# ALAMEDA NAVAL AIR STATION

# LANDFILL #1 AND #2

# FINAL
# RADIOLOGICAL SURVEY REPORT

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## 1.0 Executive Summary

Comprehensive characterization surveys have been conducted at the two landfills located on the former Alameda Naval Air Station. The surveys confirmed that radioactive materials have been disposed of in both landfills. Detailed maps have been produced to locate the sources of radioactivity in each landfill. Data which correlates the radiation readings at various levels with the potential additional radiation exposure to individuals is presented to aid in making remediation decisions. Unexploded ordnance had been discovered in landfill #1. Radiological remediation at landfill#1 will require coordination with ordnance removal.

## 2.0 Introduction

This report provides radiological survey results for high-density near surface radiation surveys of sixty-six acres of two previously used landfills located on the former Alameda Naval Air Station (Alameda NAS). Over 3 million individual survey data points were collected and processed to create the survey maps contained herein. Background radiation levels were determined from the data obtained. State-of-the-art survey equipment and technology was used and is briefly described. Based on information developed as the surveys progressed, additions were made to the initial survey scope. Survey results are included in histogram form and in composite map form. Data is included to correlate ground level survey data which is reported in counts per minute to exposure rates in microRem per hour.

## 3.0 Background

Landfill #1 is a former landfill that was operated between 1943 and 1956. Landfill #2 which operated after closure of Landfill #1 was closed in 1978. During their operation, both landfills were used for disposal of industrial and municipal waste from Alameda NAS including low level radioactive materials. Elevated radiation levels have been detected at both landfills during previous radiation surveys. Landfills #1 and #2 are shown in Figure 1. They are both located on the western end of the Alameda Point. Landfill #1 is at the northwest end of the Alameda Point and includes a former rifle range, several buildings, a jogging trail, and portions of two runways. Landfill #2 is at the southwest end of the Alameda Point and includes several buildings, a former radioactive waste storage area, two jogging trails and a large wetlands area. A radiological survey work plan titled Work Plan Final, Naval Air Station Alameda, Landfill 1 and 2 (I R Sites 1 and 2) Radiological Surveys and Anomaly Removal was issued by the Supervisor of Shipbuilding, Conversion and Repair, Portsmouth, VA., Environmental Detachment, Vallejo (SSPORTS Environmental Detachment) on 6/18/98. The survey boundaries as initially established in the work plan are shown on Figure 2.

## 4.0 Radiation Survey History

Several recent radiation surveys have been performed at Landfills 1 and 2. Each survey has demonstrated the presence of buried radioactive materials. Each survey has also indicated a need for more thorough surveys to allow characterization of the landfills.

a. In September 1995 an near surface radiological scoping survey was performed of the accessible surfaces of Landfills 1 and 2. This survey by PRC Environmental Management Inc. (PRC) was performed using a "2 X 2 " Sodium Iodide (Na I) detector on 20 meter grid blocks. Over 700 grid points were surveyed. Additionally, a "1 X 1" NaI detector calibrated to readout in microRem per hour (uR per hour) was used to scan transects and resulted in scanning over 14,000 linear meters. A total of 23 anomalies were noted during these surveys.

b. In May through September of 1996 approximately 1.2 acres of the landfill #1 area were surveyed again by PRC. This survey revealed 19 anomalies of which two were previously noted in the 1995 survey. Approximately 2000 feet of the jogging trail were surveyed and revealed an additional 6 anomalies. Approximately 12500 feet of jogging trails at the Landfill #2 were surveyed with no anomalies noted. Several anomalies were identified within the perimeter of the former radioactive waste storage area in Landfill #2. Additionally, two soils samples taken from the former waste storage area showed the presence of radium-226 (Ra-226) decay products with activities several orders of magnitude above background levels.

c. In June of 1997, a scope of work was published calling for the use of high density survey technology (USRADS) to perform a 100% survey of landfills #1 and #2. The survey work plan discussed in paragraph 3 above was prepared and issued to meet the requirements of that scope of work.

Note: USRADS is a registered trademark of the Chemrad Tennessee Corporation. The technology makes use of ultrasonics to transmit survey data from a mobile unit equipped with sensitive radiation detection equipment to a base station and uses a number of fixed transmitters positioned around the survey area to communicate with both the mobile unit and the base station to establish location. This process provides a permanent record of radiation level and coordinate location for retrieval at a later time. The USRADS

technology is better suited for use in an indoor environment. For the surveys described herein which were performed out-of-doors, a similar system, which makes use of global positioning system (GPS) technology, was selected.

## 5.0 Survey Equipment and Techniques

The survey equipment combines a commercial differential global positioning system and data management system with a Navy designed radiation detector array. The combined system provides a "look down" capability to efficiently detect small buried radioactive sources, e.g., radium buttons, dials, etc., at depths up to 20 inches in soil and a method to collect, manage and analyze high density scan data.

a. CHEMRAD GPS. The CHEMRAD GPS System is a combination positioning and data analysis system designed to assist in evaluation and remediation of sites suspected of being radioactively contaminated.

(1) Data Positioning. The positioning system uses location data from a number of satellites to establish the location of the survey detectors relative to a 'zero point' near the area to be surveyed. The software with the system then identifies the location of the data collection point and assigns X and Y coordinates to the data point for later analysis. The system can locate the data collection point to within 6 to 18 inches.

(2) Data Collection. The system transmits data from up to eight collectors (detection instruments) each second. The data collectors may be of varying types, e.g. sodium iodide detectors, geiger-mueller detectors, gas proportional detectors, magnetometers, etc. The data pack takes detection instrument input through a serial port and transmits the data to the master controller for entry into the survey data base. Each detector produces a signal every second.

(3) Data Analysis. The data analysis software can provide screen displays in real time of the data as it is being collected. The data can be color coded to different thresholds as specified by the user. Statistical information (high, low, mean and standard deviation) can be calculated for the entire survey file or operator specified blocks. The software can also apply gridding and calculate the average values for each grid and display them by operator

specified thresholds in accordance with the Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) recommended protocols for remediation of a site.

b. Detector Array: Two different detector arrangements were employed for the surveys of the landfills at Alameda NAS.

(1) Four Detector Array: The four detector array consisted of four "3x3" inch shielded sodium iodide detectors connected to Eberline E-600 multi-function RADIACs. Shielded "3x3" inch detectors were chosen over the industry standard "2x2" or "1x1" inch detectors in order to achieve a greater efficiency (larger volume of sodium iodide), lower background (shielding minimizes lateral background contribution), and a more focused field of view. The detectors were mounted approximately six inches apart in a straight line on a tray. The tray was positioned perpendicular to the line of travel. The tray was attached to the underside of a cart and coupled to a small commercial tractor. The separation between the surface of the ground and the detectors was approximately 3-4 inches depending on the roughness and contour of the surface of the ground. The tractor was operated with a speed control to maintain an approximate speed of 18-24 inches per second. Operating at this speed with a four detector array results in generation of more than 40,000 data points per acre. The four detector array was utilized for the flat areas of the landfills.

