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Date: August 20, 2008
Refer To: EP2008-0445

James P. Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of the Pilot Test Report for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G. This report presents results following implementation of the Pilot Test Work Plan for Evaluating FLUTe Vapor-Sampling System in use at Material Disposal Area G, Los Alamos National Laboratory.

If you have any questions, please contact Steve Paris at (505) 606-0915 (smparis@lanl.gov) or Edwin Worth at (505) 606-0398 (eworth@doeal.gov).

Sincerely,

Susan G. Stiger, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

David R. Gregory, Project Director
Environmental Operations
Los Alamos Site Office

SS/DG/DM/SP:sm

Enclosures: 1) Two hard copies with electronic files - Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G (EP2008-0445)

Cy: (w/enc.)
Neil Weber, San Ildefonso Pueblo
Steve Paris, EP-CAP, MS M992
RPF, MS M707 (with two CDs)
Public Reading Room, MS M992

Cy: (Letter and CD only)
Laurie King, EPA Region 6, Dallas, TX
Steve Yanicak, NMED-OB, White Rock, NM
Tom Anderson, Apogen, Los Alamos, NM
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Kristine Smeltz, WES-DO, MS M992
EP-CAP File, MS M992

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Tom Skibitski, NMED-OB, Santa Fe, NM
Alison Bennett, DOE-LASO (date-stamped letter emailed)
Susan G. Stiger, ADEP, MS M991
Dave McInroy, EP-CAP, MS M992
Alison M. Dorries, WES-DO, MS M992
IRM-RMMSO, MS A150 (date-stamped letter emailed)

LA-UR-08-5385
August 2008
EP2008-0445

Pilot Test Report for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G

Los Alamos
NATIONAL LABORATORY
EST.1943

Prepared by the Environmental Programs Directorate

LA-UR-08-5385
EP2008-0445

Pilot Test Report for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G

August 2008

Responsible project leader:

Printed Name	Signature	Title	Organization	Date
Steve Paris		Project Leader	Environmental Programs	

Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Susan G. Stiger		Associate Director	Environmental Programs	

Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
David R. Gregory		Project Director	DOE-LASO	

EXECUTIVE SUMMARY

This investigation report presents the results from the implementation of the pilot test work plan for evaluating FLUTe vapor-sampling systems in use at Material Disposal Area (MDA) G, Los Alamos National Laboratory. The objective of the pilot test is to evaluate three subsurface vapor-sampling systems: current Flexible Liner Underground Technology (new FLUTe) systems, older FLUTe monitoring systems installed in MDA G during the 1990s (vintage FLUTe), and a stainless-steel (SS) system. The vintage FLUTe system was installed adjacent to new FLUTe and SS vapor-monitoring systems installed in support of the MDA C pilot test. Subsurface vapor samples were collected from similar depth interval(s) using the three vapor-monitoring systems located south of the MDA C boundary. Vapor samples were collected from borehole 50-603373 using the SS system, from borehole 50-603502 using the vintage FLUTe system equipped with nylon tubing, and from borehole 50-603468 using the new FLUTe system.

Based on the results of this investigation, it cannot be concluded that significant differences exist between vintage FLUTe and new FLUTe samples or for vintage FLUTe and SS samples. Although relative percent different calculations indicated a slight trend toward higher results in the SS system samples, Student's *t*-test results confirmed statistically significant differences in only 4 of 16 VOC comparisons in each side-by-side sampling system comparison.

Finally, the comparison of volatile organic compound (VOC) data from the vintage FLUTe and SS sampling systems does not support the proposition that adsorption of VOCs in the vintage FLUTe sampling trains is occurring that would bias samples collected using MDA G FLUTe systems. Statistical testing performed for this evaluation confirmed that the vintage FLUTe sampling system produced similar results to the SS sampling system.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility that is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft above sea level.

The sites addressed in this report are Consolidated Unit 54-013(b)-99, also known as Material Disposal Area (MDA) G (Figure 1.0-1), and Solid Waste Management Unit (SWMU) 50-009, also known as MDA C (Figure 1.0-2). MDA G is a decommissioned (i.e., removed from service) subsurface site established for the disposal of low-level radioactive waste, radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls. It is also used for the belowground storage of retrievable transuranic waste. In addition, active operations involving the disposal of low-level radioactive waste occur adjacent to the inactive MDA G disposal units. MDA C is an inactive 11.8-acre landfill consisting of 6 disposal pits, a chemical disposal pit, 108 shafts, and is potentially contaminated with both hazardous chemicals and radionuclides. Contaminants in soil vapor beneath MDA C are similar to those in vapor beneath MDA G.

This investigation report presents the results from the implementation of the "Pilot Test Work Plan for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G, Los Alamos National Laboratory" (LANL 2008, 102653). The New Mexico Department of Environment (NMED) requested that tests be conducted to evaluate and compare three different vapor-sampling systems, all of which have been used at the Laboratory because of possible adsorption of contaminants to sampling tubing. The objective of the pilot test is to evaluate three subsurface vapor-sampling systems: the current Flexible Liner Underground Technology (new FLUTe) system, the older FLUTe monitoring system installed in MDA G during the 1990s (vintage FLUTe), and a stainless-steel (SS) system. The vintage FLUTe system was installed adjacent to new FLUTe and SS vapor-monitoring systems, which were installed in support of the approved MDA C pilot test (LANL 2008, 101653) and NMED modifications (NMED 2008, 101704); therefore, some of the samples referenced in this report were collected as part of the MDA C pilot test comparing the new FLUTe with the packer, and SS sampling systems (LANL 2008, 102653).

1.1 Background and Purpose of the Pilot Test

Subsurface pore-gas samples have been collected at MDA G since the late 1990s using the FLUTe system for vapor monitoring. The FLUTe system uses a flexible liner that provides a seal against the borehole wall once it is filled with sand or air. The sampling ports and the tubing are installed in the interior sleeves of the liner, and the tubing runs to the surface where vapor samples are collected. The FLUTe membrane liner is made of urethane-coated nylon fabric, and the tubing is made of nylon. Recently, FLUTe has been integrating a vapor diffusion barrier into their subsurface sampling systems. At MDA G, more recent subsurface vapor-sampling systems have been constructed using SS tubing to connect the sampling ports to the surface.

Vapor-sampling results from samples at MDA H have raised concerns regarding the potential for adsorption of contaminants by the nylon membrane and tubing used in the FLUTe system. The test described in this report was conducted to compare volatile organic compound (VOC) concentrations in subsurface vapor samples collected using the vintage FLUTe system, the new FLUTe system, and the SS system. All three systems have been used at the Laboratory for collecting vapor-phase samples at

different sites. This report presents the results of sampling conducted at a single location in conjunction with MDA C pilot test field activities and evaluates VOC concentrations in samples collected using each system.

1.2 Three Vapor-Sampling Systems

The operation of the three vapor-sampling systems is described in detail below.

The vintage FLUTe system uses a flexible liner that provides a seal against the borehole wall. The sampling ports and the nylon tubing are installed in the interior sleeves of the liner. The liner is contained in the borehole and is connect to a polyvinyl chloride riser system at the surface. Before sampling, the vintage FLUTe system is inflated with air to temporarily seal the liner against the borehole wall, pressing the sampling ports against the formation. This pressure is maintained throughout the sampling process. Vapor is drawn through a permeable spacer material between the liner and the borehole wall and into the nylon tubing. In the new FLUTe system, a diffusion barrier is installed in the permeable spacer material to minimize the potential for interactions with the material that could affect analyte concentrations.

The SS system uses continuous lengths of 0.25-in.-outside diameter SS tubing with a single port installed at the target depth of each tube. Bentonite is used above and below each sampling port to seal off the interval to be sampled. The 5-ft space between the bentonite seals at each sampling interval is filled with sand. Sampling is performed by extracting the formation air through the sand layer and into the SS tubing.

2.0 SCOPE OF ACTIVITES

This section describes the field investigation activities conducted for the pilot test at MDA C that apply to the MDA G FLUTe/SS comparison study. The quality procedures (QPs) and standard operating procedures (SOPs) used during the pilot test are listed in Table B-1.0-2 in Appendix B of the “Pilot Test Investigation Report for Evaluating Vapor-Sampling Systems at Material Disposal Area C” (LANL 2008, 101653). The most current revisions of all QPs and SOPs were used. Specific details of the methods used for drilling and sampling activities are presented in Appendix B, along with descriptions of deviations from the approved pilot study work plan (LANL 2008, 101653) and NMED modifications (2008, 101113).

2.1 Number, Locations, and Depths of Boreholes

Subsurface vapor samples were collected from boreholes 50-603502, 50-603468, and 50-603373 constructed adjacent to each other and located south of the MDA C boundary. The boreholes are less than 10 ft apart. All the borehole locations for the pilot test are shown in Figure 2.1-1. Borehole 50-603373 was drilled to 300 ft below ground surface (bgs) and was completed with an SS system. Borehole 50-603468 was drilled to a total depth (TD) of 450 ft bgs and was installed with the new FLUTe system using standard nylon tubing with sample port depths corresponding with the SS system port depths. Borehole 50-603502 was drilled to 300 ft bgs and constructed with a vintage FLUTe system.

2.2 Drilling and Installation of Vapor-Sampling System

Air-rotary drilling was used to drill boreholes 50-603373, 50-603468, and 50-603502 to TD. Borehole logs were recorded, which included lithologic descriptions and notes regarding lithologic unit contacts, fractures encountered, and any other conditions that may have affected sampling results. All wastes were managed as part of the MDA C Phase II field program.

During the MDA C Phase II field operations, a vintage FLUTe system was initially installed in borehole 50-24821 but failed before sampling because of settlement, which resulted in the detachment of the flexible liner material from the well head and loss of sample tubing. Borehole 50-603502 was completed as a replacement for the initial vintage FLUTe. Subsequently, it was observed that the system in borehole 50-603502 had settled 6 ft, and the sample tubes were secured and the system was sampled. The system has since settled an additional 6 ft following the sampling event, and the condition of the sample ports is currently unknown. Borehole 50-24821 was logged during drilling activities. The borehole log for 50-24821 is provided in Appendix C of the MDA C pilot test report (LANL 2008, 102653). Lithology encountered and vapor-sampling system construction details are shown in Figure 1.2-1, which depicts the new FLUTe (50-603468) and SS (50-603373) systems, and in Figure 1.2-2, which depicts vintage FLUTe system.

