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NAVY RADON ASSESSMENT AND MITIGATION PROGRAM
PROGRESS REPORT
FOR THE PERIOD
JUNE 1989 THROUGH MAY 1990

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HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
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EXECUTIVE SUMMARY

During the reporting period, June 1, 1989, through May 30, 1990, radon detectors were sent to all Department of the Navy installations that contained housing areas, child-care centers, schools, hospitals, bachelor quarters, and brigs. This action was part of the screening phase of the Navy Radon Assessment and Mitigation Program. Because of detector losses, a few facilities will require rescreening.

The length of time the detectors are exposed in the buildings is dependent on the time of year they were placed and the time when the doors and windows are normally closed. A 3-month exposure time is sufficient for facilities that placed detectors in buildings when they would be closed. Otherwise detectors will be exposed for about 1 year.

To date, about 9,000 detectors (out of a total of 27,100 detectors sent to the field) have been returned for a determination of exposure levels. About 2,000 detectors have been analyzed and the information sent to the Naval Facilities Engineering Command Headquarters for forwarding to the installations. Except for the additional installations requiring rescreening, the screening effort results should be available this calendar year. The rescreening results should be available by mid-1991.

Assessment will start this calendar year based on the results from screening. Initial emphasis will be on housing, child-care centers, schools, and hospitals.

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1. INTRODUCTION

The following is taken from Document 1730 of the Naval Facilities Engineering Command (NAVFACENGCOM), dated April 22, 1988:

By DASD(E) memo of 14 October 1987 the Services were tasked to take appropriate action to establish an indoor radon assessment and mitigation program. As a result, the Naval Facilities Engineering Command (NAVFACENGCOM) was tasked to identify potential hazards to personnel from exposure to naturally occurring radon gas and prioritize corrective actions, and to coordinate these actions with the major claimants.

In responding to this memorandum, NAVFACENGCOM established the Navy Radon Assessment and Mitigation Program (NAVRAMP), which consists of the following phases:

- Screening - A statistical sample of structures, mainly housing, is selected from each installation, and radon measurements are made.
- Assessment - Every structure on the installation is measured for radon, if the results of the screening measurements indicate such action is required.
- Mitigation - Structures determined from the assessment phase to have radon levels greater than 4 pCi/L are mitigated to reduced levels. Greater than 4 pCi/L is an Environmental Protection Agency (EPA) action level.
- Postmitigation follow-up - Radon levels in structures that have been mitigated are measured again to ensure that levels are below the action level.

The Department of the Navy (DON) requested assistance from the Department of Energy (DOE), through Interagency Agreement 40-1791-86, in carrying out NAVRAMP because DOE had personnel within its Management and Operating Contractor with considerable experience in the radon field. The persons responsible for NAVRAMP and the internal organizations to which they belong are (1) Hugo W. Bertini, Program Manager, Hazardous Waste Remedial Actions Program (HAZWRAP); (2) David L. Wilson, Technical Manager, Oak Ridge National Laboratory (ORNL); (3) Charles Dudney, Technical Radon Staff, ORNL; (4) Tommy Wright, Statistician, ORNL; and (5) Charles Turner, Quality Control, Quality and Technical Services Division, Oak Ridge Gaseous Diffusion Plant.

2. EVENTS IN THE PROGRAM

2.1 EXPOSURE TIME

To accommodate the various times that the detector exposures began at the installations, a decision was made to alter the length of detector exposure time at each installation. The current exposure time was determined by the time the detectors were placed in the buildings and the season of the year in which they were placed. For example, at some of the installations, the detectors were placed in the buildings in May or June 1989. If the installation was located in a climate in which air conditioners would be used over the summer, the detectors were left in place for the 3 months of summer because the buildings would essentially be closed. If the climate was not such that the buildings would normally be closed, the detectors were left in place for about a year. The tables in Appendix A indicate the duration of exposure at each installation.

The object of the placement procedure discussed above was to get an estimate of the average annual radon level in each building because EPA action levels are based on annual averages. The ideal measurement is for a full year to include periods when the buildings are generally opened and closed. However, in screening measurements such as these, it is acceptable to use a 3-month measurement made when the building is closed because this period gives an upper limit to the actual annual average (i.e., the actual annual average will be equal to or less than the 3-month measurement, which will, therefore, be conservative).

2.2 SIGNIFICANT EVENTS

2.2.1 Corrections to the Data

To aid in better understanding some of the discussion that follows, a brief description of the alpha-track radon detectors that are used in NAVRAMP is provided. The main part of the detector is a small piece of plastic about 1/8 in. thick by 1/4 in. by 1/2 in. The plastic is mounted in a small container about the size of a pill bottle with holes in the top to allow air to enter. This combination composes the detector. Before deployment, the detector is sealed in an aluminized pouch to prevent exposure to radon. When placed in a building, the detector is removed from the pouch. The radon gas and its daughter products emit mainly alpha-particles, which are ionized helium atoms. When the emitting particles are near the plastic in the detector, the alpha-particles impinge on the plastic surface and damage it while penetrating slightly. This is called a "track." After exposure, the detector is returned to the manufacturer who disassembles it and places the plastic in a caustic etching bath, which etches out the damaged surface and also etches the track made by the alpha-particle. The plastic is rinsed, and the number of tracks are counted under an automated microscope. The greater the number of tracks, the greater the exposure. This means that, if placed in the field for 3 months where the radon level is 4 pCi/L, the number of tracks on the detector will represent an exposure of 360 pCi/L days ($4 \text{ pCi/L} \times 3 \text{ months} \times 30 \text{ days/month}$). The same number of tracks would appear if the detector were exposed for 12 months in a 1 pCi/L level.

The event having the most significance for NAVRAMP was the discovery that the aluminized pouches containing the detectors were not sealed tightly enough to keep background radon out. This was discovered in processing data from quality control (QC)

tests. The data to support this conclusion will be described in Sect. 6. With considerable foresight, DON Headquarters agreed to allow the initiation of a substantial QC program to examine events that could have a bearing on any future data regarding exposure in the field.

Samples of detectors from each manufactured lot were exposed to known quantities of radon at ORNL. Included in each exposed batch were detectors that were not removed from their pouches. These should have indicated only small radon readings because of exposure to background levels of radon before being packaged. However, when analyzed for radon exposures, radon levels were detected ranging from background (which was expected) to levels as high as the exposed detectors.

Measuring the radon level in the area where the detectors were stored while they were in our possession has partially corrected this problem. If the detectors used as travel blanks had been treated properly by the personnel in the field, the correction would have been completed. Travel blanks were detectors used solely to measure the radiation while the detectors were in transit and also while they were stored at each facility. Unfortunately, few facilities followed the instructions for the exposure of these blank detectors, and, therefore, these corrections could not be made.

The corrections made because of leaky pouches are relatively small, about 0.5 to ~ 1 pCi/L. Because other corrections could not be made, most of the results reported will be conservative (i.e., most will be somewhat higher than the actual values). All decisions made on the basis of these results, therefore, will err on the side of safety, if they do err. Detailed discussions along with the data will be given in Sect. 4.

The QC program also revealed a lot-to-lot variation. That is, the manufacturer reports radon levels that vary from manufacturing lot to manufacturing lot even though the detectors were exposed at the same levels at ORNL. Because this variation was measured, corrections for it were applied. Correction involved generating a series of lot-dependent correction curves that account for the systematic variation between the manufacturer's reported results of the radon levels from our exposed samples to the actual levels of those exposed detectors. Additional details are given in Sect. 4.

2.3 PRIORITIZATION

Installations where a radon reading greater than 4 pCi/L is obtained from the screening results from housing will have their housing, child-care centers, schools, and hospitals assessed. In these cases, assessment will begin shortly after such results are obtained. The remaining structures on these and other installations will be prioritized by one of the methods discussed in Sect. 5.

2.4 STATISTICAL CONSIDERATIONS FOR CALIBRATION CURVES

This section discusses the effect that the number of calibration exposures has on the error associated with the calibration curve derived from the exposures.

Detectors will be exposed to seven known levels of radon intensity. These detectors will be sent to the vendor, who reports the exposure levels after determining them. These points will be plotted on a graph, with the vendor values on the Y-axis and the known exposure values on the X-axis. A calibration curve will then be drawn through those points. When the vendor is sent a detector that has been exposed in the field, the vendor reports

the exposure measurements. From that value (a Y-value), a point will be located on the curve at that value, and the corresponding X-value will be read. This X-value is the "true," or corrected, X-value of the exposure.

An error is associated with this procedure, however. The greater the number of detectors exposed at each known level, the smaller the error. The object is to determine this error for several cases.

Details are presented in Sect. 6. It is tentatively concluded that three detectors per exposure level should ensure an error within 15%. Three detectors per exposure rather than two are selected because of possible detector losses.

2.5 QUALITY ASSURANCE

DOE has mandated that all work done within its purview will comply with the applicable portions of The American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME) NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*. Although these quality assurance (QA) requirements are stringent, the key words are "applicable portions;" therefore, those portions of the document directed toward the safe handling of man-made radioactive products do not apply to NAVRAMP. However, other portions do, and NAVRAMP must comply. In addition, HAZWRAP requires compliance with EPA Guidance Document QAMS 005/80, *Interim Guidelines and Specifications for Preparing a Quality Assurance Project Plan*, to ensure that EPA QA requirements are met on all projects in which EPA has responsibilities. A NAVRAMP QA document is in preparation that should be consistent with both DOE and EPA requirements.

3. CURRENT STATUS

Detectors have been sent to all DON sites that have family housing areas, child-care centers, schools, hospitals, bachelor quarters, and brigs. To review briefly, 33 detectors were sent to each housing area; 2 were sent for each child-care center, school, brig, and bachelor quarters (but no more than 4 per installation for bachelor quarters); and 3 were sent for each hospital. These numbers do not include QC samples. If there were fewer than 33 ground-floor units in a housing area, each unit received a detector. A total of 27,100 detectors were sent to the field for exposure.

To date, about 9,000 detectors have been returned. About 50% of the housing facilities have returned detectors, and about 40% of the facilities containing nonhousing structures have returned detectors. These fractions are different from the fractions of detectors returned as indicated in the figures in this section.

From the figures above, it is clear that detectors have been received mainly from small facilities. The bulk of the detectors have yet to be returned. Details of the current status are contained in Tables A.1a-f through A.5a-f, included in Appendix A. It should be noted that the retrieval notices are sent 1 month in advance of the time for scheduled retrieval. Attempts are made to recoup missing information by telephoning the facilities.

In Tables A.2a, c, d, e, and f containing months for placement and retrieval, the next to last column indicates the month in which the detectors were taken down, and the last column contains the month in which the detectors were returned. In these same tables, the column labeled "mailed" contains the month the retrieval notices were mailed or are scheduled to be mailed.

In Tables A.5a-f containing the status of nonhousing facilities, the time the detectors were placed and the time they were retrieved represent the average time of placement and removal of detectors from all of the nonhousing buildings at the facility.

The charts in Figs. 3.1 through 3.7 indicate the current status. In Figs. 3.4 and 3.5, the percentages lost are percentages of all the detectors sent to the field. Fig. 3.8 illustrates the fraction of detectors sent to housing facilities that have been lost, and Fig. 3.9 illustrates the fraction lost plus damaged (not usable). An intense effort with follow-up telephone calls is made to recoup the losses.

NAVRAMP DETECTOR UTILIZATION

27,100 DETECTORS TOTAL

Fig. 3.1. Overall Navy Radon Assessment and Mitigation Program (NAVRAMP) detector utilization for screening.

HOUSING DETECTOR USE

23,500 DETECTORS

HOUSING UNITS
86 %

Fig. 3.2. Distribution of screening detectors for housing.

NONHOUSING DETECTOR USE

2,100 DETECTORS

Fig. 3.3. Distribution of screening detectors for nonhousing.

HOUSING DETECTORS RETRIEVAL

ALL DIVISIONS

Fig. 3.4. Retrieval status for housing.

NONHOUSING DETECTOR RETRIEVAL

ALL DIVISIONS

Fig. 3.5. Retrieval status for nonhousing.

HOUSING DETECTOR RETRIEVAL

AS OF MAY 15, 1990

MONITORS

Fig. 3.6. Retrieval status for housing by Engineering Field Division.

NONHOUSING DETECTOR RETRIEVAL

MONITORS

AS OF MAY 15, 1990

Fig. 3.7. Retrieval status for nonhousing by Engineering Field Division.

Fig. 3.8. Current percentage of detectors returned from family housing facilities, including usable and damaged detectors.

HOUSING RETRIEVAL

Fig. 3.9. Current fraction of usable detectors recovered from housing facilities as a percentage of total detectors sent.

4. ANALYSIS OF ERRORS AND APPLICATION TO RADON MEASUREMENTS

4.1 ERROR ANALYSIS

To determine time-weighted average radon concentrations at over 20,000 sites, DON personnel have deployed detectors that have been or will be retrieved about 1 year after deployment. The detectors used were functionally similar to the devices described by Alter and Fleischer (1981).¹ The operating principles of the device have been described in Sect. 2. Measuring devices of all kinds have errors associated with them. In the following subsections, the efforts to determine the magnitude of the errors associated with the alpha track detectors are described. The magnitude found is acceptable.

4.2 SOURCES OF ERROR

Some potential sources of error were identified. The QA plan included testing of detectors in the radon chamber at ORNL and of some detectors at DON sites (Wilson and Dudney, 1989).² The specific sources of error that were tested included manufacturing lots, chemical processing/etching batches, leaking pouches, and calibration. Each of these will be discussed below.

The vendor supplying the detectors identified the lot from which each detector had come. From each lot containing a sufficient number of detectors, ORNL staff set aside several detectors for exposure in a large, environmentally controlled radon chamber. The location within the ORNL chamber was recorded for each detector so any systematic variation within the chamber could be identified. About five detectors per lot were exposed to 0.2 pCi/L for 129 days, which is an exposure of 25.8 pCi/L days. About 12 alpha track detectors per lot were exposed to 5.5 pCi/L for 61 days (334 pCi/L days), and 2 detectors per lot were exposed to 102 pCi/L for 61 days (6,500 pCi/L days). These detectors were all removed from their pouches and otherwise handled like the detectors at DON sites. Using standard techniques, the variance was analyzed in the number of tracks recorded in 43.1 nm² for detectors exposed simultaneously in the chamber (Snedecor and Cochran, 1967),³ using a rejection criterion of $P < 0.05$. Variation among sites in the chamber was examined, along with variation among manufacturing lots in a two-way analysis of variance using commercially available software (SAS Institute, 1985).⁴ Table 4.1 presents the results from these analyses of variance. A $Pr(>F)$ value less than .05 indicates a dependence on the effect, under the assumed criterion.

Table 4.1. Analyses of variance due to manufacturing lot and location in Oak Ridge National Laboratory chamber

Chamber exposure	No. of lots	No. of loc'n	Effect of lot		Effect of loc'n ¹	
			F ²	Pr ³ (>F) ⁴	F	Pr(>F)
25.8 pCi/L day	52	6	5.03	<0.01	1.63	0.15
334 pCi/L day	52	12	5.53	<0.01	0.51	0.90
6500 pCi/L day	48	4	1.62	0.05	1.19	0.32

¹Loc'n = location.

²F = variance ratio.

³Pr = probability.

⁴The probability of a larger value of F if the indicated effect (i.e., lot, batch, location, etc.) did not truly cause an effect on the observed measurement.

These results show a statistically significant variation among lots but not among sites within the chamber. Figures 4.1a, b, and c show the magnitude of this effect. The distribution of mean numbers of tracks recorded for detectors from single lots for the three chamber exposures exhibits considerable variation among lots. Because of the range of mean results by lot for identically exposed alpha track detectors, calibration formulae specific to each manufacturing lot were developed for use in this program.

In addition to the lot, the vendor identified the processing (etching) batch in which each acrylic plastic chip from a detector had been etched before counting. With regard to the numbers of tracks recorded in 43.1 mm², the variation among processing batches was analyzed along with variation among chamber locations for the data described in Table 4.1. Table 4.2 summarizes the results.

Table 4.2. Analyses of variance due to chemical processing batch and location of Oak Ridge National Laboratory chamber

Chamber exposure	No. of processes	No. of loc'ns	Effect of process		Effect of loc'n ¹	
			F ²	Pr ³ (>F)	F	Pr(>F)
25.8 pCi/L day	61	6	1.81	<0.01	0.62	0.69
334 pCi/L day	61	12	2.66	<0.01	0.64	0.80
6500 pCi/L day	48	4	1.04	0.45	1.31	0.28

¹Loc'n = location.

²F = variance ratio.

³Pr = probability.

These results show a statistically significant variation among processing batches but not among sites within the chamber. Figures 4.2a, b, and c show the magnitude of this effect. The distribution of mean numbers of tracks recorded for detectors from single processing batches for the three chamber exposures exhibits considerable variation among batches. This source of error cannot be compensated for because arrangements had not been made with the vendor to require inclusion of positive controls in each processing batch that includes DON detectors. Planning for future contracts with vendors will include provisions for batch-specific correction to data generated for DON.

There were 61 instances, involving 128 detectors, in which 2 or 3 detectors from the same lot were processed in the same batch after exposure to 334 pCi/L days in the ORNL chamber. This subset of the available data was used in a two-way analysis of variance, and variations due to lot and processing batch were examined simultaneously. Variation due to location within the chamber was not included because it was not significant in the previous tests. Table 4.3 summarizes the results. These results suggest that both factors, lot and process batch, are significant contributors to variation and that chemical process batch is possibly the larger contributor of the two.

