The DPRNET Program from 1972 to 2017

LA-UR-18-24501

Michael McNaughton

Introduction

Direct penetrating radiation (DPR) in the environment of Los Alamos has been measured using thermo-luminescent dosimeters (TLDs) since 1972.

Before 1999, this program of environmental measurements was called TLDNET. The name DPRNET is appropriate because the radiation is “direct” from the source to the receptor and “penetrating” because it consists of gamma-, neutron-, and cosmic-radiation. Less-penetrating alpha and beta particles are shielded by the air between the sources and the dosimeters, and also by the dosimeters’ weatherproof protective packages. As a result of this shielding, alpha particles are not detected. In some cases, high-energy beta particles such as those from strontium-90 or protactinium-234m could be detected if the shielding is small, though in practice this has never been observed.

DPRNET is described in the Technical Project Plan EPC-ES-TPP-007. The results have been reported in the annual site environment reports (ASERs) from 1972 to the present. Detailed data are in spreadsheets stored in the DPRNET folder of the Project drive: \\envision\ENVRAD\DPRNET, and summarized in the files DPRNET-data-1972-1998.xls and DPRNET-data-1999-2017.xls.

Dosimeters

Until 2002, the environmental dosimeters were different from the personnel dosimeters used at Los Alamos. The environmental dosimeters consisted of several (3 – 6) TLD “chips” of a thermo-luminescent material known as TLD100. They were contained in weatherproof packages known as an “acorns”. These packages excluded rain, sunshine, ultra-violet radiation, alpha particles, and most beta particles. Alpha and beta radiation from a LANL facility is also shielded by the building walls and the air between the facility and the dosimeter.

TLD100 chips are made of LiF containing 7.5% ^{6}Li and 92.5% ^{7}Li. In 1996, new materials known as TLD600 and TLD700 were tested. These are enriched with either ^{6}Li or ^{7}Li (respectively) in order to measure neutrons and gammas separately.

After a series of successful tests and inter-comparisons, the DPRNET program retired the TLD100 chips and began using the LANL Model-8823 dosimeter (Hoffman and Mallett 1999). In 2001, the Model-8823 dosimeters were evaluated alongside the TLD100 dosimeters (McNaughton LA-UR-04-1294) and beginning in 2002, the DPRNET program used the Model-8823 exclusively. These are the same as the TLDs used for personnel dosimetry at LANL. They are calibrated and read by the External Dosimetry team in the LANL Radiation Protection division.

Calibration

Until 2002, the TLDs were calibrated at the ESH calibration facility, which at that time was at TA-3; at present it is at TA-36 building 214. The dosimeters were exposed to 80 mR of gamma radiation from cesium-137, and units of mR were converted to mrem using a conversion factor. Prior to 1981, the conversion factor was assumed to be 0.943 mrem/mR, based on a publication by Harold Elford Johns and John Robert Cunningham (1969). From 1981 to 2001, the conversion factor was assumed to be 0.958 mrem/mR, based on Table 4, page 63, of NCRP Report No. 69 (1981.)

From 2002 to the present, the TLDs have been calibrated by the same group that issues LANL personnel dosimeters (presently RP-PROG). The dosimeters are issued and read by this team, and the results are reported in mrem using the methods and procedures approved by the Department of Energy Laboratory Accreditation Program, DOELAP.

Accuracy

The one-standard-deviation accuracy of the TLD dosimeters is approximately 8%. This is the accuracy of a single measurement at a fixed location and has been verified by comparison with various types of dosimeter (McNaughton 2004), by comparison with the aerial flyover (DOE/NV 2012), and by the results of international inter-comparisons (Klemic 1999). During the 12th International Inter-comparison of Environmental Dosimeters (Monetti 2002) LANL dosimeters measured 1.04 times the officially-measured dose, thus demonstrating an accuracy better than 8%.

