# 5.0 Air Pathway

This chapter describes the air-pathway monitoring program used to track and evaluate airborne emissions from the Fernald Preserve. It includes a discussion of radiological air particulates, radon, and direct radiation.

**Results in Brief: 2008 Air Pathway**

**Radiological Air Particulates**—Data collected from the site boundary AMSs show that average concentrations for each radionuclide monitored were less than 1 percent of the corresponding DOE derived concentration guide.

**Radon**—There were no exceedances of the 10 CFR 834 proposed standard (0.5 pCi/L annual average above background) at the site boundary and off-property locations. The maximum annual average concentration at the Fernald Preserve boundary measured by continuous radon monitors was 0.2 pCi/L above background.

**Direct Radiation**—2008 direct radiation measurements at the site boundary were similar to those measured in 2007. The maximum measured annual dose at the site boundary was 6 mrem above background.

Air-pathway monitoring focuses on airborne pollutants carried from the site as particles or gas and how these pollutants are distributed in the environment. The physical form and chemical composition of pollutants influence their dispersal in the environment and the delivered radiation dose. For example, fine particles and gases remain suspended, while larger, heavier particles tend to settle and deposit on the ground. Chemical properties determine whether the pollutant will dissolve in water, be absorbed by plants and animals, or remain in sediment and soil.

The final year of soil remediation at the Fernald Preserve was 2006. By the end of October 2006, all major sources of airborne contamination were removed from the site or placed in the OSDF. Therefore, the number of AMSs was decreased from 17 to 11 in April 2006 (DOE 2006c) and from 11 to 6 in November of 2006 (DOE 2006d). The six remaining monitors are placed at five boundary locations and one background location (Figure 5−1). They are used to demonstrate that wind erosion of the remediated soil poses no significant threat to the public or the environment.

The site's air monitoring approach (presented in the IEMP) provides an ongoing assessment of the particulate emissions originating from wind erosion of soil, as well as radon and direct radiation levels at the site boundary. Results of the 2008 assessment indicate that particulate, radon, and direct-radiation measurements remain at the low levels observed in 2007, which reflects the absence of any significant surface contamination source on the Fernald Preserve.

## 5.1 Activities Affecting the Air Pathway

As the mission of the Fernald Preserve changed from production to remediation to wildlife preserve, work activities also changed. This change in work scope altered the characteristics of sources that emit pollutants in the environment via the air pathway. During the production years, the primary emission sources were point sources (i.e., stacks and vents) from process facilities. During remediation, the dominant emission sources were associated with construction activities in the form of fugitive emissions (i.e., excavation, hauling and processing of waste and contaminated soil, demolition of production facilities, and general activities supporting the remediation process) and the storage of radon-generating waste materials.

