        0.       2373.    2398.         -25.             -25.
  4      9    1055.        0.       1301.    1343.         -17.             -42.
  4     10     856.        0.        437.     487.          -8.             -50.
  4     11     524.     4230.       4152.    4193.           9.             -41.
  4     12    1285.     2060.       4948.    4968.          21.             -20.
  4     13    1195.        0.       3759.    3773.           6.             -14.
  4     14    1158.        0.       2616.    2615.          15.               1.
  4     15     630.     3750.       5744.    5735.           8.               9.
  4     16     921.        0.       4815.    4814.          -8.               1.
  4     17     784.        0.       4021.    4030.         -10.              -9.
  4     18    1453.        0.       2554.    2577.         -14.             -23.
  4     19     532.     5110.       7102.    7155.         -30.             -53.
  4     20    1028.        0.       6073.    6127.          -1.             -54.
  4     21     881.        0.       5214.    5246.          22.             -32.
  4     22     992.        0.       4218.    4254.          -4.             -36.
  4     23     488.        0.       3693.    3766.         -37.             -73.
  4     24    1169.     4100.       6594.    6697.         -30.            -103.
  4     25     528.        0.       6073.    6169.           7.             -96.
  4     26     827.        0.       5214.    5342.         -32.            -128.
  4     27     786.        0.       4416.    4556.         -12.            -140.
  4     28     661.        0.       3759.    3895.           4.            -136.
  4     29     842.     5240.       8125.    8293.         -32.            -168.
  4     30     827.        0.       7289.    7466.          -9.            -177.
  5      1    1401.        0.       5876.    6065.         -12.            -189.
  5      2    1051.        0.       4815.    5014.         -10.            -199.
                  END OF PERIOD CUMULATIVE VARIANCE

                                -199.

                  NUMBER OF NEGATIVE DAILY VARIANCES

                                 19

                       DELIVERY DISCREPANCIES

                        MONTH    DAY      AMOUNT
                          4      12         46.
```

Figure E-1. WRA Inventory Report

```
                 WARREN ROGERS ASSOCIATES, INC
                    65 BELLEVUE AVENUE
                    NEWPORT, RI  02840
                     (401) 846-4747
                                                      10/27/85
                    INVENTORY ANALYSIS
                    ------------------

TANK ID :    1
PRODUCT :   UNLEADED

TANK SIZE          10000

                  MONTH    DAY       AMOUNT
                    4      29          -17.

            UNEXPLAINED ONE TIME GAINS AND LOSSES

                  MONTH    DAY       AMOUNT
                    4      14           39.
                    4      21           19.
                    4      23          -36.
                    4      26          -19.

                     PUMP METER ERROR

                          NONE

                       DAILY TREND

                          -8.37

                   AVERAGE STICK ERROR

                           6.95

                    LARGE STICK ERRORS

                       MONTH    DAY
                         4      19

                 TEMPERATURE DIFFERENTIAL

                            -2.66

                   SIGNIFICANCE OF TREND

                           0.00
```

1

The PTIC system reports its leak findings as an estimated leak rate, in gallons per day, and as a "probability of leak" (see the sample inventory report in Figure E-2). According to the model's developers, the probability of leak is based on a Bayesian-type analysis which accounts for various factors including the quality of the inventory data. Details are proprietary. Typically, the decision rule is phrased in terms of the leakage probability as follows:

Leak probability	Decision
< 10%	Tank is tight
10% - 50%	Inconclusive
≥ 50%	Tank is leaking

The 50 percent cutoff point corresponds to a false-positive rate of approximately two percent. To obtain a more typical five percent false-positive rate, a cutoff of 30 percent leak probability should be used to decide that the tank is leaking.

```
TANK # =  2      STAGE II VAP CONTROL LEVEL (9=NO VAP LOSS) =  1
TANK SIZE =      4000.     3 =REG UNLD; INSTYR=1973

INVENTORY RECORDED GALLONS:    0 = GROSS,   1 = NET
    0  DELIVERIES
    0  STICK INVENTORY
    0  DISPENSED PRODUCT


N.B.!!   STICK-READING AND TOTALIZING OCCURS ON THE MORNING AFTER THE LISTED DATE

  I      DATE  DISPENSED    STORAGE      DELIV    DISCREP
  1    1/ 2/85     147.8     1374.0        0.0        0.0
  2    1/ 3/85     147.8     1221.0        0.0       -5.2
  3    1/ 4/85     180.4      925.0        0.0     -115.6
  4    1/ 5/85     230.8      584.0        0.0     -110.2
  5    1/ 7/85     202.8     1846.0     1100.0      364.8
  6    1/ 8/85     156.4     1766.0        0.0       76.4
  7    1/ 9/85      86.0     1569.0        0.0     -111.0
  8    1/10/85     121.5     1374.0        0.0      -73.5
  9    1/11/85     179.8     1108.0        0.0      -86.2
 10    1/12/85     134.4      925.0        0.0      -48.6
 11    1/14/85     192.9      649.0        0.0      -83.1
 12    1/15/85     230.3      289.0        0.0     -129.7
 13    1/16/85     232.5     1569.0     1100.0      412.5
 14    1/17/85     160.1     1297.0        0.0     -111.9
 15    1/18/85      84.1     1221.0        0.0        8.1
 16    1/19/85     180.8      961.0        0.0      -79.2
 17    1/21/85     174.7      716.0        0.0      -70.3
 18    1/22/85     111.7      521.0        0.0      -83.3
 19    1/23/85     291.5     1687.0     1100.0      357.5
 20    1/24/85     177.5     1451.0        0.0      -58.5
 21    1/25/85     201.5     1145.0        0.0     -104.5
 22    1/26/85     130.2      961.0        0.0      -53.8
 23    1/28/85     181.6      682.0        0.0      -97.4
 24    1/29/85     184.2      429.0        0.0      -68.8
 25    1/30/85     280.9     1530.0     1100.0      281.9
 26    1/31/85     224.5     1297.0        0.0       -8.5
 27    2/ 1/85      46.1     1221.0        0.0      -29.9
 28    2/ 2/85     112.0     1034.0        0.0      -75.0
 29    2/ 3/85     194.5      784.0        0.0      -55.5
 30    2/ 4/85     239.7     2005.0     1100.0      360.7
 31    2/ 5/85     120.5     1806.0        0.0      -78.5

TOTALS
         EVCT  DISPENSED    STORAGE      DELIV    DISCREP
         30.0     5191.7      432.0     5500.0      123.7

DISCREP DISTRIBUTION
  NUMBER OF DAYS WITH (+) DISCREP =   7  ( 23.3%)
  NUMBER OF DAYS WITH (-) DISCREP =  23  ( 76.7%)


DV STATS
DV = DISCREP (GAL) CORRECTED FOR TEMP, VAPOR LOSS AND WATER INFLOW
DV COUNTS =                     30.00000
DV AVG =                         4.00511
DV S.D. (BIASED)'=             164.96200
DV VARIANCE (BIASED) =          27212.47
LAG-1 AUTOCORR =                -0.19435
```

Figure E-2. Entropy Limited Inventory Report

```
DV DISTRIBUTION
  NUMBER OF DAYS WITH (+) DV =   7  ( 23.3%)
  NUMBER OF DAYS WITH (-) DV =  23  ( 76.7%)


DIPSTICK READ ERRORS
   NONE

DELIVERY DISCREPANCIES
   5    1/ 7/85       389.75  =DELIVERY OVER(+) OR UNDER(-)
  13    1/16/85       425.84  =DELIVERY OVER(+) OR UNDER(-)
  19    1/23/85       411.26  =DELIVERY OVER(+) OR UNDER(-)
  25    1/30/85       347.07  =DELIVERY OVER(+) OR UNDER(-)
  30    2/ 4/85       401.91  =DELIVERY OVER(+) OR UNDER(-)

UNEXPLAINED ONE-TIME DISCREPANCY
   NONE
UNMODIFIED DISCREPANCIES
DISCREPANCIES CORRECTED FOR TEMP, VAP, CHART CALIB AND METER ERR


SOURCES OF INVENTORY DISCREPANCIES
                                                  ESTIMATE      UNCER
  1  LEAK RATE (GAL/DAY) =                         53.168     6.578
  2  CALIB CHART ERR (100%*GAL/GAL-THRU) =          3.15      1.51
  3  TOTAL METER ERR (100%*GAL/GAL-THRU) =         00.00     00.00
  4  THERMAL SHRINKAGE LOSS (GAL) =                -9.0      17.3
  5  VAPOR LOSS (GAL) =                             5.5       9.8
  6  NET DELIVERY DISCREPANCY (GAL) =            1975.8      83.6
  7  ONE-TIME UNEXPLAINED GAIN/LOSS (GAL) =         0.0       0.0
  8  WATER INFLOW TO TANK (GAL) =                   0.0       0.0
  9  WATER OUTFLOW FROM TANK (GAL) =                0.0       0.0

