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LAS VEGAS AREA (ARMS-II)

R. B. Guillou, J. E. Hand, and H. M. Borella

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LAS VEGAS AREA (ARMS-II)

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Santa Barbara, California

October 1961

ABSTRACT

An Aerial Radiological Measuring Survey (ARMS) of the Las Vegas area was made for the Civil Effects Test Operations, Division of Biology and Medicine, U. S. Atomic Energy Commission, by Edgerton, Germeshausen & Grier, Inc., between May 21 and June 23, 1961. The survey was part of a nationwide program to measure present environmental levels of gamma radiation. Approximately 6000 traverse miles were flown, at an altitude of 500 ft above the ground, in a 100-mile square centered near Las Vegas. The EG&G ARMS-II instrumentation was used in the survey.

The data are presented in aeroradioactivity units, or areas with similar gamma radiation rates at 500 ft, at two map scales: (1) generalized at about 1:1,500,000 and (2) detailed at 1:250,000. Maximum readings in most of the north half of the area are below 400 counts/sec; in only one sizable area are they above 800 counts/sec. The south half of the area, which is much more radioactive, can be divided into three sections: (1) a west section, where the maximum count rate is usually below 800 counts/sec; (2) a center section, where the maximum count rate is less than 4000 counts/sec in half the section and less than 1200 counts/sec in the other half; and (3) a heterogeneous east section, where less than 1200 counts/sec predominates but where there are sizable higher areas.

The general distribution of radioactivity can be directly attributed to the geology of the area. Carbonate and clastic rocks usually are associated with low aeroradioactivity levels; metamorphic, intrusive, and volcanic rocks generally give rise to moderate to high aeroradioactivity levels. Although artificial radionuclides may have influenced the distribution of aeroradioactivity units in a few places in the extreme northwest portion of the area, the natural plus the artificial radioactivity in the northern area was much lower than the natural radioactivity of many units in the southern section.

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LAS VEGAS AREA (ARMS-II)

1 INTRODUCTION

1.1 Location of Area

An Aerial Radiological Measuring Survey (ARMS) of the Las Vegas area was made for the Civil Effects Test Operations (CETO), Division of Biology and Medicine, U. S. Atomic Energy Commission, by Edgerton, Germeshausen & Grier, Inc. (EG&G), between May 21 and June 23, 1961. The 100-mile-square area surveyed lies between $114^{\circ}05'$ and $115^{\circ}50'$ West longitude and between $35^{\circ}31'$ and $36^{\circ}58'$ North latitude (Fig. 1). The center of the area is near Las Vegas, Nev. A small extension in the northwest part of the area joins the ARMS-II Las Vegas area with the ARMS-I Nevada Test Site area, surveyed in 1958 by the U. S. Geological Survey, and with the Frenchman Flat Area,¹ surveyed by EG&G in November 1960. Most of Clark County

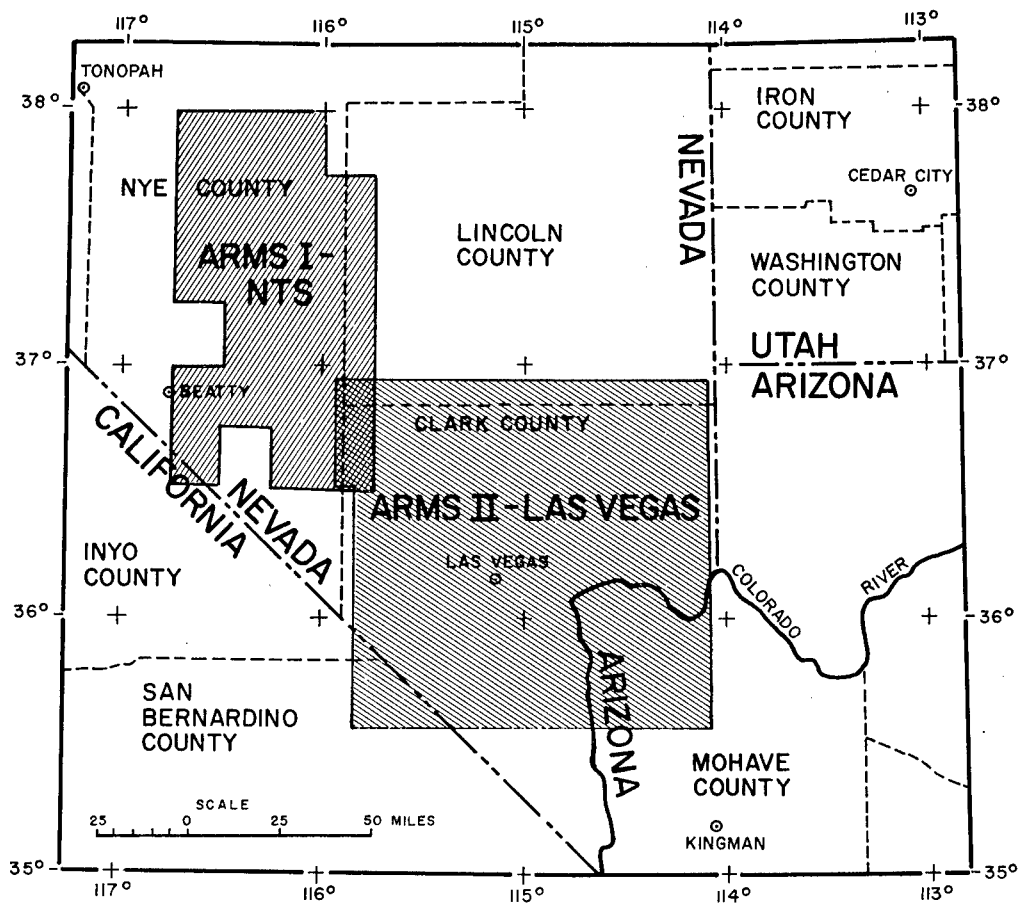


Fig. 1—Index map showing location of ARMS-II Las Vegas area and ARMS-I Nevada Test Site area.

and parts of Lincoln and Nye counties (Nev.), San Bernardino and Inyo counties (Calif.), and Mohave County (Ariz.) are included in the area.

1.2 Purpose of Survey

The ARMS-II Las Vegas survey was one of many that have been flown for the CETO since the nationwide ARMS program was started (1958). Figure 2 shows the location of the areas that have been surveyed to date. The purpose of the program is to measure the present environmental levels of gamma radiation in areas around nuclear facilities and planned nuclear activities. It is desirable to document the environmental radiation, which results primarily from the natural radioactivity of the surface soil and rock, to establish a base line or environmental datum. ARMS data from selected areas, in conjunction with data from resurveys of these areas, can be used to appraise changes in environmental levels of radiation brought about by debris from nuclear weapons testing programs, operation of nuclear facilities, and radiation accidents. The data are also important to an understanding of the long-term biological effects of low-level radiation.

1.3 Air-borne Survey Procedure

The ARMS-II Las Vegas area was laid out on appropriate United States Geological Survey (USGS) topographic maps. The area boundaries were drawn, and the proposed flight lines were added. The flight lines were drawn in the north-south direction and were spaced about one mile apart.

Ground check points were then selected along the flight lines and, where possible, at the ends of the flight lines in order that aircraft-position information obtained along the flight path could be correlated to an area map.

Survey flights over the broad valleys and plains between the mountain ranges were conducted along the north-south lines. The nominal survey altitude was 500 ft above the ground; therefore much of the mountainous terrain was, of necessity, omitted. In several instances individual traverse lines were flown through the narrow passages and valleys in these regions to obtain partial coverage even over the most rugged terrain.

The survey flights in the Las Vegas area were conducted at a time when the air temperatures were very high (between May 21 and June 23, 1961). The survey flights were conducted between 6 and 11 a.m. so that severe midday turbulence and extreme temperatures could be avoided.

The daily flight procedure included equipment-stabilization time and in-flight calibrations on the radiation-detection apparatus. As soon as the aircraft was air-borne, the equipment was turned on and was allowed to reach temperature equilibrium. When thermal stabilization of the circuitry was reached, the radiation apparatus was calibrated with a Cs¹³⁷ source. Measurements of air-borne, cosmic, and extraneous radiation were then taken at 3000 ft above terrain. After arriving at the initial survey line for the day, the aircraft descended to the 500-ft survey altitude, and the value of the undesirable radiation, as measured at 3000 ft, was set into the radiation computer. The radiation data taken as the aircraft progressed down the survey line represented net terrestrial gamma radiation. During the survey flight each day the radiation-detection apparatus was periodically calibrated to keep the drift in the detection system to a minimum.

Upon completion of each flight, the data tapes were removed from the aircraft and were immediately edited by the flight personnel. Pertinent information, such as missing or obliterated ground check points, new points selected during flight, and equipment malfunctions, was immediately related to map locations and the radiation data. The corrected data were then entered onto the area working maps.

1.4 Instrumentation

The EG&G ARMS-II instrumentation was installed in a Beech model 50 twin Bonanza, N702B. The apparatus consists of three subsystems (Fig. 3): (1) the radiation-detection and -measurement subsystem; (2) the aircraft space-positioning subsystem; and (3) the informa-

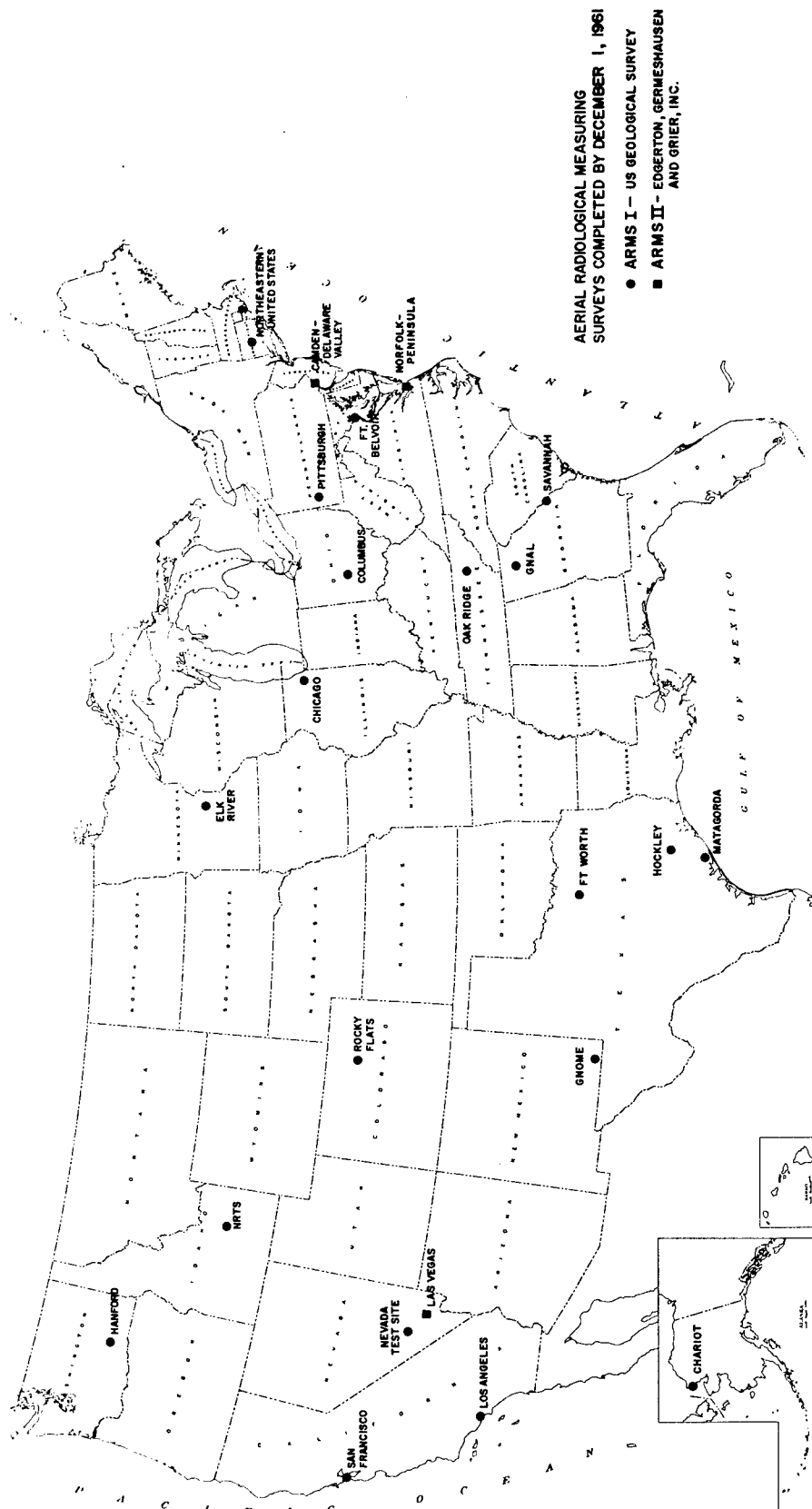


Fig. 2—Civil Effects Test Operations ARMS program.

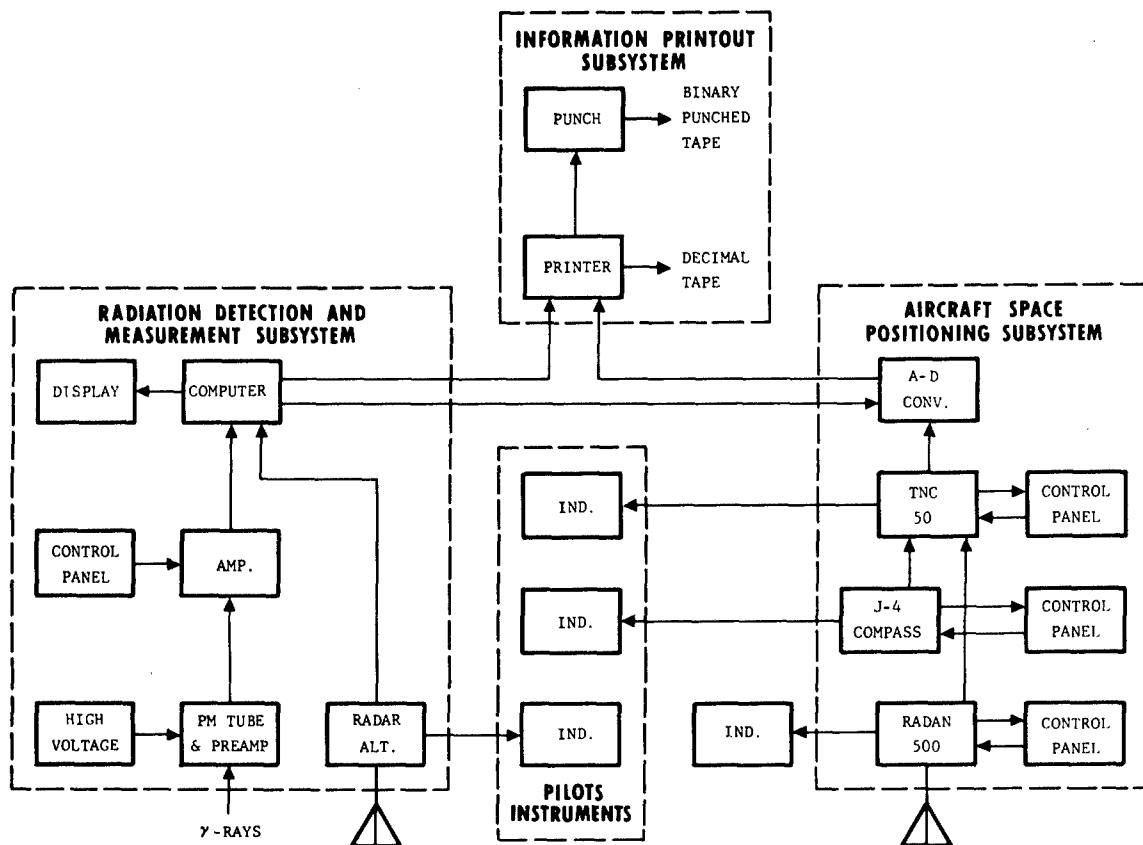


Fig. 3—Diagram of EG&G ARMS-II instrumentation.

tion printout subsystem. The functions of these subsystems and their components are described in detail² in Ref. 1.

