ABSTRACT

CHARLES E. MAPLES. Survey Of Tritium In Soil In An Assessment Of A University Low-Level Radioactive Waste Facility. (Under The Direction of Dr. DOUGLAS CRAWFORD-BROWN)

Soil samples from two low-level radioactive waste facilities belonging to the University of North Carolina at Chapel Hill were evaluated for their tritium content. The interstitial soil water and associated tritium activity was separated from the soil by distillation at high temperatures. Condensed water from the soil samples was then counted in a liquid scintillation counter. At the Horace Williams Airport site, no detectable tritium activity was found. At the Mason Farm site, no tritium activity was found off site but trace amounts (less than 30 pCi/g of soil) were found in soil between individual burial pits inside the site boundaries. Soil sampled from the pits at the Mason Farm site had tritium values that ranged from non-detectable to 735 pCi/g of soil.

TABLE OF CONTENTS

FIGURES

TABLES

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And I give thanks to God, who provided me with the opportunity and guidance to complete this project.

Section I

INTRODUCTION

In past years, many institutions maintained their own burial site for the disposal of their low-level radioactive waste. The University of North Carolina has two such waste sites. One site is located on University property known as Horace Williams Airport. The other is located on University property known as Mason Farm. Figure 1 shows the location of these sites in relationship to Chapel Hill, North Carolina.

As the understanding of the consequences of low-level radioactive waste burials has increased over the years, it has become increasingly important to examine these sites. Many such sites have allowed movement of the buried radionuclides into the soil and groundwater around the sites. This movement brings with it a concern for public health in areas surrounding the sites.

In this study, an examination of tritium migration will be made in the assessment of the University's two low-level radioactive waste (LLRW) burial sites. In the examination, it will be necessary to determine what was buried, the quantities buried, as well as how it was buried. The size of the pits, the depth of burial, soil type, and the amount of ground water present in the soil also play an important role in the migration of tritium as well as other radionuclides.

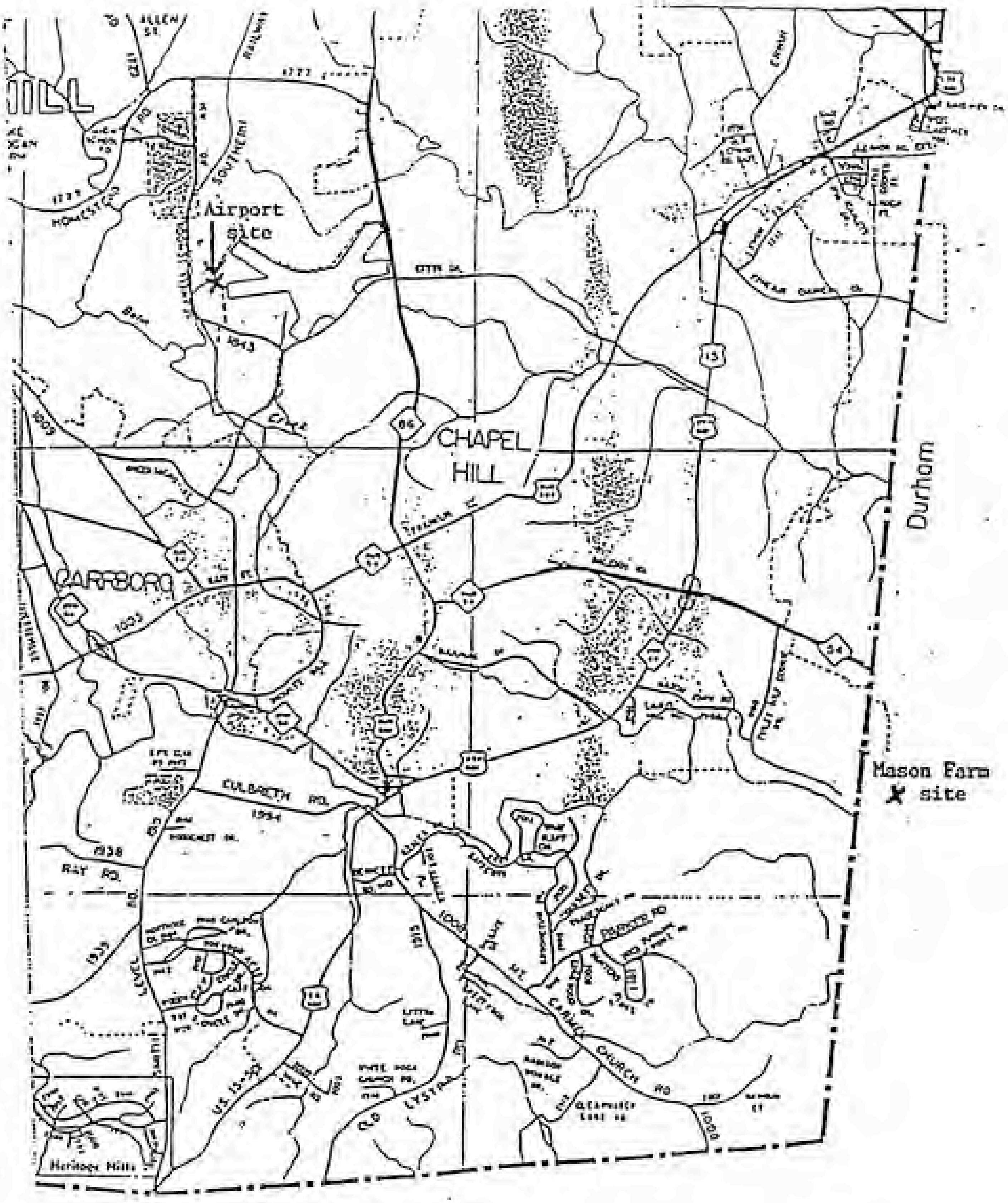


Figure 1

Location of the two LLRW sites belonging to the University of North Carolina at Chapel Hill

SCALE: 0 4000' 6000'

Section II

DATA SOURCES

There were two different sources of data used in the preliminary investigation into the two LLRW sites. The first was a series of personal conversations (8,13) with people who were associated with the burials. The second source was written burial records which included some Radiation Safety Office Annual Reports (9).

There were a few problems associated with each method, since these burials were made from 19 to 28 years ago. Over the years the burial sites were used, different people were responsible for the management of records and the disposal process itself. The records on file (9) show the differing methods used for record keeping by different people. Some methods were not as detailed as others, leaving blanks in the retrievable data. There were also blanks and gray areas in the memories of people associated (8,13) with the burials.

2.1 Personal Conversations

An attempt was made to get information from people who had participated in the burials. Two people were very helpful. They were: Ray Pfleger, Radiation Safety Officer from 1961 to 1965 and Kay Slaughter, Radiation Technician from 1968 to the end of the burial period. Information on the types of containers in the pits and the method of burial was obtained. Also, information on some of the forms of materials that were buried was received from these sources.

It was learned that a backhoe was used to dig the pits in both sites (8). When the backhoe finished digging a pit for that days burial, it was removed. A waste collection vehicle was then backed to the pit and the waste was thrown or pushed in. There were usually no special containers used for the waste (13). Sometimes glass containers (such as scintillation vials or gallon jugs) were broken as they were thrown in. Other times they remained intact. Some vials were placed in cardboard boxes that held up to 8 flats (800 vials), some individually tossed in. In latter years at the Mason Farm Site, some plastic jugs were used for a portion of the liquid waste.

Dry waste was treated in much the same manner. It was often thrown into the pits in plastic collection bags or in cardboard boxes. Often there was no special care taken to see that the bags remained sealed when placed in the pits. Dry waste included rubber gloves, empty vials, paper, hyperdermic needles, etc.

Animals were buried at both sites. This continued for all but the last couple of years of operations. These carcasses were usually wrapped in plastic, but the plastic would sometimes be torn in the transportation and burial process. These animals included mice, rats, cats, pigs, sheep, and dogs. Also buried was their bedding and waste.

The depth of the burial depended on the amount to be buried: the more waste, the deeper the hole. The pits varied from 5 feet to over 8 feet in depth. This seemed to be a problem at the Mason Farm Site as the water table was only a few feet under the surface. Often there was

2 feet or more of water in the pit before the waste was thrown in.

2.2 Airport Site Burial Records

The Airport Site is the smaller of the two burial sites. This site was in use from May, 1961 through July, 1963. The fence surrounding the site measures 20 feet by 30 feet. The records (9) show seven burials were made in this area (Appendix A). The records do not show the relationship of the location of an individual pit to a burial date.

The individual pits were marked by steel pegs on the corners (Figure 2). They all vary in length and width. The pits were as close as six inches apart, with some pits using a common corner peg. Their depth was determined by the then current guide to burial of carbon-14 (12), which gave a recommended depth of 4 feet of compacted soil on top of the waste.

From Appendix A, a list of radionuclides with remaining activity can be determined (Table 1). The original buried activity in this site was approximately 40 mCi. Of this activity, 35% was carbon-14 and tritium. The total remaining activity after radioactive decay cannot be precisely determined. Some nuclides were listed together in burial records. Appendix A shows this co-listing. One burial lists chlorine-36 and carbon-14 as one radionuclide and another burial lists carbon-14 and tritium as one. All calculations of decay used the longer half life of the two co-listed nuclides to determine the remaining amount of that burial. Using this method, only about 9 mCi remain as of May, 1989. Of this remaining activity, 99% is carbon-14 and tritium.

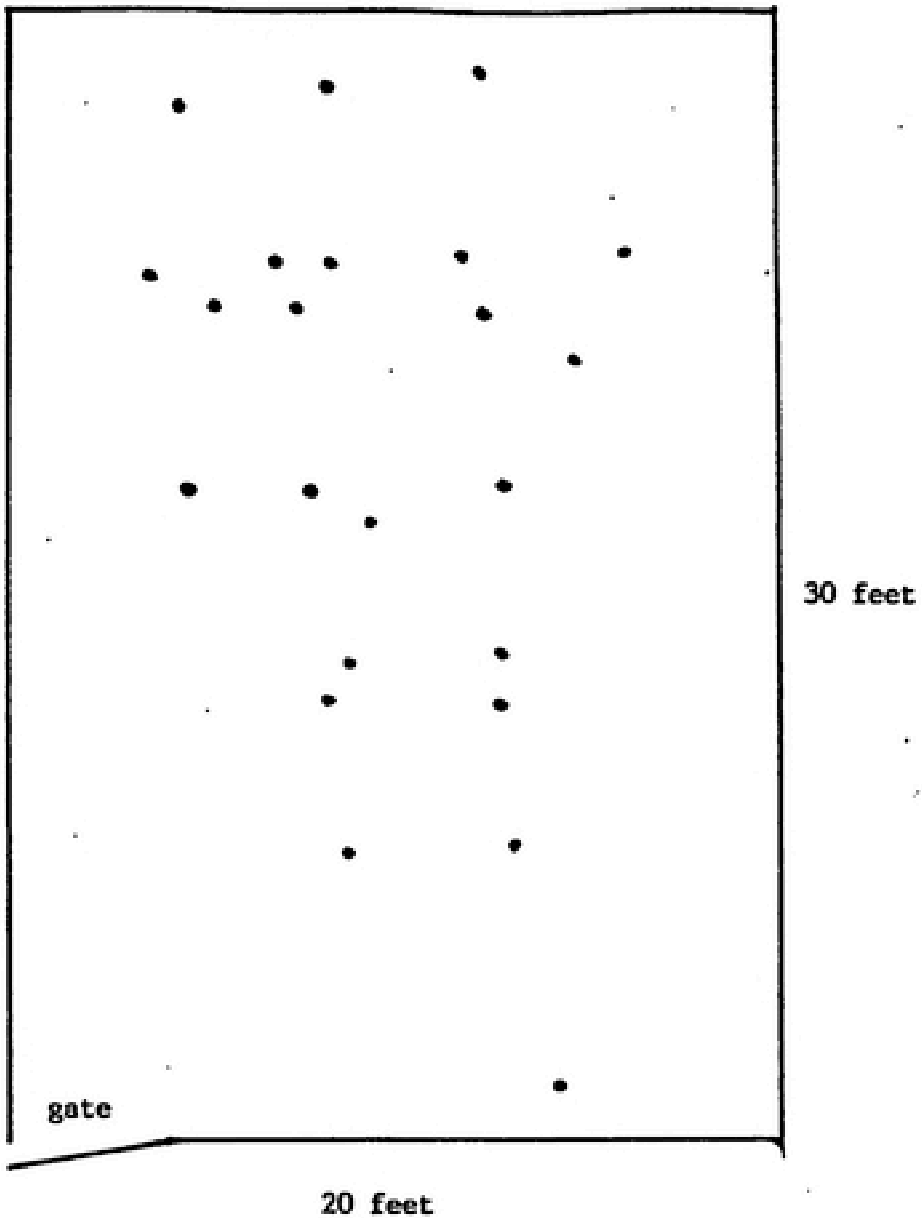


FIGURE 2 : Scale drawing of the Airport site.
Dots represent position of steel pegs

Table 1

Radionuclides Buried at the Airport Site

Nuclide Buried	T½	Type Decay	Product	Amt Deposited (mCi)	Amt Remaining as of 5/1/89
Ba-133	7.2y	ε,γ	stable	0.275	0.044
C-14	5730y	β	stable	5.969	5.950
C-14/H-3*	5730y	β/β	stable	2.000	1.993
Ca-45	163d	β	stable	6.900	0.000
Ce-141	32.5d	β	stable	$1X10^{-6}$	0.000
Cl-36	$3X10^{5}$y	β	stable	0.053	0.053
Cl-36/* C-14	$3X10^{5}$y	β/β	stable	0.020	0.020
Cr-51	27.8d	ε	stable	0.178	0.000
Cs-134	2.1y	β,γ	stable	0.290	0.000
Fe-55	2.4y	ε	stable	0.100	0.000
H-3	12.3y	β	stable	5.890	1.361
Hg-203	46.6d	β	stable	0.010	0.000
I-131	8.1d	β	stable	6.062	0.000
Na-22	2.6y	β+,γ	stable	2.320	0.002
P-32	14.3d	β	stable	4.662	0.000
Pm-147	2.6y	β,γ	Sm-147**	5.000	0.004
Se-75	120d	ε	stable	0.040	0.000
Sr-85	65d	ε	stable	0.010	0.000

* When two radionuclides were buried without distinction of amounts of each, the longer half-life of the two was used for calculations.

** Sm-147 is a naturally occuring isotope with a half-life of $1.08 X 10^{11}$ years
the activity of Sm-147 would be $1.21 X 10^{-10}$ mCi after all of the Pm-147 decays

The ratio of carbon-14 to tritium cannot be determined. This is because of the one co-listing of the two radionuclides. Those burials that list the two separately show a 4 to 1 ratio, carbon-14 to tritium.

Records of this site were not as complete as they were of the Mason Farm site. Log books (9) of incoming material were not kept untill 1966. There was no way to check the types and quantities of materials that may have been buried at the Airport site. Records that are available do show that the site was no longer used after the Mason Farm site was established. The exact beginning date of the Airport site is of question.

2.3 Mason Farm Site Burial Records

The Mason Farm site is the larger of the two sites. The fenced area measures 100 feet by 150 feet. In the site are 52 to 56 (or more) individual burial pits (Appendix B). This site was used from November, 1963 to 1970 (the exact month of the final burial is not clear). A drawing of this site can be seen in Figure 3. This site is also in the flood pool of Jordan Lake (2).

