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Beryllium in Soils of the Nevada Test Site:
A Preliminary Assessment

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EXECUTIVE SUMMARY

A preliminary assessment of the occurrence and distribution of beryllium in soils of the Nevada Test Site (NTS) was conducted by identifying sites on the NTS where beryllium might have been used in past operations and measuring current soil beryllium concentrations at those sites. Eighty-one soil samples were collected from six sites on the NTS. The six sites were chosen after interviews with persons who are or were involved with NTS operations and stated that beryllium might have been used in operations at those sites. The soil samples were prepared for analysis using EPA procedures and analyzed by flame-atomic-absorption spectrophotometry. Beryllium concentrations in the soil samples ranged from the analytical detection limit of 0.46 parts-per-million (ppm) to 4.65 ppm. The beryllium concentrations in NTS soils may be higher than estimated local background soil beryllium concentrations, but in concentrations that fall within the range found in surface soils of the United States. Air beryllium concentrations were conservatively estimated to be considerably lower than regulatory exposure limits. Further work is recommended in assessing the spatial distribution of beryllium in soils around several of the sites, with a sampling design that incorporates statistical procedures to ensure statistically valid results.

I. INTRODUCTION

This study was a preliminary assessment of the occurrence and distribution of beryllium in soils of the Nevada Test Site (NTS). The scope of this study was to identify areas of the NTS where beryllium was used in past operations, collect soil samples from these areas for the determination of soil beryllium concentrations, and report the findings of the study. Included in this study is the determination of background soil beryllium concentrations at the NTS, an estimation of aerosol beryllium concentrations from resuspended NTS soils, and a determination of the water-soluble beryllium concentrations that could be available to vegetation on the NTS. This assessment is part of a designated task of the U. S. Department of Energy, Nevada Operations Office (DOE/NV) sponsored Basic Environmental Compliance and Monitoring Program (BECAMP) at the NTS (Patton 1988).

There are four sections to this report: introduction, methods, results, and conclusions. The introduction provides information relevant to an assessment of beryllium occurrence at the NTS and includes information on (1) the toxicity of beryllium and permissible exposure limits to beryllium, (2) the natural occurrence of beryllium in soils, and (3) background-aerosol-dust concentrations found on the NTS. The methods section describes the rationale in choosing sampling sites, and the procedures for sample collection and laboratory analyses. The results section presents the findings of the laboratory analyses and the conclusions section provides an interpretation of the data, a discussion on aerosol beryllium concentrations, and recommendations for further actions.

A. Toxicity of Beryllium and Permissible Exposure Limits

Beryllium has been reported to exhibit carcinogenic properties in animals and is a suspected human carcinogen (a summary of the literature can be found in Anderson et al., 1990). The primary pathway of human exposure to beryllium is inhalation. The U. S. Environmental Protection Agency does not regulate the amount of beryllium in soils, but it does limit the amount of beryllium discharged into the air. Emissions to the atmosphere from stationary sources are limited to that which would result in an ambient beryllium concentration in the vicinity of the source of 0.01 micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) averaged over a 30-day period (40 CFR 61, Subchapter C, Subpart C 61.30).

The Federal government has set a permissible occupational exposure standard for beryllium and beryllium compounds in air at $2\mu\text{g}/\text{m}^3$ as an 8-hour TWA (time-weighted average) with an acceptable ceiling concentration of $5\mu\text{g}/\text{m}^3$. The acceptable maximum occupational exposure to beryllium is $25\mu\text{g}/\text{m}^3$ for a duration of 30 minutes (Sittig 1985).

The toxic effects of beryllium in crop plants has been demonstrated by Romney and Childress (1965). They showed soluble beryllium levels greater than 2 ppm in nutrient solution significantly reduced the growth of crop plants. In addition, low beryllium concentrations in solution (soluble forms of beryllium available for uptake by plants), ranging from 2 to 16 ppm, have been reported as toxic to plants (Kabata-Pendias and Pendias, 1984).