RECORDKEEPING FLAGS:
  EXCESSIVE DELIVERY DISCREPANCIES
  EXCESSIVE VARIANCE IN STICK READINGS

PROBABILITY OF TANK LEAKAGE=            100.00%
PROBABLE TANK LEAKAGE
```

APPENDIX F

DATA COLLECTION FORMS AND MATERIALS

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

THE ADMINISTRATOR

OCT 15 1984

OPEN LETTER TO OWNERS AND MANAGERS OF UNDERGROUND MOTOR FUEL STORAGE TANKS

The Environmental Protection Agency (EPA) is conducting a national survey to learn more about the problem of leaking underground motor fuel storage tanks and piping. The purposes of the study are to find out how widespread the leakage problem is, and to collect information on factors that cause tanks to leak. The study will help the Agency assess the impact of leaking tanks on the economy and the environment, and the need for Federal regulations to prevent leaking tanks.

I am writing to personally ask for your participation in this vital project, the results of which could have a major impact as to how we deal with this potential environmental threat.

Let me assure you that EPA is <u>not</u> conducting this survey to locate owners of leaking tanks to take legal action against them. To do so would defeat the purpose of the survey. In the case of leaking tanks, however, EPA will request that the owner report any leak to the proper local authority and take corrective action such as tank repair, replacement or removal from use.

In order to conduct this study, EPA has selected a random sample of about 1,000 establishments nationwide including farms, gasoline service stations, transportation-related businesses, businesses with private gas pumps, and government facilities. The sample of 1,000 establishments was selected to represent as many types of underground storage tank facilities as possible in order to develop national estimates of leakage on a scientific basis. Your establishment is one of the 1,000 selected to participate in this important study.

Within the next 2 weeks, an interviewer from Westat, Inc., a private contractor conducting the survey for EPA, will be contacting you to schedule an appointment for an interview with you at your place of business. A copy of the interview form is enclosed. We would appreciate it if you would take the time to fill out the questionnaire before the interviewer arrives, but do not mail the questionnaire back to EPA. The interviewer will review your answers with you during the visit.

In addition to the interview, the interviewer will be making a sketch map of your facility layout, and will want to know where each of your tanks is located. It would be helpful if you have a map of your tank and dispenser layout ready to show the interviewer.

As part of the survey, we will be asking you to provide product inventory records for a 30-day operating period, so it is necessary that we know the accuracy of your pump readings. If the calibration of your pump (or dispenser) meters has not been checked and certified within the past three months, the interviewer will need to check the meter calibration with a certified 5-gallon metering can.

Your inventory data for each tank system will be analyzed by computer to identify and explain any shortages or overages. Results of the analyses will be provided to you at no cost and will be confidential if you so request. Later, we will want to conduct professional tightness tests on some fraction of the tanks inventoried in the survey. All tests will be provided free to the participant, and, if requested, results will be treated as confidential by the Agency.

The enclosed booklet of General Instructions will provide you with definitions of key terms, answers to questions you might have about the survey, and directions on completing the questionnaire and providing inventory information. If you have any further questions about this questionnaire, or need any other assistance, please call Westat at the toll-free survey assistance number 800/638-8985, and ask for the EPA Specialist.

You may claim confidentiality for all or any part of your response under 40 CFR Part 2. You should do this when you provide the information to the interviewer. A confidentiality request form is included in the instructions booklet.

Although EPA is conducting the survey under Federal authority, we are seeking your full and active participation on a cooperative basis. I hope we can count on your help.

Enclosures

Sincerely,

William D. Ruckelshaus

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U.S. ENVIRONMENTAL PROTECTION AGENCY
UNDERGROUND STORAGE TANK SURVEY

GENERAL INSTRUCTIONS

Prepared by:

WESTAT
An Employee-Owned Research Corporation
1650 Research Blvd • Rockville MD 20850 • 301 251-1500

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GENERAL INSTRUCTIONS FOR COMPLETING THE ESTABLISHMENT OPERATOR'S QUESTIONNAIRE

PLEASE READ THE FOLLOWING INSTRUCTIONS BEFORE YOU BEGIN TO FILL OUT THE ENCLOSED QUESTIONNAIRE. IF YOU SHOULD NEED FURTHER ASSISTANCE, CALL WESTAT AT THE TOLL FREE SURVEY ASSISTANCE NUMBER, (800) 638-8985, AND ASK FOR THE EPA SURVEY SPECIALIST.

PURPOSE OF THE SURVEY

The Environmental Protection Agency (EPA) is conducting this study to learn more about the problem of leakage in underground storage tanks. The purposes of this study are to find out how widespread the leakage problem is, and to collect information on factors that cause tanks to leak. The study will help the Agency assess the impact of leaking tanks on the economy and the environment, and the need for Federal regulations to prevent leaking tanks.

HOW ESTABLISHMENTS WERE SELECTED

Establishments were selected to participate in this survey from a preliminary listing of facilities that are likely to have underground storage tanks. This list was compiled by EPA from a variety of sources, including government agencies, federal program rosters, and private and telephone directories. Your facility was not purposely chosen from this listing, but sampled on a probability basis using scientific random selection procedures. The purpose of the probability selection procedures is to obtain a broad representation of kinds of establishments with underground motor fuel storage tanks.

If your company operates more than one establishment that has underground motor fuel storage tanks, the establishment you are to respond for can be identified by the facility's name and address on the questionnaire label. If the questionnaire label does not provide you with enough information to know which estab-ishment to respond for, please call the EPA Survey Specialist t the toll free hot line number, (800) 638-8985.

HOW THIS SURVEY WILL BE CONDUCTED

Within the next two weeks, an interviewer from Westat, Inc. will be contacting you to arrange an appointment for an in-person interview with you at the establishment location. (Westat, Inc. is a survey research company that is assisting the EPA in conducting the Underground Storage Tank Survey.) Enclosed with this instruction booklet is a copy of the questionnaire, so that you will know what questions the interviewer will ask. In order to answer some of the questions, you may need to consult your records, so you should prepare your answers to the interview before the interviewer calls. Since the interviewer will record your answers in a separate copy of the interview, the enclosed copy is yours to keep.

AUTHORITY

This survey is being conducted under authority of Sections 9005 and 9009 of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. Subsections (a) and (b) of Section 9005 detail EPA's authority for conducting the survey and the conditions under which EPA will treat information provided by owners and operators as confidential business information (see CONFIDENTIALITY). Section 9009 details EPA's responsibilities in conducting studies of underground storage tanks.

REIMBURSEMENT

Section 9009(f) specifies that owners or operators of underground storage tanks shall be provided "fair and equitable reimbursement" for "costs, including the loss of business opportunity, due to closure or interruption of operation of an underground storage tank solely for the purpose of conducting studies authorized by this Section." Under Section 9009(f)(2), claims for reimbursement must be "filed with the Administrator [of EPA] not later than 90 days after the closure or interruption which gives rise to the claim."

CONFIDENTIALITY

Section 9005(b) of RCRA, as ammended requires EPA to make survey information available to the public upon request, unless you have requested that the information be treated as confidential business information under 40 CFR, Part 2 and Section 1905 of Title 18 of the United States Code. As explained in the Administrator's open letter, you can request that all of the information you provide be treated as confidential business information, or that certain items be treated as such. Information that has been determined by EPA to be confidential business information cannot be made available to the public by EPA, but can be made available to authorized officers, employees and representatives of EPA, and to the Congress, if requested.

Although EPA is conducting this survey under Federal authority, we are seeking your participation on a cooperative basis. Be assured that the contractor and staff conducting the survey are pledged not to disclose the name or address of any participant. The contractor provides survey data to EPA identified only by a participant code number. Only if an establishment refuses to participate will the name and address be given to EPA. Should this occur, the Agency may be required to take legal steps to obtain data necessary to the survey. However, we would use legal action as a last resort and would strive to avoid its use.

If you want to request that some or all of the information you provide will be treated as confidential business information, please read and complete the "Request for Confidential Treatment of Business Information" form enclosed with this package. You should give the completed, signed request form to the interviewer at the time of the interview.

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REQUEST FOR CONFIDENTIAL TREATMENT OF BUSINESS INFORMATION

I hereby request that information I have provided to the Environmental Protection Agency in response to (certain/all) the questions in the "Underground Storage Tank Establishment Operator's Questionnaire" or the "Inventory Record Form" be treated as confidential business information under 40 CFR Part 2, and Section 1905 of Title 18 of the United States Code.

LIST THE QUESTION NUMBERS OF THE RESPONSES FOR WHICH YOU ARE REQUESTING CONFIDENTIAL TREATMENT: ______________________

____

____

____

PLEASE PRINT OR TYPE:

ESTABLISHMENT NAME: ______________________________

MAILING ADDRESS: ______________________________
Street

______________________________ ☐☐☐☐☐
City State Zip

TELEPHONE: ☐☐☐ - ☐☐☐ - ☐☐☐☐ ____________
Extension

ESTABLISHMENT OWNER/
OPERATOR: ____________________ ____________________
(Print or type) (Signature)

DATE: ______ / ______ / ______
Month Day Year

DEFINITION OF TERMS

Cathodic Protection - Used to reduce or eliminate corrosion of a metallic structure which is in contact with corrosive soil by applying an electric current to the structure which is greater in strength and opposite in direction to the current that is causing corrosion.

Passive (galvanic) Cathodic Protection - The required current is generated by the corrosion of sacrificial anodes, such as Magnesium or Zinc, which are attached to the surface of the protected material (tank or pipe) in the soil.

Impressed Current Cathodic Protection - The required current is provided by an external source and is passed through the system using non-sacrificial anodes, such as Carbon or Platinum, which are buried in the ground.

Continuous Electronic Monitoring System - This system could include the following:

- thermal conductivity sensors;
- electrical resistivity sensors;
- gas detector; and
- interstitial monitoring in double-walled tanks.

Establishment - The term establishment is used to mean a commercial or non-commercial location that is used for any purpose other than just a residence. That is, any location that is used for a nonresidential purpose (even if it is also used as a residence) is considered to be an establishment. Examples of establishments include gasoline service stations, farms, schools, factories, fire stations, highway maintenance facilities, parks, stores, offices, delivery services, military installations, airports, etc. (If you believe that your facility does not fit the definition of an establishment, please call the toll free survey assistance number, (800) 638-8985, and explain your situation to the EPA Survey Specialist.)

External Corrosion Protection System - This system could include the following special equipment or materials:

- cathodic protection;
- electric isolotion;
- polyethylene wrappings;
- coatings; and
- paints.

Inventory Reconciliation - The balancing of "book" inventories against observed inventories (meter/dipstick readings).

Manway - A means of entrance into an underground storage tank allowing internal inspection.

Motor Fuel - Any substance that is used to power a motorized vehicle (such as an automobile, boat, airplane, truck, etc.). For example, motor fuels such as:

- leaded gasoline;
- unleaded gasoline;
- diesel fuel;
- aviation gas;
- jet fuel; and
- gasohol.

Pressure Pump Delivery System (also called submerged pump delivery system) - This system works on the principle of positive pressure to push the liquid from a low point to a high point using a submerged pump (coupled with an electric motor) mounted inside the tank.

Remote Gauge - A measuring device that indicates the quantity of fuel stored in a tank on an external scale or dial.

Secondary Containment - A secondary enclosure or barrier intended to contain any spills or leakage from the primary storage tank or from pumps, piping and other equipment. These may include:

- concrete vaults or basins;
- plastic or clay lined basins;
- soil sealants (soil cement or bentonites); or
- double-walled tanks or pipes.

Siphon Pump Delivery System (also called suction pump delivery system) - This system works by drawing liquid from a low point because of a vacuum at a high point, using a suction pump. This pump is located at grade (i.e., ground level), either directly above the storage tank or, as in the case of some dispensing operations, at some distance from the storage tank (at the pump islands).

Underground Storage Tank - A large vessel or container placed beneath the surface of the earth used for storing and handling of liquids (such as petroleum products) or waste materials (such as used or waste oil).

Used or Waste Oil - Oils (whether used or unused) that are no longer fit for their intended use because of contamination or degradation. These oils include, but are not limited to:

- automotive engine oils;
- gear lubricants;
- diesel engine oils;
- railway diesel oils;
- oil storage and treatment residuals (such as bottoms);
- hydraulic oils;
- metal working oils;
- transformer oils; and
- oils contaminated with water.

Water Finding Paste - A paste applied to the bottom of the dipstick which changes color when it comes in contact with water.

Water Table - The upper limit of the portion of the ground (soil) wholly saturated with water.

ORGANIZATION OF THE QUESTIONNAIRE

The Establishment Owners/Operators Questionnaire is designed to obtain data on your establishment's underground fuel and waste oil storage operation, including such items as tank design, operating and installation characteristics, tank corrosion protection and tank leakage monitoring. The questionnaire is divided into seven sections, as follows:

A. Screening Information

This section of eleven questions asks for information about the establishment itself, including questions about the type of establishment, the owner and operator of the establishment, and the number of tanks at the establishment. Question A.11 provides instructions for completing Tank Description Sheets for the establishment.

Tank Description Sheets - A Tank Description Sheet must be completed for each underground tank. Questions asked will include information on specific tank characteristics, such as reported age, size and typical fill volume, manufacturer, installer, materials of construction, inspections or leak tests, and other design characteristics.

B. Operating Practices

This section asks questions about practices such as taking tank inventories using a dipstick, checking and recording dispenser meter readings, inventory procedures after a delivery and inventory reconciliation or "balancing" between stick readings, dispenser meter readings, and delivery records.

C. Operating History

In this section you will be asked about any tanks that have been replaced, removed without being replaced, or abandoned in place, and in what year and why this occurred.

D. Permits and Licenses

This is a short section about any special permits or licenses needed for tank installation or storage of flammable materials.

E. Installation

Section E includes overall questions about how the tank was installed.

F. Protection

This section asks questions about any protection systems in use against external corrosion, and any monitoring systems used to detect tank leakage.

G. Information Needs

Section G is about the kinds of information and services relating to tank monitoring that are currently available to you.

USE OF THE QUESTIONNAIRE

The questionnaire has been designed to minimize the effort required for it's completion. "Skip patterns" have been incorporated to enable respondents to by-pass sections of the questionnaire which are not relevant to them. The following section describes how you are to complete the questionnaire in preparation for the call from a Westat interviewer.

EXAMPLES OF QUESTIONS

Most of the questionnaire items are straightforward and require only the circling of the correct code(s) or the completion of short answers on the lines which are provided. The following examples illustrate the use of other question formats found throughout the questionnaire.

Example A

Some questions require that you indicate a distance or frequency and also circle the correct unit of measurement or time as indicated in the sample questions below. Different units have been specified for your convenience. Please do not neglect to circle a unit code (as shown) or to write in an appropriate unit of measurement or time. This question, as with all questions, includes its own instructions printed in capital letters and enclosed in brackets.

E4. What is the shortest distance between any of your tanks and any neighboring underground tank or other solid underground structure (such as a basement wall, sewer, or utility vault)? [ENTER DISTANCE AND CIRCLE UNIT CODE]

SHORTEST DISTANCE FROM UNDERGROUND STRUCTURE: 6 /23-2

[CIRCLE ONE]:

INCHES. 01

FEET. . . . . [✓ 02] /29-3

OTHER [SPECIFY]: ____________________ 03

____

F2. **How often do you inspect your external corrosion protection system? [ENTER FREQUENCY AND CIRCLE UNIT CODE]**

IF YOU NEVER INSPECT THE EXTERNAL CORROSION PROTECTION SYSTEM, CHECK HERE ☐ AND SKIP TO F3. /19

FREQUENCY OF INSPECTION: 2 /20-22

[CIRCLE ONE]:

PER DAY 01
PER WEEK. 02
PER MONTH . . . . [✓ 03] /23-24
PER YEAR. 04
OTHER [SPECIFY]: ______________ 05

____

Example B

Other questions require that you code a "yes or "no" answer for each category listed, as indicated in the sample question below. The "Other [SPECIFY]" line enables you to enter an answer not covered by the preprinted response categories.

I12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

		YES	NO
a.	Leaded gasoline	[✓ 1]	2
b.	Unleaded gasoline	1	[✓ 2]
c.	Diesel fuel	1	[✓ 2]
d.	Aviation fuel	1	[✓ 2]
e.	Gasohol	[✓ 1]	2
f.	Other [SPECIFY]: Kerosene	[✓ 1]	2

/58-65

Example C

When a series of similar questions apply consistently to a given category, they have been formatted into tables or grids to facilitate the administration of the questions. Notice also that Question C6b requests that all applicable response categories be circled, not just the most prominent one, as indicated in the sample question below.

C6. Please answer the following questions about each tank that has been removed without being replaced. [SPACE HAS BEEN PROVIDED FOR UP TO FOUR TANKS. IF MORE THAN FOUR TANKS HAVE BEEN REMOVED WITHOUT BEING REPLACED, WRITE THE ANSWERS FOR THE ADDITIONAL TANKS ON A PLAIN SHEET OF PAPER]

	First Tank	Second Tank	Third Tank	Fourth Tank
C6a. In what year was the (first/second/third) tank removed?	74 (year) /20-23	74 (year) /34-37	81 (year) /48-51	(year) /62-65
C6b. Why was the tank removed? [CIRCLE ALL THAT APPLY FOR EACH TANK]				
a. Because it was leaking?. . . .	01	[✓ 01]	[✓ 01]	01
b. Because other tanks were being removed at that time? . . .	[✓ 02]	02	02	02
c. Because it was no longer needed/in use?.	03	03	[✓ 03]	03
d. Or for some other reason [SPECIFY]: .	04	04	04	04
	(specify) /24-33	(specify) /38-47	(specify) /52-61	(specify) /66-74

SKIP INSTRUCTIONS

Skip instructions indicate the next question to be answered. They save time by allowing you to ignore irrelevant questions. The following is an example of a skip instruction attached to an answer category.

B1. Do you (or another establishment employee) inventory the contents of your tank(s) by measuring the depth of the contents with a dipstick? [CIRCLE ONLY ONE CODE]

YES [GO ON TO B2]	1	/16
NO [SKIP TO B5]	[✓ 2]	

Skip instructions are sometimes not attached to an answer but are enclosed in a box, as shown below.

B14. How often is the accuracy of your dispenser meters checked? [CIRCLE ONLY ONE CODE]

IF THE ACCURACY OF YOUR DISPENSER METERS IS NEVER CHECKED, CHECK HERE ☑ AND SKIP TO B16. /32

DAILY	01	
WEEKLY	02	
EVERY TWO WEEKS	03	
MONTHLY	04	/33-34
ANNUALLY	05	
OTHER [SPECIFY]: ____________________	06	

THE MOTOR FUEL INVENTORY SHEETS

Enclosed in the survey package are four kinds of sheets for keeping daily motor fuel inventory records. The type of tank and dispenser systems you operate will determine which inventory sheet(s) you will need to use. You may need only one kind of sheet or as many as three kinds.

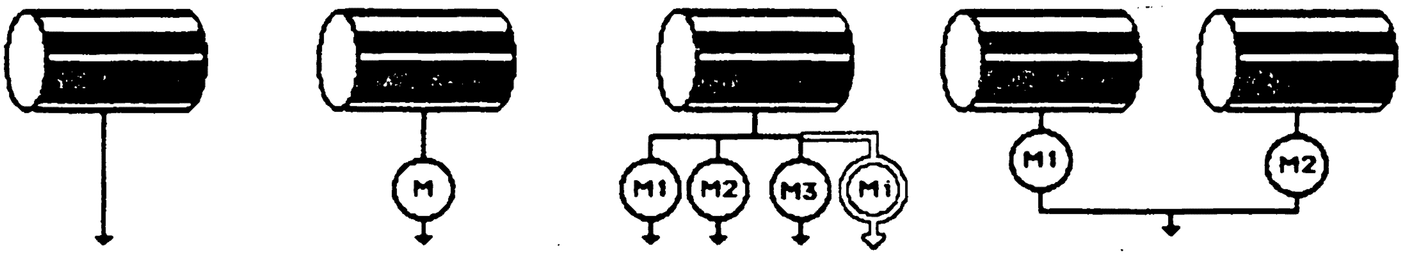
In Figure 1 on the following page, you will find schematic diagrams of the seven most common tank and dispenser hookup systems currently in use. These seven hookup systems are listed in Table 1, below. Use the diagrams in Figure 1 to determine which tank and dispenser hookup system(s) you have. Then use Table 1 to determine which kind(s) of sheet(s) you should use for inventory recording.

Table 1. Inventory Recording

	Appropriate Inventory Review Forms			
Possible tank/Dispenser Meter/ Dispenser Hookups	Inventory Sheet for Tanks without Metered Dispensing Pumps	Inventory Sheet for Tanks with Metered Dispensing Pumps	Dispensing Meter Recording Sheet	Manifolded Tank System Recording Sheet
Single tank, unmetered	X			
Single tank with single dispensing meter		X	X	
Single tank with multiple dispensing meters		X	X	
Custom Blending: 2 tanks, 2 dispensing meters, 1 dispenser		X	X	
Custom Blending: 2 tanks, multiple dispensing meters and dispensers		X	X	
Manifolded Tanks: Multiple interconnected tanks, multiple dispensing meters		X	X	X
Manifolded Tanks, Custom Blending		X	X	X

Figure 1

Schematic Diagrams of Possible Tank/ Dispensing Meter/Dispenser Hookup



Single tank, unmetered

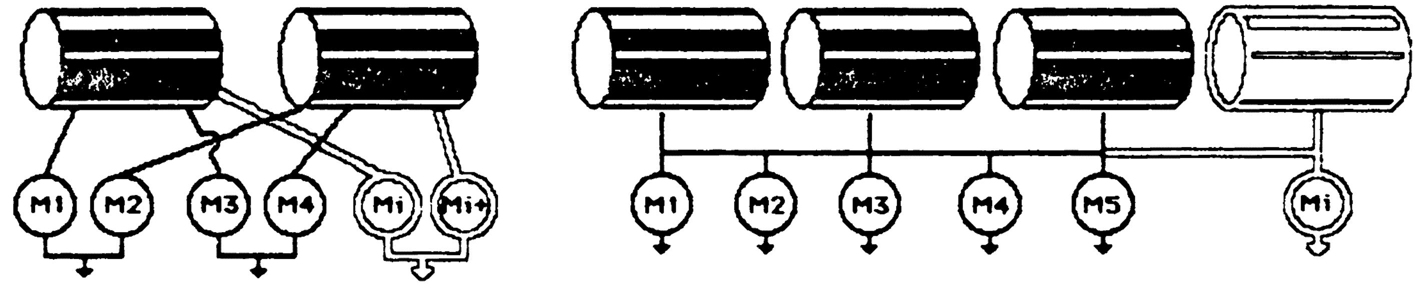
Single tank, single dispensing meter

Single tank, multiple dispensing meters

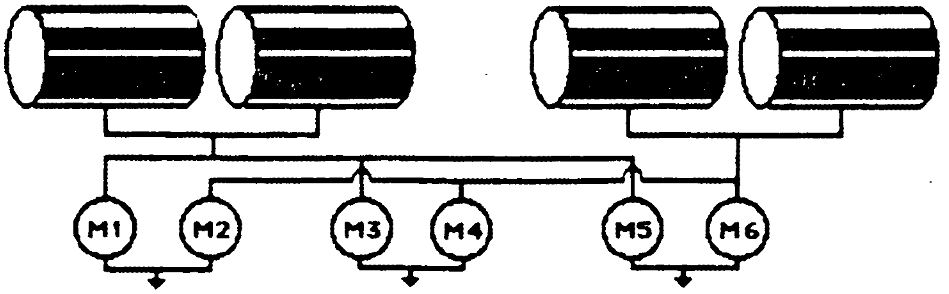
Custom Blending: 2 tanks, 2 dispensing meters, 1 dispenser

Custom Blending: 2 tanks, multiple dispensing meters and dispensers

Manifolded Tanks: multiple interconnected tanks, multiple dispensing meters



Manifolded Tanks, Custom Blending



Regardless of which inventory sheets you use, you will need to provide 30 complete inventory readings for each of your tanks. It is preferable that each of these readings represents one operating day. Many tanks and tank systems are inactive (not used) for certain days during the week. If your tank(s) are inactive on a particular day, you can use the inactive day as an inventory day only if you take and record dipstick readings for the tank(s) for that day. (You cannot carry down the closing stick readings from the previous day.) You must provide actual stick readings (or remote gauge readings, if available) for each of the 30 inventory days. If your dispensers are metered, you must also provide meter readings for each of the 30 inventory days. If you do not have complete inventory information for a day, do not use that day as an inventory day.

Instructions for using each of the four kinds of Motor Fuel Inventory Sheets, along with example copies of the Sheets, are provided on the following pages of this booklet. After you have used Figure 1 and Table 1 to determine which inventory sheets you will be using, please read the instructions on how to complete the sheets.

If you have any questions about:

- Which sheets you should use for your tanks;
- How to complete the sheets; or
- Any recording problems you may have;

please call Westat at the toll-free survey assistance number, (800) 638-8985, and ask for the EPA Survey Specialist.

INSTRUCTIONS FOR COMPLETING THE INVENTORY SHEET FOR TANKS WITH METERED DISPENSING PUMPS

The Inventory Sheet for Tanks with Metered Dispensing Pumps is used for any individual tank or system of connected tanks (i.e., manifolded tanks) that has one or more metered dispensing pumps. The sheet is used to record daily physical inventory measurements (stick readings and deliveries) and volume of fuel pumped from the tank, as calculated from dispensing meter readings. You will need one Inventory Sheet for Tanks With Metered Dispensing Pumps for each tank (or system of tanks) that has metered dispensers.

You should fill out one line of the Inventory Sheet for each day that inventory readings are taken. (Days for which inventory readings are not taken should not be entered on the sheet.)

- In Column 1, enter the date of the reading (day and month).
- In Column 2, enter the opening dipstick reading, in gallons. (On days 2 through 30, opening dipstick reading will be the same as the closing stick reading of the line above.)
- In Column 3, enter the day's deliveries to the tank, in gallons.
- In Column 4, enter the sum of Columns 2 and 3. (This is your "opening physical inventory."
- In Column 5, enter your closing dipstick reading to the nearest quarter inch.
- In Colunn 6, enter your closing dipstick reading, converted to gallons (using your conversion chart for this tank).
- In Column 7, subtract the amount in Column 6 (your closing stick inventory) from the amount in Column 4 (your opening physical inventory) and write the remainder in Column 7. This column represents the quantity gone from the tank, according to your physical inventory records.

- In Column 8, enter the "meter sales" (the number of gallons pumped from the tank according to your meter readings). You must record the actual meter readings and calculate the meter sales on a Dispenser Meter Recording Sheet. Column 8 of the Inventory Sheet should equal Line I of the Dispenser Meter Recording Sheet for the same date.