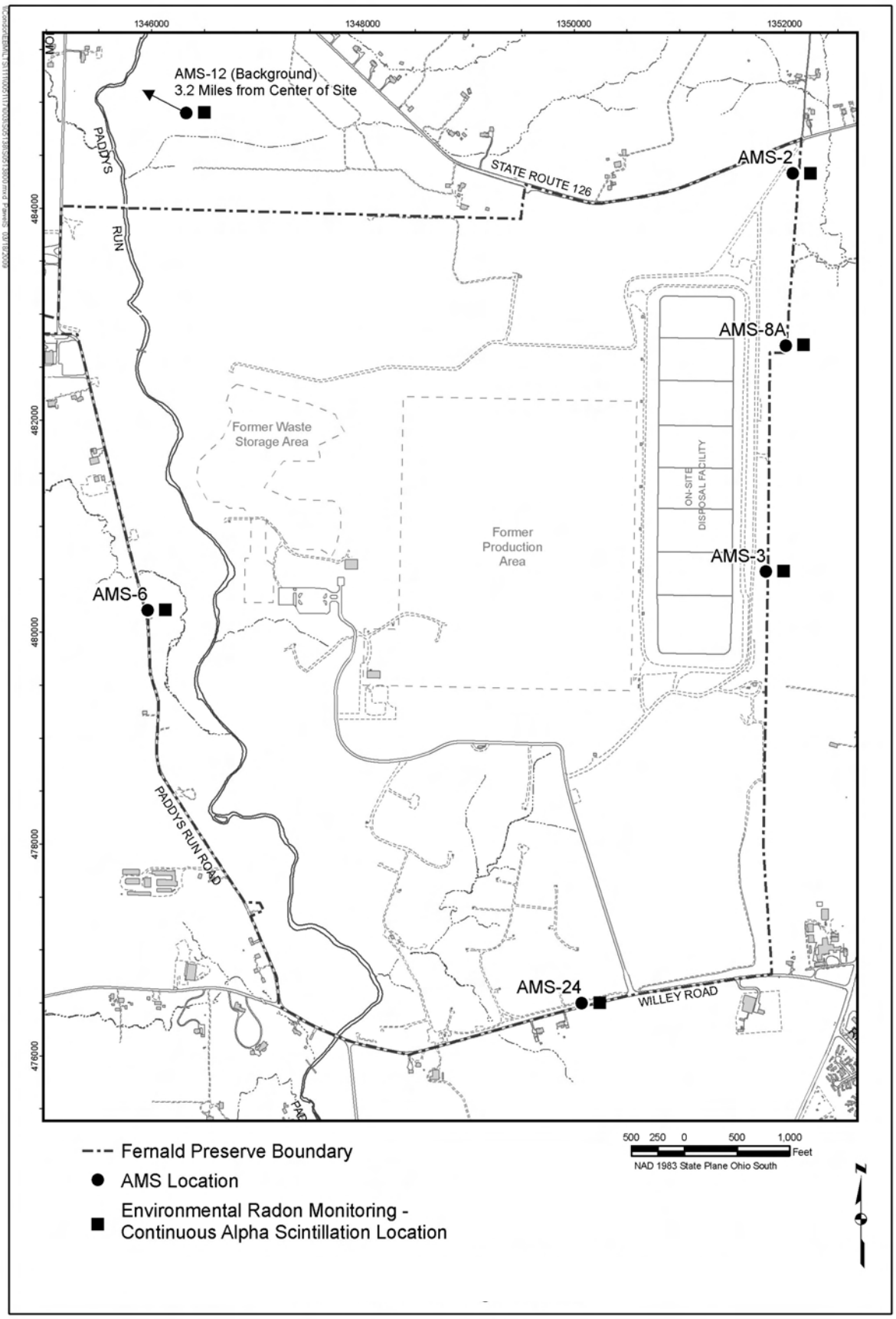


*Figure 5–1. Radiological AMS Locations*

During 2008, minor construction activities were associated with the remodeling of the silo warehouse building into the Visitors Center, grading work around the Visitors Center parking lot, ecological restoration activities associated with mowing, soil conditioning and reseeding, construction of the Bio-Wetland and Shingle Oak Trails, maintenance activities for erosion repairs and culvert replacement at the OSDF, and work to narrow and add gravel to the north access road. This last activity appears to have contributed to the maximum observed particulate air concentration for 2008 (Section 5.3).

## 5.2 Air Monitoring Program Summary for 2008

The site's air monitoring program, as defined in the IEMP, consists of three components:

- Radiological air particulate
- Radon
- Direct radiation

Each component of the air monitoring program is designed to address a unique aspect of air-pathway monitoring, and each has distinct sampling methodologies and analytical procedures. The key elements of the air monitoring program design are:

- **Sampling**—Sample locations, frequency, and the constituents were selected to address DOE and EPA requirements for assessing radiological emissions from the Fernald Preserve. Key considerations in the design of the sampling program included prevailing wind directions and the location of off-property receptors.
- **Data Evaluation**—The data evaluation process focuses on tracking and trending data against historical ranges and DOE, EPA, and OEPA standards. Sections 5.3 through 5.5 in this chapter present the air data and a comparison to applicable standards and guidelines.
- **Reporting**—All data are reported through the annual Site Environmental Report.

## 5.3 Radiological Air Particulate Sampling Results

As described in the IEMP, high-volume air particulate monitoring stations are used to measure the collective contributions from fugitive particulate emissions from the site. Many factors contribute to the amount of particulate captured at the stations; the most significant factors are the frequency of soil disturbance, amount of vegetation cover, moisture content of the soil, and average daily wind speeds. Figure 5−1 provides the locations of the AMSs in operation during 2008. As the predominant wind direction is from the southwest (Appendix C, Attachment C.4), three of the five boundary monitors are located along the northeastern perimeter of the site.

The sampling and analysis program for the site boundary and background locations consists of monthly total uranium and total particulate analyses and a quarterly composite sample. The quarterly composite sample is analyzed for radium-226, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235, and uranium-238 to evaluate compliance with the following:

- NESHAP Subpart H requirements that stipulate radionuclide emissions (excluding radon) to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/yr (0.1 mSv/yr) above background levels. This dose is reported in the annual NESHAP Subpart H compliance report, which is attached as Appendix D.

- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, guidelines for concentrations of radionuclides in air emissions. These guidelines, referred to as derived concentration guide values, are concentrations of radionuclides that, under conditions of continuous exposure for one year by one exposure mode (e.g., inhalation or ingestion), would result in a dose of 100 mrem (1.0 mSv) to the public. These derived concentration guide values are not limits, but serve as reference values to assist in evaluating the radiological air particulate data.

Table 5−1 presents a summary of the minimum, maximum, and average concentrations for total uranium and total particulate in 2008 and 2007, as based on monthly samples. The 2008 maximum values for uranium and particulate are slightly higher than the 2007 maximums. At the five boundary stations, uranium ranged from $5.1 \times 10^{-6}$ to $77 \times 10^{-6}$ picocuries per cubic meter ($pCi/m^3$), which is much less than 1 percent of the DOE derived concentration guide value of $100{,}000 \times 10^{-6}$ $pCi/m^3$. Total particulate concentrations at the boundary ranged from 4.0 to 65 micrograms per cubic meter ($\mu g/m^3$). There are no general or site-specific regulatory limits associated with total particulate measurements.

