Report Number N18765

An Aerial Radiological Survey of the King and Pierce Counties, Washington

Summary Report

July 11-22, 2011

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Prepared for:

State of Washington
Department of Health

Aerial Measuring Systems
Remote Sensing Laboratory
National Security Technologies, LLC

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Derivative Classifier

ABSTRACT

As the result of a request from the State of Washington's Department of Health, the U.S. Department of Energy/National Nuclear Security Administration's Remote Sensing Laboratory (RSL) Aerial Measuring Systems (AMS) (operated by National Security Technologies, LLC [NSTec]) conducted an aerial background radiological survey of the King and Pierce Counties, Washington. The survey was executed during the two-week period of July 11-22, 2011 and resulted in 23 flights being flown over the King County, which includes the city of Seattle, an area of 345 square miles. Five flights were also conducted over the Pierce County, which includes the city of Tacoma, covering 60 square miles. The survey crew included personnel from the RSL-Nellis, Las Vegas, Nevada and RSL-Andrews, Suitland, Maryland locations.

Considering the sensitivity provided by twelve 2" × 4" × 16" sodium iodide thallium-activated NaI(*Tl*) crystals of the aerial acquisition system and flight safety considerations, a survey altitude of 300 feet Above Ground Level (AGL) was agreed upon. The flight pattern consisted of a set of parallel lines 600 ft apart. Several measurements were taken using a pressurized ionization chamber (PIC) and a high-purity germanium (HPGe) spectroscopic system at four specific locations on the ground (a runway at the King County airport was used as a survey test line) to validate the data derived from the aerial measurements.

Collected spectral data were processed and finalized as gross count (GC), man-made gross-count (MMGC), and isotopic extracted data, and are included as Geographic Information System (GIS) layers in a CD provided to the state of Washington Department of Health.

The baseline of natural background exposure rate values and any radiological anomalies present in the survey areas would be used in the event of a radiological emergency to compare radioactive contamination to the normal levels found during this study. The data from the background study will be referenced in the State Radiological Response Plan. The Washington State Department of Health, Office of Radiation Protection oversaw the project, which was funded by the U.S. Department of Homeland Security.

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INTRODUCTION

This Summary Report accompanies the Technical Report entitled: An Aerial Radiological Survey of King and Pierce Counties, Washington, prepared by the AMS Survey Team for the State of Washington Department of Health. The Technical Report contains detailed information on the survey equipment, survey procedures, quality control checks, data analysis and survey results (with identification of the detected radiological anomalies). This Summary is an abbreviated version of the Technical Report with fewer details concerning the surveying techniques, and data analysis.

An aerial radiological survey of portions of King County, including the city of Seattle, and Pierce County, including the city of Tacoma, in the state of Washington was conducted during the period July 11-22, 2011, at the request of the Washington State Department of Health. The survey area was divided into two distinctive sites. The first one covered a region of approximately 23 × 15 miles for a total area of 345 square miles and included the city of Seattle and a portion of King County. The second area, a rectangle of 8.6 × 7 miles (60 sq miles) covered the city of Tacoma and a portion of Pierce County. The survey was conducted by an Aerial Measuring Systems (AMS) team from the U.S. Department of Energy/National Nuclear Security Administration's (DOE/NNSA) Remote Sensing Laboratory (RSL), which is maintained and operated by National Security Technologies, LLC, at Nellis Air Force Base in Las Vegas, Nevada, and Andrews Air Force Base in Suitland, Maryland.

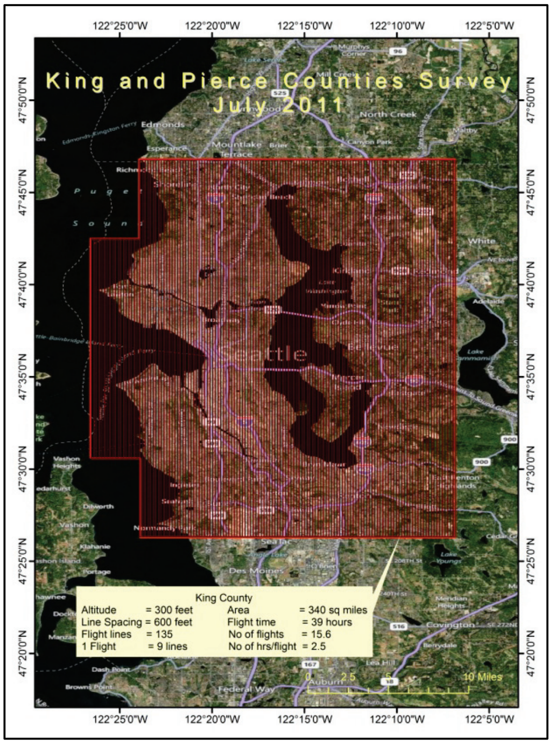
The survey was conducted for the Washington State Department of Health and was funded by the U.S. Department of Homeland Security (DHS). The purpose of the survey was to provide the state with current radiation background readings for the specified areas (the largest population centers of the state of Washington). The importance of the data from the background survey will be referenced and used as a baseline for the State Radiological Response Plan. The intent of the plan is to coordinate radiological response policies among the responding agencies in the Urban Area Security Initiative (UASI), to provide radiological response and recovery guidance, and to provide a series of Protective Action Recommendations that can be used to coordinate various response and recovery activities.