For the installation of the FLUTe and SS systems, the sand pack for the FLUTe system and the bentonite for the SS system were placed in the boreholes using a tremie pipe. The outside diameter of the tremie pipe during FLUTe installation was 4 in. The outside diameter of the tremie pipe during SS installation was 2 in.

2.3 Subsurface Vapor Sampling

2.3.1 Subsurface Vapor Sampling at Each Borehole

All subsurface vapor sampling was conducted in compliance with Section IX.B.2.g of the Compliance Order on Consent. The vapor-sampling systems were purged to ensure rock formation air filled the systems. Purge times for each vapor-sampling system are based on the inside diameter of the tubing used (0.18 in. for all tubing), the length of tubing for each port, and the nominal flow rate of the pumps (30 ft^3/h). The time required to purge the entire tubing volume for the two FLUTe and SS systems was less than 1 min. Purge times for each port were 5, 10, and 20 min in each sampling system. These purge times are conservative and allow for the complete purging of all parts of each sampling system to ensure that samples contain only formation air.

Vapor samples for VOC analysis were collected in SUMMA canisters, one sample per canister, and for tritium using silica gel columns. One vapor sample was collected after each purge time. Therefore, a total of three SUMMA samples and one tritium sample were collected at each depth interval from each sampling system. In each borehole, vapor samples were collected from three depths: 30 ft, 90 ft, and 260 ft bgs. Therefore, a total of nine VOC samples and three tritium samples were collected from each system. Table 2.3-1 presents the details of the vapor samples collected for the pilot test.

2.3.2 Collection of Subsurface Vapor Samples

All vapor-sampling activities were performed according to the approved MDA C pilot test work plan (LANL 2008, 101653) and NMED modifications (2008, 101113) as follows. Sample collection logs for borehole 50-603502 (vintage FLUTe) are included in Appendix A. Sample collection logs for borehole 50-603468 (new FLUTe) and borehole 50-603373 (SS) are included in Appendix E of the MDA C pilot test report (LANL 2008, 102653).

- The nominal flow rate for all tests was 30 ft^3/h. Actual flow rates were collected during purging and sampling and were recorded on field-screening log. Field-screening logs for 50-603502 (vintage FLUTe) are provided in Appendix B. The flow rate was measured using a Kobold Instruments, Inc., SCFH Air Meter.

- Vapor samples were collected in SUMMA canisters after each depth was purged for 5, 10, and 20 min.
- After the third SUMMA sample was collected at each depth, a vapor sample was collected using a silica gel sampler for tritium analysis.
- Concentrations (percent) of methane, carbon dioxide, and oxygen were measured every 2 min during purging, between samples, and immediately before samples were collected. These readings were recorded on the field-screening logs (Appendix B). Concentrations were measured using a LANDTEC GEM 500 Gas Extraction Meter.
- Ambient air temperature and barometric pressure were recorded on the field-screening logs immediately before each sample was collected.
- Any other field condition that may influence sampling results, if any, was recorded in a field notebook.

2.3.3 Analysis of Subsurface Vapor Samples

SUMMA canisters were submitted through the Laboratory's Sample Management Office (SMO) to an off-site contract analytical laboratory for analysis of VOCs by U.S. Environmental Protection Agency (EPA) Method TO-15. Silica gel columns were submitted through the SMO to an off-site contract analytical laboratory for analysis of tritium by EPA Method 906.0.

3.0 ANALYTICAL RESULTS

The analytical methods and the data quality review are presented in Appendix D of the MDA C pilot test report (LANL 2008, 102653 The analytical suites and results for samples collected from boreholes 50-603502, 50-603373, and 50-603468 are presented in Appendix C. Analytical results for VOCs that are primary chemicals of potential concern (COPCs) at MDA G are in Table 3.0-1. Tritium results are contained in Table 3.0-2.

3.1 Boreholes 50-603502, 50-603373, and 50-603468

The following seven VOCs were detected in vapor samples collected from the 30-ft port depth that are also primary COPCs at MDA G (Table 3.0-1): carbon tetrachloride, chloroform, dichlorodifluoromethane, dichloroethene[cis-1,2-], methylene chloride, tetrachloroethene, and trichloroethene. Four of the seven COPC VOCs were detected in vapor samples from all three sampling systems: carbon tetrachloride, chloroform, dichlorodifluoromethane, and trichloroethene. Only chloroform and trichloroethene were detected in all three samples from each sampling system. For these two VOCs, concentrations varied among the three sampling systems, with concentrations in the SS system samples showing higher detections by approximately a factor of 3 (Table 3.1-1). Tritium was only detected at the 30-ft depth in only one sample, the vintage FLUTe system (Table 3.1-2)

The following seven VOCs were detected in vapor samples collected from the 90-ft port depth that are also primary COPCs at MDA G (Table 3.0-1): carbon tetrachloride, chloroform, dichlorodifluoromethane, dichloroethene[cis-1,2-], methylene chloride, tetrachloroethene, and trichloroethene. All seven VOCs were detected in all three 90-ft samples from all three sampling systems. Of the seven VOCs, mean concentrations were similar among sampling systems (i.e., no VOC-specific mean value was more than approximately 1.5 times either of the two other VOC-specific means). Mean concentrations were highest in samples from the SS systems for three VOCs, in new FLUTe samples for three VOCs, and in vintage FLUTe samples for one VOC (Table 3.1-1). Tritium was detected only in the SS and vintage FLUTe

samples, with the SS system sample approximately 2 times higher than the vintage FLUTe system sample (Table 3.1-2).

The following seven VOCs were detected in vapor samples collected from the 260-ft port depth that are also primary COPCs at MDA G (Table 3.0-1): carbon tetrachloride, chloroform, dichlorodifluoromethane, dichloroethene[cis-1,2-], methylene chloride, tetrachloroethene, and trichloroethene. All seven VOCs were detected in all three 260-ft samples from all three sampling systems. Of the seven VOCs, mean concentrations were similar among sampling systems (i.e., no VOC-specific mean value was more than approximately 1.5 times of either the two other VOC-specific means). Mean concentrations were highest in samples from the SS systems for six VOCs, and were similar between SS and new FLUTe samples for one VOC (Table 3.1-1). The vintage FLUTe sample means were lowest for all seven VOCs. Tritium was detected in all three vapor-sampling system samples, with the SS sample showing concentrations 3 times higher than the new FLUTe sample and 5 times higher than the vintage FLUTe sample (Table 3.1-2).

4.0 STATISTICAL COMPARISON OF SAMPLE RESULTS

Three VOC samples were collected (following 5-, 10-, and 20-min purge times) from each borehole/depth/sampling system. The three samples from each borehole/depth/sampling system are not true replicates because the second and third samples could be affected by extraction of the previous sample(s). However, based on the results and assumptions presented in the MDA C pilot test report (LANL 2008, 102653), the statistical analyses performed for this study assumes that purge time did not affect sample results and that each of the three samples collected from a particular sampling system and depth are independent samples. If the three purge time samples are assumed to represent independent samples (replicates), there are sufficient samples in most cases to statistically compare the sampling system results with each VOC at single sample depths. Interval plots for VOCs detected in all three sampling systems at 30, 90, and 260 ft are provided in Figures 4.0-1, 4.0-2, and 4.0-3, respectively.

4.1 Statistical Test Results

Independent Student's *t*-tests were performed to compare whether the means of two data sets were different at a 95% confidence level. Based on the 95% confidence level, the Student's *t*-test decision rule for this study is as follows: When the calculated p-value is <0.05, the assumption is that a difference between the two means is statistically significant, hereafter referred as significant. When the calculated p-value is >0.05, there are no differences in the means.

A relative percent difference (RPD) analysis was performed to compare vintage FLUTe (50-603502) with new FLUTe (50-603468) systems and vintage FLUTe (50-603502) with SS (50-603373) systems. An RPD value was calculated for each VOC detected in both systems, and a mean RPD was calculated for all the VOCs for each system. The mean RPD qualitatively shows the magnitude and general trend of the differences between the two systems. A negative RPD value indicates that the second mean is lower than the first mean).

4.1.1 Relative Percent Difference

For the comparison of the vintage FLUTe (50-603502) and new FLUTe (50-603468) systems, 9 out of 16 RPDs were negative with a mean RPD for all VOCs of –7.00, indicating generally higher results for samples from the new FLUTe system (Table 4.1-1). RPDs showed a trend of higher new FLUTe results in the 30-ft and 90-ft samples, with negative RPDs for both VOCs detected in all samples from the 30-ft

depth, and negative RPDs for six of seven VOCs at the 90-ft depth. However, at the 260-ft depth, RPDs were positive for six of seven VOCs.

For the comparison of the vintage FLUTe (50-603502) and SS (50-603373) systems, 15 out of 16 RPDs were negative with a mean RPD for all VOCs of –28.28, indicating a strong trend toward higher results from the SS sampling system (Table 4.1-2). RPDs for all VOCs were negative for 30- and 260-ft depth samples, with six of seven negative RPDs for VOCs at the 90-ft depth.

4.1.2 Independent Student's t-test Results

To evaluate differences in VOC concentrations from the new FLUTe and the vintage FLUTe systems, independent Student's *t*-tests were performed. In 30-ft samples, VOC means from the vintage FLUTe and new FLUTe systems were not significantly different for chloroform and trichloroethene (Table 4.1-3). In 90-ft samples, mean VOC concentrations from the vintage FLUTe and new FLUTe systems were not significantly different for carbon tetrachloride, dichlorodifluoromethane, and trichloroethene but were significantly higher in new FLUTe samples for chloroform, dichloroethene[cis-1,2-], methylene chloride, and tetrachloroethene (Table 4.1-4). In 260-ft samples, mean VOC concentrations from the vintage FLUTe and new FLUTe systems were not significantly different (Table 4.1-5).

Because the vintage FLUTe and SS systems are being used for vapor monitoring at MDA G, independent Student's *t*-tests were conducted to evaluate for the VOC concentrations samples. For the t-test comparison of vintage FLUTe and SS system VOCs, only 4 of 16 results were found to be significantly different. In 30-ft samples, mean VOC concentrations for both VOCs were significantly different (Table 4.1-6). In 90-ft samples, the mean VOC concentrations were not significantly different for any of the VOCs (Table 4.1-7). In 260-ft samples, the mean VOC concentrations were not significantly different for chloroform, dichlorofluoromethane, dichloroethene[cis-1,2-], methylene chloride, or trichloethene, but were significantly different for chloroform and tetrachloroethene (Table 4.1-8).