There is some confusion as to the exact number of burials at this site. There is a scaled map showing the location of the first 36 burials (Figure 3 is a scale drawing of this map). A rough hand drawing of the site indicates 56 burials, while a detailed listing of burials stops at 52. Burial 52 was listed as November, 1968. There are references in Radiation Safety Office Annual Reports that burials continued after this date. An additional 722 mCi is listed as being

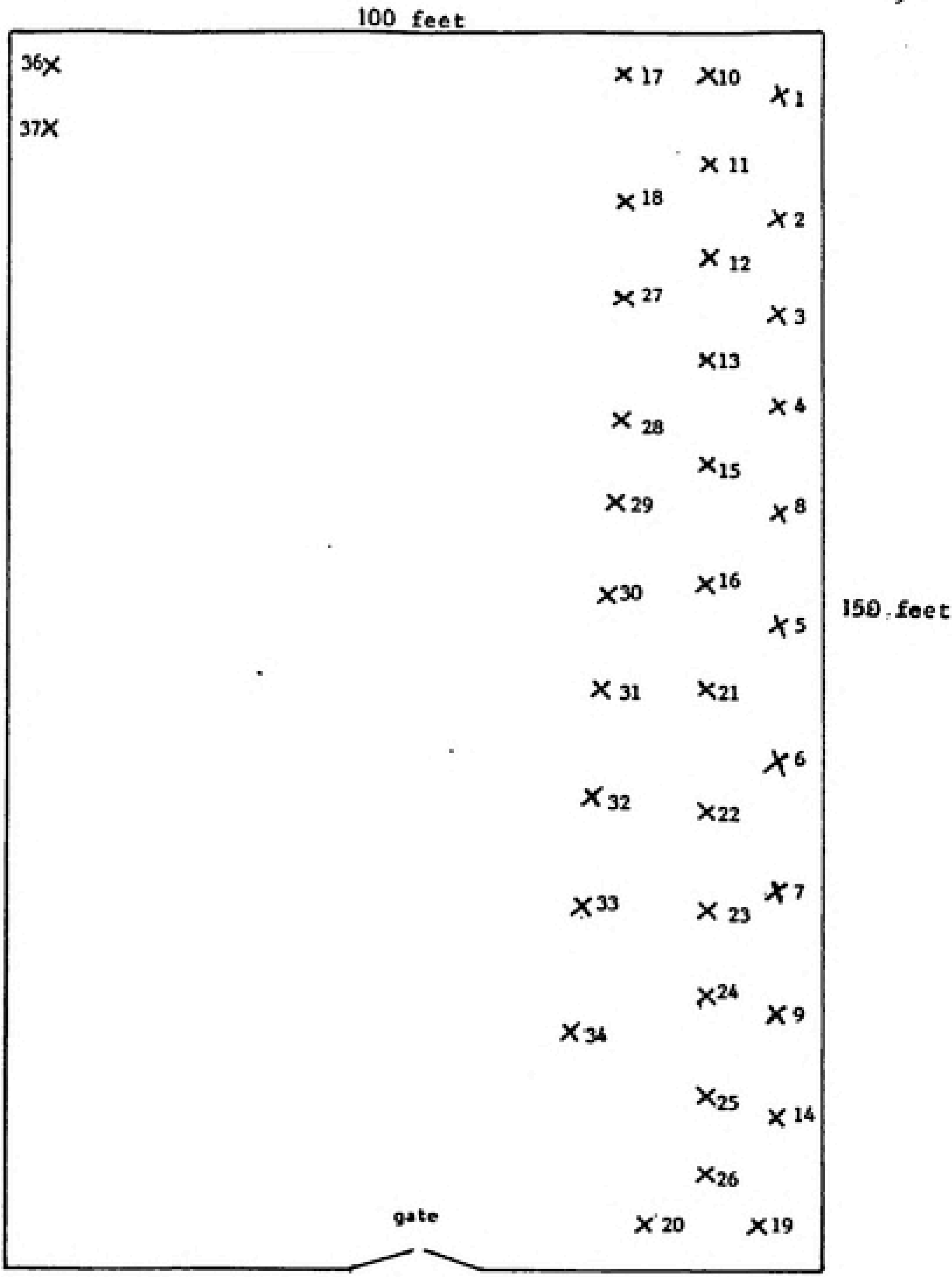


FIGURE 3 : Relative position of the Mason Farm pits based on a scale drawing on file.
X - center of a pit
numbers are the burial number on record for an individual pit

buried through June, 1970. Figure 4 shows a probable location pattern of additional pits, assuming this additional 722 mCi is correct. This pattern is based on the burial pattern of the scaled drawing, the pattern given in the rough hand drawing, the pits with visible top subsidence, and the probable number of monthly burials from November, 1968 to June, 1970.

This site used the standards set by the state of North Carolina as an agreement state (7). The pits were at least 6 feet apart and covered by at least 4 feet of compacted earth. As in the Airport site, the pits varied in length and width as well as depth, depending on amounts to be buried. There were no pegs or other markings on the surface to show individual pit locations.

The types and amounts of radionuclides buried can be seen in Table 2. The total activity buried at this site was approximately 1.16 Ci (this does not include the 722 mCi of unlisted burials). The remaining activity after decay, as of May, 1989, is approximately 331 mCi. Of this remaining activity, 99.9% is carbon-14 and tritium. Looking at the total remaining activity of tritium and carbon-14, the ratio of tritium to carbon-14 is 1.7 to 1.

For this study, it is assumed the unlisted burials are of the same types of materials and at the same ratios as the knowns. A search through the log books (9) on record show no unusual shipments of radionuclides during this period. Of the total quantity given in the original burials, carbon-14 comprised 10.5% while tritium made up 67.6%. By applying these percentages to the additional 722 mCi, there would be an additional 76 mCi of carbon-14 and 488 mCi of tritium

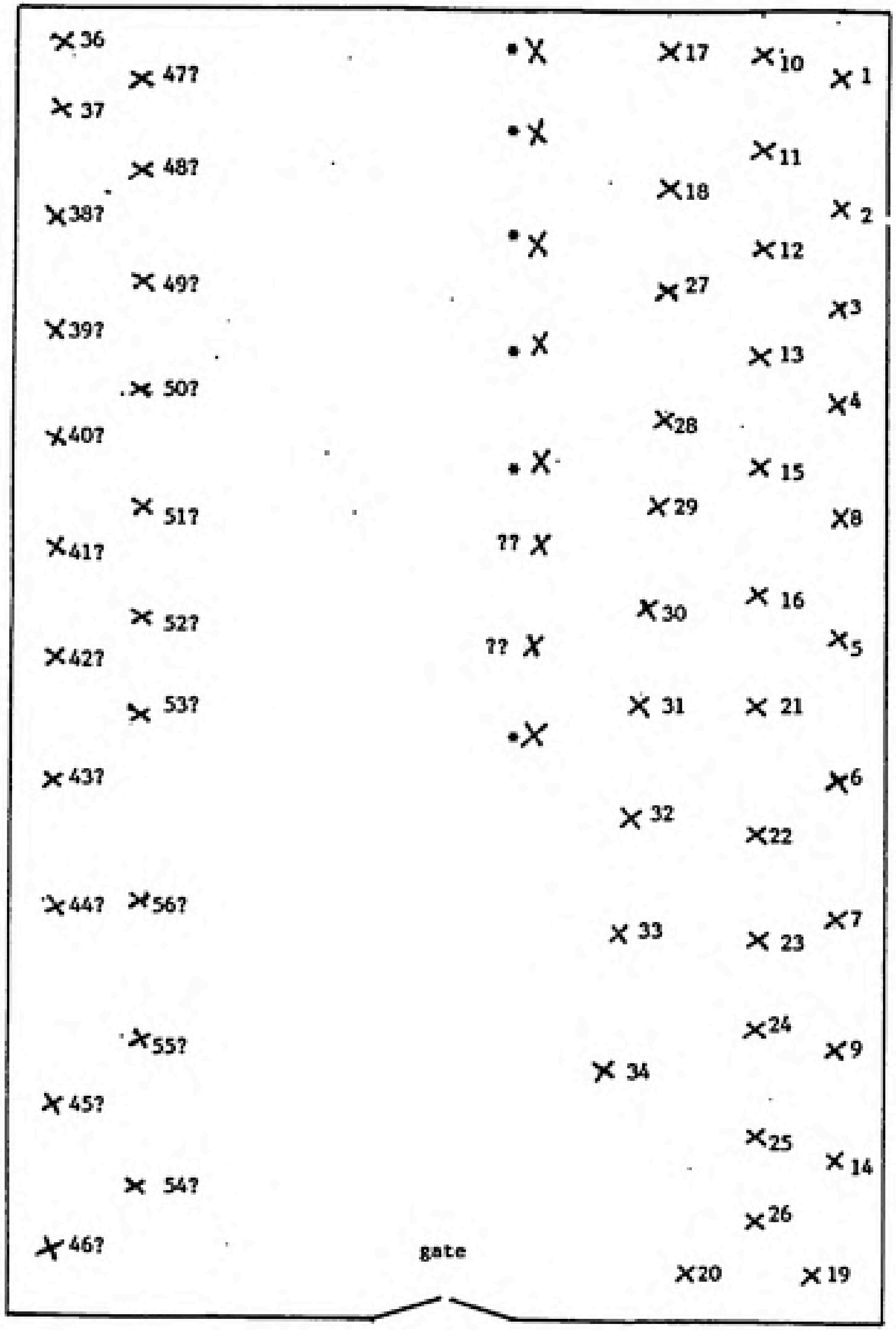


FIGURE 4 : Estimated number and position of Mason Farm burial pits. Pits 1-37 from scale drawing. Pits 38-56 (?) from hand drawing in burial log book. Exact position is unknown. Pits listed as * are estimated from additional burials . ?? are two pits that can be seen because of top subsidence. X - center of pit.

Table 2

Radionuclides Buried at the Mason Farm Site

Nuclide Buried	T½	Type Decay	Product	Amt Deposited (mCi)	Amt Remaining as of 5/1/89
Ag-110	253d	β,γ	stable	0.026	0.000
Au-198	2.7d	β,γ	stable	11.145	0.000
Ba-133	7.2y	ε,γ	stable	0.070	0.008
C-14	5730y	β	stable	121.892	121.597
Ca-45	163d	β	stable	4.585	0.000
Cd-115	44.1d	β,γ	In-115**	0.015	0.000
Ce-141/*	32.5d/	β,γ/	stable/	$3X10^{-4}$	0.000
-144	284.4d	β,γ	stable		
Cl-36	$3X10^{5}$y	β	stable	0.157	0.157
Co-60	5.3y	β,γ	stable	0.278	0.012
Cr-51	27.8d	ε	stable	45.884	0.000
Cs-134	2.1y	β,γ	stable	0.077	0.000
Cs-137	30.2y	β,γ	stable	0.100	0.060
Fe-59	45.6d	β,γ	stable	1.859	0.000
H-3	12.3y	β	stable	786.609	209.276
Hf-181	42.4d	β,γ	stable	0.021	0.000
Hg-197	65h	ε,γ	stable	0.357	0.000
Hg-197/*	65h/	ε,γ/	stable/	0.228	0.000
-203	46.6d	β	stable		
Hg-203	46.6d	β	stable	0.602	0.000
I-125	59.7d	ε,γ	stable	6.738	0.000
I-125/*	59.7d/	ε,γ/	stable/	2.800	0.000
-131	8.1d	β	stable		
I-131	8.1d	β	stable	73.097	0.000
Na-22	2.6y	β+,γ	stable	1.840	0.003
Na-24	15h	β,γ	stable	0.150	0.000
P-32	14.3d	β	stable	69.366	0.000
S-35	87.2d	β	stable	33.218	0.000
Se-75	120d	ε	stable	0.822	0.000
Sr-85	65d	ε	stable	0.078	0.000
Sr-89	50.8d	β,γ	stable	0.015	0.000
Tc-99m	6h	e,γ	Tc-99***	0.585	0.000
Y-91	58.8d	β,γ	stable	0.001	0.000
Zn-65	243.7d	β+,ε,γ	stable	0.164	0.000

* When two radionuclides were buried without distinction of amounts of each, the longer half-life of the two was used for calculations.

** In-115 is a naturally occuring isotope with a half-life of 5 X 10^{14} years. The In-115 present would have an activity of 3.62 X 10^{-10} mCi

*** Tc-99 is a naturally occuring isotope with a half-life of 2.13 X 10^{5} years. The amount present would be 1.88 X 10^{-8} mCi buried at the site. After 19 years of decay, this would lead to an additional 76 mCi of carbon-14 and 167 mCi of tritium. This would make the remaining activity on the site 574 mCi, an increase of 58%. This will be the assumed activity for the remainder of this study.

Section III

TRITIUM

The tritium atom has many distinguishing properties that allow for it's detection and activity measurement in soil. This study will use some of these properties in an assessment process of the LLRW sites.

3.1 Tritium Properties

The tritium atom is a beta emitter, decaying to helium-3. Its beta particle has an 18.6 keV maximum energy with an average energy of 5.67 keV. The half-life of tritium is given as 12.3 years (10). The biological half-life is given as 10 days.

Tritium is produced naturally in the atmosphere by the interaction of high energy cosmic rays with nitrogen (5) and is produced by man in nuclear reactors and in nuclear weapons testing. The natural production is estimated to be about 0.20 ± 0.05 tritons per cm^2 per sec (6). About 90% of the natural tritium is found in the hydrosphere, 10% in the stratosphere, and 0.1% in the troposphere (11).

The natural production rate yields a steady state inventory of 26 MCi in the biosphere (3). The annual absorbed dose from tritium of natural origin is estimated to be 0.001 mrem/yr (3).

The concentration of tritium in rainwater is 130 to 185 pCi/l (6). This can be a confounding factor in low level environmental counting processes. At room temperature, tritium will readily replace hydrogen in water molecules forming tritiated water ($HT + H_2O \rightleftharpoons HTO + H_2$) (5). Tritium follows the movement of water, constantly dispersing as it moves. The dryer the soil the slower the tritium movement, but conversely, an over abundance of soil water will slow the movement of tritium due to lateral molecular diffusion (14).

Bonding of tritium molecules to micas in the soil is found at room temperature (14). The water of hydration reaches equilibrium with it's environment in a short time. The removal of this bonded molecule can be accomplished by heating the micas to the 100 to 500°C range (5, 14).

Intake of tritiated water vapor occurs both by inhalation and by skin absorption. The rate of skin absorption is approximately half the lung intake(6). The ALI for tritiated water is 75 mCi (6). An acute uptake would lead to the following risk factors (6).

Table 3 - Doses and Risks from Tritium Intakes

intake	committed dose equiv.	associated risk
7.5 Ci	500 rem	serious risk of death
1.5 Ci	100 rem	mild radiation sickness
75 mCi	5 rem	1 in $1X10^3$ risk of cancer
7.5 mCi	500 mrem	1 in $1X10^4$ risk of cancer
750 μCi	50 mrem	1 in $1X10^5$ risk of cancer
75 μCi	5 mrem	1 in $1X10^6$ risk of cancer

3.2 Tritium as an Assessment Tool

The use of tritium as a tool in the assessment of the two LLRW sites arises from two facts. First the high mobility of tritium and secondly, the amount of tritium buried at the sites. Associated with the high tritium mobility, is the possibility that over the years most, if not all, of the tritium may have migrated from the burial pits and dispersed to non-detectable levels.

At the Airport Site, of the 9.4 mCi of remaining inventory, as much as 1.5 mCi may be tritium. If the tritium has dispersed to non-detectable levels, only 7.5 mCi of total activity (primarily carbon-14) would remain buried on the site. This would be a 20% reduction in activity.

At the Mason Farm Site, tritium was the major radionuclide buried. Tritium is also the major remaining radionuclide at this site. Of the 574 mCi of total remaining inventory buried at the site, 376 mCi is tritium. If the tritium has dispersed to non-detectable levels, this would leave 198 mCi total activity, a reduction of approximately 63%. Almost all of this remaining activity would be carbon-14.

Section IV

METHODOLOGY

This study examined the soil in and around the burial pits for tritium movement. The interstitial soil water, as well as ground water, provides pathways for tritium movement. In order to examine the soil, a soil sampling criteria was established. That is, what method was to be used to collect samples, and at what locations will the samples be taken. To examine these soil samples for tritium activity, extraction and counting processes were established.

4.1 Method of Site Surveys

The samples were taken using a boring tool. This was twisted into the ground bringing up a 8 to 10 inch section of soil when the tool was extracted. Two opposing blades on the tool cut through the soil leaving a 3 inch diameter hole. The cutting action mixed the slices of soil in the holding chamber of the tool. The result was that no exact depth of samples was possible. There was a range in depth for each of the soil samples. This range was about 4 inches.

Soil samples were taken at 3 or more different depths from each individual test hole. Top soil and vegetation samples were not taken in this study. They have been taken and analyzed by the North Carolina Division of Radiation Protection for a number of years with no detection of radionuclides (4). The first sample of each hole was selected to be approximately 1 foot deep. Since the burials were reported to be covered with 4 feet of earth, another sample was taken at a depth of 4 feet. A third sample from about 2.5 feet was taken to check for upward movement of the tritium. Additional samples were taken at lower depths whenever actual pits were entered or in test holes close to these pits. This usually resulted in samples from 5.5, 6, or 6.5 feet. The equipment used was limited to 6 feet 10 inches.

The first set of samples taken was at the fence perimeter surrounding each site. A series of 10 test holes was dug within 2 feet of the outside of the fence. This can be seen in figures 5 & 6. Although the Airport site is much smaller than the Mason Farm site, the same number of holes was used because of the lack of exact burial records. At the Mason Farm site, most of the burials along the fence were plotted and recorded.

The strategy for sampling inside the two sites differed slightly. The pegs at the Airport site identified pits and gave a starting point for soil sampling (Figure 5). Test holes were dug in the pits and in the soil around them. Many extra holes were dug to determine if the old burial records were complete and to check for movement of tritium.

