3.0 Environmental Monitoring

3.1 Water Monitoring

3.1.1 Introduction

This section presents data collected to satisfy water monitoring objectives implemented at the Site in accordance with RFLMA Attachment 2, "Legacy Management Requirements," Table 2, "Water Monitoring Locations and Sampling Criteria." The RFSOG provides a guidance framework in support of conducting LM activities, including monitoring, at the Site.

This annual report focuses on data collected during CY 2014 (January through December 2014). This section includes:

- An evaluation of analytical results from routine monitoring as required by RFLMA and detailed in the RFSOG, organized by monitoring objective;
- A summary of hydrologic data for the calendar year; and
- Supplemental data interpretation and evaluation for CY 2014.

Figure 2 shows the RFLMA Attachment 2 water monitoring locations. Analytical water quality data for the fourth quarter of CY 2014 are available in Appendix B. Refer to previous quarterly reports (DOE 2013c, 2013d, 2014b) for analytical data collected during the prior quarters of CY 2014.

3.1.1.1 Water Monitoring Highlights: CY 2014

During CY 2014, the water monitoring network successfully fulfilled the targeted monitoring objectives as required by RFLMA and using the RFSOG implementation guidance. During CY 2014, the routine RFLMA network consisted of 88 wells, 8 gaging stations, 11 surface-water grab sampling locations (3 of which are predischarge pond locations),[1] and 8 treatment system grab sampling locations. During CY 2014, 158 samples composed of 5,541 individual aliquots ("grabs") were collected at the routine surface-water locations,[2] 74 samples were collected from routine treatment system locations, and 155 samples were collected from monitoring wells. Additional samples were collected beyond the RFLMA requirements, as discussed in this report.

Groundwater was monitored in accordance with RFLMA (CDPHE et al. 2012). Analytical data from Area of Concern (AOC) wells did not trigger any reportable conditions. Analytical data from other wells were generally consistent with previous results. Groundwater monitoring results at the PLF and OLF are evaluated in Section 3.1.2.6 and Section 3.1.2.7, respectively, of this report.

[1] Predischarge sampling locations are used only when the terminal ponds are being operated in a batch-and-release mode.
[2] Composite samples consist of multiple grabs of identical volume. Each grab is delivered by the automatic sampler to the composite container at each predetermined flow volume or time interval.

Precipitation in CY 2014 was about average, with the precipitation gaging stations measuring 11.99 inches of precipitation, which is approximately 98 percent of the average (the CY 1993–2013 average is 12.25 inches). (Note that the precipitation gages used in the automated surface-water monitoring network are not heated due to the lack of AC power at the locations. Thus, the gages do not accurately measure snowfall [as water equivalent]).

The June through August period was wetter than average (124 percent of the CY 1993–2013 average of 4.16 inches for the summer season). July was significantly wetter than average (289 percent of the average). The December through May period was drier than average (69 percent of the average). April was very dry with only 0.59 inch of precipitation (30 percent of average). The largest daily events occurred on July 30 (1.68 inches) and October 9 (0.76 inch). July 29–30 was also the largest 2-day total (2.31 inches).

The highest peak flow rates for the year from the former Industrial Area were 7.17 cubic feet per second (cfs) in North Walnut Creek, 2.44 cfs in South Walnut Creek, and 0.34 cfs in the South Interceptor Ditch (SID). These peak flows occurred on July 30, 2014, for North and South Walnut Creeks, and on May 13, 2014, for the SID.

The highest peak flow rates for the year from the Site (at the eastern COU boundary) were (1) 4.65 cfs in Walnut Creek on July 31 and (2) 14.4 cfs in Woman Creek on May 13.

Reportable 30-day average uranium (U) concentrations occurred from December 18, 2013, through May 17, 2014, for surface water at RFLMA POC monitoring station WALPOC, which is located on Walnut Creek at the eastern COU boundary. The same sample results causing the reportable 30-day average also caused the 12-month rolling average to subsequently become reportable on October 31, 2014. As of December 31, 2014, the 12-month rolling average remained at a reportable level (17.0 micrograms per liter [µg/L]). Water quality at WALPOC is evaluated in Section 3.1.2.1 of this report.

All other RFLMA POC analyte concentrations remained below reporting levels throughout CY 2014.