Another potential source of error was leaks through the vendor-supplied pouches in which each detector is packed. If such leaks were to have occurred, indicators of exposure (i.e., tracks) would accumulate on the detectors before opening and deployment at DON sites. Potential leaks were determined by exposing detectors in the pouches in the ORNL chamber simultaneously with the opened detectors described above. About five detectors per lot were exposed to 25.8 pCi/L days, two detectors per lot to 334 pCi/L days, and two per lot to 6500 pCi/L days. The data were analyzed on a lot-by-lot basis by examining the ratio of mean number of tracks recorded for unopened detectors from a lot to the mean number of tracks recorded for opened detectors from the same lot (see Table 4.4 and Fig. 4.3).

Fig. 4.1(a). Number of manufacturing lots showing mean response as indicated for 25.8 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

Fig. 4.1(b). Number of manufacturing lots showing mean response as indicated for 334 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

Fig. 4.1(c). Number of manufacturing lots showing mean response as indicated for 6500 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

Nominal exposure of 25.8 pCi/L days

Fig. 4.2(a). Number of chemical processing batches showing mean response as indicated for 25.8 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

Nominal exposure of 334 pCi/L days

Fig. 4.2(b). Number of chemical processing batches showing mean response as indicated for 334 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

NUMBER OF CHEMICAL PROCESSING BATCHES

MEAN NUMBER OF TRACKS

Nominal exposure of 6500 pCi/L days

Fig. 4.2(c). Number of chemical processing batches showing mean response as indicated for 6500 pCi/L days exposure in the Oak Ridge National Laboratory radon chamber.

Fig. 4.3. Number of manufacturing lots indicating mean response for open and closed detectors.

Table 4.3. Analyses of variance due to manufacturing lot and chemical processing batch and location in Oak Ridge National Laboratory chamber (data from 21 lots and 25 process batches)

	F ₁	Pr ² (>F)
Process	2.31	<0.01
Lot	1.72	0.05

¹F = variance ratio.

²Pr = probability.

Table 4.4. Comparison of results from detectors in vendor-supplied pouches to normally deployed detectors

Exposure	No. of lots	Closed:opened ratio		
		Mean	Minimum	Maximum
25.8 pCi/L day	52	0.84	0.51	1.24
334 pCi/L day	52	0.72	0.22	1.06
6500 pCi/L day	47	0.63	0.09	0.97

For most lots, the presence of the pouches reduced the apparent radon concentration by about 25 to 50%. Because of this finding, estimates were made of the exposure that could be attributed to storage and handling of the detectors before shipment to DON sites. Where possible, the data are being corrected for non-DON exposures. Non-DON exposures that occur after shipment and before receipt by the vendor's analytical laboratory cannot be estimated. Planning for future measurements will include provisions to prevent leaks from compromising the integrity of the data.

4.3 ACCURACY

As discussed previously, several detectors from each lot were exposed to 25.8, 334, and 6,500 pCi/L days of radon in the ORNL chamber. These measurements plus the data from the detectors currently undergoing exposure to about 3,000 pCi/L days of radon constitute the data set for lot-specific calibration formulae. For analysis of these data, a quadratic relationship between estimated exposure (in pCi/L days) and the observed number of tracks in 43.1 mm² of plastic was used. The quadratic form was used because the vendor currently uses the following formulae, which are not lot-specific, to estimate exposure (in pCi/L days) from the tracks recorded on each detector:

$$\text{Net track density (NTD)} = (\text{tracks in } 43.1 \text{ mm}^2 / 43.1 \text{ mm}^2) - 1.34$$

$$\text{Exposure (in pCi/L days)} = 41.8 * \text{NTD} + 0.474 * \text{NTD}^2 - 0.98$$

Table 4.5 summarizes the results from regressing exposure, as determined by ORNL, onto recorded tracks and the square of recorded tracks for detectors from 50 different lots. The regression coefficients for the squared term are not shown because none of the field results have been large enough to warrant use of higher order terms. If the results from the regression with the quadratic formula indicated that the second-order coefficient was not significantly greater than zero, the regression was recomputed with a linear formula. The square root of the mean squared error is shown in Table 4.5 because this is the best available estimate of the error resulting from the chosen calibration procedures and results.

It should be noted that a better statistical treatment of these data would be to treat exposure as the independent variable in the regression because exposure is the experimental quantity that is known more accurately. When the regression is inverted in this way, the formula becomes nonlinear in the regression coefficients. Methods are being developed to analyze the data in this way after the intermediate range exposure data become available.

Exposures at 25.8 and 334 pCi/L days were emphasized when the experimental plan for QA was designed (Wilson and Dudney, 1989).² The typical number of tracks recorded for detectors exposed to 25.8 and 334 pCi/L days were about 165 (see Fig. 4.2a) and about 415 (see Fig. 4.2b), respectively. Figure 4.4 shows the distribution of results from DON sites as of April 15, 1990. Most results from the field are between the calibration exposures at 25.8 and 334 pCi/L days. For data in this range, the error attributable to calibration uncertainty is less than 15%.

4.4 PRECISION

Another estimate of error is the precision of the measurement process. Precision reflects the ability of the measurement process to yield similar results when independent detectors are placed in the same monitoring site for the same monitoring interval. The most commonly used measure of precision is the standard deviation of measurements from co-located detectors. The analysis of variance in results from co-located detectors has provided estimates of the standard deviation and the coefficient of variation as shown in Table 4.6. As a reminder, the coefficient of variation is the standard deviation divided by the mean.

Table 4.6 Analysis of variation in results from colocated detectors

Exposure conditions	Standard deviation (Tracks/43.1 mm ²)	Coefficient of variation (%)
Oak Ridge National Laboratory chamber:		
25.8 pCi/L days	26	16
334 pCi/L days	43	10
6500 pCi/L days	120	2.7
Department of Navy Sites	30	12

The precision of these results is quite good under field conditions. Typical values reported in other surveys of radon in occupied houses tend to be 15% or greater.

Fig. 4.4. Number of monitors showing mean response.

Table 4.5. Summary of lot-specific calibration data

Manufacturer's lot	Numbers of detectors exposed			Regression coefficients		Root mean square error (pCi/L days)
	to 25.8 pCi/L days	to 334 pCi/L days	to 6530 pCi/L days	Intercept (pCi/L days)	Slope (pCi/L days per track)	
881106	4	11	2	-128	1.145	56
881110	5	11	2	-118	1.106	74
881111	5	11	2	-163	1.231	44
881112	5	11	2	-209	1.520	41
881203	5	11	2	-175	1.324	105
881205	5	9	1	-188	1.302	28
881206	5	11	2	-149	1.280	58
881207	5	10	3	-178	1.336	105
881208	1	5	2	-120	1.164	32
881209	5	11	2	-157	1.328	51
881214	5	11	4	-153	1.256	72
881215	4	11	1	-211	1.405	45
881216	5	11	0	-148	1.234	30
881217	5	11	2	-168	1.320	63
881218	5	10	2	-196	1.392	42
881219	5	11	2	-126	1.193	118
881220	3	9	1	-207	1.549	21
881222	5	9	2	-137	1.223	74
881223	5	11	2	-111	1.207	63
881224	5	11	2	-116	1.195	47
881225	5	11	2	-191	1.354	58
881227	4	11	2	-177	1.205	89
881230	5	11	2	-137	1.243	94
881231	4	11	2	-139	1.302	59
881232	5	11	2	-174	1.387	64
881233	5	8	2	-174	1.272	99
881234	5	11	2	-153	1.312	80
881235	5	11	2	-112	1.153	97
881236	5	11	1	-121	1.092	43
881238	5	21	2	-125	1.200	68
881240	5	10	2	-152	1.264	79
881241	5	11	2	-142	1.186	77
881242	5	10	2	-147	1.224	74
881244	5	11	2	-174	1.379	88
881245	5	10	2	-127	1.231	39
881247	5	11	2	-128	1.179	74
881249	5	10	2	-164	1.335	40
881250	5	11	2	-157	1.307	46
881251	5	11	2	-134	1.224	37
881252	5	11	2	-110	1.147	47
881253	5	11	2	-106	1.112	28
881254	10	22	4	-125	1.220	96
881255	5	10	2	-105	1.093	37
881263	5	10	2	-131	1.210	48
881264	5	11	2	-147	1.275	56
881265	4	11	2	-104	1.120	38
890101	10	18	2	-30	0.917	52
890106	5	11	0	-76	1.067	25
890107	4	11	0	-120	1.302	29
890108	5	11	0	-70	1.145	27

4.5 SUMMARY

Considering all the previously discussed sources of error, the reliable lower limit of quantification is estimated to be 0.5 pCi/L for a detector placed for 3 to 15 months. Table 4.7 summarizes estimated errors by source for a typical detector reading, which might be about 325 tracks. Where possible, the estimates in Table 4.7 come from analysis of variance results. The estimate for leaky packaging is based on best judgment. Thus the estimated error for an exposure for 1 year at 1 PCi/L is 44%. For a 1 year exposure at 4 PCi/L, the estimated error decreases to about 30%.

Table 4.7. Source of errors in a typical measurement result
(1 pCi/L for 1 year)

Source of error	Coefficient of variation (%)	Error (tracks)
Calibration	12	36
Batch	14	43
Leaky pouches	20	60
Counting (or random)	6	18
Total	44	131

5. PRIORITIZATION METHODS

5.1 INTRODUCTION

In this section, a general description is given of a plan for possible prioritization of DON installations following initial sampling and screening with a focus on family housing. Eight different methods of prioritization are described and illustrated, using early sample data (uncorrected) from 11 installations. Before the eight methods are described, the following setting in Table 5.1, which provides an overview of the DON housing, should be noted.

Table 5.1. Department of Navy universe radon distributions

Installation	Number of housing units at the installation	True (unknown) distributions of houses Radon intervals ^a					
		1	2	3	4	5	6
1	N_1	N_{11}	N_{12}	N_{13}	N_{14}	N_{15}	N_{16}
2	N_2	N_{21}	N_{22}	N_{23}	N_{24}	N_{25}	N_{26}
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
i	N_i	N_{i1}	N_{i2}	N_{i3}	N_{i4}	N_{i5}	N_{i6}
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
I	N_I	N_{I1}	N_{I2}	N_{I3}	N_{I4}	N_{I5}	N_{I6}

^a Radon intervals:

1 = $0 \leq RR < 2$	3 = $4 \leq RR < 10$	5 = $20 \leq RR < 70$
2 = $2 \leq RR < 4$	4 = $10 \leq RR < 20$	6 = $RR \geq 70$

Thus in Table 5.1, N_{23} represents the true (and unknown) number of houses at DON Installation 2, with radon readings (RR) ≥ 4 pCi/L and < 10 pCi/L. Ideally, all of the numbers in Table 5.1 should be known.

Instead of measuring each and every house at each DON installation, a sample of houses was monitored, ultimately providing the data in Table 5.2. In Table 5.2, n_{23} represents the observed number of houses in the sample at Installation 2, with radon readings ≥ 4 pCi/L and < 10 pCi/L. Also $\max_2$ is the maximum observed sample reading at Installation 2. Note that all of the numbers in Table 5.2 are known.

Table 5.2. Department of Navy sample radon distributions

Installation	Number of housing units at the installation	Number of houses selected for sample	(Known) Sample distributions of houses Radon intervals						Maximum sample reading
			1	2	3	4	5	6	
1	N_1	n_1	n_{11}	n_{12}	n_{13}	n_{14}	n_{15}	n_{16}	$\max_1$
2	N_2	n_2	n_{21}	n_{22}	n_{23}	n_{24}	n_{25}	n_{26}	$\max_2$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
i	N_i	n_i	n_{i1}	n_{i2}	n_{i3}	n_{i4}	n_{i5}	n_{i6}	$\max_i$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
I	N_I	n_I	n_{I1}	n_{I2}	n_{I3}	n_{I4}	n_{I5}	n_{I6}	$\max_I$

While Table 5.2 gives an idea of the relative distribution of the numbers that should go into Table 5.1, the sample distributions in Table 5.2 do not directly give the (unknown) values in Table 5.1. It is clear that one way to estimate N_{23} , say, is to take the estimate (basically of the form)

$$\hat{N}_{23} = N_2 \left[\frac{n_{23}}{n_2} \right]$$

The exact details are slightly more involved. Proceeding in an analogous way on each row of Table 5.2, estimates of the numbers in Table 5.1 could be produced, as given in Table 5.3.

Table 5.3. Simple projections of Department of Navy universe radon distributions

Installation	Number of housing units at the installation	Number of houses selected for sample	Simple projected distributions based on observed sample distributions					
			Radon intervals					
			1	2	3	4	5	6
1	N_1	n_1	$\hat{N}_{11}$	$\hat{N}_{12}$	$\hat{N}_{13}$	$\hat{N}_{14}$	$\hat{N}_{15}$	$\hat{N}_{16}$
2	N_2	n_2	$\hat{N}_{21}$	$\hat{N}_{22}$	$\hat{N}_{23}$	$\hat{N}_{24}$	$\hat{N}_{25}$	$\hat{N}_{26}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
i	N_i	n_i	$\hat{N}_{i1}$	$\hat{N}_{i2}$	$\hat{N}_{i3}$	$\hat{N}_{i4}$	$\hat{N}_{i5}$	$\hat{N}_{i6}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
I	N_I	n_I	$\hat{N}_{I1}$	$\hat{N}_{I2}$	$\hat{N}_{I3}$	$\hat{N}_{I4}$	$\hat{N}_{I5}$	$\hat{N}_{I6}$

A somewhat more involved method of determining projected distributions makes use of the observed sample distributions (in Table 5.2) and on assumed distributions for each installation (actually each family housing area at an installation) such as lognormal, normal, exponential, etc. This leads to the projected distributions as given in Table 5.4.

Table 5.4. Projections of Department of Navy universe radon distributions using lognormal or other distributions

Installation	Number of housing units at the installation	Number of houses selected for sample	Projected distributions using lognormal or some other distributions					
			Radon intervals					
			1	2	3	4	5	6
1	N_1	n_1	N_{11}^*	N_{12}^*	N_{13}^*	N_{14}^*	N_{15}^*	N_{16}^*
2	N_2	n_2	N_{21}^*	N_{22}^*	N_{23}^*	N_{24}^*	N_{25}^*	N_{26}^*
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
i	N_i	n_i	N_{i1}^*	N_{i2}^*	N_{i3}^*	N_{i4}^*	N_{i5}^*	N_{i6}^*
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
I	N_I	n_I	N_{I1}^*	N_{I2}^*	N_{I3}^*	N_{I4}^*	N_{I5}^*	N_{I6}^*

With this background and after the sampling, the desire is to assign each DON installation to one of the following four action categories and to prioritize (rank) the installations within each action category, hence leading to an overall ranking of the DON installations for the assessment phase of NAVRAMP. The four action categories are:

Action Category	Definition
0	$0 \leq \text{Max radon Reading} < 4$
1	$4 \leq \text{Max radon Reading} < 20$
2	$20 \leq \text{Max radon Reading} < 70$
3	$70 \leq \text{Max radon Reading}$

5.2 THE EIGHT PRIORITIZATION METHODS

Each of the eight methods is described below.

5.2.1 Prioritization Method I

- Step 1 For the i^{th} installation, assign it to Category 0, 1, 2, or 3 depending on its "max_i" value from Table 5.2.
- Step 2 Within each category, order the installations from largest to smallest "max" value.
- Step 3 To obtain overall ranking, order all installations with the ordered 3's first, the ordered 2's next, then the ordered 1's, and finally the ordered 0's.
- Step 4 Review ranking for reasonableness.

5.2.2 Prioritization Method II

- Step 1 Same as Method I.
- Step 2 (a) Using the sample data, compute a (weighted) mean $\bar{y}$ radon reading for each installation.
(b) Within each category, order the facilities from largest to smallest " $\bar{y}$ " value.
- Step 3 Same as Method I.
- Step 4 Review ranking for reasonableness.

5.2.3 Prioritization Method III

- Step 1 Same as Method I.
- Step 2 (a) To each radon interval, assign a score between 0 and 1, and let the score for each interval increase from interval 1 to interval 6. For example,

Interval	Score
1	0.0005
2	0.001
3	0.005
4	0.01
5	0.05
6	0.1

- (b) For each installation, compute a projected average score $\hat{S}$ using the $\hat{N}_{ij}$'s in Table 5.3.
- (c) Within each category, order the installations from largest to smallest " $\hat{S}$ " value.

Step 3 Same as Method I.

Step 4 Review ranking for reasonableness.

5.2.4 Prioritization Method IV

Step 1 Same as Method I.

Step 2 (a) Same as Method III.

(b) Same as Method III, but use N_{ij}^* 's instead of $\hat{N}_{ij}$'s.

(c) Same as Method III.

Step 3 Same as Method I.

Step 4 Review ranking for reasonableness.

5.2.5 Prioritization Method V

Step 1 Same as Method I.