The Inventory Sheet for Tanks With Metered Dispensing Pumps is printed as a four-page booklet along with a Dispenser Meter Recording Sheet. (The dispenser Meter Recording Sheet is the last three pages of the booklet.) Six copies of the Inventory and Dispenser Sheet booklet are included in the survey package. If there are more than six tanks with metered dispensers at your establishment, please photocopy as many additional sheets as are required.

INVENTORY SHEET FOR TANKS WITH METERED DISPENSING PUMPS

Tank Number: ____________________

Dispenser Meter Numbers: ____________

____

(Name of Facility)

____

(Street Address)

Type of Fuel: ____________________

Size of Tank: ____________________

____

(City/Town) (State) (Zip)

Year Installed: __________________

		Dipstick* Inventory						
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
Day	Date	Opening Dipstick* Inventory (gallons)	Deliveries (in gallons)	[Column 2] plus [Column 3]	Closing Dipstick* Inventory (inches)	Closing Dipstick* Inventory (gallons)	Gone from Tank: [Column 4] minus [Column 6]	Meter sales** (gallons) (from meter sheet)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

*If tank has remote gauge, check here ☐ and use remote gauge readings instead of stick readings.

**Transferred from Line I of Dispenser Meter Recording Sheet.

INSTRUCTIONS FOR COMPLETING DISPENSER METER RECORDING SHEET

The Dispenser Meter Recording Sheet is used to record daily meter readings and to calculate volume of fuel pumped for all dispenser meters connected to an individual tank or system of tanks. One 30-day set of Meter Sheets is kept for each individual tank or connected tank system. On each day of inventory readings, record each meter's closing reading (in gallons) on Line G ("Today's Closing Meter"). Record "Yesterday's Closing Meter" on Line H. (For Day 2 through Day 30, "Yesterday's Closing Meter" will be the same as Line G ["Today's Closing Meter"] from the day before.)

The gallons of fuel dispensed daily through a given meter is calculated by subtracting "Yesterday's Closing Reading" (Line H) for that meter from its "Today's Closing Reading" (Line G). Enter the difference between the two readings in Line I for each meter. This is the number of gallons dispensed (pumped) through that meter during that day. After you have entered the gallons dispensed by each meter in Line I, add up Line I for all meters and enter that figure in the column marked "Line I Totals." The "Line I Total" figure is the daily "gallons dispensed" for all meters. The "Line I Total" must also be recorded for the same day in Column 8 of the Inventory Sheet for this tank.

Dispenser Meter Recording Sheets are printed in a four-page booklet, along with an Inventory Sheet. Six copies of this booklet are included in the survey package. Please photocopy extra copies if needed.

DISPENSER METER RECORDING SHEET

(FOR TANKS WITH METERED DISPENSING PUMPS)

Tank* No.: ______________________

Type of Fuel: ______________________

Day	Date	Meter Recordings in Gallons	Meter #1	Meter #2	Meter #3	Meter #4	Meter #5	Meter #6	Meter #7	Meter #8	Line I** Totals
1		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
2		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
3		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
4		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
5		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
6		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
7		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
8		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
9		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
10		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									

*For a manifolded tank system, list the numbers of all of the tanks in the system.

**Transfer Line I totals to Column 8 of Inventory Sheet.

DISPENSER METER RECORDING SHEET

(FOR TANKS WITH METERED DISPENSING PUMPS)

Tank* No.: ____________________

Type of Fuel: ____________________

Day	Date	Meter Recordings in Gallons	Meter #1	Meter #2	Meter #3	Meter #4	Meter #5	Meter #6	Meter #7	Meter #8	Line I** Totals
11		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
12		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
13		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
14		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
15		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
16		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
17		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
18		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
19		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
20		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									

*For a manifolded tank system, list the numbers of all of the tanks in the system.

**Transfer Line I totals to Column 8 of Inventory Sheet.

DISPENSER METER RECORDING SHEET

(FOR TANKS WITH METERED DISPENSING PUMPS)

Tank* No.: ____________________

Type of Fuel: ____________________

Day	Date	Meter Recordings in Gallons	Meter #1	Meter #2	Meter #3	Meter #4	Meter #5	Meter #6	Meter #7	Meter #8	Line I** Totals
21		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
22		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
23		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
24		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
25		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
26		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
27		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
28		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
29		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									
30		G. Today's Closing Meter									
		H. Yesterday's Closing Meter									
		I. Gallons Dispensed (G - H)									

*For a manifolded tank system, list the numbers of all of the tanks in the system.

**Transfer Line I totals to Column B of Inventory Sheet.

INSTRUCTIONS FOR COMPLETING THE MANIFOLDED TANK SYSTEM RECORDING SHEET

The Manifolded Tank System Recording Sheet is an eight-page booklet that is used whenever two or more tanks are connected by piping to make a multiple or manifolded tank system. One Manifolded Tank System Recording Sheet booklet is to be used for each manifolded tank system that is to be inventoried.

The purpose of the Manifolded Tank System Recording Sheet is to provide a convenient way to keep individual daily stick and delivery records for each tank in the system. At the end of each day, you should add up and record each line of inventory measurements (Lines A through F) for all tanks in the manifolded system. These daily totals are entered in the "Tank System Totals" column of the Manifolded Tank System Recording Sheet, and then transferred to the appropriate columns of the Inventory Sheet for the tank systems. The "Transfer to Inventory Sheet" column on the righthand side of the sheet indicates that Inventory Sheet column number to which the total should be transferred. You must also complete a Dispenser Meter Recording Sheet for the tank system.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Tank Numbers of Tanks in This Manifolded System: ______________________

Type of Fuel: ______________________

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
1		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
2		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
3		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
4		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
5		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
6		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
7		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
8		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
9		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
10		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
11		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
12		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
13		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
14		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
15		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
16		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
17		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
18		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
19		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
20		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
21		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
22		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
23		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
24		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
25		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
26		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
27		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
28		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

MANIFOLDED TANK SYSTEM RECORDING SHEET

Day	Date	Meter Recordings in Gallons	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Tank #6	Tank #7	Tank #8	Tank System Totals	Transfer to Inventory Sheet
29		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7
30		A. Opening Stick (gals) (Yesterday's Line E)										Col 2
		B. Deliveries (gals)										Col 3
		C. Total of Fuel in Tank (A + B)										Col 4
		D. Closing Stick (inches)										Col 5
		E. Closing Stick (gals)										Col 6
		F. Fuel Gone from Tank (gals) (C - E)										Col 7

*Transfer Tank System Totals to the indicated columns on the correct Inventory Sheet for this Tank System.

INSTRUCTIONS FOR COMPLETING
INVENTORY SHEET FOR TANKS WITHOUT METERED DISPENSING PUMPS

The Inventory Sheet for Tanks Without Metered Dispensing Pumps is the only sheet to be used with tanks having unmetered dispensing pumps. Without metered dispensing pumps, it is difficult to use inventory records to monitor for fuel losses, because the quantities of fuel being pumped from that tank are unknown. As a result, inventory calculations must be based on stick readings alone. You will need an accurate dipstick and the correct inches-to-gallons conversion chart for your unmetered tank.

You will need to make a series of 30 opening and closing dipstick readings of your unmetered tank. There should be one or more days between each of the 30 readings. Figure 2, below, shows two plans for taking the 30 readings.

Figure 2

Inventory Readings Plans for Unmetered Tanks

PLAN A: Immediately before each withdrawal or delivery of fuel, enter the date and opening stick readings for the tank on the inventory sheet. Immediately after the withdrawal or delivery make and record the closing stick reading on the inventory sheet. Deliveries should be entered from the delivery receipt you receive from the fuel truck driver. (All deliveries will be made when the facility is "open," since the delivery will be occur between the opening and closing stick readings.)

PLAN B: At the beginning of each operating day (before any withdrawals of fuel) record the date and opening stick reading for the day. At the end of the day (after all withdrawals of fuel) record the closing stick readings. If a delivery occurs while "closed" (after the closing dipstick reading was taken) record the quantity delivered (from the receipt) on the line for the following day and circle the code (2) for "closed." If a delivery occurs while your facility is open, record the quantity delivered on the line for the day the delivery occurred and circle the code (1) for "open." NOTE: It is not necessary to have withdrawals or deliveries during an operating day in order to fill in an inventory line, as long as you make and record both opening and closing stick readings.

If your tank is used very infrequently (once a day or less) you may wish to follow Plan A. Plan A requires that you record dipstick readings on the tank each time you use the tank. If the tank is used more than once a day, you should follow Plan B. Plan B requires that you record dipstick readings at the opening and closing of each operating (business) day.

The step-by-step instructions for recording inventory on the "Inventory Sheet for Tanks <u>Without</u> Metered Dispensing Pumps" are:

- In Column 1, record the date that the inventory reading will be made (day and month).

- In Column 2, record the opening dipstick reading, in inches (<u>to the nearest quarter inch</u>).

- In Column 3, record the opening dipstick reading, in gallons (as calculated from your inches-to-gallons conversion chart for this tank).

- In Column 4, record the closing dipstick reading, in inches (<u>to the nearest quarter inch</u>).

- In Column 5, record the closing dipstick reading, in gallons (as calculated from your inches-to-gallons conversion chart for this tank).

- In Column 6, record the amount delivered to the tank since your closing reading on the line above. (The "Gallons Delivered" should be taken from the receipt provided by the fuel delivery truck driver.)

- Finally, in Column 7, please indicate whether the fuel delivery was made <u>before</u> the opening stick reading on this line (i.e., when the facility was <u>closed</u>) or during the time <u>between</u> the opening and closing stick readings (i.e., when the facility was <u>open</u>).

INVENTORY SHEET FOR TANKS <u>WITHOUT</u> METERED DISPENSING PUMPS

Tank Number: ________________

Type of Fuel: ________________

Size of Tank: ________________

Year Installed: ________________

____

(Name of Facility)

____

(Street Address)

____

(City/Town) (State) (Zip)

		Dipstick* Inventory						
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	
Day	Date	Opening Dipstick* Reading (inches)	Opening Dipstick* Reading (gallons)	Closing Dipstick* Inventory (inches)	Closing Dipstick* Inventory (gallons)	Deliveries (in gallons)	Was delivery made while open or closed? (Circle one) Open	Closed
1							1	2
2							1	2
3							1	2
4							1	2
5							1	2
6							1	2
7							1	2
8							1	2
9							1	2
10							1	2
11							1	2
12							1	2
13							1	2
14							1	2
15							1	2
16							1	2
17							1	2
18							1	2
19							1	2
20							1	2
21							1	2
22							1	2
23							1	2
24							1	2
25							1	2
26							1	2
27							1	2
28							1	2
29							1	2
30							1	2

*If tank has remote gauge, check here ☐ and use remote gauge readings instead of stick readings.

REPORTING RESPONSIBILITIES
OF TANK OWNERS AND OPERATORS

On November 8, 1984, President Reagan signed the Hazardous and Solid Waste Amendments of 1984, amending the Resource Conservation and Recovery Act (RCRA). Section 9005(a) of RCRA, as amended, states:

> "FURNISHING INFORMATION--For the purposes of developing or assisting in the development of any regulation, conducting any study, or enforcing the provisions of this subtitle [Subtitle I of Title VI, 'Regulation of Underground Storage Tanks], any owner or operator of an underground storage tank . . . shall upon request of any officer, employee or representative of the Environmental Protection Agency duly designated by the Administrator, . . . furnish information relating to such tanks, their associated equipment, their contents, conduct monitoring or testing, and permit such officer at all reasonable times to have access to, and copy all records relative to such tanks [underline added for emphasis]. For the purposes of developing or assisting in the development of any regulation, conducting any study, or enforcing the provisions of this subtitle, such officers, employees or representatives are authorized --
>
> "(1) to enter at reasonable times any establishment or other place where an underground storage tank is located;
>
> "(2) to inspect and obtain samples from any person of any regulated substance contained in such tank; and
>
> "(3) to conduct monitoring or testing of the tanks, associated equipment, contents, or surrounding soils, air, surface water or ground water.
>
> Each such inspection shall be commenced and completed with reasonable promptness.

Section 9006, "FEDERAL ENFORCEMENT," gives EPA the authority to issue compliance orders and to commence civil actions for noncompliance with the requirements of Section 9005. Section 90006(a)(3) authorizes EPA to seek civil penalties for violation of such an order, not to exceed $25,000 per day of continued noncompliance.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

Dear Establishment Owner/Operator:

If there are no underground motor fuel storage tanks located at your establishment, please sign the certification statement below indicating this and return in the postage paid envelope provided. If there are abandoned or out of service underground motor fuel storage tanks at this establishment you <u>should not</u> sign this statement. If the interviewer calls after you have mailed the signed statement, inform him/her that you have done so.

Sincerely,

Martin P. Halper, Director
Exposure Evaluation Division

Establishment Name:
Establishment Address:

Establishment Telephone:

CERTIFICATION STATEMENT FOR
ESTABLISHMENTS WITHOUT TANKS

> THE OWNER OR THE OPERATOR OF THE FACILITY, OR HIS AUTHORIZED REPRESENTATIVE, SHOULD SIGN AND DATE THE CERTIFICATION WHERE INDICATED. THE PRINTED OR TYPED NAME OF THE PERSON SIGN-THE CERTIFICATION SHOULD ALSO BE INCLUDED WHERE INDICATED.

CERTITIFICATION:

I hereby certify that there are no underground motor fuel storage tanks at the establishment at the above address. I am aware that there are significant penalties for submitting false information, including the possibility of a fine.

Print or Type Name	Signature	Date Signed

OMB No.: 2070-0037

Expires: December 31, 1985

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNDERGROUND STORAGE TANK SURVEY

ESTABLISHMENT OPERATOR'S QUESTIONNAIRE

Conducted by:

WESTAT
An Employee-Owned Research Corporation
1650 Research Blvd • Rockville MD 20850 • 301 251-1500

A. SCREENING INFORMATION

01

A1. What type of establishment is this? [CIRCLE ONLY ONE CODE]

a. FARM OR RANCH . . . . 01 /60-61
b. GASOLINE SERVICE STATION.

[PLEASE SELECT ONE OF THE FOLLOWING SUBCATEGORIES]: /62-63

- b1. FULL SERVICE STATION (WHERE MOTOR VEHICLE REPAIR WORK IS DONE) 02
- b2. LARGE, HIGH VOLUME STATION 03
- b3. CONVENIENCE STORE. 04
- b4. SELF SERVICE GASOLINE STATION. 05
- b5. OTHER [PLEASE DESCRIBE] ______________ ______________ 06 /64-65

c. MILITARY FACILITY 07
d. FEDERAL AGENCY OR OFFICE. 08
e. STATE AGENCY OR OFFICE. 09
f. LOCAL GOVERNMENT AGENCY OR OFFICE 10
g. MARINA. 11
h. TAXI SERVICE OR COMPANY 12
i. BUS FLEET FACILITY. 13
j. TRUCK FLEET FACILITY. 14
k. AIRPORT OR AIRFIELD 15
l. RAILROAD DEPOT. 16
m. OTHER BUSINESS [PLEASE SPECIFY YOUR ESTABLISHMENT'S PRIMARY PRODUCT OR SERVICE]: ______________ ______________ 17 /66-67

n. BULK FUEL PLANT OR TERMINAL . . . . 18 →
o. PRIVATE RESIDENCE THAT IS NOT ASSOCIATED WITH A FARM OR RANCH. . . . . 19 →
p. OTHER [SPECIFY]: ______________ 20

PLEASE DO NOT COMPLETE THE REST OF THIS QUESTIONNAIRE! PLEASE CALL WESTAT AT THE 800-638-8985 (TOLL FREE NUMBER) AND ASK FOR THE "EPA SPECIALIST."

/68-69

BOX A1

IF A1 = MILITARY, FEDERAL, STATE OR LOCAL AGENCY (CODES 07, 08, 09 OR 10), CHECK HERE ☐ AND SKIP TO A6. OTHERWISE, GO ON TO A2. /70

A2. Is this establishment owned and/or operated by a major petroleum company? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /71

A3. What is the name and address of the owner of this establishment?

Owner's Name ______________________________

Owner's Address ______________________________

____

A4. What is the name and address of the operator of this establishment?

Operator's Name: ______________________________

Operator's Address: ______________________________

____

A5. What is the motor fuel that is stored at this establishment used for: retail sales, wholesale sales, or for use by the establishment itself? [CIRCLE ONE CODE FOR EACH ITEM]

	<u>YES</u>	<u>NO</u>	
a. RETAIL SALES	1	2	/72
b. WHOLESALE SALES.	1	2	/73
c. USE BY THIS ESTABLISHMENT.	1	2	/74
d. OTHER [SPECIFY]: ________________	1	2	/75
____________________________			/76-77

A6. Does this establishment have any underground storage tanks that are used to store <u>motor</u> fuel? [CIRCLE ONLY ONE CODE] /78

YES [GO ON TO A7]. . 1

NO . . . . 2 →

PLEASE DO NOT COMPLETE THE REST OF THIS QUESTIONNAIRE! PLEASE CALL WESTAT AT 800-638-8985 (TOLL FREE NUMBER) AND ASK FOR THE "EPA SPECIALIST."

A7. How many underground storage tanks currently in use are used to store motor fuels?

NUMBER OF TANKS: ____________________ /79-81

A8. Does this establishment have any underground storage tanks that are used to store <u>used or waste oil</u>? [CIRCLE ONLY ONE CODE]

YES [GO ON TO A9]. 1

NO [SKIP TO A11] . . . . 2 /82

A9. How many underground storage tanks currently in use are used to store used or waste oil?

NUMBER OF USED OR WASTE OIL UNDERGROUND TANKS: ______________________________ /83-85

A10. What (is/are) the capacity/ies of your used or waste oil tank(s)? [ENTER CAPACITIES IN GALLONS]

a. Capacity of used or waste oil tank #1 . . . . ______________ gallons /86-91

b. Capacity of used or waste oil tank #2 . . . . ______________ gallons /92-97

c. Capacity of used or waste oil tank #3 . . . . ______________ gallons /98-103

A11. Please fill out one Tank Description Sheet for each underground storage tank that this facility uses to store motor fuel. There are six (6) Tank Description Sheets bound into this booklet. If there are more than six underground storage tanks at this establishment, either photocopy as many additional sheets as are required to describe all the tanks, or write the answers to the questions for each extra tank on a plain sheet of paper.

TANK DESCRIPTION SHEET INSTRUCTIONS

1. Use the space on the next page to draw a map of the underground tank area at your establishment. On the map, show the location of each tank, the pumps/dispensers for each tank, and any buildings and features associated with the tanks (such as a garage, driveway, or wall). See the example map below showing a gasoline service station with three tanks and two pump islands.

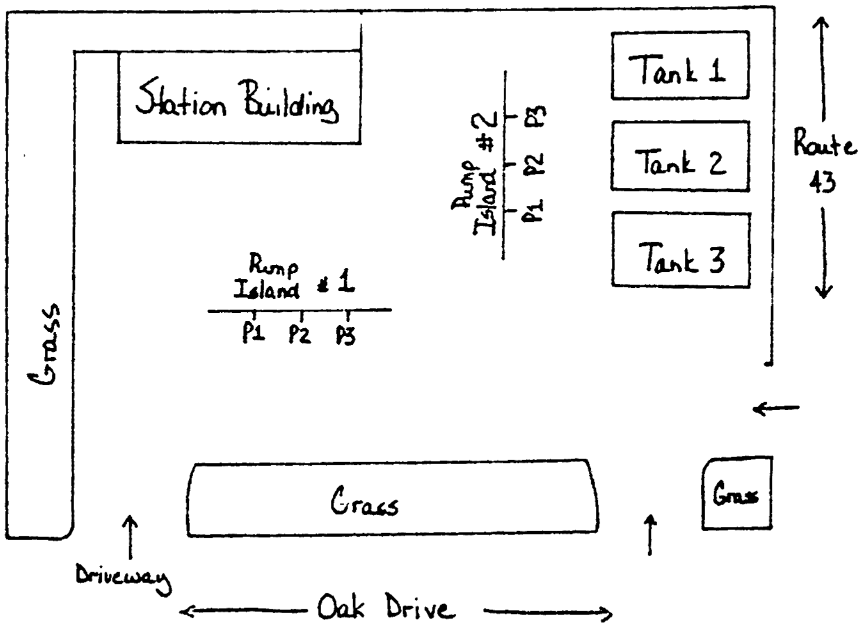
2. Assign a number to each underground storage tank at this establishment, and write that number on the tank in your map. (See example below.) Also write the tank number in the upper lefthand corner of the Tank Description Sheet for that tank.

3. It is only necessary to fill out Tank Description Sheets for tanks that are on site at this establishment. Do not fill out Tank Description Sheets for any tanks that this establishment may use, own or maintain off site.

4. If another establishment uses or maintains an underground storage tank on your establishment's site/property, you should complete a Tank Description Sheet for that tank and include it on your map.

5. Large establishments with more than one tank area may find it easier to draw individual maps of each tank area, rather than drawing one large map.

Example Map



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02

TANK DESCRIPTION SHEET

TANK NUMBER: ________

T1. What is the capacity of this tank? (That is, what is the maximum number of gallons of fuel it can hold?) [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ________ gallons 16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ________ gallons 22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ________ gallons 28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: ________ gallons /34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ________ /40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8
/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ________ /45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8
/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ________ /50-53

T11. What types of repairs were done to this tank?

REPAIRS: ________ /54-55

____

________ /56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

	YES	NO
a. Leaded gasoline	1	2
b. Unleaded gasoline	1	2
c. Diesel fuel	1	2
d. Aviation fuel	1	2
e. Gasohol	1	2
f. Other [SPECIFY]: ________ ________	1	2

/58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2
/66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ________ /67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: ________ 03

________ /70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ________ /72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ________ /76

________ 1
NO. 2
/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ________ 04
/79-80

T20. Does this tank have a manway or other means of being entered for internal inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ________ /83-86

T23. Has the tank ever been tested for leaks after it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8
/87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ________

________ /88-89

____

________ /90-91

TANK DESCRIPTION SHEET (Continued)

TANK NUMBER: ____________

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ______________________ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: ____________ 03

____________________ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8
/22

T28. In what year was the lining installed?

YEAR LINED: ______________ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______________ 05

____________________ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8
/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: __________ 05

____________________ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8
/32

T33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: ______ 05

____________________ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8
/35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: ______ 05

____

T36. What is the name of the company that installed the tank?

INSTALLER: ______________________ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2
/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: ____________ 04

____________________ /41-42

T39. How thick is the pavement?

THICKNESS: ______________ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /46-47

____________________ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: __________ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /51-52

____________________ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: ____________	1	2	/55

____________________ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8
/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 /59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: ____________

____________________ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /69
DON'T KNOW 8

02

TANK DESCRIPTION SHEET

TANK NUMBER: ____________

T1. What is the capacity of this tank? (That is, what is the maximum number of gallons of fuel it can hold?) [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ____________ gallons /16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ________ gallons /22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ____________ gallons /28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: ________ gallons /34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ____________ /40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8

/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ____________ /45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2

/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8