The main detection unit utilizes a 9-in.-diameter 3-in.-thick thallium-activated sodium iodide crystal and a 12-in. photomultiplier tube. The radiation amplifier unit consists of a voltage amplifier, a pulse shaper, and an energy discriminator set to reject pulses due to gamma rays with energies below 50 kev for routine surveying and 662 kev for calibration purposes. The arithmetic computer performs the cosmic background correction, the compensation of the data for deviations from the nominal surveying altitude, the classification of count rate into channels, and gives print command signals to the information printout subsystem. The correction for cosmic and other undesirable background consists of subtracting from the gross count, at 500 ft above the ground, a count rate equal to the undesirable background; this gives the net count. This background is normally measured at 3000 ft above the ground. Compensation of the data for deviations from the nominal surveying altitude was accomplished through control of the sampling period by the introduction of a signal from the radar altimeter. The normal sampling period was 1 sec. The sampling period was less than 1 sec when the aircraft was below 500 ft and greater than 1 sec when the aircraft was more than 500 ft above the ground. The count rate was normalized to 500 ft above the ground in the range from 300 to 900 ft above the ground. The arithmetic computer classifies the count rate into digital channels of predetermined width. In the range of most natural materials, between 0 and 2000 counts/sec, the channel width is narrow; above 2000 counts/sec a progressively wider channel width is used.

The position of the aircraft was determined by a modified General Precision Laboratories Doppler navigation system. The J-4 compass system establishes a reference line against which the actual path of the aircraft is compared, the heading information being held by either a driven

gyro or a magnetically slaved gyro. The RADAN 500 Doppler radar unit determines the ground speed and drift angle of the aircraft relative to the J-4 reference line. Signals from the J-4 compass and the RADAN 500 go to the TNC-50 (track navigation computer), where the along-track and the across-track distances relative to an initial ground point are computed. The along-track and the across-track distance signals then go to the analog-to-digital converter. Upon receipt of a print command from the radiation computer, the outputs go to the printer and are recorded.

The information printout subsystem consists of two data recorders: (1) a decimal printer and (2) a binary tape punch. The data recorded are: survey leg number, radiation channel, along-track distance, across-track distance and direction, and detector sensitivity. Since the radiation-detection subsystem also contains a small crystal that is used in high-intensity fields, it is necessary to record which detector is in use during collection of the data.

2 THEORETICAL CONSIDERATIONS OF ARMS DATA

2.1 Sources of Gamma Rays

The gamma-ray activity that was measured by ARMS equipment at 500 ft above the ground had three principal origins: (1) cosmic radiation; (2) atmospheric sources, or the radionuclides in the air; and (3) terrestrial sources, which were the radionuclides in the surficial materials of the earth. It was not possible to measure directly the relative contribution of each source at a particular time while surveying, but certain assumptions and calibration procedures permitted good estimates of the components of the gross gamma radiation to be made. A detailed discussion of sources of gamma rays is included in Uses of ARMS Data,² a report in preparation by EG&G. The following paragraphs present a brief summary of the most important of the gamma-ray sources that affect ARMS data.

The cosmic radiation component at 500 ft above the ground is due mainly to the air-scattered gamma rays induced by cosmic particles. The count rate at 3000 ft above the ground, where negligible radiation from the ground is present, is considered to be due to the cosmic component, the atmospheric sources, and the extraneous radiation. This contribution was measured each day while the ARMS flights were being conducted and was subtracted from the gross count at 500 ft above the ground to give the recorded net count rate. The average 3000-ft background during the ARMS-II Las Vegas survey was 1030 counts/sec; of this amount, 800 counts/sec was due to the calibration source in the aircraft.

The component of the gamma-ray activity at 500 ft above the ground which is due to radionuclides in the atmosphere cannot be separated directly from the terrestrial or cosmic components. Measurements of the artificial and natural radionuclides in ground-level air, however, have been made for several years by various investigators, and these measurements indicate that the contribution of atmospheric sources (principally radon daughter products) to the total count rate is normally insignificant. Abnormal situations occur during periods of severe inversion or immediately after testing of nuclear devices. When fission products are present in the air, they are assumed to be uniformly distributed; therefore their contribution to the count rate is removed with the cosmic background.

The terrestrial component of the gamma radiation found at 500 ft above the ground comes from the radionuclides in the surficial 12 in. of earth materials. Radionuclides in soil and, to a lesser extent, in rock are the major sources of gamma rays. Artificial radionuclides are generally concentrated in the surficial inch or two of material and, as is described later, probably have little effect on the distribution of aeroradioactivity units in the Las Vegas area. The present distribution of the surficial material and the concentrations of natural radionuclides in it are determined by the original content and form of the radioactive material in the parent rock and by changes brought about by geologic and pedologic processes.

The principal natural gamma-producing radionuclides found in rocks and soils are K^{40} and the members of the uranium and thorium series. The content of these radionuclides in various rocks is shown in Table 1.

There is a general trend for the content of these radionuclides in igneous rocks to increase with increasing silica content. Among the sedimentary rocks, shales are generally more radioactive than sandstones and carbonate rocks. The natural radioactivity of meta-

TABLE 1—K⁴⁰, THORIUM, AND URANIUM IN IGNEOUS AND SEDIMENTARY ROCKS
(in parts per million)

	K ⁴⁰		Thorium		Uranium	
	Average	Range	Average	Range	Average	Range
Igneous rocks						
Basaltic	0.8	0.2 to 2	4.0	0.5 to 10	1.0	0.2 to 4
Granitic	3.0	2 to 6	12	1 to 25	3	1 to 7
Sedimentary rocks						
Shales	2.7	1.6 to 4.2	12	8 to 18	3.7	1.5 to 5.5
Sandstones	1.1	0.7 to 3.8	1.7	0.7 to 2.0	0.5	0.2 to 0.6
Carbonates	0.3	0 to 2	1.7	0.1 to 7	2.2	0.1 to 9

morphic rocks, unless radionuclides were added or removed during metamorphism, reflects the potassium, uranium, and thorium content of the original sedimentary or igneous rock. The concentrations of the natural radionuclides in soils are probably similar to the concentrations in sedimentary rocks because both are produced by the breakdown of preexisting rocks. The fine clayey and silty soils are generally more radioactive than coarser sandy soils because much of the soil radioactivity results from radioelements that are fixed or absorbed on clay. The interaction of various soil-forming processes, however, sometimes produces a concentration of radioactive accessory minerals and therefore increases the total radioactivity in the surficial soil.

2.2 Effect of Meteorological Conditions on Gamma-ray Flux from Terrestrial Sources

Changes in meteorological conditions have only a small effect on the gamma-ray flux at 500 ft which is produced by terrestrial sources. A detailed treatment of this subject⁴ is presented in Report CEX-59.4. The largest effect is caused by changes in the density of the air between the detector and the ground. The most important factor here, of course, is that of temperature variations. A temperature deviation of $\pm 10^{\circ}\text{F}$ would create a maximum variation in count rate of ± 3 per cent. The effect of air-pressure variations on the uncertainty in the data is negligible. The change in air pressure of ± 8 mm would introduce an error of only 0.15 per cent in the count rate. Changes in relative humidity also have a small effect on the attenuation of gamma rays. If survey operations were proceeding at 80°F at 500 ft and the relative humidity was 50 per cent, the error that a change of ± 50 per cent in the relative humidity would introduce into the data would be about 0.9 per cent. The meteorological parameters of humidity, temperature, and pressure were recorded for each survey day, but, since their combined effect on the radiation levels was small, they were not used in the present application of the data. They are available, however, if a more detailed analysis of the data is required at some future time.

2.3 Conversion of Count Rate to Dose Rate

The EG&G ARMS-II instrumentation was designed to give data that are compatible with the data of the existing USGS ARMS-I equipment. Both units were flown over the Extended Source Calibration Area at the Nevada Test Site for cross-calibration purposes. The calibration range consisted of 400 equal-valued sources spaced on 100-ft centers to form a square that was 2000 ft on a side. The central source in the area was replaced by 100 smaller sources, spaced on 10-ft centers, the total intensity of which equaled that of the replaced source. The results of the flight measurements are being reported by F. J. Davis, Oak Ridge National Laboratory.⁴

The gamma dose rate 3 ft above terrain in the center of the area was measured by R. M. Johnson of Oak Ridge National Laboratory. The results of his measurements, combined with the EG&G ARMS-II data taken at 500 ft above terrain, give the following conversion factors:

Co⁶⁰ gammas: 22 counts/sec at 500 ft = 1 $\mu\text{r/hr}$ at 3 ft

Cs¹³⁷ gammas: 25 counts/sec at 500 ft = 1 $\mu\text{r/hr}$ at 3 ft

These figures should be applied to ARMS-II survey data with caution since any individual reading obtained with the ARMS-II equipment represents a radiation intensity that is integrated over a ground area approximately 900 ft in radius. In addition, no information is available concerning the energy of the radiation detected during survey operations.

3 AERORADIOACTIVITY DATA

3.1 Interpretation and Compilation

The present manual reduction of ARMS-II data from the decimal tape which was obtained during the survey to the aeroradioactivity units map, the form in which the data are presented, required two compilation and two interpretation steps.

The first step consisted of editing the decimal tape by selecting the data points that divide the flight lines into segments having similar radioactivity and the points that indicate known locations on the flight maps or major changes in flight path. The flight line was divided into segments because aeroradioactivity data for the ARMS-II Las Vegas area were recorded every 3 sec or about every 700 ft, resulting in about 45,000 data points. The distribution of radioactivity on the ground is such that a range in count rate is usually recorded on any segment of a flight line. If an area on the ground has a uniform gross gamma radioactivity it will have associated with it a narrow range in count rate. A nonuniform gross gamma radioactivity, such as the bands of different width with different radioactivity produced by alternating sandstone, shale, and limestone beds, gives rise to a wide range in count rate. The segments were chosen to show as much information about the radioactivity as is consistent with the 1:250,000 compilation scale.

The second step, a compilation process, consisted of plotting the selected data points on tracing paper at map scale (1:250,000). The recorded Doppler distances were used to plot the flight line.

In the third step the flight lines were corrected for instrumental error, and the true positions of the data points were plotted on the compilation map. The correction consisted of the graphical proportioning of the error between the map locations of the segment end points. The "Doppler error," or the difference between the map position and the Doppler-indicated position of an end point, was less than 0.5 per cent of the distance flown. However, after the "Doppler error" was properly proportioned, the data points were accurate to within 0.1 mile, or 0.03 in. at map scale.

The final interpretative step in the reduction of the data was the delineation of aeroradioactivity units, or the selection of borders for areas having similar count rates on adjacent flight lines. Since the natural background radioactivity was commonly complex and since this detail was easily recorded by the ARMS instrumentation, the delineation of aeroradioactivity units put the data in a form that could be readily understood. The size of the units represents a compromise between the narrowest possible range in count rate and the largest possible area within one unit. Dissimilar count rates on adjacent lines, as well as fluctuations along a flight line, contributed to the width of the range of count rate for a particular aeroradioactivity unit. The upper limit of one unit may be the lower limit of an adjacent unit or the range of one unit may overlap the range of an adjacent unit. Since the data were prepared for presentation on a map at a scale of 1:250,000, or 4 miles equal 1 in., most of the units should be more than 2 miles wide (along the flight line) and should encompass more than four survey lines. Aeroradioactivity units as narrow as $\frac{1}{2}$ mile are shown on the map if they differ substantially from adjacent units.

The aeroradioactivity data and units shown in Fig. 4 illustrate the philosophy and problems connected with the delineation of aeroradioactivity units. The numerical values that are listed represent gamma count rates in hundreds of counts per second. It can be seen that in many places the position of a unit boundary is unique and obvious, such as at A, B, and C. At other places, such as D, the placement of the boundary was arbitrary and the dashed line could have been used. The selected boundary was chosen to indicate a unit with a slightly lower radioactivity to the right of the line; a single unit (3-7) instead of three units (4-7, 3-6, and 4-7) could have been used in this region. At E a unit boundary was drawn through a fairly

uniform segment (8-10). This arbitrary division of a segment is avoided if possible, but it sometimes is necessary to simplify the shape of units while holding the range of units as narrow as possible. The 8-25 unit to the right of E is an example of a complex area that required a wide range in count rate to avoid a multitude of small units.

The diagrammatic plan sketch in Fig. 5 shows how poorly defined aeroradioactivity units result from alluvial materials that are derived from bedrock that would produce distinct units. Three types of bedrock are assumed: A, high radioactivity; B, low radioactivity; and C, moderate radioactivity. Letters in parentheses indicate alluvium that is composed of different rock fragments; the first letter indicates the dominant rock type. An alluvial slope separates the hills at the top of the sketch from the left-to-right drainage at the bottom. In front of each ridge is a small area of alluvium that was derived from the ridge: (A), (B), (B), and (B). An alluvial fan composed of the materials in each watershed extended from the mouth of each canyon: (A), (A + B), (B), (B + C), and (C + B). Where the alluvial fans coalesce, the surficial material contains contributions from two fans: (A + B), (B + A), (B + C), and (C + B). The alluvial material along the drainage contains fragments of all rock types exposed upstream: (A), (A + B), (B + A), (B + C + A), and (C + B + A).

Activity data taken on a flight line over the bedrock formations A, B, and C would give sharply defined, uniform aeroradioactivity units. Data taken over the alluvial fans at the canyon mouths would show activity units that begin to vary in uniformity and borders that are not as distinct as over the bedrock. Finally, data taken on flight lines that pass over the lowermost part of the sketch would show irregular variations in count rate which are due directly to the heterogeneity of the surficial materials. The only type of aeroradioactivity unit that could be drawn in an area such as this would encompass a wide range in count rate.

3.2 Presentation of Aeroradioactivity Data

Aeroradioactivity data for the ARMS-II Las Vegas area are presented in two forms: (1) a page-size generalized version at a scale of about 1:1,500,000 (24 miles equal 1 in.) (see Fig. 6); and (2) a full-size version at a scale of 1:250,000 (4 miles equal 1 in.) (see plates 1, 2, 3, and 4 in pocket for detailed study).

3.2.1 Generalized Aeroradioactivity Data

Four patterns are used in Fig. 6 to denote the generalized aeroradioactivity data for the area: areas where the maximum radioactivity was (1) mostly less than 400 counts/sec, (2) less than 800 counts/sec, (3) less than 1200 counts/sec, and (4) less than 4000 counts/sec. Only the gross features of the area are shown in this figure; aeroradioactivity unit boundaries have been smoothed, and small units have been deleted.

Figure 6 shows clearly that the radioactivity of the north half of the area is markedly lower than the south half. Maximum readings in most of the north half are below 400 counts/sec; in only one sizable area are they above 800 counts/sec. The south half of the area can be divided into three sections: (1) a west section (where the maximum count rate is usually below 800 counts/sec); (2) a central section (where the maximum count rate is less than 4000 counts/sec in one-half the section and less than 1200 counts/sec in the other half); and (3) a heterogeneous east section (where less than 1200 counts/sec predominates but sizable regions are higher and lower).

3.2.2 Detailed Aeroradioactivity Data

The detailed aeroradioactivity units in the ARMS-II Las Vegas area are shown on plates 1 through 4: the northwest quarter is shown on plate 1; the northeast quarter is shown on plate 2; the southwest quarter is shown on plate 3; and the southeast quarter is shown on plate 4. These maps are printed without margins on two sides so that the entire area can be studied by putting the four sheets together. Topography and more-detailed cultural information for the area can be obtained from the Kingman and Las Vegas sheets, Topographic Maps of the United States, 1:250,000 series; these maps are available from the U. S. Geological Survey.