Step 2 (a) For the i^{th} installation and using Table 5.4, compute

$$d_1 = .0005(N_{i3}^* + N_{i4}^* + N_{i5}^* + N_{i6}^*).$$

(b) For the installation, compute

$$d_2 = \begin{cases} 0 & \text{if highest index } j \text{ with nonzero projected } N_{ij}^* \text{ is } N_{i1}^*, N_{i2}^*, \text{ or } N_{i3}^* \\ 0.1 & \text{if highest index } j \text{ with nonzero projected } N_{ij}^* \text{ is } N_{i4}^* \\ 0.3 & \text{if highest index } j \text{ with nonzero projected } N_{ij}^* \text{ is } N_{i5}^* \\ 0.5 & \text{if highest index } j \text{ with nonzero projected } N_{ij}^* \text{ is } N_{i6}^* \end{cases}$$

(c) For each installation, compute $d = d_1 + d_2$.

(d) Within each of the four categories, order the installations from largest to smallest " d " value.

Step 3 Same as Method I.

Step 4 Review ranking for reasonableness.

5.2.6 Prioritization Method VI

Step 1 For the i^{th} installation, assign it to Category 0, 1, 2, or 3 and subcategories as follows, using Tables 5.2 and 5.4.

Category	Subcategory	Condition
3	a	If $\max_i \geq 70$
2	a	If $20 \leq \max_i < 70$ and $N_{i6}^* \neq 0$
	b	If $20 \leq \max_i < 70$ and $N_{i6}^* = 0$
1	a	If $4 \leq \max_i < 20$ and $N_{i5}^* \neq 0$
	b	If $4 \leq \max_i < 20$ and $N_{i5}^* = 0$
0	a	If $0 \leq \max_i < 4$ and $N_{i3}^* \neq 0$
	b	If $0 \leq \max_i < 4$ and $N_{i3}^* = 0$

Step 2 From Step 1, there are seven ordered subcategories:

3a
2a
2b
1a
1b
0a
0b

Within each subcategory, order from largest to smallest according to "max" value.

Step 3 Same as Method I but applied to the seven subcategories.

Step 4 Review ranking for reasonableness.

5.2.7 Prioritization Method VII

Step 1 Same as Method VI.

Step 2 From Step 1, there are seven ordered subcategories:

3a
2a
2b
1a
1b
0a
0b

Within each subcategory, order according to " N_{ij}^* " (and largest "max" values).

- Step 3 Same as Method I but applied to the seven subcategories.
- Step 4 Review ranking for reasonableness.

5.2.8 Prioritization Method VIII

- Step 1 For the i^{th} installation, assign it to Category 0, 1, 2, or 3, depending on the largest index j with nonzero projected N_{ij}^* from Table 5.4.
- Step 2 (a) For the installations assigned to Category 3, rank from largest to smallest according to projected value N_{i6}^* .
- (b) For the installations assigned to Category 2, rank from largest to smallest according to projected value at N_{i5}^* .
- (c) For the installation assigned to Category 1, first rank from largest to smallest value of N_{i4}^* those installations where $N_{i4}^* \neq 0$.
- Follow this with a ranking from largest to smallest value of N_{i3}^* those installations where $N_{i3}^* \neq 0$ and $N_{i4}^* = 0$.
- (d) For the installations assigned to Category 0, first rank from largest to smallest values of N_{i2}^* those installations where where $N_{i2}^* \neq 0$.
- Follow this with a ranking from largest to smallest value of N_{i1}^* those installations where $N_{i1}^* \neq 0$ and $N_{i2}^* = 0$.
- Step 3 Produce overall ranking based on Step 2.
- Step 4 Review ranking for reasonableness.

5.3 SUMMARY, COMPARISON, AND ILLUSTRATION OF THE PRIORITIZATION METHODS

The prioritization methods can be summarized as follows.

Method	Summary
I	Uses largest observed sample value at the installation to assign installation to Category 0, 1, 2, or 3, and the same is used to rank the installations within each category.
II	Uses largest observed sample value at the installation to assign installation to Category 0, 1, 2, or 3, and uses an estimated average installation reading to rank the installations within each category.
III	Uses largest observed sample value at the installation to assign installation to Category 0, 1, 2, or 3, and uses a (simple) projected average installation score to rank the installations within each category.
IV	Uses largest observed sample value at the installation to assign installation to Category 0, 1, 2, or 3, and uses a projected average installation score to rank the installations within each category.

Method	Summary (Continued)
V	Uses largest observed sample value at the installation to assign installation to Category 0, 1, 2, or 3, and uses a score based on projected number of units in each interval to rank the installations within each category.
VI	Uses a combination of largest observed sample value at the installation and projected number of units in the intervals to assign installations to Subcategories 0b, 0a, 1b, 1a, 2b, 2a, or 3a, and uses the largest observed sample value at the installation to rank the installations within each subcategory.
VII	Uses a combination of largest observed sample value at the installation and projected number of units in the intervals to assign installations to Subcategories 0b, 0a, 1b, 1a, 2b, 2a, or 3a, and uses the projected number of units in the intervals (and the largest observed sample value at the installation) to rank the installations within each subcategory.
VIII	Uses projected number of units in the intervals to assign installation to Category 0, 1, 2, or 3, and uses the same to rank the installations within each category.

Table 5.5 shows the extent to which projections are used in the prioritization methods. From Method I to Method VIII, one goes from using only the raw sample data to projections based on the sample data to prioritize.

Table 5.5. Extent to which projections are used

Methods	Mostly observed sample	Observed sample and some projections	Observed sample and projections	Some observed sample and projections	Mostly projections
I	X				
II		X			
III		X			
IV		X			
V			X		
VI			X		
VII				X	
VIII					X

Table 5.6 shows the extent to which each prioritization method considers the size (number of houses) of each installation.

Table 5.6. Influence of the size of the installation
with each method

Methods	No	Indirectly (weighted averages)	Yes
I	X		
II		X	
III		X	
IV		X	
V			X
VI			X
VII			X
VIII			X

As an illustration, the overall prioritization of 11 installations based on early (uncorrected) data for each of the methods is given in Table 5.7. While the illustration does not provide details of category and subcategory assignments, all installations were assigned to either Category 0 or 1. If needed, it is recommended that a prioritization method (e.g., Method V or Method VII) be employed, which makes use of the raw sample data as well as projections based on statistical methods. As seen from the bottom half of Table 5.7, some of the small facilities here had 100% or near 100% sampling. Their highest reading will determine their category, and the remainder of the readings will determine their positions within the subcategories. For these facilities, projection methods do not apply.

Table 5.7. An illustration of the prioritization methods using early data

Rank	METHOD							
	I (max first, then max)	II (max first, then $\bar{y}$)	III (max first, then $\hat{S}$ using $\hat{N}_{ij}$)	IV (max first, then $\hat{S}$ using N_{ij}^*)	V (max first, then d and N_{ij}^*)	VI (max, N_{ij}^* , and Subcategories with max)	VII (max, N_{ij}^* , and Subcategories with N_{ij}^* and max)	VIII (N_{ij}^* first then N_{ij}^*)
First	3	3	3	3	*8	3	*8	*8
Second	11	11	11	11	*6	11	*6	*6
Third	5	10	1	1	11	5	11	11
Fourth	*8	5	4	10	*9	*8	*9	*9
Fifth	10	4	10	4	10	10	10	10
Sixth	*9	1	5	5	4	*9	4	4
Seventh	4	*8	*8	*8	3	4	3	3
Eighth	*6	*6	*6	*6	5	*6	5	5
Nineth	1	*9	*9	*9	1	1	1	1
Tenth	2	2	2	2	2	2	*7	*7
Eleventh	*7	*7	*7	*7	*7	*7	2	2

*Indicates an installation where sample number of houses n_i is less than one-third of total number of houses N at the facility.

Installation	N_i	n_i
1	5	5
2	8	6
3	11	11
4	43	29
5	24	24
6	415	63
7	52	16
8	1276	61
9	407	113
10	50	43
11	55	55

6. QUALITY CONTROL: SOME STATISTICAL CONSIDERATIONS ON FITTING A QUADRATIC AND ON THE REQUIRED NUMBER OF REPEATED MEASUREMENTS

6.1 INTRODUCTION

After each detector has been exposed in the field, it is returned to ORNL and sent to the vendor for a reading of measured radon level. The value the vendor reports for a given detector is in terms of (Y) tracks. However, it is desired to have the reading of the value from each detector in terms of (X) pCi/L days. Thus, there is a need to convert the measurements given in tracks into equivalent measurements given in pCi/L days. Evidence also shows that there is an effect in the readings due to the lots in which new detectors are received. Thus, for the detectors from a given lot, a calibration curve will be developed to make the conversions from tracks to pCi/L days for each detector. There will be as many calibration curves as there are lots.

In this section, a discussion is given of the proposed methodology for regressing Y on X in terms of a quadratic (e.g., $Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \epsilon$) for a given lot. For each lot, n detectors will be selected and used to develop the calibration curve. Actually,

n_1 detectors will be exposed at 0 pCi/L days;
 n_2 detectors will be exposed at 365 pCi/L days;
 n_3 detectors will be exposed at 730 pCi/L days;
 n_4 detectors will be exposed at 1,460 pCi/L days;
 n_5 detectors will be exposed at 5,475 pCi/L days;
 n_6 detectors will be exposed at 7,300 pCi/L days; and
 n_7 detectors will be exposed at 25,550 pCi/L days.

Following exposure in the ORNL radon chamber, these $n (= n_1 + n_2 + \dots + n_7)$ detectors from a given lot will be returned to the vendor for readings in terms of tracks. The main focus in this section is on appropriate choices of $n_1, n_2, n_3, n_4, n_5, n_6$, and n_7 for each lot. Assuming a quadratic and using data from previous lots, it has been tentatively decided to use $n_1 = n_2 = \dots = n_7 = 3$. The details supporting this choice are given in the remainder of this section.

For both physical and statistical reasons, an appropriate calibration curve must be developed. Statistical methods require the identification of independent and dependent variables to develop a calibration curve. Although the distinction between which variable should be independent and which one should be dependent is not always clear, usually the independent variable is taken to be the one that can be set at various predetermined levels. Thus a proper calibration curve would likely have exposure (in pCi/L-days) as the independent variable and numbers of tracks observed in a given area (in tracks per square millimeters) as the dependent variable.

The physical nature of the measurement process will further constrain the choice of a calibration curve. The curve must be monotonically increasing because as the exposure increases so will the number of tracks that result until the saturation limit is reached at extremely high exposures. The curve must also be concave down. As the density of the tracks increases, the mean distance between tracks will decrease and an increasing fraction of the tracks will not be discernible from their nearest neighbors. This implies that the first-order derivative of the dependent variable (i.e., tracks) with respect to the independent variable (i.e., exposure) must decrease as the independent variable increases. ORNL staff are working to develop appropriate curves for these purposes for use in this project.

Linear models have properties that facilitate experimental design computations. Section 6.2 illustrates how a specific linear model, namely a calibration curve in the form of a quadratic equation, can be used to estimate the most cost-effective numbers of ATDs to be used in

calibration experiments. It should be noted that Oak Ridge is also considering the model $Y = \gamma_0 + \gamma_1 X + \gamma_2 X^2 + \epsilon$, and maybe others, for a determination of appropriate $n_1, n_2, \dots, n_7$. The results of this investigation will occur in subsequent reports. The final determination of the n 's will be decided after the investigation.

6.2 GENERAL DESCRIPTION OF THE CALIBRATION CURVE

By taking repeated measurements of Y 's at each of seven X values, an attempt is made to fit a quadratic using the method of least squares. The variable X is an ORNL EXPOSURE and the variable Y is a VENDOR'S OBSERVED VALUE.

At X_h , assume there is a normal random variable

$$Y_h = \beta_0 + \beta_1 X_h + \beta_2 X_h^2 + \epsilon_h \quad (\text{for } h = 1, 2, 3, 4, 5, 6, 7)$$

where β_0, β_1 , and β_2 are constants to be estimated and ϵ_h is random error. The "conditional" mean of Y_h is $E(Y_h | X_h) = \beta_0 + \beta_1 X_h + \beta_2 X_h^2$ and the conditional variance of Y_h is $\sigma^2(Y_h) = \sigma^2$. The details are summarized in Table 6.1.

Table 6.1. Model summary at seven levels

pCi/L	$X_h = (\text{pCi/L})(365)$	Y_h	$E(Y_h X_h)$
0	$X_1 = 0$	$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2 + \epsilon_1$	$E(Y_1 X_1) = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2$
1	$X_2 = 365$	$Y_2 = \beta_0 + \beta_1 X_2 + \beta_2 X_2^2 + \epsilon_2$	$E(Y_2 X_2) = \beta_0 + \beta_1 X_2 + \beta_2 X_2^2$
2	$X_3 = 730$	$Y_3 = \beta_0 + \beta_1 X_3 + \beta_2 X_3^2 + \epsilon_3$	
4	$X_4 = 1460$	$Y_4 = \beta_0 + \beta_1 X_4 + \beta_2 X_4^2 + \epsilon_4$	
15	$X_5 = 5475$	$Y_5 = \beta_0 + \beta_1 X_5 + \beta_2 X_5^2 + \epsilon_5$	
20	$X_6 = 7300$	$Y_6 = \beta_0 + \beta_1 X_6 + \beta_2 X_6^2 + \epsilon_6$	
70	$X_7 = 25550$	$Y_7 = \beta_0 + \beta_1 X_7 + \beta_2 X_7^2 + \epsilon_7$	$E(Y_7 X_7) = \beta_0 + \beta_1 X_7 + \beta_2 X_7^2$

For X_h , the desire is to observe a random sample of n_h values of Y_h and use these observations, along with observations at the other X values, to produce a least squares estimator of $E(Y_h | X_h)$, which is often denoted by $\hat{Y}_h$. The details of the sample data are summarized in Table 6.2.

Table 6.2. The sample data and estimates at the seven levels

X_h	Random Sample	Estimator of $E(Y_h X_h)$
X_1	$Y_{11}, Y_{12}, \dots, Y_{1n_1} \rightarrow$	$\hat{Y}_1$
X_2	$Y_{21}, Y_{22}, \dots, Y_{2n_2} \rightarrow$	$\hat{Y}_2$
X_3	$Y_{31}, Y_{32}, \dots, Y_{3n_3} \rightarrow$	$\hat{Y}_3$
X_4	$Y_{41}, Y_{42}, \dots, Y_{4n_4} \rightarrow$	$\hat{Y}_4$
X_5	$Y_{51}, Y_{52}, \dots, Y_{5n_5} \rightarrow$	$\hat{Y}_5$
X_6	$Y_{61}, Y_{62}, \dots, Y_{6n_6} \rightarrow$	$\hat{Y}_6$
X_7	$Y_{71}, Y_{72}, \dots, Y_{7n_7} \rightarrow$	$\hat{Y}_7$

The figure below presents a graphical representation of Table 6.2.

Fig. 6.1. Graphical representation of data presented in Table 6.2.

6.3. HOW TO DETERMINE $n_1, n_2, n_3, n_4, n_5, n_6$, and n_7

As far as can be determined, the statistical literature does not provide an explicit answer to this question. For a given $n (= n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + n_7)$, one practice is to partition n among the values of X by considering the effect on the variances of the $\hat{Y}_h$ [i.e., by considering $\sigma^2(\hat{Y}_1), \sigma^2(\hat{Y}_2), \dots, \sigma^2(\hat{Y}_7)$]. One can show (e.g., Neter and Wasserman, p. 231)⁵ that $\sigma^2(\hat{Y}_h)$ is given by

$$\sigma^2(\hat{Y}_h) = [1 \ X_h \ X_h^2] (\underline{X}'\underline{X})^{-1} \begin{bmatrix} 1 \\ X_h \\ X_h^2 \end{bmatrix} \sigma^2$$

where $\underline{X}$ is the $n \times 3$ matrix

$$\underline{X} = \begin{bmatrix} 1 & X_1 & X_1^2 \\ \vdots & \vdots & \vdots \\ 1 & X_1 & X_1^2 \\ 1 & X_2 & X_2^2 \\ \vdots & \vdots & \vdots \\ 1 & X_2 & X_2^2 \\ 1 & X_3 & X_3^2 \\ \vdots & \vdots & \vdots \\ 1 & X_3 & X_3^2 \\ 1 & X_4 & X_4^2 \\ \vdots & \vdots & \vdots \\ 1 & X_4 & X_4^2 \\ 1 & X_5 & X_5^2 \\ \vdots & \vdots & \vdots \\ 1 & X_5 & X_5^2 \\ 1 & X_6 & X_6^2 \\ \vdots & \vdots & \vdots \\ 1 & X_6 & X_6^2 \\ 1 & X_7 & X_7^2 \\ \vdots & \vdots & \vdots \\ 1 & X_7 & X_7^2 \end{bmatrix} \begin{matrix} \left. \begin{array}{c} \\ \\ \end{array} \right\} n_1 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_2 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_3 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_4 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_5 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_6 \text{ rows} \\ \left. \begin{array}{c} \\ \\ \end{array} \right\} n_7 \text{ rows} \end{matrix}$$

As can be seen from the formula for $\sigma^2(\hat{Y}_h)$, there is a need to know σ^2 . From 54 sets (lots) of prior data on related measurements, estimated values of σ^2 by fitting 54 separate quadratics are given in Table 6.3.