B. Soil Concentrations of Naturally Occurring Beryllium

The natural occurrence of beryllium in soils is generally low but highly variable. Anderson et al. (1990) reported published ranges of soil beryllium concentrations from 0.1 to 40 mg per kg soil (equivalent to parts-per-million (ppm)) with the world average near 6 mg/kg. Estimates of the abundance of beryllium in the earth's crust ranged from 2 to 10 ppm (Merck, 1983). Kabata-Pendias and Pendias (1984) reported that beryllium in U. S. soils is widely distributed and fairly uniform, with concentrations ranging from less than 1 to 15 ppm with a mean of 1.6 ppm.

The forms, distribution and availability of beryllium in soils are not clear, although the chemistry of beryllium in soils is believed to be similar to that of aluminum (Romney and Childress, 1965). Beryllium appears to be rather immobile in soils, but its soluble salts (BeCl_2 and BeSO_4) can be mobile and available for plant uptake.

C. Aerosol Dust Concentrations at NTS

In order to determine potential air beryllium concentrations from measured soil beryllium concentrations, background aerosol dust concentrations at the NTS are needed. Shinn (1991) measured aerosol dust concentrations (mass loading) in several areas of the NTS (Areas 5, 11, 19 and 20) during one-month studies. These studies were conducted during the summer when soil conditions at the NTS were expected to be the driest and dust concentrations to be the highest. In addition, measurements of dust concentrations were made for a full year in Area 5 to establish seasonal trends. The mean mass loading values measured at the four sites were Area 5 - $17 \mu\text{g}/\text{m}^3$, Area 11 - $41 \mu\text{g}/\text{m}^3$, Area 19 - $22 \mu\text{g}/\text{m}^3$, and Area 20 - $7 \mu\text{g}/\text{m}^3$. The means of the year-long measurements from two locations in Area 5 ranged from approximately 8 to $25 \mu\text{g}/\text{m}^3$, with the highest aerosol dust concentrations occurring in July and the lowest in January.

To make estimates of beryllium air concentrations from measurements of soil beryllium concentrations, the following formula can be used:

$$\begin{array}{lcl} \text{air concentration} & = & \text{soil concentration} \quad \times \quad \text{mass loading} \\ (\mu\text{g Be}/\text{m}^3 \text{ air}) & & (\mu\text{g Be}/\text{g soil}) \quad (\mu\text{g soil}/\text{m}^3 \text{ air}) \end{array}$$

Several assumptions are made in using this approach to estimate beryllium concentrations in air above soil containing beryllium: (1) the size of the beryllium particle is small enough to be in the aerosol dust and resuspendable, and (2) the beryllium particle is in the resuspendable fraction of the soil or in the top fraction (5 cm) of soil if the aerosol dust is due to a disturbance of the soil.

II. METHODS

Soil samples were collected from several areas of the NTS that were suspected of possible beryllium contamination. Six sites and three background areas were sampled in Area 26, Area 25, and Area 5 of the NTS. The six sites suspected of beryllium contamination from past operations were based on interviews with persons who are or were involved with operations at the NTS. The soil samples were collected and prepared for analysis by Reynolds Engineering & Electrical Company, Inc. (REECO) Soils Laboratory, located at the NTS. Two analytical laboratories were used for the analysis of the soil samples: REECO's Industrial Hygiene Laboratory at the NTS analyzed all soil samples for beryllium content, and an additional ten aliquots, randomly chosen from the samples, were sent to the University of California - Los Angeles (UCLA), Laboratory of Biomedical and Environmental Sciences, Los Angeles, California, for determination of water-soluble beryllium concentrations.

The following description of the sample-site locations includes figures and maps and a brief discussion on past operations at these sites. After the sample-site description are descriptions of procedures used in soil-sample collection and laboratory analyses.

