Connecticut Yankee Atomic Power Company
Haddam Neck Plant
East Hampton, Connecticut

Groundwater Monitoring Report
March and June 2003
Quarterly Sampling Events

Prepared by

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Table of Contents

List of Tables

List of Figures

Figure………………..…………………………………………………………..…Page

List of Appendices

Appendix……………..…………………………………………………………..…Page

1 Introduction

This monitoring report presents the compilation of two (2) groundwater-sampling events performed in March and June 2003. The samples collected during these events were analyzed for various radiological substances of concern (SOCs) and boron. The objective of this monitoring report is to provide a summary of these two sampling events to enhance the understanding of the radiological groundwater quality beneath the Connecticut Yankee Atomic Power Company (CYAPCo) facilities and property.

Thirty-four (34) samples from thirty-three (33) locations within the existing site-wide monitoring well network were collected and analyzed during the March 2003 quarterly groundwater-sampling event. A total of thirty-nine (39) samples were collected for analysis from thirty-eight (38) monitoring wells during the June 2003 event. Samples were collected from five (5) new monitoring wells during the course of these sampling events. The results of analysis of these samples are discussed in detail in Section 4.

The groundwater samples were forwarded to off-site, certified laboratories for analyses of radiological constituents and boron. This monitoring report provides a summary of the resulting data. Some biases were observed in the analytical data at low-level concentrations near the reported MDC. These positive and negative biases were observed in rank order trend plots for several nuclides. In some cases where a positive bias was observed, these results were concluded to be false positives and part of the underlying background or baseline distribution based on the homogeneity and normality of the results. These biases are generally limited to analyses performed via liquid scintillation counting (LSC) and gas proportional counting (GPC).

CYAPCo employed the services of two laboratories for analyses of radiological constituents. Samples obtained during the March 2003 sampling event were analyzed by the STL Richland Lab. Samples obtained during the June 2003 sampling event were analyzed by the Framatome ANP Environmental Lab. CYAPCo is in the process of pursuing additional certified laboratory(ies) in order to satisfy current and future sample requirements. The laboratories will be evaluated to ensure the integrity of future laboratory results.

CYAPCo continues to implement the Phase II Hydrogeologic Investigation Work Plan (Reference HIWP 2002) that, when completed, will further characterize and develop an understanding of the hydrogeologic conditions beneath the site. This Plan was developed with assistance from Connecticut Department of Environmental Protection (CTDEP), United States Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) personnel. When fully implemented, the Plan, and potential additional work scope variations, will allow for a better understanding of these hydrogeologic conditions.

During the current implementation of the Phase 2 Hydrogeologic Work Plan, several changes have been identified, previously approved and incorporated into the continued advancement of the Work Plan Objectives. A summary of these changes are identified as follows:

1) Reporting frequency is semi-annual instead of quarterly (quarterly groundwater-sampling continues);
2) Packer testing of the bedrock portions of the "deep" borings is at approximately 20-foot from the bottom of a pre-determined depth up, to the top of bedrock, in place of twenty-foot intervals as the boring is advanced downward;
3) The Work Plan identified five (5) "deep" bedrock borings to be advanced with the completion of the Work Plan activities. Due to site-specific work activity, four (4) "deep" bedrock borings will be advanced during this drilling evolution, the fifth will be installed at a later time; and
4) An option has been incorporated to use a drilling method known as "mud rotary" to advance the protective overburden casing, sealing off the soils and groundwater, from the lower bedrock aquifer formation.

These changes in the original Phase 2 Hydrogeologic Work Plan have been discussed with the regulatory stakeholders and agreement has been achieved for their incorporation. Additionally, these changes are viewed as enhancements that should provide for supplemental implementation of the Work Plan in an effective and efficient manner.

2 Groundwater Elevation and Flow Direction

Depth-to-water (DTW) measurements were performed in all monitoring wells during each sampling event. Additional DTW measurements were collected for the specific purpose of developing groundwater contour maps for the industrial/northern peninsula and the landfill areas. These additional DTW measurements were typically performed on the first day of the sample event within an 8-hour time frame, to minimize the impact of tidal and local precipitation fluctuations. Table 1 is a summary of the measured DTW for the March and June 2003 sample events and also includes historical data through April 1999. The DTW is the distance in feet, from the top of the inner PVC well casing (TIC). Table 1 also includes the reference or surveyed elevation of the TIC for each monitoring well based on Reference GMR 1999 or global positioning system (GPS) measurements.

Table 2 summarizes groundwater elevations referenced to mean sea level (msl). Groundwater elevations are calculated in Table 2 by subtracting the recorded depth-to-water measurement in each monitoring well from the reference elevation or TIC. Industrial area wells typically range from 5 to 15 feet above msl. Peninsula wells typically range from 2.5 to 6.3 feet above msl. Landfill water table levels are typically 26 to 36 feet above msl.

Table 3 presents a summary of the overall change in groundwater elevation from the previous sample event. The elevation changes summarized in Table 3 provide an indication of the temporal variation in groundwater from sample event to sample event. Elevation changes in red indicate a decrease in groundwater levels from the previous sample event. Elevation changes in black indicate an increase in groundwater elevation.

Table 4 presents hydraulic head differences between the shallow and deep wells within a well cluster (i.e., two wells at different depths in one location). Head differences in red indicate negative head differences while head differences in black indicate positive differences in the vicinity of the well cluster. Also included in Table 4 is a summary of the percentage of positive and negative head differences at a particular well cluster. This summary provides an indication of the apparent trends in hydraulic head at these well clusters.

2.1 March 2003 Quarterly Sampling Event

Groundwater elevations for industrial area wells were generally lower during the March 2003 sample event as compared to December 2002 (summarized in Table 3). Thirteen of twenty-one industrial area monitoring wells exhibited decreases in groundwater elevation as denoted in red in Table 3. Groundwater elevations for peninsula area and land fill monitoring wells were generally higher than the December 2002 sample event. Nine of the monitoring wells located in the peninsula and landfill area wells exhibited increases in groundwater elevation as denoted in black in Table 3.

Figure 1 lists groundwater elevation data for the industrial/northern peninsula areas. Some facility structures that extend below the water table in the industrial area are also illustrated in Figure 1. Absent from these figures are groundwater table contours, equipotential lines and flow direction arrows that we have provided in the past to illustrate major features of groundwater flow. Due to the presence of significant substructures and other barriers to shallow groundwater flow, groundwater flow in the vicinity of the industrial area is too complex to treat with simplistic and general contour intervals. In the future, additional interpretation of groundwater flow gradients are expected, as our understanding of the groundwater flow matures.

Horizontal shallow groundwater flow direction in the industrial area during this time period was generally from the hillside in the north to the south toward the Connecticut River, with a minor component of flow toward the head of the discharge canal. The overall shallow water table hydraulic gradient or slope of the shallow groundwater table, between monitoring wells MW-101S and MW-110S during the March 2003 sampling event was approximately 0.016 foot per foot (ft/ft). The calculated hydraulic gradient between these locations during the December 2002 sampling event was approximately 0.018 ft/ft. This minor difference in overall hydraulic gradient between December 2002 and March 2003 suggests that there was no significant change in the rate of shallow ground water flow across the site during the period.

Hydraulic head differences in well clusters were consistent with historical trends during the March 2003 sample event. Negative head differences as indicated in red in Table 4 were observed at well clusters MW-100, MW-101, MW-103, MW-106 and MW-122. Positive head differences were observed at well clusters MW-105, MW-107, MW-109 and MW-110.

Figure 2 presents the groundwater elevation data for the landfill area. The groundwater flow direction in the area of the landfill area was eastward, in the general direction of Salmon Cove and included a minor component of flow toward Dibble Creek (also known as the beaver pond). The hydraulic gradient between monitoring wells MW-202 and MW-201, at the northwest and southeast perimeters of the landfill area, was approximately 0.027 ft/ft, in March 2003. The calculated hydraulic gradient between these locations during the December 2002 sampling event was approximately 0.028 ft/ft. This minor difference in overall hydraulic gradient between December 2002 and March 2003 suggests that there was no significant change in the rate of shallow ground water flow across the landfill area during the period.

2.2 June 2003 Quarterly Sampling Event

Groundwater elevations for industrial area wells were generally higher during the June 2003 sample event as compared to March 2003 and summarized in Table 3. Fifteen of twenty-six industrial area monitoring wells exhibited increases in groundwater elevation as denoted in black in Table 3. Groundwater elevations for peninsula area and land fill monitoring wells were generally lower than the March 2003 sample event. Seven of the monitoring wells located in the peninsula and landfill area wells exhibited decreases in groundwater elevation as denoted in red in Table 3.

Figure 3 lists groundwater elevation data for the industrial/northern peninsula areas for the June 2003 sample event. Shallow groundwater flow in general was similar to the March 2003 sample event. The overall shallow water table hydraulic gradient or slope of the shallow groundwater table, between monitoring wells MW-101S and MW-110S during the June 2003 sampling event was approximately 0.018 foot per foot (ft/ft). The calculated hydraulic gradient between these locations was approximately 0.016 ft/ft during the March 2003 sampling event. No significant change in the rate of shallow ground water flow across the site was observed during these sample events.

Hydraulic head differences in well clusters were consistent with historical trends during the June 2003 sample event with one exception. Monitoring well cluster MW-103 exhibited a slight positive head difference.

Figure 4 presents groundwater elevation data for the landfill area. Groundwater flow was in the general direction of Dibble Creek with no easterly flow component toward Salmon Cove. The hydraulic gradient between monitoring wells MW-202 and MW-201, at the northwest and southeast perimeters of the landfill area, was approximately 0.007 ft/ft, in June 2003. The calculated hydraulic gradient between these locations during the March 2003 sampling event was approximately 0.027 ft/ft. The difference in overall hydraulic gradient between the March 2003 and June 2003 data suggests a significant change in the rate of shallow ground water flow across the landfill area during this time period.

3 Groundwater Sampling and Analyses

This monitoring report includes the radio-analytical and boron results for two quarterly ground-water sampling events. One quarterly sampling event occurred between March 24 and April 7, 2003. The other sampling event occurred between June 24 and July 3, 2003.

Measurements of field parameters were included as components of the groundwater sampling and are discussed in Section 3.1 and Section 3.2. Copies of the applicable procedures that were used to direct the groundwater sampling activities are contained within Appendix A.

Groundwater samples were collected using a Grundfos low-flow stainless steel submersible pump with dedicated polyethylene tubing. There were exceptions to this sampling technique during the June 2003 sampling event. As a result of low water level conditions, monitoring wells MW-102D, MW-103D, MW-200, MW-201 and MW-208 were purged and sampled with a dedicated polyethylene bailer.

3.1 Field Tests

Several forms of field-testing were implemented during each sampling event, including gauging of water levels, evaluation of the potential presence of separate-phase fluid and measurement of groundwater field parameters. Each of these tests yields different information that allows for the evaluation of water quality and conditions within the respective monitoring wells.

Depth-to-water and bottom-of-monitoring-well measurements were collected with a Solinst electronic interface meter. This device can electronically differentiate between the presence of separate-phased light non-aqueous phase liquids (LNAPLs), dense non-aqueous phase liquids (DNAPLs) and water. The resolution of the instrument is 0.01 foot. An example of an LNAPL, which has a specific gravity less than that of water and floats on the water table, is gasoline; whereas a DNAPL, which has a specific gravity greater than water and sinks through the water column, may include chlorinated solvents. During each sampling event, neither separate-phased LNAPL nor DNAPL were detected in any of the monitoring wells gauged with this device.

Additional monitoring well-specific groundwater parameters were collected during the sampling of each well, including specific conductivity, pH, dissolved oxygen, temperature, oxidation-reduction potential and turbidity. The purpose of collecting these data is to confirm that stagnant water in each monitoring well is removed so that a representative groundwater sample can be collected from the aquifer of interest. This is accomplished by making several iterative measurements of field parameters while ground water is removed from the well, until the parameters have stabilized to within a 10% variation. These parameters were measured using a multi-parameter meter, with sensors arrayed within a flow-through cell. The resulting measurements are included within this report as Appendix B.

3.2 Field Conditions

As presented within Appendix B, the field parameters typically stabilized within an acceptable range. One of the goals of the sampling event was to collect samples with a turbidity level in the range of 5 to 15 nephelometric turbidity units (NTUs). This range is typically used to indicate the absence of fine silt that may adversely affect the analytical results of the groundwater sample. In general, with few exceptions, the turbidity levels of the groundwater samples were within this range and were fairly consistent with previously collected data. During the March 2003 sample event, an inline filter was used for monitoring well MW-122D due to high turbidity readings in excess of 1000 NTUs.

As previously noted in past groundwater reports, pH continues to trend high at monitoring well MW-106D. During the March 2003 ground-water sampling event, the pH readings from monitoring well MW-106D were within the range of 9.51 to 9.81. In June 2003, the range in pH in this well was from 9.07 to 9.40. This well has trended as high as 11.18 to 11.39 during the June 2001 sampling event. Future pH measurements from this location will be monitored and evaluated closely.

3.3 Routine Lab Analyses and Locations

Various locations from across the CYAPCo Haddam Neck Plant (HNP) facility and the Emergency Operation Facility (EOF) were sampled and analyzed during each quarterly sampling event. All wells sampled were analyzed for gross alpha, gross beta and gamma isotopic constituents. A number of industrial area monitoring wells were also sampled and analyzed for boron and Sr-90. A sub-set of these monitoring wells are routinely analyzed for select HTD radionuclides.

Monitoring well MW-200 was not sampled during the September 2002 event due to insufficient water within the monitoring well. The locations that were sampled are located within the power station, peninsula, support building(s) and landfill areas, as indicated below:

<u>March 2003 Monitoring Event</u>

- <u>Power Station Area (28 samples from 27 wells in 17 clusters or locations)</u>:

MW-100D, S	MW-101D, S	MW-102D, S	MW-103D, S	MW-104S
MW-105D, S	MW-106D, S	MW-107D, S	MW-108S	MW-109D(2), S
MW-110D, S	MW-114S	MW-115S	MW-122D, S	MW-123S
MW-124S	MW-125S			

- <u>Landfill Area (5 samples)</u>:

MW-200	MW-201	MW-203	MW-205	MW-207

- <u>Peninsula Areas (4 samples)</u>:

MW-111S	MW-112S	MW-113S	MW-117S

- <u>Emergency Operations Facility Area (1 sample)</u>:
  EOF-2

<u>June 2003 Monitoring Event</u>

- <u>Power Station Area (28 samples from 27 wells at 17 clusters or locations)</u>:

MW-100D, S	MW-101D, S	MW-102D, S	MW-103D, S	MW-104S
MW-105D, S	MW-106D, S	MW-107D, S	MW-108S	MW-109D(2), S
MW-110D, S	MW-114S	MW-115S	MW-122D, S	MW-123S
MW-124S	MW-125S			

- Landfill Area (6 samples):
  MW-200 MW-201 MW-203 MW-205 MW-207 MW-208

- Peninsula Areas (4 samples):
  MW-111S MW-112S MW-113S MW-117S

- Emergency Operations Facility Area (1 sample):
  EOF-2

Groundwater samples that exhibited satisfactory turbidity values were collected unfiltered. Samples that exhibited higher turbidity values were filtered prior to preservation. Certified, off-site laboratories analyzed all samples for the following constituents and by the listed methodologies:

- Boron via EPA method 6010B and 200.7
- Gross Alpha via EPA method 900
- Gross Beta via EPA method 900
- H-3 via EPA method 906.0
- Reactor-generated radionuclides using gamma spectroscopy (e.g., Cs-137, Co-60)
- Sr-90 via EPA method 905.5 and gas proportional counting (March 2003)
- Sr-89 and Sr-90 (Sr-89,90) via proprietary method via Cerenkov liquid scintillation (June 2003

The results of analysis of the quarterly site-wide groundwater samples are discussed in Section 4.0. Additional location-specific analyses are described below.