The RSL aerial survey data products are presented in the form of contour maps superimposed on maps of the surveyed areas. The products present the gamma-ray exposure rates (ER) attributable to natural radioactive nuclides and any man-made radiological anomalies expressed in terms of standard deviations above background.

The data collected by the RSL AMS team used a radiation data acquisition system built by Radiation Solutions Inc., based on an array of twelve 2" × 4" × 16" sodium iodide thallium-activated NaI(*Tl*) detectors, flown onboard a twin-engine Bell 412 helicopter and were geo-referenced using a differential Global Positioning System (DGPS). Gamma energy spectra were collected continuously each second during the survey. This spectral data provides the capability to distinguish ordinary fluctuations in the natural background radiation levels and radiological signatures produced by man-made radioactive sources. Spectral data can also be used to identify specific radioisotopes and produce isotope-specific contour maps.

SURVEY SITE DESCRIPTION

The two survey areas in King and Pierce Counties, with the planned survey flight lines, are shown in Figure 1.



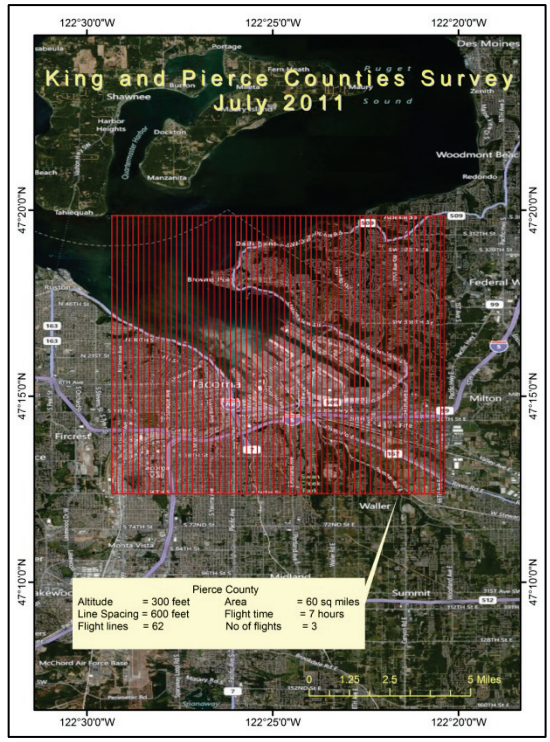


Figure 1. ***King County (left) and Pierce County (right) survey area and planned flight lines.***

The King County survey area covered approximately 345 square miles and included the Seattle metropolitan area. The area was roughly bounded by Puget Sound to the west, the city of Redmond to the east, SeaTac Airport to the south, and the I-5/104 intersection to the north. This area includes the densely populated urban centers of Seattle, as well as several of the adjacent suburbs, with a metropolitan population of about 3.5 million. A small portion of the survey lines was flown over the waters of Puget Sound. To reduce the flight time over water, the first 18 lines on the west side were shortened. Seattle is located at a mean-sea-level (MSL) elevation that varies from 0 ft to 520 ft.

The Pierce County survey area was bounded by Commencement Bay on the north, South 56th Street on the south, Union Avenue on the west, and South 1st Avenue on the east. The rectangular survey area covered approximately 60 square miles. The city elevation is about 240 ft MSL.

SURVEY PROCEDURE

Aerial Measurements

The aerial survey was planned to provide one-hundred percent coverage of the designated survey area with the aerial detector footprint. This task was accomplished by flying sets of parallel flight lines with the spacing twice the flight altitude. In the case of the King County and Pierce County survey, with the flight altitude selected as 300 ft AGL, the flight lines were spaced 600 ft apart. The areas were surveyed at a nominal ground speed of 70 knots (~120 ft/sec.)

The basic methodology of the aerial radiological survey is presented in Figure 2.