(2) Single Detector Backpack Mode: The land at the waters edge is too rough to permit the tractor and cart arrangement to be utilized. For these areas and for other areas within the landfills where the surfaces would not support use of the tractor and cart, the survey was performed using a single "2x2" unshielded sodium iodide detector. In this application, the surveyor carries the detector suspended approximately 3 to 4 inches above the ground. The surveyor also carries the readout meter, and with the use of a backpack, carries the electronic equipment and the antenna necessary to transmit the location signal and the radiation survey data signal to the base station receiver. The data is transmitted every second to the base station. The unshielded "2x2" detector is used in this application vice the shielded "3x3" detector to minimize the weight the surveyor must carry. The background level measured by the "2x2" detector is higher because the detector is unshielded, but it is still low enough to easily distinguish between a background reading and a radioactive device.

c. Survey Thresholds and Analysis Techniques: The previous surveys of the Landfill areas had indicated the presence of relatively few below ground surface radioactive materials. Since they were detectable with hand-held survey instruments, it was expected that although below surface, they would be relatively close to the surface. Based on the relatively few numbers of anomalies found during the earlier surveys, it was also expected that there would be at most one hundred to two hundred anomalies identified. The survey work plan calls for establishing a radiation level above which investigation and manual surveys would be performed to identify those locations with levels greater than 1½ times background and which are detected by more than one of the four detectors in the four detector system. The expectations of only a few hundred anomalies and hence the ability to use a 1½ times background investigation level were incorrect. As an alternative, histograms of each survey were plotted to identify departures from the normal distribution. For purposes of plotting the survey data, a threshold of 10,000 cpm was selected. Thus all data points greater than 10,000 cpm are plotted using a larger symbol than that data below 10,000 cpm. Color-coding of the data also displays all data points greater than 10,000 cpm as shades of yellow or red to set that data apart from the data points of lower value. In instances where there appeared to be only a single detector showing a point significantly greater than 10,000 cpm, further investigation was done and in many cases that reading was eliminated as being spurious.

## 6.0 Areas Surveyed Using the Chemrad Equipment

a. Landfill #1:- The boundaries of the Landfill #1 survey area are shown on Figure 2. This figure shows the locations of where the four detector cart system would be used, where the single detector backpack system was expected to allow partial coverage, and the few areas where no survey coverage is possible. The original survey plan included an estimated 28.5 acres bounded on the north and west by the San Francisco Bay and on the south and east by runways #7 and #13. Of the 28.5 acres, approximately 22.5 acres were expected to allow full survey with the four detector system. Approximately 4 acres would allow 20-30% coverage with the backpack system and approximately 2 acres were inaccessible for survey. Surveys of the landfill #1 area began on 28 August 1998. In January 1999, an old construction plan was found which shows the existence of burial pits in the

landfill #1 area but which extended to the east of runway #13. The burial pits were a triangular area of approximately 5.5 acres. This area is identified as Area 1A on Figure 3, and was added to the Landfill #1 survey package. An additional estimated 30.4 acres, identified as Areas 2 and 3, were added to the Landfill #1 survey package in mid-March 1999 following review of the survey data to that date which indicated that buried radioactive material may be present outside the then existing Landfill #1 survey boundaries. Thus a total of approximately 64.4 acres were ultimately included in the Landfill #1 survey area. Fifty-seven acres were to be surveyed using the four detector system, 5.4 acres were to be surveyed with 20-30% coverage in single detector mode and 2 acres were not accessible for survey. Figure 3 shows the total area to be surveyed in Landfill #1. The actual area added in mid-March was approximately 19.5 acres rather than the estimated 30.4 acres.

b. Landfill #2:- The boundaries of the Landfill #2 survey area are shown in Figure 2. This figure also depicts those areas which were expected to be accessible for the four detector tractor and cart survey arrangement and those areas which were only accessible for the backpack arrangement or not accessible at all. An estimated 19.5 acres were included in the Landfill #2 survey package. Approximately 15.7 acres were to be surveyed using the four detector system and approximately 3.5 acres were to be surveyed with 20-30% coverage using the single detector system. The remaining approximately 1.5 acres were not accessible for survey.

c. Resurveys of Landfills #1 and #2:- Over the eight months of the initial surveys of the Landfills, the dependability of the survey equipment and the techniques used by the operator to ensure adequate survey coverage of the area improved considerably. Some of the early surveys, when analyzed, revealed gaps in coverage which were not acceptable. Consequently, some resurveys were performed to fill in the gaps. A total of 9.0 acres (6.7 acres in Landfill #1, 2.3 acres in Landfill #2) were designated to be resurveyed. All resurveys required were completed by 6/30/99.

## 7.0 Survey Results

a. Landfill #1 results (including the burial pits and area 2 and 3):- The actual area surveyed in Landfill #1 is 48.8 acres. Of that area, 47 acres were surveyed using a four detector system. Approximately 1.8 acres were surveyed using the single detector back-pack system. As each individual

survey was conducted, the survey data for that area was collected on a standard 3.5 inch high density floppy disk. The data capacity for the disks is 1.44 megabytes. Due to the need to setup a number of different base locations for the survey of such a large area, most of the individual surveys were much smaller than the maximum 1.44 MB allowed by the data collection media. For Landfill #1, a total of 158 individual surveys were conducted resulting in collection of 2,958,681 data points. Histograms of each survey were plotted. A composite histogram of all 158 surveys is shown in Figure 4. A composite map of the Landfill #1 survey is presented in Figure 5. The mean values for the individual surveys ranged from a low of 3,106 counts per minute (cpm) to a high of 6,394 cpm. The average of the means is between 4,500 and 5,000 cpm. Approximately two times the mean or 10,000 cpm was chosen as the threshold value for the composite map of the surveys. All data points above the 10,000 cpm threshold value are shown in various colors ranging from light yellow to dark red. All values below the threshold are shown as a single color (gray). Using the 10,000 cpm threshold results in approximately 4900 data points, less than 0.2% of the total, which would require further investigation and potentially remediation. This does not however indicate that there are 4900 separate radioactive material items to be investigated. Recent experience at another site being surveyed with the same equipment has shown that a single source may be responsible for a number of high individual data point readings. Since the four detector system was utilized for the majority of the surveys it is clear that more than one detector could 'see' a source as the cart passes by, and would likely 'see' the stronger sources more than once as the detector approaches and then recedes from it. Further, in an effort to ensure complete coverage of the area being surveyed, the operator overlaps the survey track in resulting, in many instances, in passing over the same location more than once. Finally, as mentioned earlier, some of the first surveys performed were considered to provide inadequate coverage and therefore additional surveys were performed which overlap the original surveys. Table 1 below provides a breakdown of the more than 2.9 million survey data points from landfill #1.