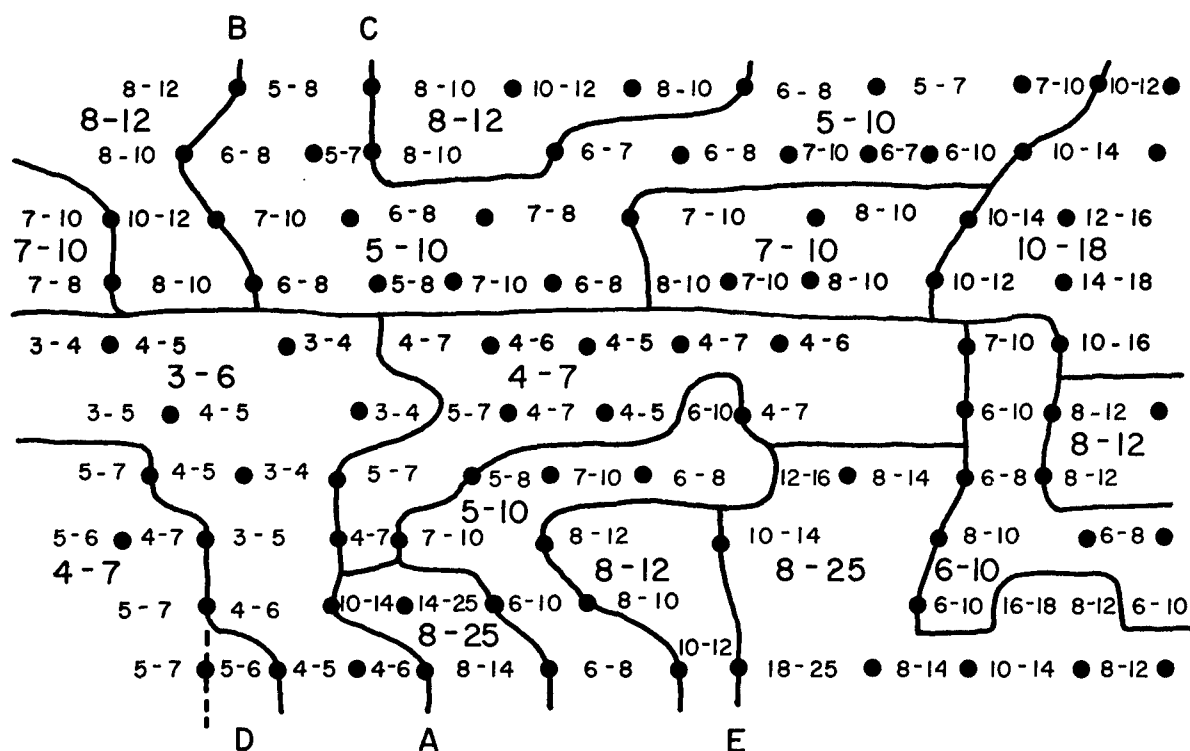


Fig. 4—Aeroradioactivity data and units (count rate in hundreds of counts per second).

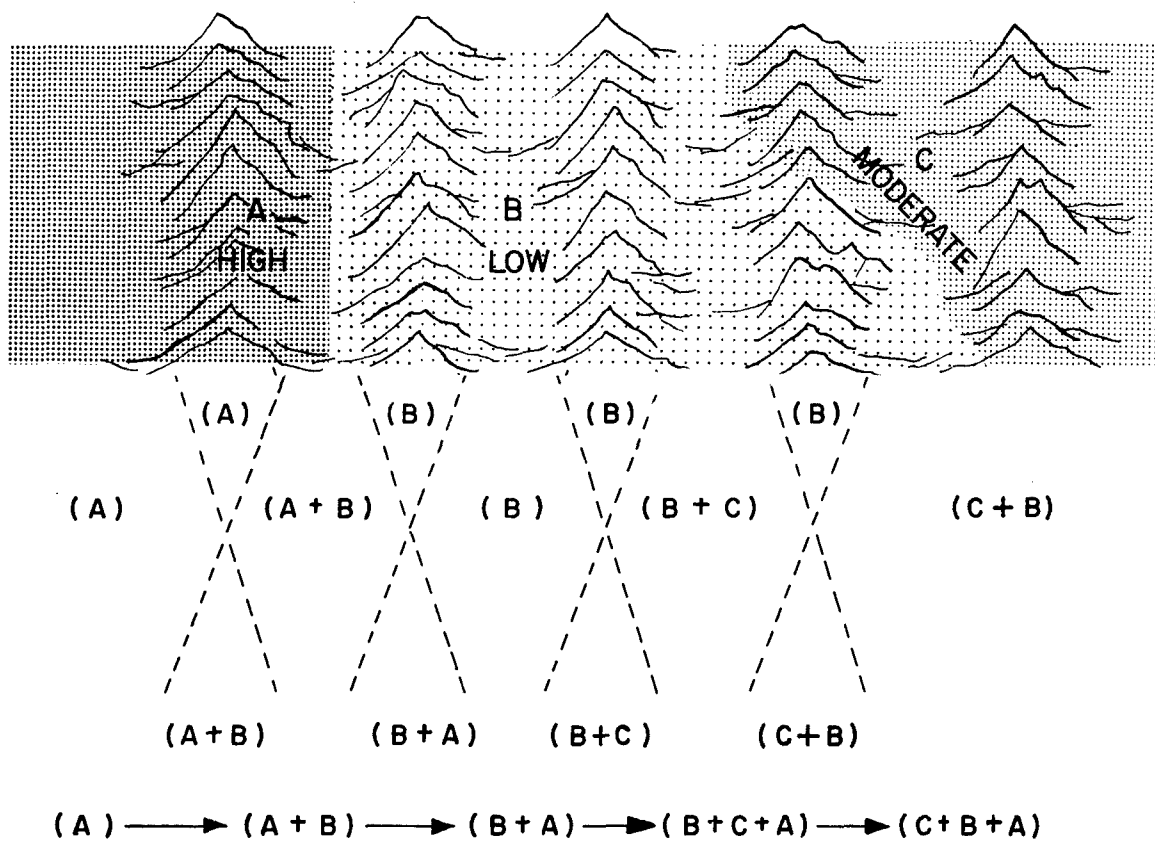


Fig. 5—Distribution of rock fragments in alluvium.

4 CORRELATION OF AERORADIOACTIVITY UNITS

The general distribution of the terrestrial radioactivity in the ARMS-II Las Vegas area can be directly attributed to the geology of the area. It is believed that a detailed study of the surficial geologic materials in the area would provide reasons for most of the aeroradioactivity units. Artificial radionuclides may have influenced the distribution of units in a few places in the extreme northwest, but the total radioactivity of these units is much lower than the radioactivity of many units in the south that result from natural radionuclides.

4.1 Correlation of Aeroradioactivity Units with Geology

The gross radioactivity of the ARMS-II Las Vegas area, as shown in Fig. 6, is a direct consequence of the geology of the area. In the northern part of the area, the exposed rocks and the alluvium derived from them are mostly carbonate and clastic rocks⁵ with a low inherent radioactivity, which produces a generally low aeroradioactivity. Carbonate and clastic rocks are common, and some metamorphic and intrusive rocks are present in the southwest part of the area.^{6,7} This heterogeneous geology results in a slightly more radioactive area. In the south-central and southeast parts of the area, metamorphic, intrusive, and volcanic rocks predominate.^{6,8} These rocks are much more radioactive than the carbonate rocks, which is evidenced by these areas having a higher activity.

Several specific correlations between individual aeroradioactivity units and geologic units were noted in this brief study. On the west side of Frenchman Mountain (extreme right top of plate 3), a small area of Pre-Cambrian metamorphic rock produced a 4-8 aeroradioactivity unit. Near Sloan (plate 3) two small areas of volcanic rock, separated by carbonate rock, caused the following sequence of units: 7-14, 3-5, and 8-14. Devils Peak, west of Borax (plate 3), consists of an intrusive rock (rhyolite). This rock is similar to granite in silica content and apparently is moderately radioactive because units of 3-5 and 5-7 were associated with it. North of Nelson, in the El Dorado Mountains (plate 4), an olivine basalt (a silica-deficient rock and therefore probably weakly radioactive) could be correlated with a 3-6 unit.

4.2 Correlation of Aeroradioactivity Units with Other Sources

Nuclear debris from activities in Frenchman Flat may be the determining factor in two or three aeroradioactivity units in the northwest corner of plate 1. The 8-12, 6-10, and 5-8 units in this area are slightly high to be attributable directly to natural radionuclides, but, since geologic data for this region are incomplete, natural causes cannot be ruled out. It should be noted that the natural plus any artificial radioactivity in this area is much lower than the obviously natural radioactivity in the area south of Las Vegas.

Slight increases in aeroradioactivity occurred over dry lakes in the three valleys east of Frenchman Flat. These increases could be due to the higher natural radioactivity of the clays in the lake beds or partially to the concentration in the lake beds of nuclear debris which heavy rains may have washed in from large areas.

Conclusive evidence that the location of any of the aeroradioactivity unit boundaries is related to the presence of artificial radionuclides is lacking in the ARMS-II Las Vegas area, even in the region that is adjacent to the Nevada Test Site. A ground study of the surface soil would permit a definite identification of the radionuclides present.

5 SUMMARY AND CONCLUSIONS

The ARMS-II Las Vegas survey was the first operational survey of a large area with the EG&G ARMS-II instrumentation. Shakedown of the EG&G system was accomplished while performing the operational tasks. The operating procedures developed and proved in this survey indicate that the system is extremely versatile, being capable of routine surveying on straight lines over areas of flat to moderate topography or flying irregular individual traverses in mountainous terrain.

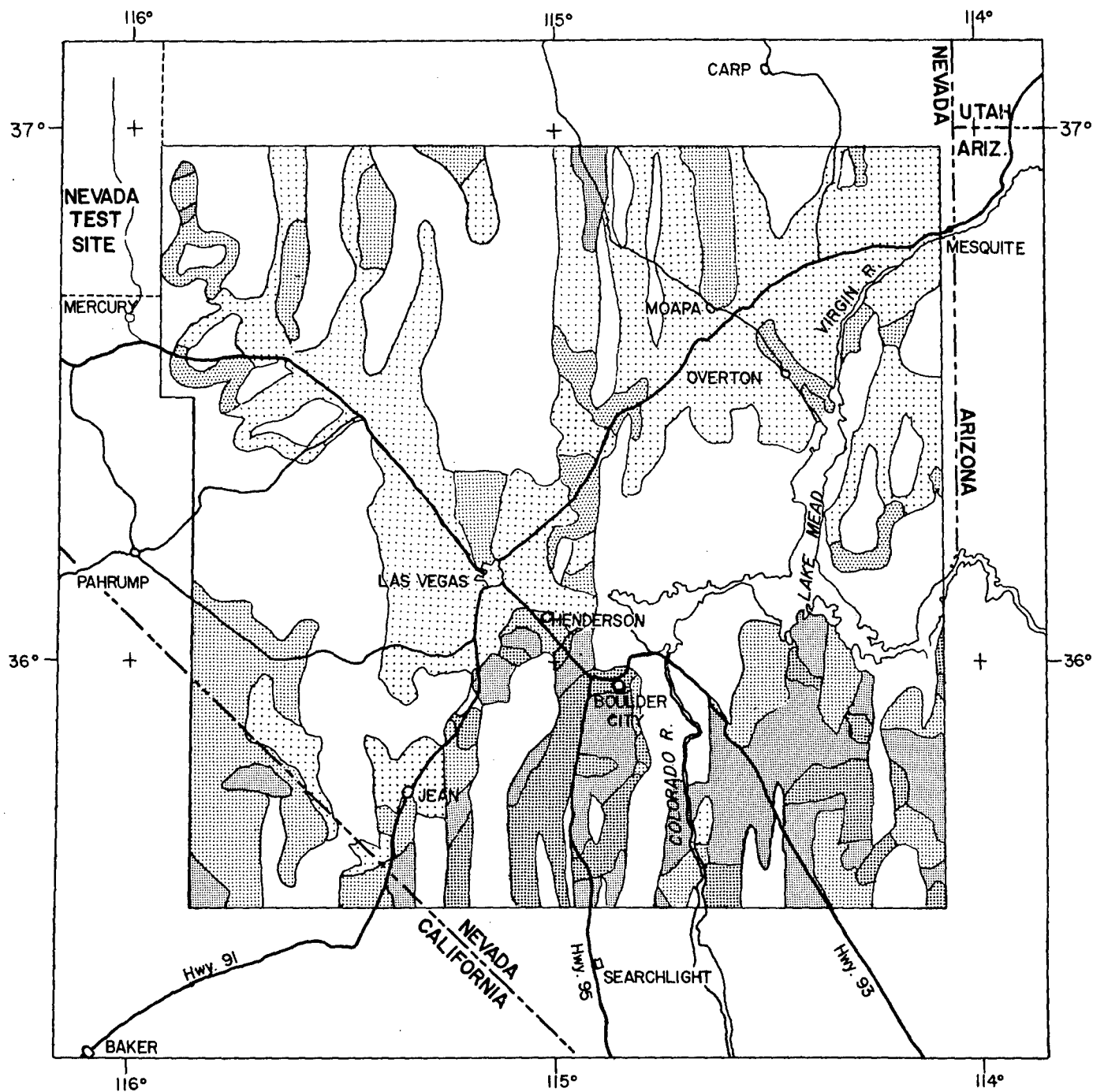
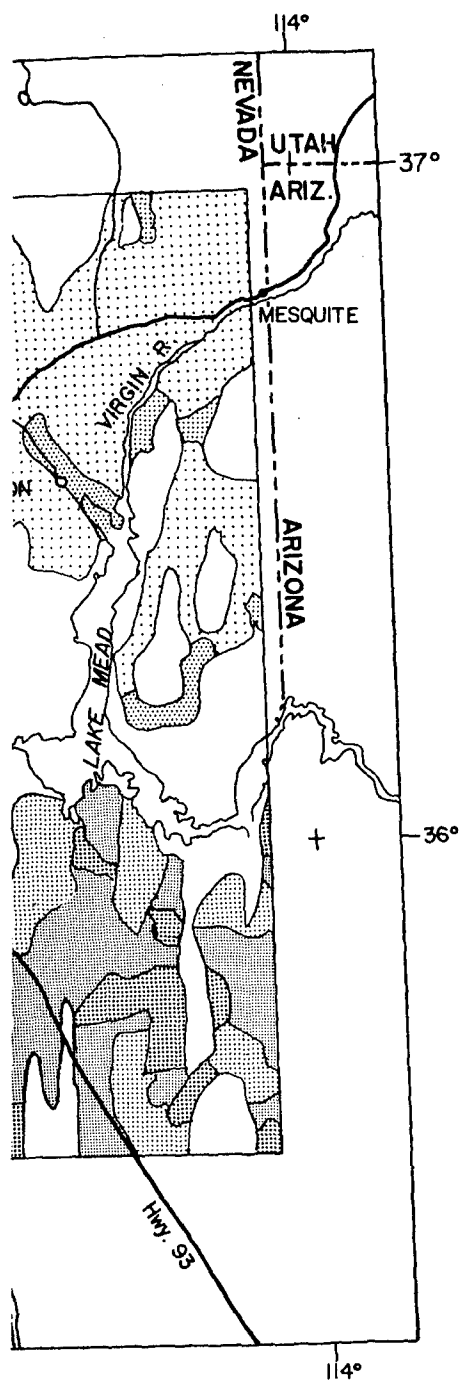


Fig. 6—Generalized aeroradioactivity map of the ARMS-II Las Vegas area.