/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ____________ /50-53

T11. What types of repairs were done to this tank?

REPAIRS: ____________ /54-55

____

____________ /56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

		YES	NO
a.	Leaded gasoline	1	2
b.	Unleaded gasoline	1	2
c.	Diesel fuel	1	2
d.	Aviation fuel	1	2
e.	Gasohol	1	2
f.	Other [SPECIFY]: ________	1	2

____________ /58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2

/66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ____________ /67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: ________ 03

____________ /70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ____________ /72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2

/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ____ /76
____________ 1
NO. 2

/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ____________ 04

/79-80

T20. Does this tank have a manway or other means of being entered for internal inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8

/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8

/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ____________ /83-86

T23. Has the tank ever been tested for leaks after it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8

/87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ____________

____________ /88-89

____

____________ /90-91

TANK DESCRIPTION SHEET (Continued)

TANK NUMBER: ____________

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ____________________ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: ____________ 03

____________________ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8
/22

T28. In what year was the lining installed?

YEAR LINED: ______________ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______________ 05

____________________ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8
/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: __________ 05

____________________ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8
/32

33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: ______ 05

____________________ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8
/35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: ______ 05

____________________ /36-37

T36. What is the name of the company that installed the tank?

INSTALLER: ____________________ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2
/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: ____________ 04

____________________ /41-42

T39. How thick is the pavement?

THICKNESS: ______________ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /46-47

____________________ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: __________ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /51-52

____________________ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: ____________	1	2	/55

____________________ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8
/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 /59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: __________

____________________ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /69
DON'T KNOW 8

TANK DESCRIPTION SHEET

TANK NUMBER: ______

T1. What is the capacity of this tank? That is, what is the maximum number of gallons of fuel it can hold? [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ______ gallons /16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ______ gallons /22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ______ gallons /28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: ______ gallons /34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ______ /40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8
/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ______ /45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8
/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ______ /50-53

T11. What types of repairs were done to this tank?

REPAIRS: ______ /54-55
______
______ /56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

		YES	NO
a.	Leaded gasoline	1	2
b.	Unleaded gasoline	1	2
c.	Diesel fuel	1	2
d.	Aviation fuel	1	2
e.	Gasohol	1	2
f.	Other [SPECIFY]: ______	1	2

______
/58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2
/66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ______ /67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: ______ 03
______
/70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ______ /72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ______ /76
______ 1
NO. 2
/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ______ 04
/79-80

T20. Does this tank have a manway or other means of being entered for internal inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ______ /83-86

T23. Has the tank ever been tested for leaks after it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8
/87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ______
______ /88-89
______
______ /90-91

03

TANK DESCRIPTION SHEET (Continued)

TANK NUMBER: ____________

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ______________________ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: ____________ 03

______________________ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8
/22

T28. In what year was the lining installed?

YEAR LINED: ________________ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______________ 05

______________________ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8
/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: __________ 05

______________________ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8
/32

T33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: _____ 05

______________________ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8
/35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: _____ 05

______________________ /36-37

T36. What is the name of the company that installed the tank?

INSTALLER: ______________________ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2
/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: __________ 04

______________________ /41-42

T39. How thick is the pavement?

THICKNESS: ______________ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /46-47

______________________ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: __________ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /51-52

______________________ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: ____________	1	2	/55

______________________ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8
/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 /59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: __________

______________________ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /59
DON'T KNOW 8

02

TANK DESCRIPTION SHEET

TANK NUMBER: ____________

T1. What is the capacity of this tank? (That is, what is the maximum number of gallons of fuel it can hold?) [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ________________ gallons /16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ________ gallons /22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ______________ gallons /28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: __________ gallons /34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ____________________ /40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8
/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ____________________ /45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8
/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ____________________ /50-53

T11. What types of repairs were done to this tank?

REPAIRS: ______________________________ /54-55

____

______________________________ /56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

	YES	NO
a. Leaded gasoline	1	2
b. Unleaded gasoline	1	2
c. Diesel fuel	1	2
d. Aviation fuel	1	2
e. Gasohol	1	2
f. Other [SPECIFY]: __________	1	2

______________________ /58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2
/66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ____________ /67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: __________ 03

______________________ /70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ____________________ /72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ____ /76

____________________ 1
NO. 2
/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ________________ 04
/79-80

T20. Does this tank have a manway or other means of being entered for internal inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ____________________ /83-86

T23. Has the tank ever been tested for leaks after it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8
/87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ______________________________

______________________________ /88-89

____

______________________________ /90-91

03

TANK
NUMBER: ______________

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ______________ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: __________ 03

______________ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8

/22

T28. In what year was the lining installed?

YEAR LINED: ______________ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______________ 05

______________ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8

/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: __________ 05

______________ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8

/32

T33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: ______ 05

______________ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8

/35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: ______ 05

____

T36. What is the name of the company that installed the tank?

INSTALLER: ______________ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2

/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: __________ 04

______________ /41-42

T39. How thick is the pavement?

THICKNESS: ______________ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /46-47

______________ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: __________ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /51-52

______________ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: __________	1	2	/55

______________ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8

/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 /59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: __________

______________ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /59
DON'T KNOW 8

02

TANK DESCRIPTION SHEET

TANK NUMBER: ____________

T1. What is the capacity of this tank? (That is, what is the maximum number of gallons of fuel it can hold?) [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ____________ gallons 16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ________ gallons 22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ____________ gallons /28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: ________ gallons /34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ____________ /40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8
/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ____________ /45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8
/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ____________ /50-53

T11. What types of repairs were done to this tank?

REPAIRS: ____________ /54-55

____

____________ /56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

	YES	NO
a. Leaded gasoline	1	2
b. Unleaded gasoline	1	2
c. Diesel fuel	1	2
d. Aviation fuel	1	2
e. Gasohol	1	2
f. Other [SPECIFY]: ________	1	2

____________ /58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2
/66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ____________ /67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: ________ 03

____________ /70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ____________ /72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ____ /76

____________ 1
NO. 2
/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ____________ 04
/79-80

T20. Does this tank have a manway or other means of being entered for internal inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ____________ 83-86

T23. Has the tank ever been tested for leaks after it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8
/87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ____________

____________ 88-89

____

____________ 90-91

TANK NUMBER: ______

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ______ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: ______ 03

______ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8
/22

T28. In what year was the lining installed?

YEAR LINED: ______ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______ 05

______ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8
/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: ______ 05

______ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8
/32

T33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: ______ 05

______ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8
35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: ______ 05

______ 36-37

T36. What is the name of the company that installed the tank?

INSTALLER: ______ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2
/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: ______ 04

______ /41-42

T39. How thick is the pavement?

THICKNESS: ______ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ______ /46-47

______ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: ______ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ______ /51-52

______ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: ______	1	2	/55

______ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8
/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: ______

______ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO 2 69
DON'T KNOW 8

02

TANK DESCRIPTION SHEET

TANK NUMBER: ____

T1. What is the capacity of this tank? (That is, what is the maximum number of gallons of fuel it can hold?) [ENTER CAPACITY IN GALLONS]

TANK DESIGN CAPACITY: ____ gallons
/16-21

T2. What is the average amount of fuel in this tank just before a delivery? (That is, what is the low point of the product level?) [ENTER QUANTITY IN GALLONS]

AVERAGE CONTENTS BEFORE DELIVERY: ____ gallons
22-27

T3. What is the average amount of fuel delivered to this tank? [ENTER QUANTITY IN GALLONS]

AVERAGE SIZE OF DELIVERY: ____ gallons
28-33

T4. What is the maximum number of gallons of fuel that has ever been stored in this tank? (That is, how full have you actually filled it?) [ENTER QUANTITY IN GALLONS]

LARGEST QUANTITY HELD IN TANK: ____ gallons
/34-39

T5. In what year was this tank installed?

YEAR OF INSTALLATION: ____
/40-43

T6. Was this tank new or used when it was installed? [CIRCLE ONLY ONE CODE]

NEW [SKIP TO T8]. 1
USED [GO ON TO T7]. 2
DON'T KNOW [SKIP TO T8] . . . 8
/44

T7. How old was this tank when it was installed?

AGE IN YEARS: ____
/45-47

T8. Is this tank scheduled for replacement or repair within the next 12 months? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/48

T9. Has this tank ever been repaired? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T10]. 1
NO [SKIP TO T12]. 2
DON'T KNOW [SKIP TO T12]. . . 8
/49

T10. In what year was this tank last repaired?

YEAR LAST REPAIRED: ____
/50-53

T11. What types of repairs were done to this tank?

REPAIRS: ____
/54-55

____
/56-57

T12. Which of the following fuel types were stored in this tank during the past 12 months? [CIRCLE ONE CODE FOR EACH FUEL TYPE]

		YES	NO
a.	Leaded gasoline	1	2
b.	Unleaded gasoline	1	2
c.	Diesel fuel	1	2
d.	Aviation fuel	1	2
e.	Gasohol	1	2
f.	Other [SPECIFY]: ____	1	2

____

58-65

T13. Does this tank have a pump?

YES [GO ON TO T14]. 1
NO [SKIP TO T18]. 2
66

T14. How many pumps are connected to this tank?

NUMBER OF PUMPS ____
/67-69

T15. Does this tank have a "suction" or a "submerged" (pressure) pump delivery system? [CIRCLE ONLY ONE CODE]

SUCTION 01
SUBMERGED 02
OTHER [SPECIFY]: ____ 03

____
/70-71

T16. How many dispensers (nozzles) are connected to this tank?

NUMBER OF NOZZLES: ____
72-74

T17. Do the product dispensers (nozzles) for this tank have meters to measure the total quantity of product that has been pumped from the tank? [CIRCLE ONLY ONE CODE]

YES 1
NO. 2
/75

T18. Is this tank attached to another tank by pipes or lines? [CIRCLE ONLY ONE CODE]

YES [PLEASE SPECIFY THE TANK NUMBER(S) OF THE CONNECTED TANK(S)] ____ /76

____ 1
NO. 2
/77-78

T19. How is this tank situated in relation to the water table? Is it: [CIRCLE ONLY ONE CODE]

Completely above the water table. . . . 01
Partially above and partially below the water table. 02
Or, is the top surface of the tank completely below the water table . . . 03
Other [SPECIFY]: ____ 04
/79-80

T20. Does this tank have a manway or other means of being entered for *internal* inspection? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T21]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/81

T21. Has the interior of the tank ever been inspected? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T22]. 1
NO [SKIP TO T23]. 2
DON'T KNOW [SKIP TO T23]. . . 8
/82

T22. When was the most recent internal inspection of this tank?

MOST RECENT INSPECTION: ____
/83-86

T23. Has the tank ever been tested for leaks *after* it was placed in service? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T24]. 1
NO [SKIP TO T26]. 2
DON'T KNOW [SKIP TO T26]. . . 8
87

T24. What test method was used to test the tank? (Please give the brand name of the test, if known, and describe the test procedure. If more than one method was used, describe all methods used.)

METHOD(S): ____

____
88-89

____

____
90-91

TANK DESCRIPTION SHEET (Continued)

TANK NUMBER: ____________

T25. In what year was the tank last tested by this/these methods?

YEAR LAST TESTED: ______________________ /16-19

T26. Of what material is this tank constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS-REINFORCED PLASTIC . 01
STEEL 02
OTHER [SPECIFY]: __________ 03

______________________ /20-21

T27. Is the inside of this tank lined? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T28]. 1
NO [SKIP TO T30]. 2
DON'T KNOW [SKIP TO T30]. . . 8

/22

T28. In what year was the lining installed?

YEAR LINED: ________________ /23-26

T29. Of what material is the liner constructed? [CIRCLE ONLY ONE CODE]

EPOXY-BASED RESINS. 01
FIBERGLASS REINFORCED PLASTIC . . . 02
ISOPHTHALIC POLYESTER-BASED RESINS. 03
POLYURETHANE-BASED RESINS 04
OTHER [SPECIFY]: ______________ 05

______________________ /27-28

T30. Is the outside of this tank coated? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T31]. 1
NO [SKIP TO T32]. 2
DON'T KNOW [SKIP TO T32]. . . 8

/29

T31. Of what material is the coating constructed? [CIRCLE ONLY ONE CODE]

FIBERGLASS/EPOXY. 01
ASPHALTIC MATERIAL. 02
URETHANE. 03
COAL TAR EPOXY. 04
OTHER [SPECIFY]: __________ 05

______________________ /30-31

T32. Is there secondary containment for this tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T33] 1
NO [SKIP TO T34] 2
DON'T KNOW [SKIP TO T34] 8

/32

T33. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall tank?. 04
or something else [SPECIFY]: ______ 05

______________________ /33-34

T34. Is there secondary containment for any equipment that is attached to this tank (such as pipes, pumps, valves, etc.)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T35] 1
NO [SKIP TO T36] 2
DON'T KNOW [SKIP TO T36] 8

/35

T35. Is this secondary containment a:

concrete basin?. 01
plastic-lined earth basin? 02
clay-lined basin?. 03
double-wall piping?. 04
or something else [SPECIFY]: ______ 05

______________________ /36-37

T36. What is the name of the company that installed the tank?

INSTALLER: ______________________ /38-39

T37. Is there a paved surface over the tank?

YES [GO ON TO T38] 1
NO [SKIP TO T40] 2

/40

T38. Is this pavement:

asphalt?. 01
concrete? 02
gravel? 03
other [SPECIFY]: __________ 04

______________________ /41-42

T39. How thick is the pavement?

THICKNESS: ________________ /43-45

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /46-47

______________________ 03

T40. What is the distance from the surface to the top of the tank?

DISTANCE TO SURFACE: __________ /48-50

[CIRCLE ONE]:
INCHES 01
FEET 02
OTHER [SPECIFY]: ________ /51-52

______________________ 03

T41. Does this tank have any of the following kinds of protection against corrosion? [CIRCLE ONLY ONE CODE FOR EACH ITEM]

		Yes	No	
a.	Passive cathodic protection (using sacrificial anodes)? . .	1	2	/53
b.	Cathodic protection using impressed current?.	1	2	/54
c.	Other [SPECIFY]: ____________	1	2	/55

______________________ /56-57

T42. Has this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES [GO ON TO T43] 1
NO [SKIP TO T44] 2
DON'T KNOW [SKIP TO T44] . . . 8

/58

T43. How was the leak detected and/or verified? [CIRCLE ALL THAT APPLY]

INVENTORY RECONCILIATION . . . 01 /59-60
ENVIRONMENTAL MONITORING . . . 02 /61-62
FACILITY INSPECTION. . . . . . 03 /63-64
TANK TESTING . . . . 04 /65-66
OTHER [SPECIFY]: __________

______________________ 05 /67-68

T44. Have the lines (piping) for this tank ever been found to be leaking? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /69
DON'T KNOW 8

B. OPERATING PRACTICES

04

B1. Do you (or another establishment employee) inventory the contents of your tank(s) by measuring the depth of the contents with a dipstick? [CIRCLE ONLY ONE CODE]

YES [GO ON TO B2]	1	/16
NO [SKIP TO B5]	2	

B2. How often do you inventory the tank contents? [CIRCLE ONLY ONE CODE]

TWICE DAILY	01	
DAILY	02	
WEEKLY	03	
EVERY TWO WEEKS	04	/17-18
MONTHLY	05	
OTHER [SPECIFY]: ____________________	06	

B3. Do you have a chart (or charts) that show how to convert the depth of the product in the tank(s) to gallons? [CIRCLE ONLY ONE CODE]

YES	1	/19
NO	2	

B4. Are the inventory (stick) readings recorded in a log or journal or other permanent record such as a daily inventory report? [CIRCLE ONLY ONE CODE]

YES	1	/20
NO	2	

B5. Do any of the underground motor fuel storage tanks at this establishment have <u>remote gauges</u> (either float or electronic) that show the quantity of product in the tank? [CIRCLE ONLY ONE CODE]

YES [GO ON TO B6]	1	/21
NO [SKIP TO B8]	2	

B6. How often do you (or another establishment employee) inventory the contents of your tank(s) by reading the remote gauge(s)? [CIRCLE ONLY ONE CODE]

TWICE DAILY	01	
DAILY	02	
WEEKLY	03	
EVERY TWO WEEKS	04	/22-23
MONTHLY	05	
OTHER [SPECIFY]: ____________________	06	

B7. Are the inventory (gauge) readings recorded in a log or journal or other permanent record such as a daily inventory report? [CIRCLE ONLY ONE CODE]

YES	1	/24
NO	2	

B8. Do the product dispensers for your tank(s) have meters that record the total quantity of fuel that has been pumped from the tank(s)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO B9]	1	/25
NO [SKIP TO B16]	2	

B9. Do you (or another establishment employee) check and record the dispenser meter readings for the tank(s)?

YES [GO ON TO B10]	1	/26
NO [SKIP TO B12]	2	

B10. How often do you check and record the dispenser meter readings? [CIRCLE ONLY ONE CODE]

TWICE DAILY	01	/27-28
DAILY	02	
WEEKLY	03	
EVERY TWO WEEKS	04	
MONTHLY	05	
OTHER [SPECIFY]: ______________________	06	

B11. Are the dispenser meter readings recorded in a log or journal or other permanent record such as a daily inventory report? [CIRCLE ONLY ONE CODE]

YES	1	/29
NO	2	

B12. Do you (or another establishment employee) check the accuracy of your dispenser meters to make sure the meters correctly measure the amount pumped? [CIRCLE ONLY ONE CODE]

YES	1	/30
NO	2	

B13. Does anyone other than you or another establishment employee (such as a state or county Weights and Measures official) check the accuracy of your dispenser meters? [CIRCLE ONLY ONE CODE]

YES	1	/31
NO	2	

314. How often is the accuracy of your dispenser meters checked? [CIRCLE ONLY ONE CODE]

IF THE ACCURACY OF YOUR DISPENSER METERS IS NEVER CHECKED, CHECK HERE ☐ AND SKIP TO B16. /32

DAILY	01	
WEEKLY	02	
EVERY TWO WEEKS	03	
MONTHLY	04	/33-34
ANNUALLY	05	
OTHER [SPECIFY]: ____________________	06	

B15. About how often is it necessary to recalibrate (adjust the gauge of) your dispenser meters? [CIRCLE ONLY ONE CODE]

DAILY	01	
WEEKLY	02	
EVERY TWO WEEKS	03	
MONTHLY	04	/35-36
ANNUALLY	05	
OTHER [SPECIFY]: ____________________	06	

B16. Approximately how often do you receive deliveries to your tank(s)?

FREQUENCY: ____________________ /37-39

[CIRCLE ONE]:

PER WEEK	01	
PER MONTH	02	/40-41
OTHER [SPECIFY]: ____________________ ____________________	03	

B17. Are inventory (stick or remote gauge) readings of your tank(s) taken <u>immediately before</u> receiving a fuel delivery? [CIRCLE ONLY ONE CODE]

YES	1	/42
NO	2	

B18. Are inventory (stick or remote gauge) readings of your tank(s) taken immediately after receiving a fuel delivery? [CIRCLE ONLY ONE CODE]

YES	1	/43
NO	2	

B19. Is the quantity delivered to each tank recorded in a log or journal or other permanent record such as a daily inventory report? [CIRCLE ONLY ONE CODE]

YES	1	/44
NO	2	

B20. Do you reconcile your inventory (stick or remote gauge) readings with your book inventory (meter readings and deliveries)?

YES [GO ON TO B21]	1	/45
NO [SKIP TO B22]	2	

B21. How often do you reconcile your tank inventory (stick or remote gauge) readings with your book inventory (meter readings and deliveries)? [CIRCLE ONLY ONE CODE]

DAILY	01	
WEEKLY	02	
EVERY TWO WEEKS	03	
MONTHLY	04	/46-47
ANNUALLY	05	
OTHER [SPECIFY] ____________________	06	

B22. Do you ever use water-finding paste to check the water level in the bottom of your tank(s)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO B23]	1	/48
NO [SKIP TO C1]	2	

B23. How often do you use water-finding paste to check the water level in the bottom of your tank(s)? [ENTER FREQUENCY AND CIRCLE UNIT CODE]

FREQUENCY: ____________________ /49-51

[CIRCLE ONE]:

PER DAY	01	
PER WEEK	02	
PER MONTH	03	/52-53
PER YEAR	04	
OTHER [SPECIFY]: ____________________ ____________________	05	

C. OPERATING HISTORY

05

C1. Have any tanks at this establishment ever been replaced? [CIRCLE ONLY ONE CODE]

YES [GO ON TO C2]. . . . . 1 /16
NO [SKIP TO C4]. 2
DON'T KNOW [SKIP TO C4]. 8

C2. How many tanks have been replaced?

NUMBER REPLACED: ______________________ /17-19

C3. Please answer the following questions about each tank that has been replaced, beginning with the tank that was replaced most recently. [SPACE HAS BEEN PROVIDED FOR UP TO FOUR TANKS. IF MORE THAN FOUR TANKS HAVE BEEN REPLACED, WRITE THE ANSWERS FOR THE ADDITIONAL TANKS ON A PLAIN SHEET OF PAPER.]

	First Tank	Second Tank	Third Tank	Fourth Tank
C3a. In what year was the (first/second/third) tank replaced?	________ (year) /20-23	________ (year) /36-39	________ (year) /52-55	________ (year) /68-71
C3b. Why was the tank replaced? [CIRCLE ALL THAT APPLY FOR EACH TANK]				
a. Because it was leaking?. . . .	01	01	01	01
b. Because other tanks were being replaced at that time? . . .	02	02	02	02
c. Because it was no longer needed/in use?.	03	03	03	03
d. To increase storage capacity.	04	04	04	04
e. Or for some other reason? [SPECIFY]: .	05	05	05	05