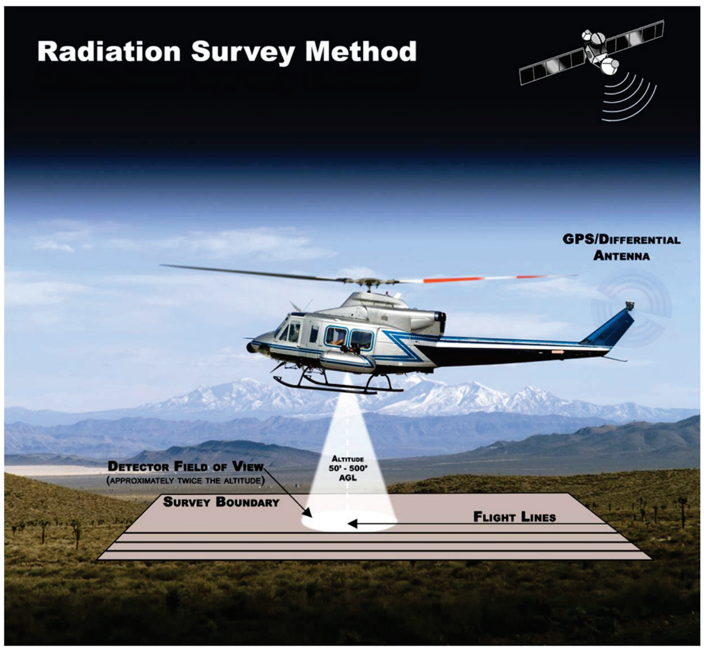


Figure 2. ***Methodology of the aerial radiation survey***

Completing the King County survey area required establishing 135 flight lines, and as the helicopter's fuel capacity restricted the flight time to approximately 2.5 hrs, (on average nine lines were flown during each flight), resulting in a total of 23 flights to completely cover the survey area. As the Pierce County survey area was significantly smaller in surface area, it required only 62 flight lines and five 2.5-hr flights to complete the survey. In both cases, the lines were arranged in a north-south direction and were flown starting with the lines on the western edge of the survey area progressing east.

For quality assurance and system background measurements, at the beginning of each flight, the fixed land-test line and water-test-line were flown at the nominal survey altitude of 300 ft AGL. The same over flight was repeated after completion of the survey flight-lines, just before landing for refueling. The refueling was done at the King County International Airport/Boeing Field, Tukwila, Washington in the Clay Lacy Fixed Base of Operation (FBO).

SURVEY EQUIPMENT

Rotary Wing Bell 412 and RSI Data Acquisition System

AMS utilized a Bell-412 helicopter (Figure 3) and a detection system acquired from Radiation Solutions Inc. for AMS applications (Figure 4). The Bell-412 is a twin engine utility helicopter that has been manufactured by Bell Helicopter since 1981. With a standard fuel capacity of 330 gallons, it is capable of flying for up to 3.7 hours, with a maximum range of 356 nautical miles and a cruising speed of 122 knots. However, with the AMS radiation survey configuration of 12 detectors, four crew members (two pilots, a mission scientist and an equipment operator), the AMS Bell 412 was capable of 2.5 hours of flight time with a survey speed of 70 knots (120 feet/sec) at survey altitude of 300 ft AGL.

Figure 3. ***AMS Bell 412 helicopter with externally mounted radiation detector pods.***

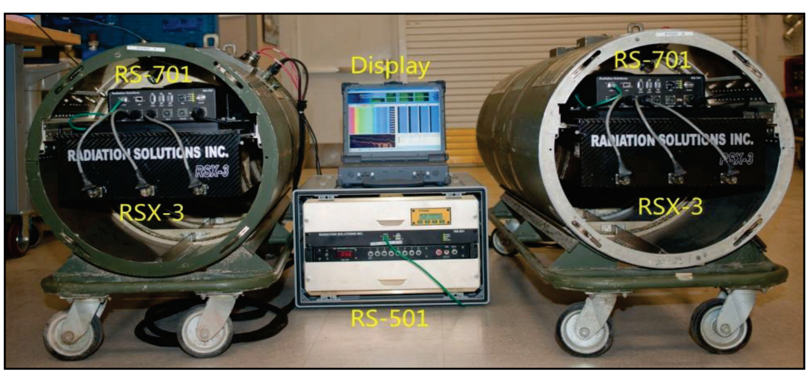


Figure 4. ***Components of the AMS RSI Aerial Radiation Data Acquisition System***

The RSI system, configured for AMS applications, employs a total of twelve sodium iodide thallium-activated NaI(*Tl*) crystals, fabricated as log-type detectors with dimensions of 2" × 4" × 16" (128 cu in ≈ 2 liter). These detectors are packaged in four RSX-3 units. Each RSX-3 unit is a carbon fiber box containing three 2" × 4" × 16" sodium iodide thallium-activated NaI (*Tl*) logs. The logs are coupled to a photomultiplier tube system that produces analog signals for digital analysis by the Advanced Digital Spectrometer (ADS) module (Figure 4).

Data from each of the three ADS modules is sent to one of four RS-701 consoles. An RS-501 aggregator box combines the outputs of the RSX-3/RS-701 units, provides a power distribution unit, and houses the Trimble differential GPS receiver. Four RSX-3 boxes and four RS-701 consoles are fitted into the externally mounted aluminum pods (two RSX-3s and two RS-701s per pod) on the left and right sides of the Bell 412 helicopter.