At the Mason Farm site, the scale drawing of the first 37 burials along with the burial record book (9) were used to establish a slightly different pattern for sample holes. A search through the records gave 3 pits having the greatest amount of tritium and/or carbon-14 buried in them. These were pits number 9, 22, and 30. The amounts buried here can be seen in Appendix B. Again, a hole was dug through the center (given

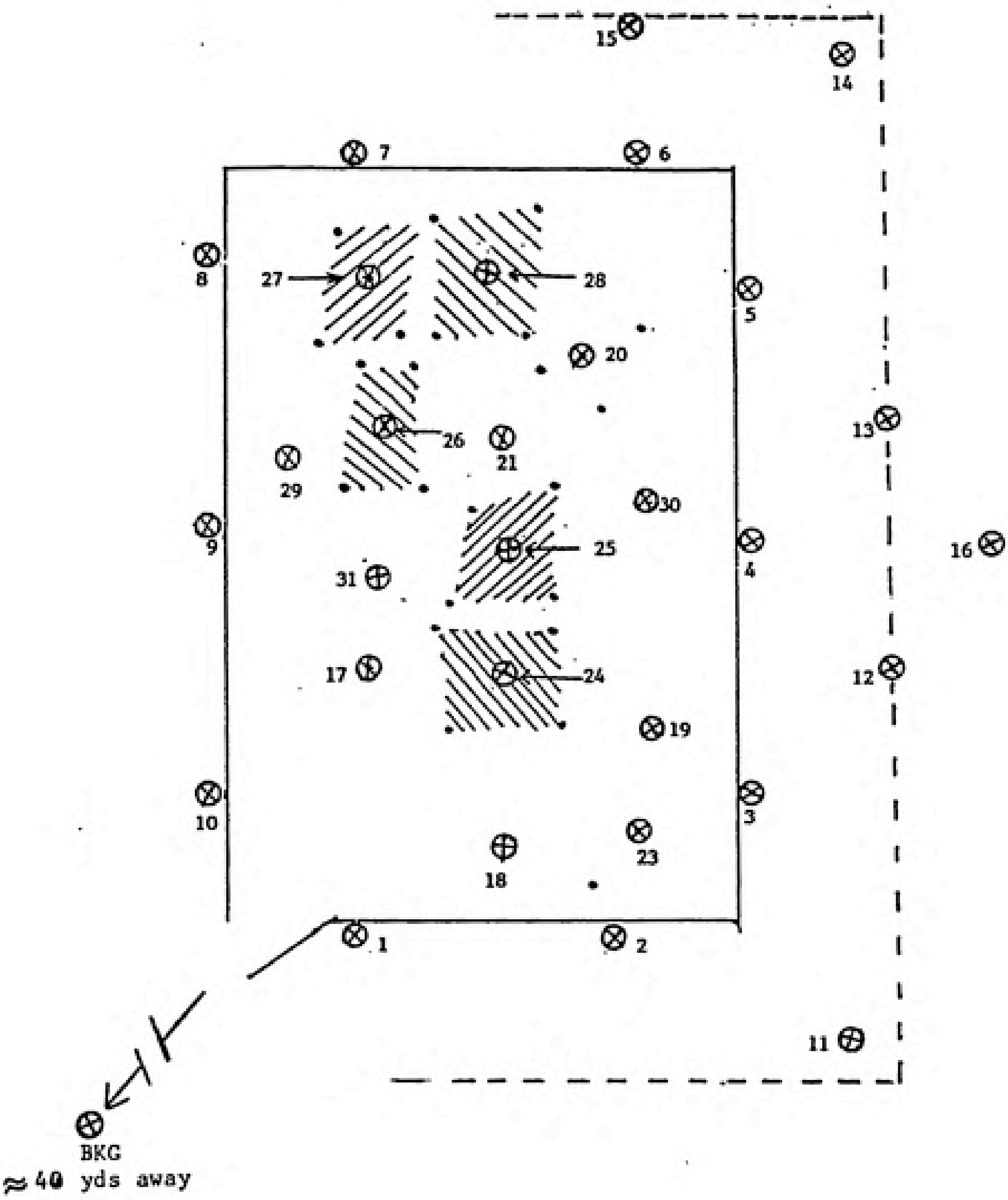


FIGURE 5 : Airport site drawing showing position of sample holes. Numbers are the same as in Appendix C. ⊗ - position of hole /// - known pit area

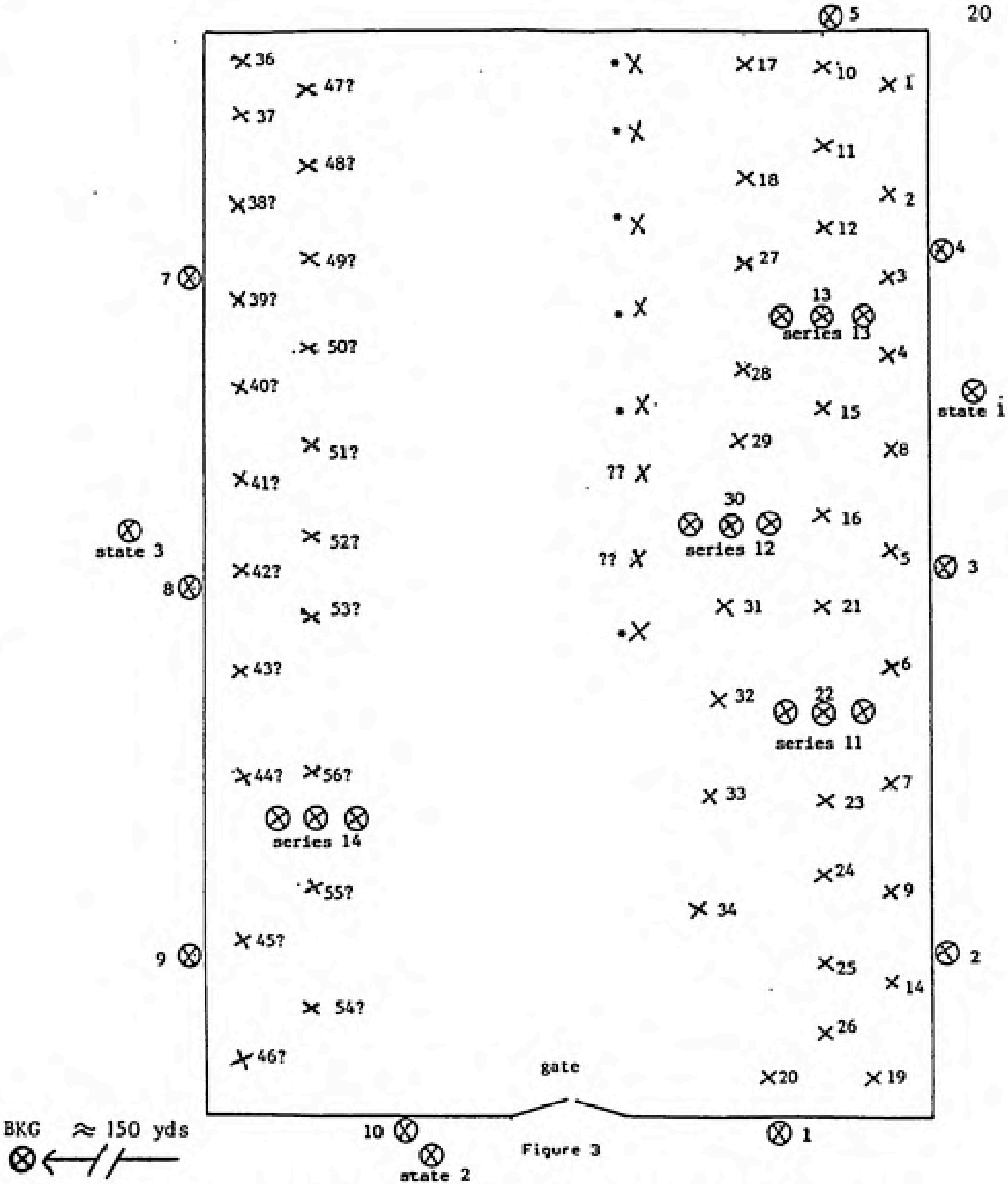


FIGURE 6 : Mason Farm drawing showing position of sample holes. Numbers are individual burial pits. ?, ??, and * represent pits in which the exact center is unknown. ? from burial log book, ?? visible from surface, * based on unlisted burials. X - center of a pit. ⊗ - position of sample Sample site listed as state is position of ground water samples taken by the state of North Carolina in its survey.

on the scale drawing on file) of the pit. At about 5.5 feet to the left and right of this center hole, another hole was dug to test for movement of tritium out of the pits (Figure 6).

An additional set of holes was dug to check an area of the site where the pits were not so carefully marked (series 14 on Figure 6). The placement of series 14 was based on the rough hand drawing in the burial log book on file (9). Contact with buried material in this area would prove that there were more than 52 burials at the site.

Ground water from the test holes was also examined. This was taken in all holes except those in the center of the pits. Mud and particulate matter was filtered out before counting to reduce quenching. The method used for counting was the same as for the interstitial water.

Background soil samples were taken to compare with soil samples from the sites. At the Airport site, a hole was dug about 40 yards uphill (towards the runway) from the burial site. Samples were taken at 1.5 and 3.5 feet. At the Mason Farm site, the same method was used with background samples coming from approximately 150 yards from the site. These background samples were processed in the same manner as site samples. The background value for soil (an average of both depths) at the Airport site was 59.75 ± 1.54 dpm/ml of interstitial water. The background value at the Mason Farm site was 49.79 ± 1.62 dpm/ml of interstitial water. The site background values include counter background. The error given is counting error only.

Pure water (ChromAR*HPLC from Mallinckrodt Chemical) was used to determine a background for the counting system. This water was also used for the preparation of a set of control samples. Using 1 ml of water gave a counter background value of 36.19 ± 1.44 dpm. Using the count rate of this sample, and a counting time of 180 minutes, a MDA of 1.68 pCi/ml is obtained. The MDA was calculated by first using the formula $LLD = 2.71 + 4.65\sqrt{B}$, where LLD is the lower limit of detection and B is the background in counts. Next, the LLD was divided by 180 minutes to give counts per minute. This value was divided by the counting efficiency (32%) to get a MDA in decays per minute. Dividing the dpm value by 2.22 dpm/pCi gives the MDA in pCi. All of the samples counted were 1 ml aliquots, resulting in a MDA in pCi/ml.

4.2 Method of Tritium Extraction and Counting

After the samples were collected, they were brought back to the lab for processing. The soil was placed in a flask with a ground glass top. This was attached to a Graham condensing coil with a ground glass connector. The flask was placed on a hot plate to drive off the interstitial soil water. When the vapor condensed, the water was collected in a small beaker and transferred to scintillation vials for storage. Soil samples were kept frozen while waiting to be processed. All samples were processed within 2 to 3 days. This method of extraction was used by the state of Kentucky when examining the Maxey Flats burial site (1). NCRP 47 states any method that is feasible in the laboratory that will yield reasonably pure interstitial water from soil samples is potentially useful, one of which is distillation at very high temperatures. A record was kept as to the % of water to dirt by weight for each sample.

A 1 ml aliquot of the condensed water was then used for counting in a liquid scintillation counter. The water was placed in 10 ml of scintillation cocktail (ScintiVerse BD - Fisher Chemicals). The water and cocktail was shaken to completely mix the solution. The sample was allowed to dark adapt for 30 minutes and then counted for 180 minutes by a Packard MINAXI, Tri-Carb model 4430 liquid scintillation counter.

A control group of tritiated soil samples was made to test the efficiency of this method of extraction and counting. Dried soil from background holes and holes where no activity had been found was mixed together to make a composite sample of the site. To this dried soil, an amount of water was added to bring the soil to a moisture content which was the average (21% interstitial water to soil by weight) for the site.

Seven soil samples were made to this specification. A known activity of tritium was added to the soil and allowed to sit for 1 to 2 days. Differing amounts of tritium was added to see if low environmental levels made a difference in extraction efficiency. Using standard tritiated water (Amersham Corporation), samples were made by pipetting the standard in varying amounts into the soil and pure water mixture. There was an average extraction efficiency of 77%. Table 4 gives the values of this process. Figure 8 gives the resultant graph.

FIGURE β : Recovery efficiency for the tritium extraction process. Variations are due to counting error.

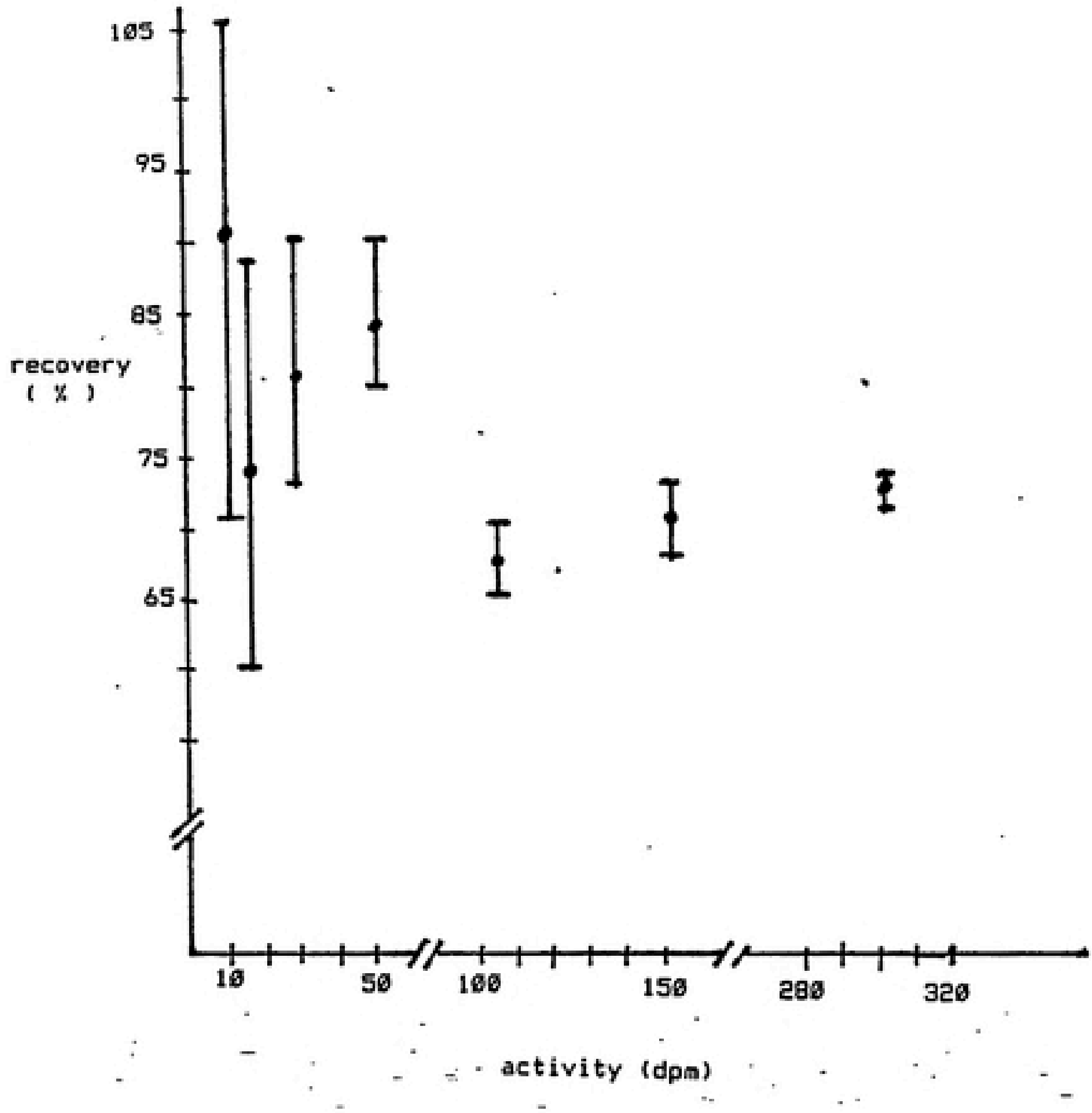


Table 4 - Values For Tritium Extraction Efficiency

Amt.Deposited(dpm/ml)	Amt.Recovered(dpm/ml)	Efficiency(%)
303	220.1±4.49*	72.6±1.5**
152	106.8±3.48	70.5±2.3
105	71.5±2.93	67.7±2.8
52	44.3±2.56	83.9±4.9
30	24.6±2.52	81.1±8.3
16	11.9±2.25	74.4±14.1
11	9.6±2.04	91.0±18.5