3.4 Special HTD Lab Analyses and Locations

In addition to the above analyses, samples from a subset of various locations were analyzed during each sampling event via special analyses for Hard-To-Detect (HTD) plant-related radionuclides. These HTDs include alpha, beta and X-ray emitting radionuclides.

The subset of monitoring wells analyzed for HTDs, per monitoring event, included the following:

March 2003 Monitoring Event

MW-102S	MW-103S	MW-105S	MW-106S	MW-114S

June 2003 Monitoring Event

MW-103S	MW-105S	MW-106	MW-122D, S	MW-123S
MW-124S	MW-125S			

Each sample was analyzed for gross alpha, gross beta, H-3 and gamma isotopic activity. In addition, the HTD analytes and analytical methodologies included the following:

- Carbon-14 via liquid scintillation
- Iron-55 via liquid scintillation
- Nickel-63 via liquid scintillation
- Plutonium-241 via liquid scintillation
- Sr-90 via EPA method 905.5 and gas proportional counting
- Sr-89,90 via proprietary method via liquid scintillation
- Tc-99 via liquid scintillation
- Alpha-emitting transuranics (isotopic plutonium, curium, americium) via alpha spectroscopy
- Beta-emitting Pu-241 via liquid scintillation

Strontium-89 was not analyzed for any well sampled during the March 2003 sampling round. Strontium-89 was analyzed during the June 2003 sampling round. According to Reference LTP 2002, Sr-89 is not expected to be present at HNP due to its 60-day half-life and the seven years since the plant has been shut down. For this reason, Sr-89 has been deleted from the list of nuclides to be analyzed for. In the case of the June 2003 sampling event, Sr-89 results were reported as part of the analytical labs routine strontium analysis. The results of analyses for HTD constituents in the subset of monitoring wells listed above are discussed in Section 4.6.

4 Lab Analytical Results for Quarterly Sampling Locations

Laboratory analytical data packages in support of the ground-water sampling events are included as Appendix C.

4.1 Boron

Boron is a good indicator element in groundwater at the HNP because it is chemically stable and was added to the water in the reactor vessel to control neutron flux when the plant was in operation. Therefore, the occurrence of elevated concentrations of boron in groundwater may be a general indicator of areas that have been impacted by previous releases. Results from the September 1999 Groundwater Monitoring Report (GMR 1999) show the presence of boron and tritium in groundwater beneath the power station are roughly coincident. Groundwater analytical results for boron analyses are summarized in Table 5.

Twenty-five (25) samples were collected in the March 2003 round resulting in twenty-three (23) samples greater than the Contract Required Detection Limit (CRDL) of 50 micrograms per liter (µg/L). Monitoring well MW-105S continued to exhibit the highest concentrations of boron with the March 2003 results at 915 µg/L.

Twenty-seven (27) samples were collected in the June 2003 round that resulted in twenty (20) monitoring wells with concentrations of boron greater than the CRDL of 50 µg/L. Concentrations above the CRDL for boron during June 2003 ranged from a minimum of 51 µg/L at MW-106D to a maximum of 1145 µg/L at MW-100S. MW-100S will be retested since this is the first time boron has been detected at this concentration. CYAPCO believes this detection at MW-100S to be a laboratory anomaly. The boron concentration at MW-100S is typically below 250 µg/L though a previous maximum concentration of 710 µg/L was observed during the March 2002 sampling event. A decreased boron concentration of 618 µg/L was observed at MW-105S.

Attached in Figures 5 through 9 are box and whisker diagrams or box plots for analyte concentrations in groundwater as a function of time. Box plots provide a mechanism to graphically compare 2 or more sets of data, in this case, temporal or seasonal groundwater monitoring results from multiple quarterly sampling events. In particular, trends with respect to the median, extreme values and data dispersion over time are visually evident. The median value provides an unbiased central tendency of the data that is not affected by extreme outliers. The position of the median value in the vertical box provides information regarding the symmetry of the inter-quartile range when viewed on a linear scale. The inter-quartile range describes the spread of the central 50% of the data. The length of the vertical boxes shows the extent of the inter-quartile range. The length of the vertical lines or whiskers shows the overall extent of the data above and below the inter-quartile range. We have selected a log concentration scale since the detectable concentrations ranged over 2 or more orders of magnitude.

The box plot displays a quartile summary of quarterly sample event data with some key statistics. The quarterly sample event results are sorted in increasing numerical order and divided into 2 groups at the median or second quartile (Q_2). The median of the lower group is the first quartile (Q_1) and the median of the upper group is the third quartile (Q_3). The difference between Q_3 and Q_1 is the inter-quartile range and is represented by the central vertical box or rectangle in the box plot diagram. The horizontal line dividing the central vertical box is the second quartile (Q_2) or median value of the data set. The two lines extending out from the center box are the whiskers and the end points in this case represent the minimum or zero quartile (Q_0) and maximum or fourth quartile (Q_4) values.

Attached in Figure 5 is a box plot for Boron concentrations as a function of time ranging from March 1999, through June 2003. The plotted values display results for all wells sampled during the sampling event with concentrations greater than the method detection limit (MDL). There has been a general decrease in the observed maximum boron concentration since March 1999. Median results from have fluctuated from a low of about 45 µg/L in June 2001 to a high of 188 µg/L during September of 2002 with no apparent temporal or seasonal trend.

CYAPCo has plans to propose alternative groundwater protection criteria for boron, pursuant to Section 22a-133k-3(h)(1), Additional Polluting Substances, of the CTDEP RSRs. This proposed criteria will be based upon the risk-based equation and constants provided in the RSRs, as well as the boron reference dose provided by the USEPA.

4.2 Gross Alpha

Gross alpha results for the two quarterly sampling events are summarized in Table 7. Gross alpha results ranged from non-detects to 24 pCi/L. Three results were observed with concentrations greater than the EPA MCL of 15 pCi/L. Higher gross alpha levels were generally detected in the deeper wells completed in bedrock during these sampling events. The source of most of the activity is erosion of naturally occurring alpha-emitting nuclides, including Ra-226 and Ra-224 that are likely present in the granitic gneiss bedrock. Natural levels of gross alpha activity can range as high as a few hundred pCi/L. Although it is possible that plant-related radionuclides contribute to some of the observed gross alpha activity, it is not probable since alpha isotopic analysis generally results in non-detects with nominal detection sensitivity on the order of 0.3 pCi/L or less.

In Figure 6 is a box plot for gross alpha concentrations as a function of time ranging from December 2001, through June 2003. Plotted values in this case represent statistically significant results with concentrations greater than the 2-σ TPU. The maximum gross alpha concentration has ranged from 7.8 to 24 pC/L since December of 2001. Median results from have fluctuated from a low of about 1.3 pCi/L to a high of 5.1 pCi/L. There were no apparent temporal or seasonal trends.

4.3 Gross Beta

Gross beta results for the two quarterly sampling events are summarized in Table 7. Gross beta results ranged from 1.6 to 490 pCi/L. The EPA screening level for gross beta radioactivity is 15 pCi/L though natural levels may range as high as a few hundred pCi/L. As shown on Table 7, gross beta activity roughly correlates with Sr-90 (a beta emitter) data, in that the highest concentration of Sr-90 is also found in MW-105S. Another beta emitter which contributes to gross beta activity is Cs-137 and has been detected in MW-102D, MW-103S and MW-115S. Table 7 shows that groundwater from these locations also has relatively high concentrations of gross beta activity.

In Figure 7 is a box plot for gross beta concentration as a function of time ranging from December 2001, through June 2003. The maximum gross beta concentration has ranged from 142 to 490 pC/L since December of 2001. Median results have fluctuated from a low of about 5.4 pCi/L to a high of 10.0 pCi/L. There are no apparent temporal trends associated with gross beta results. There does appear to be a seasonal trend associated with the maximum gross beta results. The maximum gross beta levels observed to date are at MW-105S, and these levels tend to coincide with sampling events associated with peak groundwater elevation including March and June time periods.

4.4 Tritium

Groundwater analytical results from the March and June 2003 sampling events indicate that samples from monitoring wells MW-103D and MW-102D contained H-3 at the highest concentrations. The results including the previous eight quarterly sampling events are summarized in Table 6. Results for MW-102D ranged from 27,100 to 28,630 pCi/L during the March and June 2003 events. These concentrations are greater than the EPA Maximum Contaminant Level (MCL) for H-3 of 20,000 pCi/L. Monitoring well MW-102D is the deeper well located in a 2-well cluster near the south end of the overhead yard crane near the Spent Fuel Building.

Results for MW-103D ranged from 10,300 pCi/L during the March 2003 event to 11,460 pCi/L during the June 2003 event. As indicated on Figure 1, monitoring well MW-103D, is the deeper well in the cluster located in the vicinity of the former Refueling Water Storage Tank (RWST). This well has exhibited fairly constant H-3 concentrations in the 20,000 pCi/L range over the sampling events prior to December 2001. Since December 2001, H-3 levels in MW-103D have ranged from 8,100 pCi/L to 12,900 pCi/L.

Historically, monitoring well MW-105S exhibited the highest concentration of H-3 recorded to date at 138,700 pCi/L, during the March 1999 sampling event. Generally, there has been a significant downward trend in H-3 concentrations at this location. Results for MW-105S ranged from 5,410 to 4,470 pCi during the March and June 2003 sampling events.

Monitoring well MW-110D, located on the northern peninsula, approximately midway between the head of the discharge canal and the Connecticut River (Figure 1), exhibited its lowest observed H-3 concentrations to date. Tritium concentrations were initially identified in this well in March 1999 at 27,630 pCi/L. In December 2002, the H-3 concentration decreased to 11,100 pCi/L. Results ranged from 4,630 to 5,310 pCi/L during the March and June 2003 sampling events.

In Figure 8 is a box plot for H-3 concentrations as a function of time ranging from March 1999, through June 2003. Maximum H-3 concentrations have ranged from 13,900 to 28,630 pCi/L since September of 1999. Median results from have fluctuated from a low of about 1170 pCi/L to a high of 4430 pCi/L during this same period. There were no apparent seasonal trends in the median results. An overall downward trend in the median H-3 concentrations has been observed since March 1999.

4.5 Cesium-137

Cesium-137 was the only gamma-emitting radionuclide detected at statistically significant concentrations and greater than the MDC during the March and June 2003 sampling events. Low levels of other gamma-emitters have been detected in the past at concentrations slightly greater than the 2-σ TPU (see discussion below), but not consistently in any particular monitoring well. These very low-level "detections" may be attributed to false positive noise at the lower limit of the measuring technique.

Table 7 summarizes Cs-137 analytical results in all wells since December 2001. Prior to the March and June 2003 sampling events, Cs-137 has been consistently identified in groundwater at location MW-103S between a minimum of 8.39 pCi/L and a maximum of 87.6 pCi/L. The EPA MCL for Cs-137 is 200 pCi/L and no result to date has exceeded this level. MW-103S is the shallow monitoring well in the cluster located in the vicinity of the former RWST. The March 2003 Cs-137 concentration of 87.6 pCi/L was the maximum observed concentration to date. A decreased concentration of 26.6 pCi/l was observed during the June 2003 sample event.

Cesium-137 has also been consistently detected at two additional monitoring wells, MW-115S and MW-102D. Cesium-137 was detected in MW-115S in March 2003 at a concentration of 2.55 pCi/L (Table 7). Previously, Cs-137 was detected at this location in concentrations ranging from 1.6 to 7.59 pCi/L. Cesium-137 was also detected at MW-102D in March 2003 at a concentration of 12.7 pCi/L. Historically, results at this location have ranged from 2.0 to 11.1 pCi/L.

4.6 HTD Plant-related Radionuclides

Samples from a subset of twenty-one monitoring wells were also analyzed via special analyses for HTD plant-related, alpha-emitting and beta-emitting radionuclides during the quarterly sampling rounds. Table 8 presents a summary of the analytical results and the laboratory data reports are included as Appendix C to this report.

As illustrated on several of the summary data tables, several of the reported analytical values are shaded. The shading indicates that the reported value is greater than the two-sigma (2-σ) total propagated uncertainty (TPU) of the analysis, but less than the sample specific MDC. As such, these low concentrations are statistically significant at the 95% confidence level, but have a relatively high level of uncertainty. Trend analysis of radionuclide data at these 2-σ TPU levels and near the sample specific MDC has indicated the presence of bias in some analyses. Specifically, analytical results determined by liquid scintillation counting (LSC) and gas proportional counting (GPC) exhibited the most significant analytical bias. In most cases, the magnitude of the analytical bias was less than sample specific MDC. By comparison, sample specific MDCs were factors of 2 to 3 less than the CRDLs. Additional trend data, to be collected during future ground water sampling events, will determine if these reported detections are statistically significant, or false positive values.

Factors that may affect the uncertainty of radiological analyses, and the ability to discern plant-related activity from the natural background activity include; interference from naturally occurring radionuclides due to incomplete radiochemical separation, specificity of radiochemical counting technique, and difficulty in identifying the ambient background or blank contribution. In low-level radiochemical counting, these limitations are imposed by the accurate determination of the systematic and random uncertainty associated with the analytical blank. Section 5.0 provides a more detailed discussion of the issues related to measurement of low-level analyte concentrations in groundwater with respect to the HTD nuclides. Generally speaking, gamma isotopic and alpha isotopic analyses are the most specific counting methods with the least amount of systematic bias in the underlying background or blank. GPC and LSC are less specific counting methods and may be subject to systematic and random variability in the underlying blank distribution. CYAPCo will continue to statistically evaluate and trend lab data in order to understand limitations and irregularities in analytical results.