5.0 CONCLUSIONS

Subsurface vapor samples were collected using three different types of vapor-monitoring systems from boreholes located south of the MDA C boundary: SS, new FLUTe, and vintage FLUTe. Tritium was detected in six of nine samples collected for this test. Tritium was detected at the 30-ft depth in a sample from the vintage FLUTe system, from the 90-ft depth in SS and vintage FLUTe samples, and from all three samples collected at the 260-ft depth. In the 90 ft tritium detects, the SS system sample was approximately 2 times higher than the vintage FLUTe system sample. In the 260-ft samples, tritium was approximately 3 times higher than the New FLUTe sample and 5 times higher than the vintage FLUTe sample.

When comparing new FLUTe and vintage FLUTe VOC results, based on independent Student's *t*-test results, there was a significant difference in means in only 4 of 16 VOC comparisons. All of the differences in means between vintage and new FLUTes were observed in the 90-ft samples. RPD calculations indicated no significant trend toward higher results in either of the two FLUTe systems.

When comparing the vintage FLUTe and SS sampling systems, 15 of 16 SS and vintage FLUTe VOC RPD comparisons indicated higher mean values from SS system samples. Student's *t*-test results showed significant differences in both VOCs from the 30-ft samples, but there were no significant differences between the mean VOC concentrations in 12 of 14 VOCs comparisons in 90- and 260-ft samples.

Based on the results of this investigation, it cannot be concluded that significant differences exist between vintage FLUTe and new FLUTe samples, or for vintage FLUTe and SS samples. Although RPD calculations indicated a slight trend toward higher results in the SS system samples, Student's *t*-test results confirmed statistically significant differences in only 4 of 16 VOC comparisons in each side-by-side sampling system comparison.

Finally, the comparison of VOC data from the vintage FLUTe and SS sampling systems does not support the proposition that adsorption of VOCs in the vintage FLUTe sampling trains is occurring that would bias samples collected using MDA G FLUTe systems. Statistical testing performed for this evaluation confirmed that the vintage FLUTe sampling system produced similar results to the SS sampling system.

6.0 REFERENCES

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; DOE-Los Alamos Site Office; EPA, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), March 2008. "Pilot Test Work Plan for Evaluating Vapor-Sampling Systems at Material Disposal Area C," Los Alamos National Laboratory document LA-UR-08-1614, Los Alamos, New Mexico. (LANL 2008, 101653)

LANL (Los Alamos National Laboratory), May 2008. "Pilot Test Work Plan for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G," Los Alamos National Laboratory document LA-UR-08-3175, Los Alamos, New Mexico. (LANL 2008, 102653)

NMED (New Mexico Environment Department), March 28, 2008. "Approval with Modification, Pilot Test Work Plan for Evaluating Vapor-Sampling Systems at Material Disposal Area C," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2008, 101113)

NMED (New Mexico Environment Department), May 28, 2008. "Approval with Direction, Pilot Test Work Plan for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2008, 101704)

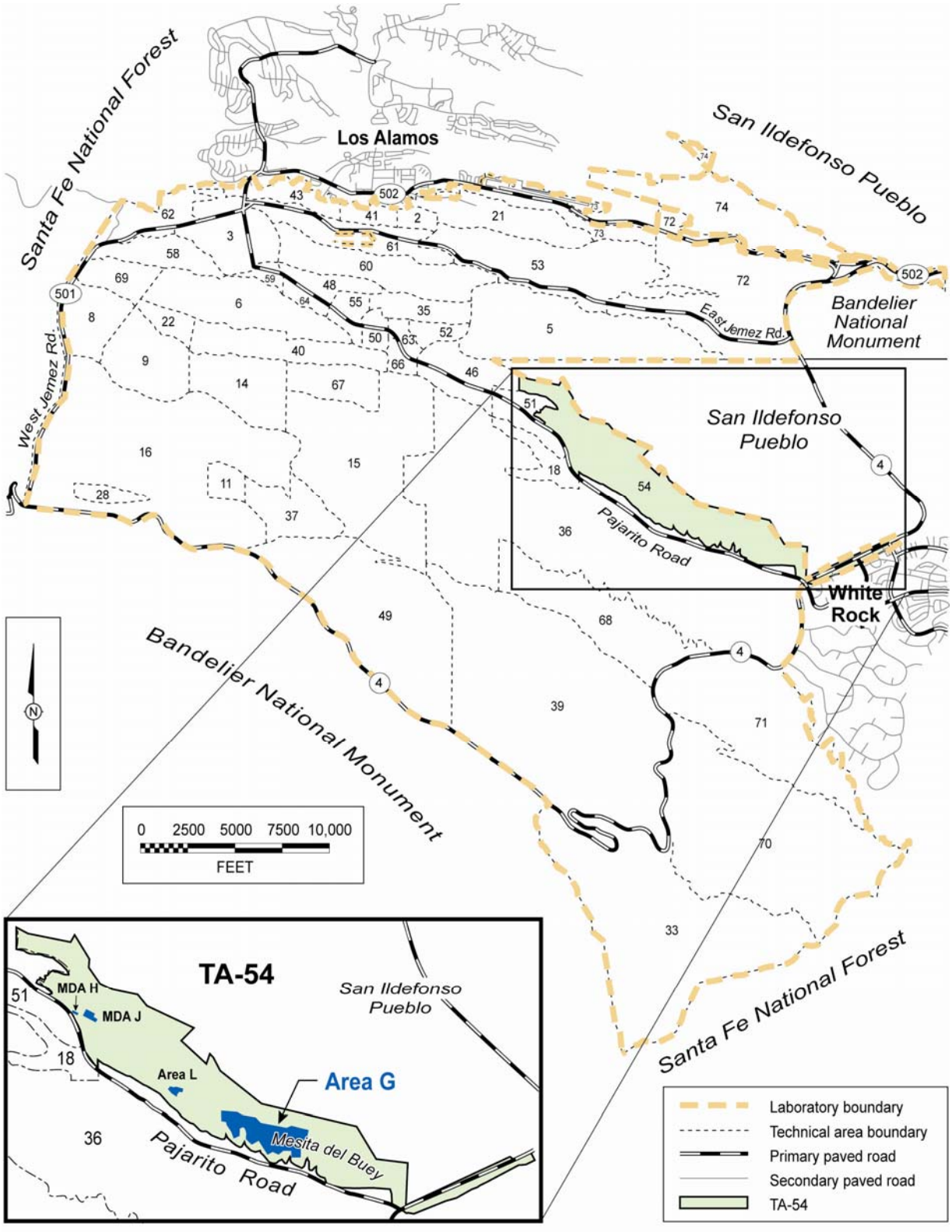


Figure 1.0-1 MDA G with respect to Laboratory technical areas and surrounding land holdings

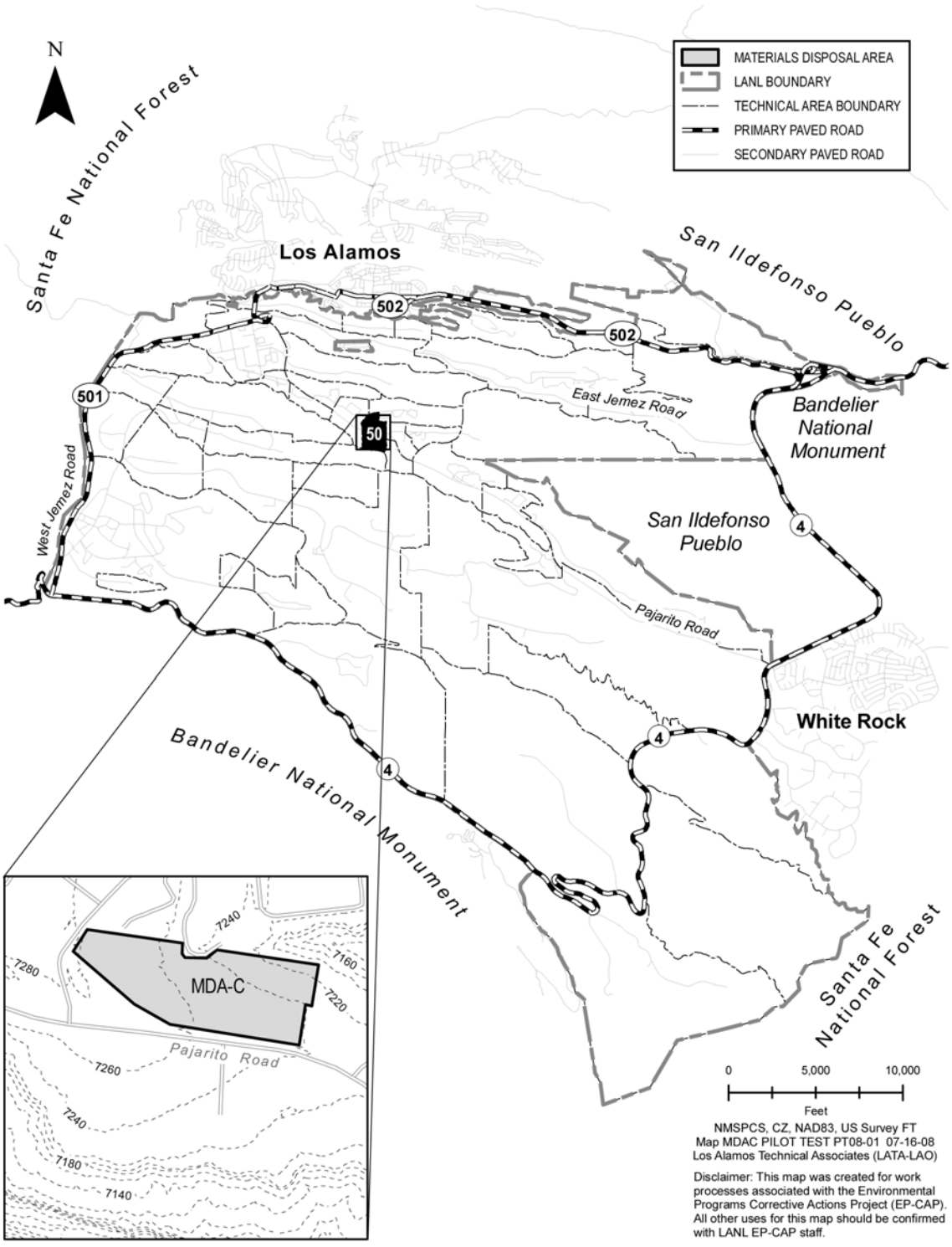


Figure 1.0-2 MDA C with respect to Laboratory technical areas and surrounding land holdings