Table 6.3. Estimates of σ^2 from previous lots

Lot	n	n_1	n_2	n_3	X_1	X_2	X_3	$\hat{\sigma}^2$	$\hat{\sigma}$
881106	17	4	11	2	58.2	429.79	6635.02	2017.66	44.9
881110	18	5	11	2	51.5	409.99	6627.62	3455.57	58.8
881111	18	5	11	2	58.8	431.59	6635.72	770.96	27.8
881112	18	5	11	2	64.6	448.70	6642.12	675.41	26.0
881203	18	5	11	2	53.6	416.20	6629.92	3560.34	59.7
881205	15	5	9	1	53.7	416.40	6620.02	441.83	21.0
881206	18	5	11	2	52.5	413.00	6628.72	1721.09	41.5
881207	18	5	10	3	59.6	434.00	6636.62	3961.45	62.9
881208	8	1	5	2	52.1	412.00	6628.22	577.40	24.0
881209	18	5	11	2	56.8	425.60	6633.42	1222.63	35.0
881214	20	5	11	4	54.6	419.20	6631.02	1671.32	40.9
881215	16	4	11	1	51.5	410.00	6627.62	937.66	30.6
881216	16	5	11	--	50.4	406.70	--	1464.91	38.3
881217	18	5	11	2	56.5	424.90	6633.12	1641.03	40.5
881218	17	5	10	2	49.5	404.20	6625.42	848.18	29.1
881219	18	5	11	2	53.7	416.60	6630.12	4317.86	65.7
881220	13	3	9	1	66.6	454.60	6644.32	184.90	13.6
881222	16	5	9	2	56.9	426.00	6633.62	1909.97	43.7
881223	18	5	11	2	51.5	409.90	6627.52	1914.07	43.8
881224	18	5	11	2	62.7	443.02	6640.02	1352.74	36.8
881225	18	5	11	2	54.1	417.80	6630.52	1385.36	37.2
881227	17	4	11	2	47.7	398.70	6623.32	3213.75	56.7
881230	18	5	11	2	45.7	392.70	6621.12	3672.84	60.6
881231	17	4	11	2	53.7	416.60	6630.02	1766.71	42.0
881232	18	5	11	2	46.4	394.70	6621.82	1592.80	39.9
881233	15	5	8	2	45.1	391.10	6620.52	4393.61	66.3
881234	18	5	11	2	38.3	370.70	6612.82	2602.63	51.0
881235	18	5	11	2	35.3	362.00	6609.62	3785.08	61.5
881236	17	5	11	1	34.7	360.00	6608.82	1388.06	37.3
881237	7	5	--	2	27.1	--	6600.52	3862.77	62.2
881238	28	5	21	2	38	369.90	6612.62	1851.75	43.0
881239	7	5	--	2	36.7	--	6611.12	21,518.08	146.7
881240	17	5	10	2	39.1	373.20	6613.82	2323.91	48.2
881241	18	5	11	2	36.6	365.70	6611.02	2584.44	50.8
881242	17	5	10	2	35.8	363.50	6610.12	2050.88	45.3
881244	18	5	11	2	44.9	390.50	6620.32	3941.22	62.8
881245	17	5	10	2	38.3	370.90	6612.92	934.97	30.6
881247	18	5	11	2	40.4	377.20	6615.32	2307.45	48.0
881248	13	--	11	2	--	333.80	6599.02	3830.61	61.9
881249	17	5	10	2	40.4	377.00	6615.22	751.73	27.4
881250	18	5	11	2	37.6	368.70	6612.12	1110.62	33.3
881251	18	5	11	2	38.0	369.80	6612.52	751.35	27.4

Table 6.3. Estimates of σ^2 from previous lots (Continued)

Lot	n	n_1	n_2	n_3	X_1	X_2	X_3	$\hat{\sigma}^2$	$\hat{\sigma}$
881252	18	5	11	2	39	372.80	6613.62	1515.51	38.9
881253	18	5	11	2	46.7	395.70	6622.22	613.26	24.8
881254	36	10	22	4	41.6	380.70	6616.62	3648.01	60.4
881255	17	5	10	2	42.8	384.00	6617.82	933.46	30.6
881263	17	5	10	2	34.1	358.40	6608.22	1368.70	37.0
881264	18	5	11	2	48	399.50	6623.62	1309.85	36.2
881265	17	4	11	2	34.4	359.30	6608.62	816.28	28.6
881273	11	--	11	--	--	333.80	--	1395.50	37.4
890101	28	10	18	--	37.6	368.90	--	6333.77	79.6
890106	16	5	11	--	31.2	349.90	--	2839.61	53.3
890107	15	4	11	--	32.4	353.43	--	1681.14	41.0
890108	16	5	11	--	29	343.20	--	2170.56	46.6

Now for given h and for given $n, n_1, n_2, n_3, n_4, n_5, n_6$, and n_7 , what is the probability $1 - \alpha$ (usually .90 or .95) so that $\hat{Y}_h$ is within B of $E(Y_h | X_h)$, that is

$$Pr(|\hat{Y}_h - E(Y_h | X_h)| < B) = 1 - \alpha \quad (1)$$

That is for given h , we have

From Equation (7.50) on page 232 of Neter and Wasserman,⁵ Equation (1) is equivalent to

$$B = t_{1 - \frac{\alpha}{2}; n-p} \sigma(\hat{Y}_h) \quad (2)$$

where for a t -distribution with $n-p$ "degrees of freedom" $t_{1 - \frac{\alpha}{2}; n-p}$ is such that

$$Pr(t_{n-p} \leq t_{1 - \frac{\alpha}{2}; n-p}) = 1 - \frac{\alpha}{2}.$$

In our case, $p = 3$ for β_0, β_1 , and β_2 .

Now for X_h , Equation (2) becomes

$$B = t_{1-\frac{\alpha}{2}; n-p} k \sigma \quad (3)$$

$$\text{where } \sigma = \sqrt{\sigma^2} \text{ and } k = [1 \ X_h \ X_h^2] (\underline{X}' \underline{X})^{-1} \begin{bmatrix} 1 \\ X_h \\ X_h^2 \end{bmatrix}.$$

Equivalently, Equation (3) is

$$t_{1-\frac{\alpha}{2}; n-p} = \frac{B}{k \sigma} \quad (4)$$

For $n = 14$ and $n_1 = n_2 = n_3 = n_4 = n_5 = n_6 = n_7 = 2$, the following results in Table 6.4 for $1 - \alpha$ were obtained using equation (4). For example, from Table 6.4 for $h = 3$ and $\sigma = 50$, the probability is between .90 and .95 that $\hat{Y}_3$ is within $B = .05X_3 = .05(730) = 36.5$ of $E(Y_3|X_3)$. The table provides results for two other cases when $n = 21$. Note that Cases B and C are almost equivalent. Case B has tentatively been selected over A to allow for some detector losses while maintaining accuracy.

Table 6.4. $1 - \alpha$ as in (1) for various alternativesCase A. $n = 14$ and $(n_1, n_2, n_3, n_4, n_5, n_6, n_7) = (2, 2, 2, 2, 2, 2, 2)$

h	pCi/L	$X_h = (\text{pCi/L})(365)$	$\sigma = 50$			$\sigma = 100$			$\sigma = 150$		
			$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$
1	0	0	--	--	--	--	--	--	--	--	--
2	1	365	.60-.70	.90-.95	.98-.99	.30-.40	.60-.70	.80-.90	.20-.30	.40-.50	.60-.70
3	2	730	.90-.95	.99-.999	.999+	.60-.70	.90-.95	.99-.999	.50-.60	.80-.90	.90-.95
4	4	1460	.999+	.999+	.999+	.95-.98	.999+	.999+	.80-.90	.99-.999	.999+
5	15	5475	.999+	.999+	.999+	.999+	.999+	.999+	.99-.999	.999+	.999+
6	20	7300	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+
7	70	25550	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+

Case B. $n = 21$ and $(n_1, n_2, n_3, n_4, n_5, n_6, n_7) = (3, 3, 3, 3, 3, 3, 3)$

h	pCi/L	$X_h = (\text{pCi/L})(365)$	$\sigma = 50$			$\sigma = 100$			$\sigma = 150$		
			$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$
1	0	0	--	--	--	--	--	--	--	--	--
2	1	365	.70-.80	.95-.98	.99-.999	.40-.50	.70-.80	.90-.95	.30-.40	.50-.60	.70-.80
3	2	730	.98-.99	.999+	.999+	.70-.80	.98-.99	.99-.999	.60-.70	.90-.95	.98-.99
4	4	1460	.999+	.999+	.999+	.99-.999	.999+	.999+	.90-.95	.99-.999	.999+
5	15	5475	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+
6	20	7300	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+
7	70	25550	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+

Case C. $n = 21$ and $(n_1, n_2, n_3, n_4, n_5, n_6, n_7) = (2, 3, 4, 4, 2, 4, 2)$

h	pCi/L	$X_h = (\text{pCi/L})(365)$	$\sigma = 50$			$\sigma = 100$			$\sigma = 150$		
			$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$	$B = .05X_h$	$B = .10X_h$	$B = .15X_h$
1	0	0	--	--	--	--	--	--	--	--	--
2	1	365	.70-.80	.95-.98	.99-.999	.40-.50	.70-.80	.90-.95	.30-.40	.50-.60	.70-.80
3	2	730	.98-.99	.999+	.999+	.70-.80	.98-.99	.999+	.60-.70	.90-.95	.98-.99
4	4	1460	.999+	.999+	.999+	.99-.999	.999+	.999+	.90-.95	.999+	.999+
5	15	5475	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+
6	20	7300	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+
7	70	25550	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+	.999+

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APPENDIX A
STATUS OF DETECTOR PLACEMENT AND RETRIEVAL

Table A.1a. Summary of sampling plan and exposures for family housing: Atlantic

UIC	Facility	No. of FHAs*	No. of units	Mailed detectors	Returned detectors	Exposure days
M00146	CHERRY POINT MCAS, NC	10	2757	331	91	210
M67001	CAMP LEJEUNE MCB, NC	14	4453	449	302	—
N00109	YORKTOWN NWS, VA	5	468	121	—	—
N00181	PORTSMOUTH NSY, VA	5	406	116	—	—
N00183	PORTSMOUTH NAVHOSP, VA	4	19	19	—	—
N00187	NORFOLK, VA	17	3314	527	—	—
N00197	LOUISVILLE NOS, KY	1	8	8	6	120
N00281	DAM NECK FCTC, VA	6	25	25	18	328
N00389	ROOSEVELT ROADS NS, PR	3	372	89	—	—
N32960	LA MADDALENA NSO, ITALY	5	162	91	—	—
N57049	ANTIGUA NF, CARIBBEAN	1	28	28	—	—
N57075	ARGENTIA NFD, NEWFOUNDLAND	1	215	53	24	322
N60138	CHEATHAM ANNEX NSC, VA	1	13	13	13	346
N60191	OCEANA NAS, VA	5	1129	125	—	—
N60514	GUANTANAMO BAY NS, CUBA	3	1253	99	—	—
N61414	LITTLE CREEK NAB, VA	4	1000	132	—	—
N61751	CAIRO NARNAMRU-3, EGYPT	1	1	1	1	270
N62481	BERMUDA NAS (ANNEX), BERMUDA	15	396	129	—	—
N62585	LONDON NAVACTS, UNITED KINGDOM	7	185	72	—	—
N62588	NAPLES NSA, ITALY	1	409	33	—	—
N62863	ROTA NS, SPAIN	12	814	262	—	—
N62995	SIGONELLA NAS, ITALY	1	120	33	—	—

Table A.1a. Summary of sampling plan and exposures for family housing: Atlantic (continued)

UIC	Facility	No. of FHAs*	No. of units	Mailed detectors	Returned detectors	Exposure days
N63032	KEFLAVIK NS, ICELAND	13	915	266	225	156
N63063	CAMP PERRY AFETA, VA	1	22	22	--	--
N63073	EDZELL NSGA, UNITED KINGDOM	3	263	99	--	--
N63395	THURSO NCS, UNITED KINGDOM	3	76	57	--	--
N63891	CHESAPEAKE NSGA, VA	4	140	104	88	355
N64981	ST MAWGAN, UNITED KINGDOM	1	19	19	--	--
N65895	LISBON IBERIANCMD, PORTUGAL	1	1	1	--	--
N65995	NAVSUPPACT HOLY LOCH, UNITED KINGDOM	6	421	166	--	--
N66691	SOUDA BAY NAVSUPACT, CRETE	1	1	1	--	--
N66754	SABANA SECA NSGA, PUERTO RICO	10	141	92	--	--
N66833	PANAMA CANAL NS, CANAL ZONE	6	249	134	--	--
N70295	NEA MAKRI NCS, GREECE	1	1	1	--	--
N70310	SUGAR GROVE NRS-R, WV	3	50	50	50	--

*Family housing areas.

Table A.2a. Detector status for family housing: Atlantic

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
M00146	CHERRY POINT MCAS, NC	03/89	04/89	Early*	11/89	11/89	
M67001	CAMP LEJEUNE MCB, NC	03/89	04/89	03/90	---	---	
N00109	YORKTOWN NWS, VA	03/89	04/89	03/90	---	---	
N00181	PORTSMOUTH NSY, VA	03/89	04/89	02/90	---	---	
N00183	PORTSMOUTH NAVHOSP, VA	03/89	03/89	02/90	---	---	
N00187	NORFOLK, VA	03/89	05/89	04/90	---	---	
N00197	LOUISVILLE NOS, KY	03/89	03/89	Early	07/89	07/89	
N00281	DAM NECK FCTC, VA	03/89	04/89	03/90	03/90	04/90	
N00389	ROOSEVELT ROADS NS, PR	03/89	---	01/90	---	---	
N32960	LA MADDALENA NSO, ITALY	03/89	10/89	06/90	---	---	
N57049	ANTIGUA NF, CARIBBEAN	03/89	04/89	03/90	---	---	
N57075	ARGENTIA NFD, NEWFOUNDLAND	03/89	05/89	02/90	03/90	04/90	
N60138	CHEATHAM ANNEX NSC, VA	03/89	04/89	03/90	04/90	04/90	
N60191	OCEANA NAS, VA	03/89	05/89	04/90	---	---	
N60514	GUANTANAMO BAY NS, CUBA	04/89	05/89	04/90	---	---	
N61414	LITTLE CREEK NAB, VA	03/89	06/89	05/90	---	---	
N61751	CAIRO NARNAMRU-3, EGYPT	05/89	06/89	01/90	03/90	04/90	
N62481	BERMUDA NAS (ANNEX), BERMUDA	03/89	07/89	06/90	---	---	
N62585	LONDON NAVACTS,	03/89	06/89	07/90	---	---	
N62588	NAPLES NSA, ITALY	03/89	08/89	07/90	---	---	
N62863	ROTA NS, SPAIN	03/89	05/89	01/90	---	---	

Table A.2a. Detector status for family housing: Atlantic (continued)

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
N62995	SIGONELLA NAS, ITALY	03/89	06/89	05/90	---	---	
N63032	KEFLAVIK NS, ICELAND	03/89	10/89	01/90	03/90	02/90	
N63063	CAMP PERRY, VA	03/89	10/89	02/90	---	---	
N63073	EDZELL NSGA, UNITED KINGDOM	03/89	11/89	02/90	---	---	
N63395	THURSO NCS, UNITED KINGDOM	03/89	05/89	04/90	---	---	
N63891	CHESAPEAKE NSGA, VA	03/89	04/89	03/90	03/90	04/90	
N64981	ST MAWGAN, UNITED KINGDOM	03/89	06/89	01/90	---	---	
N65895	LISBON IBERIANCMD, PORTUGAL	04/89	---	01/90	---	---	
N65995	NAVSUPPACT HOLY LOCH, UNITED KINGDOM	03/89	02/90	01/90	---	---	
N66691	SOUDA BAY NAVSUPACT, CRETE	03/89	---	01/90	---	---	
N66754	SABANA SECA NSGA, PUERTO RICO	03/89	05/89	04/90	---	---	
N66833	PANAMA CANAL NS, CANAL ZONE	05/89	08/89	08/90	---	---	
N70295	NEA MAKRI NCS, GREECE	03/89	---	01/90	---	---	
N70310	SUGAR GROVE NRS-R, WV	03/89	05/89	04/90	---	---	

*"Early" means that detectors were returned without having received retrieval notices.