DATA ANALYSIS PROCEDURES

AMS uses a dedicated in-house developed data processing methodology and software, the PC-based Radiation and Environmental Data Analysis Computer (PC-REDAC). The collected spectral data are processed in several steps, starting with the correction of the gross-counts to the nominal flight altitude, correcting for all background components (radon, cosmic, helicopter), deriving terrestrial exposure rate, extracting man-made activity, and finally calculating activity from individual isotopes. All data are then presented as contour maps using commercial GIS software (ESRI ArcGIS Desktop 10.0).

The primary data products generated from the aerial data are:

1) Terrestrial exposure rate (ER) 1 m above ground, based on the net counts recorded by the acquisition system in the energy window 24 (kiloelectronvolt)keV and 3027 keV.
2) Man-Made Gross Counts (MMGC): The MMGC is the portion of the total count rate that is directly attributed to the gamma rays from the man-made radionuclides: industrial, medical, etc.
3) Isotope Extraction: Data analysis method used to perform identification of radiation anomalies on the ground, or to produce contour maps of ground contamination by specific isotopes.

Quality Controls

During radiation surveys, AMS applies several quality checks to monitor the performance and stability of the data acquisition system. They are:

1) Before takeoff, one minute of data is acquired with a 10 microcuries (μCi) Cesium-137 calibration source placed at the specified location on each of the pods containing radiation detectors.
2) Before takeoff, four minutes of background data are acquired at the helicopter parking location that remains constant during the survey.

3) Collected source and background data are used to perform a series of checks of detectors linearity, energy calibration, and efficiency. These actions are called the “pre-flight.”
4) The “pre-flight” is reviewed by the mission scientist for consistency.
5) During the survey, land-based and water-based test lines are established and they are over-flown before and after each survey flight. The test line data are used to verify the data acquisition system performance before and after each survey flight, and to derive the flight-specific values of radon and system background. The test line length is selected to generate about 60 data points (one minute duration over-flight).
6) After landing, one minute of background data is collected at the helicopter parking location to verify once more that nothing has changed in the acquisition system.
7) The collected survey data are checked for consistency with the set of computer subroutines called “post-flight” to discover any dropouts in GPS signal, detector stabilization issues, increase in system electronic noise level, etc.

RESULTS

Exposure Rate Contour Map

Using the methodology described earlier, the 1-second gross count data was converted to the terrestrial exposure rate values and then contoured using the PC REDAC software package.

Figures 5 and 6 are the resulting maps for King and Pierce Counties. The maps present contours of terrestrial exposure rates. The values for both cities show extremely low values ranging from 2 to 6 micro roentgen per hour (µR/h). For comparison, the terrestrial exposure rates derived from aerial radiometric data in the United States reported by the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) program of the 1970s and early 1980s are presented in Figure 9, showing King and Pierce Counties in the range 2.5-4.5 µR/h. Despite such low exposure rate values, the aerial measurements easily distinguished the terrain features including the two bridges over Lake Washington, Highway 520 Bridge and I-90 Bridge, differentiating the higher radioactivity (NORMs) in the bridge construction materials over the water.

Man-Made Gross Counts Map

To locate any radiological anomalies in the survey areas, the man-made (MMGC) algorithm is applied to the 1-sec spectral data and resulting count rates are plotted as contour maps. The resulting map shows only the gross counts produced by man-made sources typically with energies bellow 1400 keV. The man-made count rate contour maps for King and Pierce Counties are presented in Figures 7 and 8. The map of King County (Figure 7) shows several small areas of slightly elevated man-made activity (count rates). These anomalies were investigated during the survey, and the results of the investigation are presented in the Technical Report. The map of Pierce County (Figure 8) shows no elevated man-made activity.