Reportable 12-month rolling average americium (Am) and plutonium (Pu) activities were observed during the first half of CY 2014 in surface water at RFLMA Point of Evaluation (POE) monitoring station GS10, which is located on South Walnut Creek upstream of former Pond B-1. As of June 30, 2014, the 12-month rolling averages for Am and Pu were no longer reportable.

All other RFLMA POE analyte concentrations remained below reporting levels throughout CY 2014.

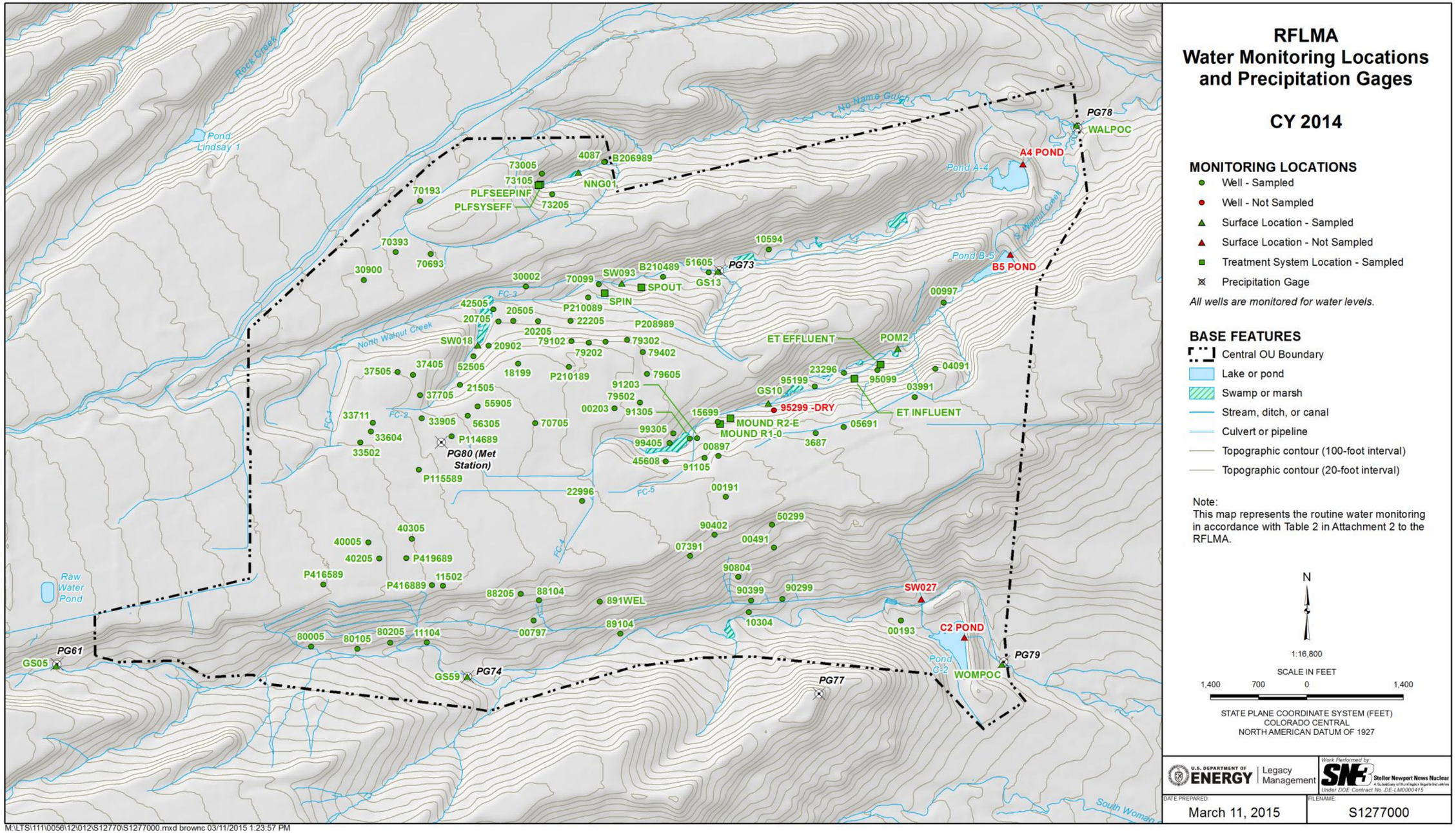

Figure 2. Rocky Flats Site Water Monitoring Locations and Precipitation Gages in CY 2014

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3.1.1.2 Use of Analytical Data

Analytical data are evaluated statistically to meet many objectives in accordance with RFLMA. Rejected data are not included in statistical evaluations. Statistical and other evaluations of analytical data focus solely on those results reported for RFLMA analytes (as listed in RFLMA Attachment 2, Table 1 [CDPHE et al. 2012]).