Table A.3a. Summary of field QC samples for family housing: Atlantic

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Duplicates	Blanks	Duplicates	Blanks
M00146	CHERRY POINT MCAS, NC	30	19	8	6		
M67001	CAMP LEJEUNE MCB NC	43	31	23	3		
N00109	YORKTOWN NWS, VA	10	10	--	--		
N00181	PORTSMOUTH NSY, VA	8	10	--	--		
N00183	PORTSMOUTH NAVHOSP, VA	2	2	--	--		
N00187	NORFOLK, VA	48	31	--	--		
N00197	LOUISVILLE NOS, KY	0	2	0	2		
N00281	DAM NECK FCTC, VA	2	4	2	4		
N00389	ROOSEVELT ROADS NS, PR	9	6	--	--		
N32960	LA MADDALENA NSO, ITALY	5	6	--	--		
N57049	ANTIGUA NF, CARIBBEAN	3	2	--	--		
N57075	ARGENTIA NFD, NEWFOUNDLAND	3	2	3	0		
N60138	CHEATHAM ANNEX NSC, VA	2	2	0	0		
N60191	OCEANA NAS, VA	12	8	--	--		
N60514	GUANTANAMO BAY NS, CUBA	9	6	--	--		
N61414	LITTLE CREEK NAB, VA	12	8	--	--		
N61751	CAIRO NARNAMRU-3, EGYPT	0	0	0	0		
N62481	BERMUDA NAS (ANNEX), BERMUDA	12	8	--	--		
N62585	LONDON NAVACTS, UNITED KINGDOM	6	4	--	--		
N62588	NAPLES NSA, ITALY	3	2	--	--		
N62863	ROTA NS, SPAIN	20	16	--	--		

Table A.3a. Summary of field QC samples for family housing: Atlantic (continued)

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks		Duplicates	Blanks	
N62995	SIGONELLA NAS, ITALY	3	2		--	--	
N63032	KEFLAVIK NS, ICELAND	19	22		18	17	
N63063Z	CAMP PERRY AFETA, VA	3	2		--	--	
N63073	EDZELL NSGA, UNITED KINGDOM	9	6		--	--	
N63395	THURSO NCS, UNITED KINGDOM	8	6		--	--	
N63891	CHESAPEAKE NSGA, VA	10	8		7	0	
N64981	ST MAWGAN, UNITED KINGDOM	3	2		--	--	
N65895	LISBON IBERIANCMD, PORTUGAL	0	0		--	--	
N65995	NAVSUPPACT HOLY LOCH, UNITED KINGDOM	15	10		--	--	
N66691	SOUDA BAY NAVSUPACT, CRETE	0	0		--	--	
N66754	SABANA SECA NSGA, PUERTO RICO	7	6		--	--	
N66833	PANAMA CANAL NS, CANAL ZONE	12	12		--	--	
N70295	NEA MAKRI NCS, GREECE	0	0		--	--	
N70310	SUGAR GROVE NRS-R, WV	5	6		5	6	

Table A.4a. Numbers and status of detectors placed in various buildings for nonhousing: Atlantic

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
M00146	CHERRY POINT MCAS, NC	1	0	2	37	0	11	0
M67001	CAMP LEJEUNE MCB, NC	0	1	5	177	1	127	0
M67391	CMP ELMORE NORFOLK, VA	0	0	0	1	0	4	4
N00109	WPNSTA YORKTOWN, VA	0	0	2	4	0	8	0
N00181	PORTSMOUTH NSY, VA	0	0	1	54	0	6	0
N00183	PORTSMOUTH NAVHOSP, VA	2	0	0	3	0	10	10
N00281	DAM NECK FCTC, VA	0	0	0	16	1	6	5
N00306	NAS GUANTANAMO BAY, Cuba	0	0	0	9	0	4	0
N00389	ROOSEVELT ROADS NS, PR	1	0	3	90	0	26	0
N00693	NTC BAINBRIDGE, MD	0	0	1	112	1	8	8
N00743	NAVCOMMSTA ROOSEVELT, PR	0	0	0	1	0	4	0
N32960	LA MADDALENA NSO, ITALY	0	1	1	4	0	15	0
N57049	ANTIGUA NF, CARIBBEAN	0	0	0	2	0	4	0
N57075	ARGENTIA NFD, NEWFOUNDLAND	0	2	0	1	0	8	0
N57095	LANTFLT HEADSUPPACT, VA	0	0	0	5	0	4	4
N60138	CHEATHAM ANNEX NSC, VA	0	0	0	2	0	4	2
N60191	OCEANA NAS, VA	0	0	1	14	0	6	3
N60514	GUANTANAMO BAY NS, CUBA	0	4	1	104	0	14	0
N61414	LITTLE CREEK NAB, VA	0	0	1	8	0	6	0
N61564	NAVHOSP GUANTANAMO, CUBA	1	0	0	3	0	14	0
N62481	BERMUDA NAS (ANNEX), BERMUDA	0	12	0	17	0	33	0
N62585	LONDON NAVACTS, UNITED KINGDOM	0	2	1	2	0	10	0

Table A.4a. Numbers and status of detectors placed in various buildings for nonhousing: Atlantic (continued)

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
N62588	NAVSUPPACT NAPLES, ITALY	0	2	1	6	0	15	0
N62688	NAVSTA NORFOLK, VA	0	1	24	0	6	0	0
N62793	SUPSHIP NEWPORT NEWS, VA	0	0	0	4	0	4	0
N62863	ROTA, SPAIN	0	34	2	61	0	86	0
N62995	SIGONELLA NAS, ITALY	0	2	2	13	0	12	0
N63032	KEFLAVIK NAS, ICELAND	0	2	2	69	0	17	14
N63073	EDZELL NSGA, UNITED KINGDOM	0	1	1	2	0	8	0
N63395	NAVCOMMSTA THURSO, UNITED KINGDOM	0	0	0	1	0	4	0
N63891	CHESAPEAKE NSGA, VA	0	0	0	4	0	4	3
N64981	ST MAWGAN, UNITED KINGDOM	0	0	1	2	0	6	0
N66094	NAVHOSP CHERRY POINT, NC	1	0	0	0	0	3	0
N66096	NAVHOSP NAPLES, ITALY	1	0	0	0	0	3	0
N66101	NAVHOSP ROTA, SPAIN	1	0	0	0	0	6	2
N66691	SOUDA BAY NAVSUPACT, CRETE	0	0	0	8	0	4	4
N66754	SABANA SECA NSGA, PUERTO RICO	0	0	0	5	0	4	0
N66833	PANAMA CANAL NS, CANAL ZONE	0	0	1	4	0	11	0
N68093	NAVHOSP CAMP LEGEUNE, NC	1	0	0	0	0	3	0
N68165	NAVFAC BRAWDY WALES, UNITED KINGDOM	0	0	0	3	0	4	0
N70283	NAVSECGRUACT GALETA, PN	0	1	0	1	0	6	0
N70295	NEA MAKRI NCS, GREECE	0	0	0	4	0	9	0

Table A.5a. Dates associated with detector placement and retrieval for nonhousing: Atlantic

UIC	Facility	Detectors			
		Sent	Placed	Mailed	Retrieved
M00146	CHERRY POINT MCAS, NC	03/89	04/89	03/90	--
M67001	CAMP LEJEUNE MCB, NC	03/89	05/89	03/89	--
M67391	CMP ELMORE NORFOLK, VA	03/89	03/89	04/90	04/90
N00109	WPSTA YORKTOWN, VA	03/89	04/89	03/90	--
N00181	PORTSMOUTH NSY, VA	03/89	08/89	03/90	--
N00183	PORTSMOUTH NAVHOSP, VA	03/89	03/89	03/90	03/90
N00281	DAM NECK FCTC, VA	03/89	07/89	03/90	04/90
N00306	NAS GUANTANAMO BAY, CUBA	04/89	--	04/90	--
N00389	ROOSEVELT ROADS NS, PR	03/89	09/89	04/90	--
N00693	NTC BAINBRIDGE, MD	04/89	UNK	Early	10/89
N00743	NAVCOMMSTA ROSSEVELT, PR	03/89	11/89	07/90	--
N32960	LA MADDALENA NSO, ITALY	03/89	--	06/90	--
N57049	ANTIGUA NF, CARIBBEAN	03/89	04/89	03/90	--
N57075	ARGENTIA NFD, NEWFOUNDLAND	03/89	05/89	02/90	--
N57095	LANTFLT HEADSUPPACT, VA	03/89	05/89	Early	08/89
N60138	CHEATHAM ANNEX NSC, VA	03/89	04/89	03/90	04/90
N60191	OCEANA NAS, VA	03/89	05/89	04/90	04/90
N60514	GUANTANAMO BAY NS, CUBA	03/89	--	04/90	--
N61414	LITTLE CREEK NAB, VA	03/89	06/89	05/90	--
N61564	NAVHOSP GUANTANAMO, CUBA	03/89	--	04/90	--
N62481	BERMUDA NAS (ANNEX), BI	03/89	07/89	06/90	--
N62585	LONDON NAVACTS, UNITED KINGDOM	03/89	04/89	04/90	--

Table A.5a. Dates associated with detectors placement and retrieval for nonhousing: Atlantic (continued)

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
N62588	NAVSUPPACT NAPLES, ITALY	0	2	1	6	0	15	0
N62688	NAVSTA NORFOLK, VA	0	1	24	0	6	0	0
N62793	SUPSHIP NEWPORT NEWS, VA	0	0	0	4	0	4	0
N62863	ROTA, SPAIN	0	34	2	61	0	86	0
N62995	SIGONELLA NAS, ITALY	0	2	2	13	0	12	0
N63032	KEFLAVIK NAS, ICELAND	0	2	2	69	0	17	14
N63073	EDZELL NSGA, UNITED KINGDOM	0	1	1	2	0	8	0
N63395	NAVCOMMSTA THURSO, UNITED KINGDOM	0	0	0	1	0	4	0
N63891	CHESAPEAKE NSGA, VA	0	0	0	4	0	4	3
N64981	ST MAWGAN, UNITED KINGDOM	0	0	1	2	0	6	0
N66094	NAVHOSP CHERRY POINT, NC	1	0	0	0	0	3	0
N66096	NAVHOSP NAPLES, ITALY	1	0	0	0	0	3	0
N66101	NAVHOSP ROTA, SPAIN	1	0	0	0	0	6	2
N66691	SOUDA BAY NAVSUPACT, CRETE	0	0	0	8	0	4	4
N66754	SABANA SECA NSGA, PUERTO RICO	0	0	0	5	0	4	0
N66833	PANAMA CANAL NS, CANAL ZONE	0	0	1	4	0	11	0
N68093	NAVHOSP CAMP LEJEUNE, NC	1	0	0	0	0	3	0
N68165	NAVFAC BRAWDY WALES, UNITED KINGDOM	0	0	0	3	0	4	0
N70283	NAVSECGRUACT GALETA, PN	0	1	0	1	0	6	0
N70295	NEA MAKRI NCS, GREECE	0	0	0	4	0	9	0

Table A.4b. Numbers and status of detectors placed in various buildings for nonhousing: Chesapeake

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
M67353	ARLINGTON, VA	0	0	0	1	0	4	3
N00162	NAVMEDECLINIC ANNAPOL, MD	0	0	0	1	0	4	0
N00166	NAF WASHINGTON, DC	0	0	0	7	0	4	0
N00178	NAVSURWPNCEN DAHLGRE, VA	0	0	0	0	0	19	0
N00231	NAVMEDECLINIC QUANTIC, VA	0	0	0	2	0	4	4
N06266	USNA ANNAPOLIS, MD	0	0	0	0	0	4	0
N70092	NAVSECSTA WASHINGTON, DC	0	0	0	1	0	4	4

Table A.5b. Dates associated with detector placement and retrieval for nonhousing: Chesapeake

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
M67353	ARLINGTON, VA	03/89	04/89	Early	07/89	07/89
N00162	NAVMECLINIC ANNAPOL, MD	03/89	04/89	03/90	--	--
N00166	NAF WASHINGTON, DC	03/89	--	02/90	--	--
N00178	NAVSURWPNCEN DAHLGRE, VA	04/89	08/89	03/90	--	--
N00231	NAVMECLINIC QUANTIC, VA	03/89	03/89	Early	06/89	07/89
N06266	USNA ANNAPOLIS, MD	03/89	10/89	02/90	--	--
N70092	NAVSECSTA WASHINGTON, DC	04/89	04/89	02/90	03/90	03/90

Table A.1c. Summary of sampling plan and exposures for family housing: Northern

UIC	Facility	No. of FHAs*	No. of units	Mailed detectors	Returned detectors	Exposure days
M00264	QUANTICO MCDEC, VA	66	1521	905	413	90
M67029	WASHINGTON DC MARBAR, DC	1	5	5	5	353
M67443	KANSAS CITY MCFC, MO	4	240	56	57	344
N00101	S WEYMOUTH NAS, MA	7	270	110	89	317
N00102	PORTSMOUTH NSY, NH	2	234	65	60	389
N00104	MECHANISBURGH NSPCC, PA	7	91	91	—	—
N00129	NEW LONDON NSB, CT	13	2924	444	—	—
N00151	PHILADELPHIA NAVSTA, PA	8	922	145	—	—
N00158	WILLOW GROVE NAS, PA	2	6	6	5	—
N00161	ANNAPOLIS USNA, MD	16	413	174	131	347
N00163	INDIANAPOLIS, IN	1	5	5	5	90
N00164	CRANE NWSC, IN	8	31	31	29	90
N00167	BETHESDA DTNSRDC, MD	1	2	2	1	—
N00168	BETHESDA NPMC, MD	2	8	8	8	387
N00171	WASHINGTON NDW, DC	5	435	95	—	—
N00174	INDIAN HEAD NOS, MD	8	287	94	40	210
N00275	GLENVIEW NAS, IL	4	299	55	—	—
N00383	PHILADELPHIA ASO, PA	1	15	11	—	—
N00421	PATUXENT RIVER NATL, MD	8	857	236	167	346
N00702	WINTER HARBOR NSGA, ME	5	125	103	—	—
N00788	CHELTENHAM NCU, MD	3	39	38	27	330
N0417A	THURMONT NSF, MD	2	21	21	21	351

Table A.1c. Summary of sampling plan and exposures for family housing: Northern (continued)

UIC	Facility	No. of FHAs*	No. of units	Mailed detectors	Returned detectors	Exposure days
N31260	CHESAPEAKE BEACH NRL, MD	4	24	24	24	90
N35328	ANNAPOLIS RADTRANE, MD	2	21	12	11	330
N60087	BRUNSWICK NAS, ME	12	756	184	162	365
N60478	EARLE NWS, NJ	2	65	43	—	—
N60921	DAHLGREN NSWC, VA	5	186	113	—	—
N61174	NEW YORK NS, NY	13	694	138	—	—
N61533	ANNAPOLIS NSRDC, MD	6	9	7	5	342
N62037	GREAT LAKES PWC, IL	1	18	36	—	—
N62042	WATERLOO NMCRC, IA	1	22	22	14	150
N62043	SIOUX CITY, IO	1	17	34	—	—
N62084	FORT CUSTER NRC, MI	1	24	24	—	—
N62269	WARMINSTER NADC, PA	4	207	41	39	342
N62578	DAVISVILLE CBC, RI	1	8	9	9	337
N62661	NEWPORT NETC, RI	13	1660	238	151	343
N62757	FOREST PARK NMCRC, IL	1	7	7	9	—
N63038	CUTLER NCU, ME	3	61	61	58	345
N65113	GREAT LAKES PWC, IL	24	2103	437	—	—
N68101	PHILADELPHIA NRCMC, PA	3	13	9	9	—
N68317	SCOTIA, NY	1	101	33	30	337
N68335	LAKEHURST NAEC, NJ	3	223	70	53	148
N68759	NIAGARA DODFAMHSG, NY	1	113	33	31	330

*Family housing areas.

Table A.2c. Detector status for family housing: Northern

UIC	Facility	Detectors			Retrieval		
		Sent	Placed	Noice	Month	Month	Returned
M00264	QUANTICOMDEC, VA	03/89	10/89	Early*	02/90	02/90	02/90
M67029	WASHINGTON MARBAR, DC	03/89	03/89	02/90	03/90	03/90	03/90
M67443	KANSAS CITY MCFC, MO	03/89	03/89	02/90	03/90	03/90	03/90
N00101	S WEYMOUTH NAS, MA	03/89	05/89	02/90	03/90	03/90	03/90
N00102	PORTSMOUTH NSY, NH	03/89	03/89	03/90	04/90	04/90	04/90
N00104	MECHANISBURGH NSPCC, PA	03/89	10/89	02/90	—	—	—
N00129	NEW LONDON NSB, CT	03/89	11/89	02/90	—	—	—
N00151	PHILADELPHIA NAVSTA, PA	03/89	04/89	02/90	—	—	—
N00158	WILLOW GROVE NAS, PA	03/89	05/89	04/90	—	—	04/90
N00161	ANNAPOLIS USNA, MD	03/89	04/89	03/90	03/90	04/90	04/90
N00163	INDIANAPOLIS, IN	03/89	03/89	Early	06/89	08/89	08/89
N00164	CRANES NWSC, IN	03/89	05/89	Early	08/89	01/90	01/90
N00167	BETHESDA DTNSRDC, MD	03/89	06/89	05/90	—	—	—
N00168	BETHESDA NNMC, MD	03/89	03/89	02/90	04/90	04/90	04/90
N00171	WASHINGTON NDW, DC	03/80	08/89	02/90	—	—	—
N00174	INDIAN HEAD NOS, MD	03/89	08/89	02/90	03/90	04/90	04/90
N00275	GLENVIEW NAS, IL	03/89	03/89	02/90	—	—	—
N00383	PHILADELPHIA ASO, PA	03/89	05/89	04/90	—	—	—
N00421	PATUXENT RIVER NATL, MD	03/89	04/89	03/90	04/90	04/90	04/90
N00702	WINTER HARBOR NSGA, ME	03/89	05/89	05/90	—	—	—
N00788	CHELTENHAM NCU, MD	03/89	04/89	03/90	03/90	04/90	04/90
N0417A	THURMONT NSF, MD	03/89	04/89	03/90	03/90	03/90	03/90

Table A.2c. Detector status for family housing: Northern (continued)