*Table 5–1. Summary of Total Uranium and Particulate Concentrations in Air*

| Location | 2008 Total Uranium ($pCi/m^3$) | 2007 Total Uranium ($pCi/m^3$) | 2008 Total Particulate ($\mu g/m^3$) | 2007 Total Particulate ($\mu g/m^3$) |
|---|---|---|---|---|
| **Boundary Locations** | | | | |
| Minimum | $5.1 \times 10^{-6}$ | $6.0 \times 10^{-6}$ | 4.0 | 1.2 |
| Maximum | $77 \times 10^{-6}$ | $54 \times 10^{-6}$ | 65 | 46 |
| Average | $13 \times 10^{-6}$ | $15 \times 10^{-6}$ | 26 | 23 |
| **Background Location** | | | | |
| Minimum | $8.1 \times 10^{-6}$ | $7.3 \times 10^{-6}$ | 17 | 1.0 |
| Maximum | $13 \times 10^{-6}$ | $18 \times 10^{-6}$ | 44 | 36 |
| Average | $11 \times 10^{-6}$ | $13 \times 10^{-6}$ | 26 | 23 |

Figure 5−2 shows total uranium variation at the boundary and background locations. Monthly results for 2008 are shown with the reported analytical uncertainty plotted as error bars. July samples have no uranium results, as the samples were inadvertently discarded by the laboratory after particulate mass was measured. The uranium activity in the captured particulate is below $20 \times 10^{-6}$ $pCi/m^3$, with the exception of the June sample from AMS-8A (discussed below). Measurement uncertainty indicates that most monthly results for the boundary monitors slightly exceed the uranium activity measured at the background location. However, the measured uranium activity at the boundary is much less than the DOE derived concentration guidance value ($100{,}000 \times 10^{-6}$ $pCi/m^3$). Additional statistical analysis and graphical displays of the 2008 data are provided in Appendix C, Attachment C.1.

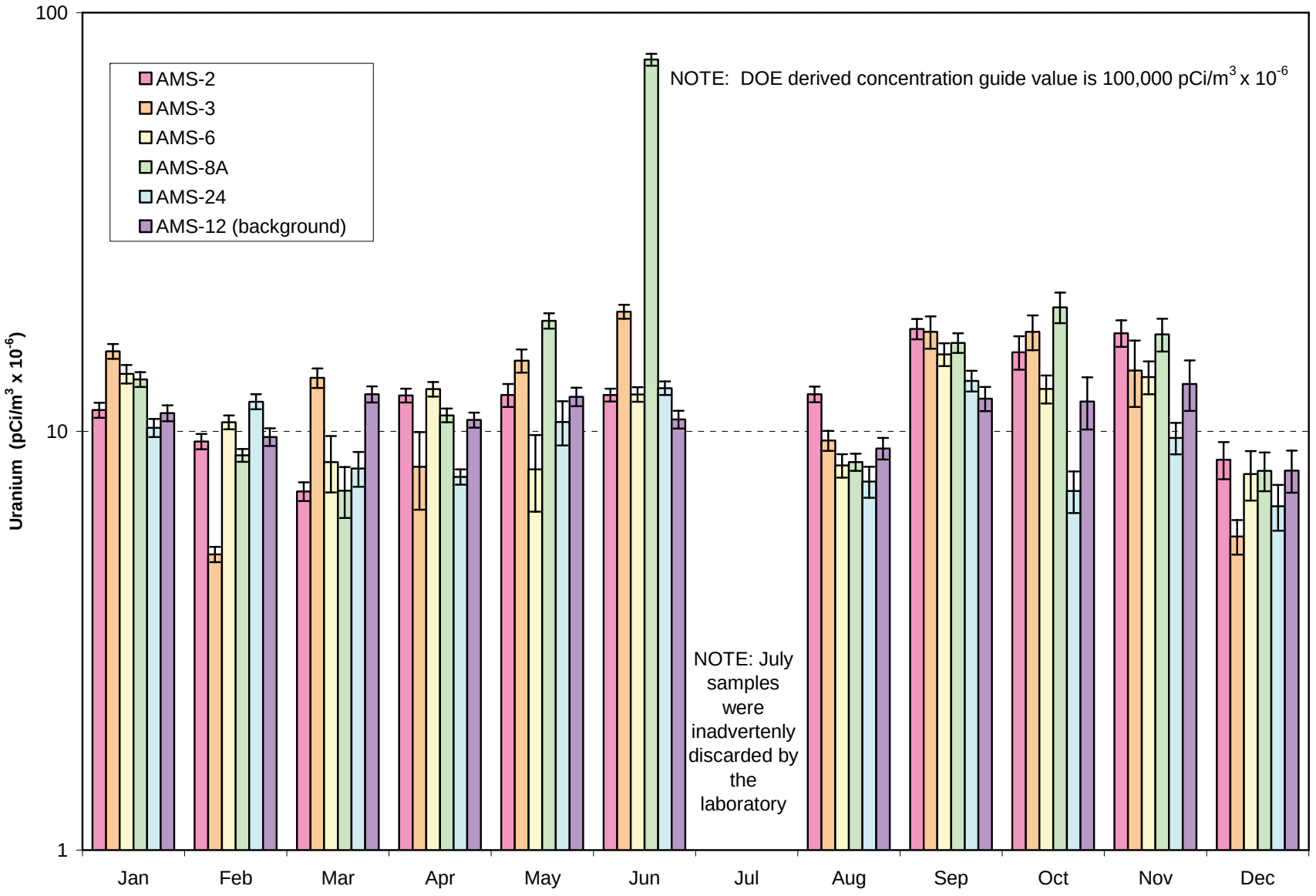


*Figure 5–2. Monthly Results and Measurement Error for Uranium in Collected Air Particulate*