Table 1
Landfill #1 Data Points

| | |
|---|---|
| all data points less than 10,000 cpm | 2953767 |
| all data points 10,000 cpm to 14,999 cpm | 3049 |
| all data points 15,000 cpm to 19,999 cpm | 718 |
| all data points 20,000 cpm to 49,999 cpm | 707 |
| all data points 50,000 cpm to 99,999 cpm | 235 |
| all data points 100,000 cpm to 499,999 cpm | 180 |
| all data points 500,000 cpm to 999,999 cpm | 20 |
| all data points 1,000,000 cpm to 1257609 cpm | 5 |
| Total | 2958681 |

b. Landfill #2 results:- The actual area surveyed in Landfill #2 is 17.2 acres. Of that area, 15.7 acres were surveyed using the four detector system. Approximately 1.5 acres were surveyed using the single detector back-pack system. For landfill #2, a total of 60 individual surveys were conducted resulting in collection of 969,749 individual data points. As with landfill #1, histograms of each survey were plotted. The composite histogram of all 60 surveys is shown in Figure 6. A composite map of the landfill #2 surveys is presented in Figure 7. The mean values for the surveys ranged from a low of 4,191 cpm to a high of 8,264 cpm. As with landfill #1, the average of the means is between 4,500 and 5,000 cpm. Again, similar to landfill #1, the threshold value for the composite map of landfill #2 was chosen as 10,000 cpm. All data points above the 10,000 cpm threshold value are shown in various colors ranging from light yellow to dark red. All values below the threshold value are shown in gray. There are approximately 951 data points, slightly less than 0.1% of the total, which would require further investigation when using the 10,000

cpm threshold. Table 2 below provides a breakdown of the more than 900,000 survey data points from landfill #2.

Table 2
Landfill #2 Data Points

| | |
|---|---|
| all data points less than 10,000 cpm | 968798 |
| all data points 10,000 cpm to 14,999 cpm | 526 |
| all data points 15,000 cpm to 19,999 cpm | 160 |
| all data points 20,000 cpm to 49,999 cpm | 200 |
| all data points 50,000 cpm to 99,999 cpm | 35 |
| all data points 100,000 cpm to 226,676 cpm | 30 |
| Total | 969749 |

c. Correlation of counts per minute (cpm) data with microR per hour data:- Radiation levels at which recommended remediation decisions are made often utilize anticipated additional radiation exposure to an average member of the most affected population group. For Alameda NAS Landfills, final land use decisions have not yet been made, hence the most affected population group is also not yet defined. However, since that information may be needed in the future, some correlation data has been collected to relate the radiation readings taken at ground level with a calibrated "3X3" NaI detector to microR per hour readings in the same location also taken at ground level. In addition, correlation data was collected using the same calibrated instruments at waist level. A log-log plot of the ground level data is shown as Figure 8. The correlation data indicates for ground level, the more conservative location, approximately 1060 cpm is equivalent to 1 uR/hr.

Using this relationship, the table below shows the range of readings of cpm vs. uR/hr.

Table 3
Counts per Minute vs microR per Hour

| Counts per minute (cpm) at ground level | MicroR per hour at ground level |
|---|---|
| 5300 | 5 |
| 10600 | 10 |
| 15900 | 15 |
| 21200 | 20 |
| 26500 | 25 |
| 31800 | 30 |

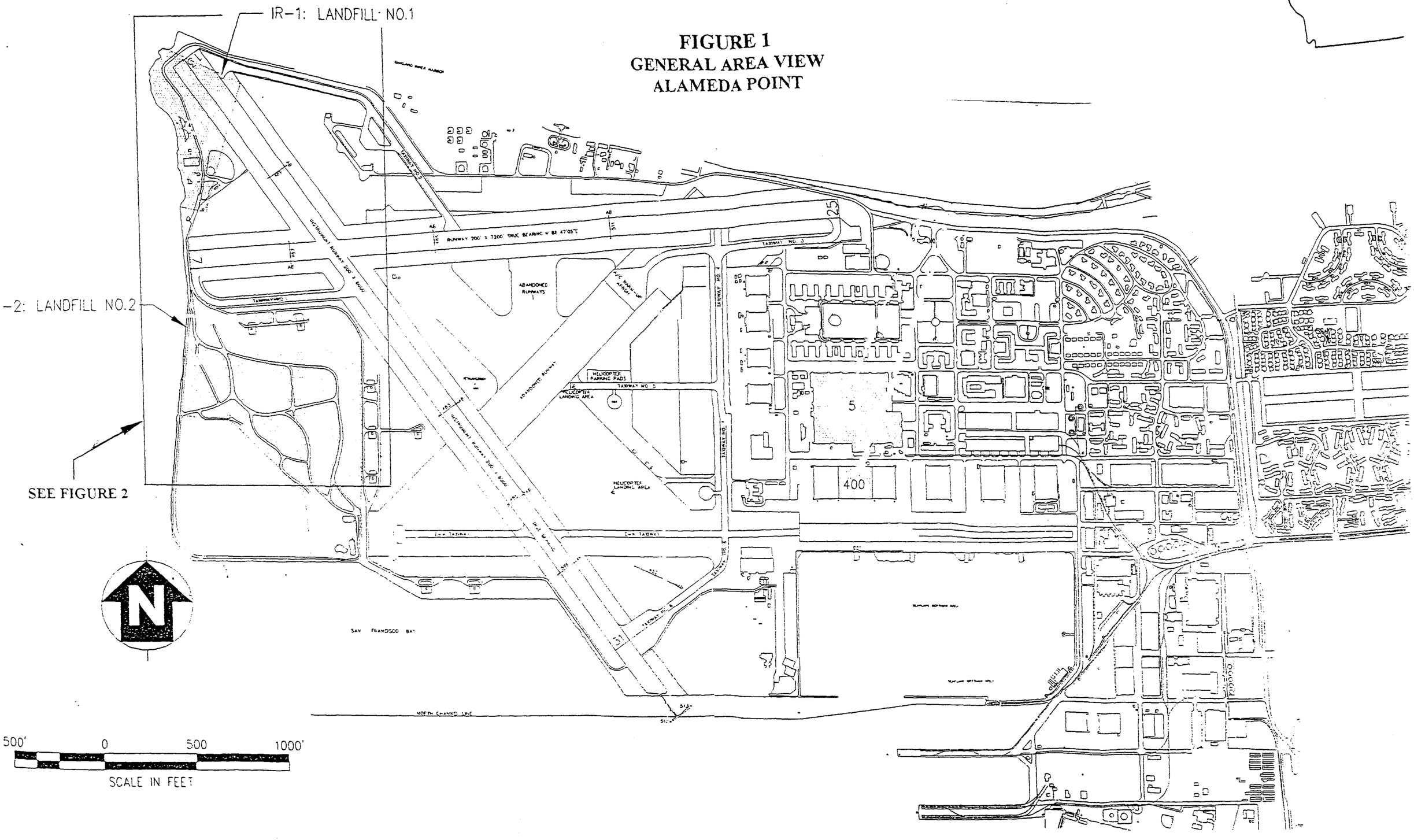
Typically, the range of additional i.e. above background annual radiation exposure above which remediation is considered is 15 millirem per year to 25 millirem per year. The amount of additional radiation exposure received is also dependent upon the time spent in the area of concern. As noted earlier, background levels are approximately 5000 cpm. Table 4 provides a matrix to relate the additional radiation exposure under various time scenarios to annual and hourly exposure rates. Using Table 4 it can be seen that for an exposure time of 1000 hours per year, the radiation exposure rates which would suggest remediation is needed range from approximately 20900 cpm (15900 + 5000) to 31500 cpm (26500 + 5000).