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
N31260	CHESAPEAKE BEACH NRL, MD	03/89	03/89	Early	06/89	08/89	
N35328	ANNAPOLIS RADTRANF, MD	03/89	03/89	02/90	02/90	03/90	
N60087	BRUNSWICK NAS, ME	03/89	04/89	03/90	04/90	04/90	
N60478	EARLE NWS, NJ	03/89	04/89	03/90	--	--	
N60921	DAHLGREN NSWC, VA	03/89	03/89	03/90	--	--	
N61174	NEW YORK NS, NY	03/89	03/89	03/90	--	--	
N61533	ANNAPOLIS NSRDC, MD	03/89	04/89	03/90	03/90	04/90	
N62037	GREAT LAKES PWC, IL	03/89	10/89	02/90	--	--	
N62042	WATERLOO NMCRC, IA	03/89	04/89	Early	09/89	10/89	
N62043	SIOUX CITY, IO	03/89	10/89	02/90	--	--	
N62084	FORT CUSTER NRC, MI	03/89	06/89	05/90	--	--	
N62269	WARMINSTER NADC, PA	03/89	03/89	02/90	03/90	03/90	
N62578	DAVISVILLE CBC, RI	03/89	04/89	03/90	03/90	03/90	
N62661	NEWPORT NETC, RI	03/89	04/89	02/90	03/90	03/90	
N62757	FOREST PARK NMCRC, IL	03/89	10/89	03/90	--	--	
N63038	CUTLER NCU, ME	03/89	04/89	03/90	03/90	03/90	
N65113	GREAT LAKES PWC, IL	03/89	09/89	02/90	--	--	
N68101	PHILADELPHIA NRMCC, PA	03/89	UNK	03/90	03/90	03/90	
N68317	SCOTIA, NY	03/89	03/90	02/90	02/90	02/90	
N68335	LAKEHURST NAEC, NJ	03/89	10/89	02/90	03/90	03/90	
N68759	NIAGARA DODFAMHSG, NY	03/89	04/89	03/90	03/90	04/90	

**Early" means that detectors were returned without having received retrieval notices.

Table A.3c. Summary of field QC samples for family housing: Northern

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Duplicates	Blanks	Duplicates	Blanks
M00264	QUANTICO MCDEC, VA	76	65	28	65		
M67029	WASHINGTON MARBAR, DC	0	0	0	0		
M67443	KANSAS CITY MCFC, MO	5	6	3	3		
N00101	S WEYMOUTH NAS, MA	9	6	0	4		
N00102	PORTSMOUTH NSY, NH	6	4	5	0		
N00104	MECHANISBURGH NSPCC, PA	7	9	---	---		
N00129	NEW LONDON NSB, CT	39	26	---	---		
N00151	PHILADELPHIA NAVSTA, PA	12	12	---	---		
N00158	WILLOW GROVE NAS, PA	0	0	0	0		
N00161	ANNAPOLIS USNA, MD	13	14	7	12		
N00163	INDIANAPOLIS, IN	0	0	0	0		
N00164	CRANE NWSC, IN	3	4	2	4		
N00167	BETHESDA DTNSRDC, MD	0	0	0	0		
N00168	BETHESDA NMMC, MD	0	0	0	0		
N00171	WASHINGTON NDW, DC	9	6	---	---		
N00174	INDIAN HEAD NOS, MD	8	8	0	0		
N00275	GLENVIEW NAS, IL	5	6	---	---		
N00383	PHILADELPHIA ASO, PA	1	2	---	---		
N00421	PATUXENT RIVER NATL, MD	23	16	13	18		
N00702	WINTER HARBOR NSGA, ME	10	8	---	---		
N00788	CHELTENHAM NCU, MD	3	4	2	2		
N0417A	THURMONT NSF, MD	2	2	2	2		

Table A.3c. Summary of field QC samples for family housing: Northern (continued)

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Duplicates	Duplicates	Blanks	Blanks
N31260	CHESAPEAKE BEACH NRL, MD	2	2	2	2	2	2
N35328	ANNAPOLIS RADTRANF, MD	2	2	2	2	2	2
N60087	BRUNSWICK NAS, ME	16	12	16	16	5	5
N60478	EARLE NWS, NJ	4	4	4	---	---	---
N60921	DAHLGREN NSWC, VA	10	8	10	---	---	---
N61174	NEW YORK NS, NY	13	8	13	---	---	---
N61533	ANNAPOLIS NSRDC, MD	0	0	0	0	0	0
N62037	GREAT LAKES PWC, IL	4	4	4	---	---	---
N62042	WATERLOO NMCRC, IA	2	2	2	1	10	10
N62043	SIOUX CITY, IO	4	4	4	---	---	---
N62084	FORT CUSTER NRC, MI	3	2	3	---	---	---
N62269	WARMINSTER NADC, PA	4	2	4	0	1	1
N62578	DAVISVILLE CBC, RI	0	2	0	0	2	2
N62661	NEWPORT NETC, RI	18	14	18	7	4	4
N62757	FOREST PARK NMCRC, IL	0	2	0	0	0	0
N63038	CUTLER NCU, ME	5	6	5	5	4	4
N65113	GREAT LAKES PWC, IL	35	34	35	---	---	---
N68101	PHILADELPHIA NPMC, PA	1	0	1	0	0	0
N68317	SCOTIA, NY	3	2	3	0	2	2
N68335	LAKEHURST NAEC, NJ	6	4	6	2	12	12
N68759	NIAGARA DODFAMHSG, NY	3	2	3	3	0	0

Table A.4c. Numbers and status of detectors placed in various buildings for nonhousing: Northern

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Monitors	
							Sent	Returned
M00264	QUANTICO MCDEC, VA	2	1	1	9	1	16	16
M67029	WASHINGTON MARBAR, DC	0	0	0	1	0	4	4
N00101	S WEYMOUTH NAS, MA	0	0	1	6	0	11	11
N00102	PORTSMOUTH NSY, NH	0	0	1	6	1	8	0
N00104	MECHANISBURGH NSPCC, PA	0	0	1	0	0	2	2
N00129	NEW LONDON NST, CT	1	0	1	14	1	11	0
N00158	WILLOW GROVE NAS, PA	0	0	0	5	0	9	8
N00161	ANNAPOLIS USNA, MD	0	1	0	4	0	6	6
N00164	CRANE NWSC, IN	0	0	0	3	0	4	0
N00168	BETHESDA NMMC, MD	1	0	0	4	0	7	7
N00171	WASHINGTON NDW, DC	0	0	0	3	0	4	0
N00174	INDIAN HEAD NOS, MD	0	0	1	8	0	11	8
N00211	NAVAL HOSPITAL GREAT, IL	1	0	0	5	0	7	7
N00275	GLENVIEW NAS, IL	0	0	0	5	0	4	0
N00383	PHILADELPHIA ASO, PA	0	0	0	1	0	4	3
N00421	PATUXENT RIVER NATL, MD	1	0	2	12	0	16	16
N00702	WINTER HARBOR NSGA, ME	0	0	0	2	0	4	4
N00788	NAVCOMMU WASHINGTON, DC	0	0	0	1	0	4	4
N0580A	GREAT LAKES, IL	0	0	0	0	0	2	0
N30315	ASTROGRPDET B ROSEMO, MN	0	0	0	1	0	4	4
N60087	BRUNSWICK NAS, ME	0	0	1	11	0	6	6
N60478	EARLE NWS, NJ	0	0	0	5	0	9	0

Table A.4c. Numbers and status of detectors placed in various buildings for nonhousing: Northern (continued)

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Monitors	
							Sent	Returned
N60921	DAHLGREN NSWC, VA	0	3	1	118	0	12	0
N61174	NEW YORK NS,	0	0	1	1	0	6	0
N61189	NAVSTA PHILADELPHIA, PA	0	2	2	14	0	17	0
N62269	WARMINSTER NADC, PA	0	0	0	1	0	4	0
N62578	DAVISVILLE CBC, RI	0	0	0	11	0	4	0
N62661	NEWPORT NETC, RI	0	1	2	15	0	10	10
N66604	NUSC NEWPORT, RI	0	0	0	1	0	4	0
N68086	NAVHOSP NEWPORT, RI	1	0	0	0	0	6	3
N68096	NAVHOSP GUAM, GQ	1	0	0	4	0	7	0
N68101	PHILADELPHIA NRMC, PA	3	1	0	3	0	15	15
N68335	LAKEHURST NAEC, NJ	0	0	1	5	0	6	4

Table A.5c. Dates associated with detector placement and retrieval for nonhousing: Northern

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
M00264	QUANTICO MCDEC, VA	03/89	03/89	02/90	03/90	03/90
M67029	WASHINGTON MARBAR, DC	03/89	04/89	02/90	03/90	03/90
N00101	S WEYMOUTH NAS, MA	03/89	03/89	02/90	04/90	04/90
N00102	PORTSMOUTH NSY, NH	03/89	04/89	03/90	--	--
N00104	MECHANISBURGH NSPCC, PA	03/89	05/89	03/90	03/90	04/90
N00129	NEW LONDON NSB, CT	03/89	--	02/90	--	--
N00158	WILLOW GROVE NAS, PA	03/89	05/89	04/90	04/90	04/90
N00161	ANNAPOLIS USNA, MD	03/89	10/89	03/90	03/90	03/90
N00164	CRANE NWSC, IN	03/89	05/89	04/90	--	--
N00168	BETHESDA NMMC, MD	03/89	03/89	Early	06/89	07/89
N00171	WASHINGTON NDW, DC	03/89	02/90	05/90	--	--
N00174	INDIAN HEAD NOS, MD	03/89	06/89	02/90	03/90	04/90
N00211	NAVAL HOSPITAL GREAT, IL	03/89	04/89	02/90	03/90	03/90
N00275	GLENVIEW NAS, IL	03/89	07/89	02/90	--	--
N00383	PHILADELPHIA ASO, PA	03/89	05/89	Early	09/89	10/89
N00421	PATUXENT RIVER NATL, MD	03/89	03/89	Early	06/89	07/89
N00702	WINTER HARBOR NSGA, ME	03/89	05/89	04/90	04/90	10/89
N00788	NAVCOMMU WASHINGTON, DC	03/89	04/89	03/90	03/90	04/90
N0580A	GREAT LAKES, IL	03/89	04/89	02/90	--	--
N30315	ASTROGRPDET B ROSE0, MN	03/89	03/89	02/90	03/90	03/90
N60087	BRUNSWICK NAS, ME	03/89	04/89	03/90	03/90	04/90
N60478	EARLE NWS, NJ	03/89	04/89	03/90	--	--

Table A.5c. Dates associated with detector placement and retrieval for nonhousing: Northern (continued)

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
N60921	DAHLGREN NSWC, VA	03/89	04/89	03/90	--	--
N61174	NEW YORK NS, NY	03/89	04/89	03/90	--	--
N61189	NAVSTA PHILADELPHIA, PA	03/89	03/89	03/90	--	--
N62269	WARMINSTER NADC, PA	03/89	--	02/90	--	--
N62578	DAVISVILLE CBC, RI	03/89	03/89	03/90	04/90	03/90
N62661	NEWPORT NETC, RI	03/89	03/89	02/90	03/90	04/90
N66604	NUSC NEWPORT, RI	03/89	07/89	06/90	--	--
N68086	NAVHOSP NEWPORT, RI	03/89	04/89	07/89	07/89	Early
N68096	NAVHOSP GUAM, GQ	04/89	06/89	03/90	--	--
N68101	PHILADELPHIA NRMCM, PA	03/89	04/89	03/90	04/90	04/90
N68335	LAKEHURST NAEC, NJ	03/89	06/89	02/90	03/90	03/90

Table A.1d. Summary of sampling plan and exposures for family housing: Pacific

UIC	Facility	No. of FHAs*	No. of units	Mailed detectors	Returned detectors	Exposure days
M62613	IWAKUNI MCAS, JAPAN	3	357	74	58	175
N0534A	BARKING SANDS PMRF, HAWAII	1	56	33	26	147
N30851	DJAKARTA NMRD, INDIA	1	6	6	3	150
N32778	CHINHAE COMFLEACT, KOREA	1	48	33	--	--
N62395	GUAM PWC, GUAM	37	2779	936	--	--
N62507	ATSUGI NAF, JAPAN	11	493	168	--	--
N62735	SASEBO COMFLEACTS, JAPAN	4	214	90	--	--
N62808	SUBIC BAY NS PWC, PHILLIPINES	15	2404	690	--	--
N63427	H.E. HOLT NCS, AUSTRALIA	2	193	66	--	--
N65115	YOKOSUKA PWC, JAPAN	14	1800	250	--	--
N70278	JAPAN NAVCOMMSTA, JAPAN	1	70	33	--	--

*Family housing areas.

Table A.2d. Summary of program dates for family housing: Pacific

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
M62613	IWAKUNI MCAS, JAPAN	03/89	05/89	09/89	11/89	01/90	
N0534A	BARKING SANDS, PMRF, HI	05/89	06/89	09/89	11/89	11/89	
N30851	DJAKARTA NMRD, INDIA	05/89	07/89	11/89	12/89	12/89	
N32778	CHINHAЕ COMFLEACT, KOREA	03/89	10/89	02/90	---	---	
N62395	GUAM PWC, GUAM	05/89	09/89	01/90	---	---	
N62507	ATSUGI NAF, JAPAN	03/89	11/89	05/90	---	---	
N62735	SASEBO COMFLEACTS, JAPAN	03/89	05/89	04/90	---	---	
N62808	SUBIC BAY NS PWC, PHILLIPINES	05/89	12/89	04/90	---	---	
N63427	H.E. HOLT NCS, AUSTRALIA	03/89	08/89	06/90	---	---	
N65115	YOKOSUKA PWC, JAPAN	03/89	06/89	05/90	---	---	
N70278	JAPAN NAVCOMMSTA, JAPAN	03/89	07/89	06/90	---	---	

Table A.3d. Summary of field QC sample for family housing- Pacific

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Duplicates	Blanks	Duplicates	Blanks
M62613	IWAKUNI MCAS, JAPAN	7	6	8	6		
N0534A	BARKING SANDS PMRF, HI	3	2	3	9		
N30851	DIAKARTA NMRD, INDIA	1	2	1	2		
N32778	CHINHAЕ COMFLEACT, KOREA	3	2	--	--		
N62395	GUAM PWC, GUAM	84	66	--	--		
N62507	ATSUGI NAF, JAPAN	14	18	--	--		
N62735	SASEBO COMFLEACTS, JAPAN	8	8	--	--		
N62808	SUBIC BAY NS PWC, PHILLIPINES	60	44	--	--		
N63427	H.E. HOLT NCS, AUSTRALIA	6	4	--	--		
N65115	YOKOSUKA PWC, JAPAN	20	18	--	--		
N70278	JAPAN NAVCOMMSTA, JAPAN	3	2	--	--		

Table A.4d. Numbers and status of detectors placed in various buildings for nonhousing: Pacific

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
M00318	MCAS KANEQHE BAY HAW, HI	0	0	2	51	0	13	0
M62613	MCAS IWAKUNI, JAPAN	0	1	3	19	0	17	15
M63026	OKINAWA, JAPAN	0	0	1	24	0	6	0
M67385	CAMP H M SMITH HAWAI, HI	0	0	0	8	0	4	0
M67400	MCB CAMP S D BUTLER, JAPAN	1	11	8	436	1	52	0
N00314	SUBASE PEARL HARBOR, HI	0	0	1	14	0	6	0
N00334	NAS BARBERS POINT HA, HI	0	0	5	12	0	19	0
N00604	NSC PEARL HARBOR HAW, HI	0	0	1	0	0	2	0
N00927	NAVCOMMSTA SAN MIGUE, PHILLIPINES	0	6	0	6	0	2	10
N00950	NAVCAMS EASTPAC HONO, HI	0	0	0	7	0	4	0
N0534A	BARKING SANDS PMRF, HI	0	0	0	1	0	4	4
N32778	CHINHAE COMFLEACT, KOREA	0	1	0	5	0	6	6
N55418	NAVSUPPPFORANT DET CH, NZ	0	0	0	8	0	4	2
N60872	NAVMAAG GUAM GQ, GQ	0	0	0	3	0	6	0
N61552	NAVSTA SUBIC BAY, PHILLIPINES	0	17	0	28	1	50	0
N61577	NAS AGANA, GQ	0	0	1	16	0	6	0
N61581	COMFLEACT YOKOSUKA, JAPAN	0	2	2	10	1	30	0
N61755	NAVSTA GUAM GQ, GQ	0	0	1	18	1	13	0
N62254	COMFLEACT KADENA OKI, JAPAN	0	0	0	10	0	4	0
N62494	NAF MIDWAY ISLAND, HI	0	1	0	8	0	6	0
N62507	ATSUGI NAF, JAPAN	0	2	1	8	0	15	0

Table A.4d. Numbers and status of detectors placed in various buildings for nonhousing: Pacific (continued)

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Returned
N62735	SASEBO COMFLEACTS, JAPAN	0	1	0	7	0	12	0
N62755	PWC PEARL HARBOR, HI	0	0	1	0	0	2	0
N62808	SUBIC BAY NS PWC, PHILLIPINES	0	0	0	1	0	4	0
N62813	NAVSTA PEARL HARBOR, HI	0	2	6	30	0	27	0
N62876	NAS CUBI POINT RP, PHILLIPINES	0	0	0	19	0	4	0
N63005	ADMINSUPPU BAHRAIN, BH	0	19	1	1	0	49	0
N63427	H.E. HOLT NCS, AUSTRALIA	0	1	1	6	0	8	0
N65491	NAVHOSP SUBIC BAY, RP	2	0	0	2	0	10	0
N68212	MISAWA, JAPAN	0	0	0	2	0	4	0
N68292	NAF MISAWA JAPAN, JAPAN	1	0	0	2	0	7	0
N68297	NAVMAG LUALUALEI HAW, HI	0	0	0	3	0	9	0
N68539	NAVSUPPFAC DIEGO GAR, INDIA	0	0	0	104	0	4	0
N70243	NAVCAMS WESTPAC GUAM, GQ	0	0	1	10	0	6	5
N70278	JAPAN NAVCOMMSTA, JAPAN	0	0	0	5	0	4	0
N70284	NAVSECGRUACT HANZA O, JAPAN	0	0	0	1	0	4	0