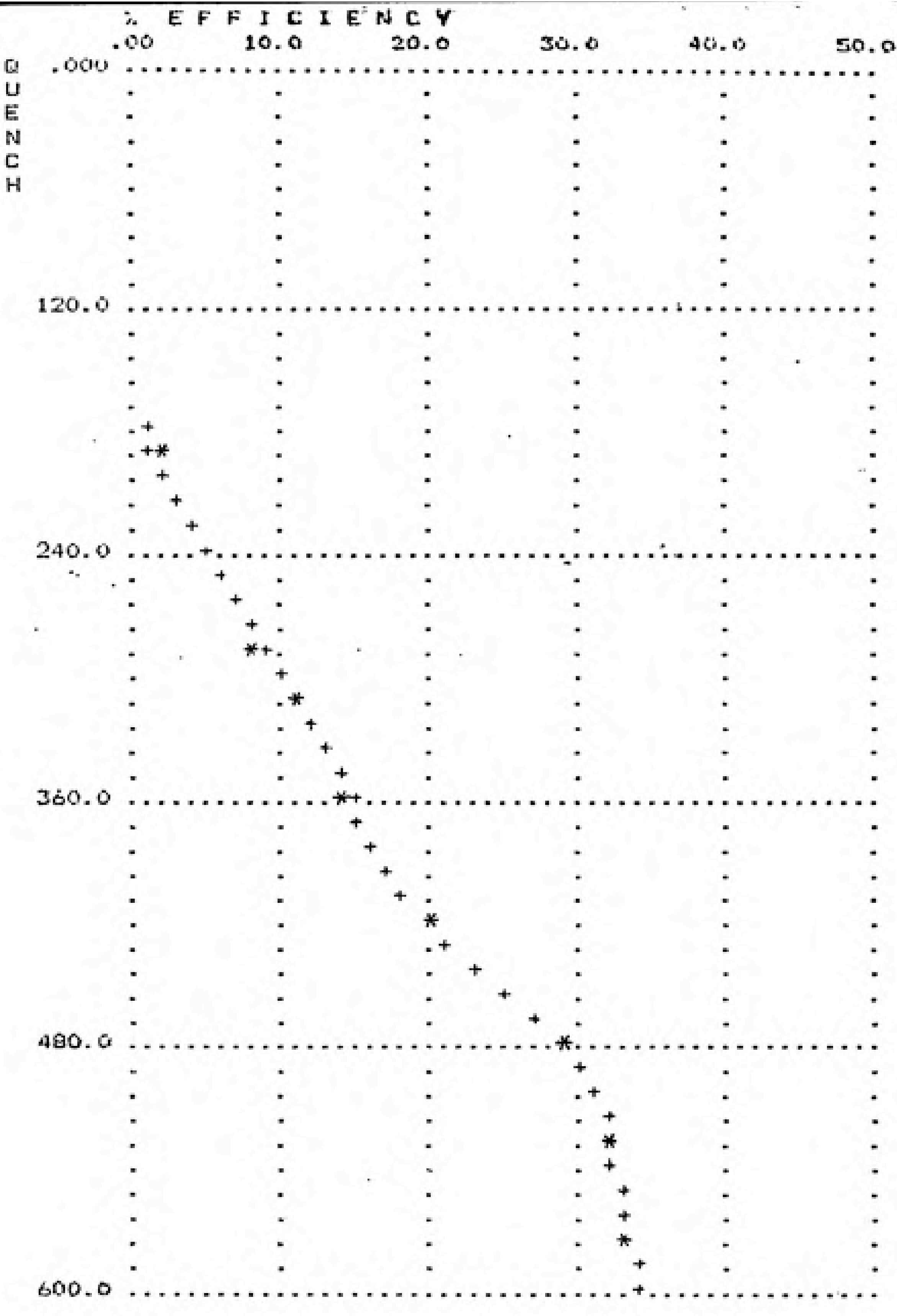
* - counting error only for these calculations

** - error due to variability in efficiency of extraction

4.3 Calculations

The liquid scintillation counter is programed to convert from cpm to dpm . This is done by inserting a quench curve either manually, by typing in values, or automatically by using a set of 10 vials with a known activity and allowing the counter to count and compare the counted values to the actual values. The latter method was used in this study. A quench curve was set up using a tritiated water standard obtained from the Amersham Corporation. Figure 9 shows the results of the curve.

The quench curve was set up in the following way. Into each of ten vials was placed 10 ml of scintillation cocktail. Also added to each vial was 25 µl of the tritiated water standard ($4.29X10^{6}$ dpm/ml) which



QUENCH	ELA	QUENCH	ELA	QUENCH	ELA
574.	33.2	529.	32.0	529.	31.7
527.	32.6	477.	28.7	420.	19.6
396.	14.3	316.	10.8	283.	8.20
196.	1.77				

FIGURE 9: Quench curve as calculated by the liquid scintillation counter. This curve is for the tritium window, channels 0 - 12.

yields 10,725 dpm per vial. Nothing more was added to vial 1. Vial 2 had 0.8 ml of pure water added. Vial 3 had 1.0 ml of water added. Vial 4 had 1.2 ml of water added. Vials 2 through 4 generated part of the curve that examined the quenching of water on the cocktail. Vials 5 through 10 all had 1.0 ml of water plus a stronger quenching agent to finish the curve. Vial 5 had 10 µl of CCl_4 added. The amount of CCl_4 was increased to 25, 50, 75, 100, 200 µl corresponding to the remaining vials 6 through 10.

The quench curve represents the counting efficiency in the tritium window in a dual label counting mode. The window was from channels 0 to 12. These channels are automatically used in the preprogrammed tritium/carbon-14 dual label counting mode of the scintillation counter. Most samples ran at about 32% efficiency using this method.

Soil activities of tritium were calculated in the following method. First the gross dpm was determined by the liquid scintillation counter. The net dpm was obtained by subtracting the appropriate (Airport or Mason Farm) background soil sample values from the gross count rate. A conversion factor was used to convert dpm to pCi (1 pCi equals 2.22 dpm). All values were determined using 1 ml aliquots of interstitial water. Figure 10 shows the tritium activity in pCi/ml of interstitial water for the four series of test holes at the Mason Farm site. Given that the density of water is 1 g/ml, the concentration of tritium in pCi/ml of water is multiplied by the water density to give pCi/g of water. Since there was determined to be a 77% extraction efficiency of the interstitial water and its related activity, the net dpm was then divided by this value (0.77). This value would be the

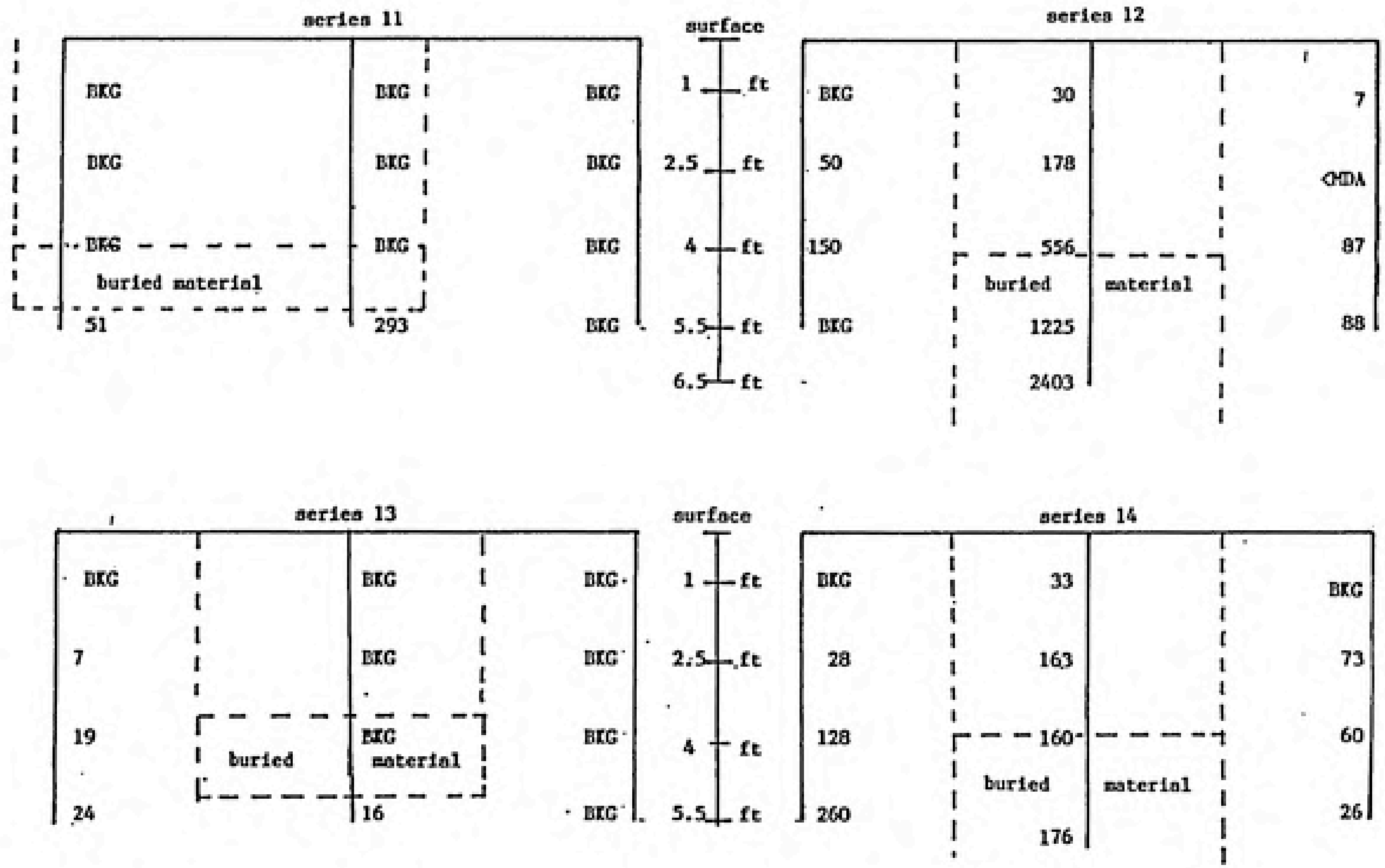


FIGURE 10: Activity (pCi/ml of interstitial water) by depth for the 11 - 14 series of sample holes. Each series has three individual holes yeilding multiple samples.

activity of interstitial water in pCi/g.

The final step involved the percentage of water by weight in the sample. By removing the interstitial water and its associated activity from the soil sample, there was a concentration effect in the activity of the water. The interstitial water was spread over a larger volume while in the soil. Therefore, to examine the activity in the soil, the water activity must be related back to the activity in the larger volume of the soil itself. This is accomplished by multiplying the percentage of water by weight in the soil by the activity of the interstitial water. It is assumed that the interstitial water is uniformly spread in a soil sample.

This leads to the equation :

$$A = N \times C \times D_w \times P_w \times \epsilon^{-1} \qquad (1)$$

Where A is soil activity in pCi/g, N is the net activity of the extracted water in dpm/ml, C is a conversion factor (1pCi/2.22dpm), Dw is the density of water (1ml/g), Pw is the percentage of interstitial water by weight in the soil, and ϵ is the efficiency of the interstitial water and tritium extraction process.

The results of these calculations can be seen in Appendix C for the Airport site and Appendix D for the Mason Farm site.

One pit in the Mason Farm site was chosen to make a comparison between the measured activity found in the soil and the amount buried in the pit (according to burial records). Pit #30 was used for this examination. Test hole series 12 (Figure 6) was used for soil sampling of this pit.

The soil surrounding the three test holes at pit #30 was divided into 13 sections (volumes), corresponding to the 13 samples taken from this area (See Figure 11). The areas corresponding to the center hole differed from that of the left and right test holes. The center area was taken as 6 feet by 6 feet, the assumed pit dimensions. The left and right areas used were 6 feet by 5 feet. This smaller area was used to keep the effects of adjacent pits to a minimum.

The thickness of a section depended on the depth of the corresponding soil sample. The top section (for the 1 foot sample) was taken from 0.5 feet below the surface to half the distance from the 1 foot sample to the 2.5 feet sample, a distance of 1.25 feet. Going from the midpoint between the 1 foot and 2.5 feet sample to the midpoint of the 2.5 feet and 4 feet sample gives the thickness of the section for the 2.5 feet sample as 1.5 feet. Using the same method, the thickness for the 4 feet sample is 1.5 feet. The 5.5 and 6.5 feet sample depths both have section thicknesses of 1 foot.

The activity in a section of soil is assumed to be uniformly spread in that volume. The activity used for a section is that of the soil sample from the center of that section. This activity, the soil volume, and the density of the soil is used to calculate the activity in one section. The 13 sections are then added together for the total activity of the pit.

The density of the soil is given as 137.4 oz/ft^3 (2). By converting to g/ft^3, multiplying by the volume in the section and multiplying again by the activity in that section, the activity for that volume of soil can be obtained.

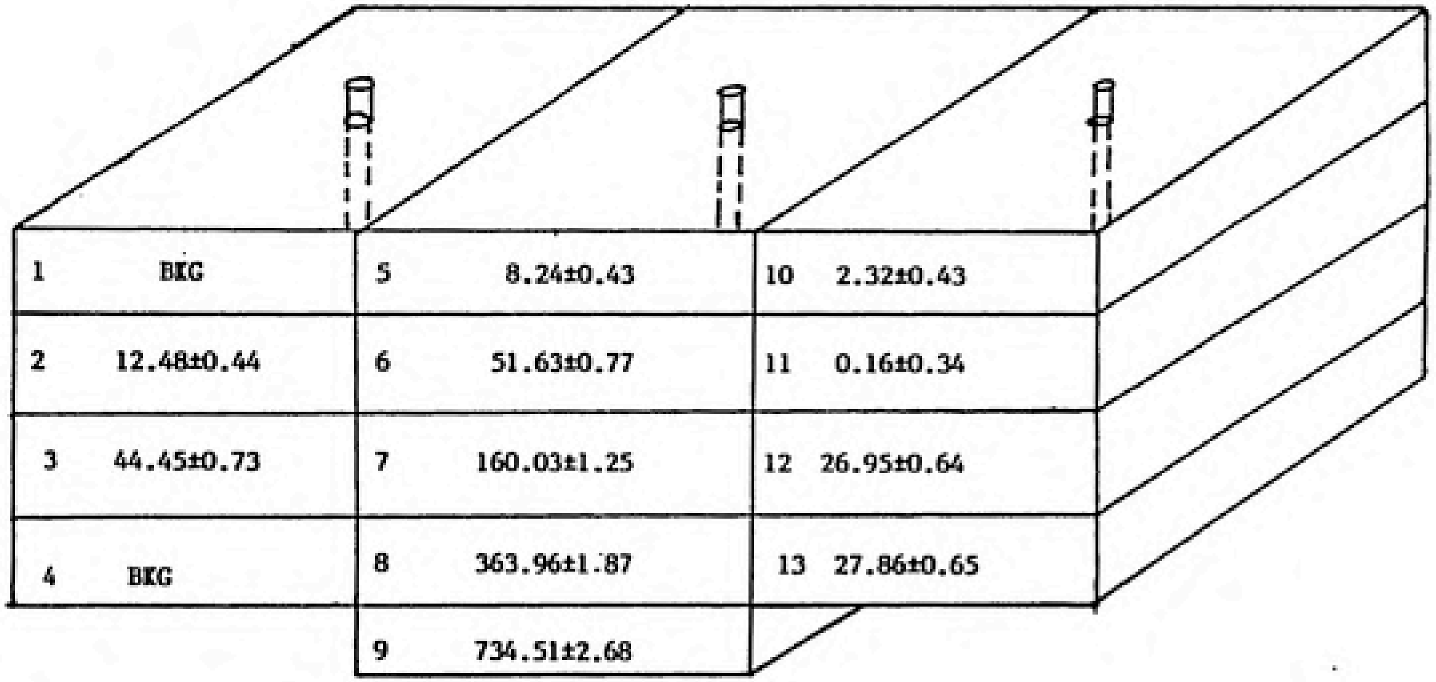


FIGURE 11 : Diagram showing volumes used for activity calculations for pit #30 at the Mason Farm site. Sample hole goes through center of volume. Values given are that of soil samples from center of each section.(pCi/g). Tritium activity for the total volume is 0.22 mCi.

This relation is given by:

$$Av = V \times D \times As \qquad (2)$$

Where Av is the volume activity in mCi, V is the volume of a section in ft^3, D is the density of the soil in g/ft^3, and As is the sample activity for that section of soil in pCi/g. The total activity for the 13 sections using this method is Ø.22 ± Ø.Ø1 mCi.

Section V

PHYSICAL OBSERVATIONS

In many ways the physical observations are as important as the measured findings. Many such sites exist, therefore information as to how the materials buried at the sites may have reacted becomes of interest. This includes the amount of decay, both physical and radioactive, that has occurred and the overall condition of the site itself.

5.1 Airport Site Observations

The Airport site is about 100 yards past the present end of the airport runway, off to the right at about a 30° angle. It is located on the side of a hill. About 30 feet from the back side of the site, there is a very steep incline to the woodland below. The soil is classified as being Wilkes gravelly loam (2).

A visual inspection of the area gave clues as to the number of burial pits. Besides the array of metal pegs, most pits show a concave top. This aided in associating pits with a particular grouping of pegs.

The soil in the site area was probably fill dirt from the airport construction. Although the dirt was mostly clay, it varied in texture slightly from test hole to test hole. Occasionally, a small amount of sand would be found in a hole.

The depths of the soil samples from each test hole were kept as constant as possible. There were some variations. The position of the test holes can be seen in figure 5. Hole # 1 only went down 3.5 feet when it struck rock. Hole # 18 and # 20 had a muddy layer at 6.5 feet and 5.5 feet, respectively. This was the only indication of any ground water on the site. No other holes had this muddy layer. Hole # 23 hit rock at 3 feet. Attempts to go deeper were made at two locations for this hole with the same result. Hole # 21 and # 26 both hit a burnt log at 5 feet and 6 feet, respectively. Since these two holes lie in a straight line, this may be the same log.

The following holes brought up buried waste material with the soil samples: In hole # 24, contact was made at about 49 inches. At that point the boring tool moved about 1 foot in an air space. A very strong odor of decay escaped. Soil samples from this depth included hair (fur) and broken scintillation vials. Nothing was found after 5.5 feet. In # 25, at about 4.75 feet, an animal carcass was found. This carcass was still intact enough to stop the progress of the boring tool. Soil containing animal skin, fat, and fur was taken. In # 27, a metal can was breached. The tool would not go through the bottom, but planchettes buried in the can were recovered and analyzed. In # 28, at 4 feet a gallon glass jug was met. The boring tool broke through and pressed into the clay below the jug. This allowed a sample of the fluid inside the jug to be trapped in the tool. Also found under the jug was straw bedding that had not completely decayed in the 26 or so years since burial.