	________ (specify) /24-35	________ (specify) /40-51	________ (specify) /56-67	________ (specify) /72-83

06

C4. Have any tanks at this establishment ever been removed without being replaced? [CIRCLE ONLY ONE CODE]

YES [GO ON TO C5]. 1
NO [SKIP TO C7]. . . . . 2 /16
DON'T KNOW [SKIP TO C7]. 8

C5. How many tanks have been removed without being replaced?

NUMBER REMOVED: ______________________ /17-19

C6. Please answer the following questions about each tank that has been removed without being replaced. [SPACE HAS BEEN PROVIDED FOR UP TO FOUR TANKS. IF MORE THAN FOUR TANKS HAVE BEEN REMOVED WITHOUT BEING REPLACED, WRITE THE ANSWERS FOR THE ADDITIONAL TANKS ON A PLAIN SHEET OF PAPER]

	First Tank	Second Tank	Third Tank	Fourth Tank
C6a. In what year was the (first/second/third) tank removed?	______ (year) /20-23	______ (year) /34-37	______ (year) /48-51	______ (year) /62-65
C6b. Why was the tank removed? [CIRCLE ALL THAT APPLY FOR EACH TANK]				
a. Because it was leaking?. . . .	01	01	01	01
b. Because other tanks were being removed at that time? . . .	02	02	02	02
c. Because it was no longer needed/in use?.	03	03	03	03
d. Or for some other reason [SPECIFY]: .	04 ______ (specify) /24-33	04 ______ (specify) /38-47	04 ______ (specify) /52-61	04 ______ (specify) /66-74

07

C7. Have any tanks at this establishment been abandoned in place? ("Abandoned in place" means that the tank is no longer in use but has not been removed.) [CIRCLE ONLY ONE CODE]

YES [GO ON TO C8]. 1
NO [SKIP TO D1]. . . . . 2 /16
DON'T KNOW [SKIP TO D1]. 8

C8. How many tanks have been abandoned?

NUMBER ABANDONED: ____________________ /17-19

C9. Please answer the following questions about each tank that has been abandoned in place. [SPACE HAS BEEN PROVIDED FOR UP TO FOUR TANKS. IF MORE THAN FOUR TANKS HAVE BEEN ABANDONED IN PLACE, WRITE THE ANSWERS FOR THE ADDITIONAL TANKS ON A PLAIN SHEET OF PAPER]

	First Tank	Second Tank	Third Tank	Fourth Tank
C9a. In what year was the (first/second/third) tank abandoned?	________ (year) /20-23	________ (year) /44-47	________ (year) /68-71	________ (year) /92-95
C9b. Why was the tank abandoned? [CIRCLE ALL THAT APPLY FOR EACH TANK]				
a. Because it was leaking	01	01	01	01
b. Because it was no longer needed/in use	02	02	02	02
c. Or for some other reason [SPECIFY]: .	03	03	03	03
	________ (specify) /24-31	________ (specify) /48-55	________ (specify) /72-79	________ (specify) /96-103
C9c. How was the tank abandoned? [DESCRIBE PROCEDURE, OR CIRCLE ALL THAT APPLY]				
a. Tank was drained. .	01	01	01	01
b. Tank was washed . .	02	02	02	02
c. Tank was cut open .	03	03	03	03
d. Tank was sand filled.	04	04	04	04
e. Tank was cement filled.	05	05	05	05
f. Other [SPECIFY]: ________________ ________________	________ (specify) /32-43	________ (specify) /56-67	________ (specify) /80-91	________ (specify) /104-115

D. PERMITS AND LICENSES

08

D1. Were you required to obtain a special building permit or license in order to have your tank(s) installed? [CIRCLE ONLY ONE CODE]

YES.	1	/16
NO	2	
DON'T KNOW	8	

D2. Are you required to maintain a special permit or license to store flammable or hazardous material at your establishment? (Often these permits are called Hazardous Use or Hazardous Materials permits, and are issued by the state, county, or local fire marshal.) [CIRCLE ONLY ONE CODE]

YES.	1	/17
NO	2	
DON'T KNOW	8	

E. INSTALLATION

E1. What type of fill was used to backfill around and over the tank(s)? [CIRCLE ONLY ONE CODE]

a. Clean sand (with no large rock)?	01	
b. Pearock or pea gravel?	02	
c. Soil from the excavation?	03	/18-19
d. Or some other kind of fill [SPECIFY]: .	04	

____

____

E2. (Is the tank/are any of the tanks) installed with the bottom resting on or in a concrete or packed earth pad? [CIRCLE ONE CODE FOR EACH ITEM]

	Yes	No	
a. A concrete pad or cradle?	1	2	/20
b. A packed earth pad?	1	2	/21

E3. Are any of the tanks strapped to a concrete pad? [CIRCLE ONLY ONE CODE]

YES.	1	
NO	2	/22
DON'T KNOW	8	

E4. What is the shortest distance between any of your tanks and any neighboring underground tank or other solid underground structure (such as a basement wall, sewer, or utility vault)? [ENTER DISTANCE AND CIRCLE UNIT CODE]

SHORTEST DISTANCE FROM UNDERGROUND STRUCTURE: ________________ /23-28

[CIRCLE ONE]:

INCHES.	01	
FEET.	02	/29-30
OTHER [SPECIFY]: ____________________	03	

____

F. PROTECTION

09

F1. Has any type of special equipment or materials been installed to prevent external corrosion of the tank(s)? [CIRCLE ONLY ONE CODE]

YES [SPECIFY AND GO ON TO F2]: ________ /16

________ 1

NO [SKIP TO F3] . . . . 2 /17-18

DON'T KNOW [SKIP TO F3]. 8

F2. How often do you inspect your external corrosion protection system? [ENTER FREQUENCY AND CIRCLE UNIT CODE]

IF YOU NEVER INSPECT THE EXTERNAL CORROSION PROTECTION SYSTEM, CHECK HERE ☐ AND SKIP TO F3. /19

FREQUENCY OF INSPECTION: ________ /20-22

[CIRCLE ONE]:

PER DAY 01

PER WEEK. 02

PER MONTH . . . . 03 /23-24

PER YEAR. 04

OTHER [SPECIFY]: ________ 05

____

F3. Since you began using the tank(s), have you ever had the tank(s) completely drained and cleaned out? [CIRCLE ONLY ONE CODE]

YES. 1 /25

NO 2

F4. Does the tank system have a continuous electronic monitoring system to detect tank leakage? [CIRCLE ONLY ONE CODE]

YES [GO ON TO F5]. . . . . 1 /26

NO [SKIP TO F6] 2

F5. How often is the electronic monitoring system inspected for maintenance? [CIRCLE ONLY ONE CODE]

a. Annually?	01	
b. Twice a year?	02	
c. Three or four times a year?	03	/27-28
d. Or at some other interval? [SPECIFY]: ______________________________	04	

____

F6. Have pressure piping (or line) leak detectors been installed at this establishment to detect leaks in the piping (lines)? [CIRCLE ONLY ONE CODE]

YES [GO ON TO F7]	1	
NO [SKIP TO G1]	2	/29
DON'T KNOW [SKIP TO G1]	8	

F7. How frequently are the pressure piping leak detectors tested to make sure they are operating correctly?

IF THE PRESSURE PIPING LEAK DETECTORS ARE NEVER TESTED, CHECK HERE ☐ AND SKIP TO QUESTION G1. /30

FREQUENCY: ______________________________ /31-33

[CIRCLE ONE]:

PER DAY	01	
PER WEEK	02	
PER MONTH	03	/34-35
PER YEAR	04	
OTHER [SPECIFY]: ____________________	05	

F8. Have the pressure piping leak detectors ever given false leak signals? [CIRCLE ONLY ONE CODE]

YES	1	
NO	2	/36
DON'T KNOW	8	

F9. Have the pressure piping leak detectors ever detected actual leaks in the piping system? [CIRCLE ONLY ONE CODE]

YES	1	
NO	2	/37
DON'T KNOW	8	

G. INFORMATION NEEDS

10

G1. Have any of the companies from whom you receive your fuel products asked you to keep inventory records (dipstick readings, meter readings and delivery records) for your tank(s)? [CIRCLE ONLY ONE CODE]

YES. 1
NO . . . . 2 /16

G2. Has anyone ever given you training or explanatory literature about any of the following topics? [CIRCLE ONE CODE FOR EACH ITEM. IF YOU HAVE RECEIVED INFORMATION OR TRAINING, PLEASE INDICATE FROM WHOM]

Type of Training	Did you receive?		If "Yes," from whom?	
	YES	NO		
a. Keeping inventory records..................	1	2	____________ ____________	/17-19
b. Doing inventory reconciliation calculations.............................	1	2	____________ ____________	/20-22
c. Measuring the quantity of product in a tank using a dipstick and conversion chart..........................	1	2	____________ ____________	/23-25
d. Checking pump meter accuracy..............	1	2	____________ ____________	/26-28
e. Line leak detection and testing...........	1	2	____________ ____________	/29-31
f. Tank or line leak prevention..............	1	2	____________ ____________	/32-34
g. Tank tightness testing methods............	1	2	____________ ____________	/35-37
h. Leak monitoring methods (such as observation wells)........................	1	2	____________ ____________	/38-40

G3. If you found out that (your tank/one of your tanks) was leaking, would you probably: [CIRCLE ONLY ONE CODE]

a.	Replace it with another tank	01	/41-42
b.	Line it and continue to use it	02	
c.	Abandon it in place.	03	
d.	Or something else [SPECIFY]: ______________________________	04	

____

G4. How much do you expect it would cost you to:

a.	Replace a tank?	$______	/43-48
b.	Line a tank?.	$______	/49-54
c.	Abandon a tank in place?	$______	/55-60

G5. Do you have an insurance policy that covers you against damage to people or property caused by sudden spills of motor fuel? [CIRCLE ONLY ONE CODE]

YES.	1	/61
NO	2	

G6. Do you have an insurance policy that covers you against damage to people or property resulting from non-sudden spills (including leaks) of motor fuel? [CIRCLE ONLY ONE CODE]

YES.	1	/62
NO	2	

TANK TO DISPENSER METER FUEL LINE CONNECTIONS

<u>Instructions:</u> Mark (X) in each block for which there is fuel line (pipe) connection from the tank to the dispenser meter. (If more tanks than spaces, use additional sheets.)

Disp. Meter Number	Tank Number and Product							
	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8
M-1								
M-2								
M-3								
M-4								
M-5								
M-6								
M-7								
M-8								
M-9								
M-1-								
M-11								
M-12								
M-13								
M-14								
M-15								
M-16								
M-17								
M-18								
M-19								
M-20								

Does the facility have a leak monitoring system (for tanks or piping) that is <u>not</u> electronic (such as observation wells)?

YES 1
NO 2

If YES, describe ____

Site Observations Recording Sheet

Site Code Label ____________________

Date __________

	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
Size of fill pipe (I.D.)						
Drop Tube (permanent or removable)						

- -

Site Code Label ____________________

Date __________

	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
Size of fill pipe (I.D.)						
Drop Tube (permanent or removable)						

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OMB No.: 2070-0037
Expires: December 31, 1985

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNDERGROUND STORAGE TANK SURVEY

LABEL VERIFICATION

MAILING ADDRESS: Verified? ... ☐

(ESTABLISHMENT NAME)

(ADDRESS)

(CITY/STATE/ZIP)

LOCATION ADDRESS: Verified? ... ☐

(ESTABLISHMENT NAME)

(ADDRESS)

(CITY/STATE/ZIP)

CONTACT NAME AND PHONE: Verified? ... ☐

Contact Name: ______________________ Contact Phone: ______________

A. Questionnaire Status: ______________

B. Inventory Status (CIRCLE ONE)

1 = Started
2 = Not Started
3 = Obtained
4 = Refused
5 = Other (SPECIFY) ______________

C. Can Test (CIRCLE ONE)

1 = No Meters
2 = Complete
3 = Partial Complete
4 = Refused
5 = Other (SPECIFY) ______________

D. Mapping (CIRCLE ONE)

1 = Complete
2 = Other (SPECIFY) ______________

E. Debriefing (CIRCLE ONE)

1 = Complete
2 = Other (SPECIFY) ______________

F. Confidentiality

1 = Form Enclosed
2 = Waived
3 = Other (SPECIFY) ______________

Conducted by:

WESTAT
An Employee-Owned Research Corporation
1650 Research Blvd. • Rockville MD 20850 • 301 251-1500

[IN YOUR TELEPHONE CALL TO SET UP THE APPOINTMENT, ASK R IF HE/SHE HAS COMPLETED THE QUESTIONNAIRE FORM AND BEGUN THE INVENTORY RECORDING. IF NOT, ENCOURAGE THE R TO DO SO.]

INTRODUCTION:

1. Hello, my name is (YOUR NAME), from Westat. [SHOW IDENTIFICATION CARD]. I'm here to conduct the interview with you about your underground storage tank(s). The other member of my team is ____________________________ from Midwest Research Institute. (He/She) will be drawing a map of the tank area(s) and taking some pictures of the surface area(s) over the tank(s).

   [IF YOU HAVE ANY OBSERVERS ON THIS INTERVIEW, INTRODUCE YOUR OBSERVERS. OTHERWISE, ASK IF THERE IS A PLACE WHERE YOU AND THE RESPONDENT CAN SIT DOWN AND GO THROUGH THE QUESTIONNAIRE. A SIDE-BY-SIDE SEATING ARRANGEMENT IS PREFERABLE, SINCE THIS ALLOWS YOU TO READ FROM THE RESPONDENT'S WORKING COPY OF THE QUESTIONNAIRE. IF THE R DOES NOT HAVE HIS SURVEY MATERIALS IN SIGHT, SUGGEST THAT HE OBTAIN THEM -- THAT THE INTERVIEW WILL BE MORE EFFICIENT, AND THAT YOU WILL HAVE TO RECORD CERTAIN INFORMATION ON HIS INVENTORY FORMS LATER ON.]

CONFIDENTIALITY:

2. As was mentioned in the letter and in the General Instructions, you can (claim/ask for) confidentiality for all or part of your responses to the questionnaire. The way you do this is by filling out the form that is in the General Instructions booklet. Have you decided to claim confidentiality for any of your answers?

   YES........ 1 [OBTAIN COMPLETED CONFIDENTIALITY FORM FROM RESPONDENT. PUT ID STICKER ON TOP OF FORM.]
   NO......... 2

[BEGIN INTERVIEW, READING QUESTIONS, ITEM-BY-ITEM. READ THROUGH THE TANK DESCRIPTION SHEET ONLY FOR THE FIRST TANK. FOR THE SECOND AND FOLLOWING TANKS, READ THE QUESTION NUMBERS AND/OR ABBREVIATED QUESTIONS.]

INVENTORY RECORDS:

3. Next, we need to review your inventory records. The General Instructions booklet discussed keeping inventory records for each of your tanks. Have you started to keep these records yet?

   YES........ 1 (GO TO 4)
   NO......... 2 (GO TO 5)

4. (IF YES): That's great! Here is a postage paid envelope in which to send the completed inventories to Westat. A Westat interviewer will be calling you in a few weeks to check with you on any problems you might be having with the inventories. While I am here, I need to review your inventory sheets and initial them. [IF NECESSARY, PROBE: If I could take a look at them now, I would appreciate it.] [IF THE TANK(S) DISPENSER(S) ARE METERED]: I will also need to record the results of my metering can tests of the dispenser meters on the inventory sheets for each tank. (GO TO 8)

5. (IF NO): Is there any reason why you have not started the inventories?

   YES........ 1 SPECIFY: ____
   ____ (GO TO 6)
   NO......... 2 (GO TO 6)

6. Will you be able to start the inventories today?

   YES........ 1 (GO TO 7)
   NO......... 2 [PROBE FOR WHEN THEY WILL BEGIN:
   ______________________________] (GO TO 7)
   REFUSED.... 7 (TERMINATE)
   IMPOSSIBLE. 9 [SPECIFY WHY: ________________
   ______________________________] (TERMINATE)

7. Here is a postage paid envelope in which to send the completed inventories to Westat.

8. When we receive your inventory(ies) they will be computerized and run through a computer program that checks for gains and losses that can't be accounted for, such as over- and under-deliveries, theft or pilfering, or leakage. We will let you know the results of that computer analysis.

DISPENSER METER ACCURACY CHECKS:

We have found in the past that a major problem in analyzing inventory records is that some dispenser meter readings are just slightly inaccurate. Often these meter errors show up in the computer analysis as small leaks. For that reason, we are checking out the accuracy of all dispenser meters, using a 5-gallon meter testing can.

Our accuracy checking procedure is the same procedure that is used by the agencies that certify meter accuracy. We will not be adjusting your meters if we find that they are misreading. What we will do is record the amount of product pumped intgo the can according to the dispenser meter, and record the amount in the metering can according to the gauge on the can. I'll need to record this on your inventory sheets as well as my copy of the questionnaire. The information will be fed into the computer program to correct for metering error in the results.

We will be pumping five gallons of product into the test can from each dispenser that has its own meter. We will then be pouring the five gallons of product back into the tank from which it was pumped. IF R HAS BEGUN INVENTORY: I will need to record the returned product as a "delivery" to the tank on your inventory sheet. FOR THE FIRST MEASUREMENT: First, I need to wet the inside of the can with about a gallon of product, and pour it back into its tank.

MAKE SURE YOU WILL BE ABLE TO RETURN THE PRODUCT TO THE TANK BEFORE YOU BEGIN PUMPING. DO ALL THE METERS FOR A TANK BEFORE MOVING ON TO THE NEXT PRODUCT TYPE. AFTER ALL OF THE TANKS ARE DONE, WASH THE CAN OUT WITH DETERGENT AND WATER, AND DRY IT AS COMPLETELY AS POSSIBLE.

DEBRIEFING:

To be completed immediately after leaving the site.

D1. Did R have the questionnaire completed?

YES........ 1
NO........ 2

D2. Did R have the inventory sheets started?

YES........ 1 (GO TO D3)
NO......... 2 (GO TO D4)

D3. Did R have errors or problems in the completed parts of the inventory?

YES........ 1 (DESCRIBE: ______________________________)
NO......... 2

D4. Did R understand inventory process?

YES........ 1
NO......... 2

D5. Did R understand most/all of the questions in the questionnaire?

YES........ 1
NO......... 2

D6. Was R:

	YES	NO
a. cooperative?...........................	1	2
b. hostile?...............................	1	2
c. guessing a lot?........................	1	2
d. Other (SPECIFY) ________________		
______________________________	1	2

D7. Was it necessary to talk to more than one R to obtain all required information?

YES........ 1
NO......... 2

D8. Comments: ____

____

TIME BEGAN: __________ A.M.
P.M.

TIME ENDED: __________ A.M.
P.M.

RECORD OF CALLS

ATTEMPT NUMBER	DAY	TIME	RESULT CODE	COMMENTS/PROBLEMS
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		
		am pm		

RESULT CODES

PRELIMINARY RESULT CODES

1 APPOINTMENT
2 RESPONDENT NOT AVAILABLE
3 RESPONDENT NOT LOCATED
4 RESPONDENT ILL
5 REFUSAL/BREAKOFF
6 RESPONDENT BROKE APPOINTMENT
7 LANGUAGE PROBLEM
8 OTHER
9 OUT-OF-SCOPE

FINAL - MAIL TO SUPERVISOR

11 COMPLETE
12 PARTIAL COMPLETE
13 ESTABLISHMENT CANNOT BE LOCATED
14 RESPONDENT UNAVAILABLE
15 REFUSAL/BREAKOFF
16 RESPONDENT AVOIDING INTERVIEW
17 LANGUAGE PROBLEM: NO INTERPRETER
18 NO TANKS
19 OUT OF PSU (MOVED)
20 OUT OF BUSINESS (CLOSED)
99 OTHER (SPECIFY) ______________

____

INSTRUCTIONS

PREPARATIONS FOR TANK TESTING

1. If you are not responsible for making the following testing arrangements, please notify those who are as soon as possible. Please notify other persons who may be involved, including the tank owner and those at your firm's or regional offices.

2. Immediately contact your fuel supplier or distributor to make arrangements for filling your tanks. Explain any tank filling problems to the test coordinator from Midwest Research Institute (MRI) when he calls.

3. Fill any business vehicles before the fuel drop off. As necessary, make arrangements for alternate sources of fuel for those vehicles on the test day.

4. Fuel delivery must be finished before 8:00 a.m. of the test day. If the test crew has to wait for fuel drop off, it means that testing will not be finished until later that evening.

5. Completely fill each tank until the fuel level comes up into neck of the fill pipe. Use your tank dipsticks to determine when the tanks are "full": the fuel depth, as measured by the dipstick, should equal the tank diameter. (In many tanks, you can see when the fuel reaches the fill pipe neck. However, for tanks with drop tubes, you must use the dipstick to know when it is full.) Testing cannot be done if the tanks are not completely full.

6. Once filled, the tanks cannot be used until testing is complete. Make arrangements to keep the tanks out of service. Your business does not need to be closed during this time, but the tanks must remain inactive.

FINAL CHECKLIST

- ☐ Notify responsible individuals.
  - ☐ Owner
  - ☐ Main or regional office
  - ☐ Others
- ☐ Contact supplier or distributor
- ☐ Fill business vehicles before filling tanks
- ☐ Fill tanks before 8:00 a.m. on test day
- ☐ Fill tanks completely
- ☐ Arrange to keep tanks out of service

ENVIRONMENTAL CONDITIONS DATA SHEET

Site Code Label ____

Date __________________________ Tank No. ______________

Test Firm ______________________________________

Test Team ______________________________________

	Temperature °F				
Time	Barometric Pressure	Surface	Ambient	Subsurface	Comments

Climatic conditions.

TEMPERATURE PROFILE DATA

Site Code Label ______________________________

Test Team ______________________ Date ____________

Test Crew ______________________ Tank No. __________

START TIME

	D	U	D	U	D	U	D

END TIME

Figure 3

Site Diagram and Detail Diagram Sheet

Site Code Label

Map # ______________________________ Test Firm ____________________

Test Team ____________________________ Date ______________________

Sketch Area and Dimensions

PICTURE DESCRIPTION

Site Code Label

Team ______________________ Date ____________

Picture No.	Description
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Critical Features Data Sheet

Site Code Label

Team ______________________________ **Date** ____________________

Tank No.	Type of Product	Number of Dispensors According to Product	Size of Tank	Size of Fill Pipe	Size of Gauge Pipe	Size of Stick Pipe	Size of Vent Pipe	Drop Tube Permanent, Removable	Delivery System Pressure, Suction	Pump Pit If Present	Depth of Tank From Grade	Surface Over Tank	Electrical Power Outlets	Powerlines Overhead	Waterways

Site Code Label

Team ______________________________ Date _________________

EDIT CHECKLIST

☐ Site code label on all pages.

☐ Be sure all maps are numbered sequentially.

☐ Photographs of critical parameters.

☐ Site code labels on photographs and filed in notebook.

☐ Check to see that all data sheets are filled our correctly.

SIMULATED LEAK TEST
VOLUME DATA

Site Code Label

Date ______________________

Tank No. __________________

Test Team ____________________________________

Test Firm ____________________________________

Volume, g				
Time	Bottle No.	Final Wt.	Tare Wt.	Total Wt.

Specific Gravity:
Temperature:

SIMULATED LEAK DATA FORM
LEAKING UNDERGROUND STORAGE TANK

Site Code Label

Test Crew ______________________________ Date _______________ Tank No. ________

Test Team ____

Rotameter No.	Rotameter Setting mm	Nominal Rate gph	Start Time Clock	End Time Hour	Elapsed Time gms	Measured Volume gph	Calculated Rate

Petro Tite
TANK TESTER

HEATH CONSULTANTS
100 TOSCA DRIVE
P.O. BOX CS-200
STOUGHTON, MA. 02072-9066
(617) 344-1400

14. ____
Name of Supplier, Owner or Dealer — Address No. and Street(s) — City — State — Date of Test

15. TANK TO TEST

______________________ Identity by position

______________________ Brand and Grade

16. CAPACITY

Nominal Capacity ______________ Gallons

By most accurate capacity chart available ______________ Gallons

Is there doubt as to True Capacity? ☐
See Section 'DETERMINING TANK CAPACITY'

From
☐ Station Chart
☐ Tank Manufacturer's Chart
☐ Company Engineering Data
☐ Charts supplied with petro tite
☐ Other ______________

17. FILL-UP FOR TEST

Stick Water Bottom before Fill-up ______________" to ⅛ in. ______________ Gallons

	Stick Readings to ⅛ in.	Gallons	Total Gallons ea. Reading
Inventory			
Fill up. STICK BEFORE AND AFTER EACH COMPARTMENT DROP OR EACH METERED DELIVERY QUANTITY			
Tank Diameter — Product in full tank (up to fill pipe)			

18. SPECIAL CONDITIONS AND PROCEDURES TO TEST THIS TANK

See manual sections applicable. Check below and record procedure in log (26).

☐ Water in tank ☐ High water table in tank excavation ☐ Line(s) being tested with LVLLT

VAPOR RECOVERY SYSTEM
☐ Stage I
☐ Stage II

19. TANK MEASUREMENTS FOR TSTT ASSEMBLY

Bottom of tank to Grade* .... ______________"
Add 30" for 4" L .... ______________"
Add 24" for 3" L or air seal .... ______________"
Total tubing to assemble Approximate .... ______________"

20. EXTENSION HOSE SETTING

Tank top to grade* .... ______________"
Extend hose on suction tube 8" or more below tank top .... ______________"

*If Fill pipe extends above grade, use top of fill.

21. TEMPERATURE/VOLUME FACTOR (a) TO TEST THIS TANK

Is Today Warmer? ( ) Colder? ( ) ___°F Product in Tank ___°F Fill-up Product on Truck ___°F Expected Change (+ or −)

22. Thermal-Sensor reading after circulation ______________ digits ______________°F Nearest

23. Digits per °F in range of expected change ______________ digits

24. ______________ total quantity in full tank (16 or 17) × ______________ coefficient of expansion for involved product = ______________ volume change in this tank per °F gallons

25. ______________ volume-change per °F (24) ÷ ______________ Digits per °F in test Range (23) = ______________ Volume change per digit. Compute to 4 decimal places. This is test factor (a)

26. LOG OF TEST PROCEDURES			30. HYDROSTATIC PRESSURE CONTROL		31. VOLUME MEASUREMENTS RECORD TO .001 GAL.			34. TEMPERATURE COMPENSATION USE FACTOR (a)			38. NET VOLUME CHANGES EACH READING	39. ACCUMULATED CHANGE
27. DATE	28. Record details of setting up and running test. (Use full length of line if needed.)	29. Reading No.	Standpipe Level in Inches		32. Product in Graduate		Product Replaced (−)	35. Thermal Sensor Reading	36. Change Higher + Lower − (c)	37. Computation (c) × (a) = Expansion + Contraction −	Temperature Adjustment	At High Level record Total End Deflection
TIME (24 hr.)			Beginning of Reading	Level to which Restored	Before Reading	After Reading	Product Recovered (+)				Volume Minus Expansion (+) or Contraction (−) #33(V) − #37(T)	At Low Level compute Change per Hour NFPA criteria

Data Chart for Tank System Tightness Test

petro Tite
TANK TESTER

PLEASE PRINT

1. OWNER Property ☐ Tank(s) ☐

Name Address Representative Telephone

Name Address Representative Telephone

2. OPERATOR

Name Address Telephone

3. REASON FOR TEST (Explain Fully)

4. WHO REQUESTED TEST AND WHEN

Name Title Company or Affiliation Date

Address Telephone

5. WHO IS PAYING FOR THIS TEST?

Company, Agency or Individual Person Authorizing Title Telephone

Billing Address City State Zip

Attention of: Order No. Other Instructions

6. TANK(S) INVOLVED

Identify by Direction	Capacity	Brand/Supplier	Grade	Approx. Age	Steel/Fiberglass

7. INSTALLATION DATA

Location	Cover	Fills	Vents	Siphones	Pumps
North inside driveway, Rear of station, etc.	Concrete, Black Top, Earth, etc.	Size, Titefill make, Drop tubes, Remote Fills	Size, Manifolded	Which tanks?	Suction, Remote, Make if known

8. UNDERGROUND WATER

Depth to the Water table ________________ "

Is the water over the tank? ☐ Yes ☐ No

9. FILL-UP ARRANGEMENTS

Tanks to be filled ______ hr. ________ Date Arranged by ________________

Name Telephone

Extra product to "top off" and run TSTT. How and who to provide? Consider NO Lead.

Terminal or other contact for notice or inquiry ________________

Company Name Telephone

10. CONTRACTOR, MECHANICS, any other contractor involved

11. OTHER INFORMATION OR REMARKS

Additional information on any items above. Officials or others to be advised when testing is in progress or completed. Visitors or observers present during test etc.

12. TEST RESULTS

Tests were made on the above tank systems in accordance with test procedures prescribed for petro Tite TANK TESTER as detailed on attached test charts with results as follows:

Tank Identification	Tight	Leakage Indicated	Date Tested

13. CERTIFICATION

This is to certify that these tank systems were tested on the date(s) shown. Those indicated as "Tight" meet the criteria established by the National Fire Protection Asociation Pamphlet 329.

Date

Serial No. of Thermal

Technicians

Testing Contractor or Company. By: Signature

Address

F-97

Double Check
COMPANY INCORPORATED
8614 PROSPECT KANSAS CITY, MO. 64130
PHONE (816) 921-5832

DATE OF TEST ____________
JOB # ____________

LIQUID VOLUMETRIC LINE LEAK TEST

1 LOCATION: ____________ Street No. and/or Corner ____________ City ____________ State ____________ Telephone No.

2 OWNER: ____________ Name ____________ Address ____________ Representative ____________ Position ____________ Telephone No.