Table A.5d. Dates associated with detector placement and retrieval for nonhousing: Pacific

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieval	Returned
M00318	MCAS KANEQHE BAY HAW, HI	03/89	04/89	03/90	---	---
M62613	MCAS IWAKUNI, JAPAN	03/89	05/89	Early	12/80	01/90
M63026	MCAS FUTENMA, JAPAN	03/80	05/89	04/90	---	---
M67385	CAMP H M SMITH HAWAI, HI	03/89	04/89	03/90	---	---
M67400	MCB CAMP S D BUTLER, JAPAN	03/89	05/89	04/90	---	---
N00314	SUBASE PEARL HARBOR, HI	03/89	06/89	04/90	---	---
N00334	NAS BARBERS POINT HA, HI	03/89	---	04/90	---	---
N00604	NSC PEARL HARBOR HAW, HI	03/89	---	04/90	---	---
N00927	NAVCOMMSTA SAN MIGUE, PHILLIPINES	04/89	06/89	04/90	---	---
N00950	NAVCOMS EASTPAC HONO, HI	03/89	05/89	04/90	04/90	---
N0534A	BARKING SANDS PMRF, HI	03/89	05/89	09/89	11/89	11/89
N32778	CHINHA COMFLEACT, KOREA	03/89	05/89	02/90	03/90	04/90
N55418	NAVSUPFORANT DET CH NZ	04/89	04/89	Early	07/89	08/89
N60872	NAVMA GQ, GQ	04/89	---	03/90	---	---
N61552	NAVSTA SUBIC BAY, PHILLIPINES	04/89	06/89	Early	---	---
N61577	NAS AGANA, GQ	03/89	07/89	03/90	---	---
N61581	COMFLEACT YOKOSUKA, JAPAN	03/89	06/89	05/90	---	---
N61755	NAVSTA GUAM GQ, GQ	03/89	07/89	02/90	---	---
N62254	COMFLEACT KADENA OKI, JAPAN	03/89	05/89	04/90	---	---
N62494	NAF MIDWAY ISLAND, HI	03/89	05/89	04/90	---	---
N62507	ATSUGI NAF, JAPAN	03/89	06/89	05/90	---	---

Table A.5d. Dates associated with detector placement and retrieval for nonhousing: Pacific (continued)

UIC	Facility	Detectors			
		Sent	Placed	Mailed	Retrieval Returned
N62735	SASEBO COMFLEACTS, JAPAN	03/89	05/89	04/90	04/90 --
N62755	PWC PEARL HARBOR, HI	03/89	04/89	03/90	--
N62808	SUBIC BAY NS PWC, PHILLIPINES	04/89	--	01/90	--
N62813	NAVSTA PEARL HARBOR, HI	03/89	04/89	03/90	--
N62876	NAS CUBI POINT RP, PHILLIPINES	04/89	6/89	04/90	--
N63005	ADMINSUPPU BAHRAIN, BH	04/89	--	04/90	--
N63427	H.E. HOLT NCS, AUSTRALIA	04/89	08/89	06/90	--
N65491	NAVHOSP SUBIC BAY, RP	04/89	06/89	05/90	--
N68212	MISAWA, JA	03/89	04/89	04/90	--
N68292	NAF MISAWA JAPAN, JA	03/89	04/89	03/90	--
N68297	NAVMAG LUALUALEI HAW, HI	04/89	08/89	07/90	--
N68339	NAVSUPPFAC DIEGO GAR, INDIA	03/89	06/89	05/90	--
N70243	NAVCAMS WESTPAC GUAM, GQ	03/89	04/89	Early	07/89 08/89
N70278	JAPAN NAVCOMMSTA, JAPAN	03/89	06/89	05/90	--
N70284	NAVSECGRUACT HANZA O, JAPAN	03/89	04/89	03/90	--

Table A.1e. Summary of sampling plan and exposures for family housing: Southern

UIC	Facility	No. of FHA*	No. of Units	Mailed detectors	Returned detectors	Exposure days
M00263	PARRIS ISLAND MCRD, SC	3	231	99	86	292
M60169	BEAUFORT MCAS, SC	2	1276	66	63	—
M67004	ALBANY MCLB, GA	14	696	217	184	219
N00153	NAVAL HOMES, MS	1	5	7	5	193
N00193	CHARLESTON NWS, SC	37	2959	633	—	244
N00196	ATLANTA NAS, GA	1	10	10	9	211
N00205	NEW ORLEANS NSA, LA	4	286	109	84	130
N00206	NEW ORLEANS NAS, LA	5	216	82	68	267
N00207	JACKSONVILLE NAS, FL	4	371	98	56	307
N00213	KEY WEST NAS, FL	15	1391	295	248	240
N00215	DALLAS NAS, TX	2	11	11	11	90
N00216	CORPUS CHRISTI NAS, TX	3	439	83	63	219
N00639	MEMPHIS NAS, TN	6	1062	175	126	311
N42237	KINGS BAY NSB, GA	2	415	66	63	90
N60200	CECIL FIELD NAS, FL	3	297	71	67	252
N60201	MAYPORT NS, FL	9	1081	186	—	—
N60241	KINGSVILLE NAS, TX	3	244	67	51	259
N60376	CHASE FIELD NAS, TX	5	415	118	113	90
N60508	WHITING FIELD NAS, FL	21	412	293	254	302
N61331	PANAMA CITY NCSC, FL	2	65	62	24	352
N61337	BEAUFORT NAVHOSP, SC	5	53	53	43	90
N62604	GULFPORT NCBC, MS	2	107	40	36	393

Table A.1e. Summary of sampling plan and exposures for family housing: Southern (continued)

UIC	Facility	No. of FHA*	No. of Units	Mailed detectors	Returned detectors	Exposure days
N62741	ATHENS NSLS, GA	5	56	58	54	90
N63043	MERIDIAN NAS, MS	2	520	66	53	245
N65114	PENSACOLA PWC, FL	38	783	255	---	---
N65928	ORLANDO NTC, FL	3	971	70	49	261

*Family housing areas.

Table A.2c. Detector status for family housing: Southern

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
*J00263	PARRIS ISLAND MCRD, SC	02/89	04/89	09/89	01/90	04/90	
M60169	BEAUFORT MCAS, SC	01/89	02/89	Early	05/89	06/89	
M67004	ALBANY MCLB, GA	02/89	04/89	09/89	11/89	12/89	
N00153	NAVAL HOMES, MS	01/89	04/89	09/89	10/89	12/89	
N00193	CHARLESTON NWS, SC	02/89	05/89	04/90	---	---	
N00196	ATLANTA NAS, GA	01/89	03/89	09/89	10/89	11/89	
N00205	NEW ORLEANS NSA, LA	02/89	06/89	09/89	10/89	11/89	
N00206	NEW ORLEANS NAS, LA	02/89	02/89	09/89	11/89	12/89	
N00207	JACKSONVILLE NAS, FL	02/89	03/89	09/89	01/90	02/90	
N00213	KEY WEST NAS, FL	02/89	06/89	09/89	01/90	02/90	
N00215	DALLAS NAS, TX	01/89	03/89	Early	06/89	06/89	
N00216	CORPUS CHRISTI NAS, TX	02/89	05/89	09/89	12/89	01/90	
N00639	MEMPHIS NAS, TN	02/89	03/89	09/89	12/89	02/90	
N42237	KINGS BAY NSB, GA	02/89	04/89	Early	07/89	07/89	
N60200	CECIL FIELD NAS, FL	02/89	02/89	09/89	10/89	11/89	
N60201	MAYPORT NS, FL	02/89	03/89	09/89	---	---	
N60241	KINGSVILLE NAS, TX	02/89	02/89	09/89	10/89	11/89	
N60376	CHASE FIELD NAS, TX	02/89	04/89	Early	07/89	07/89	
N60508	WHITING FIELD NAS, FL	02/89	03/89	09/89	03/90	03/90	
N61331	PANAMA CITY NCSC, FL	01/89	03/89	01/90	03/90	03/90	
N61337	BEAUFORT NAVHOSP, SC	02/89	03/89	Early	06/89	07/89	
N62604	GULFPORT NCBC, MS	02/89	02/89	01/90	03/90	04/90	

Table A.2e. Detector status for family housing: Southern (continued)

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
N62741	ATHENS NSLS, GA	02/89	03/89	Early	06/89	07/89	
N63043	MERIDIAN NAS, MS	02/89	03/89	09/89	11/89	12/89	
N65114	PENSACOLA PWC, FL	02/89	03/89	09/89	---	---	
N65928	ORLANDO NTC, FL	02/89	03/89	09/89	12/89	03/90	

Table A.3e. Summary of field QC samples for family housing: Southern

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Blanks	Duplicates	Blanks	Blanks
M00263	PARRIS ISLAND MCRD, SC	9	6	6	6	0	0
M60169	BEAUFORT MCAS, SC	7	3	3	5	4	4
M67004	ALBANY MCLB, GA	19	16	16	15	19	19
N00153	NAVAL HOMES, MS	0	0	0	0	0	0
N00193	CHARLESTON NWS, SC	57	44	44	--	--	--
N00196	ATLANTA NAS, GA	1	2	2	1	2	2
N00205	NEW ORLEANS NSA, LA	10	8	8	0	6	6
N00206	NEW ORLEANS NAS, LA	7	4	4	7	0	0
N00207	JACKSONVILLE NAS, FL	9	6	6	2	0	0
N00213	KEY WEST NAS, FL	25	18	18	23	0	0
N00215	DALLAS NAS, TX	1	2	2	1	2	2
N00216	CORPUS CHRISTI NAS, TX	8	6	6	4	0	0
N00639	MEMPHIS NAS, TN	16	12	12	11	0	0
N42237	KINGS BAY NSB, GA	6	4	4	4	5	5
N60200	CECIL FIELD NAS, FL	6	4	4	5	4	4
N60201	MAYPORT NS, FL	16	12	12	--	--	--
N60241	KINGSVILLE NAS, TX	6	4	4	6	4	4
N60376	CHASE FIELD NAS, TX	11	8	8	9	8	8
N60508	WHITING FIELD NAS, FL	27	23	23	24	31	31
N61331	PANAMA CITY NCSC, FL	6	4	4	3	0	0
N61337	BEAUFORT NAVHOSP, SC	5	6	6	4	9	9
N62604	GULFPORT NCBC, MS	4	4	4	3	0	0

Table A.3e. Summary of field QC samples for family housing: Southern (continued)

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks		Duplicates	Blanks	
N62741	ATHENS NSLS, GA	6	4		6	0	
N63043	MERIDIAN NAS, MS	6	4		4	0	
N65114	PENSACOLA PWC, FL	22	18		---	---	
N65928	ORLANDO NTC, FL	6	4		3	5	

Table A.4c. Numbers and status of detectors placed in various buildings for nonhousing: Southern

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Retrieved
M00263	PARRIS ISLAND MCRD, SC	0	0	1	47	0	6	0
M60169	BEAUFORT MCAS, SC	0	3	5	16	1	22	22
M67004	ALBANY MCLB, GA	0	1	1	15	0	8	8
N00193	CHARLESTON NWS, SC	0	0	2	4	0	13	9
N00196	ATLANTA NAS, GA	0	0	1	4	0	6	5
N00203	NAVHOSP PENSACOLA, FL	1	0	0	1	0	7	7
N00204	NAS PENSACOLA, FL	0	0	3	19	0	10	0
N00205	NEW ORLEANS NSA, LA	0	0	1	6	0	6	6
N00206	NEW ORLEANS NAS, LA	0	0	1	4	0	11	9
N00207	JACKSONVILLE NAS, FL	0	0	1	21	1	8	3
N00213	KEY WEST NAS, FL	1	0	1	18	0	14	0
N00215	DALLAS NAS, TX	0	0	1	4	0	6	5
N00216	CORPUS CHRISTI NAS, TX	0	0	1	5	0	6	0
N00232	NAVHOSP JACKSONVILLE, FL	1	0	0	1	0	7	0
N00267	NAVMECLINIC KEY WES, FL	0	0	0	1	0	4	0
N00285	NAVHOSP CORPUS CHRIS, TX	1	0	0	0	0	3	0
N00639	MEMPHIS NAS, TN	0	0	4	44	0	12	10
N42237	KINGS BAY NASB, GA	0	0	1	7	0	6	0
N60002	NAVHOSP MILLINGTON, TN	1	0	0	2	0	7	7
N60200	CECIL FIELD NAS, FL	0	0	0	20	1	8	0
N60201	MAYPORT NS, FL	0	0	1	8	0	8	0
N60241	KINGSVILLE NAS, TX	0	0	1	6	1	13	13

Table A.4e. Numbers and status of detectors placed in various buildings for nonhousing: Southern (continued)

UIC	Facility	Hospital	School	Child care	Bachelor quarters	Brigs	Detectors	
							Sent	Retrieved
N60376	CHASE FIELD NAS, TX	0	0	1	7	0	6	0
N60508	WHITING FIELD NAS, FL	0	0	0	5	0	8	4
N61165	NAVSTA CHARLESTON, SC	0	0	2	19	2	10	0
N61331	PANAMA CITY NCSC, FL	0	0	0	2	0	4	4
N61337	BEAUFORT NAVHOSP, SC	1	0	0	3	0	7	5
N61762	NAVORDMISTESTSTA WHI, NM	0	0	0	1	0	4	4
N62604	NCBC GULFPORT, MS	0	0	1	25	0	6	0
N62741	ATHENS NSLS, GA	0	0	0	1	0	9	6
N62795	SUPSHIP PASCAGOULA, MS	0	0	0	2	0	4	4
N63043	MERIDIAN NAS, MS	0	0	1	23	0	6	0
N63082	PENSACOLA, FL	0	0	0	16	0	4	4
N63821	NUSCDETAUTEC ANDROS, BF	0	1	0	13	0	14	0
N65492	ORLANDO, FL	1	0	0	4	0	7	7
N65928	ORLANDO NTC, FL	0	0	2	70	0	13	11
N68084	NAVHOSP CHARLESTON, SC	1	0	0	1	0	7	0
N68322	PENSACOLA, FL	0	0	0	0	0	2	1

Table A.5e. Dates associated with detector placement and retrieval for nonhousing: Southern

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
M00263	PARRIS ISLAND MCRD, SC	03/89	06/89	03/90	03/90	--
M60169	BEAUFORT MCAS, SC	03/89	05/89	03/90	03/90	03/90
M67004	ALBANY MCLB, GA	03/89	03/89	09/89	10/89	11/89
N00193	CHARLESTON NWS, SC	03/89	03/89	02/90	03/90	04/90
N00196	ATLANTA NAS, GA	03/89	03/89	09/89	10/89	11/89
N00203	NAVHOSP PENSACOLA, FL	03/89	04/89	03/90	04/90	04/90
N00204	NAS PENSACOLA, FL	03/89	03/89	03/90	03/90	--
N00205	NEW ORLEANS NSA, LA	03/89	UNK	Early	--	11/89
N00206	NEW ORLEANS NAS, LA	03/89	03/89	09/89	11/89	12/89
N00207	JACKSONVILLE NAS, FL	03/89	03/89	03/90	02/90	02/90
N00213	KEY WEST NAS, FL	03/89	04/89	09/89	04/90	--
N00215	DALLAS NAS, TX	03/89	03/89	03/90	03/90	03/90
N00216	CORPUS CHRISTI NAS, TX	03/89	03/89	09/89	11/89	--
N00232	NAVHOSP JACKSONVILLE, FL	03/89	--	03/90	--	--
N00267	NAVMEDCLINIC KEY WES, FL	03/89	04/89	03/90	04/90	--
N00285	NAVHOSP CORPUS CHRIS, TX	03/89	03/89	03/90	--	--
N00639	MEMPHIS NAS, TN	03/89	03/89	03/90	03/90	04/90
N42237	KINGS BAY NSB, GA	03/89	03/89	03/90	--	--
N60002	NAVHOSP MILLINGTON, TN	03/89	03/89	03/90	03/90	04/90
N60200	CECIL FIELD NAS, FL	03/89	04/89	Early	--	--
N60201	MAYPORT NS, FL	03/89	04/89	03/90	--	--
N60241	KINGSVILLE NAS, TX	03/89	03/89	09/89	10/89	11/89

Table A.5e. Dates associated with detector placement and retrieval for nonhousing: Southern (continued)