There was quite a bit of surprise at the observation that all the organic material buried had not decayed. It is conjectured that anaerobic conditions caused by the depth of burial in this clay soil and the fact there was no appreciable water table slowed the decay processes.

5.2 Mason Farm Site Observations

The Mason Farm site is located about 2 miles behind the Finley Golf Course. It is located in "bottom land" on the old Mason Farm property. The soil has a thick clay texture and holds water on the surface when it rains. The soil is classified as Chewacla loam (2).

Over the years, the surface water has changed at the site. There is a standing body of water at the back of the site that goes up to the fence. During a rainy period, this water will rise into the burial site and cover pits located near the fence.

Except for 2 of the pits, there is generally no standing water on the site. The tops of these 2 pits have sunken so that they hold rain water. The clay is thick enough to keep most of the water on top. One of the pits will dry up after a period of no rain but the other has sunken enough that it appears to be fed by ground water (which is no more than 2.5 feet below the surface). During the last year of observation, this pit has not been dry.

The pits were not marked in the site itself. Except for a few of the pits, there was no major sinking of their tops. The scale drawing of the first 37 pits and the rough hand drawing were relied on in most cases to locate individual pits.

By using the two drawings to locate test holes in and around the pits, contact with waste material was easily accomplished. Hole # 11 (figure 6) made contact at 4 feet. A chemical odor was noticed at about 3.5 feet. Rubber gloves, pieces of cardboard, and vials were exhumed. Hole # 11-left also made contact. After 5 feet in both holes, no more material was found. Hole # 12 also made contact at 4 feet. A very strong odor of chemicals and decay was noticed. Animal bones (rabbit or cat), cardboard, vials, and gloves were extracted. There was still material below the 6.5 foot level. Hole # 13 made contact at 3.5 feet. Again a strong chemical odor was noticed. There was nothing buried below 5 feet.

Hole # 14 also made contact with buried material. Material was found beginning at a depth of 4 feet. Downward progress was stopped at 6 feet because of the amount of glass encountered. This pit was burial 55 or 56 (from the rough hand drawing). It could not be determined which from the available records on file.

As a point of interest, the first 3 test hole series (11, 12, 13) demonstrated changes in the water table level at the individual pit sites (Figure 12). The normal water table is very high here. A test hole would hit water at about 2.5 feet. At that depth, water would run into the hole fast enough to be audible in several instances.

The 3 holes denoted # 11 showed no effect of the pit on the ground water level. The # 12 series of test holes did show an effect. This pit had material deposited at a deeper level. While the left and right hole of this series showed the normal table height, the hole in the center of the pit did not detect this level of water. Instead, it

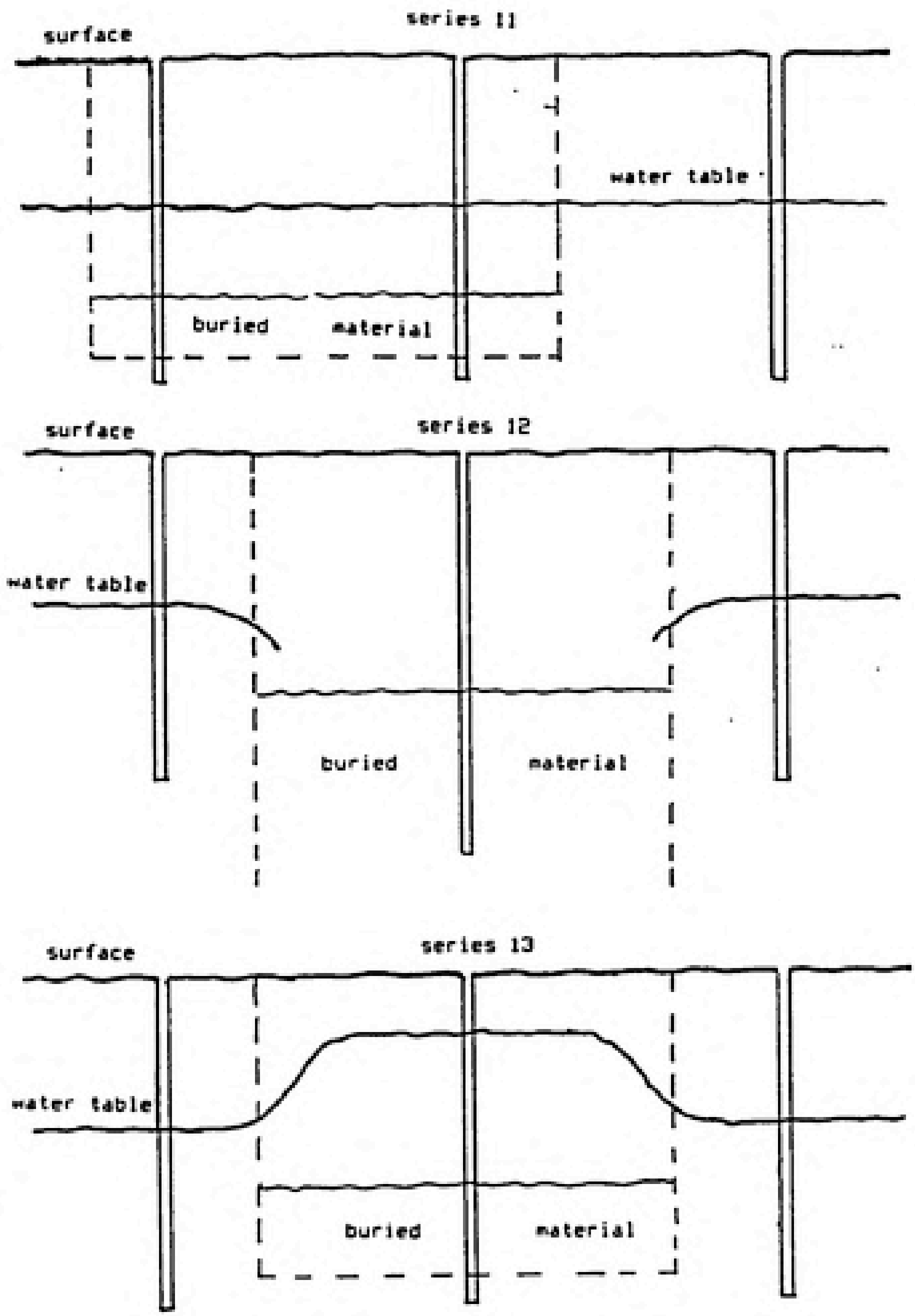


FIGURE 12: Effects of burial pits on water table levels at the Mason Farm site.

got soupy in the pit from about 4.5 feet on but no there was no running water. The water may be going to a lower water table or may be collecting in the pit and welling up.Hole series # 13 had a different outcome. The left and right holes of this series also showed normal water levels. The center hole in the pit had ground water at about 1 foot. A welling up process was occurring.

Section VI

RESULTS OF SOIL ANALYSIS

The two sites vary greatly in their physical characteristics, and in the amount of their use. They also vary in the results of their soil analysis.

6.1 Airport Site Results

An initial assessment was made on the first 10 test holes around the perimeter of the fence. The tritium values for interstitial water from these samples was compared to the tritium values for the interstitial water of the background soil taken above the site. The background value for this water was 59.75 ± 1.54 dpm/ml (26.91 ± 0.69 pCi/ml). This background value was subtracted from all values of the tritium window coming from site samples. The results of this calculation and the calculations given in equation 1 are listed in Appendix C.

All but two of the perimeter samples yielded values in the tritium window of less than 5 pCi/ml of water (above background). Carrying out the calculations of equation 1, this would convert to less than 2 pCi/g of soil. The two outlying samples were hole #3 at 2.5 ft., and hole #4 at 1 foot. Number 3 had a value of 3.00 ± 0.43 pCi/g of soil while #4 gave a initial value of about 52 pCi/g over background.

Because of this relatively high value in the #4 hole (over background sample values) it was assumed there was detectable tritium activity in this sample. No other values above 1.6 pCi/g were found. These lower values were to close to soil background values to make a definitive statement as to actual tritium activity.

Holes #11 through 16 were dug to examine the possible tritium dispersion thought to be found in #4 (Figure 5). This series of holes gave no samples above 1.1 pCi/g of soil (above background) except #16 at 1 foot. It's initial value was 7.9 pCi/g. Both samples (#4, #16) with the higher values for tritium came from the 1 foot depth and in a straight line. Samples were again taken from these two places. This time, both resulted in tritium values below the soil background value. Some other samples taken in the site at the same time as the repeat of #4 and #16 also gave values much below the background level.

Occasionally, other samples gave results that changed dramatically over time. In order to examine the reproducability of the counting system, the samples were counted again 2 to 4 days after the initial count. Certain of the samples increased in counts by as much as a factor of 10. This increase was in steps. After a period of a few days, there was no further increase, but a stabilization at the higher count rate. This seemed to indicate some sort of equilibrium process.

Looking back at the time of the sample collection, the samples with the highest (which included background soil) and/or changing results were collected on days when there was rain either that morning or the night before. The samples taken during periods of dry weather all gave a much lower tritium value. Some other agent, aided by the rain, was affecting values in the tritium window. This greatly increased the variability of the tritium values between samples. Samples taken soon after a rain had tritium levels generally in the 50's dpm/ml (including background) of interstitial water, while values taken during a dry period were generally in the 30's dpm/ml (many at counter background levels: 36.19 ± 1.44 dpm/ml). This included soil collected both inside and outside of the site boundary.

Sample holes 17 through 31 were inside the site boundary. The tritium values of these samples were all less than the background soil sample value for tritium. This included values taken from the soil around the extracted broken vials, the planchettes, the animal remains, burnt logs, etc. The lower than background values may be explained by the variability of samples due to the rain effect.

Certain samples were also analyzed for carbon-14. This was done using a combustion method. The service was preformed by Peter Mertens of the Packard Instrument Company, Chicago. The results can be found in Appendix C. One sample had higher values for carbon-14 than the others. This was the sample from hole # 25 at the 5.5 feet level. This sample gave readings of 176 dpm/g (79 pCi/g) of soil over counter background (43.7 dpm).

The scintillation cocktail recovered at this site was also analyzed. The cocktail itself showed no activity when an aliquot was counted. A chemical analysis was done using mass spectroscopy. The major portion (42.7%) was methylene chloride, a common solvent still used today. Benzene (9.8%), and toluene (0.4%) were also present. The remaining percentage consisted of hydrocarbons, and nitrogen compounds.

This is all consistent with scintillation cocktails and lab procedures from this time period.

Selected samples were also examined using gamma spectroscopy. A sodium iodide counting system was used (The Nucleus, Personal Computer Analyzer with a 2 inch crystal). The samples selected were from the burial pits. They were allowed to count for 12 hours. In no case was any activity above a background level of the system found.

6.2 Mason Farm Site Results

An initial assessment of the first 10 perimeter holes was made. These were compared to tritium values from interstitial water of a background soil sample. This background value (which includes counter background) for 1 ml of water is 49.79 ± 1.62 dpm (22.43 ± 0.73 pCi/ml). This background was subtracted from all tritium window values of interstitial water obtained from soil samples at this site. This calculation and the calculation results using equation 1 are given in Appendix D. Figure 10 shows the tritium values for the interstitial water obtained from the four sets of sample holes.

In all but one hole, values for the perimeter samples are less than 3 pCi/g of soil (above background). The higher readings are in hole #5. At the 4 foot level the value is 9.75 ± 0.41 pCi/g, while at 5.5 feet it is 18.82 ± 0.52 pCi/g of soil. Because of its location, further outward dispersion of tritium could not be examined at this position. The sample hole was at the edge of the standing body of water at the back boundary of the site. The higher readings at this spot reflect the 26 mCi of tritium buried in pit #10, just a few feet from the hole (Figure 6).

The tritium values for samples taken inside the site boundary did show some activity. All subsequent tritium values given are above the background value. In the #11 series, activity was found at the 5.5 foot level both in the center and left test holes. The center hole had a value of 86.37 ± 0.96 pCi/g while the left had a value of 17.22 ± 0.59 pCi/g. Both of these holes are in the burial pit itself.

Series #12 exhibited higher values for tritium. The center hole into the pit gave increasing values in a downward direction. This ranged from about 8 pCi/g of soil at 1 foot to about 735 pCi/g at the 6.5 feet level (See Figure 11). Some activity was found in the soil on both sides of the pit. In the left hole, about 12 and 45 pCi/g of soil was found at 2.5 and 4 feet levels, respectively. On the right, 2 pCi/g was found at 1 foot while 27 and 28 pCi/g of soil was be found at the 4 and 5.5 feet levels.

Series #13 had results similar to those of #11. The center hole into the pit had detectable tritium at the 5.5 foot level. This was 4.24 ±0.37 pCi/g of soil. The left hole of this series had values of about 2 pCi/g at 2.5 foot, 5 pCi/g at 4 foot, and 6 pCi/g of soil at 5.5 foot.

Series #14 was somewhat similar to series #12. The center hole was in the burial pit. The tritium values of the center hole started out at about 8 pCi/g of soil and increased to 43, 44, and 57 pCi/g at the 2.5, 3.5, and 6 feet depths. The left hole of this series yielded about 8, 34, and 77 pCi/g of soil for the 2.5, 4, and 5.5 feet depths. The right hole yielded tritium values of about 22, 22, and 6 pCi/g of soil at 2.5, 4, and 5.5 feet depths.

The ground water at this site was also evaluated. The ground water was counted in the same method as interstitial water. The tritium window was used for results. Background ground water was taken from the same hole as the background soil. The activity of 1 ml of this background water was 49.27 ± 2.09 dpm. This background value was subtracted from the tritium window values of the water taken from the sample holes. The results of this calculation and the conversion to pCi/ml are displayed in Appendix D.

Ground water samples were taken from holes not bored into the pits themselves. The water in these holes was came into direct contact with the buried material in the pits and was considered contaminated by the material and not representative of the ground water at the 2.5 feet level. Only six samples yielded values above MDA. The higher activity values of ground water came from the pit areas with the higher interstitial water activity values. Holes 12-right and 14-right had the highest values at 25 and 43 pCi/ml of water respectively.

In the area where hole #6 (Figure 6) should have been, only surface water was obtainable. No test hole was drilled at this location. The surface water tritium value at this location was compared to tritium values of surface water near the background soil sample hole. The water at # 6 was lower in tritium activity than the background sample.

An unbroken scintillation vial was retrieved from hole #11 center. A 1 ml aliquot of the liquid in the vial was counted. The tritium window gave a value of 826 dpm, but most of the counts were in the carbon-14 window. This window gave 1587 cpm. The counter did not have a quench curve set for carbon-14. Assuming a 50% (from the Packard Instuments manual) counting efficiency for this nuclide, 3174 dpm would be the activity for the carbon-14. This would give about 1.43 nCi per ml. This vial contained about 18 ml, which would result in a total activity of about 25.7 nCi of carbon-14. This vial was in a pit that contains 25 mCi of buried carbon-14. If the pit contained all vials of carbon-14 with this amount of activity, there would need to be approximately 10^6 vials buried in the pit. The estimated dimensions of the pit would not hold this volume.

No sample of interstitial water in this site gave any values over background in the carbon-14 window. This included soil that surrounded bones, broken vials, rubber gloves, and fragments of cardboard.

Certain samples were selected for analysis by gamma spectroscopy. These were selected from soil samples coming from the pits. In no instance was any value over the system background obtained. The method used was the same as for the Airport site samples.

The calculated activity of the soil in and around pit #30 was lower than that given in the inventory of the pit (See Figure 11). The total tritium activity remaining in pit #30 was given as 30 mCi. The amount of tritium in the soil at the area of the pit was calculated as 0.22 mCi. The calculated activity is a little more than two orders of magnitude lower than the inventory value.

Section VII

SUMMARY AND CONCLUSIONS

The results of the tritium examination vary to some extent between the two sites. This variation supports some differences in the conclusions that were drawn on the different sites.

7.1 Airport Site Summary

At the Airport site, no tritium could be found. The differences in tritium values from site samples and those of background soil were either very small or negative in value (less than background). The variation in sample and background values was due in part to rain causing an unknown confounding factor to be added to the samples.

There could be several possibile explanations for not finding tritium dispersion. One possible reason is that the tritium buried here has dispersed to non-detectable levels. Another possibility is the tritium may still be in the containers it was buried in. The scope of this study cannot determine if one of these possibilities is the true reason or if there is another reason or reasons that lead to these findings.

The carbon-14 buried at the site seems to be remaining in the pits it was placed in. This comes from the Packard Company's soil analysis. The only carbon-14 detected was still in the animal it was buried in.

This animal was relatively intact after 26 years.

The organic material at this site has not completely decayed. This was proven by the animal carcass that stopped the boring tool progress as well as samples of straw bedding and fur from other pits. The lack of a water table that enters the pits and the depth of burial in the clay soil has combined to slow the decay process.