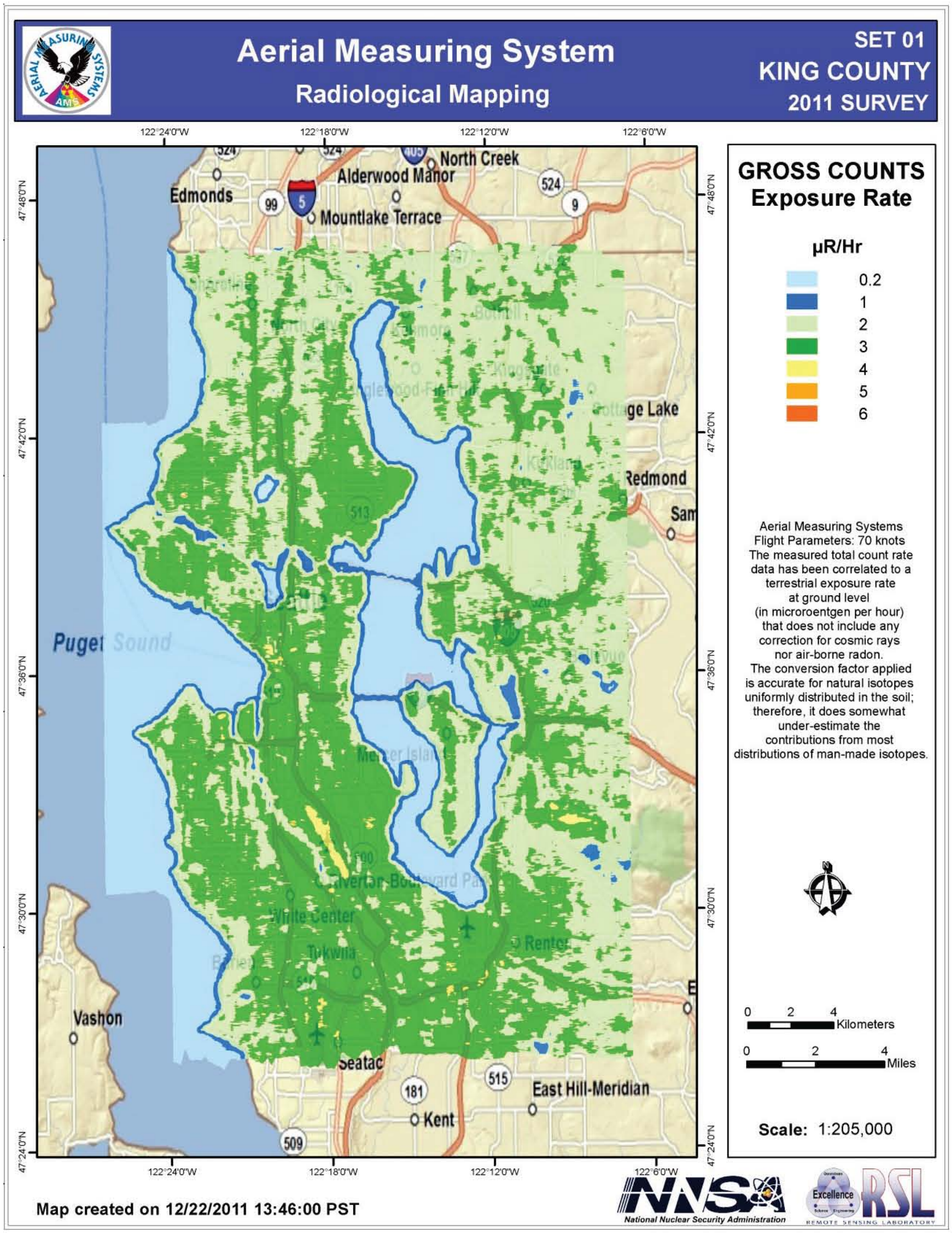


Figure 5. ***The terrestrial exposure rate map for the King County area based on the helicopter survey data.***