3 OPERATOR: ____________ Name ____________ Dealer, Mgr. or Other ____________ Address (If different than Location) ____________ Telephone No.

4 REASON FOR TEST ____________

____

5 TEST REQUESTED BY: ____________ Name ____________ Position ____________ Order No. ____________ Billing Address

6 SPECIAL INSTRUCTIONS: ____________

7 CONTRACTOR OR COMPANY MAKING TEST
MECHANIC(S) NAME ____________

8 IS A K-M TANK TEST TO BE MADE WITH THIS LINE TEST? ☐ YES ☐ NO

9 MAKE AND TYPE OF PUMP OR DISPENSERS ____________

10 WEATHER ____________ TEMPERATURE IN TANKS ______ °F ______ °C COVER OVER LINES ____________ Concrete, Black Top, etc. APPROXIMATE BURIAL DEPTH ____________

11 IDENTIFY EACH LINE AS TESTED	12 TIME (MILITARY)	13 LOG OF TEST PROCEDURES, AMBIENT TEMPERATURE, WEATHER, ETC.	14 PRESSURE		15 VOLUME			16 TEST RESULTS
			psi OR kPa		BURETTE READING		NET CHANGE	CONCLUSIONS, REPAIRS AND COMMENTS
			BEFORE	AFTER	BEFORE	AFTER		

11 IDENTIFY EACH LINE AS TESTED	12 TIME (MILITARY)	13 LOG OF TEST PROCEDURES, AMBIENT TEMPERATURE, WEATHER, ETC.	14 PRESSURE		15 VOLUME			16 TEST RESULTS
			psi OR kPa		BURETTE READING		NET CHANGE	CONCLUSIONS, REPAIRS AND COMMENTS
			BEFORE	AFTER	BEFORE	AFTER		

SCALE: ☐ 1 PACE = 3 FT. PER SQUARE – THIS SHEET = 168' x 114'

☐ 2 PACES = 6 FT. PER SQUARE – THIS SHEET = 336' x 228'

17 SKETCH OF LOCATION

SHOW NORTH ↑N. STREETS, STATION BUILDING, TANKS, ISLANDS, PIPING (IF KNOWN, OR BEST INFO), PUMPS OR DISPENSERS (USE NUMBERS ONLY IF PERMANENTLY MARKED).

Kent-Moore
TOOL DIVISION
1501 SOUTH JACKSON STREET ■ JACKSON, MICHIGAN 49203
Telephone: 517/784-8561

Form No. U78-146 (J-28818-88)

Litho in U.S.A.

APPENDIX G

NATIONAL UNDERGROUND STORAGE TANK SURVEY
NATIONAL SAMPLE OF FARMS

I. INTRODUCTION AND SUMMARY

The survey of underground motor fuel storage tanks is designed to provide national estimates of the number of underground motor fuel storage tanks at the end use point and th number and percent of these tanks which leak. The survey desig defined three segments of the overall target universe of establishments with underground motor fuel storage tanks:

- Fuel establishments (gas stations and establishments i other fuel-related or fuel-using industries) which by the nature of their business are likely to have such tanks;
- Large establishments (20 or more employees) which by virtue of their size may have an underground motor fue storage tank; and
- Farms, of which over half have motor fuel storage capacity, but an unknown proportion store motor fuel underground.

The sample design for the survey is a two-stage cluster design. The first stage is survey locations, called Primary Sampling Units (PSUs) and consisting of counties or groups of counties. The contiguous United States was divided into six survey regions, based on rough similarity of soil type and condition, as defined in Figure G-1. Thirty-four PSUs were drawn, six from each region, except four PSUs were drawn from Region 5.

Figure G-1. Six regions for National Survey of Underground Storage Tanks

1 -- <u>Northeast</u>

Maine
New Hampshire
Vermont
Connecticut
Massachusetts
Rhode Island
New York
New Jersey
Pensylvania
Maryland
Delaware
Virginia
West Virginia
Washington, D. C.

2 -- <u>Southeast</u>

Kentucky
Tennessee
Arkansas
Louisiana
Mississippi
Alabama
Georgia
North Carolina
South Carolina
Florida

3 -- <u>Midwest</u>

Wisconsin
Minnesota
Iowa
Missouri
Illinois
Indiana
Ohio
Michigan

4 -- <u>Central</u>

North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas

5 -- <u>Mountain</u>

Montana
Wyoming
Idaho
Nevada
Utah
Colorado
Arizona
New Mexico

6 -- <u>Pacific</u>

Washington
Oregon
California

Among the three survey segments, fuel establishments and large establishments are both concentrated in the same areas, where the population is. Drawing a sample of PSUs which is optimal for both of these segments is therefore no problem, because they occur together. Farms, however, tend to be found in the opposite places, those with sparse population. So optimizing the design for farms is in direct opposition to optimizing the design for fuel establishments and large establishments. Since the fuel establishments are the major focus of the survey, accounting for about 800 of the approximately 920 expected establishments with underground motor fuel storage tanks, the sample of PSUs was optimized for fuel establishments by being drawn in proportion to the number of fuel establishments in each PSU. As noted above, the resulting sample of PSUs is <u>not</u> optimal for studying farms.

The second stage of sampling is the sample of establishments within the selected PSUs. Three sample frames (master lists) were developed for the 34 sampled PSUs -- one for fuel establishments, one for large establishments, and one for farms. Samples were drawn from each list:

- 1618 fuel establishments;
- 600 large establishments; and
- 600 farms.

These establishments were contacted to determine whether they were eligible for our survey; that is, whether they had underground motor fuel storage tanks. The eligibility rates were (approximately):

- 50 percent for fuel establishments;
- 15 percent for large establishment; and
- Less than 5 percent for farms.

This appendix discusses the national farm sample of 600 farms to be screened. Subsection II discusses the target universe of farms and describes the farm sampling frame on a national basis. The 1982 Census of Agriculture conducted by the Census Bureau is taken as the standard count of farms, and a list developed by the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture (USDA) is the sample frame used. For the nation, overall, this frame offers good coverage of the farm universe. Subsection III reviews the survey design with reference to the farm sample and compares Census figures with ASCS figures for the selected PSUs. In this subsection, it is seen that the coverage of farms by the frame is weak in some parts of the country. Section IV concludes the appendix with a discussion of the ratio-adjustment weighting method proposed to minimize total sampling error in the farm estimates.

II. TARGET UNIVERSE OF FARMS AND SAMPLING FRAME

A. Two Farm Data Sources

Two sources of information on farms were used in designing and conducting this survey. One is the 1982 Census of Agriculture (the most recent) conducted by the Bureau of the

Census. This source is used as the most reliable source of national statistics about farms. The second is the "1983 Deficiency Master File" developed by the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture (USDA), which is used as the list, or sampling frame, for farms.

The Census of Agriculture is a data collection and tabulation effort which is as inclusive as possible. The 1982 Census lists 2,240,976 farms in the U.S. A farm is defined by Census as "any place from which $1000 or more of agricultural products were sold or normally would have been sold during the Census year." Tables provide breakdowns of these farms by size of farm, value of sales, type of crop, etc., both nationally, by state and by county. Some of these figures are reviewed later in this section.

What the Census of Agriculture does not provide is a list of farms or farm operators in specific places. Thus, for an actual sampling frame we used the USDA/ASCS 1983 Deficiency File. This is a list of farms developed by the USDA containing about 1,942,000 listings (87 percent as many as the Census total). The original impetus for the development of the file was to provide a mechanism for payment distribution for the PIK (Payment-in-Kind) program for 1983. In 1983, the PIK program was so popular that USDA believes that almost everyone engaged in growing PIK program crops (which include various cash grains and upland cotton) applied for it, and hence is listed on the Deficiency File. Because they saw a chance to have a near-Census of farms on a data file, USDA made a special effort to also include listings of farms not eligible for the PIK program. The basic data were gathered by the ASCS county agents.

The official USDA/ASCS statistics indicate that of 2,018,000 farms known to the ASCS, 1,942,000 (or 96 percent) are listed on the Deficiency File. The ASCS definition of a farm is all of the land farmed under one operation.

Only about 57 percent of the farms listed on the Deficiency File (1,116,000 farms) are farms that are eligible for the PIK program. The remaining 43 percent of farms on the list are not eligible for the PIK program. Some portion of the ineligible farms are ineligible because they were not growing PIK program crops, others because they did not choose to apply for the PIK program. Because of the 96 percent coverage of farms known to them, ASCS believes the Deficiency File is a very complete list of farms in the U.S.

In exploring the universe of farms and comparing the two data sources, we take the 1982 Census of Agriculture as the primary source of information on the nation's farms. Although the ASCS total is less than the Census total, it is probable that the ASCS list is not simply a subset of the farms counted by the Census, but a partially overlapping list. This is due to the fact that the two lists are constructed by different organizations for different purposes, are based on different information, and have different definitions as for including and counting specific cases. However, we can get a summary of the nation's farms from the Census and a rough idea of the ASCS coverage of those farms.

B. Summary of the Target Universe Based on the 1982 Census of Agriculture

The figures presented here are taken from Vol. 1, Part 51, U.S. Summary and State Totals of the 1982 Census of Agriculture.

The first table lists total numbers of farms by size and sales categories.

It seems likely that farms with small acreage or low sales volume would be less likely to have underground motor fuel storage tanks and would also be less likely to be included on the ASCS file than large farms. Table G-1 indicates that a number of farms are quite small, with 8 percent of farms reported having one to nine total acres. Also, many farms have quite low sales figures. Nearly one-quarter of farms reported on had less than $2,500 in sales in 1982.

The Census also gives figures for storage of various fuels (although unfortunately for our survey, no question was asked as to whether the storage was underground). Table G-2 summarizes the storage capacity data for 1982.

This indicates that roughly half of all farms reported gasoline or gasohol storage, and about 40 percent reported diesel storage. The overlap of the two groups is not given but is presumably fairly high. However, the number of farms with substantial storage capacity is much less -- 2 percent reported 2,000 gallons or more diesel storage capacity, and 1 percent reported that much gas storage capacity. Taking 1,000 gallons or more as a cutoff, 7 percent of farms reported this much gasoline storage capacity and 8 percent reported this much diesel storage capacity.

In conclusion, based on the 1982 Census of Agriculture, there were about 2.2 million farms, of which 8 percent were smaller than 10 acres, one-quarter had less than $2,500 in sales for the year, and perhaps 10 percent have 1,000 gallons or more fuel storage capacity. This last assumes a substantial overlap between storers of gasoline and diesel fuel. If there is little

Table G-1. Farms by acreage and sales (1982 Census of Agriculture)

Total U.S. Farms			2,240,976
By acreage			
1 - 9			187,665
10 or more			2,053,311
10 - 49		449,252	
50 - 499		1,238,162	
500 - 1,999		301,320	
2,000 or more		64,577	
By sales			
Less than $2,500			536,327
$2,500 or more			1,702,973
$2,500 - $9,999		560,010	
$10,000 or more		1,142,963	
$10,000 - $99,999	840,583		
$100,000 - $499,999	274,580		
$500,000 or more	27,800		

(1,676 abnormal farms not reported by sales - institutional, research and experimental farms, and Indian reservations.)

Table G-2. **Fuel storage capacity, 1982***
(1982 Census of Agriculture)

Farms reporting fuel expenses	Gasoline and Gasohol	Diesel fuel
Storage capacity reported, farms	1,123,463	924,863
1,000's gallons	583,853	648,605
Farms with storage capacity of:		
1 - 499 gallons	616,650	471,646
500 - 999 gallons	352,925	262,902
1,000 - 1,999 gallons	136,455	140,896
2,000 or more gallons	17,433	49,419
Storage capacity reported as "no", farms	451,895	150,210
Storage capacity not reported, farms	422,083	245,380

*Includes above-ground tanks and containers, as well as underground tanks.

overlap, as many as 15 percent of farms may have 1,000 gallons or more motor fuel storage capacity.

C. Comparison of Census and Sample Frame

The sampling frame, the ASCS 1983 Deficiency File, is primarily a data base of farms rather than a source of statistics. Hence, we do not have extensive national or state statistics on this file. Nationally, we can compare the number of farms from Census (2,240,976) and the ASCS file (1,942,437), showing that the sample frame file has 87 percent as many farms as the Census. (Note that these are not necessarily completely a subset of the Census farms, as mentioned above.)

We also can compare total cropland acreage between the two data sources. The Census shows 445,362,028 acres of total cropland on 2,010,609 farms with cropland, while ASCS shows 443,850,049 acres of total cropland on its 1,942,437 farms. The ASCS definition of cropland is "tillable soil" -- the land does not have to have been planted, only to be suitable for planting. The Census definition includes three categories:

- Harvested cropland;
- Cropland use only for pasture or grazing; and
- Other cropland.

The two definitions appear to be quite similar.

<u>The sample frame thus covers 99.7 percent of the total cropland reported in the Census and has 96.6 percent as many farms as those reporting cropland in the Census</u>. It appears that farms with no cropland is an area of sparse coverage for the ASCS

list. The major categories of land in farms not included in total cropland are:

- Pasture and rangeland other than cropland and woodland pastured (418,264,264 acres);
- Woodland (87,088,255 acres); and
- Land in house lots, ponds, roads, etc. (36,082,032 acres).

So farms with pasture, rangeland or woodland and <u>no</u> cropland are more likely to be in the Census but not the ASCS list. However, in the Census 90 percent of farms listed had cropland, so farms with none are relatively rare.

Other types of farms which may tend to under-represented by the ASCS list (based on discussions with Tom Meyer of ASCS) would be growers of fruits and vegetables. Most farms grow more than one crop, and so many fruit or vegetable farms may also have a PIK-eligible crop or may be listed as an ineligible farm on the ASCS file. According to Census data, 69,109 (3.1%) of farms reported vegetables harvested for sale and 123,663 (5.5%) reported land in orchards. On a national basis, these farms do not represent a major portion of the target universe, although on a regional basis their proportion varies. These figures are presented as a way of assessing the potential for undercoverage, but we have no direct way of determining the ASCS coverage of these types of farms.

III. SAMPLE DESIGN FOR UST SURVEY, FARM SEGMENT

In this subsection we again review the survey sample design, emphasizing the aspects relevant to the farm sample. The design was a two-stage cluster design. The contiguous U.S. was divided into six survey regions, as presented in Figure G-1 shown earlier. The first stage of the sample was survey locations, known as Primary Sampling Units (PSUs). These PSUs consisted of counties or groups of counties and were chosen by region with probability proportional to number of fuel establishments. The second stage was the within-PSU selection of farms. Farms were selected from a sampling frame based on the ASCS list for the selected counties with within-PSU probabilities determined so that the overall probabilities of selection would be equal for all farms. We give more details in the following sections.

A. First Stage Sample of Survey Sites (PSUs)

The first stage in the two-stage sample design was of PSUs, which were counties or groups of counties. Within each region, six PSUs (four in the Mountain Region) were selected with probability proportional to their number of gas stations and fuel-related establishments. As discussed in Subsection I, this is the optimal design for studying fuel establishments -- the main focus of the survey.

Table G-3 shows some statistics on number of farms, by region, based on the 1982 Census of Agriculture. The first two columns give the total farms in each region and the corresponding expected sample size, by region, for an equal probability sample of 600 farms to be screened for underground motor fuel storage tanks. Regions 1, 5 and 6 have expected sample sizes of less than 100, with Regions 5 and 6 less than 50. Next, in column 3, we have used the inverse of the PSU probability of selection as a PSU weight and weighted the 1982 Census of Agriculture farm counts for the selected PSUs up to the regional level. By comparing these figures with column 1, we see that our sample of PSUs has considerable variance from the actual totals. As

Table G-3. Farm summary based on 1982 Census of Agriculture, all farms

Region[1]	Agriculture Census count	Expected farm sample[2]	Weighted count, sampled PSU's	Expected farm sampl
1-Northeast	222,099	60	123,714	36
2-South	548,926	147	283,226	82
3-Midwest	725,699	195	908,358	264
4-Central	464,680	125	494,029	144
5-Mountain	121,777	33	147,071	43
6-Pacific	152,630	41	104,164	30
Continental U.S. Total	2,235,811	601	2,060,562	599

[1] Regions are defined in Figure G-1.

[2] These farms are to be screened for the presence of underground m fuel storage tanks.

mentioned in Subsection II, this is due to the PSU sample selection being based on the number of fuel establishments, a measure inversely correlated with the number of farms.

Finally, column 4 gives the expected sample size based on the 1982 Agriculture Census counts for our PSUs. Regions 5 and 6 are still very low, and Regions 1 and 2 have a lower sample size than expected from the regional totals.

B. <u>ASCS List for Selected PSUs</u>

The actual sample was drawn from a sample frame based on the ASCS 1983 Deficiency File. This file was described in Subsection II above on a national basis. Here, we compare the ASCS file counts to the Census counts for our sampled PSUs and present some relevant Census figures on a regional basis. The actual sample frame used was a modification of the ASCS file, which we describe below, leading to the final sample sizes.

In Table G-4, the Census of Agriculture counts are compared with the ASCS file counts for the sampled PSUs on a region-by-region basis. The third column shows the percent coverage the ASCS file had. For the 76 counties in our 34 PSUs as a group, the ASCS file had 70 percent as many listings as there were farms counted in the Census of Agriculture. On a region-by-region basis there is quite a bit of variation in this coverage. The ASCS list has good to excellent coverage of Regions 2 through 4, which together contain 70 percent of all farms according to the Census; and fair to poor coverage of the rest of the country. For Region 3, the Midwestern region, ASCS actually has more listings -- 118 percent as many as the Census. For Region 2 (South) and 4 (Central), the ASCS had fairly good coverage -- 90 percent and 79 percent as many listings, respectively, as the

Table G-4. Raw farm count based on sampled PSUs (1982 Census of Agriculture and 1982 ASCS Defiency File)

	Raw counts, sampled PSU's		
Region[1]	1982 Agriculture Census	1983 ASCS Deficiency File	Percent Coverage ASCS File
1-Northeast	3,743	1,573	42%
2-South	6,619	5,969	90%
3-Midwest	13,367	15,787	118%
4-Central	11,025	8,706	79%
5-Mountain	4,472	2,305	52%
6-Pacific	10,851	504	5%
Continental U.S. Total	50,077	34,844	70%

[1] Regions are defined in Figure G-1

Census. For Regions 5 (Mountain) and 1 (Northeast), the coverage was only about half -- 52 and 42 percent as many listings, respectively, in ASCS as the Census count. Finally, for Region 6 (Pacific), the coverage was very low -- the ASCS list had only 5 percent as many listings as the Census for this region.

Several attempts to understand these discrepancies have met with limited success. The two data sources rely on different bases to get their lists of farms and farm operators, employ different (and to a great extent not thoroughly documented) definitions of "a farm" and have different basic philosophies of the importance of complete coverage. We were able to determine that our ASCS list is a list with one record per farm, as defined by the County Agent, so that the comparison in Table G-4 is the relevant one.

We expected that vegetable, fruit or livestock farms would be at greater risk of under-representation on the ASCS list, so Table G-5 presents the counts of these types of farms by region, with the percent of all farms in the region, based on the 1982 Census. A farm may, of course, have crops in more than one category. For example, a cattle ranch with pastureland would likely also grow feed grain and be eligible for the PIK program. Farms with land in vegetables or orchards might also have PIK-eligible crops, or be on the ASCS File as ineligible. The most striking statistic in Table G-5 is that, while nationally 5.4 percent of farms have land in orchards, in Region 6 (Pacific), 33.7 percent of farms have land in orchards. It seems quite probable that this is a contributing factor to the severe discrepancy between the ASCS frame and the Census in that region. Region 1 (Northeast) has a higher rage of farms with vegetables (7% versus 3.1%) than the national average but scarcely enough to account for listing less than half of all farms in that region.

Table G-5. Regional data from 1982 Census of Agriculture on farms with land in vegetables, orchards, and pastureland

Region*	Farms with land in vegetables		Farms with land in orchards		Farms with pastureland	
	Number	Percent	Number	Percent	Number	Percent
1-Northeast	15,458	7.0%	12,740	5.7%	151,287	68%
2-South	19,978	3.6%	28,063	5.1%	355,467	65%
3-Midwest	17,629	2.4%	11,784	1.6%	413,446	57%
4-Central	4,761	1.0%	12,524	2.7%	353,149	76%
5-Mountain	2,858	2.3%	5,271	4.3%	82,766	68%
6-Pacific	7,638	5.0%	51,456**	33.7%	71,679	47%
Continental U.S. Total	68,322	3.1%	121,838	5.4%	1,427,794	64%

*Regions are defined in Figure G-1.

** California has 39,801 farms with land in orchards, including 10,481 with grapes, 7,512 with citrus, 6,119 with avocados, 3,664 with plums and prunes, 2,904 with apples and 2,898 with peaches.

Washington has 6,946 such farms including 5,406 with apples, 2,235 with pears, 2,066 with cherries and 1,042 with grapes.

Oregon has 4,709 such farms including 2,053 with apples, 1,717 with cherries and 1,316 with pears.

The basic pattern in Table G-4 is good coverage to over-coverage in those parts of the country which contain the majority of all farms (Regions 2, 3, and 4 contain 1,739,305 farms, or 78 percent of the total, see Table G-3), and fair to poor coverage in the remainder of the country. This underlying distribution of farms, combined with the pattern of over- and under-coverage and the PSU selection probabilities, results in a fairly decent national estimate of number of farms based on weighted ASCS data, even though the regional estimates are poor. These weighted figures are shown in Table G-6, along with the expected sample size based on weighed ASCS file counts. Regions 1, 5, and 6 continue to lose sample cases due to list undercoverage of those regions.

D. Sampling Frame and Actual Farm Sample

In order to use the ASCS list as a sampling frame, two modifications were made. First, the list of farms was collapsed into a list of farmers by aggregating records with the same name and address. We would thus be able to increase the number of farms sampled without increasing the costs by sampling 600 operators and interviewing them regarding "any farm land you own or operate" in the specific counties they were sampled for. For those few who reported underground storage tanks, we then determined which distinct farms have such tanks and how many. The second frame modification was due to the use of a purchased list for the large establishment segment of the overall survey. Any large establishments with agricultural SICs were removed from the large establishment frame and matched against the ASCS list. If they did not already appear on it, they were added to the frame.

Table G-6. Weighted farm counts from ASCS 1983 File, expected and actual sample sizes

Region[1]	Weighted counts, sampled PSU's		Farm sample size expected from ASCS file[2]
	1982 Agriculture Census	1983 ASCS Deficiency File	
1-Northeast	123,714	52,376	15
2-South	283,226	301,055	86
3-Midwest	908,358	1,105,519	314
4-Central	494,029	512,376	146
5-Mountain	147,071	132,621	38
6-Pacific	104,164	5,652	2
Continental U.S. Total	2,060,562	2,109,599	601

[1] Regions are defined in Figure G-1.

[2] These farms are to be screened for the presence of underground motor fuel storage tanks.

From the final frame of farm operators thus established, a sample of 600 cases was drawn with within-PSU probabilities set so that the entire sample had equal probability. Table G-7 reviews the results of farm operators by region, column 1 shows the distribution of farm operators by region, column 2 gives the number of distinct farms this represents, and column 3 shows the farm estimate based on the unadjusted sample weights. Comparing these estimates back to the Census totals in Table G-3, we see that there is quite a bit of region to region variation, although the grand total is fairly close. This indicates that a ratio adjustment would improve the sampling error of estimation for this survey, which we describe in the next subsection.

IV. STATISTICAL ADJUSTMENT OF WEIGHTS TO MINIMIZE SAMPLING VARIANCE

In the previous subsection, it became apparent that the actual sample of farms based on the ASCS list does not accurately reflect the regional distribution of farms as measured by the 1982 Census of Agriculture. Further, in subsection II we found that the underground tank survey regions are very unequal in numbers of farms. In order that our final estimates of number and proportion of farms with underground tanks reflect regional variation and totals more closely, we propose a system of adjustments to the sample weights by region. Since some of the six survey regions have such small sample sizes, we also propose, for farm estimates only, consolidating the survey regions into three areas which have about the same number of farms and which will have over 100 sample cases each. The proposed consolidation is given in Table G-8, which shows the three consolidated regions, their Census totals, the unadjusted sample estimates, and the approximate adjustment factor to apply to the sample weights so that our final sample estimates (of numbers of farms)

Table G-7. Results of farm sample draw

Region[1]	Number of farmers (operators) sampled[2]	Number of farms operated	Weighted number of farms using sample weight
1-Northeast	11	17	53,395
2-South	88	94	295,242
3-Midwest	324	354	1,111,868
4-Central	142	159	499,398