A. Sample Sites

Eighty-one soil samples were collected from six sites (plus three background locations) in Areas 26, 25, and 5 of the NTS. Figure 2.1 shows the general areas of the NTS where samples were collected.

1. Area 26

Three sample sites were located in Area 26; the Test Bunker, Hot Box Building and Disassembly Building. Area 26 was the site of the Lawrence Livermore National Laboratory Tory Ramjet Experiments of the early 1960's. These experiments involved testing the Tory series of nuclear reactors for ram-jet propulsion. Twenty-four soil samples were taken from an array to the northwest end of the Test Bunker. This bunker was the site of the nuclear reactor experiments, with the exhaust from the reactors venting to the north/northwest of the bunker. The sampling array extended to

Figure 2.1. Areas of the Nevada Test Site (shaded areas of map) where soil samples were collected.

500 feet from the bunker. In addition, five samples were collected in the area near the Hot Box Building and seven in the area near the Disassembly Building. Figure 2.2 shows the sites sampled in Area 26.

Four additional samples were collected from Area 26 away from the sample sites for determination of background concentrations. The samples were collected along the south side of Cane Springs Road, approximately one-half mile south of the Test Bunker.

2. Area 25

Sampling in Area 25 was centered around Test Cell "C". This site was the location of Los Alamos National Laboratory tests with a nuclear rocket (Rover program). Ten samples were collected from the vicinity of Test Cell "C". Most samples were collected from the ravine to the west of Test Cell "C" complex. This was the site where a nuclear rocket was destroyed by detonation. Two samples were collected from the south side of the train track and eight from the north side. Figure 2.3 shows the sampling locations in Area 25.

An additional four samples were collected from the area for the determination of background concentrations. The samples were collected along the sides of Lathrop Wells Road and Jackass Flats Road in the southern part of Area 25; the furthest sample was approximately 13 miles from the test complex.

3. Area 5

In Area 5, eleven samples were collected in the vicinity of Sugar Bunker and 13 samples were collected in the area around Kay Blockhouse. These sites were sampled after interviews from people involved in NTS operations indicated that beryllium may have been used in experiments at these sites. No documentation was found to support the use of beryllium in experiments at these sites. Figure 2.4 shows the sampling sites in Area 5.

At Sugar Bunker, the sampling was focused on the south side of the bunker; samples were collected from a sampling array from 10 to 400 feet from the south side of the bunker. A 200-by-200-foot sampling grid was established on the east side of Kay Blockhouse. At Sugar Bunker and Kay Blockhouse, two additional samples were collected from an area approximately 400 to 1000 ft from the structures for background measurements. An additional background sample (for a total of five background samples in Area 5) was collected from Cane Spring in the western part of Area 5.

B. Soil-Sample Collection

Samples were collected in March and April of 1988. At each sampling location, soil was collected from an area delineated by a metal ring placed on the ground. Soil

Figure 2.2. Locations of the three sites in Area 26 (Test Bunker, Disassembly Bldg., and Hot Box) where samples were collected for the determination of beryllium concentrations in soil.

Figure 2.3. Location of the Test Cell "C" complex in Area 25 where samples were collected for the determination of beryllium concentrations in soil.

Figure 2.4. Locations of the two sites in Area 5 (Sugar Bunker and Kay Blockhouse) where samples were collected for the determination of soil beryllium concentrations.

was collected to a depth of approximately five centimeters. Approximately 70 grams of soil were collected from each sample site and placed in 175-mL plastic containers.

In the laboratory, the samples were screened for gamma-radiation contamination. Then, 10-gram aliquots were taken from the plastic containers and sent to the REECO analytical laboratory for analysis. From ten samples, randomly chosen, a duplicate 10-gram aliquot was collected and sent to UCLA for additional analysis.