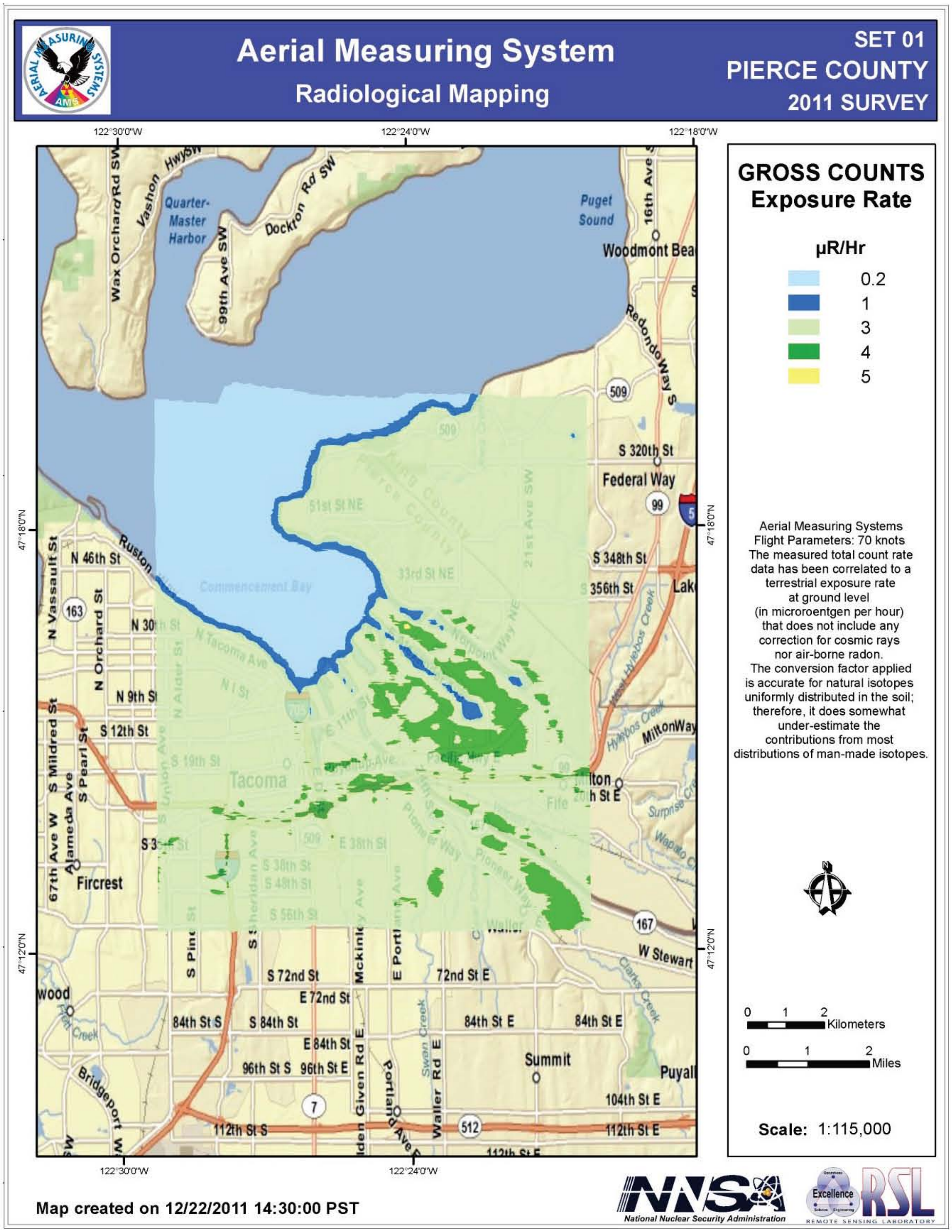


Figure 6. ***The terrestrial exposure rate map for the Pierce County area based on helicopter survey data.***