d. Unexploded ordnance (UXO):- In late September 1998, a live 20mm high explosive projectile was discovered by the survey personnel while conducting surveys in Landfill #1. An emergency removal action was conducted to clear the area of surface ordnance material. Over 300 additional live 20 mm high explosive projectiles were recovered and dispositioned. However, the site remains an ordnance concern and additional ordnance clearance is necessary during any intrusive site work including excavation and removal of radium anomalies in Landfill #1.

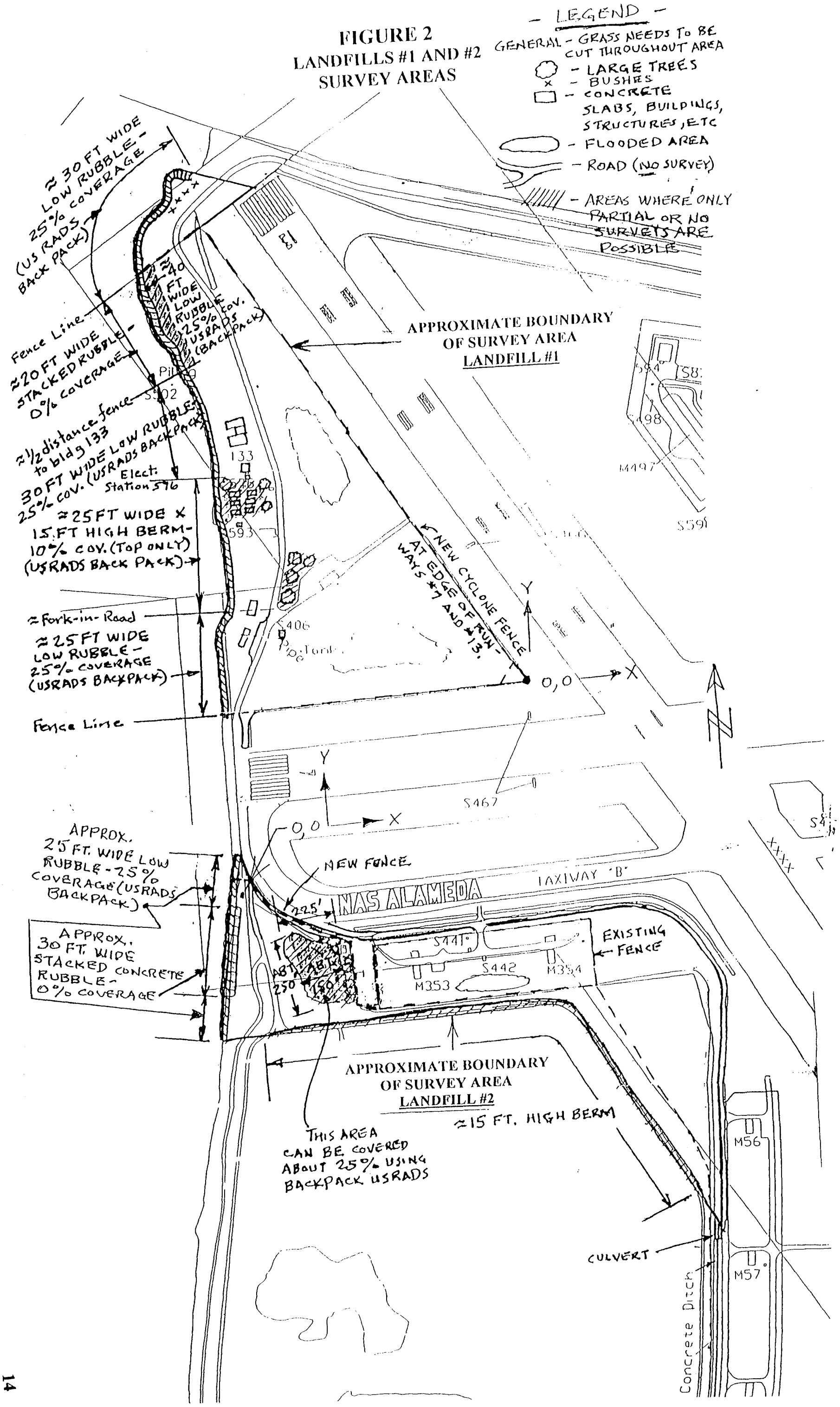
## 8.0 Conclusions

The high-density radiation surveys of the Landfills #1 and #2 have identified approximately 5865 survey data points which have radiation readings above twice background. While this number is a very small percentage of the total number of survey data points collected, it is nonetheless a significant number. Every data point can be located using the differential global positioning system data. There appears to be a reasonable correlation between the sodium-iodide detector readings which are in counts per minute and radiation exposure rate readings taken with a microR meter. Thus decisions concerning remediation levels will be facilitated.