C. Laboratory Analyses

At the NTS, REECO's Industrial Hygiene Laboratory prepared the soil samples by U.S. Environmental Protection Agency (EPA) Method 3050 for soil digestion (EPA 1986). The samples were then analyzed with a Perkin Elmer flame-atomic-absorption spectrophotometer (FAA) to determine the beryllium content of the soil sample. The limit of detection for the procedure is 0.46 microgram beryllium per gram of soil ($\mu\text{g/g}$), which is equivalent to 0.46 ppm.

Aliquots from ten soil samples were sent to UCLA for determination of the beryllium soluble fraction. Ten-gram samples of soil (<2mm in size) were leached in water and the extract analyzed by induced-coupled-plasma (ICP) spectrometry.

III. RESULTS

A total of 81 soil samples were collected from the six sites (plus three locations of background measurements) located in Area 25, Area 26, and Area 5 of the NTS. The gamma-spectrometry analysis of the soil samples did not indicate the presence of any radionuclides in the samples (naturally occurring potassium-40 (^{40}K) and thorium-228 (^{228}Th) were detected but with large uncertainties). The analysis conducted by UCLA on aliquots from 10 soil samples indicates that a very small portion of the beryllium found in soils at the NTS is in a biologically available water-soluble form. The concentrations of the water-soluble beryllium in the ten samples ranged from 0.002 to 0.08 ppm.

Beryllium concentrations in the soil samples ranged from the analytical detection limit of 0.46 to 4.65 ppm. Sixty of the 81 samples had concentrations greater than the analytical detection limit (D.L.). Table 3.1 shows the mean beryllium concentrations (for those values above the D.L. of 0.46 ppm) for the six sample sites and the background measurements. Beryllium concentrations in soil samples collected for background measurements ranged from the D.L. to 0.87 ppm, with five of the 13 samples above the D.L. Table A.1 in the Appendix lists the beryllium concentrations for each sample site. The results of the investigation are discussed below by sample site.

Table 3.1. Beryllium (Be) concentrations found at the six sample sites and three background sites of the Nevada Test Site.

Site	No. of samples	No. above detection limit (D.L.)	<u>Be Concentrations above D.L.</u>		
			Minimum (ppm)	Maximum (ppm)	Mean (ppm)
A25 Test Cell "C"	10	6	0.49	3.59	1.62
A25 Background	4	1	0.55	--	--
A26 Hot Box	5	2	0.50	0.57	0.54
A26 Disassembly Bldg..	7	4	0.48	0.64	0.53
A26 Test Stand	24	24	0.6	2.3	1.26
A26 Background	4	4	0.49	0.87	0.65
A5 Sugar Bunker	9	9	0.53	4.65	2.49
A5 Kay Blockhouse	13	10	0.46	3.54	0.93
A5 Background	<u>5</u>	<u>0</u>	--	--	--
	81	60			

A. Area 25 - Test Cell "C"

Figure 3.1 shows the beryllium concentrations found at the ten sampling locations in Area 25. The concentrations ranged from below the D.L. (<0.46 ppm) to 3.59 ppm. Six of the ten samples collected were greater than the D.L. The highest concentrations were in a valley west of the Test Cell "C" building complex, 100 feet to the south of the railroad track (sample locations C3 and C4). There were four background samples collected in Area 25. The four sampling locations and the beryllium concentrations found at those locations are shown in Figure 3.2. Only one of the four samples were above the D.L., that being 0.55 ppm at sampling site J3.

B. Area 26 - Test Stand

An array of 24 sampling locations was crudely established to approximately 450 feet north of the test bunker (Figure 3.3). The beryllium concentrations ranged from 0.6 ppm to 2.3 ppm. There were no large concentrations and little variability in measurements. There is also no discernible pattern in the beryllium concentrations across the sampling array.

Four samples were collected in Area 26, one-half mile south of the Test Stand for background measurements. The beryllium concentrations in the background samples ranged from 0.56 to 0.87 ppm.