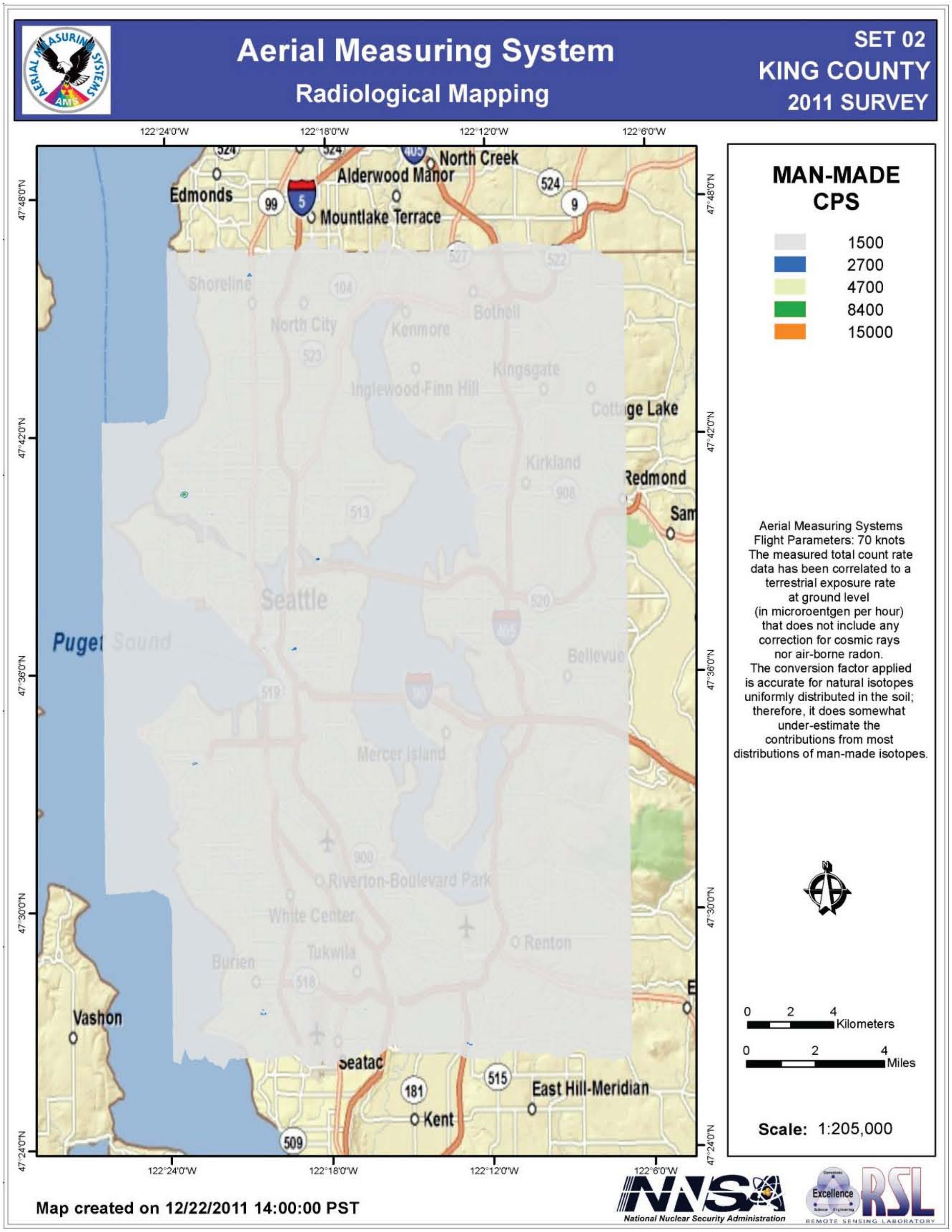


Figure 7. ***The man-made (artificial) radioactivity levels map for the King County area based on helicopter survey data.***

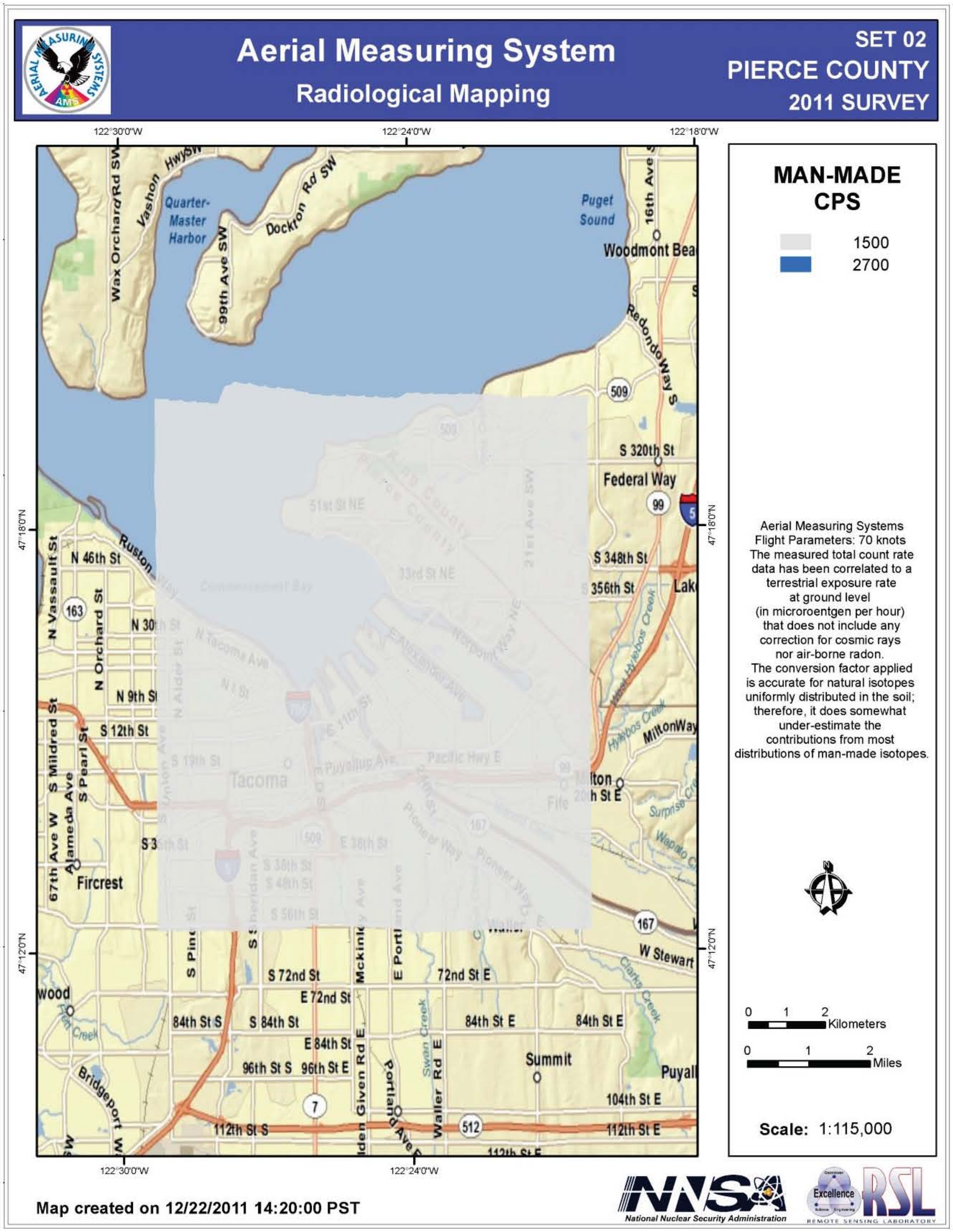


Figure 8. ***The man-made (artificial) radioactivity levels map for the Pierce County area based on helicopter survey data***