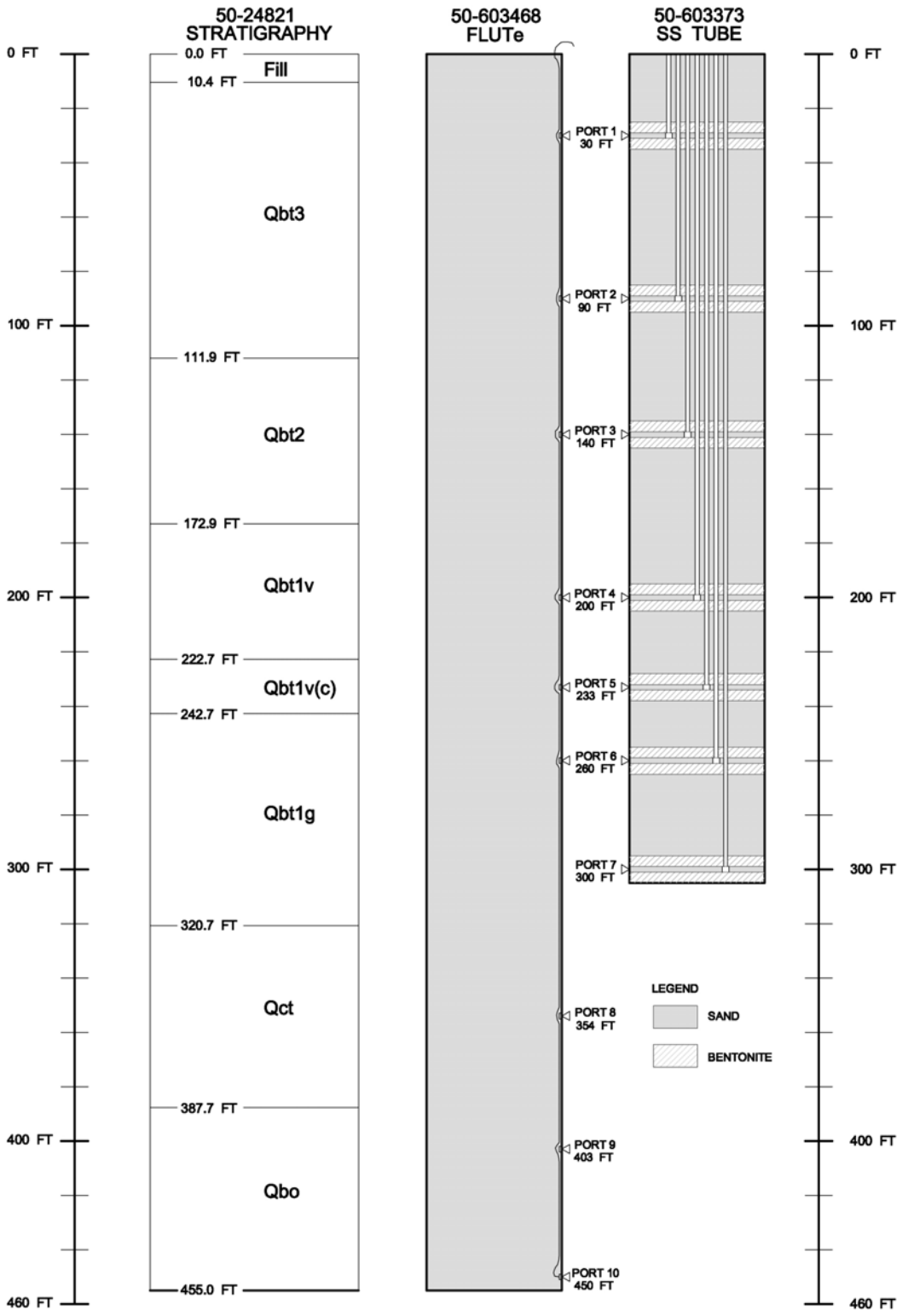


Figure 1.2-1 Installed new FLUTe and SS vapor-sampling systems in pilot test boreholes 50-603468 and 50-603373 at MDA C

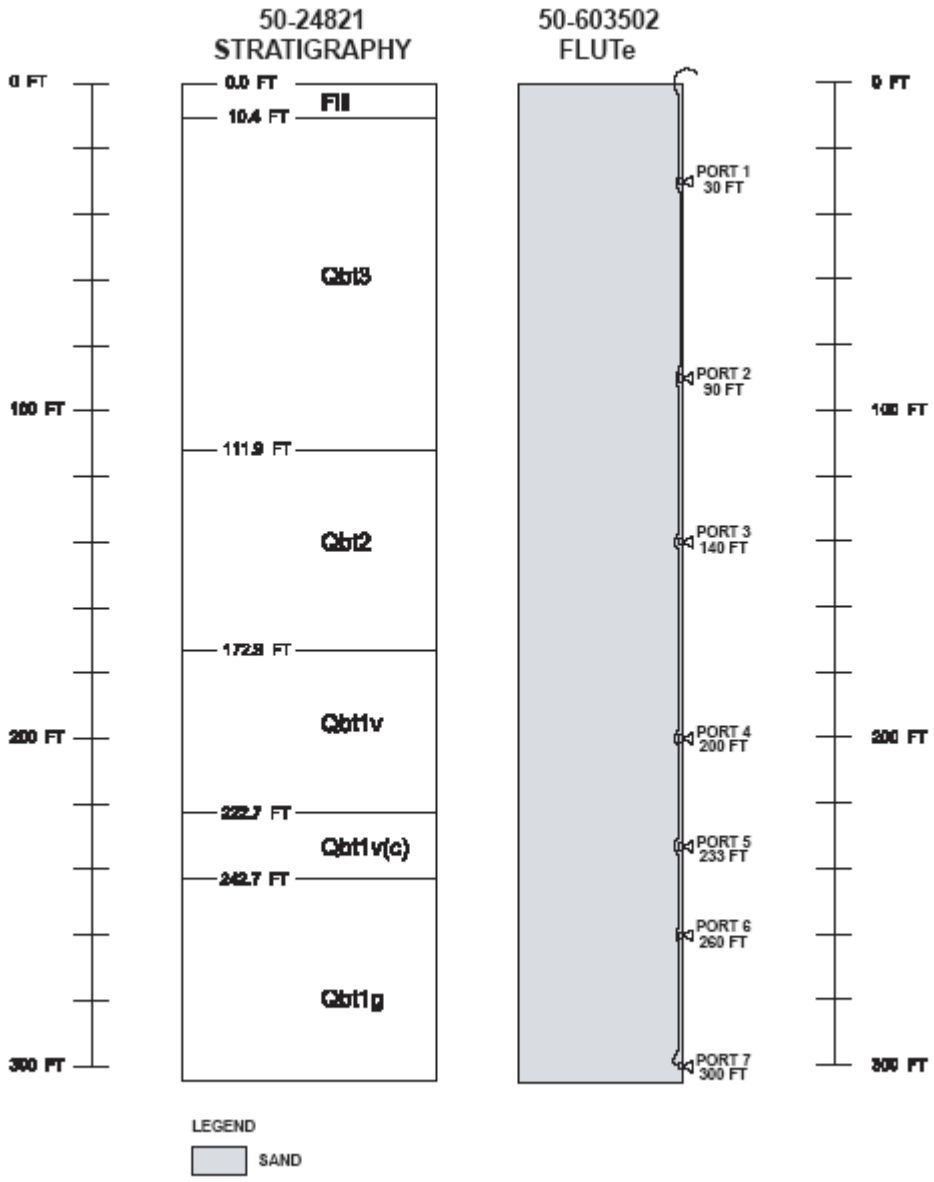


Figure 1.2-2 Installed vintage FLUTe vapor-sampling system in pilot test borehole 50-603502