Figure 3.1. Beryllium concentrations found in soil samples from Test Cell "C" in Area 25. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

Figure 3.2. Beryllium concentrations found in soil samples from background locations in Area 25. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

Figure 3.3. Beryllium concentrations found in soil samples from the Test Bunker in Area 26. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

C. Area 26 - Hot Box

Five samples were collected around the perimeter of the Hot Box in Area 26 (Figure 3.4). The beryllium concentrations ranged from the D.L. (<0.46 ppm) to 0.57 ppm, with three of the five samples having beryllium concentrations below the D.L.

D. Area 26 - Disassembly Building

Figure 3.4 also shows the locations of the seven samples collected from around the perimeter of the Disassembly building in Area 26. The concentrations ranged from the D.L. (<0.46 ppm) to 0.64 ppm, with three of the seven samples having concentrations below the D.L.

E. Area 5 - Sugar Bunker

Nine soil samples were collected along an array to the south of Sugar Bunker in Area 5 (Figure 3.5). The beryllium concentrations ranged from 0.55 to 4.65 ppm. The highest concentrations of beryllium were found closest to the south side of Sugar Bunker, with concentrations decreasing as the sampling array extends to the south. Two additional samples were collected approximately 500 feet to the west of Sugar Bunker for background measurements. Both background samples yielded beryllium concentrations below the D.L.

F. Area 5 - Kay Blockhouse

Thirteen soil samples were collected from an area around Kay Blockhouse in Area 5 (Figure 3.6). Nine samples were collected along a 200 ft. by 200 ft. grid to the east of the structure. Four samples were collected along the west side of the structure. The beryllium concentrations found in the thirteen samples ranged from the D.L. to 3.54 ppm. The highest concentration was found at the southeast corner of the structure. Two samples were collected from sites 500 feet to the north of the structure for background measurements. Both samples yielded beryllium concentrations below the D.L. The sample collected from the Cane Springs area of Area 5 for background concentrations also yielded a beryllium concentration below the D.L.

IV. CONCLUSIONS

This preliminary assessment of the occurrence of beryllium in soils of the NTS indicates a very "typical" background level of beryllium in NTS soils and identifies several areas of the NTS where beryllium has been found. Beryllium was found in

Figure 3.4. Beryllium concentrations found in soil samples from the Disassembly Building and Hot Box in Area 26. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

Figure 3.5. Beryllium concentrations found in soil samples from Sugar Bunker in Area 5. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

Figure 3.6. Beryllium concentrations found in soil samples from Kay Blockhouse in Area 5. For each location, the sample site identification number is given with the beryllium concentration presented directly below, in parts-per-million (ppm).

soils of the NTS and at several sites in concentrations that may be higher than estimated local background concentrations, but in concentrations that fall within the range found in surface soils of the United States. Air beryllium concentrations were conservatively estimated to be considerably lower than Federal regulatory exposure and emission standards. The analysis presented below is based on a small sample size and any trends identified from the analysis have not been tested statistically. Recommendations for further investigations would include determining the spatial distribution of soil beryllium concentrations and highest soil beryllium concentrations at several sites and the use of statistically valid monitoring plans and data-analysis procedures.

A. Beryllium Concentrations in NTS Soils

Log-probability analyses were used in determining the distribution of soil-beryllium concentrations found on the NTS. A log-probability analysis is a useful tool in estimating the probabilities of finding values within a distribution of values (Gilbert, 1987). In this type of analysis, it is assumed that the measured soil-beryllium concentrations represent repeated samples from a lognormal-probability distribution. But in the case of the samples from the NTS, where 26% of the 81 samples were below an analytical detection limit, the D.L. values are not included in the regression analysis but are included in the determination of the median. The analysis is divided into two sets of data, the values for background samples and the values for samples collected from suspected beryllium-contaminated sites. In both cases, the values that were below analytical detection limit were not included in the regression analyses.