# FIGURE 1
## GENERAL AREA VIEW
## ALAMEDA POINT



# FIGURE 2
## LANDFILLS #1 AND #2 SURVEY AREAS



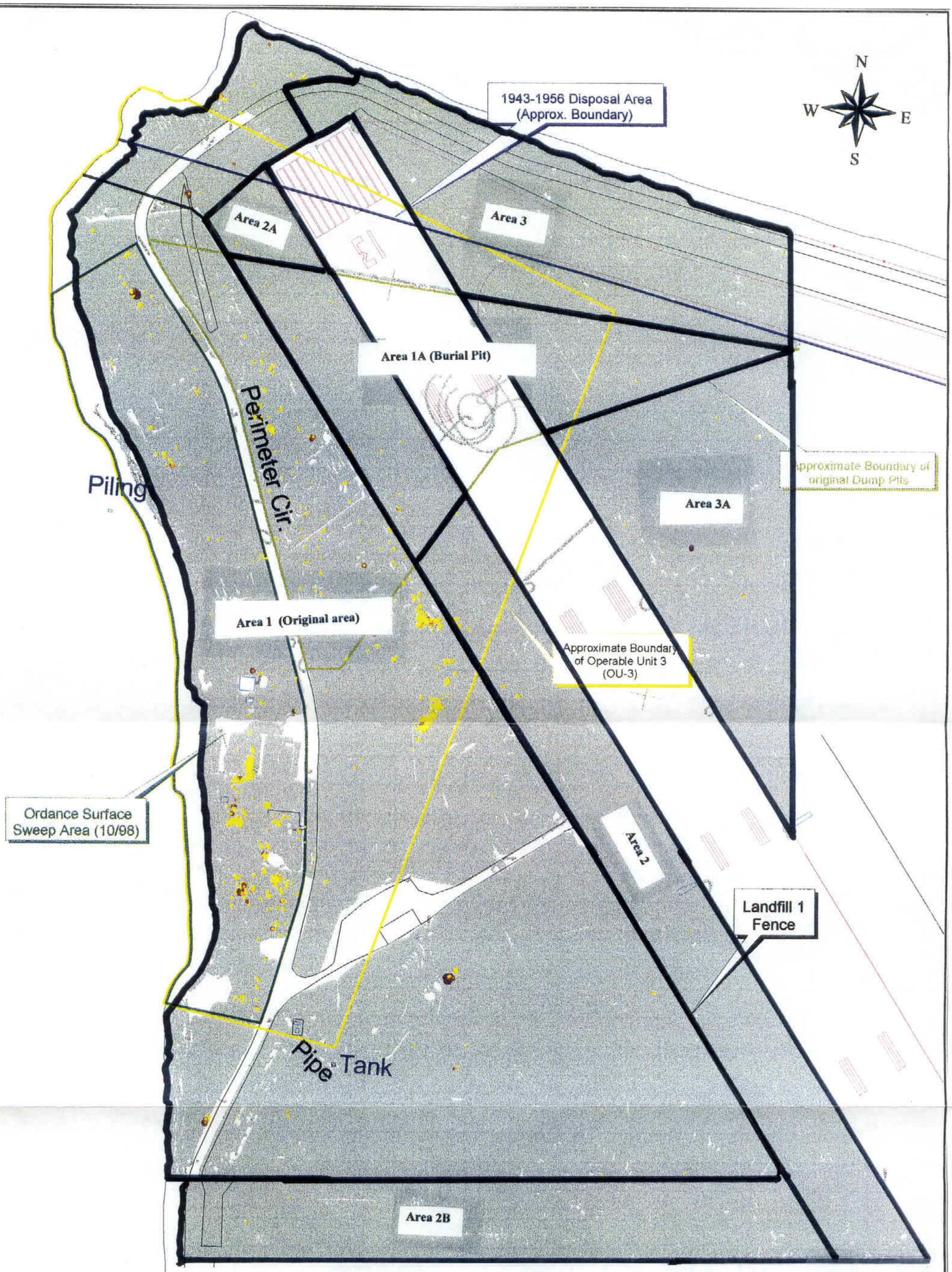



**Figure 3** **Landfill with original area (1), burial pit (1A), and areas 2, and 3.**

Produced and printed by the SSPORTS GIS Office

| Landfill #1 Composite Histogram Data | |
|---|---|
| 500 | 16034 |
| 1000 | 156 |
| 1500 | 442 |
| 2000 | 3087 |
| 2500 | 19245 |
| 3000 | 79858 |
| 3500 | 229017 |
| 4000 | 457863 |
| 4500 | 640022 |
| 5000 | 639059 |
| 5500 | 457880 |
| 6000 | 242308 |
| 6500 | 102688 |
| 7000 | 38926 |
| 7500 | 15064 |
| 8000 | 6012 |
| 8500 | 2808 |
| 9000 | 1556 |
| 9500 | 991 |
| 10000 | 751 |
| 10500 | 573 |
| 11000 | 501 |
| 11500 | 381 |
| 12000 | 327 |
| 12500 | 299 |
| 13000 | 280 |
| 13500 | 225 |
| 14000 | 164 |
| 14500 | 157 |
| 15000 | 142 |
| > 15000 | 1865 |
| | |
| **Total Data Points** | **2958681** |