7.2 Mason Farm Site Summary

The Mason Farm site findings lead to many avenues of thought. One of the findings that arouses interest is the different effects on the water table level by the different pits (Figure 8). Pits #13 and #22 had burials to about the same depth, and yet the water table rose to a higher level in #13 and remained unchanged in #22. This may be due to compaction differences at the time of burial or differences in the material buried in the pits. In the one pit (#30) that seems to act as a sump for the ground water, the water may be moving to a lower table or the pit may be filling and acting as a kettle boiling over, mixing with the water at the 2.5 foot level. The equipment used in this study could not determine which might be the case.

In two of the pits (#22 and #13) that were examined, the only tritium values above background were at the bottom of the burial pit itself. These values were relatively small. The majority of the tritium may still be in the containers it was buried in or it may have almost completely dispersed to non-detectable levels.

In the other two pits examined, it is easier to see tritium dispersion. Pit #30, examined by series #12, shows a slight movement upward of tritium (Figure 10). The value at the 1 foot depth may be a result of dispersion of the large amount of tritium buried in this pit. The 2400 pCi/ml of interstitial water value at the bottom (6.5 feet) of this pit was the largest found in any of the samples. This value for interstitial water equated to 735 pCi/g of soil in that sample. Soil 1 foot above this sample had only one-half it's activity (364 pCi/g).

The #14 series of holes (pit #55/56) has results similar to those of series #12. Again there appears to be some small upward dispersion. The left sample hole (in the soil beside the pit) in this series has a tritium window value greater than any from inside pit the itself. This may be the result of tritium dispersion in a path away from the pit.

The similar findings of pits #13 and #22 along with similarities in pits #30 and #55/56 brings out another point. The two pits with very little traceable activity (#13, #22) had burial depths of about 5 feet, while the pits with more traceable activity (#30, #55/56) had burial depths in excess of 6.5 feet. This could mean it took longer for the tritium to disperse from the deeper pits, allowing it to be found now, while it is below detectable levels in the shallow pits because of less travel distance to ground water (2.5 feet vs 4 feet)or the surface (5 feet vs greater than 6.5 feet). It cannot be determined if this is the case or if the containers of these deeper pits happened to allow escape of the tritium while containers in the shallow pits are not allowing tritium to escape.

The calculated activity of the soil in and around pit #30 showed a 100 fold difference in the anticipated inventory of the pit and what was measured. This difference may be because the tritium is, for the most part, in the containers it was buried in, or it has all dispersed to these lower levels of detectability. This detected activity may be the end result of a large movement of tritium from the pit or it may be the beginnings (because of container decay) of movement from the pit.

7.3 Closing Statements

All the State of North Carolina's tests for radionuclides over the last few years (4) have showed no movement outside the fence or on the surface of either site. Their test of ground water at the Mason Farm site (Figure 9) found no tritium and only trace amounts of toluene and benzene. This agrees with the findings of this study.

The findings of this study gives evidence to support a proposal to decommission the Airport site. The physical location of the site and the limited amounts of materials buried there would work together to support a proposal of this nature.

The Airport site is located on the side of a hill near the end of the runway. Being situated in this area, it is naturally restricted from the general public. Located on the hill at a level below the runway, any future construction to the runway or to build up the area would probably cause the waste material to be buried under additional fill.

This location also has a very low water table. The water table was not encountered in the survey and is assumed to be very deep. This has helped to slow down the organic decay and to slow any possible movement of the nuclides buried here. If there is migration of the nuclides buried here, they are dispersed to non-detectable levels.

The records indicate only 6 to 8 mCi (Table 1) of carbon-14 buried at the site. As a point of reference, according to regulations in 10 CFR 20 section 303, this entire amount could be flushed down a sewer when mixed with less than 200 gallons of water. The remaining tritium (1 to 3 mCi) at the site could be flushed down the sewer with less than 10 gallons of water.

The Mason Farm site is also on controlled usage land belonging to the University. By being in the flood pool of Jordan Lake, there are further restrictions to its future use. With its extremely high water table and surface water characteristics, the likelihood of use as a building site or for other types of public usage is doubtful. If building would occur, the site would likely be covered by many additional feet of soil to overcome the high water table.

The possibility exists that the water table, being much higher than the depth of buried material, combined with the thick drier clay below has worked as an efficient containment structure. There is very little tritium activity detectable above the 2.5 foot depth. This fact may also be due to the volume of ground water at this level dispersing any escaping tritium to non-detectable levels.

The chemical odor associated with the pits at the Mason Farm site is of some concern. Although the state has not detected any hazardous quantities of chemicals in ground water outside of the site, there is a need for further study of the types of chemicals buried there.

In conclusion, the tritium assessment of soil from the two LLRW sites shows no threat to the public health from either site. The level of tritium activity found at the Mason Farm site was insignificant when compared to the amounts on inventory. At the Airport site, no discernable levels of tritium were found at all. The low/non-detectable levels of tritium may be explained by near complete dispersion to non-detectable levels or by the retention of tritium activity in the original burial containers. Further research is suggested to examine which possibility is more correct.

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Appendix A
Burials at Airport Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (μCi)	REMAINING ACTIVITY (μCi)
** PLOT # 1						
05/01/61	Ba-133	10227		10.50	250.00	39.39
05/01/61	C-14	10227		5730.00	37.00	36.88
05/01/61	Ca-45	10227	163.00		2240.00	0.00
05/01/61	Cs-134	10227		2.10	250.00	0.02
05/01/61	Na-22	10227		2.60	250.00	0.14
05/01/61	P-32	10227	14.30		18.00	0.00
** PLOT # 2						
05/02/61	C136/C14	10226		300000.00	20.00	20.00
** PLOT # 3						
02/05/62	C-14	9947		5730.00	1951.00	1944.59
05/02/62	C-14/H-3	9861		5730.00	2000.00	1993.48
05/02/62	Ca-45	9861	163.00		1410.00	0.00
02/05/62	I-131	9947	8.05		2.00	0.00
** PLOT # 4						
07/11/62	Ba-133	9791		10.50	25.00	4.26
07/11/62	C-14	9791		5730.00	2169.00	2161.98
07/11/62	Ca-45	9791	163.00		850.00	0.00
07/11/62	Cr-51	9791	27.70		68.00	0.00
07/11/62	Cs-134	9791		2.10	25.00	0.00
07/11/62	H-3	9791		2.60	50.00	0.04
07/11/62	I-131	9791	8.05		25.00	0.00
07/11/62	Na-22	9791		2.60	1050.00	0.83
07/11/62	Na-22	9791		2.60	1000.00	0.79
07/11/62	P-32	9791	14.30		2183.00	0.00
** PLOT # 5						
07/13/62	Pm-147	9789		2.60	5000.00	3.95
** PLOT # 6						
03/26/63	C-14	9533		5730.00	512.00	510.39
03/26/63	Ca-45	9533	163.00		2350.00	0.00
03/26/63	Cl-36	9533		300000.00	25.00	25.00
03/26/63	Cr-51	9533	27.70		10.00	0.00
03/26/63	H-3	9533		12.30	615.00	141.33
03/26/63	I-131	9533	8.05		5500.00	0.00
03/26/63	P-32	9533	14.30		1611.10	0.00
** PLOT # 7						
07/05/63	C-14	9432		5730.00	1300.00	1295.95
07/05/63	Ca-45	9432	163.00		50.00	0.00
07/05/63	Ce-141	9432	35.00		0.00	0.00
07/05/63	Cl-36	9432		300000.00	28.00	28.00

Appendix A
Burials at Airport Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (μCi)	REMAINING ACTIVITY (μCi)
07/05/63	Cr-51	9432	27.70		100.00	0.00
07/05/63	Cs-134	9432		2.10	15.00	0.00
07/05/63	Fe-55	9432		2.70	100.00	0.13
07/05/63	H-3	9432		12.30	5225.00	1219.60
07/05/63	Hg-203	9432	46.60		10.00	0.00
07/05/63	I-131	9432	8.05		535.00	0.00
07/05/63	Na-22	9432		2.60	20.00	0.02
07/05/63	P-32	9432	14.30		850.00	0.00
07/05/63	Se-75	9432	120.00		40.00	0.00
07/05/63	Sr-85	9432	65.00		10.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
** PLOT # 1						
11/25/63	C-14	9289		5730.00	448.00	446.62
11/25/63	Ca-45	9289	165.00		3000.00	0.00
11/25/63	Cl-36	9289		300000.00	30.00	30.00
11/25/63	Co-60	9289		5.26	50.00	1.75
11/25/63	H-3	9289		12.30	1457.00	347.67
11/25/63	I-131	9289	8.05		8.95	0.00
11/25/63	Na-22	9289		2.60	1000.00	1.14
11/25/63	P-32	9289	14.30		3715.00	0.00
11/25/63	S-35	9289	88.00		0.20	0.00
11/25/63	Sr-89	9289	52.00		10.00	0.00
11/25/63	Zn-65	9289	245.00		100.00	0.00
** PLOT # 2						
12/06/63	Se-75	9278	120.00		99.70	0.00
** PLOT # 3						
12/06/63	Se-75	9278	120.00		99.00	0.00
** PLOT # 4						
12/06/63	Se-75	9278	120.00		98.20	0.00
** PLOT # 5						
12/30/63	Se-75	9254	120.00		95.00	0.00
** PLOT # 6						
01/17/64	C-14	9236		5730.00	8815.00	8788.08
01/17/64	H-3	9236		12.30	5225.00	1257.04
01/17/64	I-131	9236	8.05		2000.00	0.00
01/17/64	P-32	9236	14.30		3500.00	0.00
** PLOT # 7						
01/20/64	Se-75	9233	120.00		95.00	0.00
** PLOT # 8						
01/27/64	Se-75	9226	120.00		96.00	0.00
** PLOT # 9						
04/27/64	C-14	9135		5730.00	1257.00	1253.20
04/27/64	H-3	9135		12.30	58323.00	14251.77
04/27/64	Hg-197203	9135	47.00		10.00	0.00
04/27/64	I-125	9135	60.00		18.00	0.00
04/27/64	I-131	9135	8.05		1000.00	0.00
04/27/64	P-32	9135	14.30		967.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
** PLOT # 10						
05/04/64	H-3	9128		12.30	100000.00	24462.34
05/04/64	Hg-197203	9128	47.00		35.00	0.00
05/04/64	I-131	9128	8.05		10010.00	0.00
05/04/64	Se-75	9128	120.00		10.00	0.00
** PLOT # 11						
05/11/64	Se-75	9121	120.00		87.00	0.00
** PLOT # 12						
06/10/64	Ag-110	9091	253.00		10.00	0.00
06/10/64	C-14	9091		5730.00	1350.00	1345.94
06/10/64	Cl-36	9091		300000.00	120.00	119.99
06/10/64	Co-60	9091		5.26	11.00	0.41
06/10/64	Cs134	9091		2.05	17.00	0.00
06/10/64	H-3	9091		12.30	56000.00	13777.32
06/10/64	Hg-197203	9091	47.00		1.00	0.00
06/10/64	I-131	9091	8.05		210.00	0.00
06/10/64	Na-22	9091		2.60	210.00	0.28
06/10/64	P-32	9091	14.30		1000.00	0.00
06/10/64	Se-75	9091	120.00		5.00	0.00
** PLOT # 13						
08/14/64	Ba-133	9026		7.20	3.00	0.28
08/14/64	C-14	9026		5730.00	2300.00	2293.14
08/14/64	Ce-141144	9026	285.00		0.30	0.00
08/14/64	H-3	9026		12.30	105750.00	26279.17
08/14/64	Hg-197203	9026	46.60		1.00	0.00
08/14/64	I-131	9026	8.05		500.00	0.00
08/14/64	P-32	9026	14.30		3510.00	0.00
08/14/64	S-35	9026	88.00		1000.00	0.00
08/14/68	Sr-85	7565	65.00		1.00	0.00
08/14/64	Y-91	9026	59.00		1.00	0.00
** PLOT # 14						
09/21/64	C-14	8988		5730.00	400.00	398.81
09/21/64	H-3	8988		12.30	51000.00	12748.15
09/21/64	Hg-197203	8988	46.60		10.00	0.00
09/21/64	I-131	8988	8.05		100.00	0.00
09/21/64	P-32	8988	14.30		90.00	0.00
** PLOT # 15						
11/25/64	Ag110	8923	253.00		15.00	0.00
11/25/64	C-14	8923		5730.00	1250.00	1246.31
11/25/64	Cd-115	8923	44.60		15.00	0.00
11/25/64	Co-60	8923		5.26	42.00	1.68