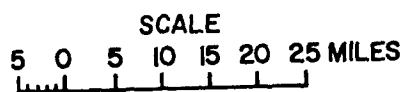
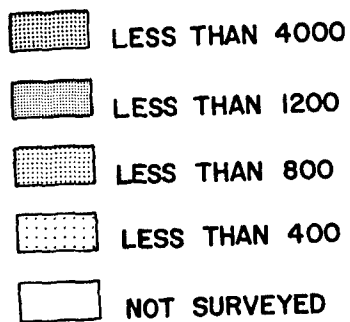
Suggested conversion factors

Co⁶⁰: 22 counts/sec at 500 ft = 1 μ r/hr at 3 ft

Cs¹³⁷: 25 counts/sec at 500 ft = 1 μ r/hr at 3 ft



**AERORADIOACTIVITY IN
COUNTS PER SECOND:**



ivity map of the ARMS-II Las Vegas area.

conversion factors

c at 500 ft = 1 μ r/hr at 3 ft

c at 500 ft = 1 μ r/hr at 3 ft

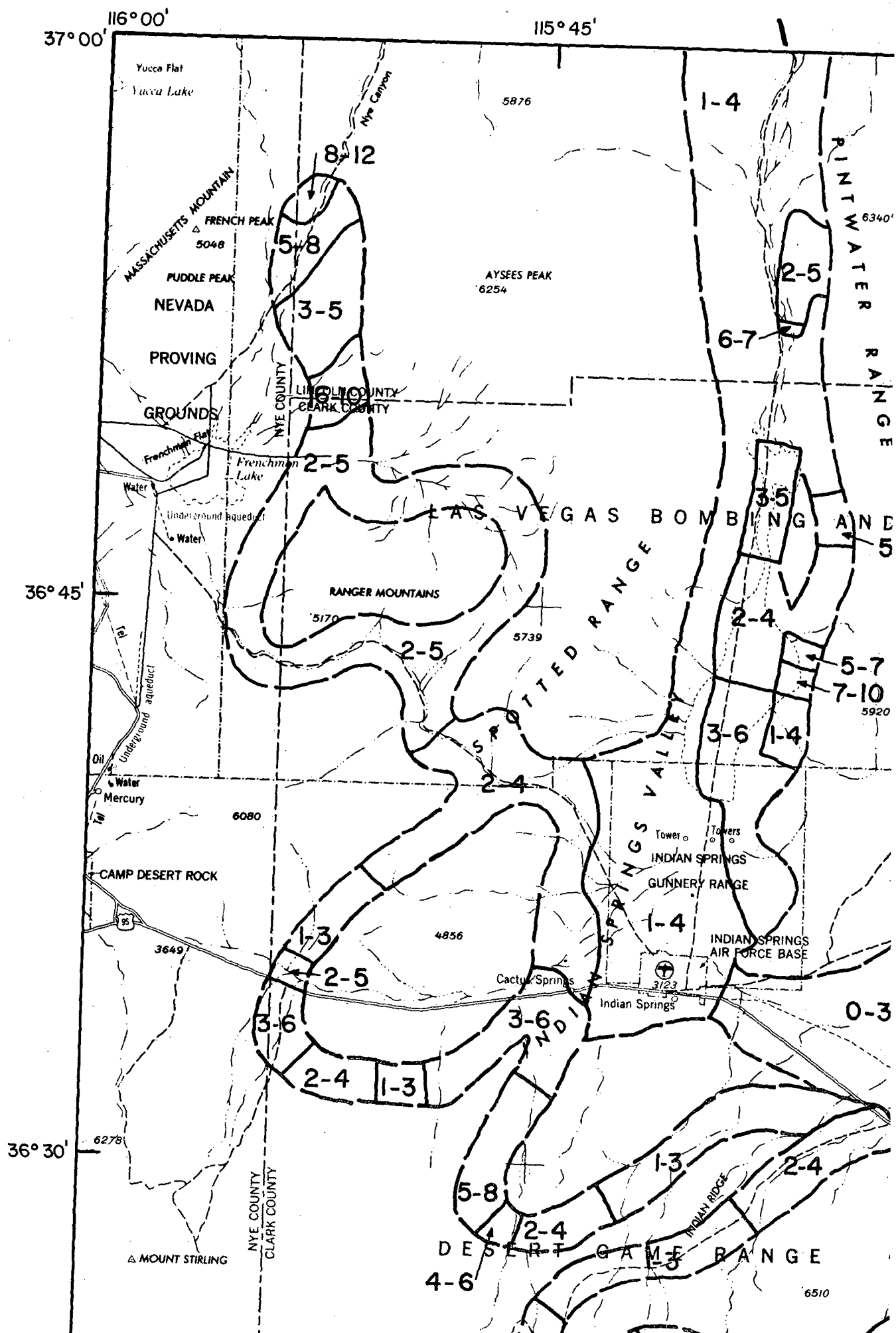
The radiation-detection and -measuring subsystem is sensitive to, and capable of recording, the environmental gamma background in a complex area where extremes of background radiation are encountered. The aircraft space-positioning subsystem can furnish accurate geographic locations in areas of flat and rugged topography and on straight or irregular flight lines.

Manual techniques for the reduction of the digital radiation and geographic position data have been developed to the point where data reduction can keep pace with surveying operations. Interpretation and reduction of the data are necessary to convert it to a form in which it can be presented on a map at a scale of 1:250,000 (or 4 miles equal 1 in.). The interpretation involves delineation of aeroradioactivity units or areas having similar gamma radioactivity. Depending on the local complexity of the environmental gamma background radiation, these units can have a wide or narrow range in count rate.

Aerial measurements of ground radiation in the ARMS-II Las Vegas area are almost everywhere consistent with what would be expected, considering the geology of the area. The north half of the area has a generally low aeroradioactivity, and the rocks in this part of the area are mostly carbonate and clastic rocks (which are usually weakly radioactive). The south half of the area has a relatively high aeroradioactivity; this was expected because of the amount of metamorphic and igneous rock exposed in this part of the area. In a few places in the northwest part of the area adjacent to the Nevada Test Site, there is a suggestion that nuclear debris might influence the boundaries of aeroradioactivity units. Environmental levels of gamma radioactivity due to natural plus artificial radionuclides in these areas, however, are less than one-half those due to natural radionuclides in many parts of the south half of the Las Vegas area. In no part of the Las Vegas area is the environmental radiation greater than that found in many parts of the United States.

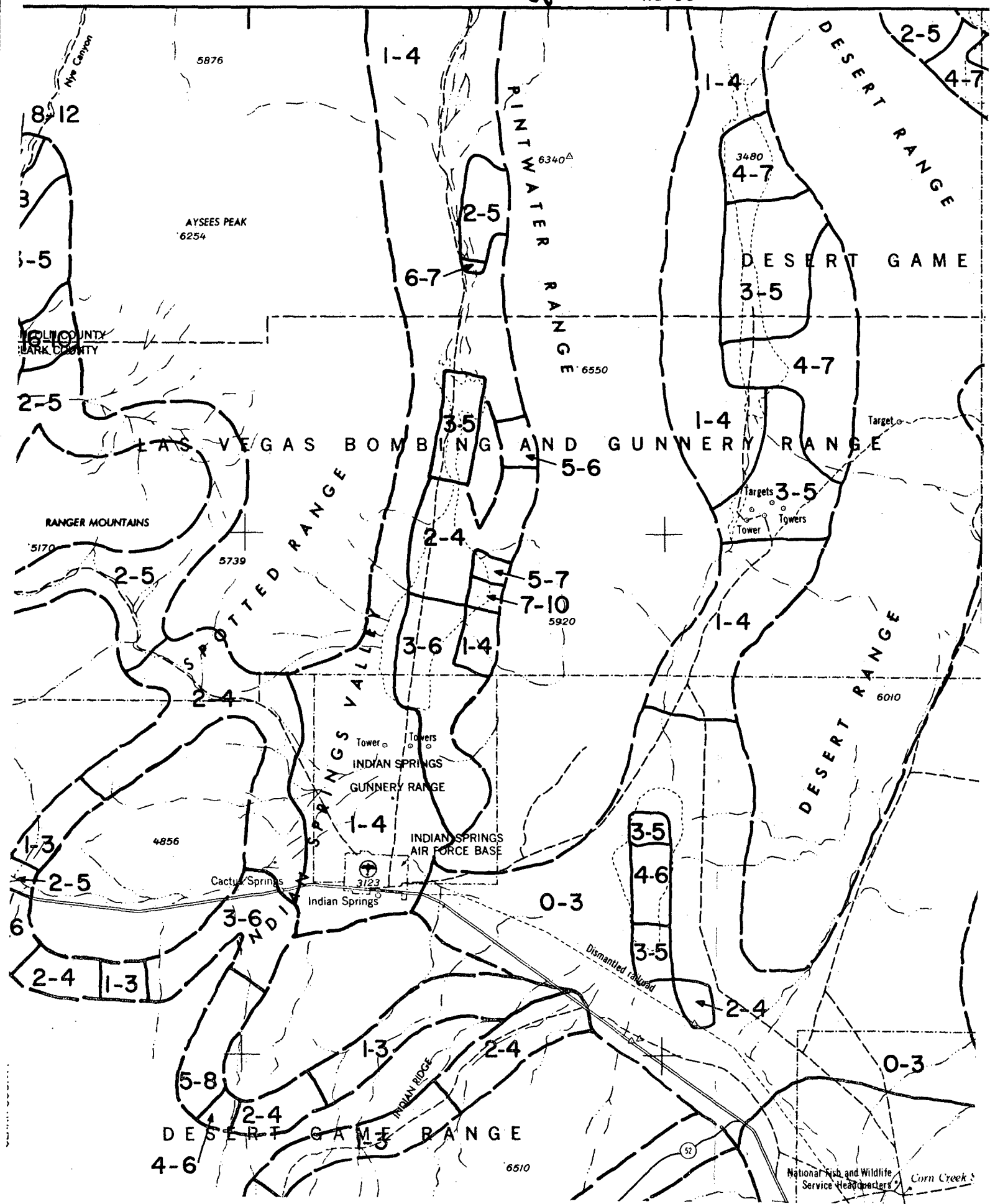
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1. F. J. Davis and P. W. Reinhardt, Extended- and Point-source Radiometric Program, USAEC Report CEX-60.3, Oak Ridge National Laboratory (in preparation).
2. Edgerton, Germeshausen & Grier, Inc., Uses of ARMS Data (in preparation).
3. R. F. Merian, J. G. Lackey, and J. E. Hand, Aerial Radiological Monitoring System. I. Theoretical Analysis, Design, and Operation of a Revised System, USAEC Report CEX-59.4, Edgerton, Germeshausen & Grier, Inc., July 1960.
4. F. J. Davis, Oak Ridge National Laboratory (CEX report in preparation).
5. Ben Bowyer, E. H. Pampeyan, and C. R. Longwell, Geologic Map of Clark County, Nevada, U. S. Geological Survey Min. Inv. Field Studies Map MF 138, 1958.
6. D. F. Hewett, Geology and Mineral Resources of the Ivanpah Quadrangle, California and Nevada, U. S. Geological Survey Prof. Paper 275, 1956.
7. C. W. Jennings, Geologic Map of California, Kingman Sheet, California Division of Mines, 1961.
8. F. C. Schrader, Mineral Deposits of the Cerbat Range, Black Mtns., and Grand Wash Cliffs, Mohave County, Arizona, U. S. Geological Survey Bull. 397, 1909.



115°45'

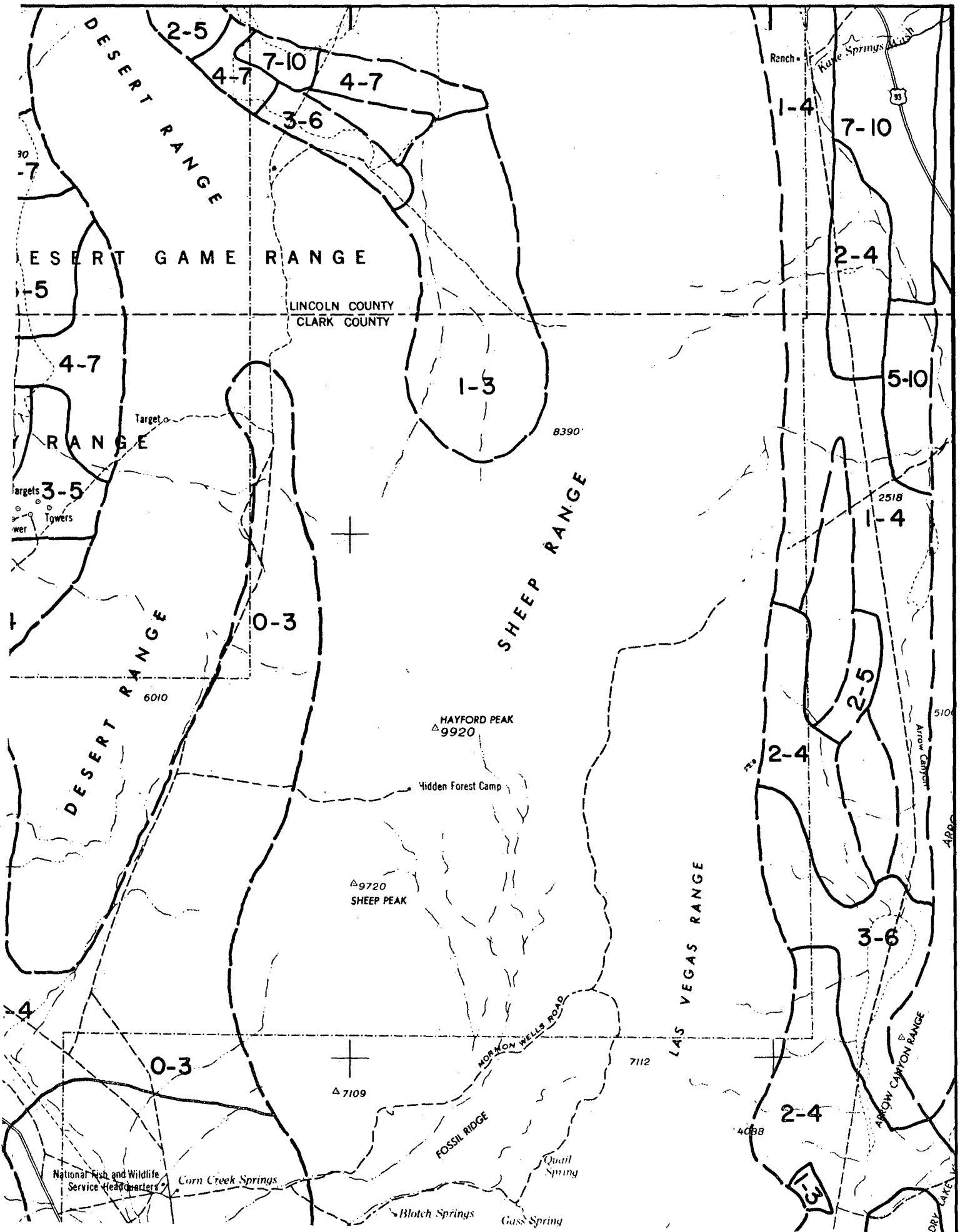
115°30'

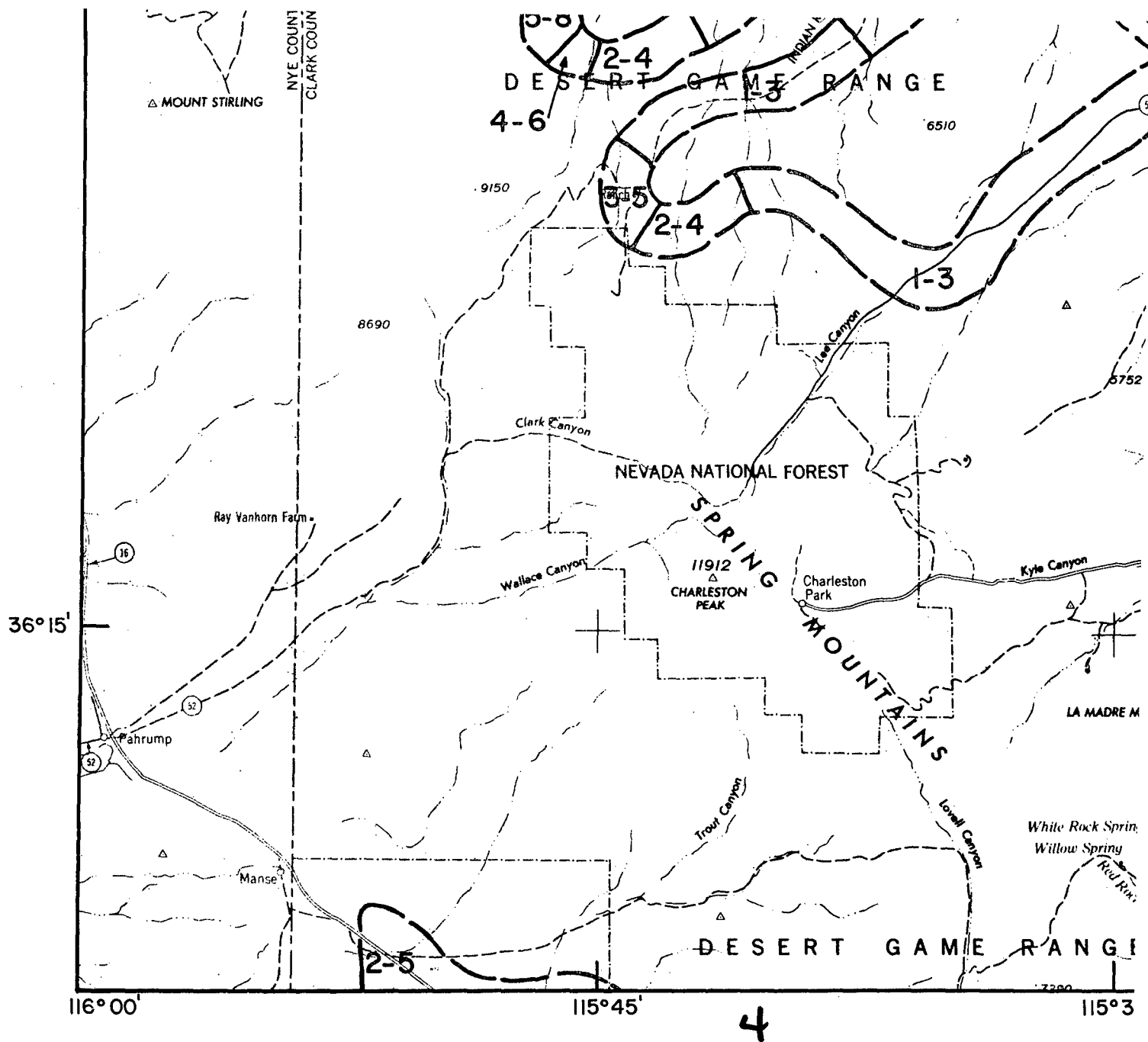


115°15'