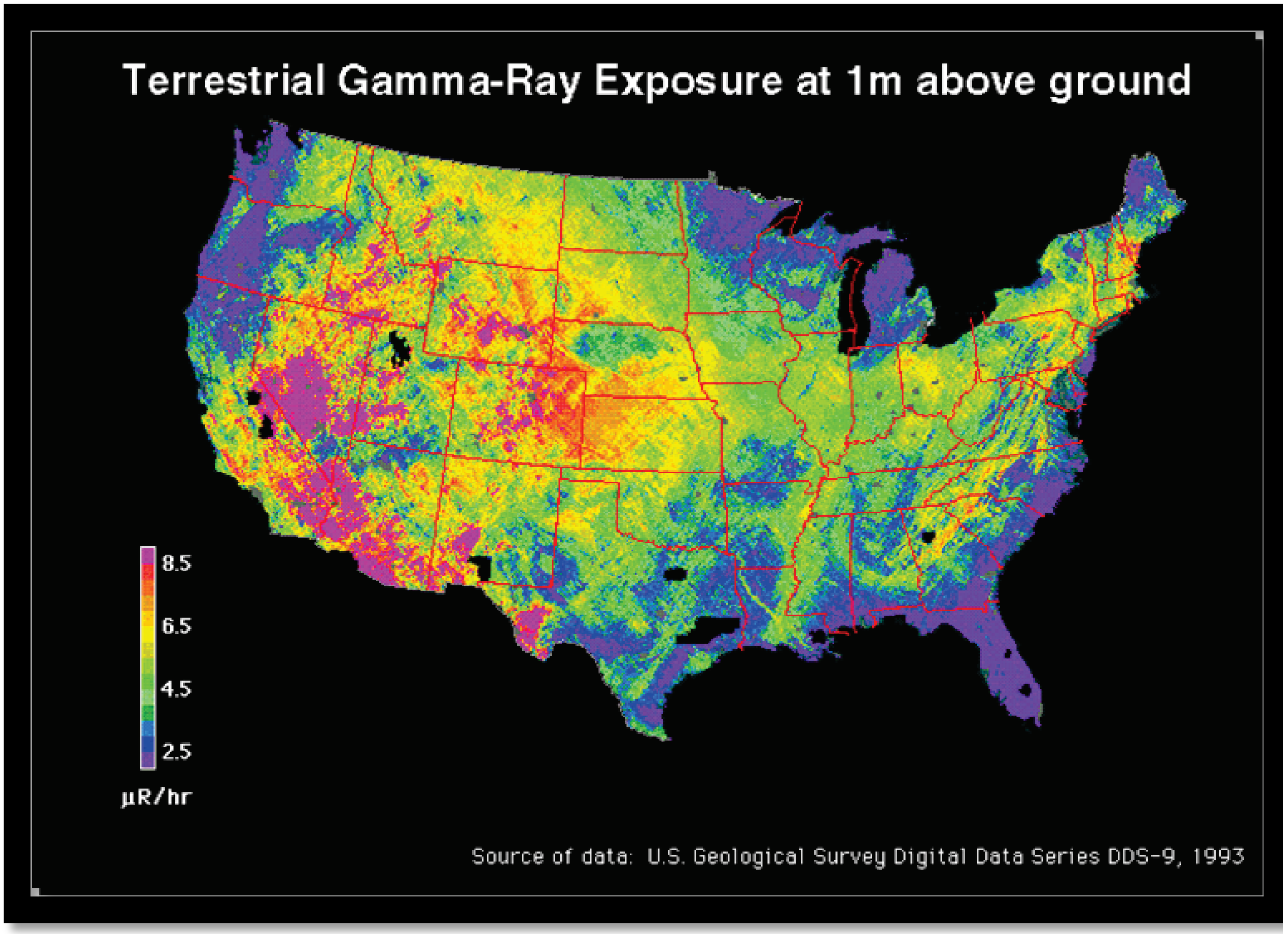


Figure 9. ***The terrestrial gamma-ray exposure in the US derived from geological data***
(URL: http://energy.cr.usgs.gov/radon/DDS-9.html).

Anomalies

Radiological anomalies recorded and investigated during the flights in the King County survey area are indicated by a blue color in Figure 7. There were also several areas of elevated natural background strong enough to be indicated by the man-made algorithm. Detailed description and results of radiological anomaly investigation are provided in the full Technical Report. No detectable man-made activity was evident in the Pierce County survey area.

CONCLUSION

The results derived from the baseline surveys over King County and Pierce County are beneficial for long-term planning by state and county emergency response officials and first responding organizations in the event of a radiological or other catastrophic incident. The accompanying report written for the state of Washington contains detailed technical information that explains the complexity of the survey and the basis of the final analysis.