Environmental Monitoring
using Gamma–Ray Spectrometers

The energies of gamma rays produced by radioactive decay are characteristic of the decaying nuclide. For example potassium-40 (^{40}K) decays to argon-40 (^{40}Ar) with the emission of gamma rays at 1460 keV. Gamma-ray spectrometers are designed to measure the intensity and energies of gamma rays and hence measure the distribution of particular radioactive nuclides.

Airborne gamma-ray spectrometry commenced in the late 1960's, primarily for uranium exploration. Since the mid-1970's, the method has been applied extensively in support of geological mapping and mineral exploration. Airborne gamma-ray spectrometry can also be used for environmental monitoring. Radioactive debris from the Russian nuclear satellite Cosmos 954 was successfully located by airborne gamma-ray spectrometry. It has also been used for mapping radioactive contamination from the Chernobyl nuclear accident and for mapping radioactive plumes from nuclear reactors.

Sander Geophysics (SGL) has over forty years experience conducting high resolution gamma-ray spectrometer surveys in Canada and internationally. SGL offers airborne environmental mapping of natural and anthropogenic radiation using gamma-ray spectrometers flown in fixed-wing aircraft and helicopters, as well as ground surveys using suitable vehicles.

SURVEY PLATFORM

Due to their slow speed, helicopter-borne surveys are capable of defining small anomalies and result in data of high resolution and sensitivity. However, fixed-wing aircraft have lower operating costs and some specialized fixed-wing aircraft, like Sander's BN-2B Islanders, can safely survey at speeds as low as 90 knots (175 km/hr), resulting in economical high resolution data. Ground-based vehicle surveys offer increased resolution at a low cost, and are ideal for relatively small areas with good ground access.

Aerospatiale AStar 350D equipped for environmental monitoring

SPECTROMETER SYSTEM

All of Sander Geophysics' gamma-ray spectrometer systems use modern NaI crystals and offer full 256 channel recording. This ensures that the exact nature and energy level of the recorded radiation can be determined accurately, and quantitative maps of individual nucleides such as K, U, Th, Cs and others can be made.

Sander Geophysics' fixed-wing aircraft can accommodate 50 litres (3000 cu in) of downward facing crystals and 8.4 litres (500 cu in) of upward facing crystals. Helicopter systems accommodate up to 33 litres facing down and 8.4 litres facing up. Our ground-based systems use up to 16.8 litres depending on the desired resolution and vehicle speed. In addition, all our aircraft and ground vehicles are equipped with an integrated navigation system (SGNAV) utilising a NovAtel GNSS (Global Navigation Satellite System) receiver for precise navigation and accurate flight path recovery.