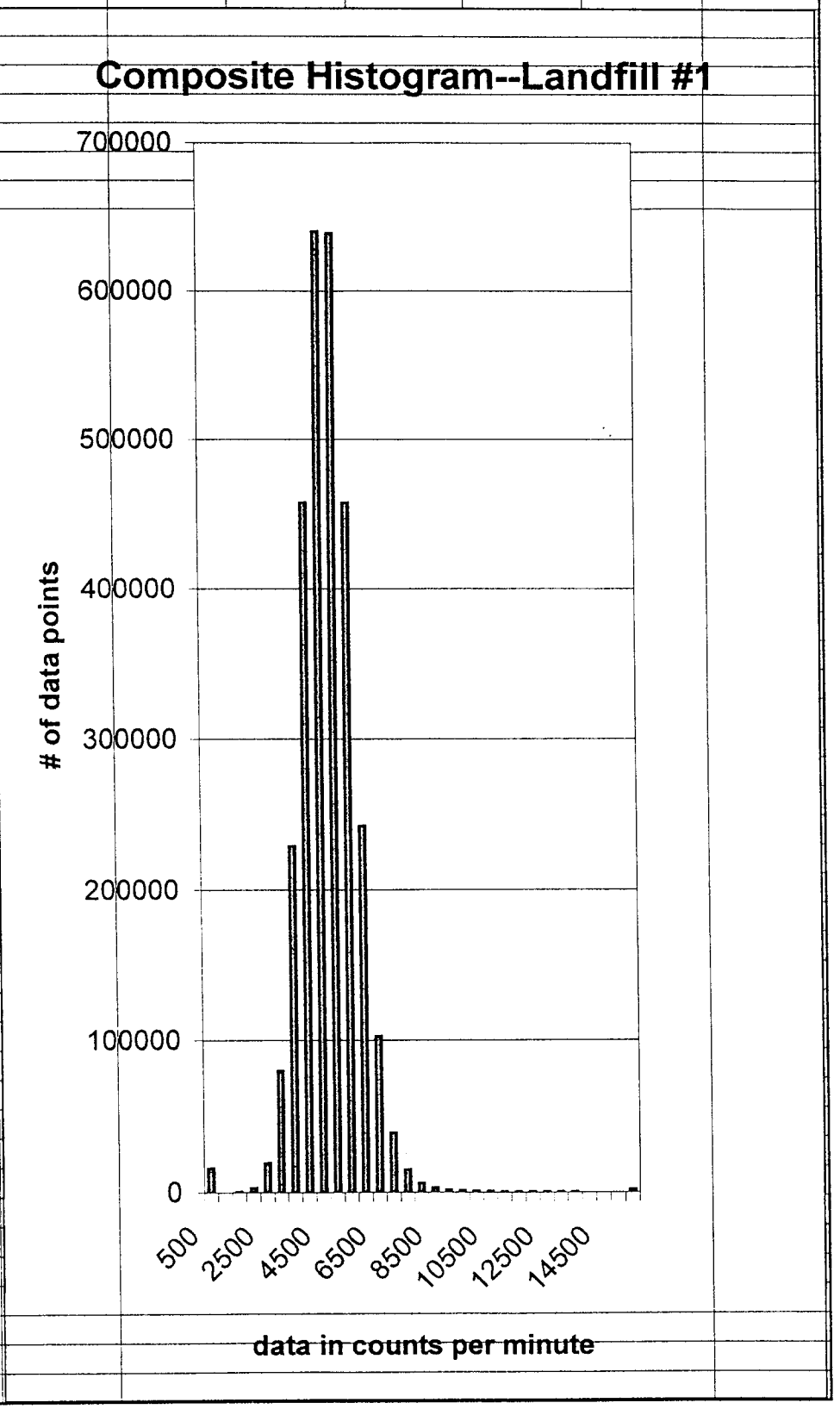



Figure 4

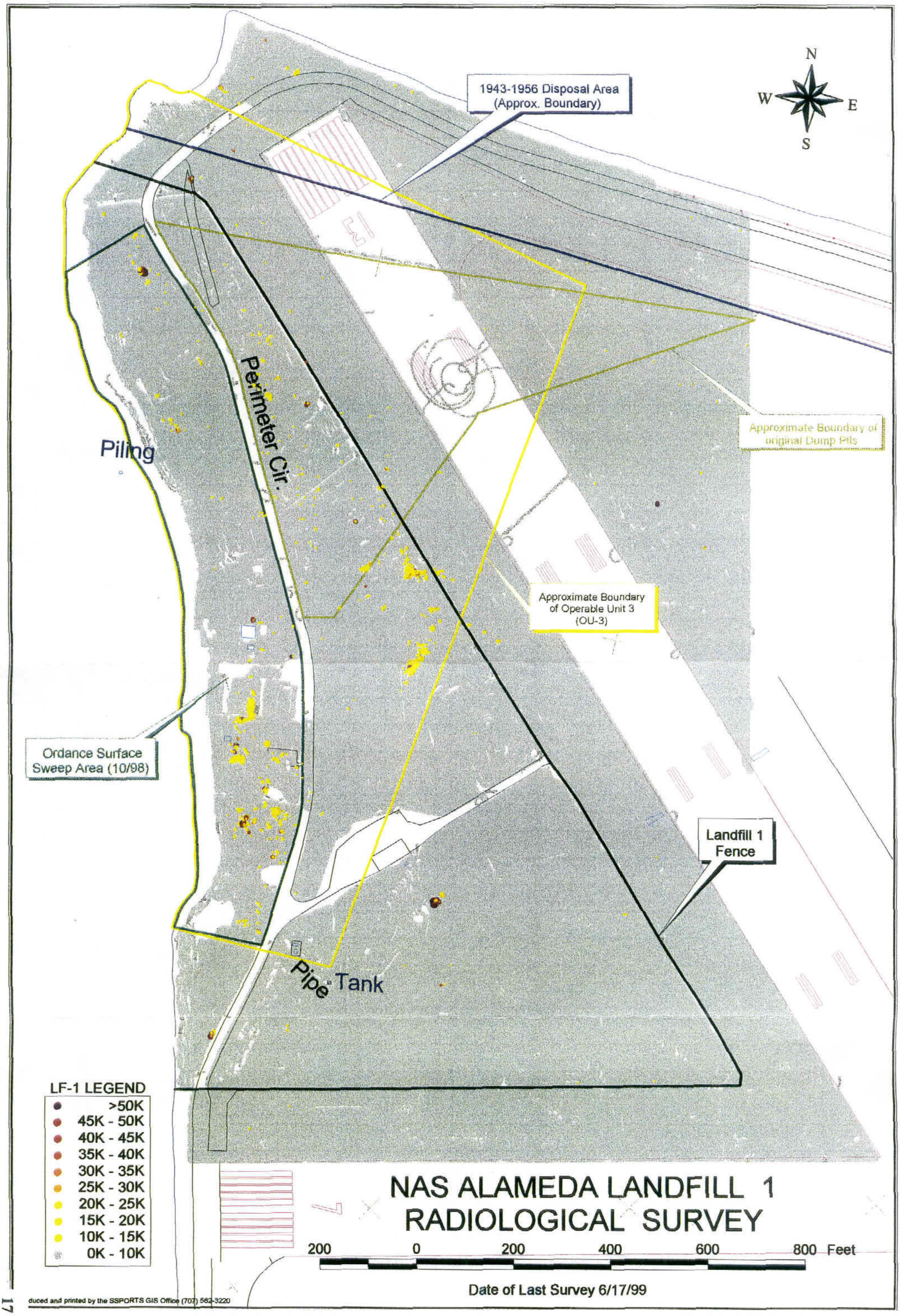

1943-1956 Disposal Area
(Approx. Boundary)
N
W
E
S
Perimeter Cir.
Piling
Approximate Boundary of original Dump Pits
Approximate Boundary of Operable Unit 3 (OU-3)
Ordance Surface Sweep Area (10/98)
Landfill 1 Fence
Pipe
Tank
LF-1 LEGEND
>50K
45K - 50K
40K - 45K
35K - 40K
30K - 35K
25K - 30K
20K - 25K
15K - 20K
10K - 15K
0K - 10K
NAS ALAMEDA LANDFILL 1
RADIOLOGICAL SURVEY
200 0 200 400 600 800 Feet
Date of Last Survey 6/17/99
duced and printed by the SSPORTS GIS Office (707) 562-3220