5-Mountain	33	33	103,649
6-Pacific	2	2	6,282
Continental U.S. Total	600	659	2,069,834

[1] Regions are defined in Figure G-1.

[2] These farms are to be screened for the presence of underground motor fuel storage tanks.

Table G-8. Consolidated regions for farm estimates and ratio adjustment factors

Regions	Consolidated region	1982 Census of Agriculture	Weighted sample, selection weights	Ratio adjustment factor (rounded)
1&2 - Northeast and Southeast	East	771,025	348,637	2.21
3-Midwest	Midwest	725,699	1,111,868	0.65
4,5&6-Central, Mountain and Pacific	West of the Mississippi	739,087	609,329	1.21

will equal the Census totals. The actual adjustment was made after the field work had been completed, so that the final number of actual farms contacted was used. After this adjustment, the ratio of largest to smallest weight was about 3.4 to 1, not an excessive gap.

In assessing the quality of the final estimates for farms, for these three consolidated regions and nationally, we have computed sample variances based on the final weights. There is a qualitative aspect to the accuracy as well, in which we acknowledge that coverage of the far West Coast especially is fairly low, and the estimates for the Western consolidated region may contain some bias if these three states are strongly different in terms of underground motor fuel storage from the rest of the west. However, since the West Coast accounts for only 20 percent of farms in Survey Regions 4, 5 and 6, it would have to be extremely different for the survey estimates of this consolidated region to be significantly affected.

APPENDIX H

ENVIRONMENTAL DATA COVERAGE

I. INTRODUCTION

Environmental data coverage by existing data bases and literature was explored for geographic locations of the OTS Leaking Underground Storage Tank survey.[1,2,3] Data sources were located and subsequently reviewed for their usefulness. From the pertinent literature and data sources found, environmental data sets were derived for survey areas and organized within an automated data base. Parameter choices were directed toward use in leak analyses and fuel migration modeling studies. The data sets were compiled into a Basic Site Information File containing locators, descriptors, and cross-reference keys pointing to additional soil, climate, and groundwater information for the sites in the survey. Fuel component chemical and physical data were also compiled and tabulated.[4]

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[1] "Literature Searching for Leaking Underground Storage Tank Project," General Software Corporation, 1985.

[2] "Environmental Scenario Assemblage for Leaking Underground Storage Tanks," General Software Corporation, 1985.

[3] "Environmental Scenarios Supporting Movement of Complex Mixtures to Groundwater," General Software Corporation, 1986

[4] "Chemical-Physical Parameters and Processes Effecting Petroleum Fuel Migration", General Software Corporation, 1985.

II. DATA SOURCE AVAILABILITY AND COVERAGE

In the search for soil, climate, and groundwater information, only major readily accessible sources were considered. These sources include, among others, the County Soil Surveys of the Soil Conservation Service, USGS publications, and the NAWDEX data base. A summary of the sources located and descriptions of the information which they contain are presented in Table H-1.

The County Soil Surveys of the Soil Conservation Service provide the most complete and comprehensive information on soil classification. The survey status of the original 76 counties in the LUST survey is provided in Table H-2. The SCS Soils-5 computerized data base contains most of the information covered in the published surveys. There were 914 site locations recorded, and of these, over 450 were covered by modern soil surveys, but approximately 150 of the latter were designated as urban land or mixed land complexes and were not fully described.

USGS publications and the NAWDEX Groundwater Site Inventory provide variable coverage for groundwater and subsurface geologic information. For areas not covered, regional ranges were recorded from "Ground-water regions of the United States" by R.C. Heath or from the ENVIRLOC database as cited in Table H-1. These ranges must be used with caution, however, since they are broad geographic approximations only.

To obtain up to date, reliable climatic information, parameters were requested directly from the National Oceanic and Atmospheric Administration (NOAA). Currently, NOAA is compiling parameter summaries from approximately 3000 U.S. Weather stations from their databases for the Exposure Evaluation Division of OTS. Publications summarizing portions of this data include the Climatic Atlas of the United States and the Statistical Abstract of the United States. Soil Surveys frequently contain brief climate summaries as well.

III. BASIC SITE INFORMATION FILE

The Basic Site Information File was designed in support of the Leaking Underground Storage Tank survey from the work performed in a preliminary study described in the Task 8 report of EPA Contract 68-02-3970. Data, data ranges, and cross reference keys covering a variety of locator, climate, soil, and groundwater information were included in the file to enable the user to have a general understanding of site location and conditions, and to obtain further information as necessary.

The file itself contains four sections: site location and identification, climate, soil, and groundwater/geologic. The parameters in the file and their corresponding lengths are shown in Table H-3. Tables H-4 through H-6 are examples from the Basic Site Information File.

A. Site Location and Identification

The site location and identification portion includes identifiers ranging in resolution from general region to specific site. These locators aid in the determination of the number of sites within a particular state, county, or region, and in the location of the actual site on a USGS topographic map.

The LUST Regions (Pacific, Mountain, Central, Midwest, Northeast, and Southeast) are the largest divisions contained in the file, dividing the United States into six parts for survey purposes. The PSU, or primary sampling unit, is a further division of the LUST Region which encompasses one or more counties. There are 34 PSUs included in the LUST Survey which cover a total of 76 counties.

The state and county FIPS codes, or Federal Information Processing Standards, are numeric codes for each state and county. The state and county codes are two and three digits respectively, and are sometimes combined into a single five digit identifier. Being a standard identifier, the FIPS Code helps to avoid confusion due to spelling errors and nonuniform abbreviations.

The USGS Topo Quad information is provided for easy reliable geographic location. This information includes the name of the topographic quadrangle on which the site may be found, the map scale of the quadrangle, and the bottom right coordinates of the map. This information may be useful in the future for digitization of mapping and site location.

Survey sites were usually received marked on a USGS topo map. Sometimes, however, sites were marked on nonstandard or state road maps, or occasionally not marked at all. If a topo quad could be determined for a site, this information was included in the file, otherwise it was omitted.

The Soil Survey Area information provides the name of the Soil Conservation Service County Soil Survey covering the site, the year the survey was published, and the survey area code. County soil surveys cover a county, group of counties, or sections of counties. Sites located in areas with no current published soil survey are labelled "Area not surveyed" at this point. Sites not marked, or marked on large scale maps are labelled "Site not specifically marked", or with some other pertinant descriptor. The Survey Area Code is obtained from section one of the Soil Conservation Service Map Unit Use File (MUUF). Every current county survey has a corresponding code, which is the county FIPS code for single whole county surveys. For partial county and multi-county surveys, codes are 600 numbers. These codes are found by searching the MUUF for state and survey area name, and are used for finding cross reference keys to specific soil information.

The specific site locators are the site ID, latitude, longitude, and approximate elevation. The site ID is an alpha-numeric code taken from the marked topo maps as received. The number includes the PSU. For sites with multiple tanks, a letter is tacked onto the end of the

ID (i.e. A, B, C, etc.) identifying each tank, so that each tank has its own unique record in the event that soil conditions may differ.

The site coordinates were determined by measuring those marked on USGS topo maps with a gridded ruler to the nearest 1/16 inch and then performing the necessary calculations. The coordinates were presented in the file in degree:minute:second format. Sites received marked on maps with insufficient scale or resolution were included with general information only (i.e. no specific coordinates). The elevation was taken from the topo map.

The Hydrologic Unit, or HU Code, is a numeric code assigned to a drainage basin or distinct hydrologic feature by the Office of Water Data Coordination. Although the HU Code is applied mainly to surface water, it is sometimes used to organize groundwater studies. An example of this is D.K. Todd's major water resource divisions in *Ground-Water Resources of the United States*. These major divisions correspond to the first two digits of the HU Code, as shown in Figure 1. HU Codes are available from ENVIRLOC.

B. Climate

State Climatic Divisions (SCDs) are areas within states which have similar climates. The National Weather Service has defined 353 divisions in the United States which frequently follow county boundaries. These divisions, which were retrieved from GEOCOLOGY, for survey locations, will help determine the closest applicable weather station from which to take climate data. NOAA will provide rainfall statistics to the Exposure Evaluation Division for those stations recording hourly precipitation as well as mean temperature and humidity by SCD.

C. Soil

The soil information included in the basic site file provides some parameters plus soil type keys for obtaining additional data from Soils-5, the soil data base of the Soil Conservation Service.

The Soil Map Unit is an alpha-numeric which is obtained from the Soil Conservation Service published soil surveys. The unit is found by locating the site on one of the soil maps in the county survey, usually by comparison with the marked topo map. The Soil Map Unit and the Survey Area Code are then used to extract the Soils-5 Recnumber from the Map Unit Use File (MUUF) section three. The Soils-5 Recnumber consists of the two character state abbreviation and a four digit number which together determine the record to access within the Soils-5 data base. The additional information include such parameters as permeability, pH, percent clay, etc. A sample of the available data is shown in Table H-7.

If a county or part of a county did not have a current published soil survey, a soil type inference was made using surrounding county soil surveys, making either an individual soil type inference or a major association inference as shown in the site file. Soils-5

Recnumbers were then found as before. If an inference could not be made with reasonable confidence, then no inference was made.

Additional information in the Basic Site File includes seasonal high water table, availability of C-Horizon (subsoil) parameters, and relative corrosivity to steel and concrete, all of which could be useful for the prediction of possible tank leaks. The seasonal high water table information provides a depth range, water table type, and the months of common occurrence. Availability of C-Horizon information is a yes or no indication of whether countysoil survey data include the mineral subsoil. Risk of Corrosion is a relative parameter (low, moderate, high) determined primarily by drainage class and texture, total acidity, resistivity at field capacity, and conductivity of saturated extract, as described in part 603 of the National Soils Handbook of the SCS.

D. Groundwater/Geologic

R.C. Heath divided the United States into major groundwater regions (referred to in the site file as Heath Regions) in his report "Ground-water regions of the United States". Figures 2 and 3 show the boundaries of the fifteen regions. Heath established ranges for transmissivity, hydraulic conductivity, and porosity for these groundwater regions, which may be used if actual data is not available. These ranges are very general, however, and should be used with caution.

Space is provided for the NWWA (National Water Well Association) subregion for future input. The NWWA is currently organizing hydrogeologic parameter ranges for subsets of the region of R.C. Heath.

A literature search was performed in the National Water Well Association bibliographic data base to locate articles and studies describing aquifers in the areas of interest. Most of the publications were USGS reports which contain good groundwater and geologic descriptions. These USGS publications were used to develop the groundwater file which is cross referenced in the Basic Site File.

Extensive searches were performed in the NAWDEX Ground Water Site Inventory to obtain water and well information. Site Resolution (position with respect to aquifer), Well Usuage Description (domestic, public, industrial, etc.), and Depth to Groundwater were usually obtained from the GWSI. Well sites within five minutes latitude and longitude of a survey site were used to determine the parameters at that site. If no well sites were within this radius of the LUST site, Depth to Groundwater was taken from ENVIRLOC (this appears as a range). The other literature sources previously mentioned were occasionally used when available.

The Basic Site Information File, Soils-5, the Groundwater Information File, and the future NOAA weather data. will be useful tools providing reasonable environmental scenarios to the modeller.

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Table H-1. Information Source Summary (1 of 5)

Source	Parameters	Geographic Coverage and Frequency
Literature:		
County Soil Surveys USDA Soil Conservation Service	soil type, level, slope, permeability, pH, available moisture capacity, temperature, precipitation, soil texture, % fragments, sieve analysis, liquid limit plasiticity, index, shrink/swell potential, erosin factors	most US counties (down to 60 inches only)
	depth to groundwater soil bulk density, cation exchange capacity, organic content, clay content	some counties
USGS Publications		
Water Resources Data	surface water data	all US states
	observation well number, location, hydrologic unit, groundwater level, well characteristics, aquifer type, groundwater quality	most US states, site specific
Guidebooks for Fieldtrips	thickness and characterization of rocks and water bearing formations	US, site specific (usually to bedrock), info variable by state
Water Resources Bulletins	hydrogeology of principal aquifers, saturated thickness ranges, temperature, water level, characterization of core samples, analysis	US, site specific, info variable by state

Table H-1. Information Source Summary (2 of 5)

Source	Parameters	Geographic Coverage and Frequency
	of rock samples, hydraulic conductivity, specific gravity, particle size, porosity, water quality	
Water Resources Bulletin	hydrogeology of prinicipal aquifers, saturated thickness ranges, temperature, water level, characterization of core samples, analysis of rock samples, hydraulic condictivity, specific gravity, particle size, porosity, water quality	US, site specific info variable by state
Geological Circulars	soil chemistry, tranmissivity, hydraulic conductivity, thickness, sieve analysis, soil layers	US, site specific, info variable by site
Water Resources Investigations	well data, water quality, pumping and drawdown studies	US, site specific, info variable by site
Open File Reports	Water level, aquifer description	US, site specific, info variable by site
Resources of the United States D.K. Todd, 1983 Premier Press	precipitation, occurrence of groundwater, storage coefficient, evapotranspiration, base of fresh water, potentiometric contours, basement slope	US major groundwater regions, info availab for most regions

Table H-1. Information Source Summary (3 of 5)

Source	Parameters	Geographic Coverage and Frequency
Statistical Abstract of the United States, 1984 US Dept. of Commerce, Bureau of Census	mean temperature, precipitation, days w/precipitation greater than 0.1 inch, average snowfall, average percent sunshine, average windspeed	selected US cities
Climatic Atlas of the United States, 1968 U.S. Dept of Commerce, Environmental Science Services Administration, Environmental Data Service	temperature, precipitation, state climatic divisions, humidity, evaporation, snowfall radiation, skycover, wind speed	US (maps)
Hourly Precipitation Data, NOAA, US Environmental Data Service (monthly publication by state)	hourly precipitation	US weather stations
Topographic Map Series, USGS, Reston, VA	elevation, coordinates	US, most areas
Ground-Water Regions of the United States, R.C. Heath, USGS Geological Survey Water-Supply Paper 2242	groundwater regions, descriptions, ranges of transmissivity, porosity, hydraulic conductivity, and recharge	US groundwater regions

Table H-1. Information Source Summary (4 of 5)

Source	Parameters	Geographic Coverage and Frequency
NOAA (National Oceanic and Atmospheric Administration)	temperature, wind speed, precipitation, state climatic division, sky cover, humidity	US weather stations, data collected variable by station
Data Bases:		
Geocology, Oak Ridge National Laboratory (contained in GEMS)	monthly temperature	US state climatic divisions
	monthly evaporation	eastern US counties
	state climatic divisions within counties	US
	soil great groups	eastern US
NAWDEX (National Water Data Exchange) Ground Water Site Inventory, USGS, Reston, VA	well description, groundwater level, water use, lithology, transmissivity, hydraulic conductivity, storage coefficient, water quality	US site specific, data variable by site
National Ground Water Information Center Data Base, National Water Well Association, Worthington, OH	bibliographic, key word search covers current literature including USGS publications	global, major emphasis in US, literature dependent

Table H-1. Information Source Summary (5 of 5)

Source	Parameters	Geographic Coverage and Frequency
ENVIRLOC, Soil/HU Code, General Software Corporation Landover, MD	approximate depth to groundwater ranges, soil parameter ranges, Hydrologic Unit Code, Heath Groundwater region number	continental US by Zip code or coordinate
Soils-5, USDA Soil Conservation Service, Washington, D.C.	essentially same information and coverage as published surveys	most US counties, info for most counties (with modern published surveys only)

Table H-2. Status of County Soil Surveys (1 of 6)

County	Survey Name	Survey Status	Year Published
Arkansas:			
Garland		Mapping in progress	
California:			
Alameda	Alameda Area (excludes western section)	Complete	1966
Los Angeles	Los Angeles County, West San Fernando Valley Area	Complete	1979
San Mateo	San Mateo Area (excludes northern section)	Complete	1961
Colorado:			
El Paso	El Paso County Area (excludes northwestern section)	Complete	1980
Teller		Mapping not started	
Connecticut:			
Hartford	Hartford County	Out of print	1962
Tolland	Tolland County	Complete	1966
Florida:			
Duval	City of Jacksonville, Duval County	Complete	1978
Illinois:			
DuPage	DuPage and Part of Cook Counties	Complete	1979
Indiana:			
Grant	Grant County	Out of print Mapping in progress	1915

Table H-2. Status of County Soil Surveys (2 of 6)

County	Survey Name	Status Survey	Year Published
Iowa:			
Pottawattamie	Pottawattamie County	Out of print	1914
		Mapping in progress	
Kansas:			
Johnson	Johnson County	Complete	1979
Waynedotte	Leavenworth and Waynedotte Counties	Complete	1977
Kentucky:			
Bullitt		Mapping in progress	
Jefferson	Jefferson County	Complete	1966
Oldham	Oldham County	Complete	1977
Minnesota:			
Ramsey	Washington and Ramsey Counties	Complete	1980
Mississippi:			
Issaquena	Issaquena County	Complete	1961
Warren	Warren County	Complete	1964
Missouri:			
Caldwell	Caldwell County	Complete	1974
Carroll	Carroll County	Out of print	1912
		Mapping in progress	
Chariton	Chariton County	Out of print	1912
Clinton	Clinton County	Complete	1983
DeKalb	DeKalb County	Complete	1977

Table H-2. Status of County Soil Surveys (3 of 6)

County	Survey Name	Survey Status	Year Published
Gentry		Mapping complete	
Montana:			
Hill		Mapping not Started	
Liberty		Mapping not started	
Toole		Mapping not started	
Nebraska:			
Arthur	Arthur and Grant Counties	Complete	1979
Blaine	Blaine County	Out of print	1954
Custer	Custer County	Complete	1982
Grant	Arthur and Grant Counties	Complete	1979
Hooker	Hooker County	Complete	1964
Logan	Logan County	Complete	1974
Loup	Loup County	Out of print	1937
McPherson	McPherson County	Complete	1969
Thomas	Thomas County	Complete	1965
New Hampshire:			
Hillsborough	Hillsborough County	Complete	1981
Rockingham	Rockingham County	Out of print	1959

Table H-2. Status of County Soil Surveys (4 of 6)

County	Survey Name	Survey Status	Year Published
New York:			
Albany	Albany County	Out of print	1942
		Mapping in progress	
Essex		Mapping not started	
Fulton		Mapping not started	
Hamilton		Mapping not started	
Queens		Mapping not started	
Rensselaer	Rensselaer County	Out of print	1937
		Mapping complete	
Ohio:			
Greene	Greene County	Complete	1978
Miami	Miami County	Complete	1978
Montgomery	Montgomery County	Complete	1976
Preble	Preble County	Complete	1969
Oregon:			
Clackamas	Clackamas County Area	Complete	1985
Rhode Island:			
Bristol	Rhode Island	Complete	1981
Kent	Rhode Island	Complete	1981
Washington	Rhode Island	Complete	1981

Table H-2. Status of County Soil Surveys (5 of 6)

County	Survey Name	Survey Status	Year Published
South Carolina:			
Lexington	Lexington County	Complete	1976
Richland	Richland County	Complete	1978
Tennessee:			
Chester		Mapping complete	—
Henderson	Henderson County	Complete	1960
Madison	Madison County	Complete	1978
Texas:			
Brooks		Mapping in progress	
Collin	Collin County	Complete	1969
Harris	Harris County	Complete	1976
Hays	Comal and Hays Counties	Complete	1984
Kenedy		Mapping not started	
Travis	Travis County	Complete	1974
Willacy	Willacy County	Complete	1982
Williamson	Williamson County	Complete	1983
Utah:			
Salt Lake	Salt Lake Area (excluding eastern section)	Complete	1974
Tooele		Mapping in progress	

Table H-2. Status of County Soil Surveys (6 of 6)

County	Survey Name	Survey Status	Year Published
Washington:			
Cowlitz	Cowlitz Area (eastern part excluded)	Complete	1974
King	King County Area (eastern part excluded)	Complete	1973
Snohomish	Snohomish County Area (eastern part excluded)	Complete	1983
Wahkiakum		Mapping complete	
Wyoming:			
Campbell	Campbell County	Out of print	1955
		Mapping in progress	
Johnson	Johnson County, Southern Part	Complete	1975
Sheridan	Sheridan County	Out of print	1939
		Mapping in progress	

Table H-3. Parameters and Record Lengths included in the Basic Site Information File.

LUST Region	30
PSU	2
State FIPS	2
County FIPS	3
USGS Topo Quad	30
Scale	9
Bottom Rt Latitude	8
Bottom Rt Longitude	9
Soil Survey Area Name	80
Year Published	4
Survey Area Code	3
Site ID	11
Latitude	8
Longitude	9
Elevation (ft)	5
HU Code	10
SCD	3
Weather Station	35
Soil Map Unit	5
Series	53
Soils5 Recnumber	6
Soil Inference	14
Inference From	33
Inference Associations	56
Inference Soils5 Numbers	54
C-Horizon Info	3
High Water Table	43
Corrosivity to Steel	13
Corrosivity to Concrete	13
Heath Region	27
NWWA Subregion	23
GW & Geologic Description	207
Site Resolution	35
Well Usage Description	35
Depth to GW (ft)	7
GW Cross Reference	25

Table H-4. Basic Site Information for Arthur County, NE.

Lust Region: Central

PSU: 23

State FIPS: 031

County FIPS: 005

USGS Topo Quad Name: Arthur

Scale: 1:62500

Bottom Right Latitude: 41:30:00

Bottom Right Longitude: 101:30:00

Soil Survey Area Name: Arthur and Grant Counties

Year Published: 1977

Survey Area Code: 601

Site ID: N230000635 **Latitude:** 41:34:05 **Longitude:** 101:41:25 **Elevation(ft):** 3730

HU Code: 10180014 **SCD:** 02 **Weather Station:**

Soil Map Unit: VaE **Series:** Valentine Fine Sand

Soils5 Recnumber: NE0091

Soil Inference: **Inference From:**

Inference Associations:

Inference Soils5 Numbers:

C-Horizon Info: no **High Water Table:** GT 5.0ft

Corrosivity to Steel: **To Concrete:**

Heath Region: 5 High Plan **NWWA Subregion:**

GW and Geologic Description: Dune sand aquifers - unconsolidated fine sand and clay with shallow water table

Site Resolution: dune sand

Well Usage Description: irrigation

Depth to Groundwater(ft): 15.00

GW Cross Reference: 52

Table H-5. Basic Site Information for Grant County, IN.

Lust Region: Midwest

PSU: 17

State FIPS: 18

County FIPS: 053

USGS Topo Quad Name: Sweetser

Scale: 1:24000

Bottom Right Latitude: 40:30:00

Bottom Right Longitude: 85:45:00

Soil Survey Area Name: area not surveyed

Year Published:

Survey Area Code:

Site ID: N170001264 **Latitude:** 40:30:29 **Longitude:** 85:49:34 **Elevation(ft):** 860

HU Code: 5120101 **SCD:** 05 **Weather Station:**

Soil Map Unit: NA **Series:**

Soils5 Recnumber:

Soil Inference: Ba,Pw **Inference From:** Miami County, 1979 (103)

Inference Associations: Blount-Pewamo Association

Inference Soils5 Numbers: IL0014,MI0042

C-Horizon Info: yes **High Water Table:** 0-3.0ft,perched apparent Dec-May

Corrosivity to Steel: high **To Concrete:** low

Heath Region: 6 Nonglaciated Central **NWWA Subregion:**

GW and Geologic Description: Unconsolidated sand and gravel deposits over water bearing limestone and dolomite bedrock

Site Resolution: over unconsolidated and bedrock aquifer

Well Usage Description:

Depth to Groundwater(ft): 3.2-10

GW Cross Reference: 29

Table H-6. Basic Site Information for Duval County, FL.

Lust Region: Southeast

PSU: 07

State FIPS: 12

County FIPS: 031

USGS Topo Quad Name: Jacksonville

Scale: 1:24000

Bottom Right Latitude: 30:15:00

Bottom Right Longitude: 81:37:30

Soil Survey Area Name: City of Jacksonville, Duval County

Year Published: 1978

Survey Area Code: 031

Site ID: D070000154 **Latitude:** 30:20:52 **Longitude:** 81:44:44 **Elevation(ft):** 20

HU Code: 3080103 **SCD:** 02 **Weather Station:**

Soil Map Unit: 26 **Series:** Pelham Fine Sand

Soils5 Recnumber: GA0015

Soil Inference: **Inference From:**

Inference Associations:

Inference Soils5 Numbers:

C-Horizon Info: no **High Water Table:** 0-1.0ft, apparent Jun-May

Corrosivity to Steel: high **To Concrete:** high

Heath Region: 10 Atlantic & Gulf Coastal **NWWA Subregion:**

GW and Geologic Description: Layers of clay, sand, shells, and limestone, very shallow water table, springs and seeps common

Site Resolution: over shallow & Florida aquifer

Well Usage Description: irrigation, public, domestic

Depth to Groundwater(ft): 23.00

GW Cross Reference: 23

Table H-7. Example of the type of information available in Soils5.