Higher uranium activity in the June sample from AMS-8A correlates with higher particulate mass in the sample, and this is probably due to construction activity on the north access road in June (road was narrowed and repaired with additional gravel). Gravel on the road is composed of carbonate rock, which generally contains background levels of uranium below 3 mg/kg. The June particulate collected from AMS-8A has a uranium concentration of 1.8 mg/kg, and this suggests a dust component derived from the carbonate gravel. The particulate from other monitors contains uranium at about one-half the value of AMS-8A particulate, and this probably indicates the lack of significant carbonate dust in these samples. Although the value for AMS-8A is elevated relative to other monitor locations, it is less than 4.5 mg/kg, which is the 95 percent confidence limit for background uranium in soil (DOE 2001e).

In 2008, the quarterly composite samples were formed for each monitor from the monthly samples and analyzed for radium-226, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235, and uranium-238. As noted above, July samples were inadvertently discarded after measurement of the particulate mass. Therefore, the third-quarter sample was a composite of samples from August and September.

Figure 5−3 plots the annual activity and uncertainty for the quarterly results to show that boundary results are similar to background, with the exception of a lower Th-228 and Ra-226 activity for AMS-24. Appendix C, Attachment C.1 presents the complete annual summary for the data, and Appendix D documents that the results are in compliance with the NESHAP 10 mrem/yr (0.1 mSv/yr) dose limit (the maximum dose for 2008 is 0.017 mrem/yr (0.00017mSv/yr) at AMS-8A).

## 5.4 Radon Monitoring

Radon-222 (referred to as radon) is a naturally occurring radioactive gas. It is produced by radioactive decay of radium-226, which can be found in varying concentrations in the earth's crust. Radon is chemically inert and tends to diffuse from the earth's crust to the atmosphere. The concentration of radon in the environment is dynamic and exhibits daily, seasonal, and annual variability. This variability is evident in the monthly data plots shown in Appendix C, Attachment C.2.

Many factors influence the concentration of radon in the environment, including the distribution of radium-226 in the ground, porosity of the soil, and weather. For instance, radon diffusion from the ground is minimized by the presence of precipitation and snow cover. Alternatively, elevated temperatures and the absence of precipitation can produce cracks in the ground and changes in porosity that increase the rate of radon diffusion to the atmosphere (e.g., summer values tend to be higher than winter values).

Environmental radon concentrations are also influenced by atmospheric conditions. During periods of calm winds and temperature inversions (when the air near the earth's surface is cooler than the air above it), air is held near the earth's surface, minimizing the mixing of air. Consequently, radon's movement is limited vertically, and concentrations tend to increase near the ground. Figures 1−7 through 1−10 in Chapter 1 and Appendix C, Attachment C.4 present a summary of meteorological data for 2008.