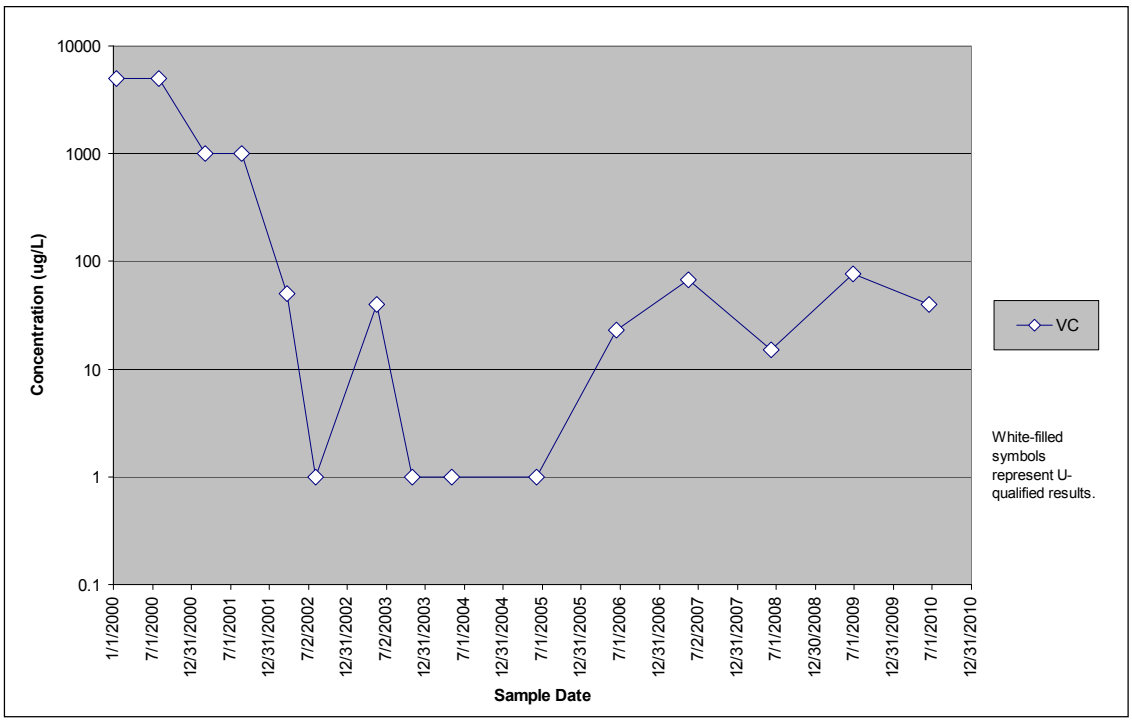
Surface-water data from POCs and POEs are evaluated twice a month, and results of these evaluations are included in the quarterly reports. Details regarding data handling for all surface water can be found in Appendix B.

Groundwater data evaluations are reported annually because the groundwater regime is less dynamic than the surface-water regime: groundwater conditions change much more gradually than surface-water conditions. Groundwater data from AOC wells are evaluated for reportable conditions as they are received; when reportable conditions exist, they are described in the corresponding quarterly report as well as in the annual report.

Groundwater statistics require a minimum of eight results representing routinely collected samples. A commercially available geostatistical software program (e.g., Sanitas, Visual Sample Plan) is used for these calculations. (**Note:** This report does not recommend any particular software; this information is merely included for the sake of completeness.) Furthermore, if trend calculations employ the Seasonal-Kendall (S-K) statistical method, the data representing these routinely collected samples must comprise four sets of results per season. For example, wells required to be monitored semiannually are sampled in the second and fourth quarters of a calendar year. Trending will require a minimum of eight sets of results from routinely collected samples, distributed as four per season—four in the second quarter and four in the fourth quarter. In this example, therefore, a well would need to be sampled for 4 years (4 samples × 2 samples/year = 8 samples total; 4 each of second quarter samples and fourth quarter samples requires 4 full years of semiannual samples) to provide the necessary and appropriate data for statistical analysis. For wells sampled quarterly, although the minimum eight sets of results could be collected in 2 years of routine sampling, the minimum four sets of results per season (four seasons) would not be collected until 4 years of successful, routine sampling had been completed.