4.6.1 Alpha Isotopic Analyses

Alpha isotopic analyses including isotopic plutonium and isotopic americium were determined by chemical separation and alpha spectroscopy (Table 8). Isotopic plutonium analyses include the alpha emitters, Pu-238 and Pu-239/240 and Pu-241 which is a beta emitter. Isotopic americium and curium analyses include Am-241, Cm-242 and Cm-243/244. All alpha isotopic plutonium and curium results for the March and June 2003 sampling events were non-detects with nominal detection sensitivities on the order of 0.4 pCi/L or less.

Nineteen of the twenty (19 of 20) Am-241 results from the March 2003 sampling event were less than 2-σ TPU and not statistically significant; however, results at MW-102S and MW-103S were slightly greater than the sample specific MDC of 0.12 and 0.13 pCi/L, respectively. Both of the Am-241 analytical blank results processed with the March 2003 batch were less than 2-σ TPU with sample specific MDCs of less than 0.16 pCi/L.

Five of the nine (6 of 9) Am-241 results from the June 2003 sampling event were less than 2-σ TPU and not statistically significant. Three (3) results were observed with statistically-significant concentrations greater than 2-σ TPU, but all were less than the nominal sample specific MDC of 0.4 pCi/L.

Statistically significant activity is identified by concentrations that are greater than 2-σ TPU and near the MDC level. One would expect a "false positive" rate of 2.5% based on the area under the standard normal distribution around a limiting mean concentration of zero at the 95% confidence level. The observed positive rate for all alpha isotopic analyses was less than 1% for the March 2003 sampling event, which is on the order of the expected false positive rate if no significant alpha-emitters are present. These sample analytical results suggest that the potential for significant alpha activity (i.e., Am-241) in groundwater is small.

The observed positive rate for all alpha isotopic analyses was 6.7% for the June 2003 sampling event, and the positive rate for Am-241 was approximately 33%, which is much greater than the expected false positive rate if no significant alpha-emitters are present. Such a high positive activity rate, especially in the case of Am-241 that is not supported by previous sample event results, suggests a bias in the analytical labs method.

4.6.2 Strontium-90

Strontium-90 results were determined by chemical separation followed by gas proportional counting (GPC) during the March 2003 sampling event. Strontium-90 was detected in nine (9) monitoring wells during the March 2003 sampling event, at concentrations greater than 2-σ TPU and the sample MDC. Three (3) wells had concentrations of Sr-90 that exceeded the EPA MCL level 8 pCi/L. These included MW-106S at 13.5 pCi/L, MW-114S at 16.6 pCi/L and MW-105S at 138 pCi/L. The wells where Sr-90 was detected at concentrations less than the EPA MCL but greater than the sample specific MDC included MW-103S, MW-107S, MW-109S, MW-115S, MW-122S, and MW-125S, with concentrations ranging from a minimum of 0.542 pCi/L (MW-107S) to a maximum of 6.75 pCi/L (MW-103S). Eight (8) wells exhibited detectable concentrations at levels less than the sample specific MDC. The average Sr-90 sample specific MDC for this sample event was 0.8 pCi/L (Table 8).

Results obtained during the June 2003 sampling event were determined by chemical separation followed by liquid scintillation counting (LSC) using Cerenkov counting methods. Strontium-90 was detected in three (3) monitoring wells during the June 2003 sampling event, at concentrations greater than the sample MDC. Two of these wells had concentrations of Sr-90 that exceeded the EPA MCL level 8 pCi/L. These wells included MW-105S at 181.6 pCi/L and MW-106S with 18.68 pCi/L. Srontium-90 was detected in MW-104S at 3.14 pCi/L, which is below the EPA MCL and above the sample specific MDC. The wells where Sr-90 was detected at concentrations less than the EPA MCL and the sample specific MDC included MW-102S, MW-103S, MW-117S, MW-122D and MW-125S, at concentrations ranging from a minimum of 1.08 (MW-102S) to a maximum of 1.41 pCi/L (MW-125S). The average Sr-90 sample specific MDC for this sample event was 1.7 pCi/L (Table 8).

In Figure 9 is a box plot for Sr-90 concentration as a function of time ranging from December 2001, through June 2003. The maximum Sr-90 concentration has ranged from 69.7 to 181.6 pC/L since December of 2001. Median results have fluctuated from a low of about 0.8 pCi/L to a high of 4.6 pCi/L. There were no apparent temporal or seasonal trends in the median values. There appears to be a seasonal trend in the highest values which all occur in MW-105S. These maximum values levels tend to coincide with March and June sampling events, which are typically characterized by peak groundwater elevation levels.

In Figure 10 is a correlation plot of gross beta activity versus total Sr/Y-90 and Cs-137 concentration. Only sample results with detectable Sr-90 or Cs-137 were used in this comparison. Yttrium-90 (Y-90) is the radioactive decay product of Sr-90. Since the half-life of Sr-90 significantly longer than Y-90, secular equilibrium is observed where both nuclides are characterized by the same concentration levels and the total concentration, denoted as Sr/Y-90, is doubled. Relative percent differences (RPD) of less than 30% were observed for predicted values of total Sr/Y-90 plus Cs-137 based on gross beta activity levels greater than 25 pCi/L. The RPD is defined as the absolute difference divided by the average result expressed as a percent difference. These results suggest that gross beta activity levels greater than 25 pCi/L can be used to obtain screening or reasonable estimates of total Sr/Y-90 and Cs-137 in groundwater.

4.6.3 Beta and X-Ray Analyses

Beta and X-ray analysis results were determined by chemical separation followed by liquid scintillation counting (LSC) or gas proportional counting (GPC). LSC results indicated positive activity rates on the order of 16%, for both sampling rounds, after removing known positive results (i.e., tritium and strontium analyses). These results were normally distributed around a limiting mean concentration. The homogeneity of this data combined with the observed positive data rate which is much greater than the expected positive result rate of 2.5%, indicates a significant false positive bias in the LSC analytical results at concentrations at or near the MDC. Refer to Appendix D for rank order plots of each radionuclide, by quarter, and to Section 5.3 for a discussion of the positive bias in beta isotopic results by LSC and GPC.

5 Data Assessment

All reported analytical results include the net concentration, the 1-s or 2-s total propagated uncertainty concentration (TPU), and the minimum detectable concentration (MDC). Net concentration results greater than the 2-s TPU generally imply that statistically significant activity is present with a 95% certainty. Net concentration results less than the 2-s TPU indicate zero or statistically insignificant activity. Net concentration results reported as negative values imply that the radioactivity in the sample is less than the average or long-term background.

The reported TPU is a combination of the counting uncertainty and any other factors that contribute to the overall uncertainty including uncertainties in the sample mass, chemical yield and determination of calibration factors. Total propagated uncertainty values reported at 2-s allow direct comparison with the net concentration for statistical significance. Total propagated uncertainty values reported at 1-s are converted to 2-s for comparison purposes.

Detection limits are essential for evaluating data quality and demonstrating that the desired sample analytical sensitivity was achieved. The lower limit of detection (LLD) is the lower limit at which a measurement can be differentiated from background with some degree of confidence. The LLD for a radionuclide is typically computed from the counting error associated with the instrument background, or blank counting conditions, at the time of analysis and is usually expressed in terms of counts, or count rate. In contrast, the MDC includes conversion factors to relate background count rate to radionuclide activity or concentration. The contractual (or *a priori*) MDCs for these results identified in the laboratory Statement of Work (SOW) are summarized in Table 9. All reported MDC concentrations are *a posteriori* and include sample specific corrections for radioactive decay, chemical yield and sample mass.

All analytical results were evaluated against Table 9 to ensure that sensitivity requirements were met. Several instances were identified in the case narrative where the sample specific MDCs were greater than the contract required detection limit (CRDL). In all cases, the CRDL for

Am-241 of 1 pCi/liter was not achieved via gamma spectrometry, but it was easily achieved by alpha spectrometry. Case narrative details are provided in Section 6.3.2.2.

Simple rules of thumb were used to evaluate analytical results that were not statistically significant with respect to background. The MDC-to-uncertainty ratio was evaluated for reasonableness. In this case, the 2-s TPU uncertainty was used in the evaluation and MDC-to-uncertainty ratios less than 1.5 were flagged for additional review. These thumb rules do not apply to low count rate results typical of alpha isotopic analyses where MDC-to-TPU ratios can range from 1 to 25.

5.1 Statistical Methods

A false-positive error is an instance when a nuclide or analyte is declared to be present but is, in fact, absent. A false-negative error is an instance when an analyte is declared to be absent but is, in fact, present. Both laboratories have exhibited some difficulty with the reporting of false-positive results, based on MAPEP performance evaluation (PE) data and trend analysis of analytical sample results. These difficulties were generally limited to radionuclides analyzed via liquid scintillation counting (LSC) and to a lesser extent, gas proportional counting (GPC).

Positive trends and biases have been observed in the past with the following nuclides analyzed via LSC at levels near the reported MDC: Fe-55, Ni-63, Tc-99 and Pu-241. Low-level analytical positive trends have also been observed for Sr-90, gross alpha and gross beta analyses, which are analyzed via gas proportional counting (GPC). Significant trends with gamma or alpha isotopic analysis results are less common.

Positive biases were observed for H-3, Fe-55 and Sr-90 analyzed via LSC during the March and June sample events. In all cases, the magnitude of the positive bias was less than the analysis sensitivity or average MDC. Positive bias was also observed in Am-241 analysis result.

Statistical and visual methods were employed to evaluate trends in the analytical results as a function of nuclide. Rank order plots for the September and December 2002 sample events were prepared as a function of nuclide (see Appendix D). The analytical data were treated as follows:

1. Net concentration results at all well locations were arranged in ascending order
2. Standard distributional statistics were calculated (i.e., mean, median, minimum, maximum and standard deviation for the net concentration, 2-s TPU and MDC)
3. Net concentration results with associated TPU error bars were graphed as a function of rank order
4. Expected zero mean concentration and 2-s zero mean concentration control limits graphed as a function of rank order
5. Average MDC graphed as a function of rank order

Graphing the expected zero mean and associated 2-s zero mean concentration control limits provides a visual indication of biases in the analytical technique at concentration levels near or below the MDC. The expected ± 2-s zero mean control limits were based on actual sample data when activity was near or less than the MDC. In most cases, the average 2-s TPU provides restrictive control limits that are more sensitive than the standard deviation of the mean concentration in the data set. For analyses that were generally statistically significant with respect to background (i.e., gross alpha, gross beta), analytical blank data were used to estimate the 2-s zero mean control limits.

Statistical methods were used in order to accurately identify and quantify biases in analytical lab data. Some basis statistical parameters for the March and June 2003 events are summarized in Tables 10 and 11, respectively. These methods included segregation of the analytical data into logical subsets, use of outlier detection methodology, and identification of statistical significant bias. Logical data subsets were typically comprised of an individual nuclide by sample event or sample analysis batch. For LSC analysis, a logical subset consists of samples counted in a single batch. Due to the number of samples collected, multiple batches may be processed for each analyte in a typical sampling event.

A typical groundwater analysis data subset (i.e., by nuclide) was assumed to be comprised of two distributions, an underlying background or zero analyte component randomly distributed around zero, and an unknown spatially or temporal varying distribution characterized by statistically significant or higher analyte concentrations. In most circumstances, the limiting mean value of the underlying blank is expected to be a constant with random fluctuations normally distributed around zero. In the case of a systematic bias in the blank, the limiting mean value of the blank distribution will be normal and randomly distributed around a non-zero (i.e., positive or negative) value. When the data are sorted in ascending order with regard to analyte concentration, the underlying background will be distributed on the low analyte concentration end while the spatially or temporally varying analyte results (i.e., statistically significant results), will be distributed on the high concentration end of the data sub-set.

Given the rank order of the data set, a modified Z-score method was used starting on the low analyte concentration end, to identify statistical outliers on the high analyte concentration end of the data set. The Z-score test is a standard statistical method to identify outlier data. Positive outliers as identified were assumed to be nonzero or part of the spatially or temporally distributed data. All others results were considered to be part of the zero analyte or baseline distribution. The limiting mean and standard deviation of these baseline mean results were used as an indicator for technique bias at concentrations near the MDC.

The underlying background or baseline data were evaluated for normality based on Filliben's r-statistic, also known as the normal probability plot correlation coefficient. Filliben r-statistics near unity are characteristic of normally distributed data. Results of the normality testing for the September and December 2002 sample events are summarized in Tables 12 and 13, respectively. Standard hypothesis testing was also used to determine if the limiting mean bias was statistically different from zero. The limiting mean baseline results were evaluated for statistical significance using the Student's t-test. In order to concentrate our efforts on analyses with the most significant bias, we used a 3-σ criterion to identify with a high degree of confidence (i.e., at the 99.97 % confidence level) analyses with significant bias with respect to the underlying background or baseline. Our selection of a 3-σ criterion in this case is based on conventional control chart theory where the analytical technique is said to be in control (i.e., no apparent bias) when the observed limiting mean value is within ± 3-σ of the expected zero analyte concentration. Results of t-testing for the September and December 2002 sample events are also included in Tables 12 and 13, respectively. Some typical examples of the application of these statistical based methods as a function of general analysis type or nuclide-of-interest are as follows.

5.2 Gamma Emitters

Manganese-54 is a gamma emitter, determined by photon counting or gamma isotopic analysis. Manganese-54 is produced by neutron reactions with structural stainless steel and has an expected low radionuclide inventory due to a short radioactive half-life of 312.7 days. It has decayed through greater than 7 half-lives since plant shutdown and less than 0.5% of its shutdown activity or inventory remains. Mn-54 is not expected to be present in detectable quantities in ground water samples from the HNP and is a good candidate analysis to demonstrate a zero analyte or underlying background distribution.

Figure 11 is a rank order plot of Mn-54 concentrations in ground water for the March 2003 sampling event. The Mn-54 results are graphed with their corresponding 2-s TPU error bars. An average and 1-s standard deviation concentration of 0.15 ± 1.22 pCi/L was observed in this data set while the average MDC was 4.6 pCi/L. The control limits are ± 2.44 pCi/L based on the 2-σ standard deviation of the lmiting mean. Approximately half the data points are distributed above or below the zero concentration level. Note that the 2-σ TPU error bars generally cross zero except in the extreme positive or negative regions of the data.

The limiting mean value of 0.15 pCi/L is statistically equal to a zero concentration level based on the t-statistic and 42 (n-1) degrees of freedom. The data are also normally distributed around the limiting mean value as illustrated by the frequency distribution in Figure 12. As expected, no significant Mn-54 activity is indicated in this trend plot and the data are equally distributed around zero. These results are typical of gamma isotopic analysis where no analyte is present and the background or energy baseline is easily and accurately determined.

Cesium-137 is a gamma emitter, determined by photon counting or gamma isotopic analysis. Cesium-137 is a fission product with a 30.17-year radioactive half-life. Due to a high radionuclide inventory and radioactive half-life, or decay considerations, Cs-137 has been detected in ground water samples from the HNP.