3

115°00'





BASE FROM TOPOGRAPHIC MAPS
OF THE U.S. SCALE 1/250,000

KINGMAN
LAS VEGAS

AERORADIOACT LAS VEGAS AREA, NE

RADIOACTIVITY LEVELS IN HUNDREDS OF COUNTS
SURVEYED BY EG&G, INC., WITH AIRCRAFT N702

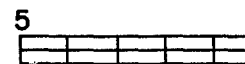
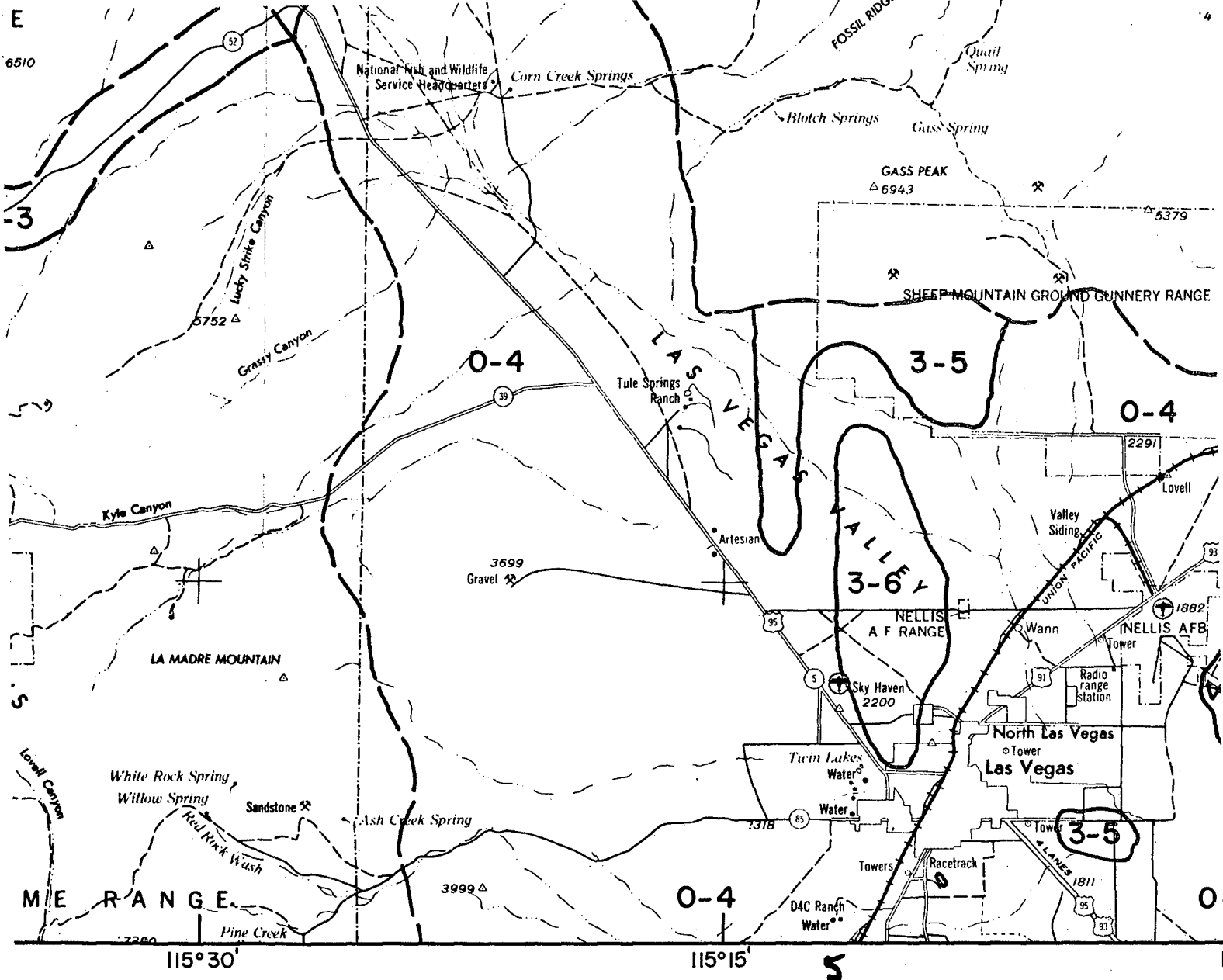


PLATE I NORTHWEST PART



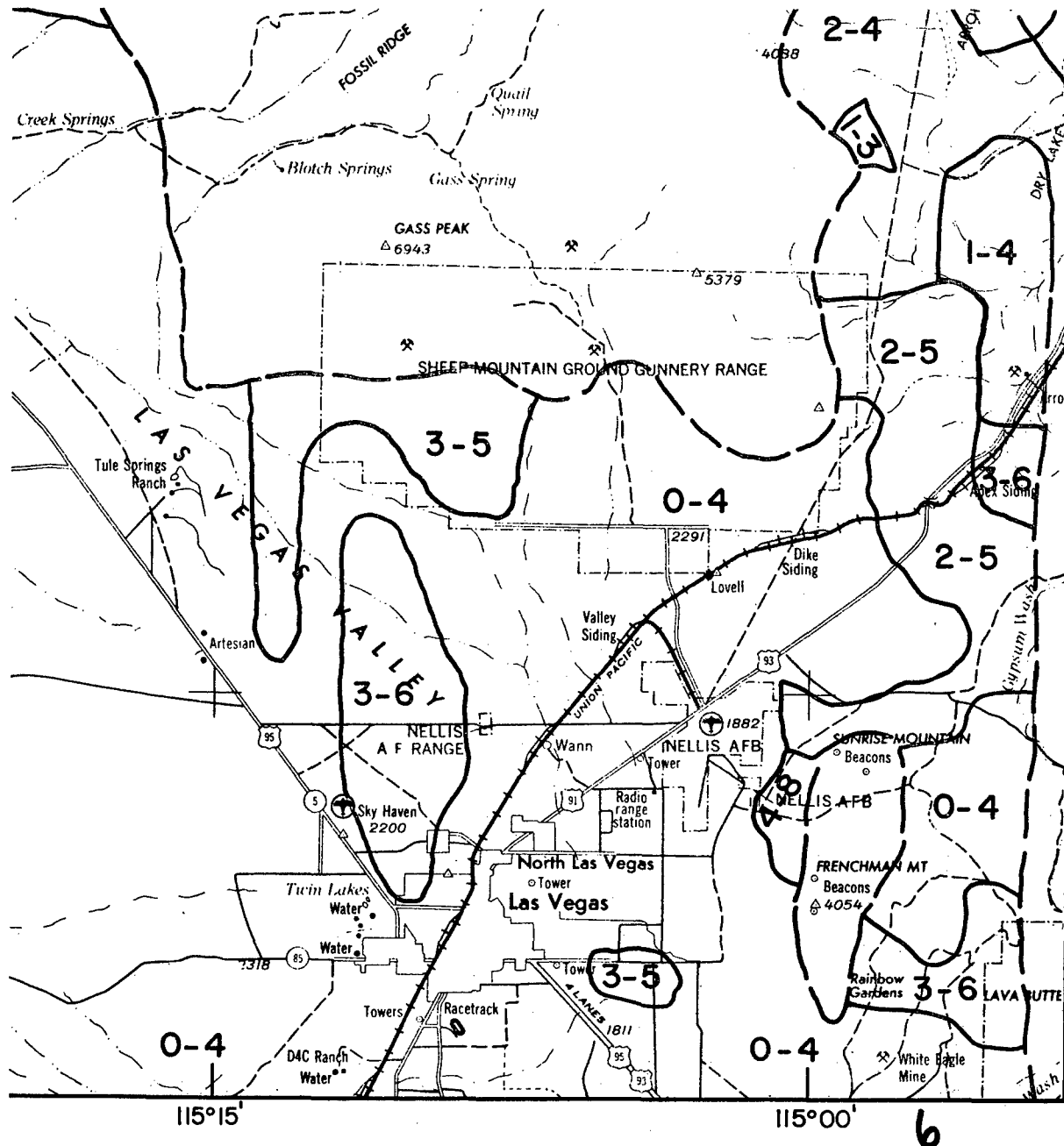
RADIOACTIVITY MAP (ARMS-II) **AREA, NEVADA, ARIZONA, AND CALIFORNIA**

SUGGESTED CONVERSION FACTOR
 25 counts/sec at 500 ft = $1 \mu r/hr$

OF COUNTS PER SECOND NORMALIZED TO 500 FT ABOVE GROUND
 CRAFT N702B
 MAY 21 - JUNE 23, 1961



— LIMIT OF SURVEYED AREA
 4-6 RADIOACTIVITY, 10^2 COUNTS/
 2-3 AERORADIOACTIVITY UNIT



RMS-II)