UIC	Facility	Detectors			
		Sent	Placed	Mailed	Retrieved
N60376	CHASE FIELD NAS, TX	03/89	06/89	03/90	---
N60508	WHITING FIELD NAS, FL	03/89	12/89	02/90	03/90
N61165	NAVSTA CHARLESTON, SC	03/89	04/89	04/90	---
N61331	PANAMA CITY NCSC, FL	03/89	03/89	Early	06/89
N61337	BEAUFORT NAVHOSP, SC	03/89	04/89	03/90	03/90
N61762	NAVORDMISTFSTSTA WHI, NM	03/89	04/89	03/90	04/90
N62604	NCBC GULFPORT, MS	03/89	04/89	Early	07/89
N62741	ATHENS NSLS, GA	03/89	04/89	03/90	03/90
N62795	SUPSHIP PASCAGOULA, MS	03/89	11/89	03/90	04/90
N63043	MERIDIAN NAS, MS	03/89	03/89	09/89	11/89
N63082	PENSACOLA, FL	03/89	03/89	Early	03/90
N63821	NUSCDETAUTEC ANDROS, BF	03/89	---	03/90	---
N65492	ORLANDO, FL	03/89	06/89	04/90	03/90
N65928	ORLANDO NTC, FL	03/89	05/89	03/90	03/90
N68084	NAVHOSP CHARLESTON, SC	03/89	03/89	02/89	---
N68322	PENSACOLA, FL	03/89	05/89	03/90	03/90

Table A.1f. Summary of sampling plan and exposures for family housing: Western

UIC	Facility	No. of FHA*	No. of Units	Mailed detectors	Returned detectors	Exposure days
M00243	SAN DIEGO MCRD, CA	2	5	5	4	350
M00681	CAMP PENDLETON MCB, CA	18	4434	470	--	--
M33610	BRIDGEPORT, CA	2	19	34	31	364
M60050	EL TORO MCAS, CA	12	2507	365	--	--
M62204	BARSTOW MCLB, CA	3	366	76	66	257
M62974	YUMA MCAS, AZ	6	849	169	145	120
M67399	TWENTYNINE PALMS, CA	19	1611	460	--	162
N00255	SEATTLE NS, WA	5	195	104	--	--
N00296	MOFFETT FIELD NAS, CA	5	806	144	--	--
N00620	WHIDBEY ISLAND NAS, WA	7	1458	210	147	300
N00886	STOCKTON NCS, CA	3	43	36	29	90
N57053	CENTERVILLE BEACH NF, CA	2	52	52	16	90
N60036	CONCORD WPNSTA, CA	2	118	51	35	367
N60042	EL CENTRO NAF, CA	6	145	99	--	--
N60259	MIRAMAR NAS, CA	4	81	79	--	--
N60462	ADAK NS, AK	19	1031	374	--	--
N60495	FALLON NAS, NV	6	300	161	128	340
N60530	CHINA LAKE NWC, CA	2	766	212	--	--
N62271	MONTEREY NPGS, CA	10	915	269	256	326
N62583	PORT HUENEME NCBC, CA	11	500	154	--	--
N63042	LEMOORE NAS, CA	4	1590	132	--	--
N63126	POINT MUGU PMTC, CA	14	734	297	109	--

Table A.1f. Summary of sampling plan and exposures for family housing: Western (continued)

UIC	Facility	No. of FHA*	No. of Units	Mailed detectors	Returned detectors	Exposure days
N63387	SAN DIEGO PWC, CA	19	6496	627	--	--
N66890	NAVSTA MARE ISLAND, CA	16	948	233	207	331
N68311	LONG BEACH NS, CA	27	2146	685	--	--
N68378	SAN FRANCISCO PWC, CA	25	3746	738	--	--
N68436	BANGOR NSB, WA	37	1623	354	--	--
N70273	JIM CREEK NRS-T, WA	1	2	2	2	363

Table A.2f. Detector status for family housing: Western

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
M00243	SAN DIEGO MCRD, CA	02/89	03/89	02/90	03/90	03/89	
M33610	BRIDGEPORT, CA	02/89	03/89	02/90	03/900	4/90	
M60050	EL TORO MCAS, CA	02/89	06/89	0290	--	--	
M62204	BARSTOW MCLB, CA	02/89	03/89	09/89	11/89	11/89	
M62974	YUMA MCAS, AZ	03/89	10/89	Early	02/90	02/90	
M67399	TWENTYNINE PALMS, CA	02/89	10/89	02/90	--	--	
N00255	SEATTLE NS, WA	02/89	04/89	03/90	--	--	
N00296	MOFFETT FIELD NAS, CA	02/89	06/89	05/90	--	--	
N00620	WHIDBEY ISLAND NAS, WA	02/89	05/89	02/90	03/90	04/90	
N00886	STOCKTON NCS, CA	02/89	03/89	Early	06/89	06/89	
N57053	CENTERVILLE BEACH NF, CA	02/89	04/89	03/90	07/89	07/89	
N60036	CONCORD WPNSTA, CA	02/89	03/89	02/90	03/90	03/90	
N60042	EL CENTRO NAF, CA	02/89	05/89	04/90	--	--	
N60259	MIRAMAR NAS, CA	02/89	06/89	05/90	--	--	
N60462	ADAK NS, AK	02/89	08/89	03/90	--	--	
N60495	FALLON NAS, NV	02/89	03/89	02/90	03/90	04/90	
N60530	CHINA LAKE NWC, CA	02/89	06/89	06/89	--	--	
N62271	MONTEREY NPGS, CA	02/89	04/89	03/90	03/90	04/90	
N62583	PORT HUENEME NCBC, CA	02/89	04/89	03/90	--	--	
N63042	LEMOORE NAS, CA	02/89	05/89	04/90	--	--	
N63126	POINT MUGU PMTC, CA	02/89	10/89	02/90	--	--	
N63387	SAN DIEGO PWC, CA	02/89	05/89	03/90	--	--	

Table A.2f. Detector status for family housing: Western (continued)

UIC	Facility	Detectors			Retrieval		Month Returned
		Sent	Placed	Notice	Month		
N66890	NAVSTA MARE ISLAND, CA	02/89	04/89	02/90	03/90	04/90	
N68311	LONG BEACH NS, CA	02/89	08/90	07/90	---	---	
N68378	SAN FRANCISCO PWC, CA	02/89	05/90	06/90	---	---	
N68436	BANGOR NSB, WA	02/89	08/89	04/90	---	---	
N70273	JIM CREEK NRS-T, WA	02/89	03/89	02/90	03/90	03/90	

Table A.3f. Summary of field QC samples for family housing: Western

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks	Blanks	Duplicates	Blanks	Blanks
M00243	SAN DIEGO MCRD, CA	0	0	0	0	0	0
M00681	CAMP PENDLETON MCB, CA	42	30	—	—	—	—
M33610	BRIDGEPORT, CA	3	2	3	3	0	0
M60050	EL TORO MCAS, CA	33	22	—	—	—	—
M62204	BARSTOW MCLB, CA	7	6	6	6	4	4
M62974	YUMA MCAS, AZ	15	10	11	11	8	8
M67399	TWENTYNINE PALMS, CA	42	31	—	—	—	—
N00255	SEATTLE NS, WA	9	6	—	—	—	—
N00296	MOFFETT FIELD NAS, CA	14	9	—	—	—	—
N00620	WHIDBEY ISLAND NAS, WA	19	14	11	11	4	4
N00886	STOCKTON NCS, CA	3	2	3	3	2	2
N57053	CENTERVILLE BEACH NF, CA	6	4	2	2	0	0
N60036	CONCORD WPNSTA, CA	5	4	1	1	4	4
N60042	EL CENTRO NAF, CA	10	6	—	—	—	—
N60259	MIRAMAR NAS, CA	7	6	—	—	—	—
N60462	ADAK NS, AK	33	30	—	—	—	—
N60495	FALLON NAS, NV	16	12	0	0	2	2
N60530	CHINA LAKE NWC, CA	20	14	—	—	—	—
N62271	MONTEREY NPGS, CA	25	18	23	23	12	12
N62583	PORT HUENEME NCBC, CA	14	12	—	—	—	—
N63042	LEMOORE NAS, CA	12	8	—	—	—	—
N63126	POINT MUGU PMTC, CA	26	22	5	5	3	3

Table A.3f. Summary of field QC samples for family housing: Western (continued)

UIC	Facility	Mailed			Returned		
		Duplicates	Blanks		Duplicates	Blanks	
N63387	SAN DIEGO PWC, CA	57	38		--	--	--
N66890	NAVSTA MARE ISLAND, CA	22	18		19	5	
N68311	LONG BEACH NS, CA	63	50		--	--	--
N68378	SAN FRANCISCO PWC, CA	67	48		--	--	--
N68436	BANGOR NSB, WA	30	28		--	--	--
N70273	JIM CREEK NRS-T, WA	0	0		0	0	0

Table A.4f. Numbers and status of detectors placed in various buildings for nonhousing: Western

UIC	Facility	Hospital	School	Child care	Bachelors quarters	Brigs	Detectors	
							Sent	Returned
M00243	SAN DIEGO MCRD, CA	0	0	1	60	0	8	8
M00681	MCB CAMP PENDLETON, CA	0	0	5	296	1	16	0
M60050	EL TORO MCAS, CA	1	0	1	30	0	9	0
M62204	BARSTOW MCLB, CA	0	0	1	11	0	6	2
M62535	MCAS (H) TUSTIN, CA	0	0	1	11	0	6	0
M62974	YUMA MCAS, AZ	0	0	1	27	0	6	6
M67399	TWENTYNINE PALMS, CA	1	0	2	71	0	11	0
N00236	NAS ALAMEDA, CA	0	0	0	4	0	4	0
N00245	NAVSTA SAN DIEGO, CA	0	0	1	22	0	11	8
N00246	NAS NORTH ISLAND SAN, CA	0	0	2	54	0	8	0
N00247	NAVAL TRAINING CENTE, CA	0	0	1	84	0	6	5
N00251	NSY PUGET SOUND BREM, WA	0	0	0	167	0	6	6
N00253	NAVUSEAWARENGSTA KEY, WA	0	0	0	9	0	8	0
N00255	SEATTLE NS, WA	0	0	0	2	1	6	0
N00259	NAVHOSP SAN DIEGO, CA	5	0	0	5	0	24	24
N00296	MOFFETT FIELD NAS, CA	0	0	1	16	0	8	0
N00620	WHIDBEY ISLAND NAS, WA	1	0	1	13	0	9	0
N00849	NAVSECGRUACT SKAGGS, CA	0	0	0	1	0	4	0
N00886	STOCKTON NCS, CA	0	0	0	6	0	4	0
N00943	FLEASWTRACENPAC SAN, CA	0	0	0	0	0	4	0
N00948	SAN DIEGO, CA	0	0	0	2	0	8	0
N57053	CENTERVILLE BEACH NF, CA	0	0	0	6	0	4	0

Table A.4f. Numbers and status of detectors placed in various buildings for nonhousing: Western (continued)

UIC	Facility	Hospital	School	Child care	Bachelors quarters	Brigs	Detectors	
							Sent	Returned
N57056	NAVFAC PACIFIC BEACH, WA	0	0	0	2	0	9	0
N60028	NAVSTA TREASURE ISLA, CA	0	0	1	17	1	8	8
N60036	CONCORD WPNSTA, CA	0	0	0	4	0	4	4
N60042	EL CENTRO NAF, CA	0	0	1	11	0	11	0
N60259	MIRAMAR NAS, CA	0	0	2	28	0	8	0
N60462	NAVAL AIR STATION AD, AK	1	0	1	17	0	11	0
N60495	FALLON NAS, NV	0	0	1	13	0	10	9
N60530	CHINA LAKE NWC, CA	0	0	5	76	0	33	19
N60701	WPNSTA SEAL BEACH, CA	0	0	0	11	0	4	4
N62021	CORONADO, CA	0	0	0	11	0	4	4
N62271	MONTEREY NPGS, CA	0	0	2	3	0	15	0
N62583	PORT HUENEME NCBC, CA	0	0	2	16	0	8	0
N63042	LEMOORE NAS, CA	1	0	1	8	0	9	0
N63126	POINT MUGU PMTC, CA	0	0	2	28	0	17	0
N63406	SAN DIEGO, CA	0	0	0	6	0	4	3
N63406	SUBASE SAN DIEGO, CA	0	0	0	6	0	4	3
N63886	NAVSECGRUACT ADAK, AK	0	0	0	4	0	9	0
N66890	NAVSTA MARE ISLAND, CA	0	0	1	14	0	6	5
N68090	NAVHOSP LONG BEACH, CA	1	0	0	2	0	12	11
N68094	NAVHOSP CAMP PENDLET, CA	1	0	1	2	0	9	0
N68097	NAVHOSP BREMERTON, WA	1	0	0	4	0	24	0
N68311	LONG BEACH NS, CA	0	0	1	78	0	12	0

Table A.4f. Numbers and status of detectors placed in various buildings for nonhousing: Western (continued)

UIC	Facility	Hospital	School	Child care	Bachelors quarters	Brigs	Detectors	
							Sent	Returned
N68378	SAN FRANCISCO PWC, CA	0	0	0	2	0	19	0
N68436	BANGOR NSB, WA	0	0	1	17	0	6	0

Table A.5f. Dates associated with detector placement and retrieval for nonhousing: Western

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
M00243	SAN DIEGO MCRD, CA	03/89	04/89	02/90	03/90	03/90
M06681	MCB CAMP PENDLETON, CA	03/89	10/89	05/90	--	--
M60050	EL TORO MCAS, CA	03/89	06/89	03/90	--	--
M62204	BARSTOW MCLB, CA	03/89	03/89	03/90	03/90	04/90
M62535	MCAS (H) TUSTIN, CA	03/89	--	04/90	--	--
M62974	YUMA MCAS, AZ	04/89	10/89	Early	01/90	02/90
M67399	TWENTYNINE PALMS, CA	03/89	10/89	02/90	--	--
N00236	NAS ALAMEDA, CA	03/89	--	04/90	--	--
N00245	NAVSTA SAN DIEGO, CA	03/89	03/89	Early	06/89	08/89
N00246	NAS NORTH ISLAND SAN, CA	03/89	03/89	03/90	--	--
N00247	NAVAL TRAINING CENTE, CA	03/89	04/89	03/90	03/90	03/90
N00251	NSY PUGET SOUND BREM, WA	03/89	04/89	03/90	04/90	04/90
N00253	NAVUSEAWARENGSTA KEY, WA	03/89	07/89	06/90	--	--
N00255	SEATTLE NS, WA	03/89	03/89	03/90	--	--
N00259	NAVHOSP SAN DIEGO, CA	03/89	06/89	03/90	03/90	03/90
N00296	MOFFETT FIELD NAS, CA	03/89	06/89	05/90	--	--
N00620	WHIDBEY ISLAND NAS, WA	03/89	06/89	03/90	--	--
N00849	NAVSECGRUACT SKAGGS, CA	03/89	04/89	03/90	--	--
N00886	STOCKTON NCS, CA	03/89	04/89	02/90	02/90	--
N00943	FLEASWTRACENPAC SAN, CA	03/89	04/89	02/90	--	--
N00948	SAN DIEGO, CA	03/89	04/89	04/90	--	--
N57053	CENTERVILLE BEACH NF, CA	03/89	04/89	03/90	04/90	--

Table A.5f. Dates associated with detector placement and retrieval for nonhousing: Western (continued)

UIC	Facility	Detectors				
		Sent	Placed	Mailed	Retrieved	Returned
N57056	NAVFAC PACIFIC BEACH, WA	03/89	04/89	03/90	--	--
N60028	NAVSTA TREASURE ISLA, CA	03/89	03/89	03/90	03/90	03/90
N60036	CONCORD WPNSTA, CA	03/89	04/89	02/90	03/90	03/90
N60042	EL CENTRO NAF, CA	03/89	05/89	04/90	--	--
N60259	MIRAMAR NAS, CA	03/89	06/89	05/90	--	--
N60462	NAVAL AIR STATION AD, AK	03/89	04/89	03/90	--	--
N60495	FALLON NAS, NV	03/89	04/89	03/90	03/90	04/90
N60530	CHINA LAKE NWC, CA	03/89	UNK	05/90	--	02/90
N60701	WPNSTA SEAL BEACH, CA	03/89	10/89	07/90	--	--
N62021	CORONADO, CA	03/89	04/89	04/90	04/90	04/90
N62271	MONTEREY NPGS, CA	03/89	11/89	03/90	--	--
N62583	PORT HUENEME NCBC, CA	03/89	04/89	03/90	--	--
N63042	LEMOORE NAS, CA	03/89	05/89	04/90	--	--
N63126	POINT MUGU PMTC, CA	03/89	11/89	03/90	03/90	--
N63406	SAN DIEGO, CA	03/89	07/89	04/90	04/90	04/90
N63406	SUBASE SAN D'EGO, CA	03/89	07/89	04/90	04/90	04/90
N63886	NAVSECGRUACT ADAK, AK	04/89	04/89	03/90	--	--
N66890	NAVSTA MARE ISLAND, CA	03/89	04/89	03/90	03/90	03/90
N68090	NAVHOSP LONG BEACH, CA	03/89	05/89	Early	08/89	09/89
N68094	NAVHOSP CAMP PENDLET, CA	03/89	--	05/90	--	--
N68097	NAVHOSP BREMERTON, WA	04/89	07/89	04/90	--	--
N68311	LONG BEACH NS, CA	03/89	07/89	06/90	--	--

Table A.5f. Dates associated with detector placement and retrieval for nonhousing: Western (continued)

UIC	Facility	Detectors			
		Sent	Placed	Mailed	Retrieved
N68378	SAN FRANCISCO PWC, CA	03/89	07/89	06/90	---
N68436	BANGOR NSB, WA	03/89	10/89	04/90	---

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