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
11/25/64	Cs-134	8923		2.05	40.00	0.01
11/25/64	H-3	8923		12.30	7750.00	1956.74
11/25/64	Hf-181	8923	44.00		20.00	0.00
** PLOT # 16						
11/25/64	Ba-133	8923		7.20	52.00	4.95
11/25/64	I-131	8923	8.05		630.00	0.00
11/25/64	Na-22	8923		2.60	180.00	0.27
11/25/64	P-32	8923	14.30		1720.00	0.00
** PLOT # 17						
12/17/64	C-14	8901		5730.00	150.00	149.56
12/17/64	Cr-51	8901	27.90		100.00	0.00
12/17/64	H-3	8901		12.30	250.00	63.34
12/17/64	Hg-197203	8901	46.60		10.00	0.00
12/17/64	Hg-203	8901	46.60		6.00	0.00
12/17/64	I-131	8901	8.05		100.00	0.00
12/17/64	Se-75	7440	120.00		25.00	0.00
** PLOT # 18						
02/09/65	Au-198	8847	2.70		100.00	0.00
02/09/65	Ba-133	8847		10.50	15.00	3.03
02/09/65	C-14	8847		5730.00	4000.00	3988.30
02/09/65	Co-60	8847		5.30	25.00	1.05
02/09/65	H-3	8847		12.30	5000.00	1277.30
02/09/65	Hg-197203	8847	46.60		11.00	0.00
02/09/65	I-131	8847	8.05		3800.00	0.00
02/09/65	Na-22	8847		2.60	70.00	0.11
02/09/65	P-32	8847	14.30		1100.00	0.00
** PLOT # 19						
05/05/65	C-14	8762		5730.00	2443.00	2435.92
05/05/65	Co-60	8762		5.30	50.00	2.17
05/05/65	Cs-134	8762		2.10	20.00	0.01
05/05/65	H-3	8762		12.30	6702.00	1734.69
05/05/65	Hg-197203	8762	46.60		40.00	0.00
05/05/65	I-131	8762	8.05		1550.00	0.00
05/05/65	Na-22	8762		2.60	10.00	0.02
05/05/65	P-32	8762	14.30		1250.00	0.00
** PLOT # 20						
06/01/65	C-14	8735		5730.00	3620.00	3609.55
06/01/65	Cr-51	8735	27.70		50.00	0.00
06/01/65	H-3	8735		12.30	9100.00	2365.20
06/01/65	Hg-197203	8735	46.60		10.00	0.00
06/01/65	I-131	8735	8.05		2062.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
06/01/65	P-32	8735	14.30		4016.00	0.00
** PLOT # 21						
06/28/65	C-14	8708		5730.00	650.00	648.13
06/28/65	H-3	8708		12.30	7500.00	1957.47
06/28/65	Hg-197203	8708	46.60		40.00	0.00
06/28/65	I-131	8708	8.05		2275.00	0.00
06/28/65	P-32	8708	14.30		700.00	0.00
06/28/65	Tc-99m	8708	0.25		175.00	0.00
** PLOT # 22						
08/24/65	Ag-110	8651	253.00		1.00	0.00
08/24/65	C-14	8651		5730.00	25000.00	24928.49
08/24/65	H-3	8651		12.30	60000.00	15798.08
08/24/65	Hf-181	8651	43.00		1.00	0.00
08/24/65	I-125	8651	60.00		1000.00	0.00
08/24/65	Se-75	8651	120.00		10.00	0.00
** PLOT # 23						
09/28/65	C-14	8616		5730.00	1950.00	1944.44
09/28/65	Cr-51	8616	27.70		100.00	0.00
09/28/65	H-3	8616		12.30	200.00	52.95
09/28/65	Hg-197	8616	2.67		5.00	0.00
09/28/65	Hg-203	8616	46.60		15.00	0.00
09/28/65	I-131	8616	8.05		300.00	0.00
09/28/65	P-32	8616	14.30		1500.00	0.00
09/28/65	S-35	8616	87.40		1000.00	0.00
09/28/65	Se-75	8616	120.00		10.00	0.00
09/28/65	Tc-99m	8616	0.25		10.00	0.00
** PLOT # 24						
11/11/65	Au-198	8572	2.70		2000.00	0.00
11/11/65	C-14	8572		5730.00	880.00	877.51
11/11/65	Cr-51	8572	27.70		30.00	0.00
11/11/65	Fe-59	8572	45.00		5.00	0.00
11/11/65	H-3	8572		12.30	1000.00	266.53
11/11/65	Hg-197	8572	2.67		40.00	0.00
11/11/65	I-131	8572	8.05		1500.00	0.00
11/11/65	P-32	8572	14.30		1000.00	0.00
** PLOT # 25						
12/22/65	Au-198	8531	2.70		1200.00	0.00
12/22/65	C-14	8531		5730.00	1100.00	1096.90
12/22/65	H-3	8531		12.30	4200.00	1126.53
12/22/65	Hg-197	8531	2.67		120.00	0.00
12/22/65	I-131	8531	8.05		1300.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
12/22/65	P-32	8531	14.30		2550.00	0.00
12/22/65	Se-75	8531	120.00		10.00	0.00
12/22/65	Tc-99m	8531	0.25		150.00	0.00
** PLOT # 26						
02/10/66	Au-198	8481	2.70		300.00	0.00
02/10/66	C-14	8481		5730.00	890.00	887.50
02/10/66	Cr-51	8481	27.70	0.00	200.00	0.00
02/10/66	H-3	8481	0.00	12.30	1880.00	508.16
02/10/66	Hg-197	8481	2.67		10.00	0.00
02/10/66	I-131	8481	8.05		2030.00	0.00
02/10/66	P-32	8481	14.30		2300.00	0.00
02/10/66	S-35	8481	87.40		3000.00	0.00
01/10/66	Tc-99m	8512	0.25		50.00	0.00
** PLOT # 27						
03/24/66	Au-198	8439	2.70		100.00	0.00
03/24/66	C-14	8439		5730.00	1102.00	1098.92
03/24/66	Cr-51	8439	27.70	0.00	200.00	0.00
03/24/66	H-3	8439		12.30	11120.00	3025.24
03/24/66	Hg-203	8439	46.60		50.00	0.00
03/24/66	I-131	8439	8.03		1600.00	0.00
03/24/66	P-32	8439	14.30		150.00	0.00
03/24/66	Tc-99m	8439	0.25		20.00	0.00
** PLOT # 28						
05/19/66	Au-198	8383	2.70		100.00	0.00
05/19/66	C-14	8383		5730.00	2550.00	2542.93
05/19/66	Cr-51	8383	27.70		100.00	0.00
05/19/66	Fe-59	8383	45.00		100.00	0.00
05/19/66	H-3	8383		12.30	6910.00	1896.20
05/19/66	Hg-197203	8383	46.60		20.00	0.00
05/19/66	I-131	8383	8.05		2850.00	0.00
05/19/66	P-32	8383	14.30		2500.00	0.00
05/19/66	Tc-99m	8383	0.25		50.00	0.00
** PLOT # 29						
07/12/66	Au-198	8329	2.70		500.00	0.00
07/12/66	C-14	8329		5730.00	2350.00	2343.53
07/12/66	H-3	8329		12.30	6800.00	1881.63
07/12/66	Hg-197203	8329	46.60		20.00	0.00
07/12/66	I-131	8329	8.05		5600.00	0.00
07/12/66	P-32	8329	14.30		1500.00	0.00
07/12/66	Tc-99m	8329	0.25		10.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
** PLOT # 30						
08/17/66	Au-198	8293	2.70		500.00	0.00
08/17/66	C-14	8293		5730.00	1700.00	1695.34
08/17/66	H-3	8293		12.30	106500.00	29633.70
08/17/66	Hg-197203	8293	46.60		20.00	0.00
08/17/66	I-131	8293	8.05		1600.00	0.00
08/17/66	Tc-99m	8293	0.25		10.00	0.00
** PLOT # 31						
09/29/66	Au-198	8250	2.70		200.00	0.00
09/29/66	C-14	8250		5730.00	932.00	929.46
09/29/66	Co-60	8250		5.30	100.00	5.22
09/29/66	Cr-51	8250	27.70		500.00	0.00
09/29/66	Cs-137	8250		30.20	100.00	59.55
09/29/66	Fe-59	8250	45.00		200.00	0.00
09/29/66	H-3	8250		12.30	920.00	257.69
09/29/66	Hg-203	8250	46.60		15.00	0.00
09/29/66	I-125	8250	60.00		50.00	0.00
09/29/66	I-131	8250	8.05		650.00	0.00
09/29/66	Na-24	8250	0.63		50.00	0.00
09/29/66	P-32	8250	14.30		590.00	0.00
09/29/66	Tc-99m	8250	0.25		10.00	0.00
** PLOT # 32						
11/04/66	Au-198	8214	2.70		500.00	0.00
11/04/66	C-14	8214		5730.00	1300.00	1296.47
11/04/66	Cr-51	8214	27.70		500.00	0.00
11/04/66	Fe-59	8214	45.00		100.00	0.00
11/04/66	H-3	8214		12.30	2260.00	636.56
11/04/66	Hg-203	8214	46.60		20.00	0.00
11/04/66	I-125	8214	60.00		200.00	0.00
11/04/66	I-131	8214	8.05		2600.00	0.00
11/04/66	Na-22	8214		2.60	200.00	0.50
11/04/66	P-32	8214	14.30		1000.00	0.00
11/04/66	Tc-99m	8214	0.25		10.00	0.00
** PLOT # 33						
12/13/66	Au-198	8175	2.70		500.00	0.00
12/13/66	C-14	8175		5730.00	1052.00	1049.16
12/13/66	Cr-51	8175	27.70		100.00	0.00
12/13/66	H-3	8175		12.30	4768.00	1351.07
12/13/66	Hg-203	8175	46.60		20.00	0.00
12/13/66	I-125	8175	60.00		2000.00	0.00
12/13/66	I-131	8175	8.05		2000.00	0.00
12/13/66	P-32	8175	14.30		1500.00	0.00
12/13/65	Tc-99m	8540	0.25		10.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
** PLOT # 34						
01/26/67	Au-198	8131	2.70		500.00	0.00
01/26/67	C-14	8131		5730.00	1567.00	1562.79
01/26/67	Cr-51	8131	27.70		700.00	0.00
01/26/67	H-3	8131		12.30	8225.00	2346.52
01/26/67	Hg-203	8131	46.60		15.00	0.00
01/26/67	I-125131	8131	60.00		1500.00	0.00
01/26/67	I-131	8131	8.05		500.00	0.00
01/26/67	Na-22	8131	0.00	2.60	50.00	0.13
01/26/67	P-32	8131	14.30		4550.00	0.00
01/26/67	Tc-99m	8131	0.25		10.00	0.00
** PLOT # 35						
03/08/67	Au-198	8090	2.70		500.00	0.00
03/08/67	C-14	8090		5730.00	3679.00	3669.16
03/08/67	Cr-51	8090	27.70		3200.00	0.00
03/08/67	Fe-59	8090	45.00		300.00	0.00
03/08/67	H-3	8090		12.30	20732.00	5952.19
03/08/67	Hg-203	8090	46.60		15.00	0.00
03/08/67	I-125131	8090	60.00		1300.00	0.00
03/08/67	Na-24	8090	0.63		100.00	0.00
03/08/67	P-32	8090	14.30		500.00	0.00
03/08/67	Tc-99m	8090	0.25		10.00	0.00
** PLOT # 36						
05/03/67	Au-198	8034	2.70		500.00	0.00
05/03/67	C-14	8034		5730.00	2075.00	2069.49
05/03/67	Cr-51	8034	27.70		5100.00	0.00
05/03/67	Fe-59	8034	45.00		500.00	0.00
05/03/67	H-3	8034		12.30	12035.00	3485.24
05/03/67	Hg-203	8034	46.60		10.00	0.00
05/03/67	I-131	8034	8.05		1600.00	0.00
05/03/67	Na-22	8034		2.60	100.00	0.28
05/03/67	Tc-99m	8034	0.25		10.00	0.00
** PLOT # 37						
06/13/67	Au-198	7993	2.70		500.00	0.00
06/13/67	C-14	7993		5730.00	1530.00	1525.96
06/13/67	Cr-51	7993	27.70		5000.00	0.00
06/13/67	Fe-59	7993	45.00		250.00	0.00
06/13/67	H-3	7993		12.30	10295.00	3000.27
06/13/67	Hg-203	7993	46.60		20.00	0.00
06/13/67	I-125	7993	60.00		50.00	0.00
06/13/67	I-131	7993	8.05		1200.00	0.00
06/13/67	P-32	7993	14.30		1000.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
06/13/67	Tc-99m	7993	0.25		10.00	0.00
** PLOT # 38						
07/21/67	Au-198	7955	2.70		219.00	0.00
07/21/67	C-14	7955		5730.00	4180.00	4169.00
07/21/67	Cr-51	7955	27.70		2500.00	0.00
07/21/67	Fe-59	7955	45.00		100.00	0.00
07/21/67	H-3	7955		12.30	8870.00	2600.18
07/21/67	I-125	7955	60.00		500.00	0.00
07/21/67	I-131	7955	8.05		400.00	0.00
07/21/67	P-32	7955	14.30		1500.00	0.00
07/21/67	S-35	7955	87.40		1500.00	0.00
07/21/67	Tc-99m	7955	0.25		10.00	0.00
** PLOT # 39						
08/23/67	C-14	7922		5730.00	3162.00	3153.72
08/23/67	Cr-51	7922	27.70		10.00	0.00
08/23/67	Fe-59	7922	45.00		14.00	0.00
08/23/67	H-3	7922		12.30	6403.00	1886.57
08/23/67	I-131	7922	8.05		2500.00	0.00
08/23/67	P-32	7922	14.30		1500.00	0.00
08/23/67	S-35	7922	87.40		1500.00	0.00
08/23/67	Tc-99m	7922	0.25		10.00	0.00
** PLOT # 40						
10/04/67	C-14	7880		5730.00	3541.00	3531.77
10/04/67	Cr-51	7880	27.70		15.00	0.00
10/04/67	Fe-59	7880	45.00		12.00	0.00
10/04/67	H-3	7880		12.30	14041.00	4163.92
10/04/67	I-125	7880	60.00		12.50	0.00
10/04/67	I-131	7880	8.05		1250.00	0.00
10/04/67	Na-22	7880		2.60	10.00	0.03
10/04/67	P-32	7880	14.30		2001.00	0.00
10/04/67	Tc-99m	7880	0.25		10.00	0.00
** PLOT # 41						
11/22/67	C-14	7831		5730.00	6686.00	6668.69
11/22/67	Cr-51	7831	27.70		3000.00	0.00
11/22/67	H-3	7831		12.30	10041.00	3000.29
11/22/67	I-125	7831	60.00		5.00	0.00
11/22/67	I-131	7831	8.05		600.00	0.00
11/22/67	Na-22	7831		2.60	10.00	0.03
11/22/67	P-32	7831	14.30		5750.00	0.00
11/22/67	Tc-99m	7831	0.25		10.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
** PLOT # 42						
01/18/68	C-14	7774		5730.00	2776.00	2768.86
01/18/68	Cr-51	7774	27.70		5000.00	0.00
01/18/68	Fe-59	7774	45.00		10.00	0.00
01/18/68	H-3	7774		12.60	9853.00	3056.14
01/18/68	I-125	7774	60.00		19.00	0.00
01/18/68	I-131	7774	8.05		1000.00	0.00
01/18/68	P-32	7774	14.30		2181.00	0.00
01/18/68	S-35	7774	87.40		300.00	0.00
** PLOT # 43						
02/22/68	C-14	7739		5730.00	2736.00	2729.00
02/22/68	Ca-45	7739	163.00		0.10	0.00
02/22/68	Cr-51	7739	27.70		5000.00	0.00
02/22/68	H-3	7739		12.60	9270.00	2890.50
02/22/68	I-125	7739	60.00		5.00	0.00
02/22/68	P-32	7739	14.30		6100.00	0.00
02/22/68	S-35	7739	87.40		3610.00	0.00
** PLOT # 44						
03/21/68	Au-198	7711	2.70		166.40	0.00
03/21/68	C-14	7711		5730.00	10440.50	10413.88
03/21/68	Ca-45	7711	163.00		237.00	0.00
03/21/68	Cr-51	7711	27.70		3430.00	0.00
03/21/68	H-3	7711		12.60	6569.00	2056.95
03/21/68	I-125	7711	60.00		2.00	0.00
03/21/68	I-131	7711	8.05		1135.80	0.00
03/21/68	P-32	7711	14.30		1200.00	0.00
03/21/68	S-35	7711	87.40		3602.10	0.00
** PLOT # 45						
04/25/68	Au-198	7676	2.70		470.00	0.00
04/25/68	C-14	7676		5730.00	2139.00	2133.57
04/25/68	Ca-45	7676	163.00		101.00	0.00
04/25/68	Cr-51	7676	27.70		3337.50	0.00
04/25/68	Fe-59	7676	45.00		12.00	0.00
04/25/68	H-3	7676		12.60	3457.00	1088.21
04/25/68	Hg-203	7676	46.60		5.00	0.00
04/25/68	I-125	7676	60.00		8.00	0.00
04/25/68	I-131	7676	8.05		104.00	0.00
04/25/68	P-32	7676	14.30		1100.00	0.00
04/25/68	S-35	7676	87.40		2800.80	0.00
04/25/68	Sr-85	7676	65.00		44.40	0.00
** PLOT # 46						
05/23/68	Au-198	7648	2.70		1021.40	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
05/23/68	C-14	7648		5730.00	1497.00	1493.21
05/23/68	Cr-51	7648	27.70		5031.00	0.00
05/23/68	Fe-59	7648	45.00		110.00	0.00
05/23/68	H-3	7648		12.60	3663.00	1157.93
05/23/68	Hg-203	7648	46.60		100.00	0.00
05/23/68	I-125	7648	60.00		10.00	0.00
05/23/68	I-131	7648	8.05		100.00	0.00
05/23/68	P-32	7648	14.30		10.00	0.00
05/23/68	S-35	7648	87.40		3270.00	0.00
** PLOT # 47						
06/20/68	Au-198	7620	2.70		5.00	0.00
06/20/68	C-14	7620		5730.00	1081.00	1078.28
06/20/68	Ca-45	7620	163.00		10.00	0.00
06/20/68	Cl-36	7620		300000.00	2.00	2.00
06/20/68	Cr-51	7620	27.70		2008.00	0.00
06/20/68	Fe-59	7620	45.00		100.00	0.00
06/20/68	H-3	7620		12.60	8321.00	2641.51
06/20/68	I-125	7620	60.00		28.00	0.00
06/20/68	I-131	7620	8.05		3965.00	0.00
06/20/68	P-32	7620	14.30		60.00	0.00
06/20/68	Se-75	7620	120.00		73.00	0.00
06/20/68	Zn-65	7620	244.40		2.00	0.00
** PLOT # 48						
07/24/68	Au-198	7586	2.70		23.70	0.00
07/24/68	C-14	7586		5730.00	2255.39	2249.73
07/24/68	Cl-36	7586		300000.00	5.00	5.00
07/24/68	Cr-51	7586	27.70		595.50	0.00
07/24/68	Fe-59	7586	45.00		12.80	0.00
07/24/68	H-3	7586		12.60	8956.00	2857.68
07/24/68	Hg-203	7586	46.60		112.00	0.00
07/24/68	I-125	7586	60.00		25.00	0.00
07/24/68	I-131	7586	8.05		6477.40	0.00
07/24/68	P-32	7586	14.30		100.00	0.00
07/24/68	S-35	7586	87.40		5135.00	0.00
07/24/68	Se-75	7586	120.00		9.50	0.00
07/24/68	Sr-85	7586	65.00		32.40	0.00
07/24/68	Sr-89	7586	50.60		5.00	0.00
07/24/68	Zn-65	7586	244.40		5.00	0.00
** PLOT # 49						
08/22/68	Au-198	7557	2.70		283.00	0.00
08/22/68	C-14	7557		5730.00	1146.00	1143.14
08/22/68	Ca-45	7557	163.00		1.00	0.00
08/22/68	Cr-51	7557	27.70		10.00	0.00

Appendix B
Burials at Mason Farm Site
Decayed Through 05/01/89

BURIAL DATE	NUCLIDE	DECAY TIME (DAYS)	T 1/2 (DAYS)	T 1/2 (YEARS)	INITIAL ACTIVITY (µCi)	REMAINING ACTIVITY (µCi)
08/22/68	H-3	7557		12.60	778.00	249.33
08/22/68	Hg-203	7557	46.60		199.00	0.00
08/22/68	I-131	7557	8.05		276.00	0.00
08/22/68	P-32	7557	14.30		100.00	0.00
08/22/68	S-35	7557	87.40		1800.00	0.00
08/22/68	Zn-65	7557	244.40		2.00	0.00
** PLOT # 50						
09/26/68	Au-198	7522	2.70		157.00	0.00
09/26/68	C-14	7522		5730.00	902.00	899.76
09/26/68	Ca-45	7522	163.00		830.00	0.00
09/26/68	Cr-51	7522	27.70		37.00	0.00
09/26/68	Fe-59	7522	45.00		25.00	0.00
09/26/68	H-3	7522		12.60	6802.00	2191.40
09/26/68	I-125	7522	60.00		5.00	0.00
09/26/68	I-131	7522	8.05		3333.00	0.00
09/26/68	P-32	7522	14.30		4550.00	0.00
09/26/68	S-35	7522	87.40		1600.00	0.00
09/26/68	Zn-65	7522	244.40		50.00	0.00
** PLOT # 51						
10/24/68	C-14	7494		5730.00	922.00	919.72
10/24/68	Ca-45	7494	163.00		405.00	0.00
10/24/68	Cr-51	7494	27.70		20.00	0.00
10/24/68	H-3	7494		12.60	5013.00	1621.86
10/24/68	I-131	7494	8.05		2000.00	0.00
10/24/68	P-32	7494	14.30		1001.00	0.00
10/24/68	S-35	7494	87.40		1200.00	0.00
10/24/68	Zn-65	7494	244.40		5.00	0.00
** PLOT # 52						
11/21/68	Au-198	7466	2.70		699.60	0.00
11/21/68	C-14	7466		5730.00	2088.00	2082.84
11/21/68	Cr-51	7466	27.70		10.00	0.00
11/21/68	H-3	7466		12.60	12670.00	4116.46
11/21/68	I-131	7466	8.05		380.00	0.00
11/21/68	P-32	7466	14.30		5.00	0.00
11/21/68	S-35	7466	87.40		1900.00	0.00