Figure 13 is a rank order plot of Cs-137 concentrations from the March 2003 sampling event. Only results with concentrations less than 10 pCi/L are displayed in order focus attention on the underlying baseline distribution. An average and 1-s standard deviation concentration of 0.09 ± 1.12 pCi/L was observed for the limiting zero mean while the average MDC was 4.4 pCi/L. The control limits are ± 2.24 pCi/L based on 2-σ standard deviations of the limiting mean. Results with concentrations greater than 2.5 pCi/L were determined to be statistically different from the underlying background based on outlier testing. It is easy to visually identify the transition from the zero background data to the statistically significant data in Figure 13. The baseline data are normally distributed around the limiting mean value of 0.09 pCi/L in Figure 14 and the limiting mean value is not statistically different from zero, based on the t-test. These results are typical of gamma isotopic analysis where zero analyte data and low-level statistically significant data are present in the same data set.

Cobalt-60 is a gamma emitter with a high radionuclide inventory at HNP due to its presence in structural material. Cobalt-60 has a radioactive half-life or 5.271-years and about 42% of its shutdown inventory or activity remains. Cobalt is a common impurity in stainless steel and is the dominant external dose producing isotope in reactor interior components on a 10-year time scale.

Figure 15 is a rank order plot of Co-60 concentrations in ground water for the March 2003 sampling event. An average and 1-s standard deviation concentration of 0.41 ± 1.22 pCi/L was observed for the limiting zero mean while the average MDC was 5.0 pCi/L. The control limits are ± 2.44 pCi/L based on 2-s standard deviations. The baseline data are normally distributed around the limiting mean value of 0.41 pCi/L, and the limiting mean is statistical greater than zero, as is evident in Figure 16. The positive bias in the baseline distribution is indicated by the presence of 27 of 43 results with net concentrations greater than zero. There were no outliers indicating a very homogenous or uniform Co-60 data set.

It is important to note that Co-60 is also a common trace contaminant in materials used in the construction of high-purity germanium (HPGe) detectors. These HPGe detectors are used for the gamma isotopic analyses. It is not uncommon to observe Co-60 peak background response rates on the order of 0.001 count per second, depending on the HPGe detector size and configuration. Given the sensitivity requirements for these analyses, the ability to accurately distinguish low-level Co-60 (i.e., pCi/L amounts) in groundwater from the detector background contribution is non-trivial. These results are typical of gamma isotopic analysis where the underlying baseline distribution is homogenous and normally distributed but is characterized by a statistically significant systematic bias on the order of 0.4 pCi/L.

5.3 Beta and X-Ray Emitters via LSC

Figure 17 is a rank order plot of C-14 concentrations in ground water for the September 2002 sampling event. C-14 is a beta emitter, determined by chemical separation and LSC. Due to an expected low radionuclide inventory, C-14 is not expected to be present in detectable quantities in ground water samples from the HNP. An average and 1-s standard deviation concentration of -0.13 ± 2.49 pCi/L was observed in this data set while the average MDC was 8.5 pCi/L. The control limits are ± 4.99 pCi/L based on the average 2-s standard deviation.

Approximately half the data points are distributed above or below the zero concentration level. Note that the 2-s error bars generally cross zero except in the extreme positive or negative regions of the data.

The limiting mean value of -0.13 pCi/L is statistically equal to a zero concentration level based on the t-statistic and 20 (n-1) degrees of freedom. The data are also normally distributed around the limiting mean value as illustrated by the frequency distribution in Figure 18. As expected, no significant C-14 activity is indicated in this trend plot and the data are equally distributed around zero. These results are typical of LSC analysis where no analyte is present and the LSC background or blank is accurately determined with no systematic bias.

Figure 19 is a rank order plot of Sr-90 in groundwater for the June 2003 sampling event. Strontium-90 is a beta emitter that is determined by gas proportional counting (GPC). Due to a high radionuclide inventory, radioactive half-life and decay considerations, Sr-90 has been detected in ground water samples from the HNP. An average and 1-s standard deviation concentration of 0.68 ± 0.49 pCi/L was observed in this sample event data set with an average MDC of 1.7 pCi/L. The control limits are ± 1.0 pCi/L based on 2-s standard deviations. Approximately half the data points are distributed above or below the limiting mean value. Note that the 2-s error bars generally cross the limiting mean concentration except in the extreme positive or negative regions of the data set.

The Sr-90 baseline data are normally distributed around the limiting mean value of 0.68 pCi/L in Figure 20, and the limiting mean value is statistically greater than zero, based on the t-test. Note that 25 of 26 results are distributed above the zero concentration level. These results are typical of LSC analysis where a significant positive or systematic bias in the underlying baseline distribution exists in the presence of low-level statistically significant activity.

Figure 21 is a rank order plot of Fe-55 in water for the September 2002 sampling event. Iron-55, which decays by electron capture and subsequent X-ray emission, is determined by LSC analysis. Iron-55 has a radioactive half-life of 2.7-years and only 19% of its shutdown inventory or activity remains. An average and 1-s standard deviation concentration of -4.0 ± 3.40 pCi/L was observed in this sample event data set with an average MDC of 11.3 pCi/L. The Fe-55 data are normally distributed around the limiting mean value of -4.0 pCi/L as indicated in Figure 22. The limiting mean value is statistically less than zero, based on the t-test and all 16 reported results are less than zero concentration. These results are typical of LSC analysis where a significant negative systematic bias in the underlying baseline distribution exists. In the past, we have observed both positive and negative biases with Fe-55 analytical results. This suggests that the analytical laboratory has some difficulty in determining the appropriate analytical blank contribution for Fe-55.

Similar results were obtained for other LSC radionuclides. CYAPCo will continue to statistically evaluate and monitor these data. In the meantime, we will report the data *as is* in order to evaluate any dose risk associated with groundwater monitoring in a conservative manner.

5.4 Beta and Alpha Emitters via GPC

Figure 23 is a rank order plot of Sr-90 in water for the March 2003 sampling event. An average and 1-s standard deviation concentration of 0.48 ± 0.36 pCi/L was observed in the limiting mean baseline data set after removing statistically significant or positive outliers. The control limits are ± 0.23 pCi/L based on the average 2-σ standard deviation of the limiting mean. Results with concentrations greater than 0.5 pCi/L were determined to be statistically different from the underlying background based on outlier testing. It is easy to visually identify the transition from the underlying background data to the statistically significant data in Figure 23. Note that 24 of 25 reported Sr-90 results for this data set were greater than the zero concentration.

The baseline Sr-90 data consisted of 16 data points and were normally distributed around the limiting mean value of 0.19 pCi/L as indicated in Figure 24. The baseline limiting mean value was statistically greater than zero based on the t-test. These results are typical of GPC analysis where a positive systematic bias in the underlying baseline distribution exists.

Similar results were obtained for gross alpha and gross beta analyses performed via GPC. In the case of gross alpha and gross beta, the positive trends observed in these analyses is actually attributed to natural levels of gross alpha and beta radioactivity.

5.5 HTD Alpha Emitters

Figure 25 is a rank order plot of Cm-242 concentrations in ground water for the June 2003 sampling event. Curium-242 is an alpha emitter with an expected low radionuclide inventory at HNP due to radioactive decay. Curium-242 has a radioactive half-life of 163.2 days and has decayed through greater than 14 half-lives since shutdown. Since less than 0.01% of the shutdown activity or inventory remains, Cm-242 is not expected to be present in detectable quantities in ground water samples from the HNP.

An average and 1-s standard deviation concentration of 0.004 ± 0.010 pCi/L was observed in this data set while the average MDC was 0.06 pCi/L. The control limits are ± 0.020 pCi/L based on 2-s standard deviations in the analytical blank. Note that the individual 2-sigma error bars generally span the region of the control limits except in the negative regions of the graph. Here the 2-s TPU is underestimated due to the presence of zeros in the analytical counting results. This is characteristic of low-level alpha counting where zero results are sometimes observed (i.e., zero counts observed in the detector region-of-interest) during the finite counting interval.

The baseline data are not normally distributed around the limiting mean value of 0.010 pCi/L in Figure 26 and the limiting mean value is not statistically different from zero, based on the t-test. Low-level counting data are not expected to be normal, around a limiting mean value. This is a characteristic of low-level alpha counting where the expected shape of the limiting mean distribution is Poisson in nature. The Poisson distribution is asymmetric and representative of a distribution that is bounded by zero on the low frequency side. T-test results for low-level counting are only qualitative in nature, since normality is a required condition for this statistical test. CYAPCo will continue to develop statistical tests to evaluate this low-level counting data in the future. As expected, no significant Cm-242 activity is indicated in this trend plot and the data are distributed around zero. These results are typical of low-level alpha isotopic analysis where no analyte is present.

Figure 27 is a rank order plot of Am-241 concentrations in ground water for the June 2003 sampling event. Americium-241 is an alpha emitter that has been detected in HNP process streams attributed to failed fuel. An average and 1-s standard deviation concentration of 0.185 ± 0.072 pCi/L was observed in this data set while the average MDC was 0.34 pCi/L. The control limits are ± 0.21 pCi/L based on the average 2-s TPU in the analytical blanks. Note that the individual 2-sigma error bars generally span the region of the control limits except in the negative regions of the graph.

The data are normally distributed around the limiting mean value of 0.185 pCi/L in Figure 28. This is an unexpected observation based on the typical count rates observed via alpha counting as previously discussed. The limiting mean value of 0.185 pCi/L is statistically greater than zero analyte level based on the t-statistic and 8 (n-1) degrees of freedom. Note that a slight elevation in Am-241 activity is indicated in this trend plot as compared to the Cm-242 trend plot and all 9 results are greater than zero concentration. No significant positive trends were observed with other alpha isotopic data.

In the past CYAPCo lab vendors have had some minor difficulties with "false positive" detects for Am-241 during the course of performance evaluation (PE) testing. See Section 6.3 for additional information. It is important to note that Am-241 is a common alpha-emitting radiotracer used in the radiochemistry lab. Solid-state alpha detectors are subject to recoil contamination after repetitive source and sample analysis. Alpha recoil contamination, which increases the detector background, occurs when fragments from the source or sample are implanted in the detector surface, by the recoil energy imparted on the nucleus of an alpha-emitting atom. Solid-state alpha detector background rates are extremely low, typically on the order of 1 count per 100,000 seconds. Given typical sample analysis parameters and the sensitivity requirements for these analyses, the ability to accurately distinguish sub-pCi/L amounts of Am-241 groundwater from the detector background contribution is non-trivial. These results are typical of low-level alpha isotopic analysis where the underlying baseline distribution is subject to large fluctuations due to the extremely low ambient background count rate.

6 Groundwater Monitoring Program QA/QC

Current quality assurance/quality control (QA/QC) efforts in support of the Ground Water Monitoring Program at the Haddam Neck Plant (HNP) are designed to assess and enhance the reliability and validity of field and laboratory measurements conducted to support these programs. Sample quality is maintained based on guidance in References LTP 2002 and GMP-QAPP 2002. On the analytical side, accuracy, precision, and detection sensitivity are the primary indicators used to assess laboratory data quality. Representativeness, completeness and comparability may also be evaluated for overall quality. These parameters are evaluated through laboratory QC checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and inter-laboratory comparisons. Acceptance criteria have been established for each of these parameters. When a parameter is outside the criteria, corrective actions are taken to minimize future occurrence.

6.1 Sample Analyses

Sample collection and control was performed using work processes and trained staff according to References RPM 5.3-0, GW-WPIR 2001 and RPM 5.3-1. The tasks included sample collection, chain-of-custody and sample shipping. The Severn Trent Lab in Richland, WA (STL-Richland) was used as the primary lab for the radiological analyses performed on March 2003 samples. Boron analyses for the March event were performed by the STL-CT facility in Shelton, CT. The Framatome ANP Environmental Lab (FANP) in Westborough, MA was used as the primary lab for June 2003 radiological analyses. Boron analyses for the June event were performed by the Northeast Generation Services (NGS) lab in West Springfield, MA. Methods employed for radiological constituents were developed by the vendor laboratories and are recognized as acceptable within the radiochemical industry. The boron methods employed were standard EPA methods.

The STL Richland lab supplied all sample containers used in the collection of the groundwater samples that they analyzed. Sample containers were delivered to the site by courier and maintained in a secure manner until use by the sampling team. Samples were packaged for transport to the laboratory with protective packing material in insulated coolers with custody seals.

The on-site HNP laboratory performed tritium and gamma isotopic analyses to support off-site sample shipments. These analyses were not used for reporting actual groundwater analytical sample results.

6.2 Field Quality Control Samples

Field QC samples typically consist of duplicates, splits and blank samples. Field duplicate samples are used to assess sampling and measurement precision. Field split samples are used to assess measurement precision. Field splits and duplicates are typically examined to monitor laboratory operations and to identify potential problem areas where improvements are necessary. One field duplicate sample was randomly collected during the course of each quarterly sampling event, after considerations for well yield and sample volume requirements.

The duplicate sample for the March 2003 sampling round was collected from MW-125S, and identified as MW-521. The blind duplicate sample was analyzed for gross alpha, gross beta, H-3, and gamma isotopic nuclides. The duplicate sample for the June 2003 sampling round was collected from MW-109S, and identified as MW-901S. The blind duplicate sample was analyzed for gross alpha, gross beta, H-3, boron and gamma isotopic nuclides. In Table 14 are the reported results for the field duplicate samples collected for this round. Typically, only those reported results with a sample-to-uncertainty concentration ratio greater than 5 are evaluated and summarized. We have included Sr-90 in this summary which has a nominal sample-to-uncertainty ratio on the order of 3 to provide an indication of precision for field duplicates with concentrations on the order of the sample MDC. The uncertainty in this ratio is the 1-s total propagated uncertainty. All field duplicate results with sample-to-uncertainty ratios greater than 5 are within 25% of the initial sample results. All field duplicate results are within ± 2-s standard deviations of the initial sample results indicating statistical agreement.

A decontamination station was established near each monitoring well location to provide for the proper decontamination of dedicated sampling equipment. The following decontamination process was used during each quarterly sampling event:

1) Wash with non-phosphate detergent (Alconox-brand utilized),
2) Rinse with potable water, and
3) Place equipment into a protective cover.

All non-disposable equipment used during the program was subject to decontamination. These components included the groundwater sampling pump, electrical lead wires and support cable, as well as the flow-through cell in which field parameters were measured.

An equipment rinsate blank sample was collected using bottled spring water and served to evaluate the effectiveness of decontamination efforts. The equipment blanks was collected as needed to verify the effectiveness of the decontamination process for reusable sampling equipment. The equipment blank sample consisted of water pumped through the decontaminated sampling pump into a laboratory-supplied container. This sample was analyzed for gross alpha, gross beta, H-3, boron and gamma constituents. Significant contamination was not identified in equipment blank rinses and contamination control efforts were effective with minimal impact on laboratory analytical data. Results for the gross alpha and gross beta analysis were statistically significant at levels near the MDC but both methods exhibited a positive bias, as previously discussed.