1. Background-Soil-Beryllium Concentrations

Figure 4.1 is the log-probability plot of background beryllium concentrations on the NTS. Although only 13 samples were used in the analysis, a graphical analysis of the samples above the D.L. extrapolate to a geometric mean of 0.41 ppm with a geometric standard deviation of 1.51. The plot allows for inferences about the range of values for any background sample. The levels of background soil-beryllium concentrations have a 98% probability to range up to 0.95 ppm.

The levels of beryllium in the samples collected for the determination of background concentrations indicate the background-beryllium concentration in NTS soils is very low. This assumption can be made from the following: (1) the beryllium concentrations in 13 background samples ranged from less than the D.L. of 0.46 to 0.87 ppm, with only five of the 13 samples above the D.L., (2) if all the samples collected from the NTS are considered, 20 of the 81 soil samples (25%) were below the D.L., and (3) the log-probability distribution indicates the local (NTS) background beryllium concentration is less than 1 ppm. The range of measured background concentrations at the NTS is within the range of published naturally-occurring beryllium concentrations found in U.S. soils (from less than 1 to 15 ppm).

NTS Soil Be Concentrations 0.46 ppm = analytical detection limit Samples taken from Background Locations

Figure 4.1. Log-probability plot of background beryllium concentrations in NTS soil samples.

2. Soil-Beryllium Concentrations at Sample Sites

Figure 4.2 shows the log-probability distribution of beryllium concentrations found at the sample sites. For the samples above the D.L., the graphical analysis gives a geometric mean of 0.71 ppm and a geometric standard deviation of 2.94. Beryllium concentrations in NTS soils at suspected beryllium-contaminated sites have a 98% probability to range up to 6.10 ppm. Although the beryllium levels found at the sample sites are higher than the estimated local background concentrations, the range of concentrations fall within the range of published naturally-occurring beryllium concentrations found in U.S. soils (from less than 1 to 15 ppm).

Several of the NTS sites suspected of beryllium contamination had very low levels of beryllium in the soils. Samples collected from Area 26 Hot Box and Disassembly Buildings were all at the analytical detection limit or slightly above (the highest concentration was 0.64 ppm), and the concentrations found in these areas could be attributed to the variability in naturally occurring beryllium in soil. Although only a few locations were sampled, information on past operations at these sites was not conclusive that beryllium was used in any operations.

The samples collected from the Test Stand in Area 26 were from an area supposedly contaminated with beryllium from past operations. All 24 soil samples collected at the Test Stand contained beryllium above the D.L., with a range of 0.6 to 2.3 ppm. The mean of the samples collected at the Test Stand is twice that of the Area 26 background samples (1.26 to 0.65 ppm, respectively), but there were no large beryllium concentrations found and only small variability in the measurements. The beryllium levels found at the Test Stand could suggest a fairly broad contamination at very low soil beryllium concentrations, although natural variability in local background concentrations cannot be ruled out.

The samples collected closest to the train track at Test Cell "C" had the highest beryllium soil concentrations found in Area 25. The samples were collected from an area within 100 feet of the trestle, with the highest soil beryllium concentrations found on the south side of the trestle (3.12 and 3.59 ppm). From information on past operations, this area was suspected of beryllium contamination.

The two sampling sites in Area 5, Sugar Bunker and Kay Blockhouse, each had locations with high soil beryllium concentrations (4.65 and 3.54 ppm, respectively). At both sites, the locations with the highest soil beryllium concentrations were closest to the structures, with soil-beryllium concentrations decreasing (eventually to concentrations equal to the D.L.) as the sampling arrays extend from the structures.

NTS Soil Be Concentrations

0.46 ppm = analytical detection limit

Figure 4.2. Log-probability plot of beryllium concentrations in NTS soil samples.