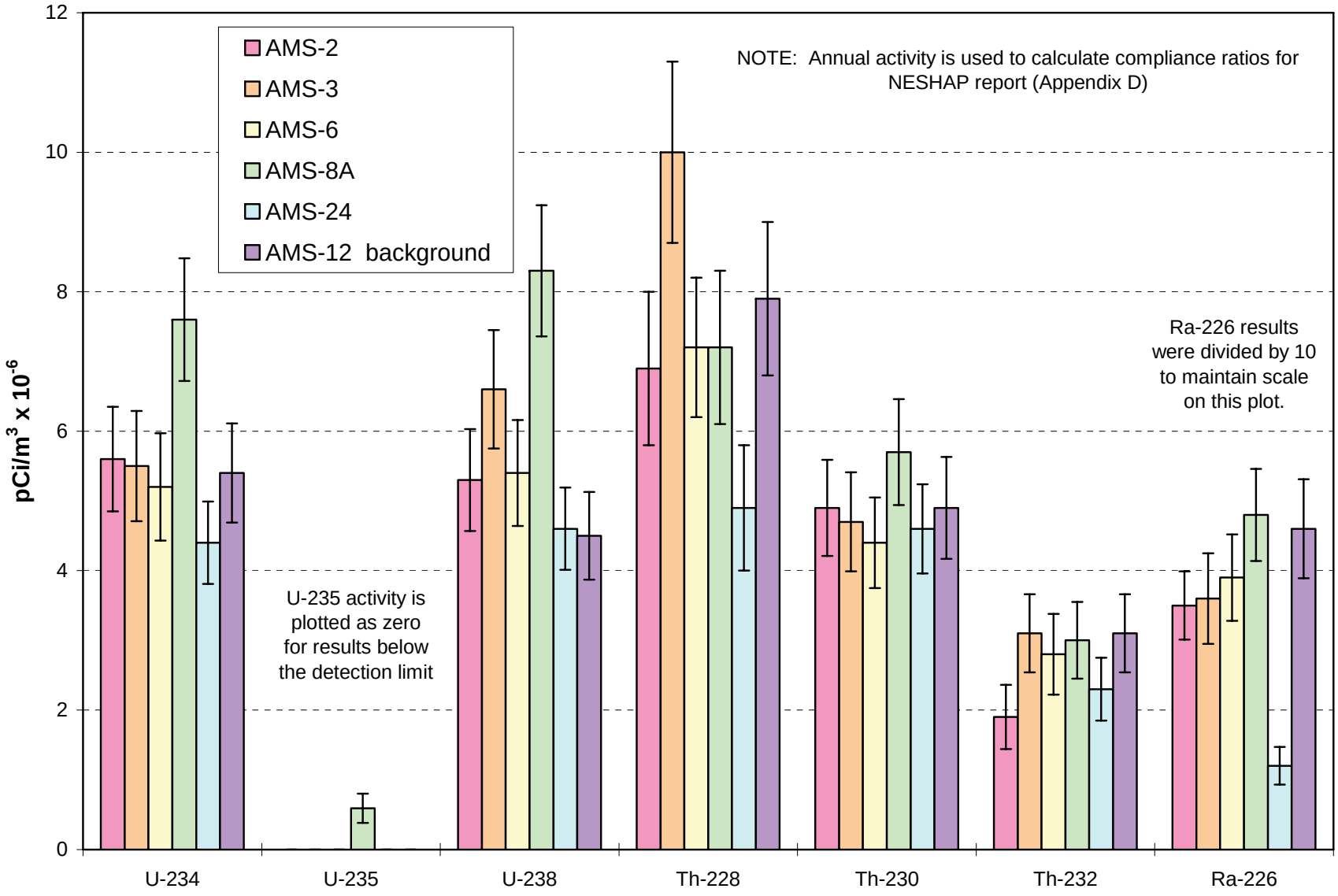


*Figure 5–3. Annual Activity and Uncertainty for Isotopes Used in NESHAP Analysis*

Waste material generated from uranium extraction processes performed decades ago contained radium-226, which produced radon. This waste material is no longer on site. Present radon sources at the Fernald Preserve are limited to residual radium-226 concentrations in the soil, which has been certified to contain radium-226 below levels that pose a risk to human health or the environment, and waste material disposed of in the OSDF. Waste materials in the OSDF are covered with a polyethylene liner and several feet of stone and soil, which provides an effective radon barrier.

DOE Order 5400.5 (first three bullets) and proposed 10 CFR 834 guidelines for radon limits at interim storage facilities state that radon must not exceed:

- 100 pCi/L at any given location and any given time.
- Annual average concentration of 30 pCi/L (above background) over the facility.
- Annual average concentration of 3 pCi/L (above background) at and beyond the Fernald Preserve boundary.
- Annual average concentration of 0.5 pCi/L (above background) at and beyond the Fernald Preserve boundary (proposed 10 CFR 834).

Figure 5−1 illustrates the continuous radon monitoring network used in 2008 to document compliance with DOE Order 5400.5 and proposed 10 CFR 834 requirements. Monitoring locations at the property boundary and a background location were selected using DOE guidance and EPA air monitoring criteria.

The radon monitors at the Fernald Preserve use scintillation cells to evaluate radon activity on an hourly average. Radon gas in ambient air diffuses into the scintillation cell through a foam barrier without the aid of a pump (this technique is called passive sampling). Inside the cell, radon and its radioactive progeny decay by emission of alpha particles. Alpha particles interact with the scintillation material inside the cell, producing light pulses that are amplified and counted, and the number of light pulses counted is proportional to the radon activity inside the cell. The instrument records activity to the nearest 0.1 pCi/L, but without a reported uncertainty.

Table 5−2 provides the annual summary of the variation in monthly average radon activity at the site boundary. The annual average radon concentration at the background monitoring location was 0.3 pCi/L. A maximum annual average of 0.5 pCi/L at several site boundary locations (AMS-3, AMS-6 and AMS-24) corresponds to 0.2 pCi/L above background (0.5 pCi/L minus 0.3 pCi/L for background), which is below the proposed 10 CFR 834 site boundary limit of 0.5 pCi/L above background. Appendix C, Attachment C.2, provides graphical displays of the monthly average radon concentrations at each location.

The 2008 results from the boundary monitoring locations indicate that radon levels are within the historical range (Figure 5−4). The radon results for the boundary locations are not corrected for background, and the uncorrected results in the past 10 years are below the proposed 10 CFR 834 limit of 0.5 pCi/L above background. As the 0.5 pCi/L limit in the past 10 years has not been exceeded, and no significant surface source for radon remains on site, EPA has agreed to DOE's request to discontinue radon monitoring in 2009 (EPA 2008).