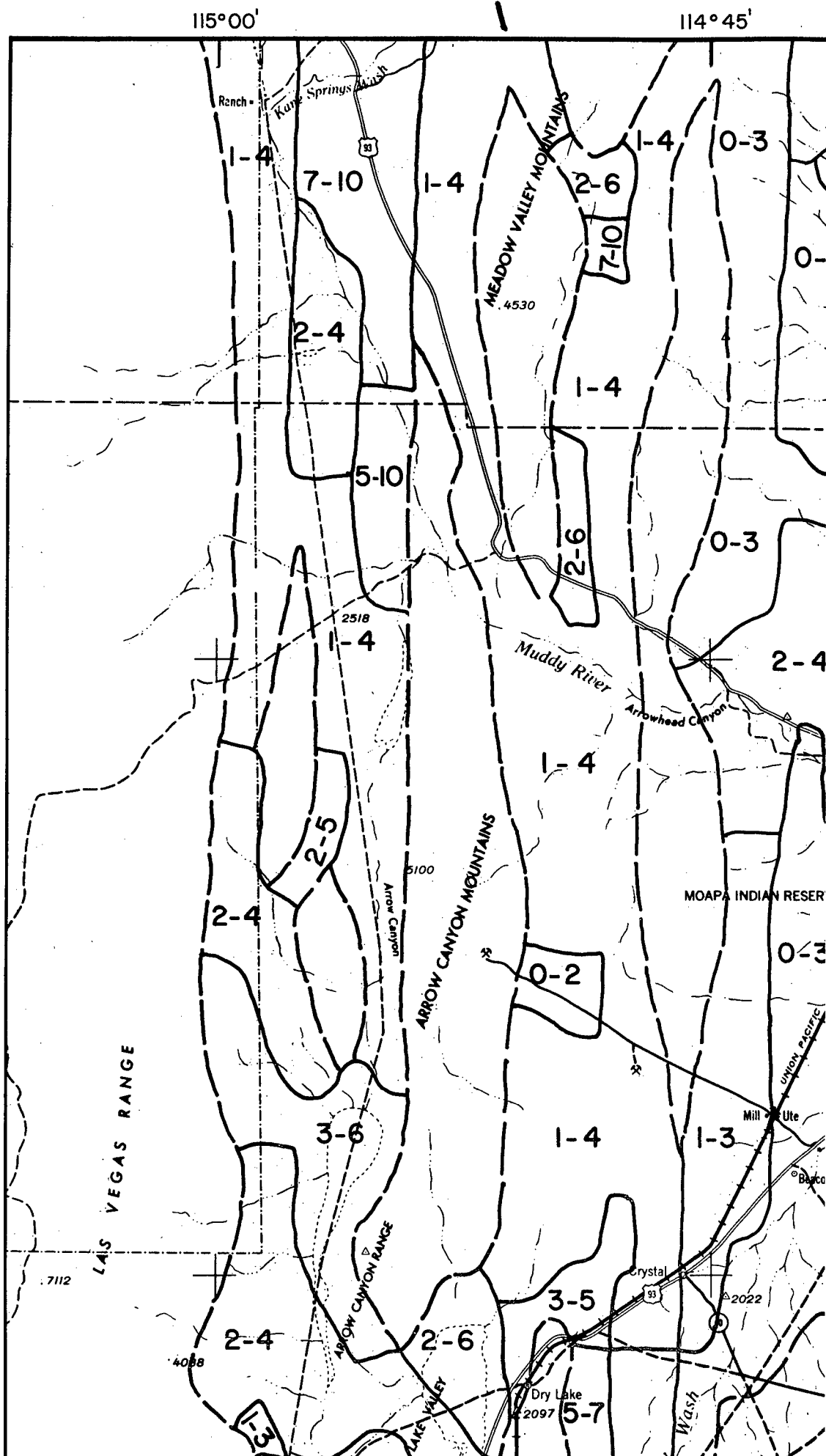
, AND CALIFORNIA

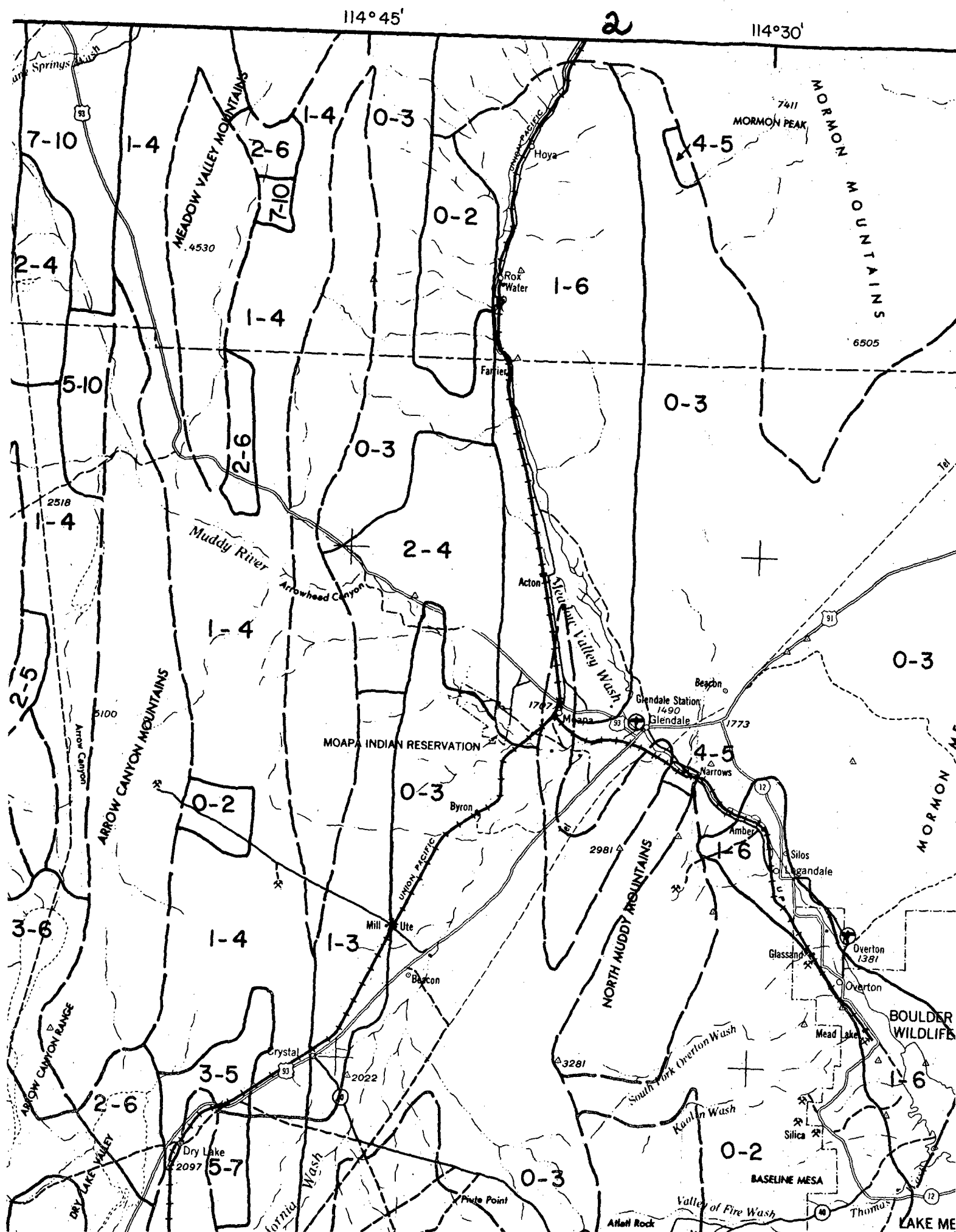
RMALIZED TO 500 FT ABOVE GROUND

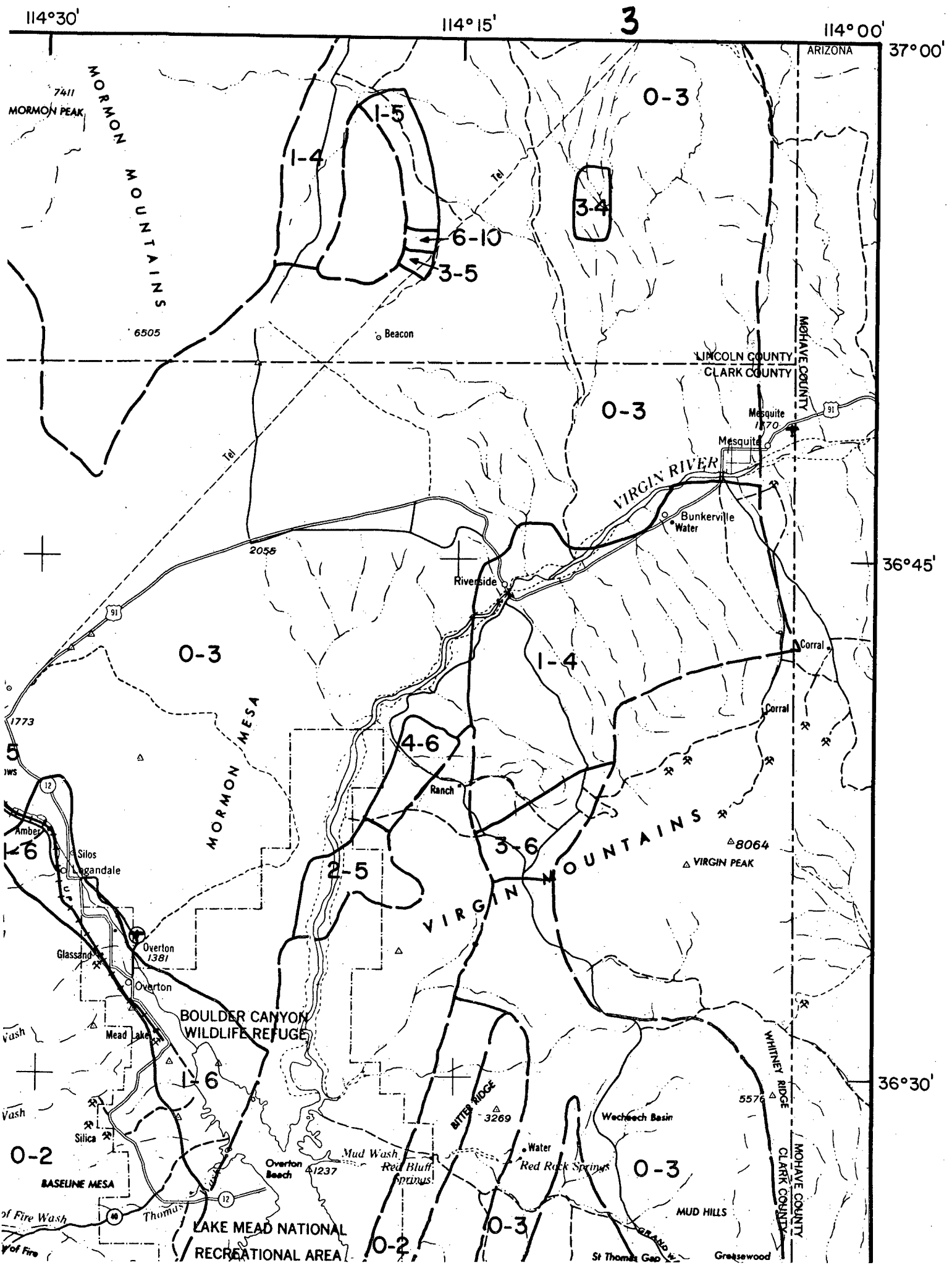
MAY 21 - JUNE 23, 1961

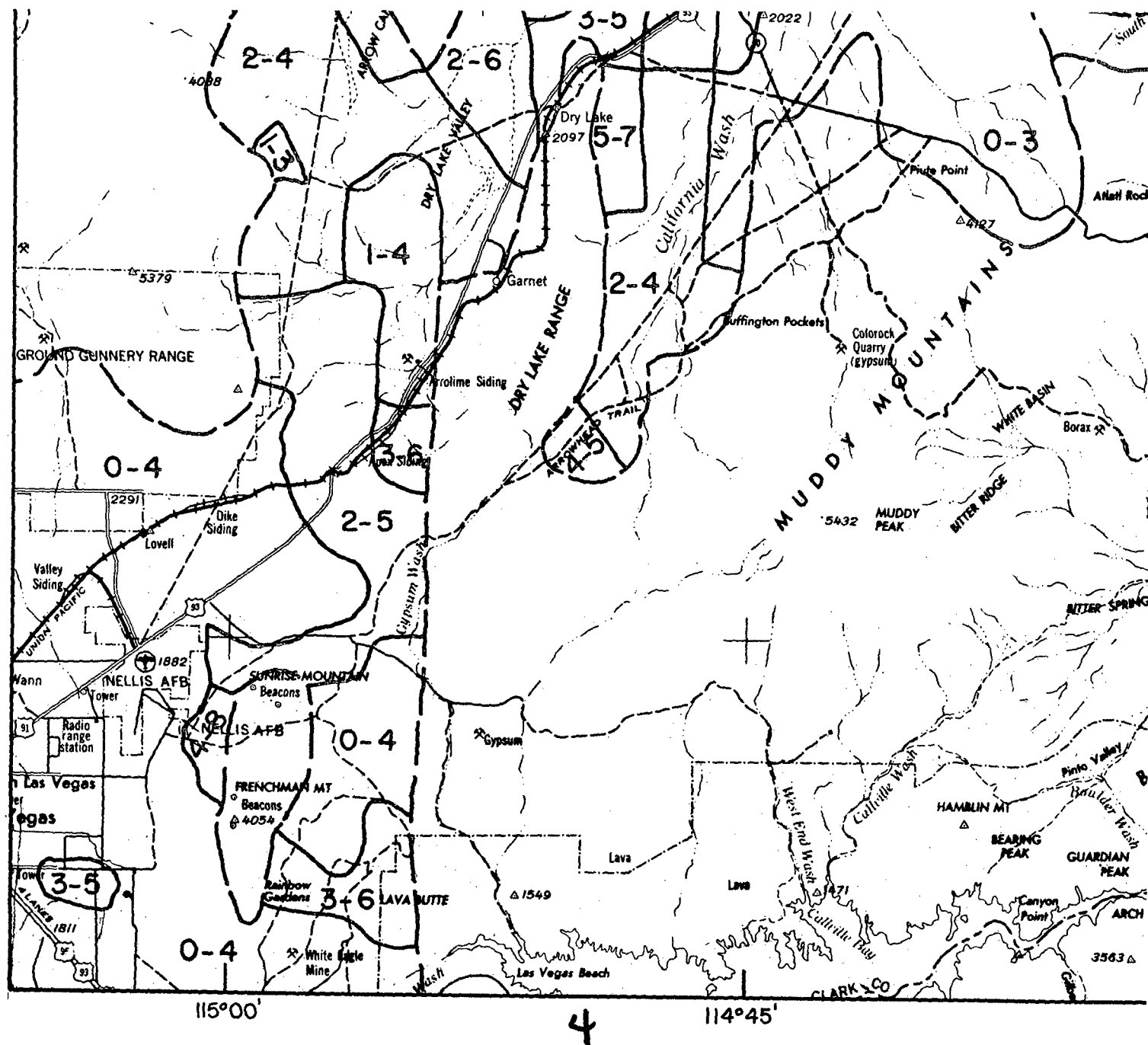
10

— LIMIT OF SURVEYED AREA
 — 4-6 RADIOACTIVITY, 10² COUNTS/SEC
 ○ 2-3 AERORADIOACTIVITY UNIT









BASE FROM TOPOGRAPHIC MAPS
OF THE U.S. SCALE 1/250,000

KINGMAN
LAS VEGAS

AERORADIOACTIVITY LAS VEGAS AREA, NEVADA

RADIOACTIVITY LEVELS IN HUNDREDS OF COUNTS PER
SURVEYED BY EG&G, INC., WITH AIRCRAFT N702B

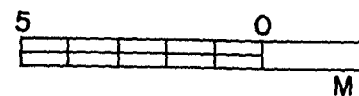
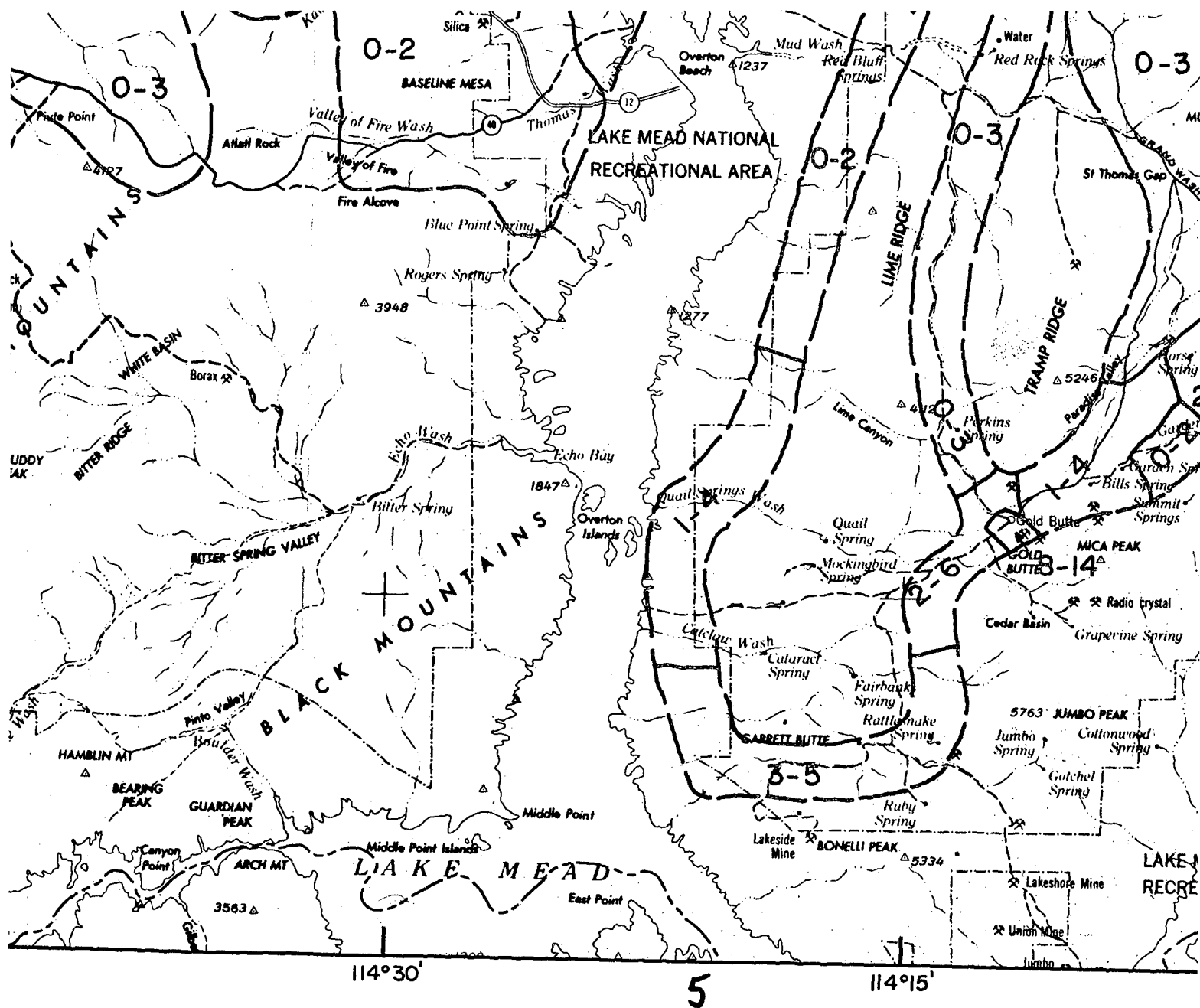


PLATE 2 NORTHEAST PART



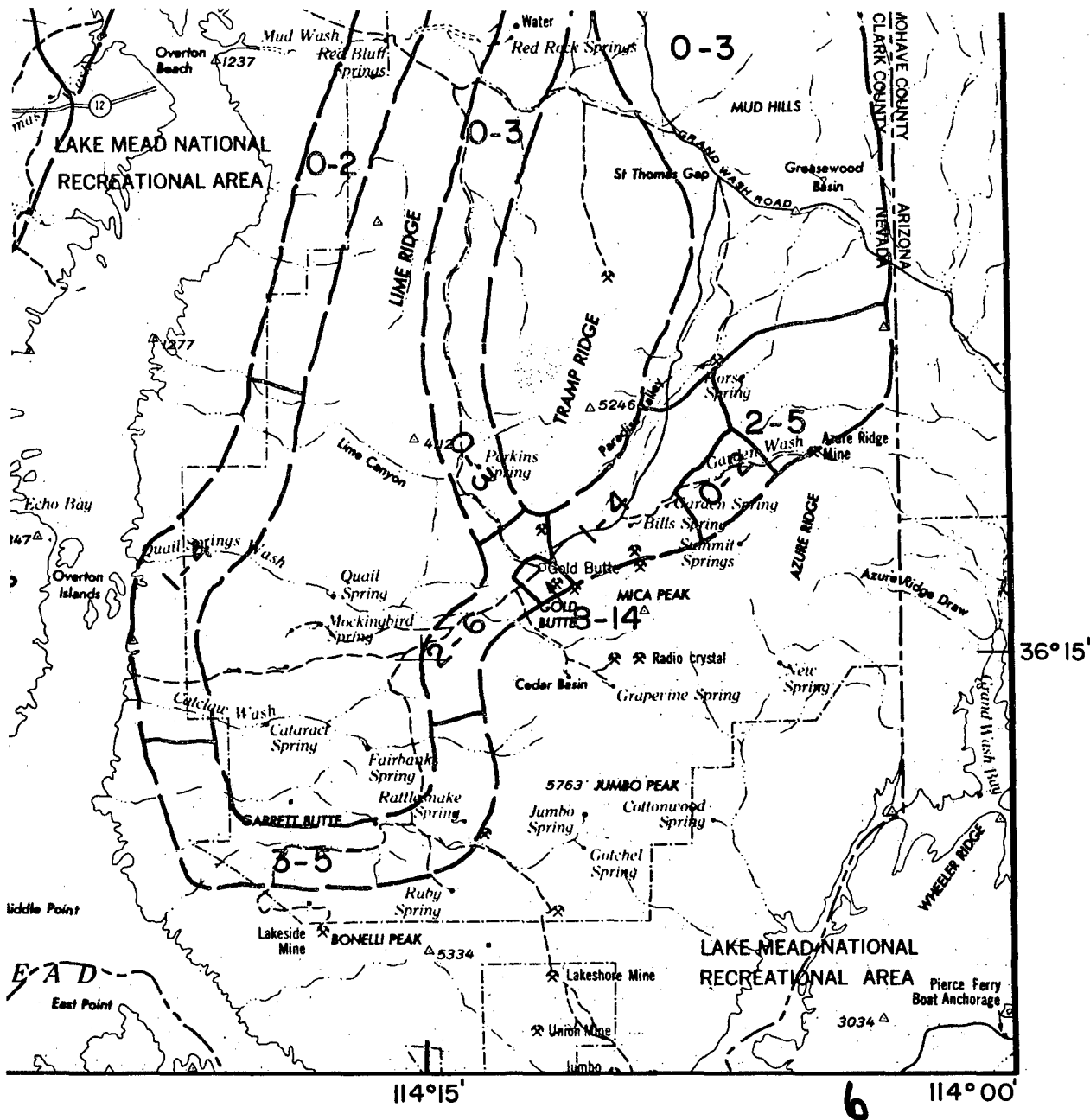
RADIOACTIVITY MAP (ARMS-II) **AREA, NEVADA, ARIZONA, AND CALIFORNIA**

OF COUNTS PER SECOND NORMALIZED TO 500 FT ABOVE GROUND
 RAFT N702B
 MAY 21 - JUNE 23, 1961

SUGGESTED CONVERSION FACTOR
 25 counts/sec at 500 ft = 1 μ r/hr at:



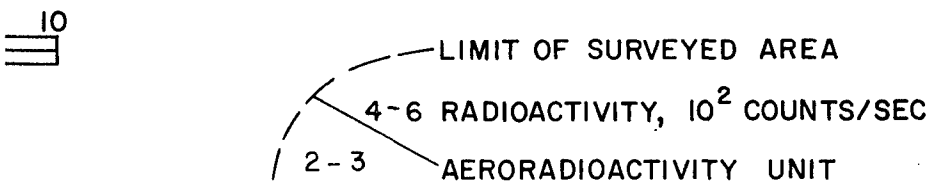
— LIMIT OF SURVEYED AREA
 4-6 RADIOACTIVITY, 10^2 COUNTS/SEC
 2-3 AERORADIOACTIVITY UNIT

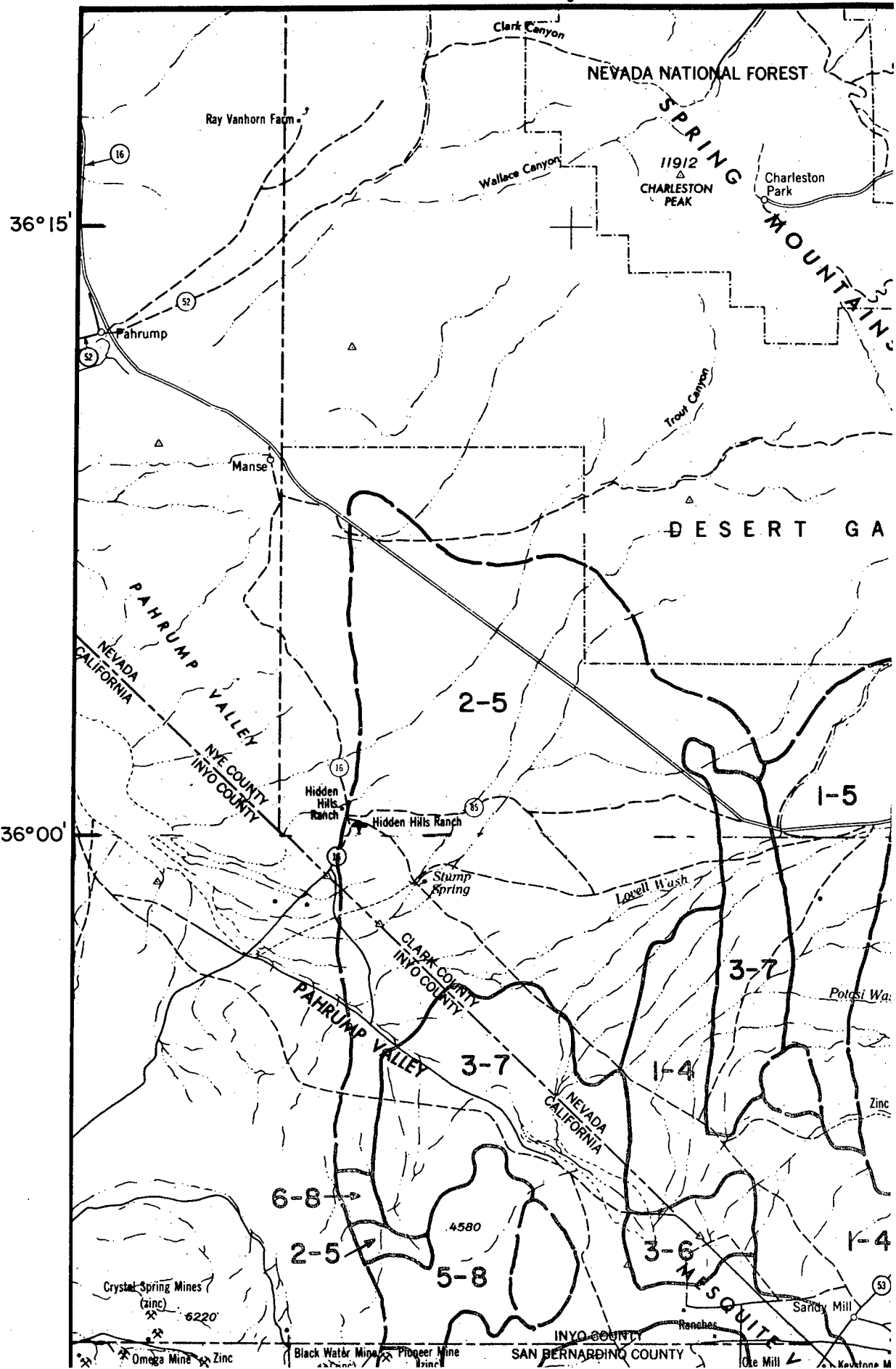


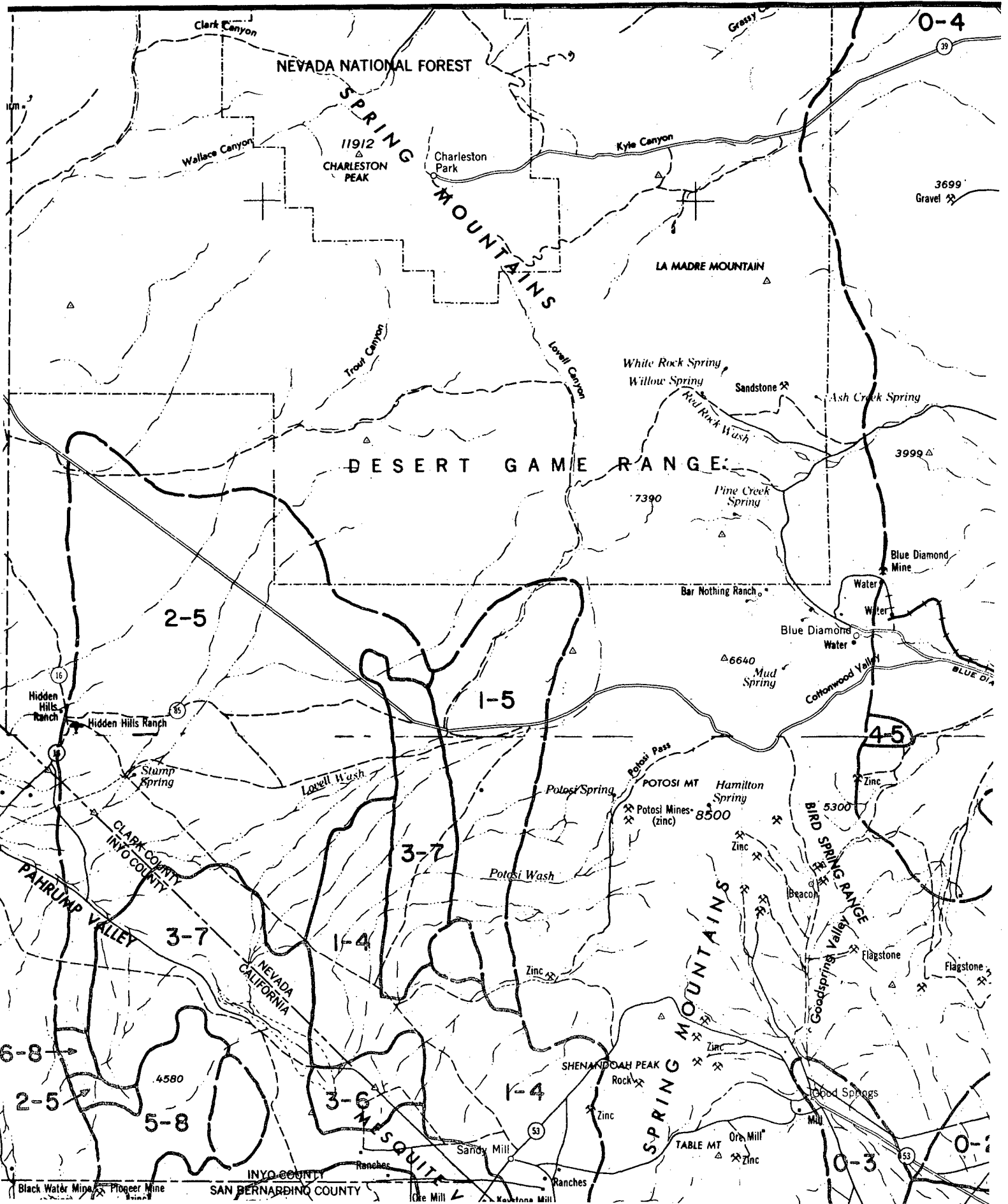
SUGGESTED CONVERSION FACTOR
25 counts/sec at 500 ft = $1\mu r/hr$ at 3 ft

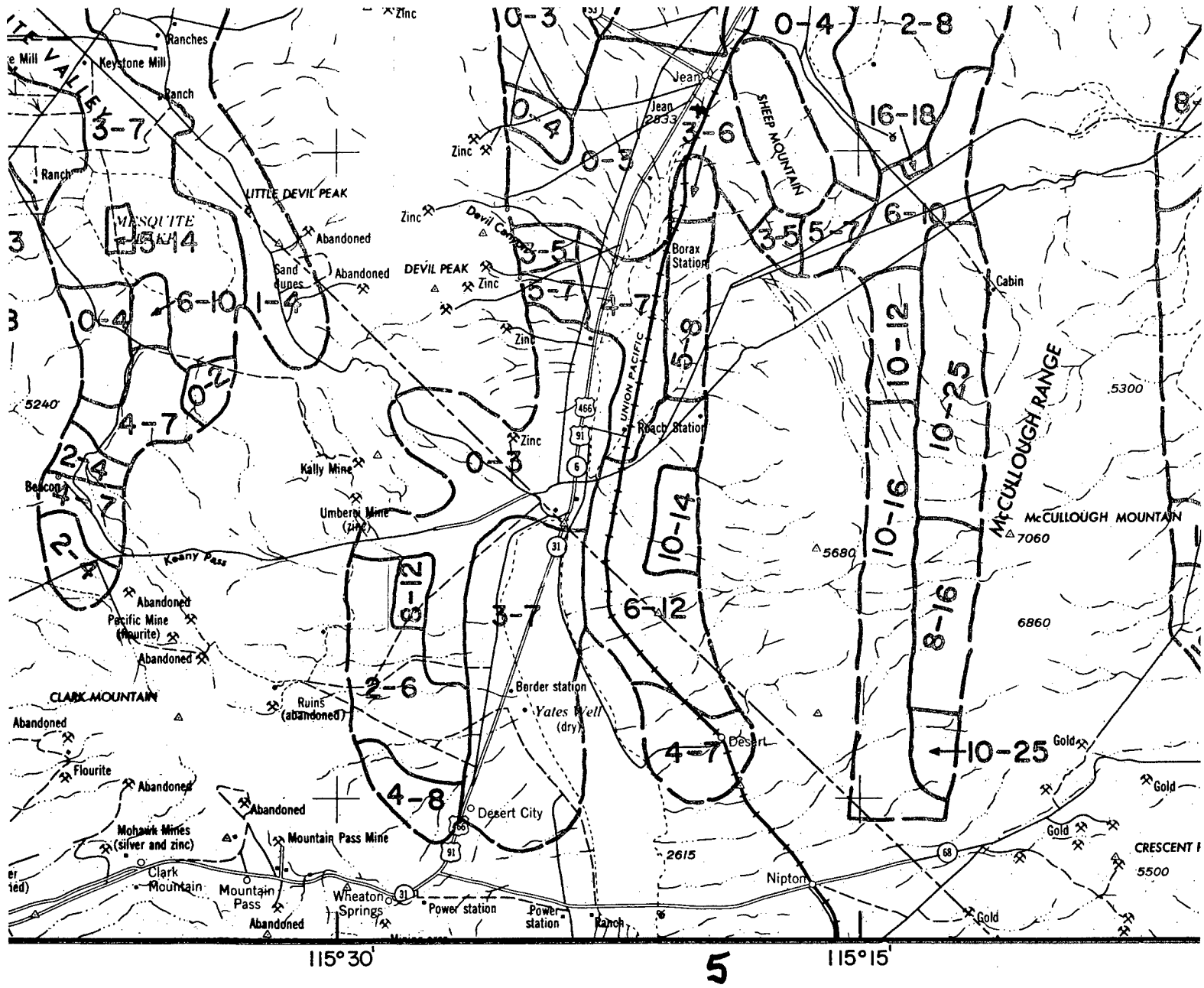
MS-II) AND CALIFORNIA

MALIZED TO 500 FT ABOVE GROUND
MAY 21 - JUNE 23, 1961









SUGGESTED COI
25 counts/sec at 5

AERORADIOACTIVITY MAP (ARMS-II)