```
SD0102                        S O I L   I N T E R P R E T A T I O N S   R E C O R D

MLRA(S): 53C, 55C, 63A, 63B                                                                     SULLY SERIES
REV. MVS.LDZ, 2-84
TYPIC USTORTHENTS, COARSE-SILTY, MIXED (CALCAREOUS), MESIC

THE SULLY SERIES CONSISTS OF DEEP, WELL DRAINED SOILS FORMED IN LOESS ON UPLANDS AND TERRACES. THE SURFACE LAYER IS
GRAYISH BROWN SILT LOAM 3 INCHES THICK. THE SUBSTRATUM IS LIGHT BROWNISH GRAY CALCAREOUS SILT LOAM. SLOPES RANGE FROM 0
TO 40 PERCENT. AREAS ARE USED FOR RANGELAND AND CROPLAND.

 -------------------------------------------------------------------------------------------------------------------
|__________________________________ESTIMATED_SOIL_PROPERTIES_______________________________________________________|
|DEPTH|                         |                        |                    |FRACT|PERCENT OF MATERIAL LESS |LIQUID |PLAS- |
|(IN.)|      USDA TEXTURE       |        UNIFIED         |       AASHTO       |>3 IN|_THAN_3"_PASSING_SIEVE_NO._| LIMIT |TICITY|
|_____|_________________________|________________________|____________________|(PCT)|__4___|__10__|__40__|_200__|_______|INDEX_|
| 0-3 |SIL                      |ML, CL, CL-ML           |A-4, A-6            |  0  | 100     100    95-100 90-100| 25-40 | 3-15 |
| 0-3 |VFSL                     |ML, CL-ML               |A-4                 |  0  | 100     100    90-100 70-95 | 20-35 | 3-10 |
| 3-60|SIL, VFSL                |ML, CL-ML, CL           |A-4, A-6            |  0  | 100   95-100   90-100 85-100| 20-40 | 3-15 |
|     |                         |                        |                    |     |                             |       |      |
|     |                         |                        |                    |     |                             |       |      |
|_____|_________________________|________________________|____________________|_____|_____________________________|_______|______|
|DEPTH|CLAY |MOIST BULK| PERMEA-  |   AVAILABLE    |   SOIL   | SALINITY | SHRINK- |EROSION|WIND |ORGANIC|    CORROSIVITY    |
|(IN.)|(PCT)| DENSITY  | BILITY   |WATER CAPACITY  |REACTION  |(MMHOS/CM)|  SWELL  |FACTORS|EROD.|MATTER |___________________|
|_____|_____|_(G/CM3)__|_(IN/HR)__|___(IN/IN)______|__(PH)____|__________|POTENTIAL|_K_|_T_|GROUP|_(PCT)_|_STEEL___|CONCRETE|
| 0-3 |10-18|1.25-1.35 | 0.6-2.0  |   0.17-0.22    |6.6-7.8   |    <2    |   LOW   |.43| 5 | 4L  |  1-2  |__HIGH___|__LOW___|
| 0-3 |10-15|1.30-1.40 | 0.6-2.0  |   0.15-0.19    |6.6-7.8   |    <2    |   LOW   |.43| 5 | 4L  |  1-2  |
| 3-60|10-18|1.35-1.50 | 0.6-2.0  |   0.15-0.20    |7.4-8.4   |    <2    |   LOW   |.43|___|_____|_______|
|     |     |          |          |                |          |          |         |   |
|     |     |          |          |                |          |          |         |   |
|_____|_____|__________|__________|________________|__________|__________|_________|___|______________________________________
|                  FLOODING                    |____HIGH_WATER_TABLE____|_CEMENTED_PAN_|____BEDROCK_____|SUBSIDENCE_|HYD|POTENT'L|
|______________________________________________| DEPTH |  KIND  |MONTHS |DEPTH|HARDNESS|DEPTH |HARDNESS|INIT.|TOTAL|GRP| FROST  |
|__FREQUENCY___|___DURATION___|MONTHS_|_(FT)__|________|_______|_(IN)_|________|_(IN)_|________|(IN)_|(IN)_|___|_ACTION_|
|_____NONE_____|______________|_______|_>6.0__|________|_______|__-__|________|_>60__|________|__-__|_____|_B_|MODERATE|
```

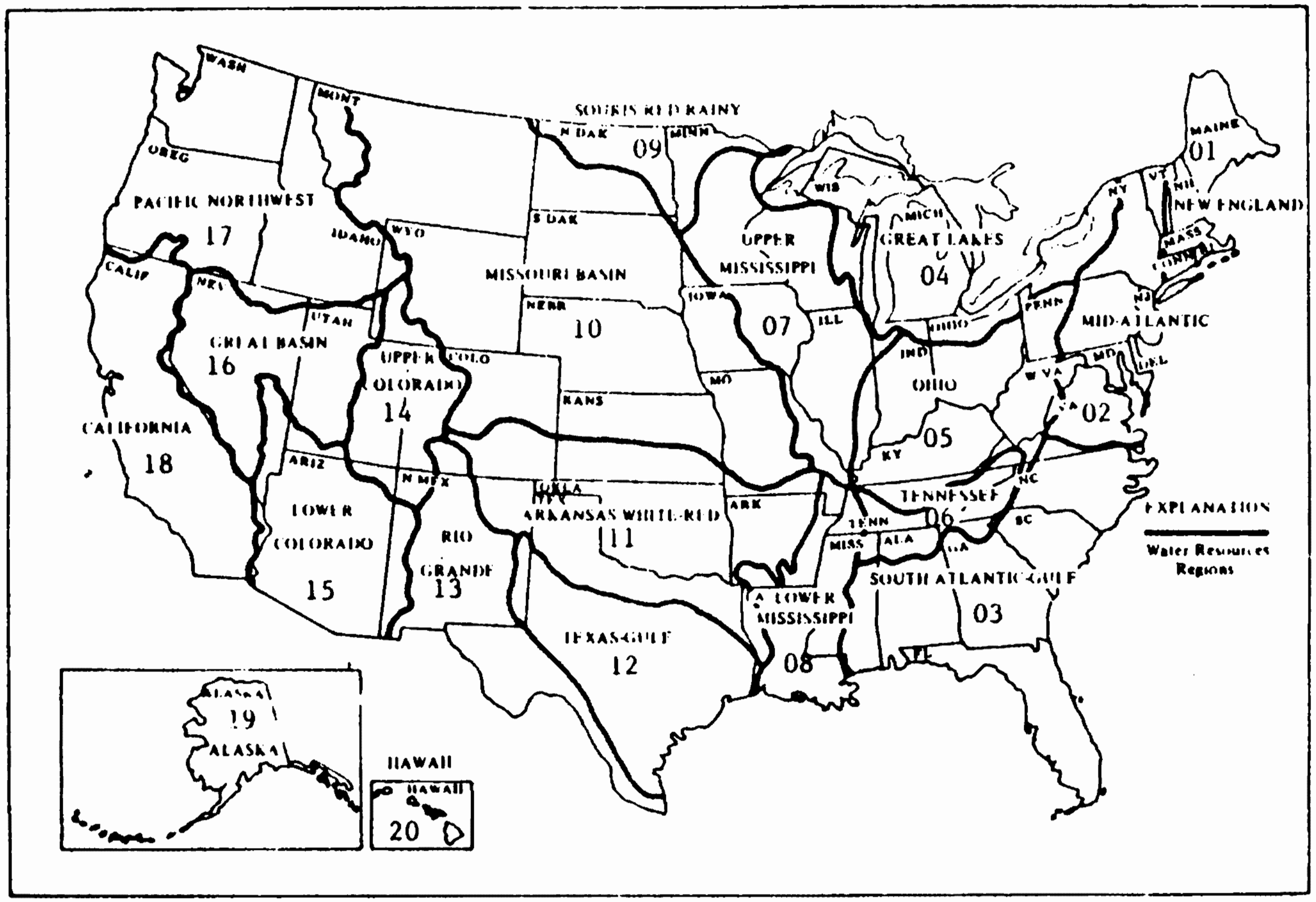

Figure 1. Major surface hydrologic units, corresponding also with groundwater regions as described in Todd, 1983.

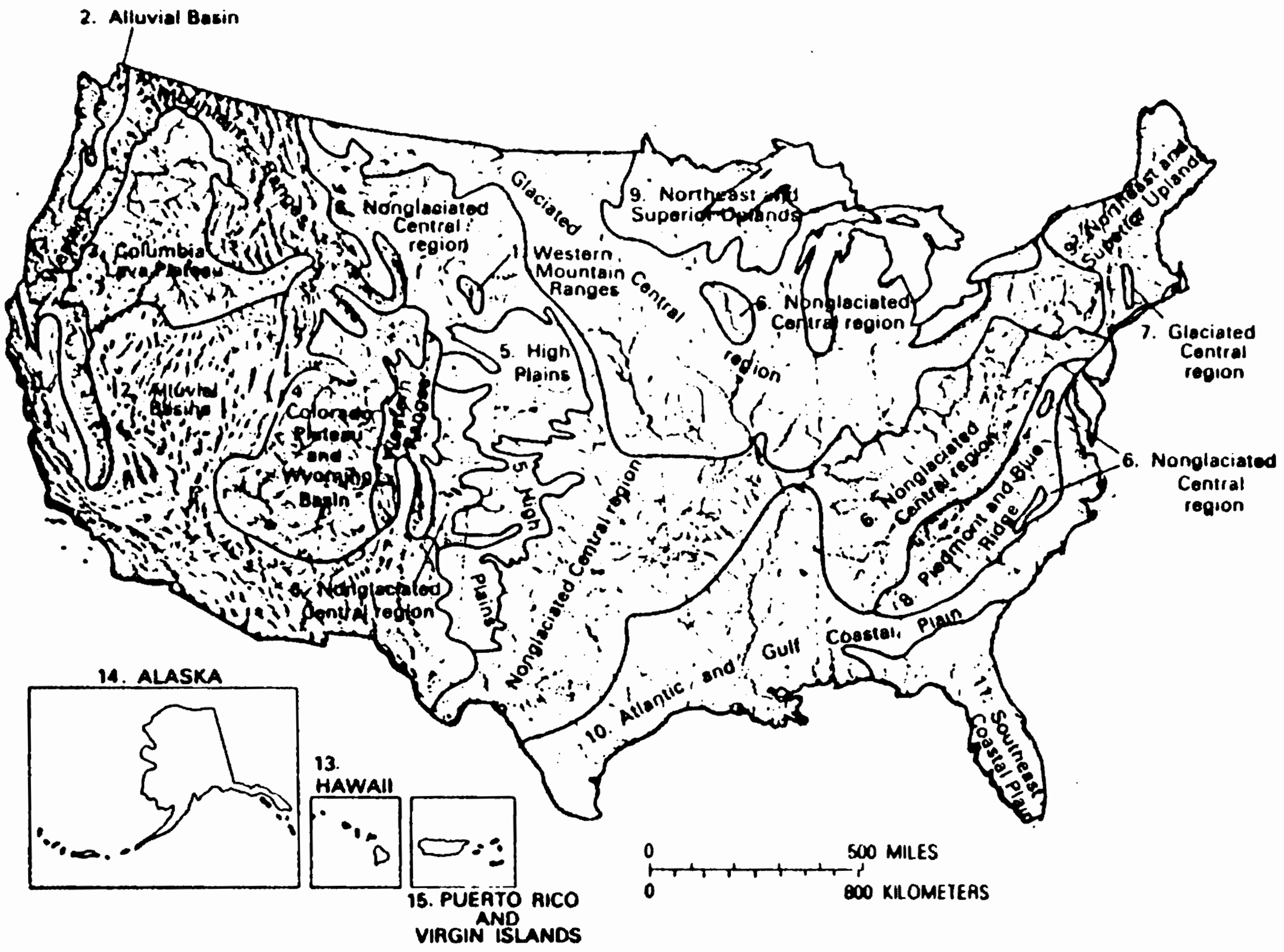

Figure 2. Major groundwater regions of Heath.

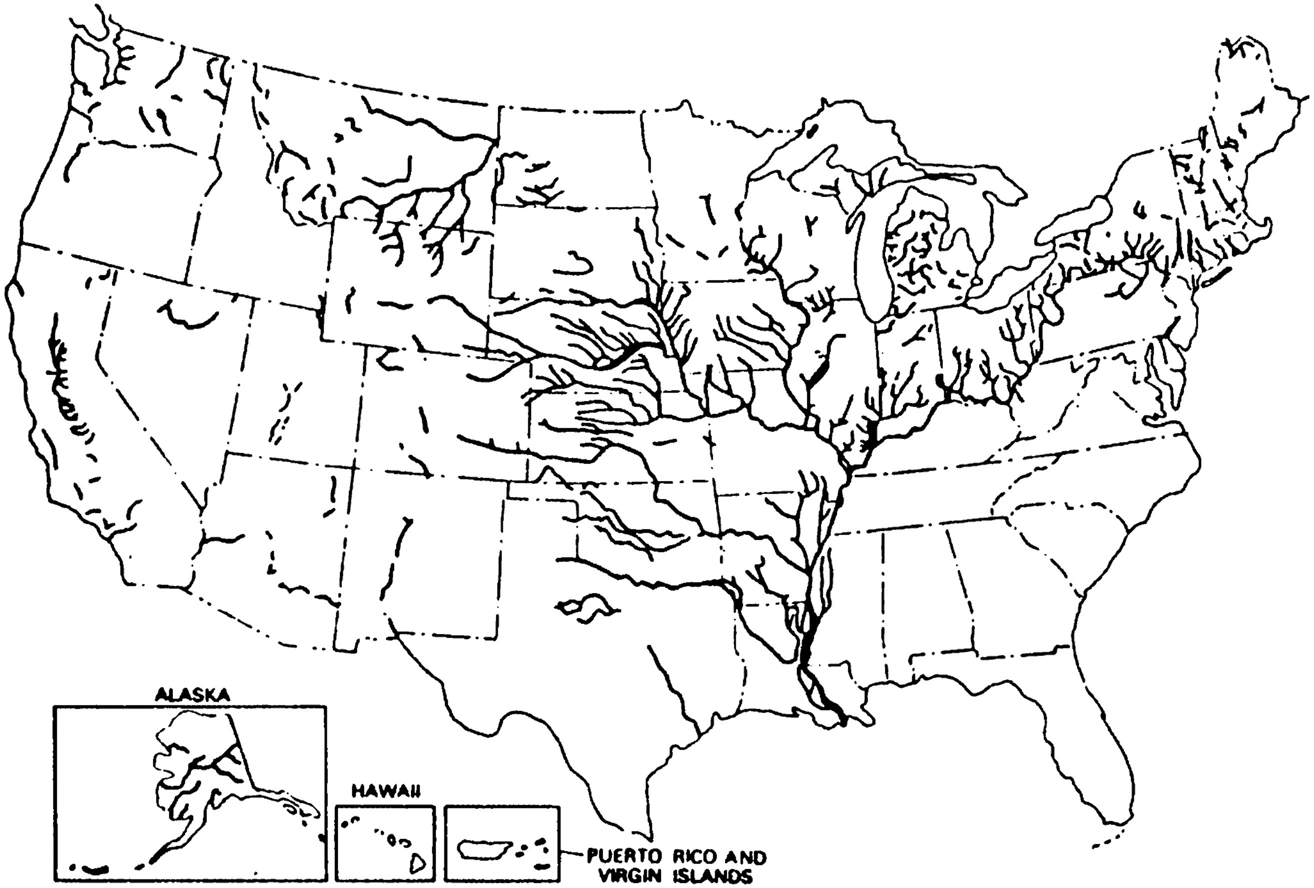

Figure 3. Heath region 12 Alluvial Valleys.

APPENDIX I

MULTIVARIATE ANALYSIS

I. INTRODUCTION

While the tables presented in Section 9 provide a useful descriptive look at leaking tanks and conditions under which leaks occur, they do not take into account the simultaneous effects of many variables. To respond to this analytical need, multivariate statistical models have been developed to examine the relationship between leak status (1 = leak, 0 = no leak) [or leak rate (gallons per hour)] and various explanatory variables.

The advantage of the multivariate analysis is that it provides a method of assessing the contribution of individual explanatory factors, while simultaneously controlling for other variables. The procedures used also allow a step-wise approach (i.e., first finding the one variable that best predicts leak status [or leak rate], then the second best predictor, etc.) and a test for the statistical significance of coefficients of each variable in the model. The results of the multivariate analysis have been summarized in the next subsection so that the reader may learn the outcome of the multivariate analysis without having to go through all the mathematical details. The technical details on mathematical formulation can be found in later subsections, along with the final equations for the multiple regression and logistic regression models developed.

II. SUMMARY OF MULTIVARIATE ANALYSIS RESULTS

The major results of the modeling efforts are presented below. The reader should also note the caveates and limitations at the end of this summary.

A. Multiple Correlations

The multiple correlation coefficients (R) from the final regression models (which retained only variables with significant regression coefficients -- see Subsection C for confidence levels) were about .30 for leak status and .45 for leak rate, demonstrating low to moderate predictive ability. This corresponds to R^2 values of aboue .08 and .20, respectively. Since R^2 can be interpreted as the fraction of variance accounted for by the model, it is clear that the models do not account for most of the variance in leak status and leak rate.

B. Predictors of Leak Status

Based on the coefficients in the regression and/or logistic models, the probability that a tank system leak tends to increase for:

- Older tanks,
- Tanks with no leaded gasoline stored,
- Tanks with passive cathodic protection, and
- Tanks for which no log of deliveries is kept.

The positive relationship between leak probability and passive cathodic protection might seem surprising. A possible explanation is that passive cathodic protection tends to be used in areas which have a history of corrosion/leak problems. Another explanation could be that passive cathodic protection is strongly correlated with the storage of aviation fuel and, thus, might be a proxy for this fuel type. (The multivariate model equations for leak status may be found in Section III, which follows.)

C. Predictors of Leak Rate

Among leaking tank systems, the *leak rate* tends to be *larger* for:

- Fiberglass tanks;
- Tanks not on a concrete pad;
- Tanks both old and steel (i.e., an interaction effect)*;
- Tanks attached to other tanks; and
- Tanks in establishments with operators trained to check for line leaks.

The above factors are not indicators of leak likelihood, but of larger leak rates among leaking tank systems. The last factor may well be a case of reverse causality -- i.e., where tank systems leak heavily, operators are trained to detect line leaks (rather than vice versa).

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*More precisely, fiberglass tank systems show less increase in leak rate as they get older.

D. Limitations and Caveats

In addition to the comments about the limitations of the scope of the study presented in Section 8, the following limitations and caveats apply to the multivariate analysis:

- Only business, government and military sectors are included (no farms).
- Manifolded tanks that could not be separated for tightness tests are not included.
- Although a long list of 49 potential explanatory variables were included, there are other possible variables which were not in our data base and whose effects are, therefore, not accounted for. In particular, soil characteristics were not available for analysis and use in the models. However, backfill around the tank (e.g., sand/gravel) is included and may be more relevant.
- The multivariate analysis finds "measures of association" rather than causality. Naturally, since the variables used were suspected of affecting leaking, the discovery of a statistically significant association tends to affirm a causal linkage. But the reader is cautioned that a different covariate could be the real causative factor, as in all statistical correlation studies. For example, the variable "age of tank" could represent the effects of aging, per se, or age of tank could be a proxy for different installation techniques which changed over time, or different resins used in the manufacture of fiberglass tanks in different production years.

III. MULTIVARIATE MODEL DEVELOPMENT PROCEDURE

A. Overview

Two regression models (one to predict leak status and one to predict leak rate) were developed using the variables in Table I-1 as candidate predictor variables. (Table I-1 also appears as Table 9-31 in Section 9 of this report.) The regression analysis followed a number of preliminary steps before arriving at the final models. This included elimination of variables with too many missing variables (X_{13}, X_{16}, X_{18}) and variables with nearly constant values (X_8, X_9, X_{21}, X_{23}). Stepwise regression runs were made to obtain a reduced set of variables which best predicted leak status or leak rate. Finally, individual regression coefficients were examined to ensure statistical significance. Sample sizes are shown below for the final model.

Model	Sample Size
Leak Status Regression	327
Leak Status Logistic	380
Leak Rate Regression	99

Table I-1. Simple Correlation of Leak Status with Explanatory Variables

Explanatory Variable	Meaning	Definition	Correlation(1) with Y1, Leak status (1 = Leak; 0 = No Leak)	Correlation(1) with Y2, Leak rate (gal/Hr), among leaking tanks(2)
X1	Gas Station	1 = Yes; 0 = No	-.08	-.06
X2	# Underground tanks	Number at facility	.12	.10
X3	Tank capacity	Gallons	.14	.34
X4	Average low fill level(3)	As fraction of tank capacity	-.05	-.07
$X5^2$	$(\text{Age of tank})^2$	in $(\text{years})^2$	.11	-.20
X6	Leaded gasoline	1 = yes; 0 = No	-.26	-.11
X7	Diesel fuel	1 = Yes; 0 = No	.24	-.08
X8	Aviation fuel	1 = Yes; 0 = No	.13	.07
X9	Gasohol	1 = Yes; 0 = No	-.07	0
X10	Other	1 = Yes; 0 = No	.08	.29
X11	Suction pump	1 = Yes; 0 = No	.003	-.12
X12	Depth buried	Inches from surface to top of tank	.10	-.006
X13	Water level	Inches from surface to water table(4)	-.15	-.005
X15	Tank tested	1 if tested after placed in service; 0 otherwise	.03	.01
X16	Years since test	Since most recent test	.0[illegible]	-.21
X17	Tank material	1 = steel; 0 = fiberglass	.02	-.09
X18	Tank lined	1 = Yes; 0 = No	.07	.02
X19	Tank coated	1 = Yes; 0 = No	-.01	-.25
X20	Passive cathodic protection	1 = Yes; 0 = No	.10	.05
X21	Impressed current cath. protection	1 = Yes; 0 = No	0	0
X23	Other protection	1 = yes; 0 = No	-.08	0
X24	Previous tank leak	1 = Yes; 0 = No	-.05	-.04
X25	Previous line leak	1 = Yes; 0 = No	.05	.23
X26	Frequency of delivers	Number per year	-.05	-.003
X27	Sand fill	1 = Yes; 0 = No	.03	-.10
X28	Gravel fill	1 = Yes; 0 = No	.006	.16
X29	Concrete pad	1 = Yes; 0 = No	.07	-.09
X30	Packed earth pad	1 = Yes; 0 = No	.03	-.09
X31	Dist. to nearest tank or structure	(feet)	-.04	-.09

[1] Pearson's correlation coefficient; Kendall's Tau-B was also calculated for all Y1 correlations and found to be the same for nearly every variable.

[2] Using data only from individual leaking tanks with quantifiable leaks.

[3] I.e., just before product is added.

[4] At time of test.

Table I-1. Simple Correlation of Leak Status with Explanatory Variables (Continued)

Explanatory Variable	Meaning	Definition	Correlation(1) with Y1, Leak status (1 = Leak; 0 = No Leak)	Correlation(1) with Y2, Leak rate (gal/Hr), among leaking tanks(2)
X32	Interaction: age & material	(X5) (1-X17)	-.03	-.07
X33	Interaction: gasohol & material	X9 (1-X17)	0	0
X34	Permit to install	1 = Yes; 0 = No	.12	.17
X35	Permit to store	1 = Yes; 0 = No	.02	.09
X36	Average high fill level(6)	As fraction of tank capacity	-.06	-.09
XT3	Average fuel delivery	in gallons (to one tank)	.15	.23
XT4	Max. ever stored	gallons	.11	.29
XT18A	Attached to other tank	1 = Yes: 0 = No	.22	.24
XT19	Tank proximity to water table	1 = above: 2 = partially above: 3 = below; 4 = other	.13	.28
XT20	Manway with tank	1 = Yes; 0 = No	.19	.13
XT36	Not self-installed	1 = Yes; 0 = No	.12	.12
XB5	Remote gauge	1 = Yes; 0 = No	-.005	.05
XB19	Log of deliveries	1 = Yes; 0 = No	-.03	.002
XC7	Any abandoned tank(5)	1 = Yes; 0 = No	-.03	.03
XC8	# Abandoned tanks	(coded as zero if none)	.12	-.09
XF1A	Corrosion prevention equip./mat.	1 = Yes: 0 = No	-.02	-.12
XG2D	Trained to check pump	1 = Yes; 0 = No	.14	.24
XG2E	Trained to check line leaks	1 = Yes; 0 = No	.10	.18
XG2F	Trained to check leak prevention	1 = Yes; 0 = No	.10	.15
XG2G	Trained to check leak monitoring	1 = Yes: 0 = No	.15	.17

[5] At that facility.

[6] I.e., Just after product is delivered.

B. Multiple Regression Models

Two models were constructed:

[1]	Leak Status Model: (among all tanks with tightness test)	Dependent Variable, Y1 = 1 if leak 0 otherwise
[2]	Leak Rate Model: (among <u>leaking</u> tank systems only)	Dependent Variable, Y2 = leak rate in gal/hr

Both models were run using the predictor variables in Table I-1. The general form of the model is:

$$Y = b_o + b_1X_1 + b_2X_2 + \ldots$$

where a few of the variables were interaction terms and the b's are regression coefficients estimated by a least-squares procedure. In addition, a non-linear transformation was used for one of the X variables. Age^2 was used rather than Age because data plots suggested a non-linear increase in the percentage of tanks that leak as a function of age.

C. Logistic Regression Model

For the leak status model, an alternative logistic regression model was run. The dependent variable can be reexpressed as an odds ratio*, in the form:

$$[1a] \quad \log \frac{\text{Probability of Leaking Tank}}{\text{Probability of Tight Tank}} = b_o + b_1X_1 + b_2X_x + \ldots$$

This alternative formulation of Model [1] should more nearly satisfy the homogeneity of variance assumption for regression.

The coefficients (b's) for the Logistic Model are estimated by maximum-likelihood methods rather than least-squares.

IV. FINAL MULTIVARIATE MODELS

Using the procedures defined above, linear and logistic regression models were developed for leak status. For leak rate, a separate linear regression model was developed. The final models appear below.

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*The assumed underlying model for the logistic regression is $Y = 1/[(1 + \exp(-b_0-b_1X_1 - b_2X_2 \ldots.)]$. From this expression it can be shown that $\log [Y/(1 - Y)] = b_o + b_1X_1 + b_2X_2 + \ldots$ In this equation Y is the probability that the tank system leaks and 1 - Y is the probability that it does not leak.

Leak Status Models

[1] Regression Model*:

$$Y1 = .22 + .00019\ X_5^{2\,**} - .25\ X_6 + .0044\ X_{12}{}^{***} + .18\ X_{20}$$

[1a] Logistic Model****:

$$\log \frac{\text{Probability of Leak}}{\text{Probability no Leak}} = 1.3 - .63\ X_6 - .0\ 17\ X_{12} - .38\ X_{B19}$$

---

*All coefficients significant at the 94 percent confidence level or better (except coefficient of X_{20} at 78 percent confidence level).

**$(\text{Age})^2$ was used rather than Age because this non-linear transformation showed a stronger correlation with leak status.

***The regression model found a + coefficient, but the logistic model found a - coefficient. This may be a case of X_{12}'s collinearity with other variables. However, no strong collinearities were detected with X_{12}. (See Tables I-2 and I-3 in Section V.) Therefore, the relationship with X_{12}, depth tank is buried, is inconclusive based on this mixed result.

****All coefficients significant at the 94 percent confidence level or better.

[2] Leak Rate Model*****:

$Y2 = .91 - .67\ X_{17} - .54\ X_{29} - .0068\ X_{32}$******

$+ .62\ X_{T18A} + .25\ X_{G2E}$

The reliability of the model was examined in several ways. For the regression models, the multiple correlation coefficient, R, provides some overall measure of the predictive ability of the model. These results are shown below.

	Multiple Correlation Coefficient, R		R^2	
Equation	Unadjusted	Adjusted	Unadjusted	Adjusted
[1]	.30	.29	.093	.081
[2]	.50	.45	.25	.20

*****All coefficients significant at the 97 percent confidence level or better.

******This is an interaction term which was included to capture the more than additive effect of age and material type together.

The "adjusted" values of R and R^2 adjust for degrees of freedom in the model and, therefore, provide a better estimate of how reliably the model might predict leak status and leak rate for other tank systems beyond the modeling data set. The R^2 term can be interpreted as the proportion of the variance in Y that can be explained for by the model. Thus, the model is able to account for less than 10 percent of the total variance in leak status and only about 20 percent the variance in leak rate.

The reliability of the coefficients of the X's in equations [1], [1a] and [2] were also examined to ensure that the value is not likely to be a chance occurrence. The probability that these coefficients are not chance occurrences is 94 percent or more for each of 9 of the 10 parameters in these equations. The remaining coefficient had a 78 percent probability of being a non-chance occurrence (i.e., there is a very low probability of the observed coefficient occurring if its true value were zero). It should be noted that these probabilities of non-chance occurrence applies one variable at a time -- i.e., with many variables tried in the model, the probability of at least one chance selection of a variable increases.

V. RELATIONSHIP BETWEEN EXPLANATORY VARIABLES (COLLINEARITY)

Multicollinearity frequently exists in large data sets. Pairwise collinearity is one sample form, and is relatively easy to visualize. In order to test for such "first order" collinearity in the models, the correlations between all pairs of independent or predictor variables (i.e., X's) were computed. The results shown in Table I-2 indicate low pairwise collinearity, except for X_{17} (tank material) and X_{32} = [(1 - tank

Table I-2. Collinearity (intercollelation) of X's in models

A. Leak status regression and logistic models -- Pearsons Correlation Coefficient between explanatory variables

	X_5^2	X_6	X_{12}	X_{20}	X_{B19}
X_5^2	1	-.03	-.07	-.08	.10
X_6		1	-.06	-.12	.002
X_{12}			1	.07	.09
X_{20}				1	-.04
X_{B19}					1

B. Leak rate regression model -- Pearson's Correlation Coefficient between explanatory variables

	X_{17}	X_{29}	X_{32}	X_{T18A}	X_{G2E}
X_{17}	1	.09	-.80	.13	.05
X_{29}		1	-.07	.38	.08
X_{32}			1	-.10	-.11
X_{T18A}				1	-.02
X_{G2E}					1

material) x (Age)^{2}] in the leak rate model (correlation of -.80). The variable, X_{32}, is an interaction term. The correlation of X_{17} with X_{32} is close to the correlation of Age^{2} with -Age^{2}. Therefore, a large intercorrelation would be expected.

Table I-3 shows correlations between variables in the models and variables <u>not</u> in the models. (Variables with small correlations, less than .20, are not included.) Any large correlations could be considered as proxies (or substitutes) for the model variable with which they are strongly correlated. For example, in the leak status model, passive cathodic protection (X_{20}) is strongly correlated (correlation coefficient = .62) with aviation fuel (X_{8}). Therefore, the apparent increase in the likelihood of a leak with passive cathodic protection, might be due, in large measure, to its relationship with aviation fuel storage.

Table I-3. Correlation Between Model X's and X's not in the Model

A. Leak Status Model

Model X	Non Model X's	Pearson's Correlation Coefficients (≥ .20)
X_5^2, (Age of Tanks)^2		None
X_6, Leaded gasoline	X_7 (Diesel fuel)	-.39
X_{12}, Depth buried		None
X_{20}, Passive cathodic	X_2 (# Underground tanks)	.33
	X_8 (Aviation fuel)	.62
	X_{18} (Tank lined)	.34
	X_{29} (Concrete pool)	.38
	X_{T18A} (Attached to other tank)	.29
	X_{T20} (Manway with tank)	.41
	X_{G2E} (Trained to chek line leaks)	.24
	X_{G2F} (Trained in leak protection)	.27
	X_{G2H} (Trained in leak monitoring)	.31
X_{B19}, Log of deliveries	X_{13} (Water level)	.30
	X_{16} (Years since test)	.34
	X_{34} (Permit to install)	.20
	X_{35} (Permit to store)	.20

B. Leak Rate Model

Model X	Non Model X's	Pearson's Correlation Coefficients (≥ .20)
X_{17}, Tank material	X_1 (Gas station)	-.21
	X_7 (Diesel fuel)	.22
	X_{11} (Suction pump)	.42
	X_{13} (Water level)	-.29
	X_{15} (Tank tested)	-.28
	X_{16} (Years since test)	-.37
	X_{18} (Tank lined)	-.35
	X_{19} (Tank coated)	.66
	X_{32} (Interaction: Age^2 & material)	-.80
X_{29}, Concrete pad	X_2 (# Underground tanks)	.46
	X_4 (Average low fill level)	.24
	X_{16} (Years since test)	-.48
	X_{20} (Passive cathodic protection)	.26
	X_{30} (Packed earth pad)	-.20
	X_{34} (Permit to install)	.24
	X_{36} (Average high fill level)	.28
	X_{T3} (Average fuel delivery)	.20
	X_{T18A} (Attached to other tank)	.38
	X_{T20} (Manway with tank)	.52
	X_{G2H} (Trained in leak monitoring)	.24
X_{32}, Interaction: Age^2 & material	X_{11} (Suction pump)	-.29
	X_{15} (Tank capacity)	.26
	X_{16} (Years since test)	.49
	X_{17} (Tank material)	-.80
	X_{18} (Tank lined)	.53
	X_{19} (Tank coated)	-.54
X_{T18A}, Attached to other tank	X_2 (# underground tanks)	.48
	X_3 (Tank capacity)	.22
	X_7 (Diesel fuel)	.23
	X_{13} (Water level)	-.30
	X_{16} (Years since test)	-.23
	X_{25} (Previous line leak)	.28
	X_{29} (Concrete pad)	.38
	X_{30} (Packed earth pad)	-.29
	X_{34} (Permit to install)	.29
	X_{35} (Permit to store)	.25
	X_{36} (Average high fill level)	.25
	X_{T3} (Average fuel delivery)	.35
	X_{T4} (Maximum ever stored)	.33
	X_{T20} (Manway with tank)	.40
	X_{G2D} (Trained to check pump)	.24

Leak Rate Model (Continued)

Model X	Non Model X's	Pearson's Correlation Coefficients ($\geq .20$)
X_{G2E}, Trained to check line leaks	X_2 (# underground tanks)	.25
	X_7 (Diesel fuel)	-.25
	X_8 (Aviation fuel)	.25
	X_{10} (Other fuel)	.41
	X_{16} (Years since test)	-.44
	X_{28} (Gravel fill)	.21
	X_{T19} (Tank proximity to water table)	.39
	X_{T20} (Manway with tank)	.22
	X_{G2D} (Trained to check pump)	.40
	X_{G2F} (Trained in leak protection)	.89
	X_{G2H} (Trained in leak monitoring)	.68