6.3 Laboratory Performance Evaluation

Laboratory performance is measured by several indicators, including nationally based performance evaluation studies, double-blind standard analyses, laboratory audits, and internal laboratory QA/QC programs. This section provides a detailed discussion of the performance indicators for both the STL-Richland and Framatome ANP laboratories.

6.3.1 DOE Performance Evaluations

Both labs took part in US Department of Energy (DOE) Quality Assessment Program and the DOE 's Mixed Analyte Performance Evaluation Program. Results of those studies related to

GW monitoring at HNP, are described in this section.

6.3.1.1 DOE Quality Assessment Program

DOE 's Quality Assessment Program (QAP) evaluates how laboratories perform when they analyze radionuclides in water, air filter, soil, and vegetation samples. This program is coordinated by the Environmental Measurements Laboratory (EML) in New York City, New York. EML provides blind standards that contain specific amounts of one or more radionuclides to participating laboratories. Gamma emitters typically include K-40, Mn-54, Co-60, Cs-137, Bi-212, Pb-212, Bi-214 and Pb-214. Alpha emitters typically include U-234, Th-234, U-238, Pu-238, Pu-239, Am-241 and Cm-244. The beta and hard-to-detect (HTD) radionuclides typically include H-3, Fe-55, Ni-63 and Sr-90.

After sample analysis, each participating laboratory forwards the results to EML for comparison with known values and with results from other laboratories. Using a cumulative normalized distribution, acceptable performance yields results between the 15th and 85th percentiles. Acceptable with warning results are between the 5th and 15th percentile and between the 85th and 95th percentile. Not acceptable results include the outer 10% (less than 5th percentile or more than 95th percentile) of historical data.

For the seven (7) QAP studies conducted from June 2000 through June 2003 (see References EML-608, 611, 613, 615, 617, 618 and 621), the percentages of acceptable or acceptable with warning results are summarized as a function of media and analysis type in Table 15. Overall, approximately 92% of the STL-Richland lab data was in the acceptable or acceptable with warning performance category. Approximately 97% of the FANP lab data was in the acceptable or acceptable with warning performance category.

6.3.1.2 DOE Mixed Analyte Performance Evaluation Program

DOE 's Mixed Analyte Performance Evaluation Program (MAPEP) examines laboratory performance in the analysis of soil and water samples containing metals, volatile and semi-volatile organic compounds and radionuclides. The program is conducted at the Radiological and Environmental Sciences Laboratory (RESL) in Idaho Falls, Idaho, and is similar in operation to DOE 's QAP discussed above. DOE evaluates the accuracy of the MAPEP results for radiological and inorganic samples by determining if they fall within a 30% bias of the reference value. Analytical results with a reported bias less than or equal to 20% are flagged as acceptable. Analytical results with a reported bias greater than 20% but less than or equal to 30% are flagged as acceptable with warning.

RESL provides blind standards that contain specific amounts of one or more radionuclides to participating laboratories. Gamma emitters typically include K-40, Mn-54, Co-57, Co-60, Zn-65, Cs-134 and Cs-137. Alpha emitters typically include U-234, U-238, Pu-238, Pu-239 and Am-241. The beta and hard-to-detect (HTD) radionuclides typically include Fe-55, Ni-63 and Sr-90.

The MAPEP program also uses false positive testing on a routine basis to identify laboratory results that indicate the presence of a particular radionuclide in a sample, when in fact the actual activity of the radionuclide is far below the required detection limit. False positive test nuclides typically include Sr-90, Fe-55 or Pu-238. Acceptable performance is indicated when the reported range encompassing the results (i.e., net concentration $\pm$ 3-σ uncertainty) included zero. Unacceptable performance is indicated when this range does not include zero.

For the seven MAPEP studies conducted through May 2002 (see References MAPEP-S6, S7, S8, S9 and MAPEP-W7, W8, W9), the percentages of acceptable or acceptable with warning results are summarized as a function of media in Table 16.

Overall, about 91% of the STL Richland lab data was in the acceptable or acceptable with warning performance category for all media. For gamma isotopic analyses, 100% of the reported lab data was in the acceptable or acceptable with warning category. Approximately 86% of the alpha isotopic results and 75% of the HTD beta results were in the acceptable or acceptable with warning range. STL Richland experienced some problems with the low level false positive testing where only 43% of the reported results were in the acceptable or acceptable with warning range.

About 91% of the Framatome ANP lab data was in the acceptable or acceptable with warning performance category for all media. For gamma isotopic analyses, 100% of the reported lab data was in the acceptable or acceptable with warning category. Approximately 93% of the alpha isotopic results and 55% of the HTD beta results were in the acceptable or acceptable with warning range. Only 45% of the low level false positive test results reported by the Framatome ANP lab were acceptable or acceptable with warning.

6.3.1.3 ERA RadCheM™ Proficiency Testing (PT) Program

Environmental Resource Associates (ERA) RadCheM™ PT program is based on the National Standards for Water Proficiency Testing Studies Criteria Document (Reference NSWPT 1998). ERA examines laboratory performance in the analysis of water samples containing gross alpha/beta, naturals including uranium, mixed beta and gamma emitters. The program is conducted by ERA in Arvada, Colorado. ERA evaluates the accuracy of submitted results for radiological samples by determining if they fall within EPA or NELAC control limits.

ERA provides blind standards that contain specific amounts of one or more radionuclides to participating laboratories. Gamma emitters typically include Co-60, Zn-65, I-131, Ba-133, Cs-134, Cs-137 and Ra-226. Alpha and beta analyses typically include gross alpha, gross beta, H-3, Sr-89, Sr-90, Ra-228 and natural uranium.

For the five (5) ERA studies conducted through January 2003 (see References ERA-49, 50, 51, 52 and 53), the percentages of acceptable or acceptable with warning results are summarized as a function of analysis type in Table 17. Overall, 99% of the STL reported lab data was in the acceptable or acceptable with warning performance category for all media.

Overall, 96% of the Framatome ANP reported lab data was in the acceptable or acceptable with warning category for the media reported.

6.3.2 Laboratory Internal QA/QC Programs

Commercial analytical laboratories generate internal analytical performance data by analyzing method blanks, laboratory control samples (LCS), matrix spikes, matrix spike duplicates, matrix duplicates and surrogates. This information provides a means to assess laboratory performance and the suitability of a method on a batch sample analysis basis. The STL-Richland lab provided a detailed summary of all internal lab performance data with each data package. The Framatome ANP lab does not provide internal lab performance with each data package. Internal lab performance data is published semi-annually in a quality assurance status report (FANP QASR 2003).

6.3.2.1 Lab Internal Quality Control Samples

STL performed a minimum of one LCS, one method or reagent blank, and one duplicate sample analysis for each analysis performed in a batch of samples according to Reference STL-QAM 2002. Internal acceptance criteria for LCS samples are summarized as follows:

- Accuracy within QC acceptance limits (see Table 18)
- Results within 2-s TPU of the observed value
- Accuracy within allowed uncertainty (based on contracted detection limit)

Method or reagent blank results are evaluated or compared to the contracted detection limit (CDL). Acceptable method blanks are those results that are less than the CDL. Method blank results greater than CDL are critically examined and documented in a Nonconformance Memo (NCM).

Duplicate analysis results greater than 5 times the CDL, must fall within ± 3-s TPU of the observed value. If the sample or duplicate sample is less than 5 times the CDL, the difference should be less than or equal to the CDL.

Matrix Spikes (MS) are first corrected for any ambient test nuclide activity. Samples with ambient activity greater than 5 times the expected value of the spike are not required to fulfill MS acceptance criteria. Acceptance criteria for MS samples are 60% to 140% with a chemical yield monitor and 40% to 160% for nuclides without a chemical yield monitor. Additionally, all QC and sample results must have chemical recoveries or chemical yields within the range of 20 to 115 percent. Individual internal QC results are contained within Appendix C and indicate that the recovery rates for the laboratories are within acceptable ranges for the analyses performed.

Approximately 20% of the samples analyzed by STL-Richland in a quarterly sampling event are QC samples. The majority of these are method blanks and duplicates. Attached in Tables 17 is a summary of the number of QC samples processed by the STL-Richland lab during the

March 2003 sample event.

FANP performs a method or reagent blank for each analysis performed in a batch of greater than five (5) samples according to Reference FANP-QAP 2003. The batch processing frequency for smaller batches is once per week. Overall, the blank processing frequency is 5%. LCS samples in the form of sample process checks, are also submitted at a 5% frequency. Internal acceptance criteria for LCS and MS samples are summarized as follows:

- Observed value within QC acceptance limits (see Table 18)
- Results within 2-s TPU of the observed value
- Chemical recovery within allowable limits

FANP Method or reagent blank results are evaluated or compared to the 3-sigma uncertainty level. Acceptable method blanks are those where no positive activity at the 3-sigma level is observed. Method blank results greater than the 3-sigma level, are critically examined and documented through the condition reporting (CR) process.

Approximately 10% of the samples analyzed by FANP in a quarterly sampling event are QC samples comprised of method blanks and process checks. Attached in Tables 20 are estimates of the number of QC samples processed by the FANP lab during the June 2003 sample event based on a routine QC frequency.

6.3.2.2 Issue Resolution/Case Narrative

Case narrative documents record detailed documentation of the analyses requested and provide additional documentation regarding problems encountered with sample receipt, sample analysis and data reporting. The forms are generated by the laboratory as required in the SOW and forwarded to the GW monitoring project with all hard copy data packages. The documentation is intended to identify occurrences, deficiencies and/or issues that may potentially have an adverse effect on data integrity. These case narratives are included in Appendix C with the laboratory analytical data sheets. Specific issues identified by the STL-Richland lab during the reporting of March 2003 sampling event data included:

- The batch process blank was lost during processing. The sample results are below the CRDL, therefore, acting as their own blank.
- Sample MW-122D for Pu-241 failed due to no recovery. The sample was re-analyzed successfully.
- Approximately three quarters of sample MW-101D leaked out of the 4-liter container in transit to the lab. Gross alpha and gross beta analyses were done first and the remainder of the sample was used for the gamma analysis.
- Gross alpha MDC for samples MW-114S was greater than the CRDL. A smaller aliquots sample was used due to high residue mass.
- Gross beta MDC's for four samples were greater than the CRDL. Smaller aliquots samples were used due to high sample residue mass. The sample results were greater

than the MDC.

In some cases, these occurrences initiated internal non-conformance action on the part of STL Richland lab with additional follow-up documentation. We will continue to monitor these case narratives and their impact on lab data quality.

At this time, the FANP lab does not provide case narrative documentation as part of the sample report. Specific issues addressed by the FANP lab included the filtering and reanalysis of samples MW-102D, MW-200 and MW-208 due to high residue mass, which resulted in higher than usual gross alpha and gross beta results.

6.3.3 Laboratory Audits/Assessments/Oversight Activities

Laboratory activities are periodically assessed through surveillance and/or auditing activities to ensure that quality problems are prevented and/or detected. Periodic assessments support the continuous process improvement. No onsite audits or assessments were conducted at either the STL-Richland or FANP facility during this time period.

6.4 Data Quality Summary

Overall, assessments of QA/QC information indicate that ground water monitoring data are generally acceptable for ground water characterization and monitoring efforts. Ground water sampling was performed in accordance with sample plans and work processes. No contamination or other sampling-related problems were identified that affected data integrity in the field. Laboratory performance was good to excellent for all gamma emitters but mixed for the alpha and HTD analyses. Performance was good to excellent for alpha, HTD and gamma isotopic analyses based on the large percentages of acceptable laboratory results in duplicate analysis and DOEQAP performance evaluation studies. MAPEP performance results for beta emitting HTDs and false positive testing results require improvement.

Attached in Table 21 is a summary of the percentage of positive results detected at concentrations that were greater than 2-σ TPU and near the MDC level. This table provides an indication of the percentage of false positive results as a function of analysis method. Only about 2.6% of the gamma isotopic analysis results were greater than the 2-σ TPU level, which is just slightly higher than the expected rate of 2.5% if there were no significant gamma emitters present. One would expect a "false positive" rate of 2.5% based on the area under the standard normal distribution around a limiting mean concentration of zero, at the 95% confidence level. These results suggest that there is little bias in the gamma isotopic analytical results at levels near the MDC, and there is little gamma isotopic activity in these samples.

Alpha isotopic results for the March and June 2003 sample events indicated overall positive activity rates on the order of 2%, which also indicates little or no significant alpha activity present in these samples with minimal bias in the analytical technique at levels near the MDC. A positive bias was observed for Am-241 in the June 2003 sample event where 3 of 9 results were statistically significant.

The percentage of HTD beta results determined via LSC and with concentration levels greater than 2-σ TPU ranged from 10% to 25.7%. These results were normally distributed around a limiting mean concentration in most cases indicating a significant false positive bias in LSC analysis techniques at concentrations at or near the MDC. Similar results were observed for beta emitters analyzed via GPC.

7 Conclusions and Recommendations

Based upon the work performed during the implementation and development of this Groundwater Monitoring Report for the March and June 2003 quarterly sampling events, the following conclusions and recommendations have been developed:

- As previously reported, several enhancements to the implementation of the Phase 2 Hydrogeologic Work Plan have been identified and incorporated including semi-annual reporting, packer test sequences, prioritization of "deep" bedrock borings, and one additional drilling methodology.
- The overall shallow groundwater flow beneath the industrial/peninsula area in March and June 2003 was in the general direction from the hillside to the south-southwest toward the Connecticut River. Horizontal groundwater flow gradients were consistent with previous calculations in the rate of horizontal groundwater flow across the industrial/peninsula areas.
- Local deflections in groundwater flow toward the containment mat drain sump are evident due to continued operation of the sump. The mat drain sump was reactivated on February 27, 2003.
- The overall shallow groundwater flow beneath the landfill area in March 2003 was in the general direction of eastward, toward Salmon Cove. In June 2003, the general direction was southward, toward Dibble Creek.
- Over time, an overall downward trend in the boron concentration has been observed at MW-105S. A maximum boron concentration of 1145 µg/L for the June 2003 sample event was observed at MW-100S. This location will be re-evaluated in September 2003 to confirm the observed increase at this location.
- Tritium was detected in about half of the wells sampled at concentrations ranging from less than the MDC to a maximum of 28,630 pCi/L, in monitoring well MW-102D, during the March and June 2003 events. Results at this location are greater than the EPA drinking water standard of 20,000 pCi/L. An overall downward trend in the median H-3 concentrations has been observed since March 1999.
- Strontium-90 was identified in thirteen (13) monitoring wells within the RCA and Industrial area during March and eight (8) locations in June of 2003. Over the two sampling events, detectable concentrations ranged from a minimum of 0.542 pCi/L at MW-107S (March) to a maximum of 181.6 pCi/L at MW-105S (June).
- In March 2003, three monitoring wells (MW-105S, MW-106S and MW-114S) contained Sr-90 concentrations greater than the EPA MCL of 8 pCi/L. In June 2003, two monitoring wells (MW-105S and MW-106S) contained concentrations greater than the EPA MCL.