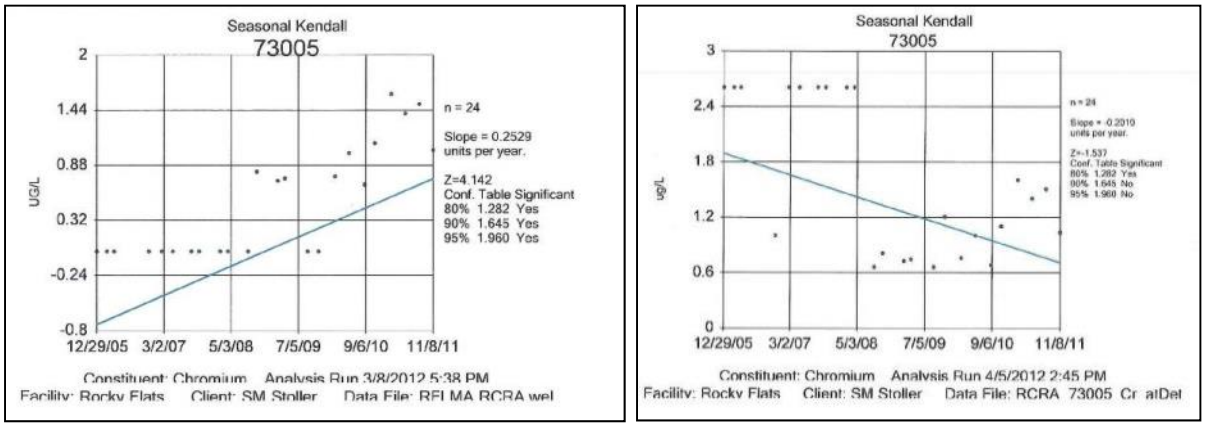
Groundwater field duplicates are omitted from statistical evaluations. Groundwater samples assigned the laboratory qualifier "J" (indicating an estimated value) are taken at face value, rather than being assigned a value of less than the method detection limit plus the practical quantitation limit (PQL). Samples assigned a "B" qualifier (which, for organics, indicates that the constituent was also detected in the blank) are also used at face value. This qualifier is commonly associated with results for methylene chloride. Because methylene chloride is a commonly used laboratory solvent, B-qualified results should be carefully reviewed alongside corresponding detection limits, concentrations in the blanks, and other relevant data before any decisions are based on them. (**Note:** In some cases, these considerations have led to the results being assigned a validation "U" qualifier, signifying that the result is so suspect as to be considered a nondetect. In such cases, the result is considered nondetect rather than a J-qualified or B-qualified value.)

For consistency with pre-closure practices, the RFSOG (DOE 2013b) instructs that nondetects reported for groundwater data be replaced by zeroes when performing statistical assessments. (This is because use of some common techniques, such as replacing the reported nondetect value with one-half the detection limit, could lead to false conclusions – especially if the detection limits change over time. This is illustrated by Figure 3, which is a chart of vinyl chloride [VC] results from the 2010 Annual Report [DOE 2011].) However, to calculate trends, the data cannot contain zeroes. Therefore, instead of zeroes, nondetects are replaced with a value of 0.001. (**Note:** This includes data with lab qualifiers as well as validation qualifiers that include the "U" qualifier.) Likewise, the statistical program cannot perform the necessary calculations if negative numbers are included in the results, as is occasionally the case for radionuclides. Therefore, any negative results are also replaced with a value of 0.001. Calculated trends may be strongly affected by this data replacement, as demonstrated by data evaluated for the 2011 Annual Report (DOE 2012) and included as Figure 4. In this figure, the calculated trend in chromium (Cr) concentrations is shown as increasing or decreasing, depending solely on how nondetects are incorporated into the calculations. In addition, a hypothetical example is provided below in Table 2. As this table demonstrates, the "true" condition is not known, but using half the detection limit, or the reported values (equal to the detection limit) themselves, would strongly suggest the presence of a decreasing trend, while replacing the nondetects with 0.001 may suggest an increasing trend. As demonstrated by these examples, the data that form the basis of calculated trends of interest should be carefully inspected before any conclusions are reached or decisions made based on these trends. The most appropriate path forward in such cases is to refrain from forming conclusions and await the collection of sufficient additional data to allow the determination of whether any concentration trend is actually present.



