Radiometric Surveys for Baseline Monitoring & Contamination Detection

With over 40 years of gamma radiation survey experience, Sander Geophysics Limited (SGL) has performed numerous specialized radiometric surveys to assess radiation due to man-made and natural sources. These surveys have included:

- helicopter and fixed-wing airborne baseline surveys of nuclear power plants and the surrounding urban areas;
- airborne baseline surveys of military establishments including nuclear submarine bases;
- airborne and ground vehicle baseline surveys of industrial and residential sites;
- ground based surveys to locate and identify radioactive particles at nuclear sites;
- ground based survey to locate a lost borehole logging cesium source; and,
- airborne surveys to determine snow depth for seasonal water volume planning.

SGL specializes in delivering a turnkey solution to our clients, and has been involved in all aspects of the projects: from survey design and survey platform modifications, data acquisition and processing to final reports, including digital data, map products, interpretation and recommendations for remediation and/or followup.

Following are case studies of two projects completed by SGL:

CASE STUDY 1: CONTAMINATION DETECTION SURVEY

The transfer of radioactively contaminated material from controlled zones within a nuclear facility to other areas within or outside the facility may occur due to the movement of vehicles, equipment and personnel. Accurate detection and identification of any radioactive particles outside the controlled zones is critical to ensure the integrity and safety of operations of the installation. Sander Geophysics, in partnership with international radiation specialist Dr. Robert Grasty (Gamma Bob Inc.), conducted a ground survey at an active nuclear facility, using a gamma-ray spectrometer equipped with large volume sodium iodide (NaI) detectors mounted on a small tractor. The purpose of the survey was to detect possible sources of radioactive contamination, principally cesium-137 (^{137}Cs) and cobalt-60 (^{60}Co), and to compare the results to a similar survey carried out by SGL at the same site 11 years earlier.

Ground survey of a nuclear facility to locate and identify contaminated particles

The spectrometer system, manufactured by Radiation Solutions Inc. (RSI), consisted of 16 NaI detectors contained in four packs, with a total volume of 67 litres (4,096 in^3). Each of the 16 NaI detectors has its own 1024 channel analyser, with the data from each detector recorded separately at 1 Hz. Natural and man-made sources of radiation were monitored using spectral windows covering specific gamma-ray energies. A Global Positioning System (GPS) coupled with an Inertial Navigation System (INS) provided accurate location information for the spectrometer data. The INS was required as the survey was carried out close to large buildings which obscured the GPS signal.

Surveying was conducted both inside and outside the Protected Area of the site, covering a total area of approximately 150,000 m^2. Several sources of ^{60}Co contamination were detected inside the Protected Area. Based on an analysis of particles found during the survey, the detection limits for the system were found to be 12 nCi for ^{60}Co and 17 nCi for ^{137}Cs.

The sources found in the gravel were as much as 2.5 cm below the surface with little or no beta radiation being detected at ground level. All sources found in the gravel or asphalt were retrieved, contained and then passed to the facility radiation personnel. A follow-up survey showed that all localized sources of contamination had been removed. Based on the survey, recommendations were made for a long-term monitoring program of the site.

Maps were produced of the total air kerma rate and the potassium-40 (^{40}K), uranium-238 (^{238}U) and thorium-232 (^{232}Th) activities of the site and showed differences in the natural radioactivity levels of roads and gravel areas. The overall radiation levels were low, ranging from around 15 nGy.h^{-1} on some of the paved roads to around 30 nGy.h^{-1} on gravel areas. These low values are consistent with the results from an earlier airborne gamma-ray survey of the site.

CASE STUDY 2: BASELINE RADIATION MONITORING SURVEY

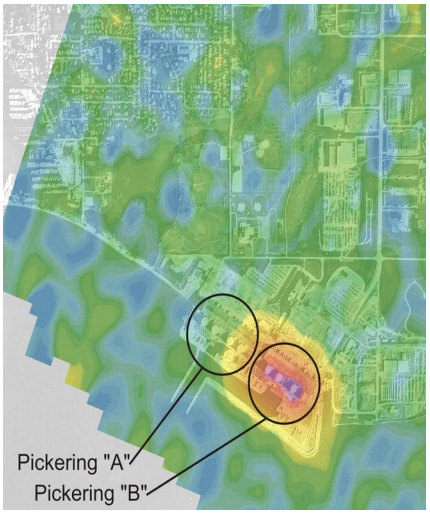
Accurate radiological characterization is relevant to all major phases of the lifetime of a nuclear facility, including background surveys prior to commissioning and after decommissioning, and site surveys at regular intervals during the operational phase as well as following any incident of possible contamination. Baseline radiation data provides background information for normal levels of radiation in the environment, and is useful as a benchmark if a radiological emergency occurs or to demonstrate that no significant changes have taken place over the lifetime of a nuclear facility. Airborne gamma spectrometry is an efficient method to rapidly survey the environs of nuclear facilities, and the airborne measurements can be converted to ground concentrations to complement any ground based measurements.

Baseline radiation survey using a helicopter

Sander Geophysics conducted a baseline radiation survey over the primary zones of a nuclear generating facility, using a gamma-ray spectrometer system mounted in a helicopter. In addition to identifying the distribution of natural and man-made gamma emitting isotopes, the data provided a gamma-ray baseline of the nuclear site and the surrounding community. Similar surveys flown at a later date, ideally at regular intervals, can then be used to demonstrate that no significant changes have occurred. Also, in the event of an accidental release of radiation from the facility, a subsequent survey could then be used to determine any increase in potential exposure for the public.

For this survey, the spectrometer recorded 256 channels of spectral information every second. The windows used to monitor natural and man-made radiation sources were centered around:

a total count window used to monitor overall levels of radioactivity
^{40}K gamma-rays at 1460 keV
1760 keV gamma-rays from bismuth-214 (^{214}Bi) in the ^{238}U series
2615 keV gamma-rays from thallium-208 (^{208}Tl) in the ^{232}Th series
^{137}Cs at 662 keV and ^{60}Co at 1173 keV
man-made radiation due to ^{41}Ar at 1294 keV between the upper boundary of the ^{60}Co window and the lower boundary of the K window
high energy gamma radiation at 6129 and 7115 keV from ^{16}N by recording all energies above 3 MeV and monitoring cosmic ray changes



Airborne survey showing ^{16}N over active and inactive cooling towers at a nuclear power station (PNGS)

Maps of the potassium, uranium and thorium radioactivity of the ground were produced, and of the total radiation levels in units of air kerma rate (nGy.h^{-1}) due to all sources of gamma radiation. The natural radiation levels of the survey area varied between 20 and 50 nGy.h^{-1} and are comparable to the values reported in government data for the area.

Maps of the equivalent surface distribution of man-made cesium-137 (^{137}Cs), the equivalent activity of cobalt-60 (^{60}Co) and the count rates from nitrogen-16 (^{16}N) were made. Although argon-41 (^{41}Ar) is produced through normal operations, none was detected, and therefore, no maps of this isotope were made. Within the plant boundaries, ^{16}N was detected directly over the operating units, and is due to normal operations. At several locations within the boundary of one of the facilities ^{137}Cs and ^{60}Co were detected. The origin of this radiation was storage facilities for spent fuel and contaminated maintenance tools, and the operator was aware of this man-made radiation before the survey was conducted.