Although the averages are accurate, the results reported for a single location-ID number may vary by more than 8% because of changes in the terrestrial conditions. The shielding caused by snow cover typically reduces the radiation by about 10%. Similarly, wet soil emits less radiation than dry soil. Furthermore, the concentrations of natural uranium, thorium, and potassium-40 vary by more than a factor of two, and often vary significantly over a distance of a meter. Dosimeters placed on trees, bushes, or fences may be moved to accommodate construction or landscaping projects. Also, new construction may require significant movement of soil, which changes the terrestrial radiation at a DPRNET location.

Locations

In the 1970s, the dosimeter locations changed frequently. The locations were referred to by names such as “Espanola” without specifying the location more accurately. Beginning in 1974, the locations were specified using a coordinate system known as the “Army Grid”, which used axes, north-south and east-west, that intersect near latitude 35.855 degrees and longitude -106.331 degrees. Using these coordinates, the locations were identified with a precision of 1,000 feet; for example, Barranca Mesa School was specified as N180 E130, which means 18,000 feet north and 13,000 feet east of the axes.

Beginning in 1980, locations were identified with identification numbers from #1 to #999. These location numbers have been used continuously from 1980 to the present. The latitude-longitude coordinates of these locations are listed in the Excel spreadsheet “DPRNET-locations-coordinates-7.xls” which is kept in the DPRNET folder of the Project drive : \\envision\ENVRAD\DPRNET.

In 1999, the locations were described in a siting study (McNaughton LA-UR-00-1168). This study recommended some changes, which were implemented in January 2000. In 2003, the study was updated (LA-UR-03-6493) and the recommended changes were implemented in January 2003. After this, most locations remained the same from 2003 to 2013, when some were changed to remain consistent with changes to the AIRNET locations.

WasteNet

From 1983 to 1999, a network of TLDs known as WasteNet was used to measure the doses around the material disposal areas (MDA) (LA-UR-80-3110, LA-UR-90-3283). Most of these locations (numbered 201 – 383) were retired after the Siting studies. Location 323 was kept and measurements continued through 2002, to monitor Cs-137 at MDA T. Also, location 361 was retained through 2013 because it was co-located with AIRNET station #20. The locations around the perimeter of MDA G (numbered 601 – 652) are still active in 2018.

LAMPF-Net

From 1978 through 2002, TLDs numbered 401- 472 were deployed along the rim of Los Alamos Canyon near East Gate in a network known as LAMPF-Net. (LAMPF is an old name for LANSCE.) These measurements successfully measured the annual doses from LAMPF when they were about 10 mrem, but by 1999 the annual doses from LAMPF or LANSCE had decreased to less than 1 mrem, which was too small to measure. At this time, the NEWNET system (ENV-ES-TPP-003) was providing more accurate data with uncertainties of less than 1 mrem/year so LAMPF-Net was discontinued at the end of 2002.

Albedo dosimeters

Starting in the second quarter of 1997, “albedo” dosimeters were deployed around TA-18 to measure the neutrons generated by apparatus such as Godiva and Sheba. Albedo dosimeters are designed to measure the “albedo” or reflection of thermal neutrons from hydrogenous materials such as Lucite, water, or human tissue.

Neutron dosimeters use a combination of TLD600 and TLD700 materials. TLD700 uses ^{7}LiF to measure gamma radiation; TLD600 uses ^{6}LiF and measures both gamma and neutron radiation. The difference, TLD600 minus TLD700, is a measure of the neutron radiation.

The neutron dose around the perimeter of Area G is measured using the algorithm reported in the publication by Hoffman and Mallett (1999) and is the same as used for RP-division personnel dosimetry. At a distance greater than 100 meters, the neutrons are moderated by the nitrogen and oxygen in air so the environmental neutron dose is calculated as follows.

At distances greater than 100 meters, the environmental neutron dose is reported as the product of a neutron correction factor, NCF, and the difference of the TLD600 and TLD700 readings: NCF×(TLD600 – TLD700). During 1997 and 1998, the NCF was assumed to be 0.07, based on unpublished measurements by William Casson. Starting in 1999, the dosimeters were calibrated using the DOE-standard deuterium-moderated neutron source and the NCF was changed to 0.145. The details of these measurements are described in the attachment to the DPRNET procedure, ENV-ES-TPP-007.