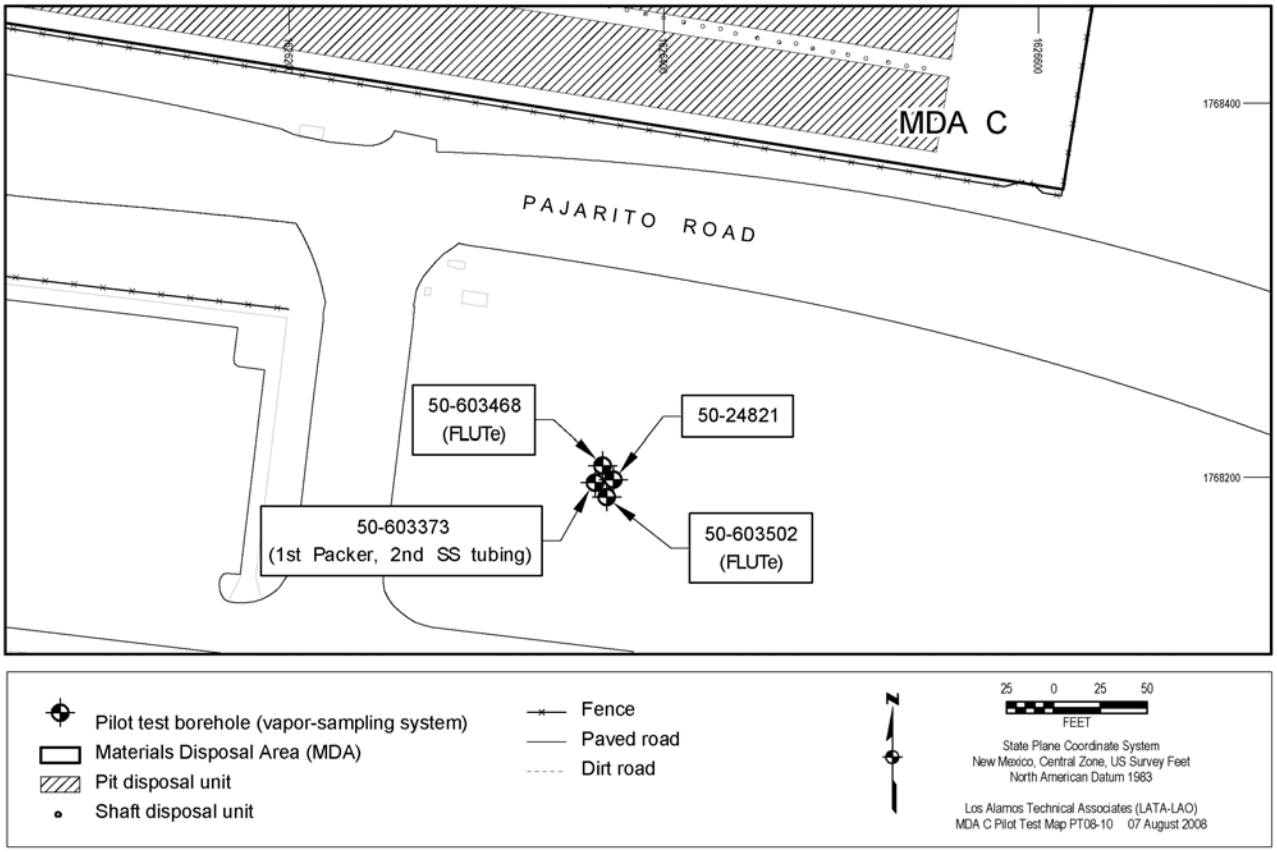
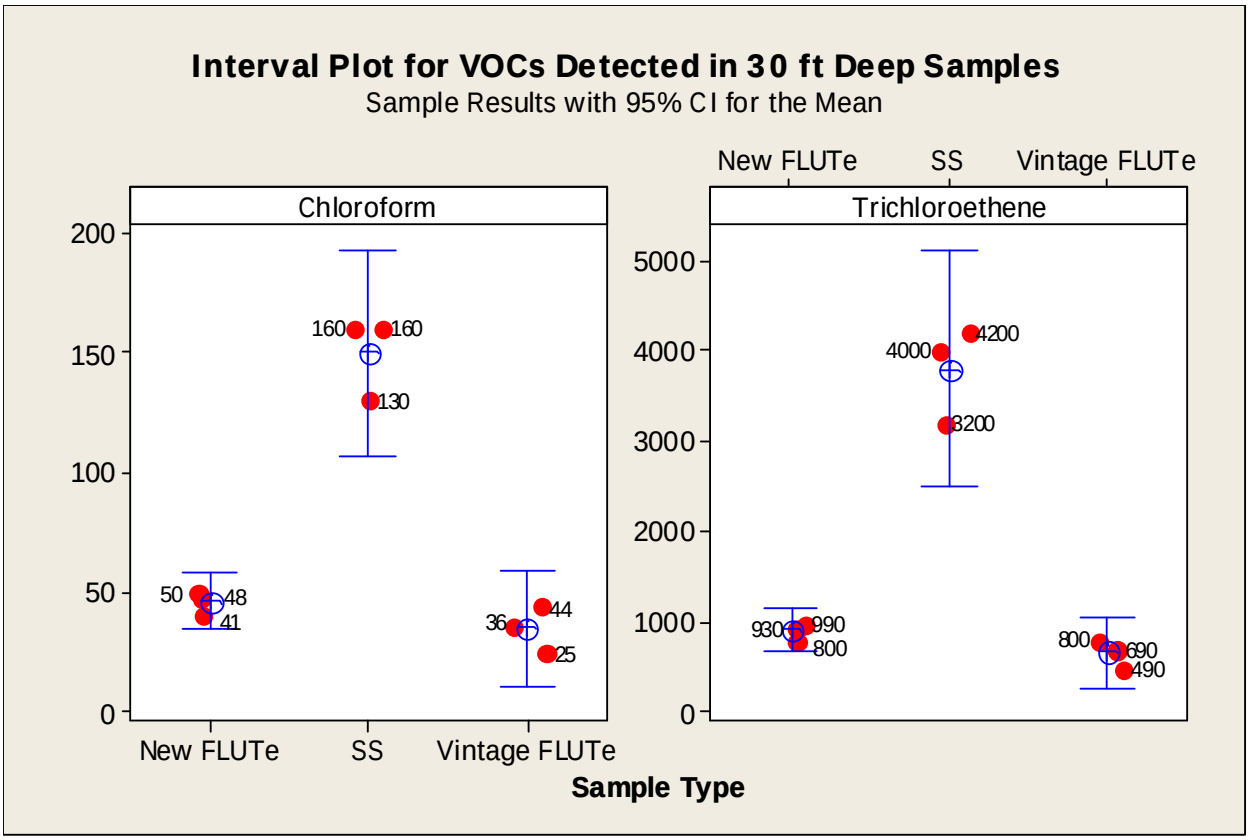
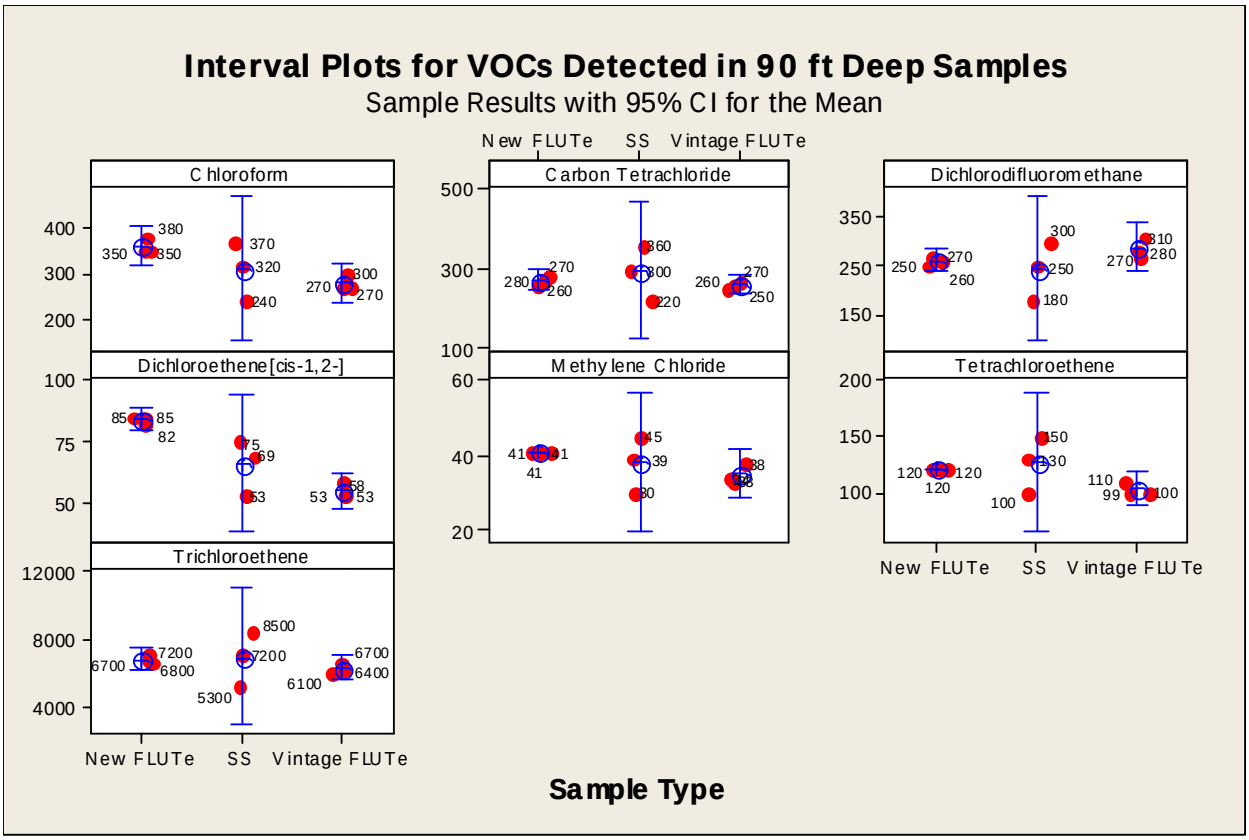


Figure 2.1-1 Pilot test vapor-sampling systems south of MDA C



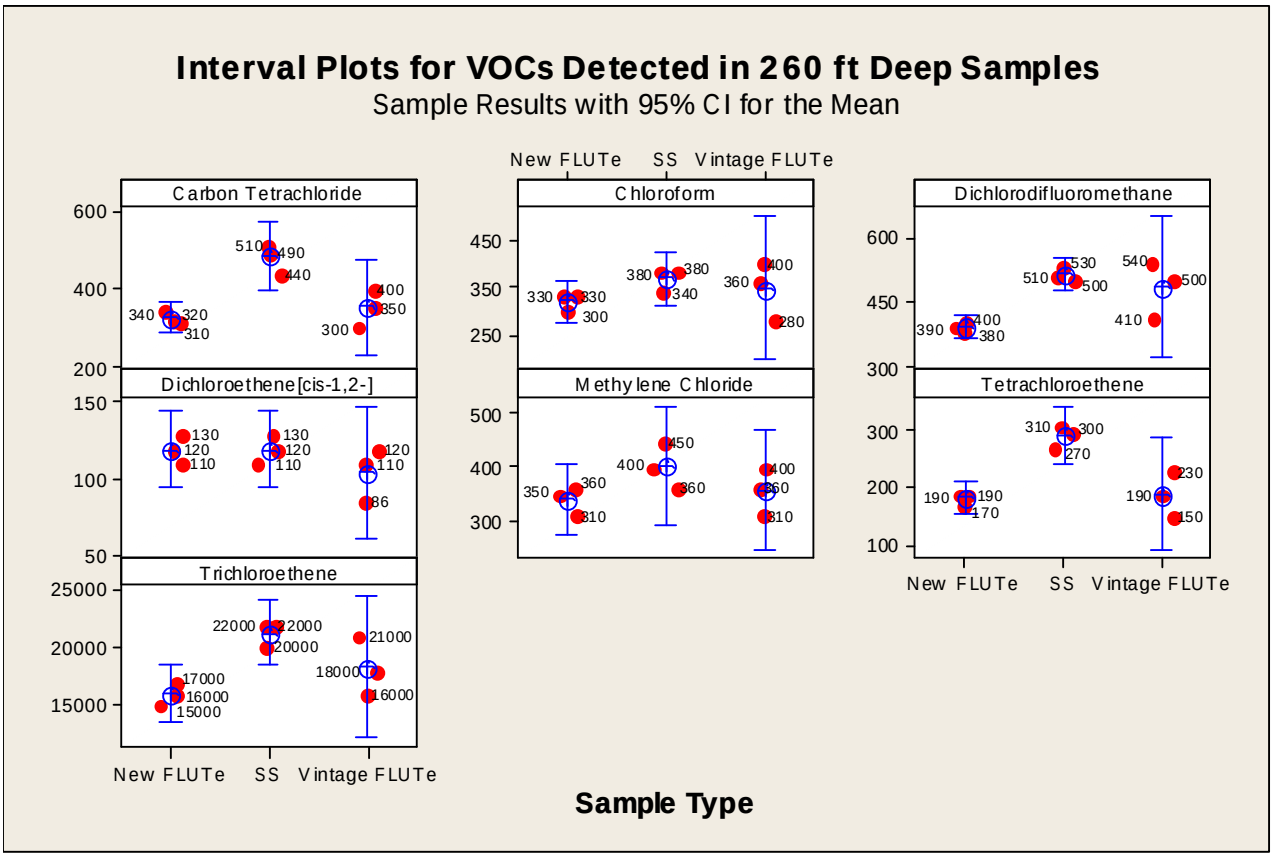
Notes: CI = Confidence interval (CI). All results are in µg/m^3.