- Cesium-137 was detected in MW-103S at a concentrations ranging from 87.6 to 26.6 pCi/L in March and June 2002. Cs-137 was also detected in MW-102D at a concentration of 12.7 pCi/L during the March 2003 event.
- Gross beta results correlate with the sum of total Sr/Y-90 plus Cs-137 at concentrations greater than 25 pCi/L.
- Systematic biases were observed in several of the HTD analyses based on statistical and graphical evaluations of the reported analytical data. Positive biases were generally observed for electron capture and beta emitting nuclides analyzed by LSC and GPC at concentrations near the MDC. The affected analyses included gross alpha, gross beta, He-3, Fe-55, Ni-63 and Sr-90. An overall false positive rate on the order of 10% to 25% was observed for the LSC analyses results. This is higher than an expected false positive rate of 2.5%.
- A positive bias was also observed for Am-241, an alpha emitter, and Co-60, a gamma emitter. A negative bias was observed for Cs-137 and Cm-242. CYAPCo will continue to statistically evaluate and trend the biases identified within this report.
- Field collected and laboratory completed QA/QC sample results were within acceptable protocol ranges. External laboratory performance evaluation data was excellent for all gamma emitters and good to average for the alpha and beta HTD analysis. Less than 50% of the false positive test results were in the acceptable or acceptable with warning range.

8 References

CTDEP RSR	CT Remediation Standard Regulations, Appendix A through E, Section 22a-133k-1 to 3
EML-608	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 52), June 2000
EML-611	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 53), December 2000
EML-613	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 54), June 2001
EML-615	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 55), December 2001
EML-617	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 56), June 2002
EML-618	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 57), December 2002
EML-621	Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program (QAP 58), June 2003
ERA RAD-49	ERA's RadChem™ Proficiency Testing Study RAD-49, July 25, 2002
ERA RAD-50	ERA's RadChem™ Proficiency Testing Study RAD-50, November 8, 2002
ERA RAD-51	ERA's RadChem™ Proficiency Testing Study RAD-51, January 23, 2003
ERA RAD-52	ERA's RadChem™ Proficiency Testing Study RAD-52, April 16, 2003
ERA RAD-53	ERA's RadChem™ Proficiency Testing Study RAD-53, July 24, 2003
FANP LQAP 2003	Framatome ANP, Laboratory Quality Assurance Plan, April 24, 2003
FANP QASR 2003	Framatome ANP, Semi-Annual Quality Assurance Status Report, January-June 2003
GMP-QAPP 2002	Groundwater Monitoring Program Quality Assurance Project Plan, Revision 0, September 2002
GMR 1999	Groundwater Monitoring Report, Malcolm Pirnie, September 1999
GW WPIR 2001	Ground Water Sample Collection Work Plan and Inspection Record, WP&IR # 24265-000-GEN-5000-00067-000, 12/06/2001
HIWP 2002	Phase II Hydrogeologic Investigation Work Plan, May 2002
LTP 2002	Haddam Neck Plant - License Termination Plan (LTP), Rev. 1a, 2002
MAPEP-99-S6	Mixed Analyte Performance Evaluation Program - Soil Sample Participating Laboratory Report, 2/8/2000
MAPEP-00-S7	Mixed Analyte Performance Evaluation Program – Soil Sample Performance Report, 1/29/2001
MAPEP-00-S8	Mixed Analyte Performance Evaluation Program – Soil Sample Performance Report, 8/8/2002
MAPEP-00-S9	Mixed Analyte Performance Evaluation Program – Soil Sample Preliminary Report, 12/5/2002
MAPEP-99-W7	Mixed Analyte Performance Evaluation Program – Water Sample Performance Report, 7/6/2000
MAPEP-00-W8	Mixed Analyte Performance Evaluation Program – Water Sample Performance Report, 5/8/2002
MAPEP-00-W9	Mixed Analyte Performance Evaluation Program – Water Sample Performance Report, 2/11/2003
NSWPT 1998	National Standards for Water Proficiency Testing Studies Criteria Document, USEPA December 30, 1998
RPM 5.3-0	Ground Water Monitoring Program, Revision 0, September 2002
RPM 5.3-1	Ground Water Level Measurement and Sample Collection in Monitoring Wells, Revision 0, September 2002
SOW 2001	Statement of Work for Bechtel Connecticut Yankee Project Environmental and Waste Characterization Analytical Services, Revision 0, February 2001
STL-QAM 2002	STL-Richland Quality Assurance Manual, Revision 4, April 26, 2002

Table 1: Depth-to-Water (DTW) Measurement Summary (feet)

Well ID	Reference Elevation (TIC)	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Min	Max	Range
MW-100D	16.47	3.71	5.62	2.35	5.70	5.43	Flooded	Flooded	Flooded	0.6	5.7	5.2
MW-100S	16.45	3.03	1.61	1.61	5.16	2.44	0.87	0.95	1.42	0.9	5.2	4.3
MW-101D	20.53	15.10	10.44	8.61	10.39	10.91	7.11	8.42	6.70	6.7	15.1	8.4
MW-101S	20.54	5.78	4.77	4.81	6.28	5.73	3.90	4.21	4.27	3.9	6.3	2.4
MW-102D	20.06	2.55	17.55	7.22	11.28	12.57	9.51	10.64	9.43	2.6	17.6	15.0
MW-102S	20.48	14.83	9.41	8.99	10.41	11.67	6.66	8.14	6.27	6.3	14.8	8.6
MW-103D	20.95	6.09	12.94	10.61	9.65	12.55	20.42	12.88	6.85	6.1	20.4	14.3
MW-103S	20.85	15.36	10.69	8.86	10.64	12.12	7.33	8.79	6.83	6.8	15.4	8.5
MW-104S	20.16	11.93	6.98	6.43	9.36	6.78	5.11	5.78	4.73	4.7	11.9	7.2
MW-105D	20.58	15.37	11.03	9.03	10.45	11.33	10.37	8.95	7.21	7.2	15.4	8.2
MW-105S	20.59	16.32	13.23	11.11	11.03	12.81	7.56	10.86	9.51	7.6	16.3	8.8
MW-106D	20.63	16.34	12.92	10.91	11.82	12.22	9.68	11.64	9.76	9.7	16.3	6.7
MW-106S	20.51	15.93	12.30	10.08	10.75	13.00	8.93	10.92	8.68	8.7	15.9	7.3
MW-107D	20.48	17.05	14.29	12.43	13.59	14.70	11.99	11.41	11.25	11.3	17.1	5.8
MW-107S	20.35	17.13	14.78	13.18	13.47	14.56	12.35	12.48	12.15	12.0	17.1	5.2
MW-108S	12.23	9.81	8.11	7.08	9.40	8.40	7.62	4.15	5.91	4.2	9.8	5.7
MW-109D	20.50	17.91	16.69	16.25	16.89	16.97	16.24	15.74	15.83	15.0	17.9	2.9
MW-109S	20.57	18.56	17.58	17.61	18.43	18.32	17.61	16.62	17.40	15.9	18.6	2.7
MW-110D	22.85	20.95	20.18	19.53	20.33	20.18	19.22	17.96	18.75	17.5	21.0	3.5
MW-110S	22.49	21.11	19.96	20.45	20.97	20.79	20.18	18.32	20.02	17.9	21.1	3.3
MW-114S	20.73	16.15	12.21	9.81	10.93	12.42	8.27	10.29	7.56	7.6	16.2	8.6
MW-115S	20.73	16.34	12.47	9.96	11.04	12.71	8.36	10.30	7.53	7.5	16.3	8.8
MW-122D	20.34	NI	NI	NI	NI	NI	NI	12.38	12.97	12.4	13.0	0.6

NS – Well not sampled
NI – Well not installed
NA – Data not available

Table 1: DTW Measurement Summary (continued)

Well ID	Reference Elevation (TIC)	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Min	Max	Range
MW-122S	20.34	NI	NI	NI	NI	NI	NI	7.98	7.67	7.7	8.0	0.3
MW-123S	20.34	NI	NI	NI	NI	NI	NI	11.40	11.92	11.4	11.9	0.5
MW-124	20.34	NI	NI	NI	NI	NI	NI	14.63	16.73	14.6	16.7	2.1
MW-125S	20.41	NI	NI	NI	NI	NI	NI	12.30	12.85	12.3	12.9	0.5
AST-1	23.59	18.53	17.45	17.39	NA	17.63	16.55	NS	NS	16.4	18.5	2.1
River Gauge	8.00	7.11	5.39	5.37	7.45	6.52	5.20	NA	NA	4.9	7.5	2.6
MW-111S	18.11	16.73	15.81	16.38	16.43	17.04	15.95	12.72	16.12	12.7	17.2	4.5
MW-112S	14.33	12.78	13.28	12.16	12.84	13.28	12.34	8.43	12.41	8.4	13.4	5.0
MW-113S	13.48	11.80	12.31	11.13	11.71	12.25	11.49	7.67	11.31	7.7	12.3	4.6
MW-117S	15.70	13.56	10.96	NA	11.38	13.59	9.79	9.03	9.13	9.0	13.6	4.6
MW-13	20.50	18.85	17.45	NA	NA	NS	NS	NS	NS	16.7	18.9	2.2
TW-1	18.00	16.71	15.11	NA	NA	NS	NS	NS	NS	14.3	16.7	2.4
EOF-2	24.12	13.38	9.22	NA	10.56	9.81	7.98	8.08	9.31	8.0	13.4	5.4
MW-200	54.67	Dry	Dry	19.56	17.31	Dry	18.96	12.75	NA	12.8	19.6	6.8
MW-201	58.78	35.90	35.91	34.75	31.81	34.94	33.82	30.22	NA	30.2	35.9	5.7
MW-202	51.62	18.25	16.69	15.07	14.13	17.36	14.75	NA	NA	12.9	18.3	5.4
MW-203	46.23	12.98	11.58	10.29	9.41	12.08	9.90	7.44	7.70	7.4	13.0	5.5
MW-204	41.85	9.14	7.77	7.10	6.45	8.09	6.89	NA	NA	5.7	9.1	3.4
MW-205	40.55	10.16	10.09	9.13	7.50	8.72	7.36	5.60	5.61	5.6	10.2	4.6
MW-206	43.08	10.26	8.96	8.55	8.25	9.23	8.36	NA	NA	7.0	10.3	3.3
MW-207	45.98	17.08	15.99	14.03	12.00	15.91	13.71	9.76	4.67	4.7	17.1	12.4

NS – Well not sampled
NI – Well not installed
NA – Data not available

Table 2 – Groundwater Elevations (feet above msl)

Well ID	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Min	Max	Range
MW-100D	12.76	10.85	14.12	10.77	11.04	-	-	-	10.8	15.9	5.2
MW-100S	13.42	14.84	14.84	11.29	14.01	15.58	15.50	15.03	11.3	15.6	4.3
MW-101D	5.43	10.09	11.92	10.14	9.62	13.42	12.11	13.83	5.4	13.8	8.4
MW-101S	14.76	15.77	15.73	14.26	14.81	16.64	16.33	16.27	14.3	16.6	2.4
MW-102D	17.51	2.51	12.84	8.78	7.49	10.55	9.42	10.63	2.5	17.5	15.0
MW-102S	5.65	11.07	11.49	10.07	8.81	13.82	12.34	14.21	5.7	14.2	8.6
MW-103D	14.86	8.01	10.34	11.30	8.40	0.53	8.07	14.10	0.5	14.9	14.3
MW-103S	5.49	10.16	11.99	10.21	8.73	13.52	12.06	14.02	5.5	14.0	8.5
MW-104S	8.23	13.18	13.73	10.80	13.38	15.05	14.38	15.43	8.2	15.4	7.2
MW-105D	5.21	9.55	11.55	10.13	9.25	10.21	11.63	13.37	5.2	13.4	8.2
MW-105S	4.27	7.36	9.48	9.56	7.78	13.03	9.73	11.08	4.3	13.0	8.8
MW-106D	4.29	7.71	9.72	8.81	8.41	10.95	8.99	10.87	4.3	11.0	6.7
MW-106S	4.58	8.21	10.43	9.76	7.51	11.58	9.59	11.83	4.6	11.8	7.3
MW-107D	3.43	6.19	8.05	6.89	5.78	8.49	9.07	9.23	3.4	9.2	5.8
MW-107S	3.22	5.57	7.17	6.88	5.79	8.00	7.87	8.20	3.2	8.4	5.2
MW-108S	2.42	4.12	5.15	2.83	3.83	4.61	8.08	6.32	2.4	8.1	5.7
MW-109D	2.59	3.81	4.25	3.61	3.53	4.26	4.76	4.67	2.6	5.5	2.9
MW-109S	2.01	2.99	2.96	2.14	2.25	2.96	3.95	3.17	2.0	4.7	2.7
MW-110D	1.90	2.67	3.32	2.52	2.67	3.63	4.89	4.10	1.9	5.4	3.5
MW-110S	1.38	2.53	2.04	1.52	1.70	2.31	4.17	2.47	1.4	4.6	3.3
MW-114S	4.58	8.52	10.92	9.80	8.31	12.46	10.44	13.17	4.6	13.2	8.6
MW-115S	4.39	8.26	10.77	9.69	8.02	12.37	10.43	13.20	4.4	13.2	8.8
MW-122D	NI	NI	NI	NI	NI	NI	7.96	7.37	7.4	8.0	0.6
MW-122S	NI	NI	NI	NI	NI	NI	12.36	12.67	12.4	12.7	0.3

NS – Well not sampled
NI – Well not installed
NA – Data not available

Table 2 – Groundwater Elevations (continued)