From 1997 through 2001, the albedo dosimeter program was separate from the DPRNET program and the albedo results were summarized in the ASER. Starting in 2002, they were reported as DPRNET locations #181 – 187 (TA-18 albedo #1 became DPRNET #181, etc.) These measurements continued until 2006, when operations at TA-18 ceased.

Natural Background Radiation

Naturally-occurring terrestrial radiation varies seasonally and geographically. Seasonally, radiation levels can vary at a given location because of changes in soil moisture and snow cover that reduce or block the radiation from terrestrial sources (NCRP 1975). Spatial variation results from both the soil type and the geometry; for example, dosimeters that are placed in a canyon receive radiation from the side walls of the canyon as well as from the canyon bottom. The aerial surveys of Los Alamos (EG&G 1989, EG&G 1990, DOE/NV 1998, and DOE/NV 1999) show variations of a factor of three in terrestrial radiation. Measurements of soil concentrations support these surveys. For example, according to Longmire (1996), thorium and uranium concentrations on the Pajarito Plateau range from 0.7 to 3 pCi/g, and potassium-40 ranges from 12 to 40 pCi/g, which result in terrestrial radiation from 50 to 150 mrem/yr.

Naturally-occurring ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding (NCRP 1975). At sea level, the dose rate from cosmic sources is 27 mrem/yr. Los

Alamos, with a mean elevation of about 2.2 km, receives 70 mrem/yr from cosmic sources, whereas White Rock, at an elevation of 1.9 km, receives 60 mrem/yr. Other locations in the region range in elevation from 1.7 km at Española to 2.7 km at the Pajarito Ski Hill, resulting in a corresponding range of 50 to 90 mrem/yr from cosmic sources.

These variations of natural background make it difficult to detect radiation from man-made sources because the man-made doses are generally much smaller than the natural-background doses.

In summary, the dose rate from natural terrestrial and cosmic sources varies from about 100 to 200 mrem/yr. In publicly accessible locations, the dose rate from man-made radiation is much smaller and is difficult to distinguish from natural radiation.

LANL DPR

Direct penetrating radiation from LANL has previously been associated with sources at TA-3, TA-18, TA-21, TA-50, TA-53, and TA-54. At present (2017), it is associated with TA-53 and TA-54.

The dose at publicly accessible locations is usually too small to measure directly so it is usually estimated by measurements close to the source combined with models to calculate the radiation farther from the source (McNaughton 2013).

For example, TLDs within TA-53 sometimes measure above-background doses, and models are used to calculate the dose at the publicly accessible Jemez Road (McNaughton 2013).

During the 1980s, significant dose was measured by DPRNET and NEWNET at East Gate and reported in the Annual Site Environmental Reports, but since 1999 the annual public dose at East Gate has been less than 1 mrem, which is too small to measure directly.

At TA-54, the annual neutron dose is typically a few mrem in Canada del Buey and at Pajarito Road. The gamma dose from Area G has been measured several times and calculated by MCNP. The annual gamma dose is much less than 1 mrem and is too small to measure.

Data

Raw data are in spreadsheets with names such as ENV17Q4 on the shared projects drive (\\envision\ENVRAD\DPRNET). Annual summaries are in spreadsheets with names such as TLD2017 and are discussed in the ASERs. And an intermediate amount of detail is summarized in spreadsheets with names such as DPRNET 1972-1998 and DPRNET 1999-2017. Blanks in these spreadsheets may indicate dates before a location was established or after a location was retired. In some cases, blanks indicate lost data, for example because a dosimeter was lost during a construction project, destroyed by a snowplow, or removed by a curious child.

Conclusion

This report provides a brief history of DPRNET. The data are discussed in the ASERs and support the conclusion that radiation doses to the public are well below the limits specified in the regulations and DOE Orders.

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