**Figure 5**

| Landfill #2 Composite Histogram Data | |
|---|---|
| 500 | 3455 |
| 1000 | 5 |
| 1500 | 35 |
| 2000 | 324 |
| 2500 | 1694 |
| 3000 | 8797 |
| 3500 | 40917 |
| 4000 | 120745 |
| 4500 | 216387 |
| 5000 | 242097 |
| 5500 | 175414 |
| 6000 | 91022 |
| 6500 | 39437 |
| 7000 | 16056 |
| 7500 | 7183 |
| 8000 | 2901 |
| 8500 | 1317 |
| 9000 | 583 |
| 9500 | 261 |
| 10000 | 166 |
| 10500 | 111 |
| 11000 | 69 |
| 11500 | 69 |
| 12000 | 48 |
| 12500 | 54 |
| 13000 | 39 |
| 13500 | 39 |
| 14000 | 42 |
| 14500 | 38 |
| 15000 | 19 |
| > 15000 | 425 |
| **Total Data Points** | **969749** |

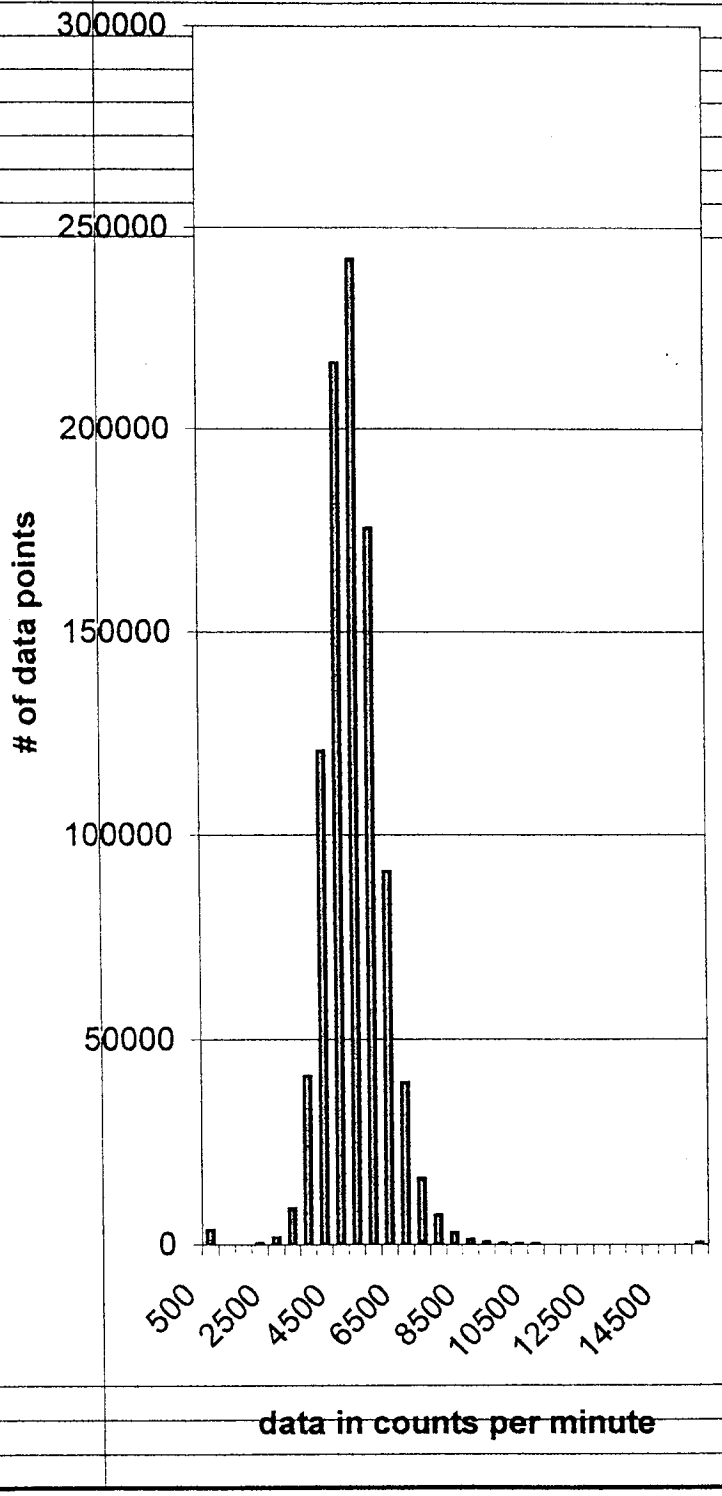



Figure 6

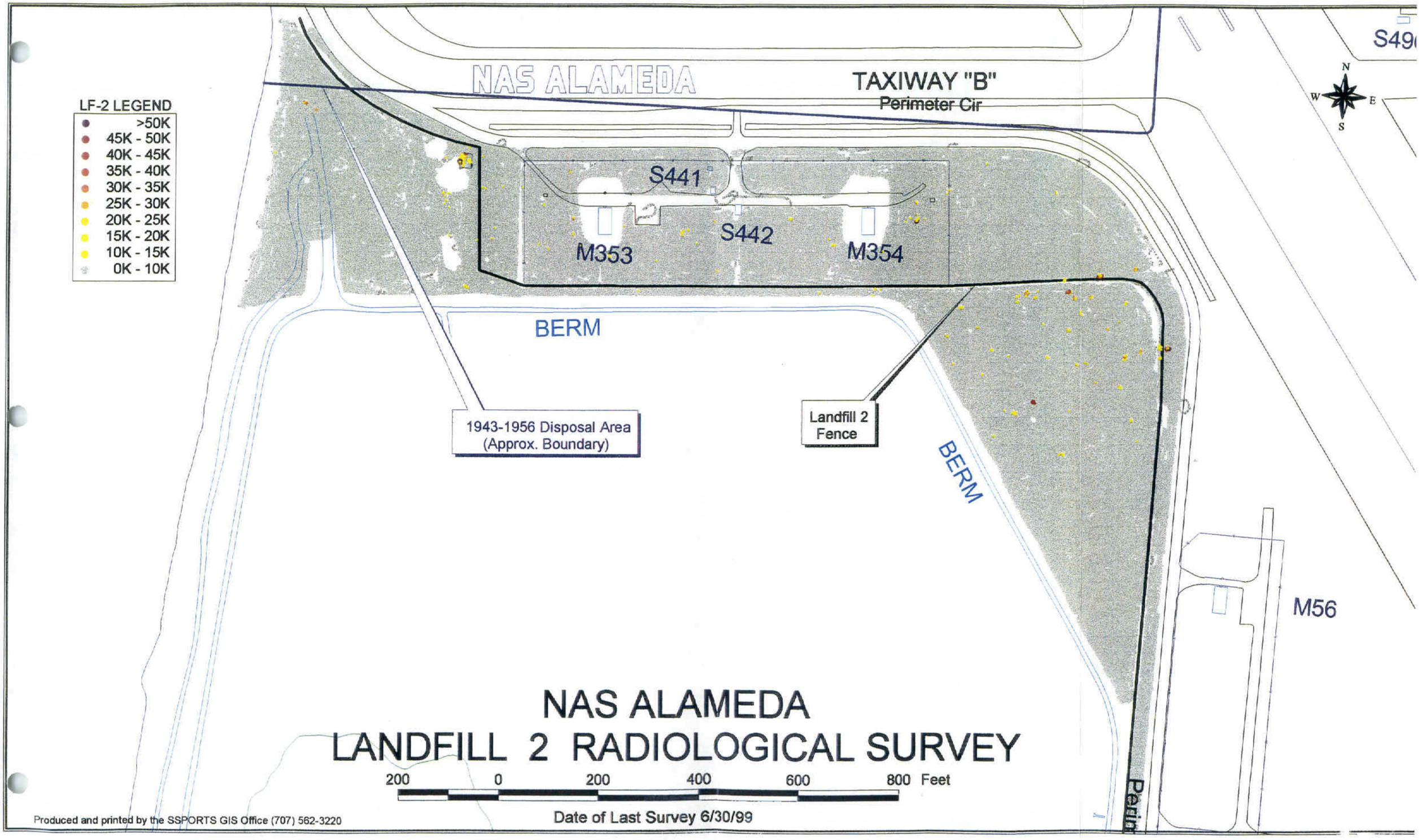

LF-2 LEGEND
>50K
45K - 50K
40K - 45K
35K - 40K
30K - 35K
25K - 30K
20K - 25K
15K - 20K
10K - 15K
0K - 10K
NAS ALAMEDA
TAXIWAY "B"
Perimeter Cir
S441
S442
M353
M354
BERM
1943-1956 Disposal Area
(Approx. Boundary)