Appendix C
Airport Site Sample Results For H-3

Hole #	Gross dpm	Net dpm	pCi/ml water	% Water	pCi/g Soil
1-a	63.81±2.36	4.06±2.82	1.87±1.27	29.70	0.72±0.49
-b	46.97±2.13	< BKG		26.32	
-c	54.65±2.30	< BKG		22.82	
2-a	70.25±2.41	10.50±2.86	4.73±1.29	25.40	1.56±0.43
-b	56.70±2.27	< BKG		26.51	
-c	69.78±2.46	10.03±2.90	4.52±1.31	16.69	0.98±0.28
3-a	67.25±2.45	7.50±2.89	3.41±1.30	24.74	1.10±0.42
-b	81.58±2.76	21.83±3.16	9.83±1.42	23.49	3.00±0.43
-c	57.18±2.12	< BKG		27.48	
4-a	51.01±2.12	< BKG		26.55	
-b	56.14±2.17	< BKG		29.84	
-c	59.83±2.16	0.09±2.65	< MDA	23.30	
5-a	64.93±2.29	5.18±2.76	2.33±1.24	23.79	0.72±0.38
-b	64.01±2.25	4.28±2.73	1.92±1.23	30.02	0.75±0.48
-c	64.18±2.39	4.43±2.84	2.00±1.28	24.35	0.63±0.40
6-a	69.13±2.35	9.38±2.81	4.22±1.27	23.69	1.30±0.39
-b	68.39±2.39	8.84±2.84	3.98±1.28	29.18	1.51±0.49
-c	67.22±2.35	7.47±2.81	3.36±1.27	22.07	0.96±0.36
7-a	66.75±2.32	7.00±2.78	3.15±1.25	27.03	1.11±0.44
-b	70.61±2.37	10.86±2.83	4.89±1.27	23.75	1.51±0.39
-c	69.39±2.48	9.64±2.92	4.34±1.32	24.18	1.36±0.41
8-a	70.56±2.38	10.81±2.84	4.87±1.28	22.69	1.43±0.40
-b	49.76±2.08	< BKG		22.88	
-c	53.96±2.14	< BKG		25.48	
9-a	65.98±2.43	6.23±2.88	2.81±1.29	28.32	1.03±0.47
-b	65.93±2.38	6.18±2.83	2.78±1.27	24.07	0.87±0.40
-c	55.39±2.23	< BKG		22.84	
10-a	52.02±2.16	< BKG		29.60	
-b	54.61±2.19	< BKG		24.12	
-c	56.60±2.24	< BKG		27.93	
11-a	66.22±2.62	6.47±3.04	2.91±1.37	26.28	0.99±0.47
-b	64.09±2.40	4.34±2.85	1.95±1.28	25.51	0.65±0.42
-c	55.56±2.34	< BKG		21.68	
12-a	67.32±2.48	7.57±2.92	3.41±1.31	23.74	1.05±0.40
-b	62.78±2.36	3.03±2.82	< MDA	26.36	
-c	65.86±2.39	6.11±2.84	2.75±1.28	27.72	0.99±0.46
13-a	61.28±2.35	1.53±2.81	< MDA	26.29	
-b	58.56±2.29	< BKG		23.73	
-c	42.59±2.06	< BKG		21.84	
14-a	59.84±2.34	0.09±2.80	< MDA	25.45	
-b	62.72±2.31	2.97±2.78	< MDA	22.71	
-c	64.70±2.36	4.95±2.82	2.23±1.27	22.03	0.64±0.36
15-a	46.20±2.13	< BKG		26.67	
-b	60.16±2.33	0.41±2.79	< MDA	19.17	
-c	53.94±2.21	< BKG		23.77	
16-a	41.97±2.10	< BKG		23.05	
-b	63.43±2.39	3.68±2.84	< MDA	18.70	
-c	64.03±2.41	4.28±2.86	1.93±1.29	21.74	0.54±0.36

Appendix C

Airport Site Sample Results For H-3

Hole #	Gross dpm	Net dpm	pCi/ml water	% Water	pCi/gSoil
17-a	51.14±2.35	< BKG		26.45	
-b	53.43±2.35	< BKG		21.72	
-c	53.52±2.35	< BKG		21.47	
18-a	38.07±2.18	< BKG		23.15	
-b	38.76±2.13	< BKG		23.97	
-c	36.38±2.19	< BKG		22.13	
-6.5	37.00±2.12	< BKG		17.16	
19-a	51.38±2.52	< BKG		23.18	
-b	54.53±2.38	< BKG		22.98	
-c	51.19±2.38	< BKG		24.67	
20-a	35.84±2.05	< BKG		27.48	
-b	39.51±2.28	< BKG		22.98	
-c	35.93±2.16	< BKG		21.47	
-5.5	38.57±2.06	< BKG		18.67	
21-a	37.40±2.09	< BKG		17.66	
-b	38.69±2.18	< BKG		21.27	
-c	38.59±2.16	< BKG		23.41	
-5-6	35.84±2.11	< BKG		29.40	
23-a	37.90±2.15	< BKG		23.37	
-b	35.03±2.06	< BKG		20.93	
24-a	48.27±2.26	< BKG		23.37	
-b	51.80±2.28	< BKG		17.86	
-c	51.19±2.29	< BKG		22.79	
-4-5	50.99±2.29	< BKG		16.76	
-5.5	49.49±2.26	< BKG		16.53	
->6	50.74±2.29	< BKG		21.16	
25-a	37.00±1.99	< BKG		24.07	
-b	37.68±1.99	< BKG		24.57	
-c	38.48±1.93	< BKG		23.39	
-5	57.13±2.26	< BKG		23.53	
26-a	37.36±2.29	< BKG		23.31	
-b	36.79±2.01	< BKG		22.69	
-c	36.61±2.01	< BKG		20.89	
-6	37.35±2.05	< BKG		21.83	
27-a	38.01±2.23	< BKG		25.26	
-b	36.82±2.01	< BKG		22.43	
-c	37.33±1.99	< BKG		23.76	
-4.5	36.71±2.02	< BKG		28.97	
-plan	37.03±1.86	< BKG		28.97	
28-a	36.29±2.02	< BKG		24.42	
-b	37.22±1.98	< BKG		26.03	
-c	37.41±2.02	< BKG		24.48	
-4.5	36.88±1.88	< BKG		? ?	
29-a	38.61±2.21	< BKG		22.69	
-b	37.22±1.98	< BKG		20.94	
-c	38.38±2.08	< BKG		24.27	
30-a	53.65±2.37	< BKG		24.35	
-b	53.30±2.33	< BKG		23.57	
-c	58.24±2.42	< BKG		27.75	

Appendix C

Airport Site Sample Results For H-3

Hole #	Gross dpm	Net dpm	pCi/ml water	% Water	pCi/g Soil
31-a	55.96±2.43	< BKG		25.70	
-b	53.27±2.37	< BKG		22.75	
-c	54.07±2.41	< BKG		20.95	

a, b, c represent the standard sample depths
"a" is the 1 foot level
"b" is the 2.5 foot level
"c" is the 4 foot level

numbers represent the depth of sample other than standard

background from soil is 59.75 ± 1.54 dpm

MDA is 1.68 pCi per ml water

?? the soil tested was mixed with the scintillation fluid, no accurate water % is available

error given is counting error

Appendix C

Airport Site Sample Results For C-14

Hole #	Position	Results (dpm)
BKG	3.5	13.5
4	1,2.5,4	16.8
2	1.5	63.6
3	3.5	37.6
4	4	47.5
7	2.5	65.4
8	4	27.7
16	1	36.7
16	2.5	37.9
21	4.5-6.5	34.9
24	> 6	18.1
24	5.5	31.6
25	5.5	176.2
25	5	24.3
26	6	21.2
27	planchette	14.5
27	5	26.9
28	soil in fluid	27.3
28	4	11.5
29	4	21.2
30	4	16.2
31	4	8.7
20	5.5	28.2
19	4	10.0

background of system subtracted - 43.7 dpm

position is depth in feet

measurements compliments Packard Instrument Company

Appendix D

Mason Farm Site Sample Results For H-3

Hole #	Gross dpm	Net dpm	pCi/ml water	% water	pCi/g Soil
1-a	53.32±2.14	3.53±2.68	< MDA	24.65	
-b	53.74±2.15	3.95±2.69	1.78±1.21	17.40	0.40±0.27
-c	62.96±2.29	13.17±2.81	5.93±1.27	22.27	1.72±0.37
2-a	51.40±2.10	1.61±2.65	< MDA	23.01	
-b	51.04±2.16	1.25±2.70	< MDA	21.55	
-c	68.15±2.39	18.39±2.89	8.28±1.30	20.15	2.17±0.34
3-a	34.55±2.11	< BKG		23.09	
-b	38.06±2.06	< BKG		18.62	
-c	44.57±2.12	< BKG		18.37	
-5.5	47.10±2.18	< BKG		19.11	
4-a	49.11±2.08	< BKG		22.85	
-b	47.32±2.05	< BKG		18.11	
-c	46.16±1.99	< BKG		20.67	
5-a	34.75±1.99	< BKG		24.24	
-b	42.35±2.01	< BKG		18.34	
-c	136.63±3.32	86.84±3.69	39.12±1.66	19.19	9.75±0.41
-5.5	204.20±3.98	154.41±4.29	69.55±1.93	20.84	18.82±0.52
7-a	45.95±1.98	< BKG		22.78	
-b	44.47±2.00	< BKG		19.11	
-c	48.20±2.02	< BKG		22.49	
8-a	42.87±2.02	< BKG		20.65	
-b	58.63±2.27	8.84±2.79	3.98±1.26	20.32	1.05±0.33
-c	71.05±2.49	21.26±2.97	9.58±1.34	22.36	2.78±0.39
-5.5	72.38±2.56	22.59±3.03	10.18±1.36	21.89	2.89±0.39
9-a	51.63±2.13	1.84±2.68	< MDA	21.89	
-b	52.98±2.16	3.19±2.70	< MDA	17.11	
-c	69.78±2.36	19.99±2.86	9.00±1.29	17.98	2.10±0.30
10-a	48.83±2.01	< BKG		24.10	
-b	52.49±2.16	2.70±2.70	< MDA	20.01	
-c	50.05±2.09	0.26±2.64	< MDA	19.13	
11L-a	35.11±2.02	< BKG		21.68	
-b	37.52±2.00	< BKG		22.56	
-c	43.47±2.92	< BKG		22.92	
-5.5	163.11±3.56	113.32±3.91	51.05±1.76	25.97	17.22±0.59
11-a	36.10±1.96	< BKG		22.21	
-b	39.50±2.05	< BKG		24.83	
-c	42.24±2.18	< BKG		24.14	
-5.5	700.74±7.08	650.95±7.26	293.22±3.27	22.68	86.37±0.96
11R-a	35.46±1.99	< BKG		22.76	
-b	37.13±1.98	< BKG		20.18	
-c	39.43±1.96	< BKG		22.35	
-5.5	41.77±2.03	< BKG		22.01	
12L-a	38.97±1.99	< BKG		24.35	
-b	160.59±3.53	110.80±3.88	49.55±1.75	19.40	12.48±0.44
-c	383.53±5.33	333.74±3.88	150.33±2.51	22.54	44.45±0.73
-5.5	39.27±3.66	< BKG		21.78	

Appendix D

Mason Farm Site Sample Results For H-3

Hole #	Gross dpm	Net dpm	pCi/ml water	% water	pCi/g Soil
12-a	117.51±3.10	67.72±3.50	30.50±1.58	20.80	8.24±0.43
-b	443.96±5.64	394.17±5.87	177.55±2.64	22.39	51.63±0.77
-c	1285.95±9.52	1236.16±9.66	556.83±4.35	22.13	160.03±1.25
-5.5	2770.16±13.85	2720.37±13.94	1225.39±6.78	22.87	363.96±1.87
-6.5	5385.82±19.39	5336.03±19.46	2403.62±8.77	23.53	734.51±2.68
12R-a	65.72±2.49	15.93±2.97	7.18±1.34	24.86	2.32±0.43
-b	51.10±2.23	1.31±2.76	< MDA	21.12	
-c	243.18±4.30	193.39±4.60	87.11±2.07	23.83	26.95±0.64
-5.5	246.13±4.26	196.34±4.56	88.44±2.05	24.26	27.86±0.65
13L-a	40.39±2.02	< BKG		23.04	
-b	65.54±2.41	15.75±2.90	7.09±1.31	19.94	1.84±0.34
-c	91.75±2.74	41.96±3.16	18.90±1.42	19.34	4.75±0.36
-5.5	104.09±2.96	54.30±3.37	24.46±1.52	19.90	6.32±0.39
13-a	36.53±1.98	< BKG		26.93	
-b	40.59±2.05	< BKG		26.75	
-3.5	48.02±2.15	< BKG		27.37	
-5.5	86.18±2.77	36.39±3.21	16.39±1.45	23.05	4.24±0.37
13R-a	35.65±1.99	< BKG		23.95	
-b	38.19±1.99	< BKG		21.29	
-c	44.85±2.13	< BKG		21.17	
-5.5	46.85±2.18	< BKG		18.87	
14L-a	45.67±2.25	< BKG		21.70	
-b	111.72±3.03	61.93±3.43	27.90±1.55	20.72	7.51±0.42
-c	335.39±4.97	285.60±5.23	128.65±2.36	20.07	33.53±0.62
-5.5	628.56±6.73	578.77±6.92	260.71±3.12	22.88	77.47±0.93
14-a	123.94±3.09	74.15±3.49	33.40±1.57	18.90	8.20±0.39
-b	413.42±5.58	363.63±5.81	163.80±2.62	20.44	43.48±0.70
-c	405.00±5.47	355.21±5.70	160.00±2.57	21.35	44.30±0.71
-6	439.83±5.72	390.04±5.94	175.69±2.68	24.79	56.56±0.87
14R-a	42.13±2.12	< BKG		25.38	
-b	211.38±4.02	161.59±4.33	72.79±1.95	23.26	21.99±0.59
-c	183.86±3.73	134.07±4.07	60.39±1.83	28.22	22.13±0.67
-5.5	107.60±3.01	57.81±3.42	26.04±1.54	17.94	6.07±0.36

a, b, c represent the standard sample depths
"a" is the 1 foot level
"b" is the 2.5 foot level
"c" is the 4 foot level
numbers represent the depth of sample other than standard
L, R represent left and right for a hole series
the background from a soil sample is 49.79 ± 1.62 dpm
MDA is 1.68 pCi per ml of water
all error listed is counting error

Appendix D

Mason Farm Results For H-3 in Ground Water

Hole #	Gross dpm	Net dpm	pCi/ml water	% water	pCi/g Soil
GW - 1	44.47±2.00	< BKG		NA	NA
GW - 2	45.14±1.96	< BKG		NA	NA
GW - 3	55.91±2.16	6.64±2.98	2.99±1.34	NA	NA
GW - 4	44.82±1.97	< BKG		NA	NA
GW - 5	46.93±2.02	< BKG		NA	NA
Sur- 5	39.37±1.89	< BKG		NA	NA
Sur- 6	44.14±1.95	< BKG		NA	NA
GW - 7	51.83±2.09	2.56±2.96	< MDA	MA	NA
GW - 8	54.78±2.18	5.51±3.02	2.48±1.36	NA	NA
GW - 9	49.74±2.08	0.47±2.95	< MDA	NA	NA
GW -10	45.27±2.01	< BKG		NA	NA
GW-11L	36.23±1.96	< BKG		NA	NA
GW-11R	38.04±1.96	< BKG		NA	NA
GW-12L	65.30±2.43	16.03±3.21	7.22±1.46	NA	NA
GW-12R	105.71±2.95	56.44±3.62	25.42±1.63	NA	NA
GW-13L	49.69±2.22	0.42±3.05	< MDA	NA	NA
GW-13R	41.37±2.07	< BKG		NA	NA
GW-14L	70.63±2.56	21.36±3.30	9.62±1.49	NA	NA
GW-14R	144.37±3.39	95.10±3.98	42.84±1.79	NA	NA

GW represents ground water

Sur is surface water

BKG from a GW sample is 49.27 ± 2.09 dpm

error given is counting error
Bkg for Sur is 45.91 ± 2.06

NA not applicable to ground water