*Table 5–2. Annual Summary for Monthly Average Radon Concentrations [a]*

| Location[b] | 2008 Summary Results[c] (Instrument Background Corrected) (pCi/L) | | | 2007 Summary Results[c] (Instrument Background Corrected) (pCi/L) | | |
|---|---|---|---|---|---|---|
| | Min. | Max. | Avg. | Min. | Max. | Avg. |
| **Boundary** | | | | | | |
| AMS-02 | 0.2 | 0.8 | 0.4 | 0.2 | 0.7 | 0.3 |
| AMS-03 | 0.2 | 0.9 | 0.5 | 0.2 | 0.8 | 0.5 |
| AMS-06 | 0.2 | 0.9 | 0.5 | 0.2 | 0.7 | 0.3 |
| AMS-08A | 0.1 | 0.7 | 0.4 | 0.2 | 0.7 | 0.3 |
| AMS-24 | 0.1 | 0.9 | 0.5 | 0.3 | 0.8 | 0.4 |
| **Background** | | | | | | |
| AMS-12 | 0.1 | 0.5 | 0.3 | 0.2 | 0.5 | 0.3 |

[a]Monthly average radon concentrations are calculated from the hourly concentrations.
[b]Refer to Figure 5–1 for radon monitoring locations.
[c]Instrument background is removed because instrument background changes as monitors are replaced.

## 5.5 Monitoring for Direct Radiation

Direct radiation originates from sources such as cosmic radiation, naturally occurring radionuclides in soil and food, and anthropogenic radioactive materials. Gamma rays and X-rays are the dominant types of radiation that create a public exposure concern because they penetrate into the deep tissues of the body. The largest historical source of direct radiation at the former Fernald Closure Project was waste material associated with the Silos Project. The last waste material associated with the Silos Project was removed from the site in 2006. Presently, there are no significant sources for direct radiation at the Fernald Preserve. During 2008, direct radiation levels at the Fernald Preserve boundary were continuously measured at five locations and at one background point located 3.2 miles from the center of the Fernald Preserve (Figure 5−5) with thermoluminescent dosimeters (TLDs). TLDs absorb and store the energy of direct radiation within the thermoluminescent material. By heating the thermoluminescent material under controlled conditions in a laboratory, the stored energy is released as light, measured, and correlated to the amount of direct radiation.

Table 5−3 provides the annual range of direct radiation measurements for 2008 and 2007, and Figure 5−6 illustrates the quarterly results and counting errors for 2008. Each quarterly result represents the average of three measurements per location (obtained from three separate dosimeters placed at each station). In general, the second-quarter results were slightly less than other quarters. On the basis of background results and plotted measurement error bars, results were slightly higher at locations 2, 3, and 8 in the first quarter, at 8 in the second quarter, and at all locations except 35 in the third and fourth quarters. However, as noted in Appendix C, Attachment C.3, the boundary measurements are similar to background when statistical variability is evaluated, which is in agreement with removal of the last direct radiation sources in 2006. This observation should be noted when reviewing the dose assessment presented in Chapter 6 and Appendix D (i.e., there is no significant dose associated with direct radiation).