Landfill 2
Fence
BERM
M56
N
W
E
S
NAS ALAMEDA
LANDFILL 2 RADIOLOGICAL SURVEY
200 0 200 400 600 800 Feet
Produced and printed by the SSPORTS GIS Office (707) 562-3220
Date of Last Survey 6/30/99

Figure 7

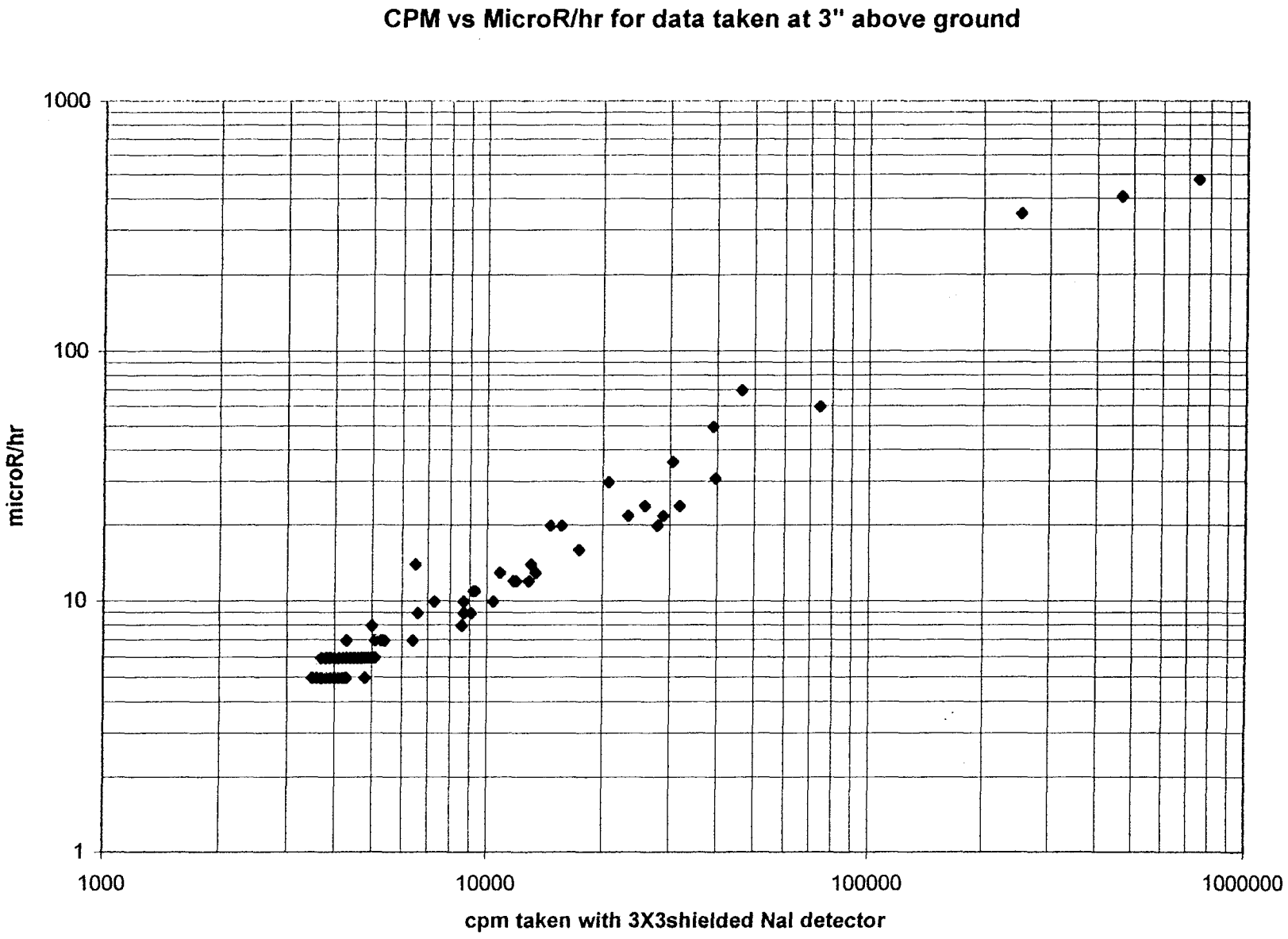

CPM vs MicroR/hr for data taken at 3" above ground
1000
100
10
1
microR/hr
1000
10000
100000
1000000
cpm taken with 3X3shielded NaI detector

Figure 8

| TABLE 4 | Comparison of Exposure Rate in millirem per year and microR per hour for various exposure scenarios | |
|---|---|---|
| Exposure Time | Hourly Exposure Rate for Annual Additional Exposure of: | |
| | 15 mr/yr | 25 mr/yr |
| continuous 8760 hrs per year | 1.7 uR/hr | 2.9 uR/hr |
| normal work week 2000 hrs per year | 7.5 uR/hr | 12.5 uR/hr |
| 1000 hrs per year | 15 uR/hr | 25 uR/hr |
| 500 hrs per year | 30 uR/hr | 50 uR/hr |
| 250 hrs per year | 60 uR/hr | 100 uR/hr |

Table 4