3. Water-Soluble Soil-Beryllium Concentrations

Concentrations of the water-soluble beryllium in the ten soil samples collected at the NTS ranged from 0.002 to 0.08 ppm. The concentrations are equivalent to a range of 0.001 to 0.042 mg/L. The aliquots were taken from soil samples collected in Areas 25 and 26; the beryllium concentrations in the soil samples from which the aliquots were taken ranged from the D.L. (<0.46 ppm) to 0.55 ppm. If we assume that all the water-soluble soil beryllium was biologically available for uptake by plants, concentrations in the NTS soils are well below the ranges reported as toxic to plants (2 to 16 ppm) by Kabata-Pendias and Pendias (1984).

B. Estimated Exposure Levels at the NTS

Assuming all the beryllium found in NTS soil is resuspendable, a conservative estimate of beryllium concentrations in air can be made using the maximum soil-beryllium concentrations and maximum mass-loading rates measured on the NTS. The estimated air concentrations can then be compared to regulatory exposure limits to beryllium. The highest concentration of beryllium in NTS soil was found in Area 5 Sugar Bunker at 4.65 ppm and the maximum mass-loading rate measured in Area 5 was 25 $\mu\text{g}/\text{m}^3$. Using the formula discussed in Section IC, the estimated air concentration of beryllium would be $1.16 \times 10^{-4} \mu\text{g Be}/\text{m}^3$ air. This concentration is approximately 85 times lower than the EPA 30-day average emission standard (0.01 $\mu\text{g}/\text{m}^3$). When compared to the occupational exposure limits for beryllium, the estimated air concentration would be approximately 17,000 times lower than the 8-hour TWA exposure limit (2 $\mu\text{g}/\text{m}^3$) and 215,000 times lower than the maximum permissible occupational exposure to beryllium dust for 30 minutes (25 $\mu\text{g}/\text{m}^3$). Even using the highest mass loading rate at the NTS measured by Shinn (1991) (41 $\mu\text{g dust}/\text{m}^3$ air in Area 11) and the highest beryllium concentration found in NTS soils (4.65 ppm), the estimated air concentration of $1.91 \times 10^{-4} \mu\text{g Be}/\text{m}^3$ air is 52 times lower than the EPA 30-day average emission standard.

C. Recommendations

Although the results of this survey indicate low levels of beryllium in NTS soils (all samples were within the range of levels found in U.S. soils) and in the air above the contaminated soils, several areas of the NTS may need to be further investigated in order to (1) fully characterize the spatial distribution of beryllium at several sites, (2) fully characterize background concentrations, and (3) determine water-soluble beryllium concentrations at sites with the highest soil beryllium concentrations. If additional samples are to be collected, a review of the monitoring plan is recommended in order to determine the number of samples needed for proper statistical analysis of the results. Additional samples should be taken at Area 5 - Sugar Bunker, Area 5- Kay Blockhouse, Area 26 - Test Cell "C", and possibly at Area 25 - Test Stand. There

appears to be no reason to take additional samples at Area 26 - Hot Box and Disassembly Building.

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APPENDIX A

Beryllium Concentrations in Soil Samples From the Nevada Test Site

The results of the soil sample analyses are shown in Table A.1. The "Area" is the area of the NTS where the sample sites are located. The "Sample site" refers to the sample locations depicted in Figures 3.1 to 3.6. "Bkgd" are the samples that were collected for determination of background soil beryllium concentrations. The "Coll. date" is the month and year the sample was collected. "Lib#" is the analytical laboratory sample number and "Sample#" is the soil sample collection number. "Be <ppm>" is the concentration of beryllium in the soil sample, in parts-per-million.

TABLE A.1. Beryllium Concentrations In Soil Samples From The Nevada Test Site.