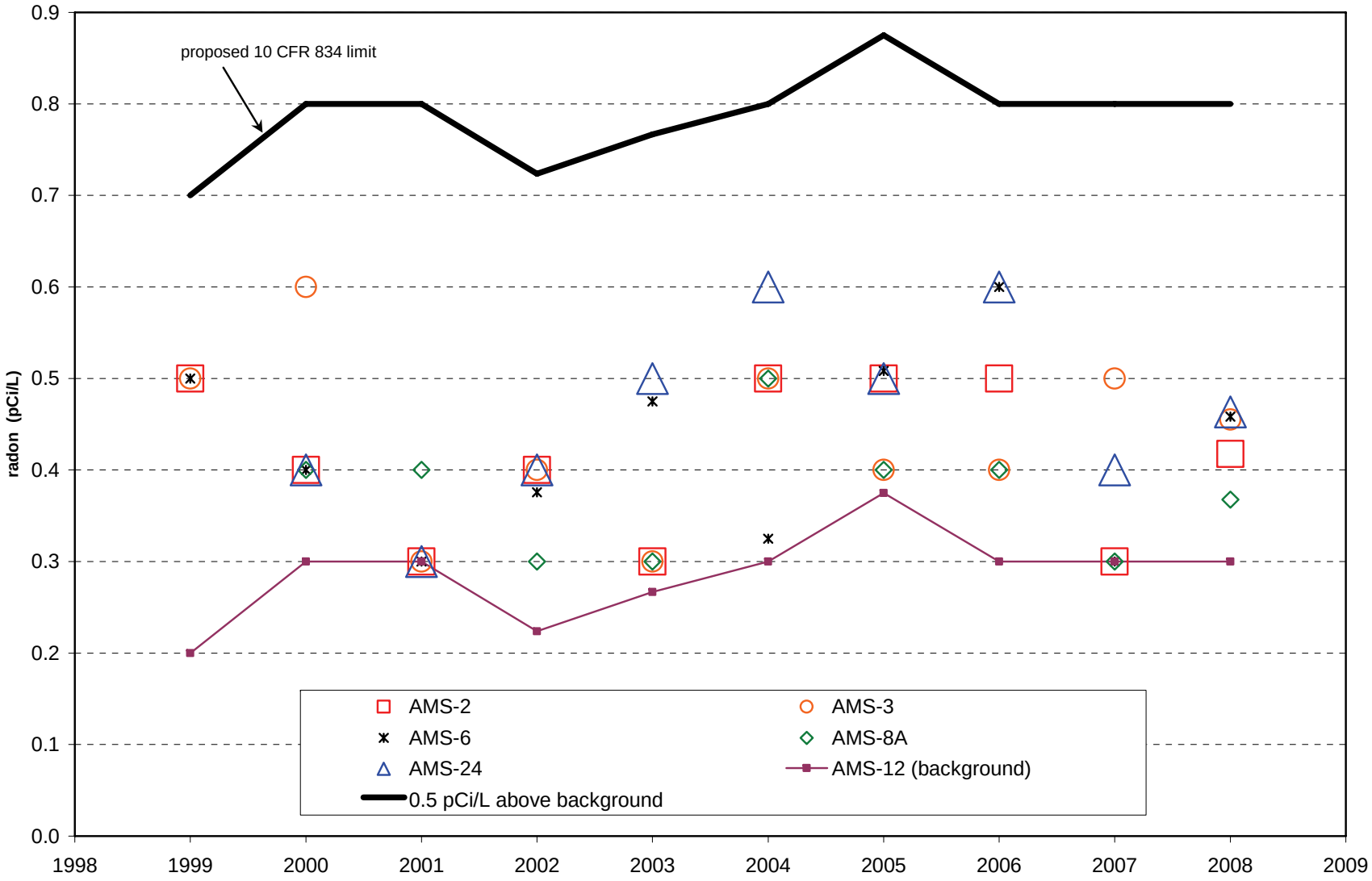


*Figure 5–4. 2008 Average Radon Results Compared to Historical Levels (no background correction)*