Figure 4.0-1 VOCs detected in 30-ft samples collected from all three sampling systems



Note: All results are in µg/m^3.

Figure 4.0-2 VOCs detected in 90-ft samples collected from all three sampling systems



Note: All results are in µg/m^3.

Figure 4.0-3 VOCs detected in 260-ft samples collected from all three sampling systems

Table 2.3-1
Summary of Pore-Gas Samples Collected for Pilot Test

Location ID	Sample ID	Depth (ft)	Vapor-Sampling System	Purge Time (min)	Tritium	VOC	Collection Date
50-603373	MD50-08-11843	30	SS Tubing	5	—[a]	08-1030[b]	4/21/2008
50-603373	MD50-08-11844	30	SS Tubing	10	—	08-1030	4/21/2008
50-603373	MD50-08-11845	30	SS Tubing	20	—	08-1030	4/21/2008
50-603373	MD50-08-11863	30	SS Tubing	n/a[c]	08-1029	—	4/21/2008
50-603373	MD50-08-11850	90	SS Tubing	5	—	08-1030	4/21/2008
50-603373	MD50-08-11849	90	SS Tubing	10	—	08-1030	4/21/2008
50-603373	MD50-08-11851	90	SS Tubing	20	—	08-1030	4/21/2008
50-603373	MD50-08-11869	90	SS Tubing	n/a	08-1029	—	4/21/2008
50-603373	MD50-08-11855	260	SS Tubing	5	—	08-1021	4/18/2008
50-603373	MD50-08-11856	260	SS Tubing	10	—	08-1021	4/18/2008
50-603373	MD50-08-11857	260	SS Tubing	20	—	08-1021	4/18/2008
50-603373	MD50-08-11875	260	SS Tubing	n/a	08-1022	—	4/18/2008
50-603468	MD50-08-12990	30	New FLUTe	5	—	08-1379	6/17/2008
50-603468	MD50-08-12991	30	New FLUTe	10	—	08-1379	6/17/2008
50-603468	MD50-08-12992	30	New FLUTe	20	—	08-1379	6/17/2008
50-603468	MD50-08-12993	30	New FLUTe	n/a	08-1391	—	6/18/2008
50-603468	MD50-08-12994	90	New FLUTe	5	—	08-1396	6/19/2008
50-603468	MD50-08-12995	90	New FLUTe	10	—	08-1396	6/19/2008
50-603468	MD50-08-12996	90	New FLUTe	20	—	08-1396	6/19/2008
50-603468	MD50-08-12997	90	New FLUTe	n/a	08-1400	—	6/19/2008
50-603468	MD50-08-12998	260	New FLUTe	5	—	08-1396	6/19/2008
50-603468	MD50-08-12999	260	New FLUTe	10	—	08-1396	6/19/2008
50-603468	MD50-08-13000	260	New FLUTe	20	—	08-1396	6/19/2008
50-603468	MD50-08-13001	260	New FLUTe	n/a	08-1400	—	6/19/2008
50-603502	MD50-08-11923	30	Vintage FLUTe	5	—	08-1585	7/24/2008
50-603502	MD50-08-11924	30	Vintage FLUTe	10	—	08-1585	7/24/2008
50-603502	MD50-08-11925	30	Vintage FLUTe	20	—	08-1585	7/24/2008
50-603502	MD50-08-11930	30	Vintage FLUTe	n/a	08-1586	—	7/24/2008
50-603502	MD50-08-11931	90	Vintage FLUTe	5	—	08-1585	7/24/2008
50-603502	MD50-08-11932	90	Vintage FLUTe	10	—	08-1585	7/24/2008
50-603502	MD50-08-11933	90	Vintage FLUTe	20	—	08-1585	7/24/2008
50-603502	MD50-08-11938	90	Vintage FLUTe	n/a	08-1586	—	7/25/2008
50-603502	MD50-08-11950	260	Vintage FLUTe	5	—	08-1585	7/24/2008
50-603502	MD50-08-11951	260	Vintage FLUTe	10	—	08-1585	7/24/2008
50-603502	MD50-08-11952	260	Vintage FLUTe	20	—	08-1585	7/24/2008
50-603502	MD50-08-11949	260	Vintage FLUTe	n/a	08-1586	—	7/24/2008

[a] — = Analysis not requested.

[b] Analytical request number.

[c] n/a = Not applicable.

Table 3.0-1
VOCs Detected in Pore Gas at Locations 50-603373, 50-503468, and 50-603502

Location Id	Sample Id	Depth (ft)	Vapor-Sampling System	Carbon Tetrachloride	Chloroform	Dichlorodifluoromethane	Dichloroethene[cis-1,2-]	Methylene Chloride	Tetrachloroethene	Trichloroethene
50-603373	MD50-08-11843	30	SS Tubing	120	160	89	30	13	67	4200
50-603373	MD50-08-11844	30	SS Tubing	110	160	72	29	12	67	4000
50-603373	MD50-08-11845	30	SS Tubing	82	130	64	27	14	60	3200
50-603373	MD50-08-11849	90	SS Tubing	220	240	180	53	30	100	5300
50-603373	MD50-08-11850	90	SS Tubing	300	320	250	69	39	130	7200
50-603373	MD50-08-11851	90	SS Tubing	360	370	300	75	45	150	8500
50-603373	MD50-08-11855	260	SS Tubing	440	340	510	110	360	270	20000
50-603373	MD50-08-11856	260	SS Tubing	490	380	500	120	450	310	22000
50-603373	MD50-08-11857	260	SS Tubing	510	380	530	130	400	300	22000
50-603468	MD50-08-12990	30	New FLUTe	—*	41	33	—	—	—	800
50-603468	MD50-08-12991	30	New FLUTe	33	48	37	10	—	16	930
50-603468	MD50-08-12992	30	New FLUTe	36	50	41	10	—	17	990
50-603468	MD50-08-12994	90	New FLUTe	260	350	250	85	41	120	6800
50-603468	MD50-08-12995	90	New FLUTe	270	350	260	82	41	120	6700
50-603468	MD50-08-12996	90	New FLUTe	280	380	270	85	41	120	7200
50-603468	MD50-08-12998	260	New FLUTe	320	330	380	120	350	190	16000
50-603468	MD50-08-12999	260	New FLUTe	340	330	400	130	360	190	17000
50-603468	MD50-08-13000	260	New FLUTe	310	300	390	110	310	170	15000
50-603502	MD50-08-11923	30	Vintage FLUTe	—	25	—	—	—	—	490
50-603502	MD50-08-11924	30	Vintage FLUTe	23	44	30	—	—	—	800

Location Id	Sample Id	Depth (ft)	Vapor-Sampling System	Carbon Tetrachloride	Chloroform	Dichlorodifluoromethane	Dichloroethene[cis-1,2-]	Methylene Chloride	Tetrachloroethene	Trichloroethene
50-603502	MD50-08-11925	30	Vintage FLUTe	19	36	26	—	—	—	690
50-603502	MD50-08-11931	90	Vintage FLUTe	260	270	270	53	33	99	6100
50-603502	MD50-08-11932	90	Vintage FLUTe	250	270	280	53	34	100	6400
50-603502	MD50-08-11933	90	Vintage FLUTe	270	300	310	58	38	110	6700
50-603502	MD50-08-11950	260	Vintage FLUTe	400	400	540	120	400	230	21000
50-603502	MD50-08-11951	260	Vintage FLUTe	350	360	500	110	360	190	18000
50-603502	MD50-08-11952	260	Vintage FLUTe	300	280	410	86	310	150	16000

Note: All results are in µg/m^3.

*— = Not detected.

Table 3.0-2
Tritium Detected in Pore Gas at Locations 50-603373, 50-503468, and 50-603502

Location ID	Sample ID	Depth (ft)	Vapor-Sampling System	Tritium	Uncertainty
50-603373	MD50-08-11863	30	SS tubing	—*	—
50-603373	MD50-08-11869	90	SS tubing	595.232	142.183
50-603373	MD50-08-11875	260	SS tubing	1005.25	171.149
50-603468	MD50-08-12993	30	New FLUTe	—	—
50-603468	MD50-08-12997	90	New FLUTe	—	—
50-603468	MD50-08-13001	260	New FLUTe	303.002	64.849
50-603502	MD50-08-11930	30	Vintage FLUTe	529.517	66.278
50-603502	MD50-08-11938	90	Vintage FLUTe	325.573	61.301
50-603502	MD50-08-11949	260	Vintage FLUTe	196.943	57.571

Note: Units are pCi/L.

*— = Not detected.

Table 3.1-1
Comparisons of VOC Detects in Stainless Steel and FLUTe Sampling Systems in Boreholes 50-603373, 50-603468, and 50-603502

Borehole ID	50-603373 (30-ft depth)				50-603468 (30-ft depth)				50-603502 (30-ft depth)			
Vapor sampling system	Stainless Steel				New FLUTe				Vintage FLUTe			
Sample ID	MD50-08-11843	MD50-08-11844	MD50-08-11845		MD50-08-12990	MD50-08-12991	MD50-08-12992		MD50-08-11923	MD50-08-11924	MD50-08-11925	
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results
Chloroform	160	160	130	**150**	41	48	50	46.33	25	44	36	35
Trichloroethene	4200	4000	3200	**3800**	800	930	990	906.67	490	800	690	660

Borehole ID	50-603373 (90-ft depth)				50-603468 (90-ft depth)				50-603502 (90-ft depth)			
Vapor sampling system	Stainless Steel				New FLUTe				Vintage FLUTe			
Sample ID	MD50-08-11849	MD50-08-11850	MD50-08-11851		MD50-08-12994	MD50-08-12995	MD50-08-12996		MD50-08-11931	MD50-08-11932	MD50-08-11933	
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results
Carbon tetrachloride	220	300	360	**293.33**	260	270	280	270	260	250	270	260
Chloroform	240	320	370	310	350	350	380	**360**	270	270	300	280
Dichlorodifluoromethane	180	250	300	243.33	250	260	270	260	270	280	310	**287**
Dichloroethene[cis-1,2-]	53	69	75	65.67	85	82	85	**84**	53	53	58	55
Methylene chloride	30	39	45	38	41	41	41	**41**	33	34	38	35
Tetrachloroethene	100	130	150	**126.67**	120	120	120	120	99	100	110	103
Trichloroethene	5300	7200	8500	**7000**	6800	6700	7200	6900	6100	6400	6700	6400

Borehole ID	50-603373 (260-ft depth)				50-603468 (260 ft depth)				50-603502 (260 ft depth)			
Vapor sampling system	Stainless Steel				New FLUTe				Vintage FLUTe			
Sample ID	MD50-08-11855	MD50-08-11856	MD50-08-11857		MD50-08-12998	MD50-08-12999	MD50-08-13000		MD50-08-11950	MD50-08-11951	MD50-08-11952	
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results
Carbon tetrachloride	440	490	510	**480**	320	340	310	323	400	350	300	350
Chloroform	340	380	380	**367**	330	330	300	320	400	360	280	347
Dichlorodifluoromethane	510	500	530	**513**	380	400	390	390	540	500	410	483
Dichloroethene[cis-1,2-]	110	120	130	**120**	120	130	110	**120**	120	110	86	105
Methylene chloride	360	450	400	**403**	350	360	310	340	400	360	310	357
Tetrachloroethene	270	310	300	**293**	190	190	170	183	230	190	150	190
Trichloroethene	20000	22000	22000	**21333**	16000	17000	15000	16000	21000	18000	16000	18333

Note: All results are in µg/m^3.
Bold – highest VOC-specific mean.