AREA	SAMPLE SITE	BKGD	COLL. DATE	LIB#	SAMPLE#	Be (ppm)	AREA	SAMPLE SITE	BKGD	COLL. DATE	LIB#	SAMPLE#	Be (ppm)
26	1N		06/87	30000	60000	1.2	5	KB1		04/88	30043	60063	0.71
26	2N		06/87	30001	60001	1.9	5	KB2		04/88	30044	60064	0.56
26	3N		06/87	30002	60002	1.9	5	KB3		04/88	30045	60065	<0.46
26	4N		06/87	30003	60003	0.9	5	KB4		04/88	30046	60066	1.44
26	5N		06/87	30004	60004	0.8	5	KB5		04/88	30047	60067	0.49
26	6N		06/87	30005	60005	0.8	5	KB6		04/88	30048	60068	0.46
26	7N		06/87	30006	60006	1.4	5	KB7		04/88	30049	60069	3.54
26	8N		06/87	30007	60007	0.9	5	KB8		04/88	30050	60070	0.54
26	9N		06/87	30008	60008	1.0	5	KB9		04/88	30051	60071	<0.46
26	10N		06/87	30009	60009	1.5	5	KB10		04/88	30052	60072	0.55
26	11S		06/87	30010	60010	1.2	5	KB11		04/88	30053	60073	0.50
26	12S		06/87	30011	60011	1.1	5	KB12		04/88	30054	60074	0.47
26	13S		06/87	30012	60012	0.8	5	KB13		04/88	30055	60075	<0.46
26	14S		06/87	30013	60013	1.9	5	KB14	*	04/88	30056	60076	<0.46
26	15S		06/87	30014	60014	0.6	5	KB15	*	04/88	30057	60077	<0.46
26	16S		06/87	30015	60015	1.6							
26	17S		06/87	30016	60016	2.3	5	SB1		04/88	30032	60052	4.65
26	18S		06/87	30017	60017	1.7	5	SB2		04/88	30033	60053	3.76
26	19S		06/87	30018	60018	0.9	5	SB3		04/88	30034	60054	0.53
26	20S		06/87	30019	60019	0.8	5	SB4		04/88	30035	60055	0.55
26	210		06/87	30020	60020	2.0	5	SB5		04/88	30036	60056	3.33
26	220		06/87	30021	60021	0.9	5	SB6		04/88	30037	60057	2.40
26	230		06/87	30022	60022	1.2	5	SB7		04/88	30038	60058	0.53
26	240		06/87	30023	60023	1.0	5	SB8		04/88	30039	60059	4.27
26	BK1		06/87	30028	60048	0.87	5	SB9		04/88	30040	60060	2.38
26	BK2	*	06/87	30029	60049	0.68	5	SB10	*	04/88	30041	60061	<0.46
26	BK3	*	06/87	30030	60050	0.56	5	SB11	*	04/88	30042	60062	<0.46
26	BK4	*	06/87	30031	60051	0.49							
26	HB1		03/88	30072	60092	<0.46	25	C1		03/88	30058	60078	<0.46
26	HB2		03/88	30073	60093	<0.46	25	C2		03/88	30059	60079	<0.46
26	HB3		03/88	30074	60094	0.57	25	C3		03/88	30060	60080	3.59
26	HB4		03/88	30075	60095	0.50	25	C4		03/88	30061	60081	3.12
26	HB5		03/88	30076	60096	<0.46	25	C5		03/88	30062	60082	0.75
26							25	C6		03/88	30063	60083	1.23
26							25	C7		03/88	30064	60084	0.49
26	DB1		03/88	30077	60097	0.64	25	C8		03/88	30065	60085	<0.46
26	DB2		03/88	30078	60098	<0.46	25	C9		03/88	30066	60086	<0.46
26	DB3		03/88	30079	60099	<0.46	25	C10		03/88	30067	60087	0.55
26	DB4		03/88	30080	60100	<0.46	25	LM30	*	03/88	30068	60088	<0.46
26	DB5		03/88	30081	60101	0.49	25	RV	*	03/88	30069	60089	<0.46
26	DB6		03/88	30082	60102	0.48	25	J3	*	03/88	30070	60090	0.55
26	DB7		03/88	30083	60103	0.50	25	J16	*	03/88	30071	60091	<0.46
26	CS25	*	03/88	30084	60104	<0.46							

**DATE
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9/22/93

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