Well ID	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Min	Max	Range
MW-123S	NI	NI	NI	NI	NI	NI	8.94	8.43	8.4	8.9	0.5
MW-124	NI	NI	NI	NI	NI	NI	5.71	3.61	3.6	5.7	2.1
MW-125S	NI	NI	NI	NI	NI	NI	8.11	7.56	7.6	8.1	0.5
AST-1	5.06	6.14	6.20	-	5.96	7.04	NS	NS	5.1	7.2	2.1
River Gauge	0.89	2.61	2.63	0.55	1.48	2.80	NA	NA	0.6	3.1	2.6
MW-111S	1.38	2.30	1.73	1.68	1.07	2.16	5.39	1.99	0.9	5.4	4.5
MW-112S	1.55	1.05	2.17	1.49	1.05	1.99	5.90	1.92	0.9	5.9	5.0
MW-113S	1.68	1.17	2.35	1.77	1.23	1.99	5.81	2.17	1.2	5.8	4.6
MW-117S	2.14	4.74	NA	4.32	2.11	5.91	6.67	6.57	2.1	6.7	4.6
MW-13	1.65	3.05	NA	NA	NS	NS	NS	NS	1.7	3.8	2.2
TW-1	1.29	2.89	NA	NA	NS	NS	NS	NS	1.3	3.7	2.4
EOF-2	10.74	14.90	NA	13.56	14.31	16.14	16.04	14.81	10.7	16.1	5.4
MW-200	NA	NA	35.11	37.36	NA	35.71	41.92	NA	35.1	41.9	6.8
MW-201	22.88	22.87	24.03	26.97	23.84	24.96	28.56	NA	22.9	28.6	5.7
MW-202	33.37	34.93	36.55	37.49	34.26	36.87	NA	NA	33.4	38.8	5.4
MW-203	33.25	34.65	35.94	36.82	34.15	36.33	38.79	38.53	33.3	38.8	5.5
MW-204	32.71	34.08	34.75	35.40	33.76	34.96	NA	NA	32.7	36.2	3.4
MW-205	30.39	30.46	31.42	33.05	31.83	33.19	34.95	34.94	30.4	35.0	4.6
MW-206	32.82	34.12	34.53	34.83	33.85	34.72	NA	NA	32.8	36.1	3.3
MW-207	28.90	29.99	31.95	33.98	30.07	32.27	36.22	41.31	28.9	41.3	12.4

NS – Well not sampled
NI – Well not installed
NA – Data not available

Table 3 – Groundwater Elevation Changes (feet) from Previous Event

Well ID	Jun-01	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03
MW-100D	-3.36	0.20	-1.91	3.27	-3.35	0.27	-	-	-
MW-100S	-2.21	0.66	1.42	0.00	-3.55	2.72	1.57	-0.08	-0.47
MW-101D	-3.74	-3.21	4.66	1.83	-1.78	-0.52	3.80	-1.31	1.72
MW-101S	-1.07	0.34	1.01	-0.04	-1.47	0.55	1.83	-0.31	-0.06
MW-102D	-6.88	13.63	-15.00	10.33	-4.06	-1.29	3.06	-1.13	1.21
MW-102S	-3.18	-3.18	5.42	0.42	-1.42	-1.26	5.01	-1.48	1.87
MW-103D	-8.77	13.18	-6.85	2.33	0.96	-2.90	-7.87	7.54	6.03
MW-103S	-3.76	-3.17	4.67	1.83	-1.78	-1.48	4.79	-1.46	1.96
MW-104S	-2.70	-2.52	4.95	0.55	-2.93	2.58	1.67	-0.67	1.05
MW-105D	-3.49	-3.31	4.34	2.00	-1.42	-0.88	0.96	1.42	1.74
MW-105S	-1.68	-3.59	3.09	2.12	0.08	-1.78	5.25	-3.30	1.35
MW-106D	-2.92	-2.69	3.42	2.01	-0.91	-0.40	2.54	-1.96	1.88
MW-106S	-2.57	-3.06	3.63	2.22	-0.67	-2.25	4.07	-1.99	2.24
MW-107D	-3.20	-2.28	2.76	1.86	-1.16	-1.11	2.71	0.58	0.16
MW-107S	-2.30	-2.88	2.35	1.60	-0.29	-1.09	2.21	-0.13	0.33
MW-108S	-1.78	-2.11	1.70	1.03	-2.32	1.00	0.78	3.47	-1.76
MW-109D	-1.64	-1.23	1.22	0.44	-0.64	-0.08	0.73	0.50	-0.09
MW-109S	-2.21	-0.47	0.98	-0.03	-0.82	0.11	0.71	0.99	-0.78
MW-110D	-2.58	-0.89	0.77	0.65	-0.80	0.15	0.96	1.26	-0.79
MW-110S	-2.85	-0.41	1.15	-0.49	-0.52	0.18	0.61	1.86	-1.70
MW-114S	-6.08	-0.57	3.94	2.40	-1.12	-1.49	4.15	-2.02	2.73
MW-115S	-3.12	-3.69	3.87	2.51	-1.08	-1.67	4.35	-1.94	2.77
MW-122D	-	-	-	-	-	-	-	-	-0.59
MW-122S	-	-	-	-	-	-	-	-	0.31
MW-123S	-	-	-	-	-	-	-	-	-0.51

Values in red indicate decrease in groundwater elevation from previous sample event.
Values in black indicate increase in groundwater elevation from previous sample event.

Table 3 – Groundwater Elevation Changes from Previous Event (continued)

Well ID	Jun-01	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03
MW-124	-	-	-	-	-	-	-	-	-2.10
MW-125S	-	-	-	-	-	-	-	-	-0.55
AST-1	-0.57	-1.53	1.08	0.06	-	-	1.08	-	-
River Gauge on Boat Dock	-0.51	-1.70	1.72	0.02	-2.08	0.93	1.32	-	-
MW-111S	-3.41	0.47	0.92	-0.57	-0.05	-0.61	1.09	3.23	-3.40
MW-112S	-3.29	0.61	-0.50	1.12	-0.68	-0.44	0.94	3.91	-3.98
MW-113S	-3.15	0.50	-0.51	1.18	-0.58	-0.54	0.76	3.82	-3.64
MW-117S (1)	-1.12	-2.56	2.60	-	-	-2.21	3.80	0.76	-0.10
MW-13 (1)	-1.97	-0.21	1.40	-	-	-	-	-	-
TW-1 (1)	-2.01	-0.40	1.60	-	-	-	-	-	-
EOF-2	-0.77	-3.21	4.16	-	-	0.75	1.83	-0.10	-1.23
MW-200	1.44	-	-	-	2.25	-	-	6.21	-
MW-201	-0.03	-5.46	-0.01	1.16	2.94	-3.13	1.12	3.60	-
MW-202	-0.63	-4.77	1.56	1.62	0.94	-3.23	2.61	-	-
MW-203	0.05	-4.16	1.40	1.29	0.88	-2.67	2.18	2.46	-0.26
MW-204	-0.25	-3.19	1.37	0.67	0.65	-1.64	1.20	-	-
MW-205	0.35	-2.74	0.07	0.96	1.63	-1.22	1.36	1.76	-0.01
MW-206	-0.79	-2.52	1.30	0.41	0.30	-0.98	0.87	-	-
MW-207	0.50	-5.90	1.09	1.96	2.03	-3.91	2.20	3.95	5.09

Values in red indicate decrease in groundwater elevation from previous sample event.
Values in black indicate increase in groundwater elevation from previous sample event.

Table 4 – Hydraulic Head Differences (feet) in Well Clusters

Well Cluster	Apr-99	Jun-01	Dec-01	Mar-02	Apr-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03	Positive Frequency	Negative Frequency
MW-100D, S	0.95	-0.20	-0.66	-3.99	-0.72	-0.52	-2.97	-	-	-	14%	86%
MW-101D, S	-3.11	-5.78	-9.33	-5.68	-3.81	-4.12	-5.19	-3.22	-4.22	-2.44	0%	100%
MW-102D, S	-1.25	-4.95	11.86	-8.56	1.35	-1.29	-1.32	-3.27	-2.92	-3.58	22%	78%
MW-103D, S	-1.97	-6.98	9.37	-2.15	-1.65	1.09	-0.33	-12.99	-3.99	0.08	22%	78%
MW-105D, S	2.47	0.66	0.94	2.19	2.07	0.57	1.47	-2.82	1.90	2.29	89%	11%
MW-106D, S	-0.31	-0.66	-0.29	-0.50	-0.71	-0.95	0.90	-0.63	-0.60	-0.96	11%	89%
MW-107D, S	0.51	-0.39	0.21	0.62	0.88	0.01	-0.01	0.49	1.20	1.03	78%	22%
MW-109D, S	0.77	1.34	0.58	0.82	1.29	1.47	1.28	1.30	0.81	1.50	100%	0%
MW-110D, S	0.73	1.00	0.52	0.14	1.28	1.00	0.97	1.32	0.72	1.63	100%	0%
MW-122D, S	-	-	-	-	-	-	-	-	-4.40	-5.30	0%	100%

Values in red indicate negative head difference.
Values in black indicate positive head difference.

Table 5: Boron Concentration Summary

Well ID	Mar-99 Round 1	Apr-99 Round 2	Sep-99 Round 3	Jun-00 Round 4	Jun-01 Round 5	Dec-01 Round 6	Mar-02 Round 7	Jun-02 Round 8	Sep-02 Round 9	Dec-02 Round 10	Mar-03 Round 11	Jun-03 Round 12
100D	<50	30.8	ND	10.8B	<200	<50	68	<250	<50	<50	<27	<10
100S	<50	22.8	ND	NS	<200	<50	710	<250	188	84.9	123	1145
101D	61.3	57.7	ND	38.1B	25.4B	<50	<50	<250	NS	<50	83.5	47
101S	29.7	28.2	ND	53.8B	34.4B	77	<50	<250	NS	<50	NS	43
102D	270.4	114.7	ND	87.5B	80.1B	290	96.4	<250	NS	428	64.2	392
102S	43.9	29.7	ND	63.4B	80.8B	220	64.3	<250	NS	<50	49	19
103D	253.3	165.2	ND	63.6B	57.9	88	165	<250	NS	69.5	105	76
103S	214.9	364.5	ND	150	111B	260	55.4	<250	NS	118	96.2	92
104S	<50	47	ND	NS	54.2B	82	74	70.2	81.8	75.6	76.4	110
105D	144.2	65.2	ND	51.7B	34.7B	64	<50	<250	NS	58.5	60.4	41
105S	7,470	9,590	ND	2,940	1,760	2,400	1340	<250	NS	945	915	618
106D	76.8	69.2	ND	52.2B	40.4B	<50	<50	<250	NS	69.4	51.3	51
106S	2,074	1,307	ND	NS	960	720	468	<250	NS	222	348	239
107D	41.2	95.4	ND	30.9B	18.4B	<50	<50	<250	<50	<50	<27	173
107S	100	108.7	ND	91.0B	169B	180	160	<250	<50	102	105	66
108S	<50	62.8	ND	NS	82.9B	120	100	<250	NS	NS	NS	NS
109D	523	577	ND	401	157B	200	150	<250	NS	59.4	183	26
109S	70	88.7	ND	107	112B	170	54	<250	510	179	76.8	126
110D	337.7	316.5	ND	234	289	320	250	<250	265	203	93.3	127
110S	172.6	547	ND	131	90.7B	81	100	<250	97.3	179	320	162
111S	<50	61.8	ND	60.9B	45.8B	<50	52	<250	NS	61.5	37.2	52
112S	<50	65.1	ND	NS	23.9B	61	<50	<50	NS	NS	NS	NS
113S	120	141.7	ND	NS	136B	180	100	89.8	NS	NS	NS	NS
114S	422	290.2	ND	265	240	NS	134	201	NS	127	NS	90
115S	76.3	145.6	ND	94.2B	80.7B	NS	175	149	NS	178	90.4	78
117S	50	62.2	ND	NS	17.8B	57/84 (1)	75	59.7	NS	NS	NS	NS

Concentrations are in micrograms per liter (µg/l) and or parts per billion (ppb)
(B) Concentration between instrument detection limit (IDL) and contract required detection limit (CRDL)
(ND) No data available (NS) Well not sampled (NI) Well not installed (1) – Results from 01/2002 and 02/2002 sampling events.

Table 5: Boron Concentration Summary (continued)

Well ID	Mar-99 Round 1	Apr-99 Round 2	Sep-99 Round 3	Jun-00 Round 4	Jun-01 Round 5	Dec-01 Round 6	Mar-02 Round 7	Jun-02 Round 8	Sep-02 Round 9	Dec-02 Round 10	Mar-03 Round 11	Jun-03 Round 12
122D	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	178	179
122S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	237	219
123S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	64.6	46
124S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	351	299
125S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	426	365
AST-1	<50	36	ND	36B	17.1B	<50	<50	NS	NS	NS	NS	NS
MAT SUMP	NS	NS	ND	177	NS	NS	NS	128	NS	NS	NS	NS
EOF 2	<50	46.2	ND	NS	46.2B	65	70	72.3	NS	NS	NS	NS
TW-1	<50	12.7	ND	NS	<200	<50	<50	NS	NS	NS	NS	NS
MW-13	<50	14.7	ND	NS	13.1B	<50	<50	NS	NS	NS	NS	NS
MW-200	NS	NS	ND	NS	19.1B	NS	NS	<50	NS	NS	NS	NS
MW-201	NS	NS	ND	NS	33.2B	NS	NS	<50	NS	NS	NS	NS
MW-202	NS	NS	ND	NS	11.8B	<50	<50	NS	NS	NS	NS	NS
MW-203	NS	NS	ND	NS	19.8B	<50	<50	<50	NS	<50	NS	NS
MW-204	NS	NS	ND	NS	24.2B	<50	<50	NS	NS	NS	NS	NS
MW-205	NS	NS	ND	NS	21.6B	<50	<50	<50	NS	NS	NS	NS
MW-206	NS	NS	ND	NS	14.1B	<50	<50	NS	NS	NS	NS	NS
MW-207	NS	NS	ND	NS	20.6B	60	55	<50	NS	NS	NS	NS
EOF Supply Well	NS	NS	ND	NS	NS	56	60	NS	NS	NS	NS	NS
Schmidt Well	NS	NS	ND	NS	NS	NS	<50	NS	NS	NS	NS	NS

Concentrations are in micrograms per liter (µg/l) and or parts per billion (ppb)
(B) Concentration between instrument detection limit (IDL) and contract required detection limit (CRDL)
(ND) No data available (NS) Well not sampled. (NI) Well not installed. [(1)] – Results from 01/2002 and 02/2002 sampling events.