Table 3.1-2
Comparisons of Tritium Detects from Stainless Steel
and FLUTe Sampling Systems in Boreholes 50-603373, 50-603468, and 50-603502

Borehole ID	**50-603373 (30-ft depth)**	**50-603468 (30-ft depth)**	**50-603502 (30-ft depth)**
Vapor sampling system	**Stainless Steel**	**New FLUTe**	**Vintage FLUTe**
Sample ID	**MD50-08-11863**	**MD50-08-12993**	**MD50-08-11930**
Tritium (pCi/L)	ND*	ND	529.517
Borehole ID	**50-603373 (90-ft depth)**	**50-603468 (90-ft depth)**	**50-603502 (90-ft depth)**
Vapor sampling system	**Stainless Steel**	**New FLUTe**	**Vintage FLUTe**
Sample ID	**MD50-08-11869**	**MD50-08-12997**	**MD50-08-11938**
Tritium (pCi/L)	595.232	ND	325.573
Borehole ID	**50-603373 (30-ft depth)**	**50-603468 (30-ft depth)**	**50-603502 (30-ft depth)**
Vapor sampling system	**Stainless Steel**	**New FLUTe**	**Vintage FLUTe**
Sample ID	**MD50-08-11875**	**MD50-08-13001**	**MD50-08-11949**
Tritium (pCi/L)	1005.25	303.002	196.943

* ND = Not Detected.

Table 4.1-1
Comparison for Vintage FLUTe (50-603502) and New FLUTe (50-603468) Sampling Systems

Borehole ID	50-603502 (30-ft depth)				50-603468 (30-ft depth)					
Vapor sampling system	Vintage FLUTe				New FLUTe					
Sample ID	MD50-08-11923	MD50-08-11924	MD50-08-11925		MD50-08-12990	MD50-08-12991	MD50-08-12992			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Chloroform	25	44	36	35	41	48	50	46.33	-27.86	0.1390
Trichloroethene	490	800	690	660	800	930	990	906.67	-31.49	0.0818
								Mean RPD =	**-29.68**	

Borehole ID	50-603502 (9050-603502)				50-603468 (90-ft depth)					
Vapor sampling system	Vintage FLUTe				New FLUTe					
Sample ID	MD50-08-11931	MD50-08-11932	MD50-08-11933		MD50-08-12994	MD50-08-12995	MD50-08-12996			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Carbon tetrachloride	260	250	270	260	260	270	280	270	-3.77	0.2879
Chloroform	270	270	300	280	350	350	380	360	-25.00	**0.0048**
Dichlorodifluoromethane	270	280	310	287	250	260	270	260	9.87	0.1161
Dichloroethene[cis-1,2-]	53	53	58	55	85	82	85	84	-41.73	**0.0001**
Methylene chloride	33	34	38	35	41	41	41	41	-15.79	**0.0171**
Tetrachloroethene	99	100	110	103	120	120	120	120	-15.25	**0.0084**
Trichloroethene	6100	6400	6700	6400	6800	6700	7200	6900	-7.52	0.0963
								Mean RPD =	**-14.17**	

Borehole ID	50-603502 (260 ft depth)				50-603468 (260 ft depth)					
Vapor sampling system	Vintage FLUTe				New FLUTe					
Sample ID	MD50-08-11950	MD50-08-11951	MD50-08-11952		MD50-08-12998	MD50-08-12999	MD50-08-13000			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Carbon tetrachloride	400	350	300	350	320	340	310	323	8.02	0.4269
Chloroform	400	360	280	347	330	330	300	320	8.00	0.5073
Dichlorodifluoromethane	540	500	410	483	380	400	390	390	21.37	0.2756
Dichloroethene[cis-1,2-]	120	110	86	105	120	130	110	120	-13.02	0.0743
Methylene chloride	400	360	310	357	350	360	310	340	4.78	0.6102
Tetrachloroethene	230	190	150	190	190	190	170	183	3.75	0.2099
Trichloroethene	21000	18000	16000	18333	16000	17000	15000	16000	13.59	0.7953
								Mean RPD =	**6.64**	
								All VOC RPD Mean =	**-7.00**	

Notes: Values in bold indicate a significant difference. All results are in µg/m^3.

Table 4.1-2
Comparison for Vintage FLUTe (50-603502) and Stainless Steel (50-603468) Sampling Systems

Borehole ID	50-603502 (30-ft depth)				50-603373 (30-ft depth)					
Vapor sampling system	Vintage FLUTe				Stainless Steel					
Sample ID	MD50-08-11923	MD50-08-11924	MD50-08-11925		MD50-08-11843	MD50-08-11844	MD50-08-11845			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Chloroform	25	44	36	35	160	160	130	150	-124.32	**0.0005**
Trichloroethene	490	800	690	660	4200	4000	3200	3800	-140.81	**0.0006**
								Mean RPD =	**-132.57**	

Borehole ID	50-603502 (9050-603502)				50-603373 (90-ft depth)					
Vapor sampling system	Vintage FLUTe				Stainless Steel					
Sample ID	MD50-08-11931	MD50-08-11932	MD50-08-11933		MD50-08-11849	MD50-08-11850	MD50-08-11851			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Carbon tetrachloride	260	250	270	260	220	300	360	293.33	-12.05	0.4614
Chloroform	270	270	300	280	240	320	370	310	-10.17	0.4863
Dichlorodifluoromethane	270	280	310	287	180	250	300	243.33	16.47	0.3045
Dichloroethene[cis-1,2-]	53	53	58	55	53	69	75	65.67	-17.68	0.1797
Methylene chloride	33	34	38	35	30	39	45	38	-8.22	0.5514
Tetrachloroethene	99	100	110	103	100	130	150	126.67	-20.16	0.1885
Trichloroethene	6100	6400	6700	6400	5300	7200	8500	7000	-8.96	0.5600
								Mean RPD =	**-8.75**	

Borehole ID	50-603502 (260 ft depth)				50-603373 (260-ft depth)					
Vapor sampling system	Vintage FLUTe				Stainless Steel					
Sample ID	MD50-08-11950	MD50-08-11951	MD50-08-11952		MD50-08-11855	MD50-08-11856	MD50-08-11857			
Purge time (min)	5	10	20	Mean Sample Results	5	10	20	Mean Sample Results	RPD (%)	Student's *t*-test p-value
Carbon tetrachloride	400	350	300	350	440	490	510	480	-13.33	**0.0217**
Chloroform	400	360	280	347	340	380	380	367	-5.60	0.6240
Dichlorodifluoromethane	540	500	410	483	510	500	530	513	-6.02	0.4892
Dichloroethene[cis-1,2-]	120	110	86	105	110	120	130	120	-13.33	0.2756
Methylene chloride	400	360	310	357	360	450	400	403	-12.11	0.2737
Tetrachloroethene	230	190	150	190	270	310	300	293	-42.65	**0.0166**
Trichloroethene	21000	18000	16000	18333	20000	22000	22000	21333	-15.13	0.1338
								Mean RPD =	**-18.02**	
								All VOC RPD Mean =	**-28.28**	

Notes: Values in bold indicate a significant difference. All results are in µg/m^3.

Table 4.1-3
Vintage FLUTe and New FLUTe Comparison of Student's *t*-test Results for VOCs Detected in 30-ft Samples

30 ft Sampling Depth t-Tests between FLUTe Types Assuming Equal Variances

Groups	n	Mean	SD	SE
Vintage Chloroform	3	35.0	9.5	5.51
New Chloroform	3	46.3	4.7	2.73
n	6			
Difference between means	-11.3			
95% CI	-28.4	to 5.7		
t statistic	-1.84			
DF	4.0			
2-tailed p	**0.1390**			

Groups	n	Mean	SD	SE
Vintage TCE	3	660.0	157.2	90.74
New TCE	3	906.7	97.1	56.08
n	6			
Difference between means	-246.7			
95% CI	-542.8	to 49.5		
t statistic	-2.31			
DF	4.0			
2-tailed p	**0.0818**			

Table 4.1-4
Vintage FLUTe and New FLUTe Comparison of Student's *t*-test Results for VOCs Detected in 90-ft Samples

90 ft Sampling Depth t-Tests between FLUTe Types Assuming Equal Variances

Groups	n	Mean	SD	SE
Vintage Chloroform	3	280.0	17.3	10.00
New Chloroform	3	360.0	17.3	10.00
n	6			
Difference between means	-80.0			
95% CI	-119.3	to -40.7		
t statistic	-5.66			
DF	4.0			
2-tailed p	**0.0048**			

Groups	n	Mean	SD	SE
Vintage Methylene Chrloride	3	35.0	1.53	2.6
New Methylene Chrloride	3	41.0	0.00	0.0
n	6			
Mean difference	6.0			
95% CI	1.8	to 10.2		
t statistic	3.93			
DF	4.0			
2-tailed p	**0.0171**			

Groups	n	Mean	SD	SE
Vintage Carbon Tet.	3	260.0	10.0	5.77
New Carbon Tet.	3	270.0	10.0	5.77
n	6			
Difference between means	-10.0			
95% CI	-32.7	to 12.7		
t statistic	-1.22			
DF	4.0			
2-tailed p	**0.2879**			