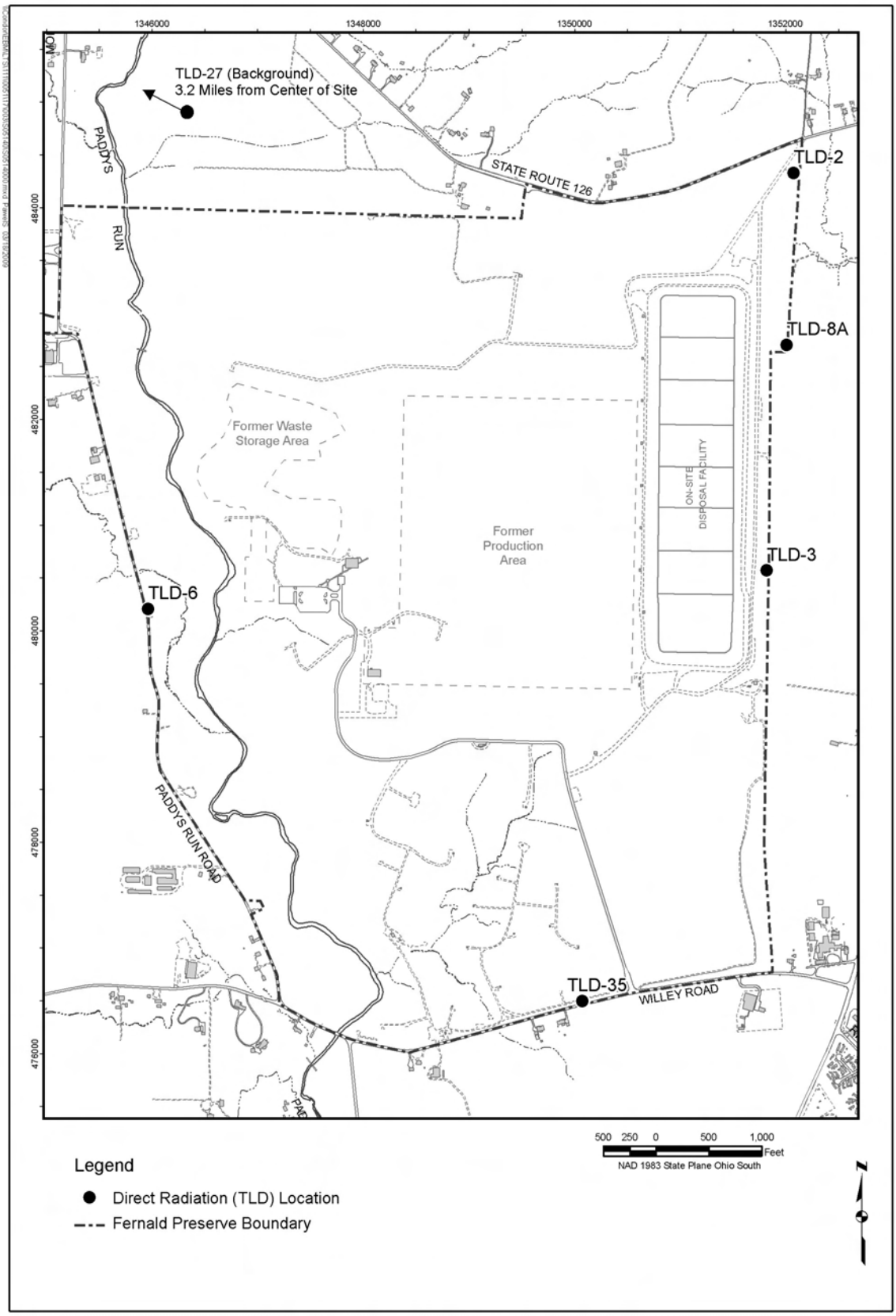


*Figure 5–5. Direct Radiation (TLD) Monitoring Locations*

*Table 5–3. Direct Radiation (TLD) Measurement Summary*

| TLD Location | Direct Radiation (mrem) | |
|---|---|---|
| | Sum of 2008 Quarterly Results | Sum of 2007 Quarterly Results |
| **Boundary** | | |
| Minimum | 48 | 47 |
| Maximum | 54 | 53 |
| **Background**[a] | | |
| Minimum | 48 | 48 |
| Maximum | 48 | 48 |

[a]The minimum and maximum results are identical because there is only one background monitor.

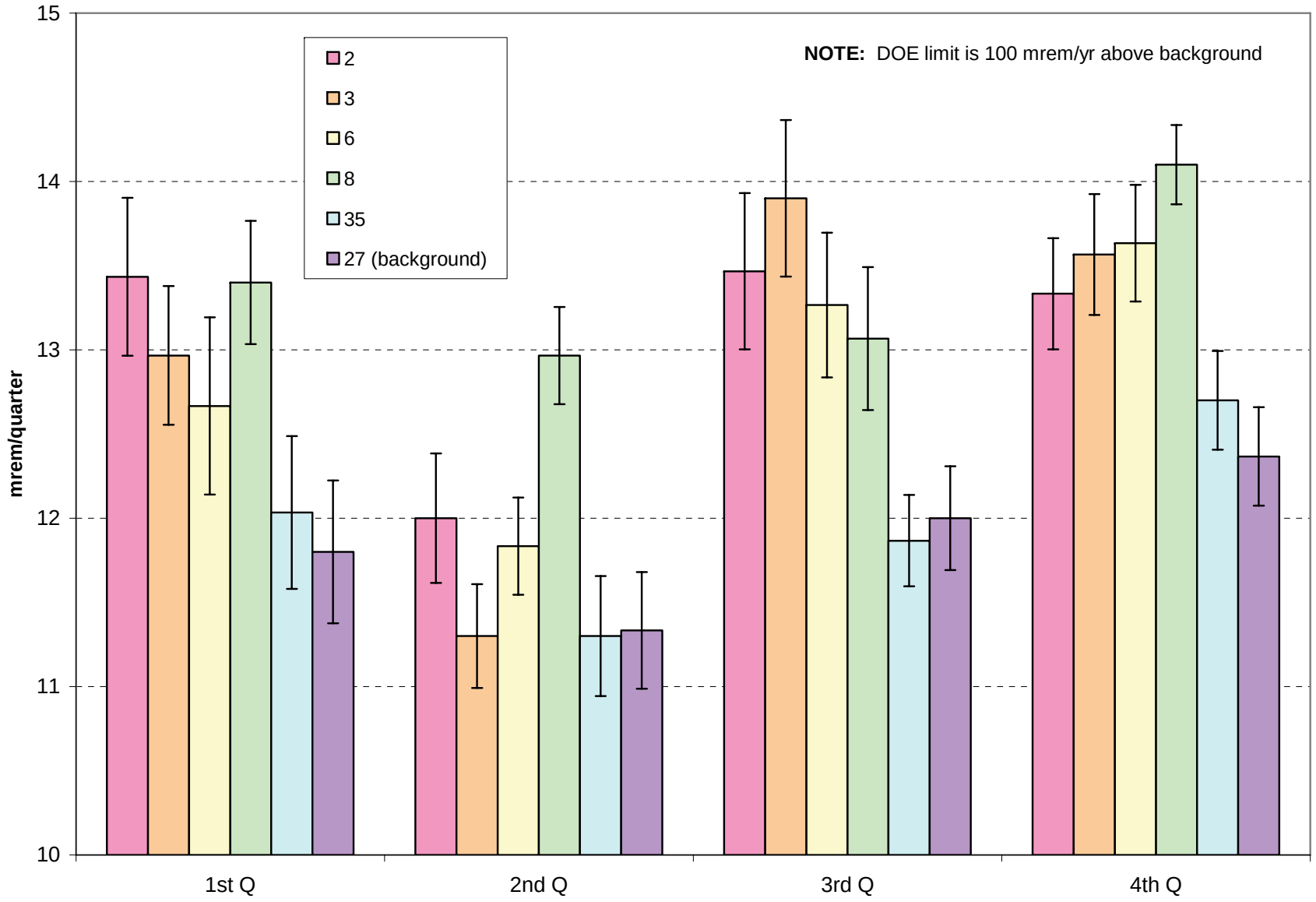


*Figure 5–6. Quarterly Results and Measurement Error for TLD Monitoring Locations*

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