SPECIALIZED PROCESSING

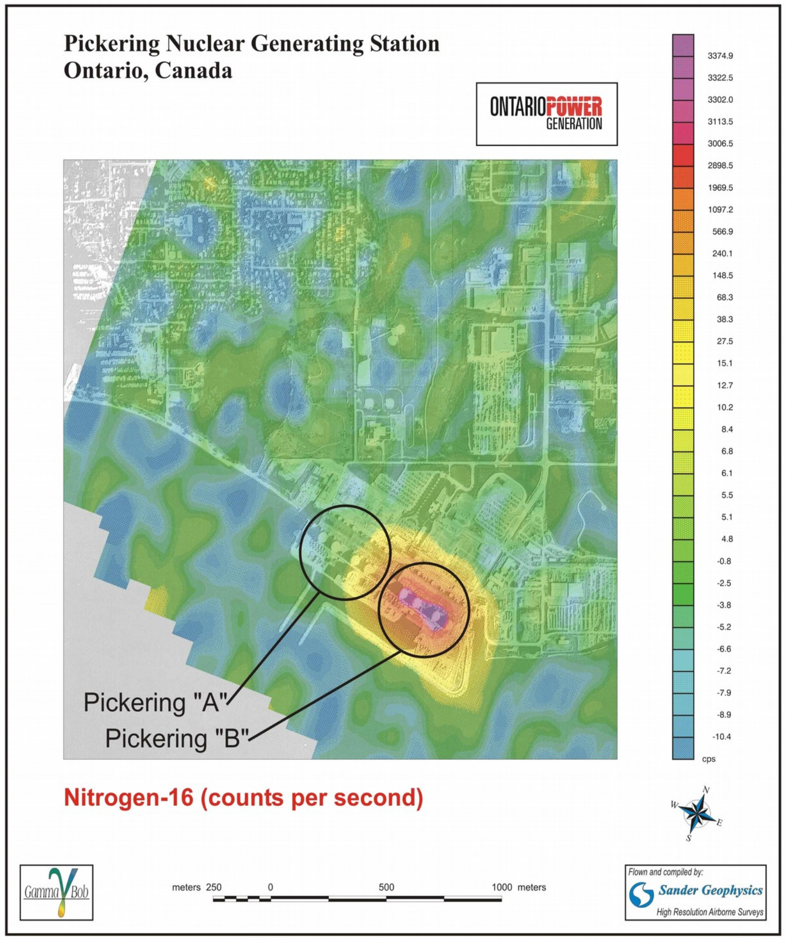
Sander Geophysics has implemented a spectral component analysis technique, based on the method of Hovgaard and Grasty (of Radiation Solutions Inc. and Gamma-Bob respectively). This noise reduction technique, called Noise Adjusted Singular Value Decomposition (NASVD), uses the full spectrum data to enhance the resolution of radiometric data. Sander also uses a combination of spectrum fitting and NASVD to produce maps of cesium and other man-made nuclides from the 256 channel radiometric data.

A CASE STUDY

Recently, airborne gamma-ray spectrometry has been used to identify and quantify the distribution of natural and man-made gamma emitting isotopes in the vicinity of nuclear power plants in order to assess the plants' dose impact on members of the public. In addition, the data provide an environmental baseline of the nuclear operating site and the surrounding community. In the event of an accidental release of radiation from the facility, a subsequent survey could then be used to determine any increase in dose to the public.

Ideally, a gamma-ray spectrometer survey of a nuclear facility will demonstrate that the gamma radiation produced at the facility is localized to the containment structures and the waste storage sites, and that no radiation from the reactor or waste storage operations is detected outside the plant boundary. Confidence in the facility is further enhanced if the natural radiation levels in the areas outside the plant boundaries are shown to be typical of the levels found within the rest of the country.

In the fall of 1999, Sander Geophysics flew an airborne gamma-ray survey over the primary zone of the Pickering nuclear generating station in Ontario, Canada. The survey was designed to address public concern of possible soil contamination resulting from the operation of the facility, and was flown under contract to Ontario Power Generation (OPG), formerly Ontario Hydro.



Map showing the distribution and intensity of nitrogen-16 in the vicinity of the Pickering Nuclear Generating Station

The survey showed that the radiation levels in the surrounding community are comparable to the values reported by the Geological Survey of Canada (GSC) as typical for Ontario. Within the plant boundary, several radioactive isotopes resulting from normal plant operations were detected within acceptable limits. These isotopes included cobalt-60 (^{60}Co), cesium-137 (^{137}Cs) and nitrogen-16 (^{16}N). Shown above is a map of the ^{16}N distribution within the survey area, with an aerial photograph as a background. Clearly visible are the four operating Pickering "B" reactor units, which show up as a localized area of high intensity (yellow-red) on the map. To the left of this high are the Pickering "A" reactor units which are shut down. Also apparent, is the generally low intensity (green-blue) of the area immediately adjacent to the plant and out into the surrounding community.

The results of the survey have familiarized the public with existing levels of both natural and man-made gamma radiation, and verified that there are no gamma-emitting radioactive materials in the surrounding residential community due to the operation of the nuclear generating station.