Table 6: Tritium Concentration Summary

Well ID	Mar-99 Round 1	Apr-99 Round 2	Sep-99 Round 3	Jun-00 Round 4	Jun-01 Round 5	Dec-01 Round 6	Mar-02 Round 7	Jun-02 Round 8	Sep-02 Round 9	Dec-02 Round 10	Mar-03 Round 11	Jun-03 Round 12
100D	<700	<1000	NS	<MDC	<270	<210	< 271	<260	134	<293	<259	<360
100S	<700	<1000	NS	NS	<270	<200	< 273	<261	<284	<294	<256	<320
101D	<700	<1000	NS	NS	<260	<210	< 280	<276	137	<275	<258	250
101S	<700	<1000	NS	<MDC	<260	<210	< 284	<278	<284	<273	<255	<350
102D	2,740	3,160	2,640	2,470	2,620	4,110	9,400	6,390	5,590	13,900	**27,100**	**28,630**
102S	<700	<1000	NS	5,540	7,250	**20,600**	6,320	4,500	12,200	1,100	2,370	770
103D	**22,180**	17,550	19,660	**20,900**	**20,800**	8,100	12,900	13,400	12,900	10,100	10,300	11,460
103S	2,580	9,260	2,980	1,230	1,120	5,350	627	6,460	495	1760	886	2610
104S	<700	<1000	NS	NS	<270	186	< 273	<261	293	142	<258	390
105D	4,590	2,450	3,030	2,150	1,360	2,110	1,780	1,510	2,060	2,390	854	1,400
105S	**138,700**	**67,400**	**23,480**	15,900	12,200	1,800	1,870	7,860	4,140	8,070	5,410	4,470
106D	3,320	1,590	5,830	1,810	1,450	14,200	1,730	1,630	2,610	1,430	1,120	1,310
106S	**24,290**	16,370	NS	NS	780	2,130	2,450	1,130	514	1,500	2,330	1,550
107D	<700	<1000	NS	<MDC	<270	<210	217	211	214	242	481	630
107S	<700	<1000	NS	<MDC	<270	219	254	274	<284	<292	346	580
108S	<700	<1000	NS	NS	<270	156	290	221	256	<291	<251	240
109D	**33,070**	**31,600**	**21,230**	15,800	6,550	5,720	3,810	5,660	4,150	593	4,550	3,350
109S	<700	<1000	NS	<MDC	<270	<240	< 265	<261	<288	<276	<257	<350
110D	**27,630**	**23,280**	**27,230**	18,300	18,700	**21,300**	16,500	10,700	15,200	11,100	4,630	5,310
110S	3,090	<1000	2,470	2,360	1,890	3,270	2,980	1,470	2,390	2,050	1,430	1,370
111S	<700	<1000	NS	<MDC	<270	<210	< 273	<259	222	<292	<253	<350

Concentrations are in picocuries per liter (pCi/l).
(<Value) indicates sample concentration is less than the sample MDC value.
(ND) No data available. (NS) Well not sampled. (NI) Well not installed.
Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values indicate sample concentrations that are greater than the EPA MCL of 20,000 pCi/l.

Table 6: Tritium Concentration Summary (continued)

Well ID	Mar-99	Apr-99	Sep-99	Jun-00	Jun-01	Dec-01	Mar-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03
	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10	Round 11	Round 12
112S	<700	<1000	NS	NS	<270	<240	< 277	<259	<277	<293	<249	<340
113S	<700	<1000	NS	NS	<270	<240	< 272	<263	160	<290	149	<340
114S	<700	1,180	2,850	2,760	1,940	NS	3,730	1,140	1,190	927	1,530	1,070
115S	<700	<1000	NS	5,550	4,500	NS	1,870	4,090	1,900	2,180	2,230	3,410
117S	<700	<1000	NS	NS	<180	<240	< 272	<261	<279	<294	<249	<340
122D	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	<258	<360
122S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	720	850
123S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	<260	<340
124S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	4850	4,350
125S	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	1540	1900
AST-1	<700	<1000	NS	NS	<260	144	245	NS	NS	NS	NS	NS
Mat Sump	2,630	2,320	NS	2,890	NS	NS	NS	2,180	NS	NS	NS	NS
TW-1	<700	<1000	NS	NS	<270	<250	< 267	NS	NS	NS	NS	NS
TW-3	NS	NS	NS	NS	NS	<200	NS	NS	NS	NS	NS	NS
TW-4	NS	NS	NS	NS	NS	<200	NS	NS	NS	NS	NS	NS
MW-1	NS	NS	NS	NS	NS	<200	NS	NS	NS	NS	NS	NS
MW-2	NS	NS	NS	NS	NS	601	NS	NS	NS	229	NS	NS
MW-4	NS	NS	NS	NS	NS	<200	NS	NS	NS	NS	NS	NS
MW-13	<700	<1000	NS	NS	<270	<240	< 267	NS	NS	NS	NS	NS
MW-200	<MDC	<MDC	NS	NS	<180	NS	NS	<261	NS	NS	NS	NS
MW-201	<MDC	<MDC	NS	NS	<180	NS	NS	<262	NS	NS	NS	NS

Concentrations are in picocuries per liter (pCi/l).
(<Value) indicates sample concentration is less than the sample MDC value.
(NA) Well not sampled for analyte. (NS) Well not sampled. (NI) Well not installed.
Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values indicate sample concentrations that are greater than the EPA MCL of 20,000 pCi/l.

Table 6: Tritium Concentration Summary (continued)

Well ID	Mar-99	Apr-99	Sep-99	Jun-00	Jun-01	Dec-01	Mar-02	Jun-02	Sep-02	Dec-02	Mar-03	Jun-03
	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10	Round 11	Round 12
MW-202	<MDC	<MDC	NS	NS	<180	<210	< 266	NS	NS	NS	NS	NS
MW-203	<MDC	<MDC	NS	NS	<270	<250	< 267	<263	NS	<329	NS	NS
MW-204	<MDC	<MDC	NS	NS	<180	<210	< 266	NS	NS	NS	NS	NS
MW-205	<MDC	<MDC	NS	NS	<180	<210	< 264	<275	NS	NS	NS	NS
MW-206	<MDC	<MDC	NS	NS	<180	<210	< 261	NS	NS	NS	NS	NS
MW-207	<MDC	<MDC	NS	NS	<180	<250	< 259	<278	NS	NS	NS	NS
EOF Supply	NS	NS	NS	NS	NS	<210	< 265	NS	NS	NS	<249	NS
EOF 2	<700	<1000	NS	NS	<270	<200	< 270	<263	<285	NS	NS	<340
Schmidt	NS	NS	NS	NS	NS	NS	<267	NS	NS	NS	NS	NS

Concentrations are in picocuries per liter (pCi/l).
(<Value) indicates sample concentration is less than the sample MDC value.
(NA) Well not sampled for analyte. (NS) Well not sampled. (NI) Well not installed.
Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values indicate sample concentrations that are greater than the EPA MCL of 20,000 pCi/l.

Table 7: Gross Alpha, Beta, Sr-90 and Cs-137 Concentration Summary

Well No.	Sample Date	Gross Alpha	Gross Beta	Sr-90	Cs-137
MW-100D	Sep ' 02	<0.830	**3.59**	NA	<3.22
	Dec ' 02	<0.875	2.37	NA	<3.46
	Mar ' 03	<.672	**3.02**	NA	<4.09
	Jun ' 03	**2.00**	**6.60**	NA	<5.9
MW-100S	Sep ' 02	**0.601**	**5.72**	NA	<3.59
	Dec ' 02	<4.02	**19.3**	NA	<3.18
	Mar ' 03	<1.24	**8.73**	NA	<4.65
	Jun ' 03	<1.8	**4.76**	NA	<6.5
MW-101D	Sep ' 02	**5.84**	**6.18**	<0.583	<3.52
	Dec ' 02	**4.8**	**5.84**	NA	<3.11
	Mar ' 03	**5.34**	**6.65**	NA	<6.21
	Jun ' 03	**5.09**	**9.12**	NA	<8.7
MW-101S	Sep ' 02	**0.913**	**5.74**	**0.547**	<3.15
	Dec ' 02	<0.643	2.45	NA	<3.09
	Mar ' 03	<.769	**2.82**	0.38	<4.06
	Jun ' 03	<2.1	**3.32**	<1.7	<8.3
MW-102D	Dec ' 01	**13.4**	**9.5**	**0.606**	<12
	March ' 02	**9.74**	**7.42**	<0.664	<2.41
	June ' 02	**5.53**	**6.97**	<0.721	1.98
	Sep ' 02	**8.93**	**8.69**	<0.636	**6.14**
	Dec ' 02	5.55	**50.1**	<0.85	**6.69**
	Mar ' 03	**3.57**	**15.6**	<0.578	**12.7**
	Jun ' 03	**8.6**	**58.1**	<1.6	<6.1
MW-102S	Dec ' 01	**2.12**	**7.99**	<0.23	<10
	March ' 02	**1.05**	**6.15**	<0.716	<3.05
	June ' 02	**1.48**	**4.52**	<0.716	<3.01
	Sep ' 02	**1.01**	**5.16**	<0.520	<2.98
	Dec ' 02	0.755	**3.05**	<0.644	<3.4
	Mar ' 03	<.84	**4.68**	0.376	<4.85
	Jun ' 03	**1.52**	**4.7**	1.08	<6.0
MW-103D	June ' 01	NA	NA	<0.69	<11
	Dec ' 01	**8.48**	**12.9**	<0.24	<11
	March ' 02	**3.07**	**3.38**	<0.603	<2.78
	June ' 02	**6.87**	**7.39**	<0.691	<2.19
	Sep ' 02	**8.63**	**12.9**	<0.630	<3.64
	Dec ' 02	**4.64**	**5.42**	<0.593	<3.3
	Mar ' 03	**4.11**	**5.68**	<1.78	<3.58
	Jun ' 03	<2.6	**4.85**	<1.9	<7.3
MW-103S	June ' 01	NA	NA	**2.55**	**35**

Concentrations are in picocuries per liter (pCi/l).
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(NA) Well not sampled for analyte. (NS) Well not sampled. (NI) Well not installed.
Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values are significant at 95% confidence level and greater than the sample MDC.

Table 7: Gross Alpha, Beta, Sr-90 and Cs-137 Concentration Summary (continued)

Well No.	Sample Date	Gross Alpha	Gross Beta	Sr-90	Cs-137
	Dec ' 01	**3.43**	**20.8**	**1.82**	8.39
	March ' 02	**1.85**	**37.6**	**5.23**	**30.2**
	June ' 02	**1.64**	**81.5**	**15.3**	**58.5**
	Sep ' 02	**1.57**	**46**	**3.81**	**38.1**
	Dec ' 02	0.677	**40.6**	**5.57**	**38**
	Mar ' 03	**4.33**	**76.9**	**6.75**	**87.6**
	Jun ' 03	<2.0	**42.2**	1.13	**26.6**
MW-104S	Sep ' 02	**2.85**	**14.8**	NA	<3.35
	Dec ' 02	**1.01**	**6.9**	NA	<3.09
	Mar ' 03	0.734	**7.56**	NA	<5.23
	Jun ' 03	**6.1**	**42.9**	**3.14**	<8.5
MW-105D	Dec ' 01	<1.7	**5.45**	<0.28	<10
	March ' 02	**1.47**	**4.72**	<0.571	<2.67
	June ' 02	**1.39**	<2.72	<0.597	<2.26
	Sep ' 02	**3.06**	**6.69**	<0.738	<3.17
	Dec ' 02	**2.15**	**5.72**	<0.596	<3.12
	Mar ' 03	**2.43**	**4.46**	0.655	<4.17
	Jun ' 03	**3.59**	**9.01**	<1.5	<7.9
MW-105S	June ' 01	NA	NA	**143**	<12
	Dec ' 01	<1.8	**226**	**69.7**	<9.8
	March ' 02	**1.11**	**242**	**122**	<2.48
	June ' 02	<1.34	**238**	**116**	<2.55
	Sep ' 02	<1.17	**180**	**101**	<3.29
	Dec ' 02	<0.872	**159**	**83.3**	<3.37
	Mar ' 03	<1.04	**253**	**138**	<4.23
	Jun ' 03	<3.2	**490.1**	**181.6**	<4.7
MW-106D	Dec ' 01	<1.7	**6.25**	<0.35	<10
	March ' 02	**1.03**	**5.89**	<0.597	<3.18
	June ' 02	**1.13**	**6.01**	<0.527	1.92
	Sep ' 02	**1.16**	**8.31**	<0.546	<2.40
	Dec ' 02	**1.43**	**4.27**	<0.624	<2.4
	Mar ' 03	1.19	**7.4**	0.362	<3.97
	Jun ' 03	**3.02**	**10.9**	<1.5	<5.0
MW-106S	June ' 01	NA	NA	**6.6**	<13
	Dec ' 01	<1.9	**25.4**	**4.67**	<15
	March ' 02	**1.36**	**25.4**	**8.38**	<2.05
	June ' 02	<1.24	**34**	**13**	<2.28

Concentrations are in picocuries per liter (pCi/l).
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(NA) Well not sampled for analyte. (NS) Well not sampled. (NI) Well not installed.
Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values are significant at the 95% confidence level and greater than the sample MDC.

Table 7: Gross Alpha, Beta, Sr-90 and Cs-137 Concentration Summary (continued)

Well No.	Sample Date	Gross Alpha	Gross Beta	Sr-90	Cs-137
	Sep ' 02	<1.49	**11.2**	**2.26**	2.76
	Dec '02	<1.26	**23.2**	**9.35**	<2.55
	Mar ' 03	1.01	**36.1**	**13.5**	<4.54
	Jun ' 03	<3.1	**54.6**	**18.68**	<8.5
MW-107D	Dec ' 01	NA	**21.5**	<1.3	<11
	March ' 02	**1.98**	**5.38**	<0.628	<3.11
	June ' 02	**1.3**	**3.87**	<0.600	<2.65
	Sep ' 02	**0.81**	**5.3**	<0.557	<2.64
	Dec ' 02	**1.1**	**3.97**	<0.572	<2.75
	Mar ' 03	**1.16**	**4.02**	NA	<3.87
	Jun ' 03	<2.0	**4.4**	<1.7	<5.4
MW-107S	Dec ' 01	NA	NA	<0.36	<12
	March ' 02	NA	NA	NA	<4.37
	June ' 02	<0.944	**4.61**	0.260	<2.42
	Sep ' 02	<1.14	**5.11**	<0.593	<3.43
	Dec ' 02	<0.822	**2.77**	0.444	<2.65
	Mar ' 03	0.633	**3.49**	**0.542**	<3.29
	Jun ' 03	<2.7	**4.2**	<1.9	<7.6
MW-108S	Sep ' 02	**1.16**	**9.36**	NS	<3.25
	Dec ' 02	0.554	2.51	NA	<2.31
	Mar ' 03	0.455	2.16	NA	<4.08
	Jun ' 03	<2.5	**4.00**	NA	<4.3
MW-109D	June ' 01	NA	NA	<0.82	<14
	Dec ' 01	**4.3**	**6.92**	<0.36	<13.
	March ' 02	**3.7**	**7.47**	<0.666	<2.6
	June ' 02	**4.62**	**5.54**	<0.495	<2.52
	Sep ' 02	**3.72**	**6.2**	<0.568	<2.13
	Dec ' 02	<0.834	1.82	<0.646	<3.13
	Mar ' 03	**6.52**	**11.9**	NA	2.4
	Jun ' 03	**9.00**	**11.5**	<1.9	<8.2
MW-109S	Dec ' 01	<2	**5.76**	**0.825**	<15
	March ' 02	<1.54	**6.33**	**0.903**	<2.88
	June ' 02	<1.23	**8.49**	**0.656**	<2.76
	Sep ' 02	<1.79	**12.8**	**0.967**	<3.25
	Dec ' 02	1.25	**10.1**	**0.901**	<3.47
	Mar ' 03	<1.5	**7.85**	**0.983**	<3.8
	Jun ' 03	<2.9	**11.2**	<1.7	<6.1

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Shaded values are significant at the 95% confidence level but are less than the sample MDC.
Bold values are significant at the 95% confidence level and greater than the sample MDC.