Notes: Y-axis has a logarithmic concentration scale.

Figure 3. Vinyl Chloride Results from Evaluation Well 07391, Illustrating Variations in Detection Limits



Notes: Left plot utilizes data replacement wherein all nondetects are replaced with a value of 0.001. Right plot incorporates reported data at face value, regardless of qualifier; nondetects are therefore plotted at the associated detection limits. Source: Annual report for 2011 (DOE 2012); refer to that document for additional discussion.

Figure 4. Effects of Data Replacement on Statistical Trends Calculated for Cr in 2011 at PLF Well 73005

Table 2. Hypothetical Example Illustrating Effects of Detection Limits and Data Replacement on Statistical Calculations

Reported Concentration	Laboratory Qualifier	Detection Limit	Concentration Used in Statistical Calculations	Actual Concentration
250	U	250	0.001	Unknown
50	U	50	0.001	Unknown
50	U	50	0.001	Unknown
50	U	50	0.001	Unknown
50	U	50	0.001	Unknown
50	U	50	0.001	Unknown
11		5	11	11
7		5	7	7
8		5	8	8
7		5	7	7

Evaluations of U in groundwater are based on total U concentrations. In some cases, surface-water data are also evaluated (e.g., at sampling location GS13, the performance monitoring location supporting the SPPTS). The latter data through mid-2009, as well as a substantial portion of earlier groundwater data, are typically reported as isotopic activities. Any negative values for individual isotopic analyses are first replaced with 0.001 as described above, and then the individual results for a given location and date are converted to mass units and summed to provide a conservative approximation of total U by mass. Any total U results that were equal to or less than zero were also replaced with 0.001 to allow for the requirements of the statistical calculations. Conversion factors used to support these groundwater evaluations are listed in Table 3.

Table 3. U Isotope Conversion Factors Used in Groundwater Evaluations

Isotope	Conversion Factor	Typical Activity Units	Typical Mass Units
U-233[a]	9,636.6 pCi/µg	pCi/L	µg/L
U-234	6,235.1 pCi/µg	pCi/L	µg/L
U-235	2.1612 pCi/µg	pCi/L	µg/L
U-236[a]	64.672 pCi/µg	pCi/L	µg/L
U-238	0.33614 pCi/µg	pCi/L	µg/L

Notes: Source of conversion factors: (Friedlander et al. 1981)
[a] U-233 and U-236 are absent in natural U and, therefore, can be used as definitive markers for anthropogenic U. Los Alamos National Laboratory analyzes U-236 and also evaluates isotopic ratios for this purpose.

Abbreviations:
pCi/µg = picocuries per microgram
pCi/L = picocuries per liter

There are many instances in the database of multiple results for U on the same date at the same well. These results may represent any of the following: isotopic analysis providing results in activity units, isotopic analysis providing results in mass units, total U analysis via a metals analytical method, total U via a total U analytical method, filtered sample, unfiltered sample, unvalidated result, partially validated result, validated result, and result of reanalysis. (Note that these last four result types are most common in pre-closure data.) Before trends were calculated, for each well where this applied, these multiple results were winnowed to a single result representing each unique date. Factors evaluated in selecting the result for statistical use included the following:

- Filtration status
- Validation qualifiers
- Lab qualifiers
- Other U results from the well

Because groundwater samples for U analysis for many years have been field-filtered, where both sample results are provided, the filtered result is typically preferred for reasons of consistency. Similarly, where two very different results are presented, the value closer to other values from the same well is retained; if the two results are similar, the higher-concentration result is retained, to be conservative.

Data from original wells are grouped with those from replacement wells to form a data set on which the statistics are based. As additional data are collected from replacement wells (most of which were installed in 2005), this may prove to be inappropriate. The data populations from original and replacement wells may be discontinuous, suggesting that data from the original wells should be removed from statistical assessments of more recent groundwater data. This determination will be made as the post-closure data set becomes large enough to allow such an evaluation. Therefore, it should be stressed that trends for some locations may be misleading in that they might be strongly affected by well replacement and do not reflect only groundwater geochemistry and hydrology.