Groups	n	Mean	SD	SE
Vintage Tetrachloroethene	3	103.0	6.1	3.51
New Tetrachloroethene	3	120.0	0.0	0.00
n	6			
Difference between means	-17.0			
95% CI	-26.8	to -7.2		
t statistic	-4.84			
DF	4.0			
2-tailed p	**0.0084**			

Groups	n	Mean	SD	SE
Vintage Dichlorodifluoromethane	3	286.7	20.8	12.02
New Dichlorodifluoromethane	3	260.0	10.0	5.77
n	6			
Difference between means	26.7			
95% CI	-10.4	to 63.7		
t statistic	2.00			
DF	4.0			
2-tailed p	**0.1161**			

Groups	n	Mean	SD	SE
Vintage Trichloroethene	3	6400.0	300.0	173.21
New Trichloroethene	3	6900.0	264.6	152.75
n	6			
Difference between means	-500.0			
95% CI	-1141.2	to 141.2		
t statistic	-2.17			
DF	4.0			
2-tailed p	**0.0963**			

Groups	n	Mean	SD	SE
Vintage Dichloroethene[cis-1,2-]	3	54.7	2.9	1.67
New Dichloroethene[cis-1,2-]	3	84.0	1.7	1.00
n	6			
Difference between means	-29.3			
95% CI	-34.7	to -23.9		
t statistic	-15.09			
DF	4.0			
2-tailed p	**0.0001**			

Table 4.1-5
Vintage FLUTe and New FLUTe Comparison of
Student's *t*-test Results for VOCs Detected in 260-ft Samples

260 ft Sampling Depth t-Tests between FLUTe Types Assuming Equal Variances

Sample Type	n	Mean	SD	SE
Vintage Carbon Tet.	3	350.0	50.0	28.87
New Carbon Tet.	3	323.3	15.3	8.82
n	6			
Difference between means	26.7			
95% CI	-57.1	to 110.5		
t statistic	0.88			
DF	4.0			
2-tailed p	**0.4269**			

Sample Type	n	Mean	SD	SE
Vintage Methylene Chloride	3	356.7	45.1	26.03
New Methylene Chloride	3	340.0	26.5	15.28
n	6			
Difference between means	16.7			
95% CI	-67.1	to 100.5		
t statistic	0.55			
DF	4.0			
2-tailed p	**0.6102**			

Sample Type	n	Mean	SD	SE
Vintage Chloroform Vintage	3	346.7	61.1	35.28
New Chloroform	3	320.0	17.3	10.00
n	6			
Difference between means	26.7			
95% CI	-75.1	to 128.5		
t statistic	0.73			
DF	4.0			
2-tailed p	**0.5073**			

Sample Type	n	Mean	SD	SE
Vintage Trichloroethene	3	18333.3	2516.6	1452.97
New Trichloroethene	3	16000.0	1000.0	577.35
n	6			
Difference between means	2333.3			
95% CI	-2007.6	to 6674.2		
t statistic	1.49			
DF	4.0			
2-tailed p	**0.2099**			

Groups	n	Mean	SE	SD
Vintage Dichloroethene[cis-1,2-]	3	105.3	10.09	17.5
New Dichloroethene[cis-1,2-]	3	120.0	5.77	10.0
n	6			
Mean difference	-14.7			
95% CI	-46.9	to 17.6		
t statistic	-1.26			
DF	4.0			
2-tailed p	**0.2756**			

Sample Type	n	Mean	SD	SE
Vintage Tetrachloroethene	3	190.0	40.0	23.09
New Tetrachloroethene	3	183.3	11.5	6.67
n	6			
Difference between means	6.7			
95% CI	-60.1	to 73.4		
t statistic	0.28			
DF	4.0			
2-tailed p	**0.7953**			

Sample Type	n	Mean	SD	SE
Vintage Dichlorodifluoromethane Vintage	3	483.3	66.6	38.44
New Dichlorodifluoromethane	3	390.0	10.0	5.77
n	6			
Difference between means	93.3			
95% CI	-14.6	to 201.3		
t statistic	2.40			
DF	4.0			
2-tailed p	**0.0743**			

Table 4.1-6
Vintage FLUTe and SS Comparison of
Student's *t*-test Results for VOCs Detected in 30-ft Samples

30 ft Sampling Depth t-Tests Comparing SS and Vintage FLUTe Systems Assuming Equal Variances

Chloroform	n	Mean	SE	SD
30 ft SS	3	150.0	10.00	17.3
30 ft Vintage FLUTe	3	35.0	5.51	9.5
n	6			
Mean difference	115.0			
95% CI	83.3	to 146.7		
t statistic	10.07			
DF	4.0			
2-tailed p	0.0005			

Trichloroethene	n	Mean	SE	SD
30 ft SS	3	3800.0	305.51	529.2
30 ft Vintage FLUTe	3	660.0	90.74	157.2
n	6			
Mean difference	3140.0			
95% CI	2255.2	to 4024.8		
t statistic	9.85			
DF	4.0			
2-tailed p	0.0006			

Table 4.1-7
Vintage FLUTe and SS Comparison of
Student's *t*-test Results for VOCs Detected in 90-ft Samples

90 ft Sampling Depth t-Tests Comparing SS and Vintage FLUTe Systems Assuming Equal Variances

Carbon Tetrachloride	n	Mean	SE	SD
90 ft SS	3	293.3	40.55	70.2
90 ft Vintage FLUTe	3	260.0	5.77	10.0
n	6			
Mean difference	33.3			
95% CI	-80.4 to 147.1			
t statistic	0.81			
DF	4.0			
2-tailed p	**0.4614**			

Methylene Chloride	n	Mean	SE	SD
90 ft SS	3	38.0	4.36	7.5
90 ft Vintage FLUTe	3	35.0	1.53	2.6
n	6			
Mean difference	3.0			
95% CI	-9.8 to 15.8			
t statistic	0.65			
DF	4.0			
2-tailed p	**0.5514**			

Chloroform	n	Mean	SE	SD
90 ft SS	3	310.0	37.86	65.6
90 ft Vintage FLUTe	3	280.0	10.00	17.3
n	6			
Mean difference	30.0			
95% CI	-78.7 to 138.7			
t statistic	0.77			
DF	4.0			
2-tailed p	**0.4863**			

Tetrachloroethene	n	Mean	SE	SD
90 ft SS	3	126.7	14.53	25.2
90 ft Vintage FLUTe	3	103.0	3.51	6.1
Mean difference	23.7			
95% CI	-17.8 to 65.2			
n	6			
t statistic	1.58			
DF	4.0			
2-tailed p	**0.1885**			

Dichlorodifluoromethane	n	Mean	SE	SD
90 ft SS	3	243.3	34.80	60.3
90 ft Vintage FLUTe	3	286.7	12.02	20.8
n	6			
Mean difference	-43.3			
95% CI	-145.6 to 58.9			
t statistic	-1.18			
DF	4.0			
2-tailed p	**0.3045**			

Trichloroethene	n	Mean	SE	SD
90 ft SS	3	7000.0	929.16	1609.3
90 ft Vintage FLUTe	3	6400.0	173.21	300.0
n	6			
Mean difference	600.0			
95% CI	-2024.2 to 3224.2			
t statistic	0.63			
DF	4.0			
2-tailed p	**0.5600**			

Dichloroethene[cis-1,2-]	n	Mean	SE	SD
90 ft SS	3	65.7	6.57	11.4
90 ft Vintage FLUTe	3	54.7	1.67	2.9
n	6			
Mean difference	11.0			
95% CI	-7.8 to 29.8			
t statistic	1.62			
DF	4.0			
2-tailed p	**0.1797**			

Table 4.1-8
Vintage FLUTe and SS Comparison of
Student's *t*-test Results for VOCs Detected in 260-ft Samples

260 ft Sampling Depth t-Tests Comparing SS and Vintage FLUTe Systems Assuming Equal Variances

Carbon Tetrachloride	n	Mean	SE	SD
260 ft SS	3	480.0	20.82	36.1
260 ft Vintage FLUTe	3	350.0	28.87	50.0
n	6			
Mean difference	130.0			
95% CI	31.2 to 228.8			
t statistic	3.65			
DF	4.0			
2-tailed p	**0.0217**			

Methylene Chloride	n	Mean	SE	SD
260 ft SS	3	403.3	26.03	45.1
260 ft Vintage FLUTe	3	356.7	26.03	45.1
n	6			
Mean difference	46.7			
95% CI	-55.6 to 148.9			
t statistic	1.27			
DF	4.0			
2-tailed p	**0.2737**			

Chloroform	n	Mean	SE	SD
260 ft SS	3	366.7	13.33	23.1
260 ft Vintage FLUTe	3	346.7	35.28	61.1
n	6			
Mean difference	20.0			
95% CI	-84.7			
t statistic	0.53			
DF	4.0			
2-tailed p	**0.6240**			

Tetrachloroethene	n	Mean	SE	SD
260 ft SS	3	293.3	12.02	20.8
260 ft Vintage FLUTe	3	190.0	23.09	40.0
n	6			
Mean difference	103.3			
95% CI	31.1 to 175.6			
t statistic	3.97			
DF	4.0			
2-tailed p	**0.0166**			

Dichlorodifluoromethane	n	Mean	SE	SD
260 ft SS	3	513.3	8.82	15.3
260 ft Vintage FLUTe	3	483.3	38.44	66.6
n	6			
Mean difference	30.0			
95% CI	-79.5 to 139.5			
t statistic	0.76			
DF	4.0			
2-tailed p	**0.4892**			

Trichloroethene	n	Mean	SE	SD
260 ft SS	3	21333.3	666.67	1154.7
260 ft Vintage FLUTe	3	18333.3	1452.97	2516.6
n	6			
Mean difference	3000.0			
95% CI	-1438.5 to 7438.5			
t statistic	1.88			
DF	4.0			
2-tailed p	**0.1338**			

Dichloroethene[cis-1,2-]	n	Mean	SE	SD
260 ft SS	3	120.0	5.77	10.0
260 ft Vintage FLUTe	3	105.3	10.09	17.5
n	6			
Mean difference	14.7			
95% CI	-17.6 to 46.9			
t statistic	1.26			
DF	4.0			
2-tailed p	**0.2756**			

Appendix A

Sample Collection Logs
(on CD included with this document)

Appendix B

Field-Screening Results
(on CD included with this document)

Appendix C

Analytical Results
(on CD included with this document)