VEGAS AREA, NEVADA, ARIZONA, AND CALIFORNIA

HUNDREDS OF COUNTS PER SECOND NORMALIZED TO 500 FT ABOVE
WITH AIRCRAFT N702B

MAY 21 - JUNE

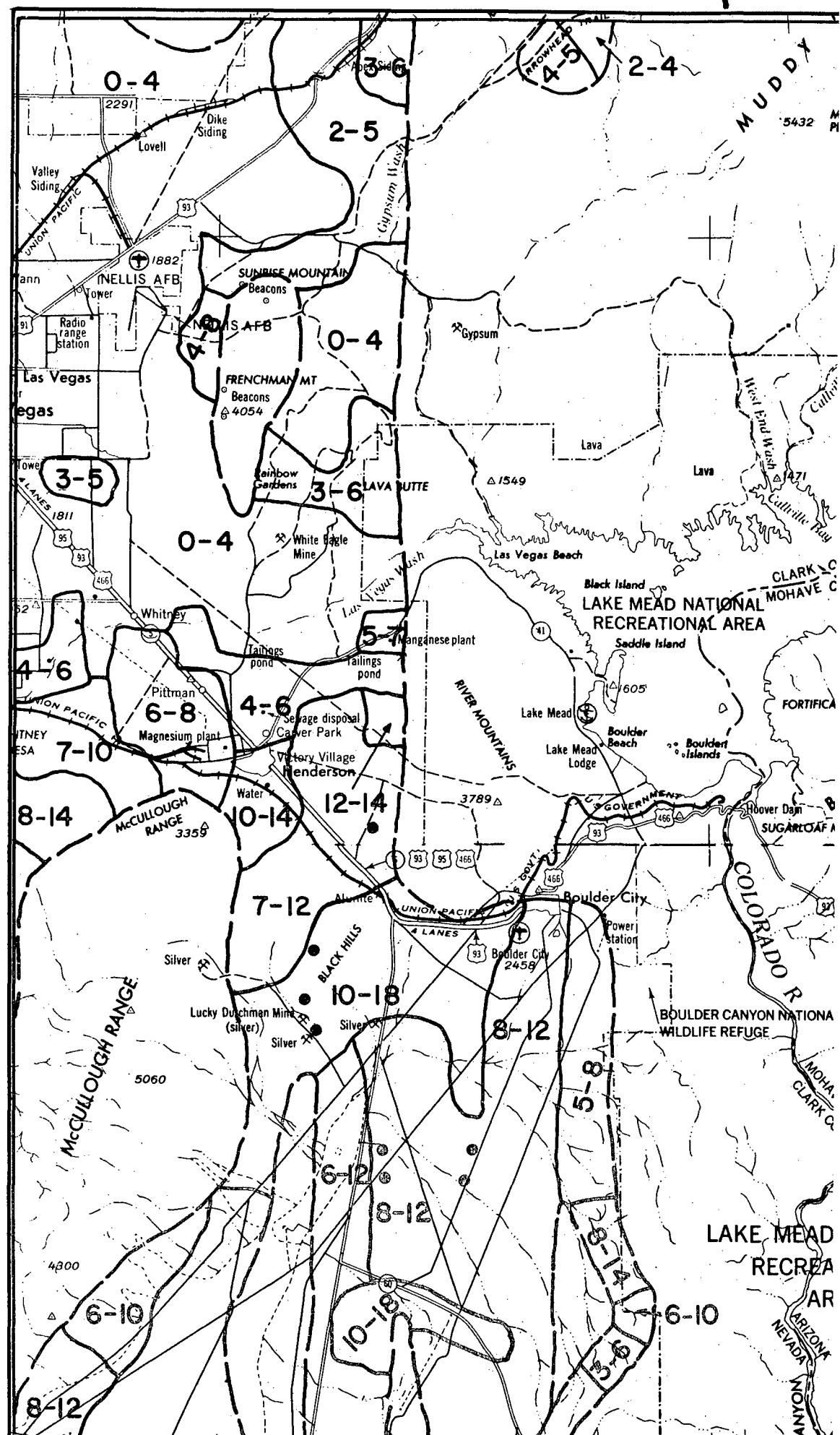
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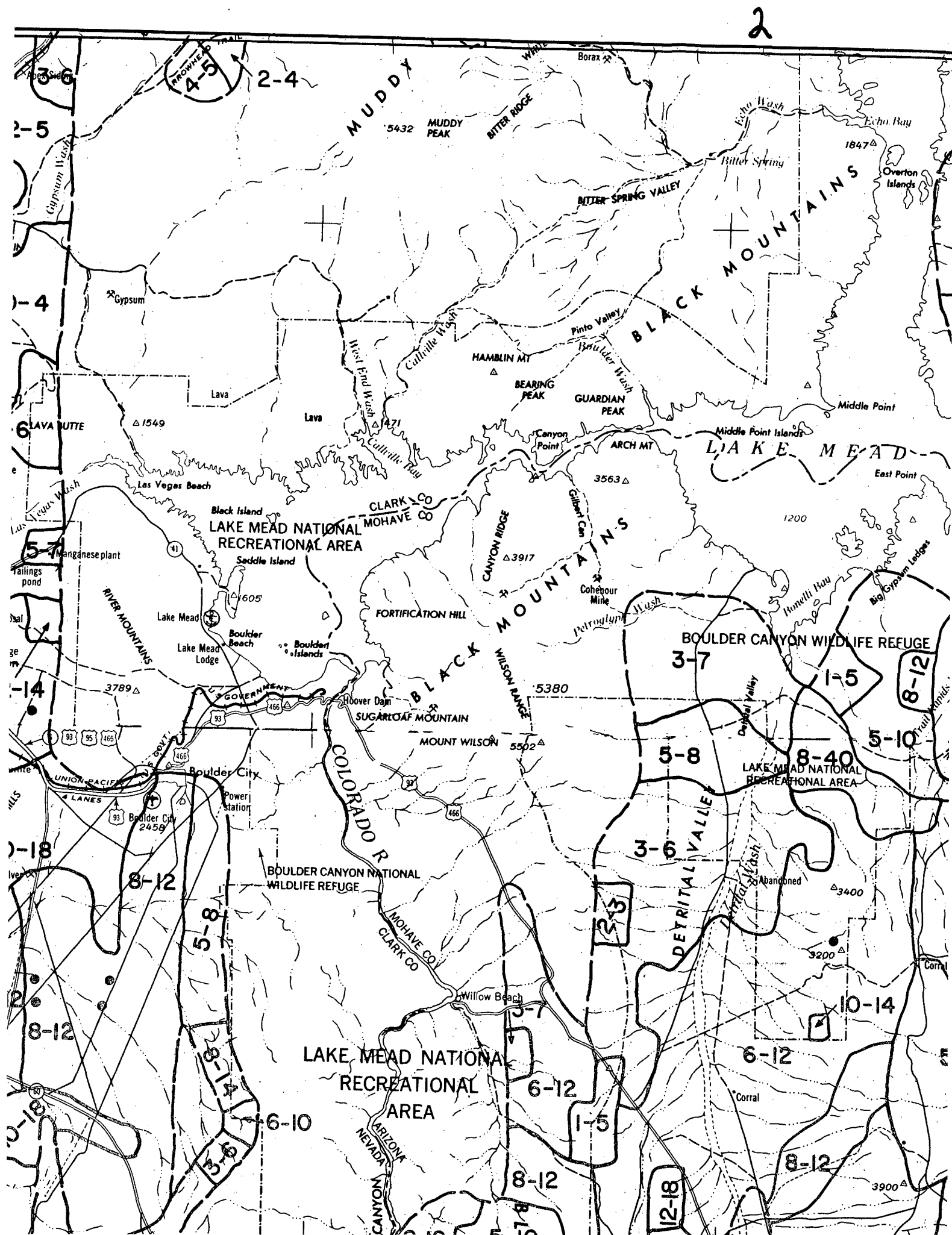
LIMIT OF SURV

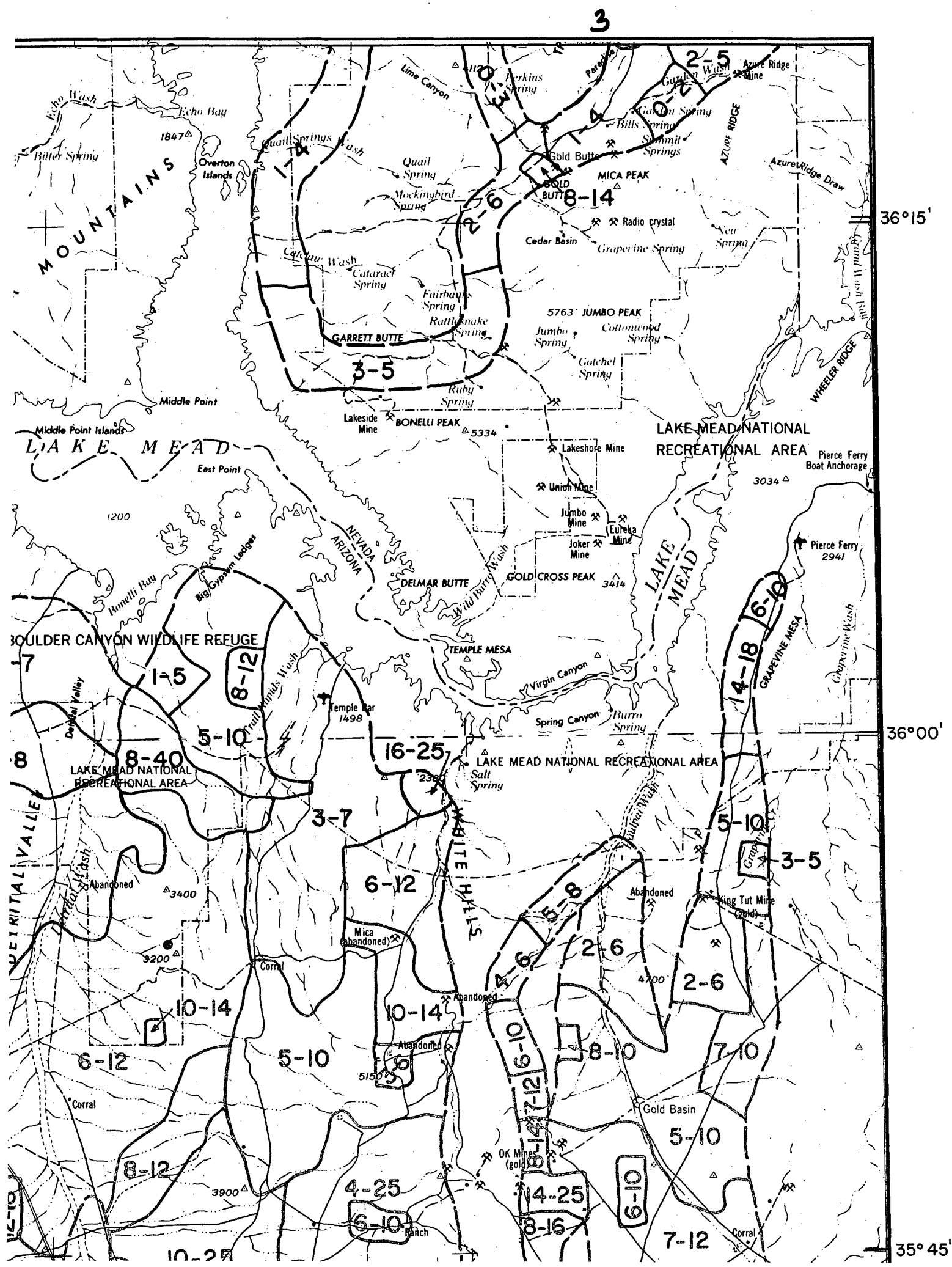
4-6 RADIOACTIVITY

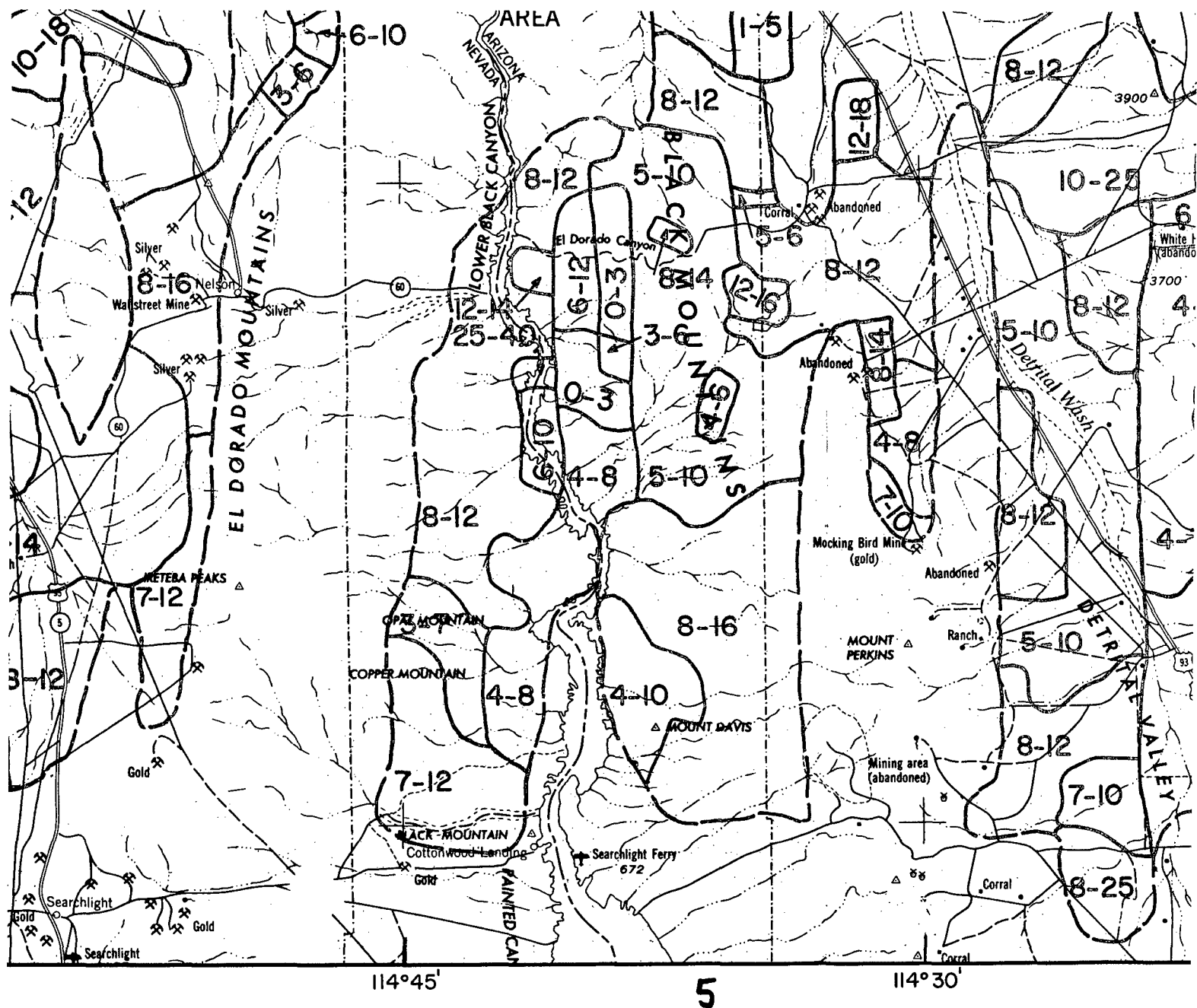
2-3 AERORADIOACT

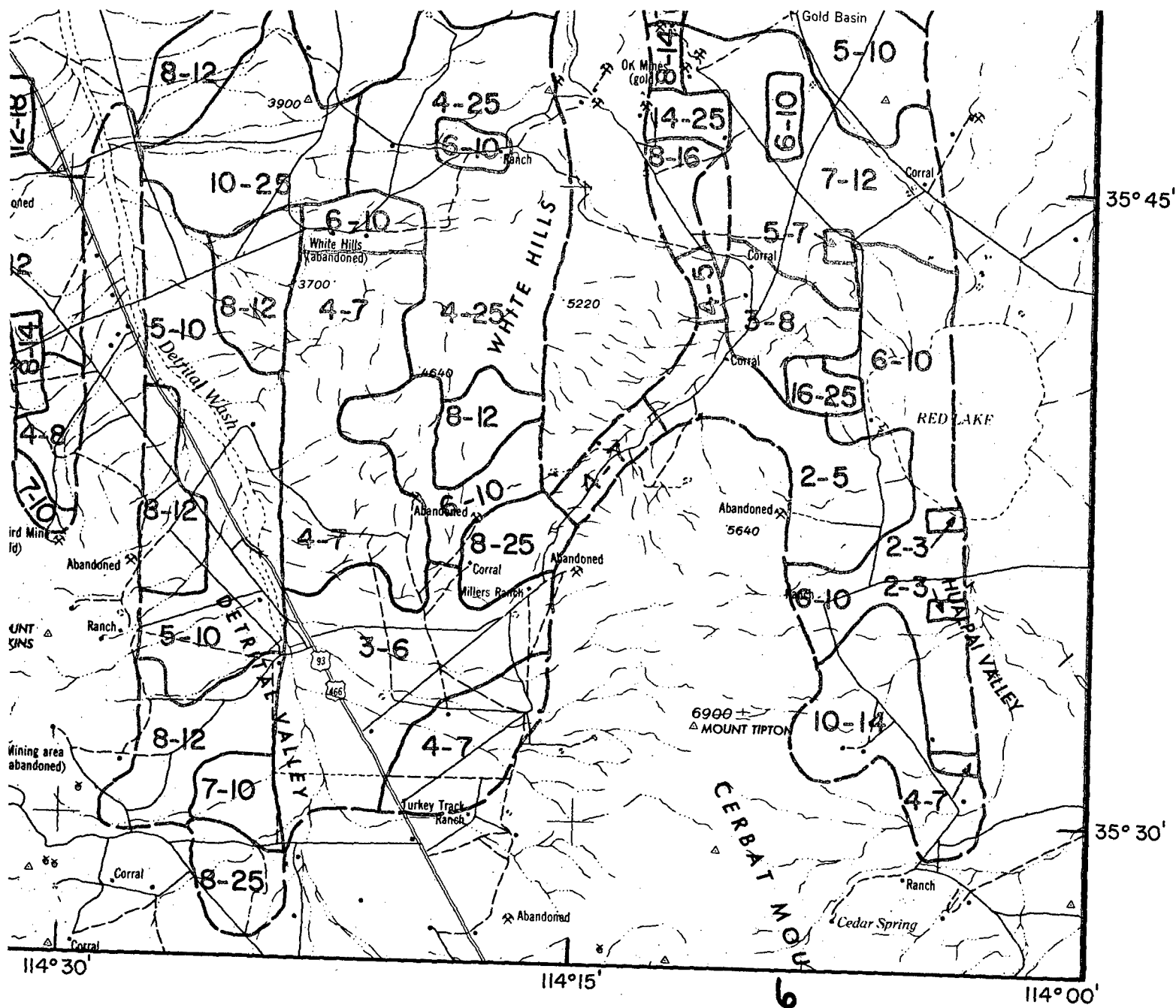
PART











SUGGESTED CONVERSION FACTOR
 25 counts/sec at 500 ft = $1 \mu r/hr$ at 3 ft